Appendix G

Pre-Hearing Ground Water Discharge Plan Analysis

PRE-HEARING
GROUND WATER DISCHARGE PLAN ANALYSIS

for

MT. TAYLOR URANIUM MILL PROJECT
GULF MINERAL RESOURCES COMPANY

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SUMMARY AND CONCLUSIONS

A technical analysis of Gulf Mineral Resources Company's proposed ground water discharge plan (DP-117) for its Mt. Taylor Uranium Mill Project has been conducted by the staff and consultants of the New Mexico Environmental Improvement Division's Water Pollution Control Bureau. The Plan presents the potential impacts to ground-water quality which may result from the proposed project. During the analysis an attempt was made to determine whether the proposed plan satisfies the technical requirements of the New Mexico Water Quality Act and the New Mexico Water Quality Control Commission Regulations.

Specifically Gulf's plan was analyzed from the perspective of whether Gulf has sufficiently demonstrated that discharges (planned or accidental releases) will not result in ground water contamination beyond standards at a place of withdrawal of water for present or reasonably forseeable future use?

There are three main features of the project, the operation of which have the potential to affect ground-water quality. These features are the mill impoundment and containment pond at the mill site, the tailings and liquid waste pipelines, and the tailings and liquid waste disposal facilities. Each potential source of contamination was examined separately by the staff to assess its possible affect on ground water. Based upon an analysis of available information, the following conclusions and recommendations were developed.

A. A mill impoundment and containment pond are planned to be constructed approximately one-half mile downstream of the Mt. Taylor Uranium Mill. The lined containment pond is provided to contain any major process spill from the mill as well as process area runoff, washdown water, and treated sewage water. The mill impoundment will hold any storm water that exceeds the capacity of the containment pond.

Routine discharges to the lined containment pond will be relatively low in volume; sufficient freeboard should exist in the pond to contain any major process spillage. Contaminated releases to the mill impoundment area, therefore, are seen to be infrequent. The containment pond liner and the geologic conditions at the mill impoundment should prevent significant seepage of contaminated fluids into underlying water bearings fromations.

The staff's analysis of the site's geology and hydrology and of the engineering concepts and designs incorporated into the containment pond and mill impoundment supports Gulf's conclusion that minimal impacts to ground water should result from these structures.

B. A waste transport pipeline system approximately six miles in length, will transport solid wastes in a slurry from the mill to the tailings disposal area and mill carry decant water back to the mill. The transport system consists of a pump station located within the mill, one slurry pipeline, and a mill liquor pipeline for carrying decant water from the evaporation pond to the mill. The liquor decant pipeline can also be utilized as an emergency slurry line.

The design of the transport system incorporates features that minimize the potential for release of waste material from the pipeline. The features include redundant instrumentation and daily inspection schedules. In addition, the pipelines are placed within a lined pipeway that will act to contain spills or leakage if required, and catchment basins will be provided at low points along the route.

It is the staff's opinion that the applicant's proposed pipeline system design is acceptable. It is believed that the redundant instrumentation and inspection schedules will virtually eliminate any possibility of accidental spills adversely affecting groundwater quality. Assuming a major release of tailings or decant liquid via pipeline rupture, it is unlikely that ground water standards would be violated at a place of forseeable future use.

A deficiency in the applicant's proposed discharge plan, is the lack of a detailed contingency plan describing the administrative, procedural and technical procedures to be used for responding to unanticipated releases of contaminated materials via a pipeline rupture. Such a detailed contingency plan should be prepared by the applicant and approved by EID before any discharge of tailings takes place.

C. The proposed tailings disposal area is in La Polvadera Canyon, approximately four miles north-northwest of the mill site. Approximately 1400 gallons per minute of tailings slurry, consisting of 20-40 percent by weight solids, is proposed to be discharged into a parallel series of dragline excavated trenches. Fluids draining from the solids will be collected and pumped to a lined settling pond(s) and thence to a lined evaporation pond which will be contained by a zoned earthfill dam. The facilities are designed so that all tailings will be sequentially buried below the existing ground surface as each of the trenches are filled to capacity, and so that most of the liquid wastes will be disposed of by evaporation. Provisions are made for burial of evaporites and for reclamation of all disturbed ground.

The proposed tailings and liquid disposal facilities were designed to take advantage of the available pore storage in the extremely dry native foundation materials which underlie the La Polvadera Canyon area. Laboratory analysis of core samples from both the Gallup Sandstone and Dilco Coal Member indicate water contents far below specific retention for these foundation materials. Therefore, the dry porous media has the potential to store water and bind it by capillary forces which are strong enough to prevent significant free drainage.

Seepage calculations indicate that significant saturation will not occur beneath the disposal trenches, the settling pond, or the evaporation pond. A monitoring system will be provided to verify seepage predictions during operations and provide data for development of contingency plans, if necessary, to solve unanticipated problems.

Seepage analyses conducted by Gulf were based on assumptions of flow through porous media having minor fracture related permeability. A deficiency in the applicant's discharge plan is the lack of information on fracture location, density, or related hydraulic conductivities. A staff evaluation of available literature and on-site conditions concluded that fracture permeability may exist in the Gallup Sandstone beneath portions of the site and that a possibility exists in which underground fluids may move easterly at relatively higher rates than assumed for the seepage analyses along pathways formed by joints and fractures in the sandstone. Given the absence of extensive outcropping of the Gallup Sandstone at the dispoal site, it is difficult to totally assess the degree of fracture related permeability prior to construction. Upon implementation of construction and monitoring activities, additional field data will become available for consideration. If site conditions are then found to reflect greater fracture related permeability than has been calculated for, the seepage projections should be revised.

Shallow monitoring wells will be installed around the evaporation pond perimeter to allow for detection of seepage front advance. The bore holes will be aired-drilled and cored; in situ moisture content measurements of the cores will be performed. If the information from the tests suggest the presence of significantly higher rock moisture contents than considered in the seepage analyses, the applicant should be obligated to quantify the effects of the increased in situ moisture.

A deficiency in the applicant's proposed discharge plan is the lack of detailed emergency response procedures to be implemented in the event of a dam failure. The probability of such an event transpiring is considered to be quite low. Nevertheless, with proper response procedures in effect, the ultimate insult of the failure could be greatly reduced. It is recommended that the application be required to develop a realistic response plan prior to any tailings discharge.

D. On the basis of the evaluation of the discharge plan and the analysis summarized in this Pre-Hearing Ground Water Discharge Plan Analysis, it is recommended by the staff that any discharge plan approval be subject to, but not limited to, the proposed conditions listed bleow. It must be emphasized that these conditions were developed without the benefit of the discussions and testimony to be presented during the forthcoming public hearing on the plan. As such, these conditions should be viewed as preliminary, subject to change as a result of new evidence presented at the hearing.

(1) Within six months of the approval date of the discharge plan, the discharger shall submit to the Division a detailed contingency plan describing the administrative, procedural and technical procedures to be used for responding to unanticipated releases of contaminated materials in the event of a dam failure or a major tailings pipeline failure. The contaminated material release will be assumed to result from realistic accident scenarios that are based on actual and hypothetical accidents at uranium mills of design and capacity similar to the discharger's.

(2) Prior to construction of the La Polvadera tailings and liquid disposal facilities, Gulf shall submit to the Division the following detailed technical specifications and procedures for review and approval:

(a) Procedures to be followed during preparation of areas within the trenches and evaporation pond. This should include a thorough inspection of impoundment bottom during excavation to identify large zones of high porosity or high hydraulic conductivity. Steps to line or seal such zones should be specified to ensure that, to the maximum degree possible, solutions are disposed of by evaporation rather than by seepage.

(b) Procedures/Technical sepcifications to be used to control installation of the liners to ensure installed properties are as specified.

(c) Procedure which ensures that the tailings will drain to the maximum extent practicable by removal of solutions from the trenches to lined ponds.

(d) Procedures to enable a determination that the system is behaving as predicted with respect to seepage. This should include checks of the overall water balance, of seepage collected in cutoff trenches in monitor wells, of drainage of and moisture content in deposited tailings, of slimes settlement. This should include annual review of operations by qualified engineers, geologists and/or hydrologists to determine whether operations are being conducted as proposed and to make recommendations for necessary design changes, changes in operating procdures, and/or changes in monitoring programs.

(3) A minimum of five (5) measurements shall be made of infiltration rates on surficial soils which overlie the tailings trench disposal area. Such tests shall be conducted at locations uniformily distributed over the disposal area. The results of the infiltration studies shall be used in designing reclamation plans. Such tests shall be made prior to commencement of any further construction in the tailings disposal area. The results of the tests shall be reported to the Division as soon as they become available.

(4) High resolution vertical aerial photographs of scale 1" = 200' or 1 to 2400 shall be made of the area within a one (1) mile radius of the proposed liquid and solid waste disposal facilities perimeter. Such photographs shall be made prior to commencement of any further construction in the La Polvadera Canyon area, and once every year thereafter following commencement of discharge in the area. Area of coverage for each set of photographs shall be identical. Photographs shall be certified by the photographer and submitted to EID as soon as prints are available.

(5) The discharger shall notify the EID in writing within a week when a trench excavation is complete. After excavation of any trench and prior to any tailings being discharged thereto, there shall be an EID inspection of the trench for fractures, unplugged drill holes, or any other features which could provide avenues of excursion from the trench. If such features are found, effective corrective action and/or additional monitoring as approved by EID shall be accomplished by the discharger before any discharge of tailings to the trench.

(6) The discharger shall notify the EID in writing within one week of the excavation of the alluvium from the evaporation pond bottom. Before installation of the pond lining there shall be an EID inspection of the pond bottom, and the discharger shall perform a detailed examination of the joint and fracture systems present on the exhumed rock surface. If the examination by EID or by the discharger reveals significantly greater fracture related permeability than therefore considered in the seepage analyses, seepage assessment shall be revised to consider the effects of the enhanced permeabilities. If the revised seepage assessments suggest that discharges to the evaporation pond may cause the standards of Section 3-103 of the regulations to be exceeded in ground water at any place of present or reasonably forseeable future use, then effective corrective action as approved by EID shall be accomplished by the discharger before any discharge of wastes to the pond. If the Director determines that the proposed corrective action constitutes a modification to the discharge plan, an amendment to the plan shall be sought.

(7) The discharger shall measure <u>in situ</u> moisture contents in the cores obtained during the installation of shallow monitor wells in the La Polvadera Canyon area. The results of the tests shall be submitted to the EID as soon as they become available. If the measured moisture contents are significantly higher than theretofore considered in the seepage analyses, the discharger shall revise the seepage assessments to consider the effects of the increased <u>in situ</u> moisture.

If the revised seepage assessments suggest that discharges to the La Polvadera Canyon disposal facilities may cause the standards of Section 3-103 of the regulations to be exceeded in ground water at any place of present or reasonably forseeable future use, then effective corrective action as approved by EID shall be accomplished by the discharger before any discharge of wastes to the pond. If the Director determines that the proposed corrective action constitutes a modification to the discharge plan, an amendment to the plan shall be sought.

(8) Prior to discharge of any waste products in La Polvadera Canyon, the discharger shall develop and submit for EID approval a revised monitoring system, and shall have received EID approval thereon. The information obtained from carrying out conditions (6) and (7) detailed above shall be used in developing the revised monitoring system.

(9) The discharger shall on a quarterly basis, collect representative samples of the evaporation pond liquid and by measurement suitable to EID estimate the total volume of liquid in the pond. The liquid samples shall be analyzed for the standard consitiuents tabulated in section 3-103 of the regulations and for total suspended solids.

TABLE OF CONTENTS

Summary and Conclusions

Table of Contents
List of Figures
List of Tables

INTRODUCTION.. 1
Background Information... 1
Major Features of the Project and of the Discharge Plan.......... 2

CHAPTER 2. PROJECTED GROUND WATER QUALITY IMPACTS FROM THE MILL FACILITY......... 6

CHAPTER 3. PROJECTED GROUND WATER QUALITY IMPACTS FROM THE TAILINGS PIPELINE......... 10
Critical Design Features... 10
Analysis of Potential Discharges to Ground Water................. 13
Gulf's Evaluation.. 13
Independent Evaluation... 14

CHAPTER 4. PROJECTED GROUND WATER QUALITY IMPACTS FROM TAILINGS AND LIQUID WASTE DISPOSAL FACILITIES.... 16

The Tailings Disposal Trenches................................... 16
Critical Design Features... 16
Analysis of Potential Discharges to Ground Water................. 18
Gulf's Evaluation.. 18
Independent Evaluation... 20
Reclamation Potential.. 21

Settling Pond.. 23
Critical Design Features... 23
Seepage Potential.. 23

Evaporation Pond... 24
Analysis of Potential Discharges to Ground Water by Seepage...... 28
Gulf's Calculations.. 28
Independent Evaluation... 35
Accuracy of the Model.. 35
Reliability of the Hydrogeologic Input Data...................... 36
Conclusions Drawn From the Simulated Results..................... 38
Evaporation Pond Dam Failure..................................... 42

Disposal Facility Monitoring.. 43
Shallow Monitoring System.. 43
Deep Monitoring System (Saturated Zone).......................... 44
Monitoring Procedures.. 44
Threshold Levels... 44
Contingency Plans.. 46
Post Operational Monitoring.. 47
Evaluation of the Proposed Monitoring Program..................... 47

LIST OF FIGURES

Figure 1. Project Location 3

Figure 2. Population Distribution Within 5 Mile Radius of Mill 4

Figure 3. Mill Plot Plan 7

Figure 4. Stratigraphic Column 8

Figure 5. Tailings Pipeline Cross Section 11

Figure 6. Uranium Mill Tailings Burial System Layout, La Polvadera Canyon 17

Figure 7. Seepage Model--Dragline Trench Tailings Disposal 19

Figure 8. Seepage Model--Settling Pond 25

Figure 9. Area Capacity Curve, La Polvadera Evaporation Pond 26

Figure 10. Time-Volume Relations, La Polvadera Evaporation Pond 27

Figure 11. Seepage Model--Evaporation Pond 30

Figure 12. Contour Map of Seepage Fronts With Time 33

Figure 13. Revised Radial Grid System--Mt. Taylor Pond Seepage Study 39

Figure 14. Seepage--Front At End of Times Labeled 41

Figure 15. Monitoring Well System, La Polvadera Canyon 45

LIST OF TABLES

Table 1. Evaporation Pond Seepage 31

Table 2. Properties of Rocks Underlying Evaporation Pond Assumed for Initial Computer Simulation 34

Table 3. EID Suggested Physical Properties of Rock and Fluids Used in Final Seepage Simulation 40

1. INTRODUCTION

Background Information

On February 18, 1980, Gulf Mineral Resources Company (Gulf) submitted a proposed ground water discharge plan (DP-117) for its Mt. Taylor Uranium Mill Project, located near the town of San Mateo, in McKinley County, approximately 30 miles northeast of Grants. The proposed discharge plan was submitted pursuant to requirements set forth in the amended New Mexico Water Quality Control Commission Regulations, adopted January 11, 1977. The plan presents the potential impacts to ground water which may result from the proposed project.

This paper highlights the results of an analysis of the proposal, conducted by the technical staff and consultants, of the New Mexico Environmental Improvement Division's Water Pollution Control Bureau. The comments/discussions herein are based upon a review of the initial submission of February 18, 1980, additional information supplied by Gulf pursuant to EID request, on-site investigations, and independent literature and laboratory sources. An attempt was made to determine whether Gulf's proposed plan satisfies the technical requirements of the New Mexico Water Quality Control Commission Regulations. Specifically, "Has Gulf sufficiently demonstrated that discharges (planned or accidental releases) will not result in ground water contamination beyond standards at a place of withdrawal during the present or foreseeable future?" (Section 3-109.C3).

For the reader to properly understand the scope of this review, some general comments regarding the Regulations seem in order. Major provisions of the NMWQCC Regulations include the following requirements:

> *Ground water having an existing total dissolved solids concentration of 10,000 milligrams per liter (mg/l) is to be protected from contamination resulting from discharges onto or below the surface of the ground. Maximum concentration levels are established at the point of use for arsenic, barium, cadmium, chromium, cyanide, fluoride, lead, total mercury, nitrate, selenium, silver, uranium, and combined radium-226 and radium-228 radioactivity, based on human health criteria. There are additional standards based on other domestic use criteria and criteria for irrigation 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 wthich will ensure ground water protection. The discharger must demonstrate that approval of the discharge plan will not result in concentrations in excess of the standards at any place of withdrawal of water for present or reasonably future use. Detailed information on site geologic and hydrologic conditions may be required for a technical evaluation of the applicant's proposed discharge plan.

*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 standards being violated at the place of use in the present or reasonably foreseeable future.

Principal investigator for this review was Bruce Gallaher, Water Pollution Control Bureau geohydrologist. Principal Water Pollutcion Control Bureau Consultants utilized for this review included: Dr. Jonathan F. Callender, structural geologist; Dr. Ronald D. Runnells, geochemist; Dr. David L. Schreiber, hydraulic engineer consulting for the Radiation Protection Bureau; Dr. Daniel B. Stephens, hydrogeologist; and Dr. Stephen G. Wells, geomorphologist. Additional discussion were held with John S. McLean and Elmer S. Santos of the United States Geological Survey, and with Dr. Edward Kelley, reclamation specialist with the New Mexico Surface Mining Bureau; their assistance is gratefully acknowledged. The United States Nuclear Regulatory Commission also performed an analysis of portions of the proposed ground water discharge plan at the request of the EID director.

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. As such, this document should be viewed as a preliminary assessment, subject to change as a result of new evidence presented at the hearing.

Major Features of the Project and of the Discharge Plan

The Mt. Taylor project consists of a processing mill for extracting uranium ore from sandstone rock, and a disposal system for liquid and solid waste products generated by the milling operations. The ore will be removed from the Mr. Taylor mine by conventional mining techniques and then trucked three miles to the proposed mill site. (Discharges associated with the Mt. Taylor Mine are regulated by other approved discharge plans and will not be directly considered in this analysis.) The mill facility is proposed to be located in Lower San Lucas Canyon, Section 1, T13N, R8W, McKinley County, New Mexico, approximately 3.5 miles north of the town of San Mateo. Within the mill, the rock material will be crushed, and the uranium removed by acidic chemical extraction. A tailings pipeline, approximately six miles in length, will transport wastes from the mill process to the tailings disposal area. Figures 1 and 2 show the project location and its relation to critical populations:

The applicant proposes to dispose of tailings in Sections 14, 15, 23, T14 N, R8W, McKinley County, in La Polvadera Canyon approximately 4 miles northwest of the mill site. Approximately 1,400 gallons per minute of the tailings slurry, consisting of 20-40 percent by weight solids, is proposed to be discharged into a parallel series of dragline excavated trenches. Fluids draining from the solids will be collected and pumped to a settling pond(s) and thence to an evaporation pond. During the planned project life from 1982 through year 2003, approximately 12.6 million tons of solid tailings will be buried. This tonnage represents one-half of the mine ore production

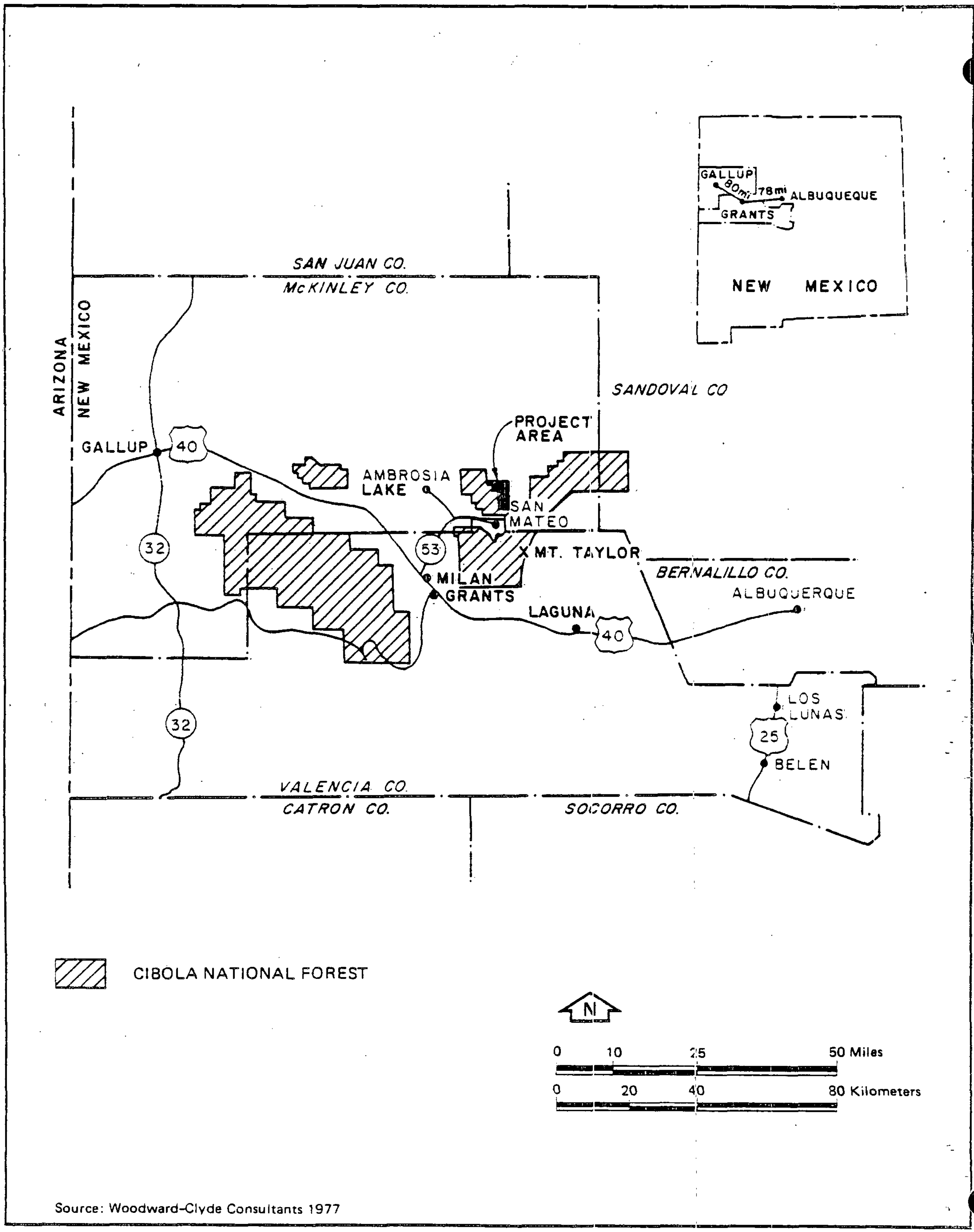
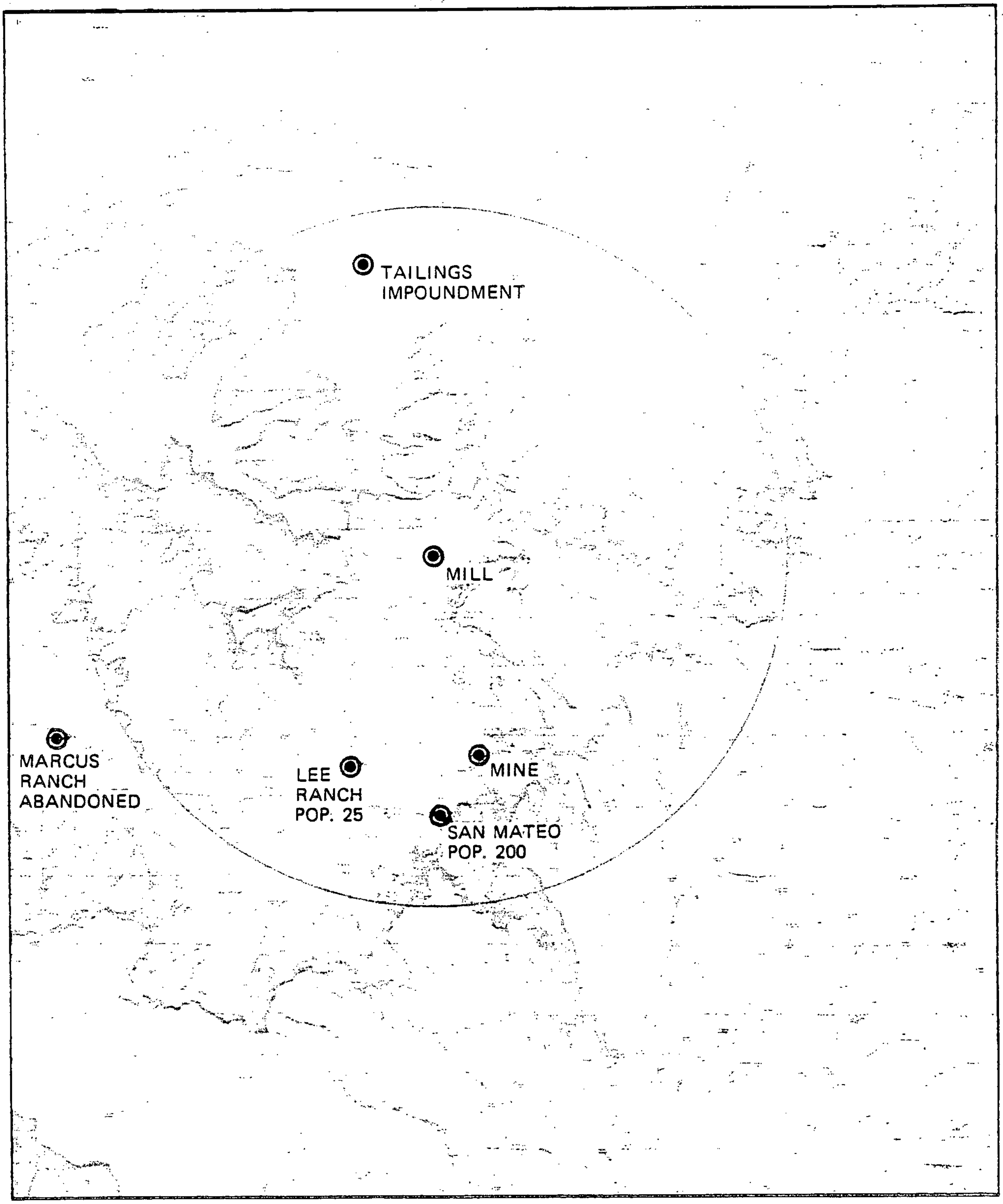


Figure 1
PROJECT LOCATION



Source: Gulf Mineral Resources Company.

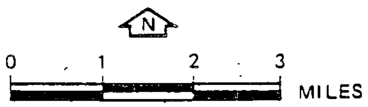


Figure 2
POPULATION DISTRIBUTION
WITHIN 5 MILE RADIUS OF MILL

minus five percent for dissolution during processing. The remaining 50 percent of the mill tailings is proposed to be returned to the Mt. Taylor Mine for use as backfill material. (Such a backfilling operation will involve a separate discharge plan analysis, and will not be further considered in this review.)

The proposed ground water discharge plan separately addresses potential ground water quality impacts from the three main features of the project: the mill site; the tailings and liquid waste pipelines; and the tailings and liquid waste disposal facilities. Our comments will similarly focus on the separate features of the project.

2. PROJECTED GROUND-WATER QUALITY IMPACTS FROM THE MILL FACILITY

Approximately one-half mile downstream (northeast) of the Mt. Taylor Uranium Mill, a lined containment pond is provided to contain any major spillage from the mill, process area runoff and treated sewage water. An impoundment to hold storm water that exceeds the capacity of the containment pond is also provided. These features are shown in Figure 3.

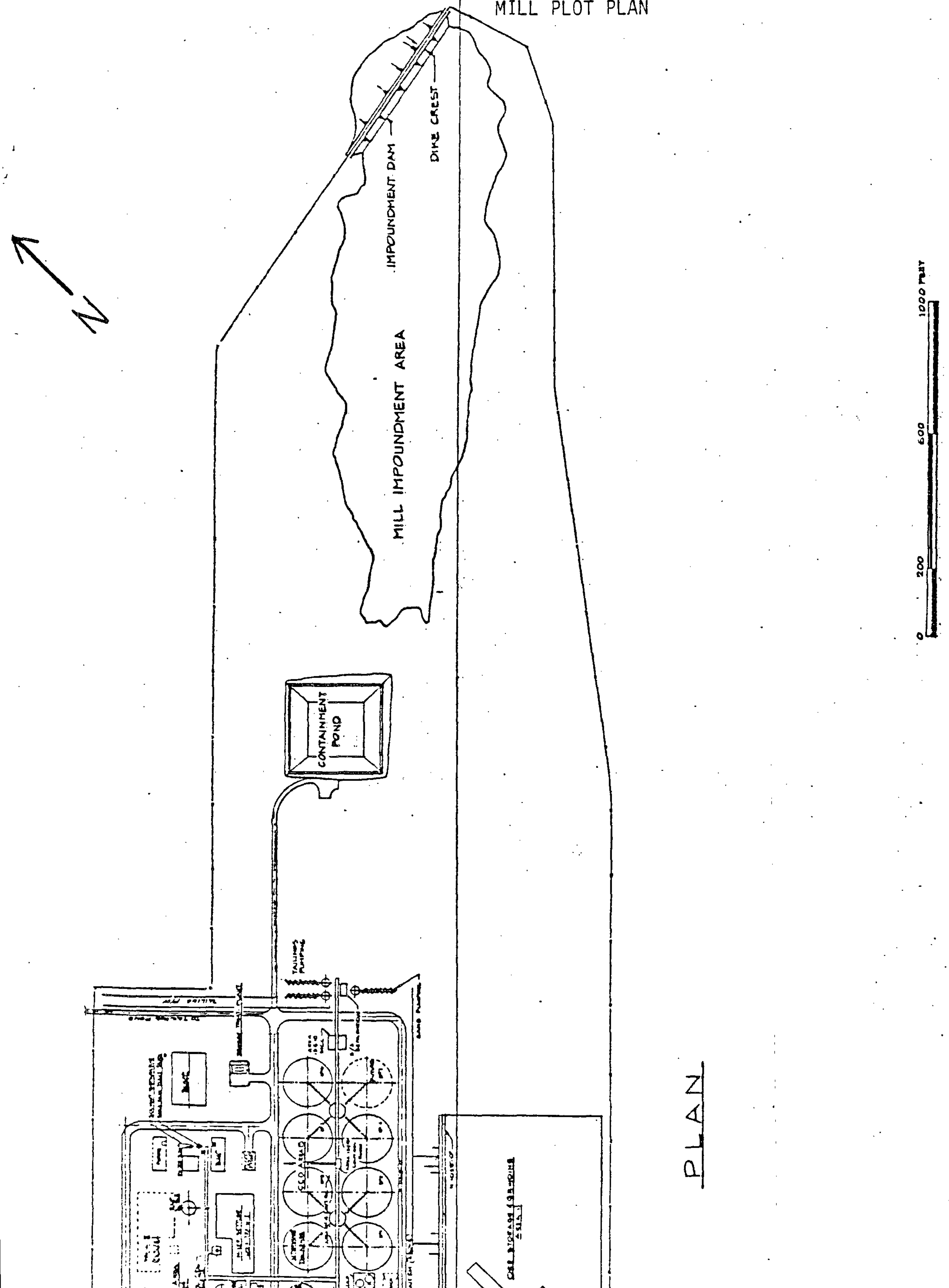
The containment pond, with a capacity of 2 million gallons, is sized to contain the spillage that would result if the largest process vessel in the mill, containing approximately 1.5 million gallons, failed. The pond is lined with 20 mil PVC plastic and covered with a 12-inch compacted earth and rock blanket. An automatic diversion system will divert storm runoff past the lined containment and into the mill impoundment when the pond's capacity is exceeded. The containment will be provided with pump back facilities for returning liquids to the mill process.

The mill impoundment, with a capacity of approximately 75 million gallons, will be created by a 565-foot long catch dam. The dam will be a earth-filled reservoir type structure which will be positively keyed five feet into bedrock at its base. To reduce seepage beneath the structure, grout will be injected into the bedrock along the dam centerline. An open cut spillway is incorporated to preclude dam overtopping.

The proposed containment pond and mill impoundment will stratigraphically overlie twenty to forty feet of fine-grained alluvium which, in turn, overlies the Menefee formation of Cretaceous age. Figure 4 shows a generalized stratigraphic section for the rocks found in the project area. The Menefee is predominately comprised of relatively impervious siltstones, sandstones, and shales. Geotechnical-related exploratory drilling conducted at the site indicates the presence of zones of saturation within the alluvium and the Menefee. Ground water encountered in the alluvium is felt by Gulf to be of a discontinuous perched nature and of insufficient volume to be used for supply. It is the applicant's position that the only potential aquifer in the mill site area is a thin resistant sandstone bed within the Menefee. Based upon a series of bailer and injection tests, low rates of production and injection (about 1 gallon per minute) were achieved by Gulf's contractors from that sandstone bed.

No water quality monitoring of the surficial alluvium is felt to be necessary by Gulf. A piezometer will be emplaced in the alluvium near the containment basin though and monitored for fluids on a quarterly basis. If seepage is indicated, an alluvial water sampling program may be initiated. Additionally, a hydrologic test well completed in the sandstone bed discussed above will be monitored on a semi-annual basis for water quantity and quality changes resulting from the operations. The monitoring instrumentation for the mill impoundment dam will consist of open-well piezometers and surface displacement monuments. The piezometers will be monitored for water levels quarterly and provide quantitative data on the effectiveness of the underseepage control measures. The surface displacement monuments will be used to monitor horizontal and vertical displacements within the dam structure, and will be read semi-annually.

FIGURE 3
MILL PLOT PLAN



SYSTEM	ROCK UNITS		LITHOLOGY	
	Group	Unit	Symbol	Description
QUATERNARY		ALLUVIUM	Qal	sand and gravel, poorly sorted and cemented
TERTIARY		VOLCANICS	Tb	basalt, andesite, rhyolite, lava flows and dikes
CRETACEOUS	MESA-VERDE GROUP	MENEFEE FORMATION	Kmf	gray, brown claystone and shale, sandstone, limestone and coal
	MESA-VERDE GROUP	POINT LOOKOUT SANDSTONE	Kpl	dark orange to yellowish gray arkosic sandstone
	MESA-VERDE GROUP	CREVASSE CANYON FORMATION Gibson Coal Member Dalton Sandstone Member Mulatto Tongue (Mancos Shale) Dilco Coal Member	Kcg Kcda Kmm Kcdi	sandstone, claystone, shale
	MESA-VERDE GROUP	GALLUP SANDSTONE	Kg	brown sandstone
		MANCOS SHALE Tres Hermanos Member	Km	dark gray shale with interbedded sandstone
		DAKOTA SANDSTONE	Kd	tan to gray quartz sandstone
JURASSIC		MORRISON FORMATION Brushy Basin Member Jackpile sandstone Poison Canyon sandstone Westwater Canyon Member Recapture Member	Jm	sandstone mudstone and sandstone sandstone and mudstone sandstone and siltstone
		BLUFF SANDSTONE	Jb	pale red to brown sandstone
	SAN RAFAEL GROUP	SUMMERVILLE FORMATION	Js	pale brown sandstone and siltstone
	SAN RAFAEL GROUP	TODILTO LIMESTONE	Jt	limestone
	SAN RAFAEL GROUP	ENTRADA SANDSTONE	Je	fine-grained sandstone
	SAN RAFAEL GROUP	CARMEL FORMATION		red, fine-grained silty sandstone
		WINGATE FORMATION		red to tan sandstone
TRIASSIC		CHINLE FORMATION	℞c	red shale with interbedded red siltstone and sandstone
PERMIAN		SAN ANDRES FORMATION Glorieta Member	Pg	limestone white to tan fine-grained, cross-bedded sandstone

Source: Modified from Hazlett and Kreek 1963

Figure 4
STRATIGRAPHIC COLUMN

Our analysis of the site's geology and hydrology and of the engineering concepts and designs incorporated into the containment pond and mill impoundment generally supports Gulf's conclusion that minimal impacts to ground water should result from these structures. This is based upon the following key factors:

1. Planned discharges at the mill site, e.g., process area washdown water and sewage water, will be relatively low in volume. Except during periods of extraordinary precipitation, sufficient freeboard should exist in the containment pond to contain any major process spillage. Contaminated releases to the mill impoundment area, therefore, are seen to be infrequent.

2. The containment basin is proposed to be lined with 20 mil PVC plus 12 inches of earth and basin so that migration of liquid from the pond into the underlying strata will be minimized. The PVC is chemically compatible with the acidic mill waste, while the earth cover will greatly reduce ozone and ultraviolet radiation weathering effects on the lining.

3. Any major process spill which drains to the basin will be pumped back to the mill circuit, thereby limiting the retention time of such liquids in the basin to a relatively short period.

4. Examination of available drilling information and of on-site hydrogeologic features supports the applicant's interpretation that a limited perched zone of saturation exists in the alluvium near the mill site. Monitoring of the perched zone, however, seems appropriate because surficial features suggest that the alluvial ground water system becomes more extensive north of the mill impoundment. This is being accomplished via an open-well piezometer near the containment pond. Seepage into the alluvium from the mill impoundment should be minimal due to the positive cutoff trench and grout curtain within the dam. Open-well piezometers within the dam should allow for detection of significant seepage to the alluvium from the impoundment.

5. Water levels established within the Menefee formation indicate extensive local saturation of the mill site bedrock. Pump test data obtained from the mill site, from Gulf installed wells in nearby San Lucas Canyon, and from other areas within the San Juan Basin, however, show the hydraulic conductivity of the formation to be relatively low. The formation is highly stratified; vertical hydraulic conductivities will therefore be even lower than reflected by pump test data. The potential for vertical excursions of seepage into the Menefee is thus considered to be slight from the containment pond or from the mill impoundment.

In summary, the applicant's proposed ground water pollution protection design for the mill facility is considered to be satisfactory to meet the NMWQCC Regulations.

3. PROJECTED GROUND WATER QUALITY IMPACTS FROM THE TAILINGS PIPELINE

Tailings and waste fluids from the milling process, are to be transported through a pipeline to the La Polvadera disposal site. The tailings pipeline system consists of two pumping facilities at the mill (one operational and one standby), one slurry pipeline from the mill to the tailings impoundment and one decant return line from the evaporation pond to the mill which, if the need arises, can also be utilized as a slurry line.

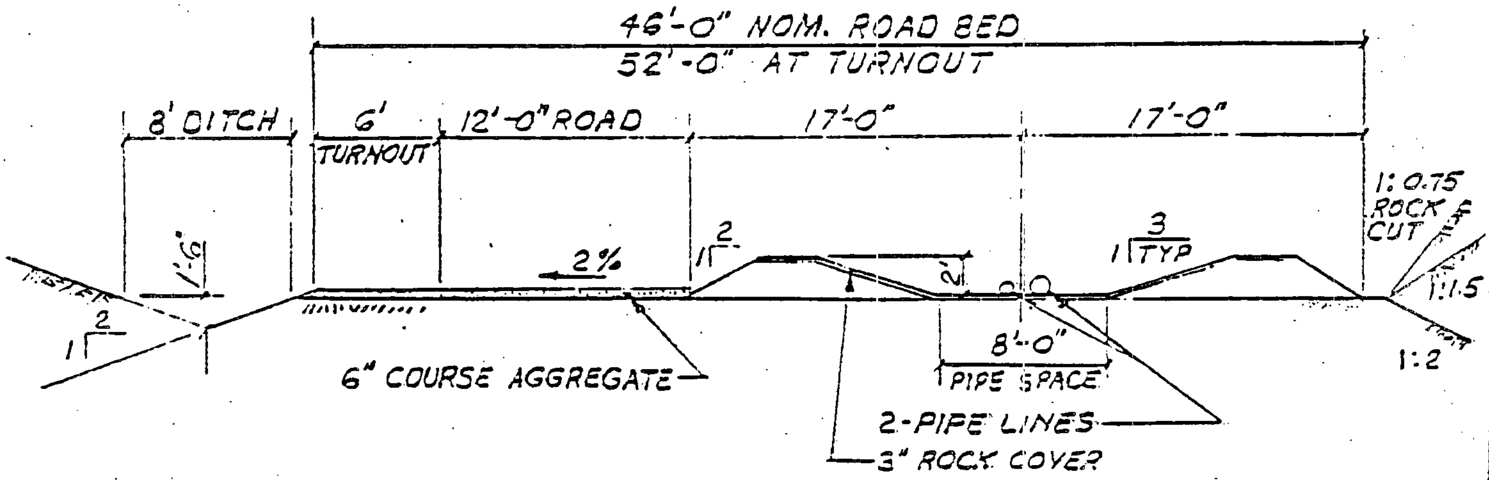
Critical Design Features

The tailings pipeline parallels San Lucas Canyon from the mill site to the La Polvadera tailings disposal area, a distance of approximately six miles. The pipeline would consist of eight-inch, rubber lined carbon-steel, schedule 30 pipe for transport of the tailings slurry and an identical pipe in the six-inch size for returning decant liquid. The entire length of the pipeline would lie within a rock faced pipeway with two-foot-high dikes. The pipeline system would be elevated above the 100-year floodplain, contain nine spill containment basins, located at low points along the pipeway, and be paralleled by a service road and security fencing. Each catchment basin is sized to hold with freeboard the full volume contained between adjacent high points in the pipeline plus an additional ten minutes flow in the two pipelines, and precipitation from a hundred year storm. The basins will be lined with 20 mil PVC plastic and covered with earth and rock. Figure 5 presents typical cross sections of the pipeway and catchment basin.

Significant statistics associated with the design of the pipeline are listed below:

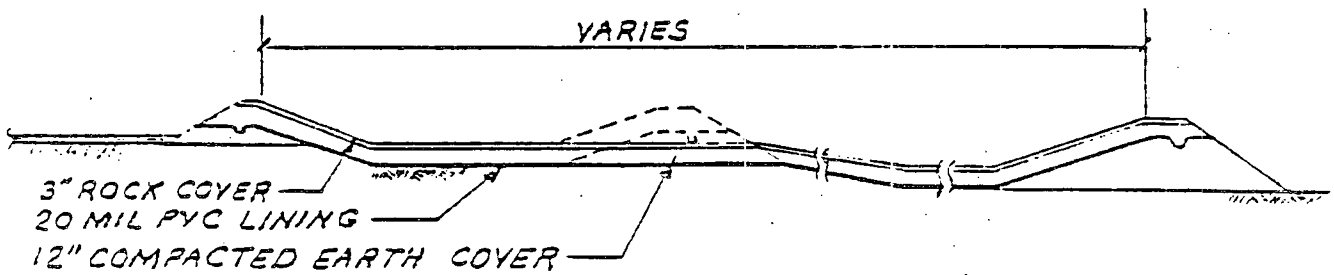
* length	6 miles
* flow	500 - 1,500 gallons per minute
* velocity	6 - 10 feet per second
* weight % solids	21 - 55%
* pipe sizes	1-8 inch; and 1-6 inch
* pipe wall thickness	1/4 inch carbon steel
* pipe liner thickness	1/4 inch rubber
* pipeline couplings	victaulic
* design pressure ratings	
pipeline	1,200 psig
fittings and couplings	800 psig

Due to the low pH of the tailings, an acid resistant piping is required. Of the two primary alternatives, rubber-lined steel piping and acid resistant plastic piping, the plastic piping was rejected because the length of the pipeline would have required multiple pump stations along the pipeway route. Multiple pump stations would not only have increased the complexity of the pipeline operation, but would greatly increase the risk of accidental spills



TYPICAL SECTION

SERVICE ROAD & TAILINGS PIPEWAY



TYPICAL SECTION

TAILINGS PIPEWAY @ CATCHMENT BASIN

1" = 10'-0"

FIGURE 5
TAILINGS PIPELINE CROSS SECTION

along the route. For safety and ease of maintenance, it was decided to transport the tailings slurry using a single lift pump station located within the mill. Utilization of a single lift to transport the tailings a distance of six miles necessitates the use of steel pipe.

The tailings pipeline is to be constructed of rubber-lined carbon steel, schedule 30 pipe. The pipeline will have a design pressure rating of 1,200 psig with fittings and couplings rated for 800 psig. The pipe sections will be joined by victaulic type couplings for ease of maintenance. The pipeline will be constructed of standard length sections so that an inventory of replacement sections can be maintained. Test spools of shorter lengths will be placed at appropriate locations for ease of inspection.

Pipeline security and spills will be controlled by redundant control and interlock flow metering systems, a round trip visual inspection of the pipeline twice per shift, and a maintenance and inspection program. Automatic shutdown of the pipeline pumping station will occur if a flow differential of ten (10) percent within the ends of the pipeline is detected by the flowmeters.

A single pump station is provided for tailings transport and is located within the mill. Any spills or releases of tailings within the pump station will be contained within sumps and the containment basin within the mill exclusion area. Pumping of tailings is accomplished by multi-stages of centrifugal pumps operating in series, that is, each pump will feed the suction of the following pump. The last pump in the train feeds the tailings pipeline. The first and last pump in the series is provided with a variable speed drive for process control. A complete series of spare pumps is provided. The pumps are sized such that they will have a maximum shutoff pressure of 650 psig, which is well below the design pressure rating of the pipeline.

The primary feature of the pipeline control system is flowmeters placed on both the inlet and outlet of each pipeline. The flowmeters on each end of a pipeline will be calibrated at frequent intervals to ensure the integrity of the instrumentation.

Flow differential of five percent between the flowmeters at the inlet and outlet of the pipeline will trigger an alarm. The operator will make an immediate inspection of the pipeline to assess the problem. Automatic shutdown of the pump train will occur if flow differential reaches 10 percent.

The pipeline operator can utilize the spare pump train and spare pipeline, but cannot stop the shutdown procedure of the affected line. Shutdown of the pumps will occur simultaneously with the detection of the 10 percent flow difference; however, it is estimated by Gulf that the momentum of the flow of fluids within the pipeline will continue flow for a period of about ten minutes. It is conservatively estimated that the flowmeters will detect flow differentials of two percent of the flow within the pipeline.

The drain and vent valves are provided with alarms displayed in the central control room. This will alert the operator to flow through the valves so that corrective action can be initiated. The vent valves are small valves atop the pipeline at the high points to allow for release of air. The drain valves are located at the low points of the pipeline immediately adjacent to the low point catchment basins.

Of critical importance to maintaining the integrity of the pipeline are the planned maintenance and inspection schedules. Physical inspection of the entire length of the pipeline will be accomplished by having a pipeline inspector traverse the round trip distance from the mill to the tailings impoundment twice per shift, or in accordance with good engineering practice. Clock stations will be installed at both ends of the pipeline route to provide records of the inspection schedule. The pipeline inspector will be equipped with a radio for alerting the mill operators to any conditions requiring immediate attention. Therefore, in case any leak is detected, repair of the pipeline, and the removal of tailings accumulated within the catchment basin will be initiated, minimizing any potential adverse impacts to the environment.

At locations that will experience the most critical wearing of the rubber lining, short spool sections will be installed that can be easily removed for detailed inspection. The results of the inspection of the test spools will dictate when pipeline sections should be replaced. Ultrasonic testing of sections most susceptible to wear will be conducted quarterly by a qualified technician.

Analysis of Potential Discharges to Ground Water

Gulf's Evaluation

The tailings pipeline obviously should not be a source of seepage except under accident conditions. Gulf has presented arguments that even under the most severe of accidents, ground water will not be degraded beyond the standards set forth in the New Mexico Water Quality Control Commission Regulations.

The tailings pipeline generally lays directly west of San Lucas Wash, an arroyo in the San Lucas Canyon, for approximately the first four miles of its six mile length. At three points along the pipeline route, the tailings pipelines will cross major drainage channels. At these crossings, a concrete pipeway of the same dimension of the rip-rapped pipeway and supported by a concrete trestle will contain the pipelines. Corrugated metal pipe culverts will provide drainage for minor channels beneath the pipeway. For the remainder of the pipeline route, the pipeline varies in distance from the wash, but is generally greater than 150 feet.

The water bearing unit in San Lucas Canyon most likely to be impacted from an accidental rupture in the pipeline is judged to be the alluvium in which the arroyo is dissected. The alluvium is underlain by the relatively impervious Point Lookout and Menefee sandstone and siltstone formations; the bedrock essentially forms a bathtub-type containment vessel beneath the alluvium. The alluvium has an estimated maximum thickness within the Canyon of approximately 100 feet. With the exceptions of slight thinning of the surficial alluvium and slight reduction in channel gradient, geologic conditions remain similar for about the next 30 miles downstream.

Gulf estimates that the maximum potential release which would occur in the event of a pipeline rupture would be 74,000 gallons of tailings slurry. Under the "worst case scenario" presented, none of the liquid portion of the slurry would infiltrate into the alluvium along the arroyo bank, and all of the slurry water would enter the San Lucas Wash within sixty minutes. The slurry would immediately commingle with about 5,000 gallons per minute of treated mine water which is discharged continuously into the wash from the Mt. Taylor mine. Dilution of the contaminated stream is anticipated to occur relatively rapidly and any stream bottom recharge to the shallow ground water system would be essentially undetectable.

An additional safety factor, applicable in the case of either a pipeline or evaporation pond dam failure, is the capability of Gulf to divert dewatering pipeline flow to Marquez Canyon. Using a large valve installed for this purpose, this diversion could be accomplished within minutes of the spill alarm, thereby eliminating the transport medium north in San Lucas Canyon.

Independent Evaluation

In conducting our analysis of the tailings pipeline system, we have reviewed the applicant's proposed engineering design and specifications for the pipeline system as well as the hypothetical rupture scenario. The designs and conclusions reached by Gulf are generally supported by the staff. It is felt that the applicant has developed and used acceptable engineering design criteria. These criteria were based on the design and operating experience of other similar slurry pipelines at several locations around the world. Safety, reliability, and maintainability were primary considerations in selecting the pipeline materials, pumps, controls, etc. The pipeline system design incorporates features that minimize the potential for undesirable release of tailings slurry. These features include multiple and redundant instrumentation and frequent inspection schedules.

The possibility of spills from the pipeline is minimized by the redundant control systems. Automatic shutdown will occur if the flow differential between the inlet and outlet of the pipeline reaches 10 percent. Drain and vent valves provided with alarms are also included in the pipeline design. The vent valves are located on top of each pipeline at the high points to allow for release of air. If the flow differential reaches 10 percent triggering a shutdown of the tailings pumping system, an interlock system will begin opening the vent valves. This feature will prevent siphoning of the slurry from beyond adjacent high points. The system cannot start up until all vent valves are closed. Furthermore, the pipelines are to be placed in a rip-rapped pipeway that will include nine catchment basins at low points along the pipeline route. The pipeway and catchment basins will act to contain spills or leakage, if required.

Regarding the discussion of a possible tailings pipeline rupture, the applicant has presented a generally realistic, albeit oversimplified, evaluation of the resulting water quality impacts. The discussion focuses on three processes to reduce the contaminant levels to acceptable limits: dilution of the contaminant stream by mine water conducted in San Lucas Wash; moisture deficits in the surficial soils which would impede rapid infiltration of the waste to the water table; and geochemical attenuation of the percolate, principally by pH change and adsorption. The staff feels that dilution provides a reliable attenuation mechanism for the waste discharge. Complete transverse and vertical mixing would occur quickly in the stream. Geologic conditions downstream would tend to encourage relatively uniform stream bottom recharge rates; this should result in recharge of a thin, narrow and elongate, horizontal tabular slug of the diluted waste stream. Continual recharge of treated mine water into the shallow ground water system will provide for further moderation of the contamination. Primary reliance should not be placed on moisture deficits or on geochemical processes for attenuation of the spillage, as their potentials remain speculative without further quantification.

The closest community along the drainage system which could be affected by a tailings release is the small village of Guadalupe which is located approximately 40 miles below the northern segment of the pipeline. Localized pockets of slightly contaminated ground water may result from the hypothetical spillage, but immediate withdrawal of that water downstream cannot be reasonably anticipated.

In summary, it is our opinion that the applicant's proposed pipeline system design is acceptable. It is believed that the redundant instrumentation and frequent inspection schedules will virtually eliminate any possibility of accidental spills adversely affecting ground water quality. Assuming a major release of tailings via pipeline rupture, it is unlikely that ground water standards would be violated at a place of foreseeable use.

4. PROJECTED GROUND WATER QUALITY IMPACTS FROM TAILINGS AND LIQUID WASTE DISPOSAL FACILITIES

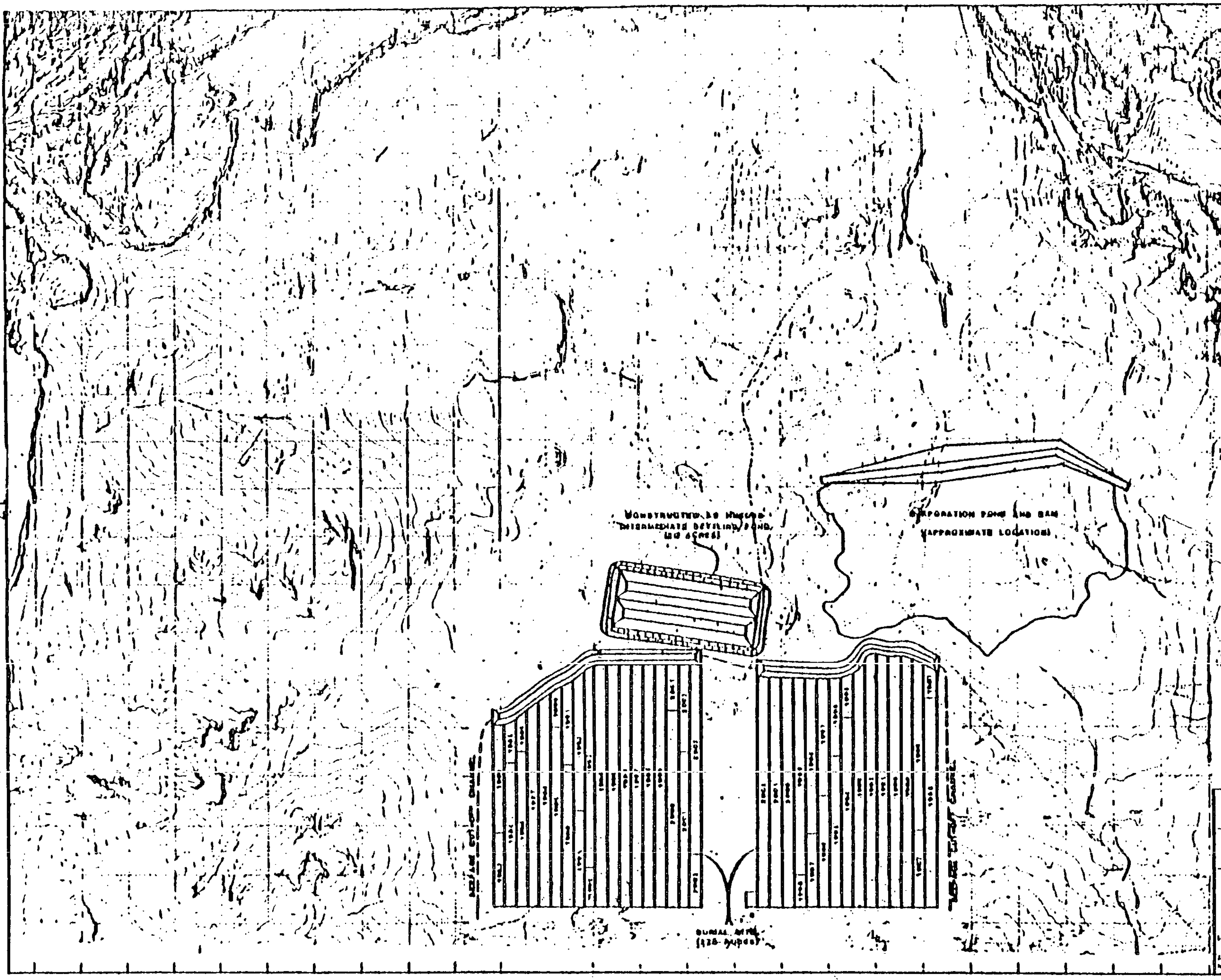
Gulf proposes to dispose of liquid and solid wastes from the Mt. Taylor Uranium Mill in La Polvadera Canyon, approximately 4 1/2 miles north northwest of San Mateo, New Mexico. The La Polvadera Canyon area is a broad, rolling, bowl-shaped basin drained by several washes that converge and drain through a series of low hogback ridges into San Lucas Canyon. At the crest of the basin where the tailings disposal area would be located, rock units are horizontal to gently dipping; at the flank of the basin, they are steeply dipping 20 to 30 degrees. The La Polvadera Canyon facility will consist of a parallel series of dragline excavated trenches for burial of tailings, a slimes settling pong and an evaporation pond. The La Polvadera Canyon burial system is illustrated in Figure 6.

The Tailings Disposal Trenches

Critical Design Features

The first trench would be excavated by the dragline to the limits of the project boundary and the excavated material (spoil) would be stock-piled beside the box cut. Each trench will be approximately one-half mile in length, 75 feet wide at the bottom, 125 feet wide at the surface, and 50 feet deep. The trenches would be excavated into the Mulatto Tongue Member of the Mancos Shale and the Dilco Coal Member of the Crevasse Canyon Formation, which are relatively tight bedrock units of predominantly shales and siltstones. The depth of excavation would be controlled such that the top of the underlying, more permeable, Gallup Sandstone would be at least ten feet below the trench bottom. Prior to excavation, the overburden rock would have to be blasted, but the shot holes would not be placed closer than five feet above the final grade to prevent fracturing the rocks forming the trench bottom. A bulldozer would be used to establish the final trench bottom configuration.

The tailings slurry would be discharged from the pipeline at the elevated end of a trench, forming a sand beach and causing deposition of the more clayey portion of the slurry (slimes) along the trench bottom. (The trenches would have a gradual longitudinal slope at the bottom of less than one percent.) Berms would be constructed at intervals along the trench bottom to promote pooling and settling of slimes. In this manner, sand beaches will eventually cover the slimes. The slimes would be concentrated at or near the bottom of the trench and would tend to seal open fractures or more permeable areas on the trench bottom and sides. Liquid which drains from the solid portion of the tailings would be pooled downslope and pumped to the slimes settling pond. When the area behind the berm is filled, tailings deposition will continue in the same manner behind a new berm constructed downstream within the trench.



ROCKY MOUNTAIN DIVISION
THE PACE COMPANY
CONSULTANTS & ENGINEERS, INC.

FOR: GULF MINERAL RESOURCES Co.

URANIUM MILL TAILINGS
BURIAL SYSTEM LAYOUT
LA POLVADERA CANYON

FIGURE 6

As each succeeding parallel cut is made, the spoil would be deposited on top of the dewatered tailings that had been placed in the previous trench. The trenches would be filled with tailings to within five feet of existing ground level. Reclamation of the tailings burial area would begin after a trench is filled and covered with spoil. The spoil would be graded to slope, covered with previously stockpiled topsoil, and revegetated.

To intercept lateral horizontal seepage along rock bedding planes, sandstone layers and shallow fractures, Gulf proposes to construct an open trench drain along the periphery of the disposal trench area. Similarly, adjacent trenches would act as drains as they are opened next to an active trench. Sump pumps would be used to collect seepage if it appears in the drains or adjacent trenches and route it to a settling pond.

Over the life of the disposal operation, approximately 225 acres of land would be required to dispose of the tailings.

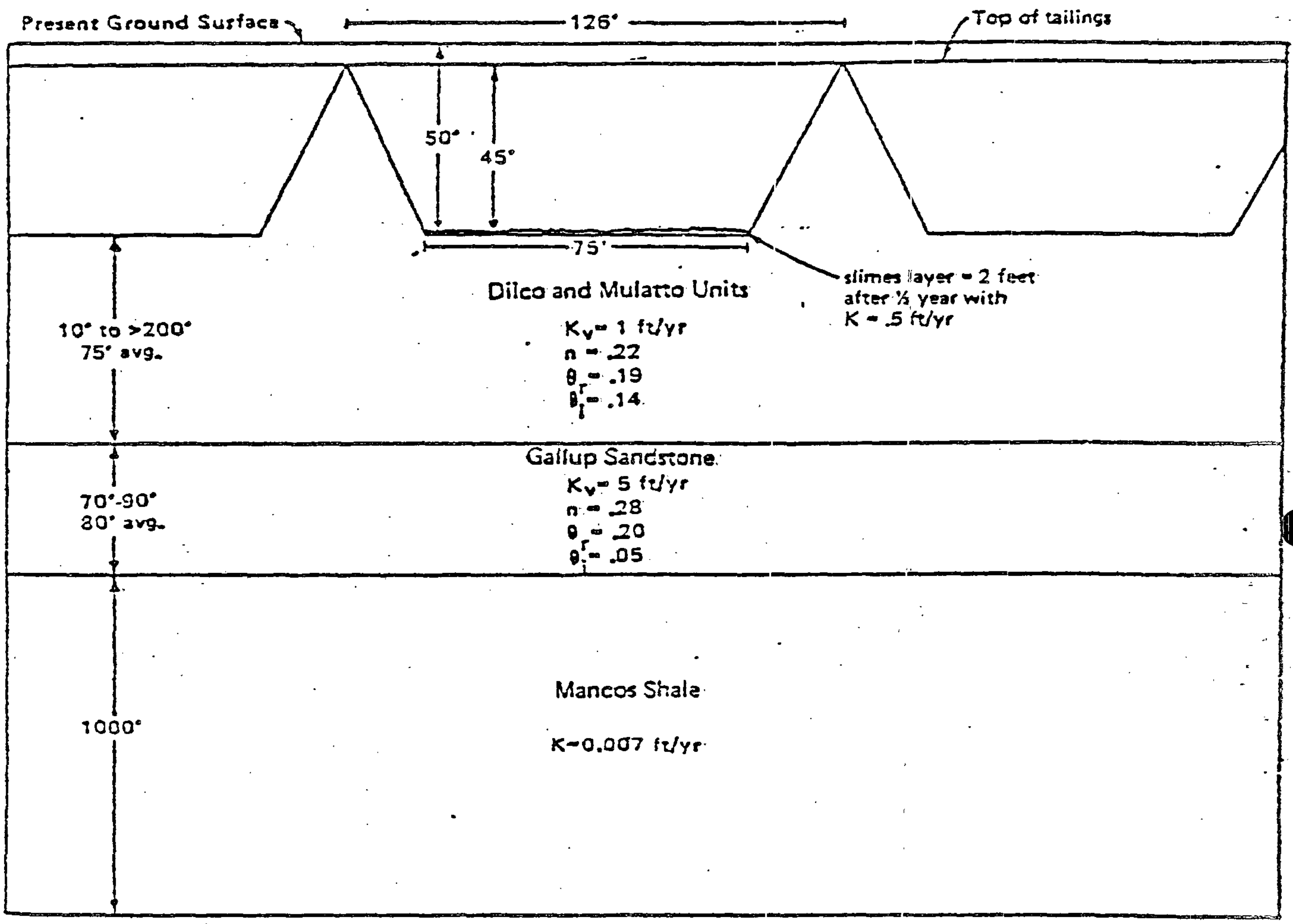
Analysis of Potential Discharges to Ground Water

Gulf's Evaluation

To investigate the seepage potential of the trench disposal scheme, the applicant used the McWhorter and Nelson computational procedure which takes into account the hydraulic conductivity and thickness of tailings, liner and foundation rocks. The seepage model used for computations is shown by Figure 7. Computations were done by 1/4-year periods, assuming that trenches would be sized for filling in one year. Slimes permeability was estimated to reach 5×10^{-7} cm/sec (0.5 feet/year) after 0.5 year. Two conditions were analyzed: a worst case condition where the Dilco unit thickness beneath the trench bottom was 10 feet; and an average condition, where the Dilco unit beneath the trench bottom was 75 feet thick. The thickness of the Dilco units, which varies beneath the disposal trenches as a result of both geological structure and topographic relief ranges from 10 to more than 200 feet, averaging about 75 feet over the 225-acre disposal area. The trenches have been sited so that at least 10 feet of Dilco siltstone and shale are present between the trench bottom and the top of the Gallup Sandstone.

For the two cases (10 feet and 75 feet of Dilco), seepage and drainage amounts (specific yield estimated at eight percent for tailings) were computed. These were compared with available retained pore water storage capacity of the underlying Gallup Sandstone, computed as (80 feet) (0.15) (126 feet wide trench) = 1,512 ft^3 per linear foot of trench. For the worst case, seepage plus drainage would equal 798 ft^3 per linear foot of trench. For the average case, seepage plus drainage would be 518.3 ft^3 per linear foot of trench. Neither of these estimates is as great as available storage retention, so that saturation of the Gallup is not expected to occur, even in the areas where the Dilco is relatively thin. Total estimated seepage (including drainage) is 919 acre-feet, assuming 77,290 linear feet of trench. Retained storage capacity in the Gallup Sandstone for this length of trench is estimated at 3,521 acre-feet, or more than three times estimated seepage. Therefore, it was concluded by Gulf that the foundation rocks will not reach field capacity, and saturation will not occur in the Gallup Sandstone. Minor

Dragline Disposal Trench
Diagrammatic Cross Section
Not to Scale



GULF MINERAL RESOURCES CO. Mt. Taylor Uranium Mill Project	
Earth Sciences Associates Palo Alto, California	
SEEPAGE MODEL – DRAGLINE TRENCH TAILINGS DISPOSAL	
Checked by D. K. [illegible] Date [illegible] Project No. 2150 Approved by [illegible] Date 2/4/77	Fig. 7

perched saturated zones are expected to occur within the Dilco unit, but if they spread, they should be intercepted by the open peripheral drains or result in retained storage over a wider area. As a result, contaminants that escape the trenches by seepage were calculated to be retained in storage in the vadose zone beneath the disposal area and not reach saturated rocks that are potential aquifers.

Independent Evaluation

An independent evaluation of seepage from the unlined trenches was performed, considering higher hydraulic conductivity values than the values used by the applicant. This is appropriate, given that the rate of seepage migration will normally be controlled by fractures and zones of materials with high hydraulic conductivities. In the calculations which were performed, hydraulic conductivities were obtained by arithmetically averaging the values from each drill hole, then using the 80 percentile value, i.e., the value greater than 80% of the values for all holes. This gave vertical hydraulic conductivities of 10 and 25 feet/year for the Dilco and Gallup units, respectively (and horizontal hydraulic conductivities of 20 and 50 feet/year, respectively).

Less than the highest hydraulic conductivities were used because the geology is such that it is unlikely that the zones of measured higher hydraulic conductivities will be completely interconnected. It appears as though the higher observed hydraulic conductivities are horizontal hydraulic conductivities occurring in relatively porous zones (such as sandstones) between more impermeable, flat lying strata. While such impermeable strata will not be continuous under the entire site, they can be expected to retard vertical flow, and thus seepage from the impoundment, to some degree.

Calculations were performed to check the reasonableness of the applicant's prediction that the quantity of seepage from the trenches would be no greater than that which would be stored in the retained storage volume directly beneath the trench area. These calculations used a vertical permeability of 10 feet/year (10^{-5} cm/sec) and a thickness of 10 feet in the underlying Dilco unit and did not consider a low permeability bottom layer of slimes. The resulting seepage amounted to approximately 13 cu. ft/yr - sq. ft. versus an available retained storage volume of 12 cu. ft/sq ft. beneath the trenches and above the Mancos Shale. Seepage for one year would result in a slight saturation mound, assuming behavior according to the model. The effect of channeling through zones of even higher permeability is unknown, but would not be expected to be a problem if the source for seepage was limited to the area of a single trench during a one-year period. As operations progress and trenches move into areas with greater thicknesses of the Dilco and Mulatto Tongue units, the thickness of the underlying Dilco layer would increase and seepage would decrease under the currently planned trench layout.

The quantity of liquid in a trench which would be available for seepage is conservative in that it is assumed that a trench would be filled with water to a 45-foot depth, i.e., a phreatic surface at the top of the tailings in a filled trench. The driving force for seepage also considers the suction provided by the Dilco Coal Member, i.e., the total hydrostatic head is taken as (45 ft + 20 ft suction =) 65 feet. Even under worst case conditions, it would be expected that there would be some drainage of the tailings to below the fully saturated level.

The actual retained storage volume available for seepage directly beneath the trench area (5% and 15% by volume in the Dilco and Gallup units, respectively) is not unreasonable.

The applicant's proposed seepage control plan for the tailings trenches is considered adequate, because significant mounding of seepage beneath the trench area is not expected to occur.

Reclamation Potential

Reclamation of the tailings burial area will begin after a trench is filled and covered with spoil. A dozer will be used to flatten the spoil ridges and to grade the side slopes. Topsoil previously stripped from the area and stockpiled will be spread over the graded surface. Plowing and revegetation will then be initiated. The reclaimed surface will be protected against erosion with drainage ditches and rock protection. All slopes will be 6:1 or shallower.

An independent evaluation of the reclamation potential of the mill waste disposal site has been conducted by the staff and is discussed below.

The general geomorphic (landscape) setting of the La Polvadera Canyon tailings disposal site is:

1. Rounded, upland ridges composed of weathered mantle resting on the Dilco Coal Member of the Crevasse Canyon Formation and on the Mulatto Tongue Member of the Mancos shale,

2. broad, shallow alluvial valleys filled with Quaternary alluvium.

The site is just east of San Mateo Mesa which displays a steep (vertical in places) cliff face. The regional slope of the landscape is to the east. In the tailings disposal site, slopes of the bedrock ridges are approximately 1:20 (vertical:horizontal); whereas, slopes in the intervening alluvial valleys are approximately 1:30.

The alluvium, colluvium (hillslope debris) and weathered mantle in the trench area of La Polvadera Canyon is undissected by deep arroyos or gully systems. Shallow swales and poorly integrated drainage lines are typical.

The mill waste disposal site is judged to be relatively stable in terms of base level changes (base level refers to the level to which a stream will erode). The lack of deeply incised arroyos or gullies, multiple fill or strath terraces and integrated drainage systems suggests relative base level stability over the Holocene (past 10,000 to 12,000 years). The late Quaternary geomorphic history of the site may be generalized as follows:

1. formation of a pediment (erosion surface cut on dipping bedrock) as a continuous surface along the base of the San Mateo Mesa,

2. dissection of the pediment after a period of base level stability and the formation of the alluvial valleys,

3. base level stability and lateral migration of the streams forming the broad (750 to 1,000 feet) wide valleys,

4. and slow aggradation as the valleys filled with sediment.

The amount of base level change is 50 to 60 feet as measured from the average ridge top to the base of the alluvium in the valley. The amount of time this change in stream level has occurred over is not known and may vary from a few thousand years to tens of thousands of years. The deep weathering mantle on the ridges suggests that it has been a relatively long time period since dramatic base level fluctuations.

The lack of headward cutting and incising arroyo systems suggests base level stability over the past tens of years. It appears that runoff from the trench area is dominated by sheetwash (unchannelized flow) rather than channelized flow. Since the trench area is dominated by pediment surfaces (erosional) rather than depositional surfaces (e.g., alluvial fans) and runoff is unchannelized, valley oversteepening and subsequent arroyo incision would not be expected to occur naturally.

It is important to note, however, that a presently stable landscape can be made unstable by oversteepening slopes, reducing vegetation or channelizing flow. Gulf should consider these operational and post-operational conditions in designing the ultimate reclamation plan. It is recommended that prior to initiating major construction in the trench area, measurements should be made of infiltration rates on the present landscape cover. These would provide guidelines for the top soil cover to be used in reclamation.

Capillary rise of residual tailings salts from the entrenched tailings into the overburden material should not present a problem to ultimate reclamation and revegetation activities. The amount of overburden placed on top of the deposited tailings (approximately 50 feet) is so great that capillary rise through the overburden to a level which plant roots would be expected to penetrate is highly unlikely. Maintaining the integrity of the tailings cover, of course, remains crucial.

In summary, the trench area appears to be in a relatively stable regime with respect to erosion. With proper care and design, Gulf should be able to maintain equivalent stability on the reclaimed surface. Revegetation of the reclaimed surface may occur, but is not essential for the long-term stability of the trench area.

Settling Pond

Critical Design Features

A slimes settling pond would be constructed to the east of the proposed tailings disposal area. Similar excavation methods will be used as in the trench area, except that the excavation will be 30 feet deep, 75 feet wide at the bottom, and have 4:1 side slopes and end slopes. The layout for the settling pond shown on Figure 8 is the maximum size considered necessary for the life of the project. Initially, a settling pond 100 feet long at the bottom will be constructed. This initial pond will accommodate approximately two years of operation assuming that one-third of the slimes remain in suspension and are pumped out of the trenches with the waste water. Additional settling ponds will be constructed as needed based on observations during the first two years of operations.

The slime settling pond is basically a backup facility in case some of the slimes remain in suspension in the waste water. The settling pond(s) will result in below-grade disposal of any slimes that escape from deposition in the trenches. Both the bottom and the sides of the settling pond will be lined with a compacted clay liner three feet thick to control seepage.

Seepage Potential

The settling pond has been designed by Gulf to have a three-foot thick clay liner in order to limit seepage to a volume less than that of storage available in the underlying bedrock. Storage was computed by the applicant for the Dilco and Gallup units by calculating the rock volume immediately underlying the settling pond, and multiplying by the percentage of available pore storage ($\theta_r - \theta_i$) for each rock type. For the Dilco, available storage was estimated at five percent, and for the Gallup, 15 percent was used, as shown in Figure 8.

Because of the geologic structure, and the topographic relief at the settling pond site, the thickness of Dilco beneath the pond bottom is highly variable. The thickness of 23 feet used in Gulf's computations represents an approximate average over the whole settling pond area, with an assumed pond level of about 7,160 feet. The Dilco below the pond bottom is thinnest at the northeastern end, and thickest in the west, near the ridge crest. A mean Gallup thickness of 85 feet was used for storage calculations, based on boring data. Total available storage beneath the 2.46-acre settling pond is 35.56 acre-feet.

Seepage during the assumed 22-year life was estimated using the same computational procedure utilized for the tailings disposal trenches, modified to eliminate the slime and coarse tailings layers. If slimes are deposited on the pond bottom and sides, they should significantly reduce seepage rates and total seepage. Since slimes deposition was ignored in the analysis, an additional safety factor is provided. Seepage rates for the pond bottom were computed using a total head of: 30 feet of water in pond + 20.1 feet of suction from the Dilco bedrock = 50.1 feet. For the side slopes, total average head used was: 15 feet of water in pond + 20.1 feet of suction from the Dilco = 35.1 feet. A clay liner three feet thick (measured perpendicular to the trench bottom and sides) was used in all calculations. The seepage estimates for a 22-year pond life are as follows:

1. Seepage through pond bottom = 3.35 acre-feet
2. Seepage through pond sides = 31.03 acre-feet

Total Seepage = 33.38 acre-feet

Since the estimated seepage is less than available storage, the Gallup beneath the pond should not become saturated. If the pond is located above elevation 7,160, additional storage in the Dilco will be available.

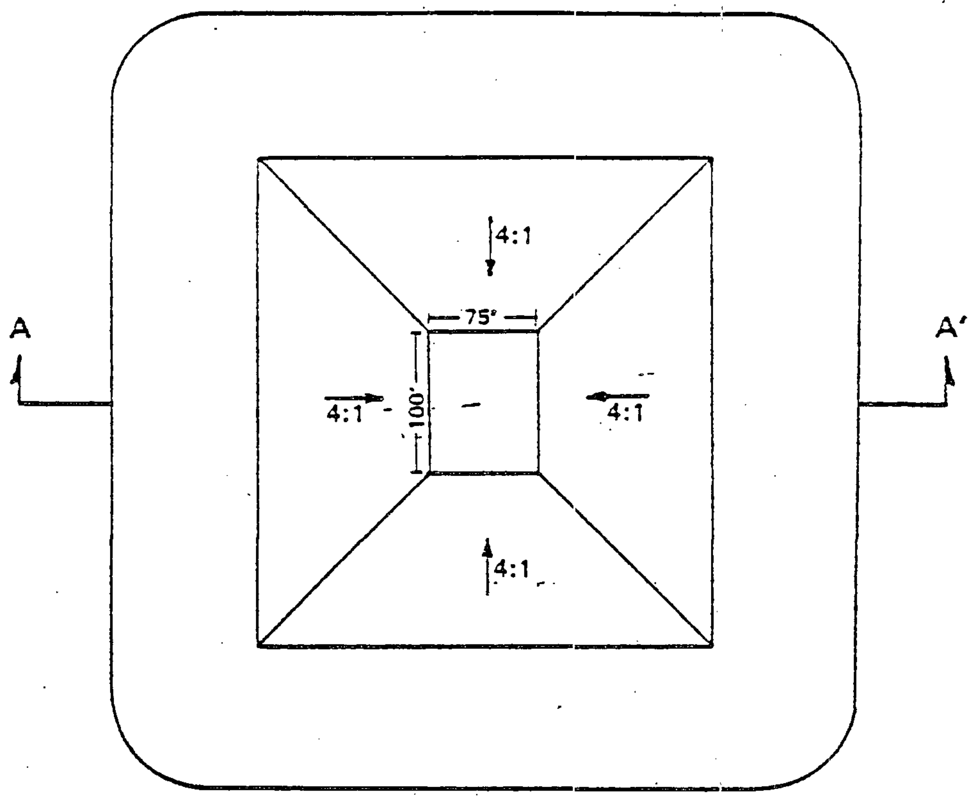
In summary, the settling pond is not considered by the staff to be a major source of seepage. The pond is underlain by and seepage is controlled by both a minimum three-foot compacted clay liner and a minimum thickness of 10 feet of the Dilco unit. The ultimate pond was sized assuming a carryover of one-third of the slimes from the tailings trenches, which is probably conservative, although the seepage period should be greater than that which was considered by the applicant, because it should take into account the drying period following operations.

The applicant's proposed seepage control plan for the sedimentation pond is considered adequate because significant mounding of seepage beneath the pond area is not expected to occur.

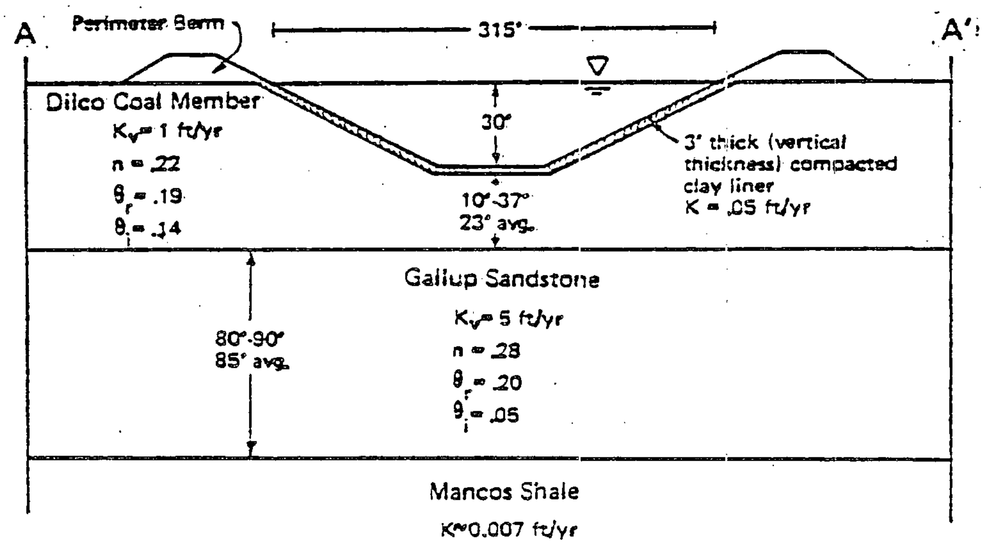
Evaporation Pond

Waste water from the disposal area will be routed through the settling pond(s), allowed to clarify, decanted and transported to the evaporation pond by pipeline. The evaporation pond will be contained by an impervious core embankment with an initial height of about 40 feet and an ultimate height of about 80 feet. The crest elevation of this dam will be approximately 7,145 feet. The embankment will have appropriate internal drains to control phreatic levels and collect seepage for discharge back to the pond. The quantities involved in embankment seepage will be negligible with respect to the overall pond water balance. The dam will be designed to meet all safety requirements for a fluid retention structure. Approval by the New Mexico State Engineer will be required.

The evaporation pond required may be larger than the one shown on Figure 6. Figure 9 shows the area-capacity curve with unconsolidated soils removed. The maximum storage capacity will be determined during final design. The projected time-volume filling and recession curve for disposal of liquid wastes is shown on Figure 10. The maximum projected storage requirement is 5,400 acre-feet which will cover a surface area of about 200 acres and have a maximum surface elevation of about 7,135 feet. The time-volume curve and associated surface areas were used for seepage analyses and design criteria for the pond lining system.

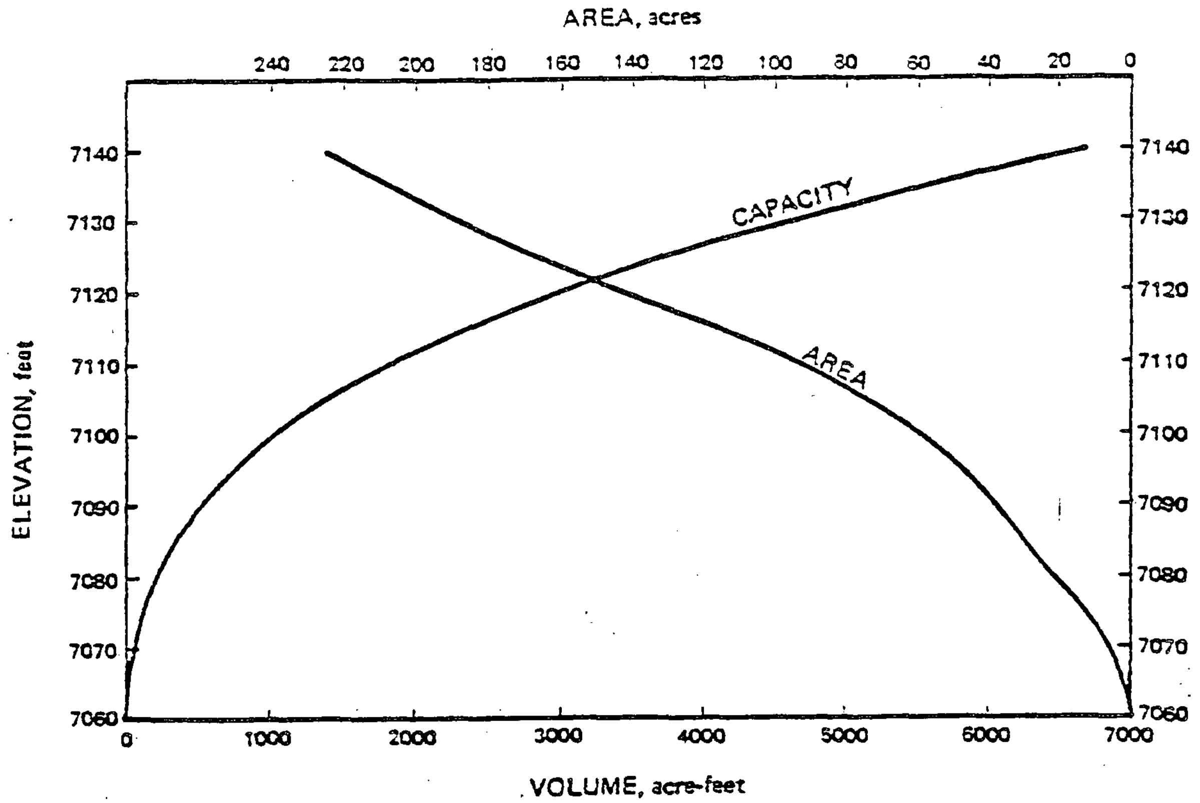


PLAN VIEW
Scale: 1"≈70'

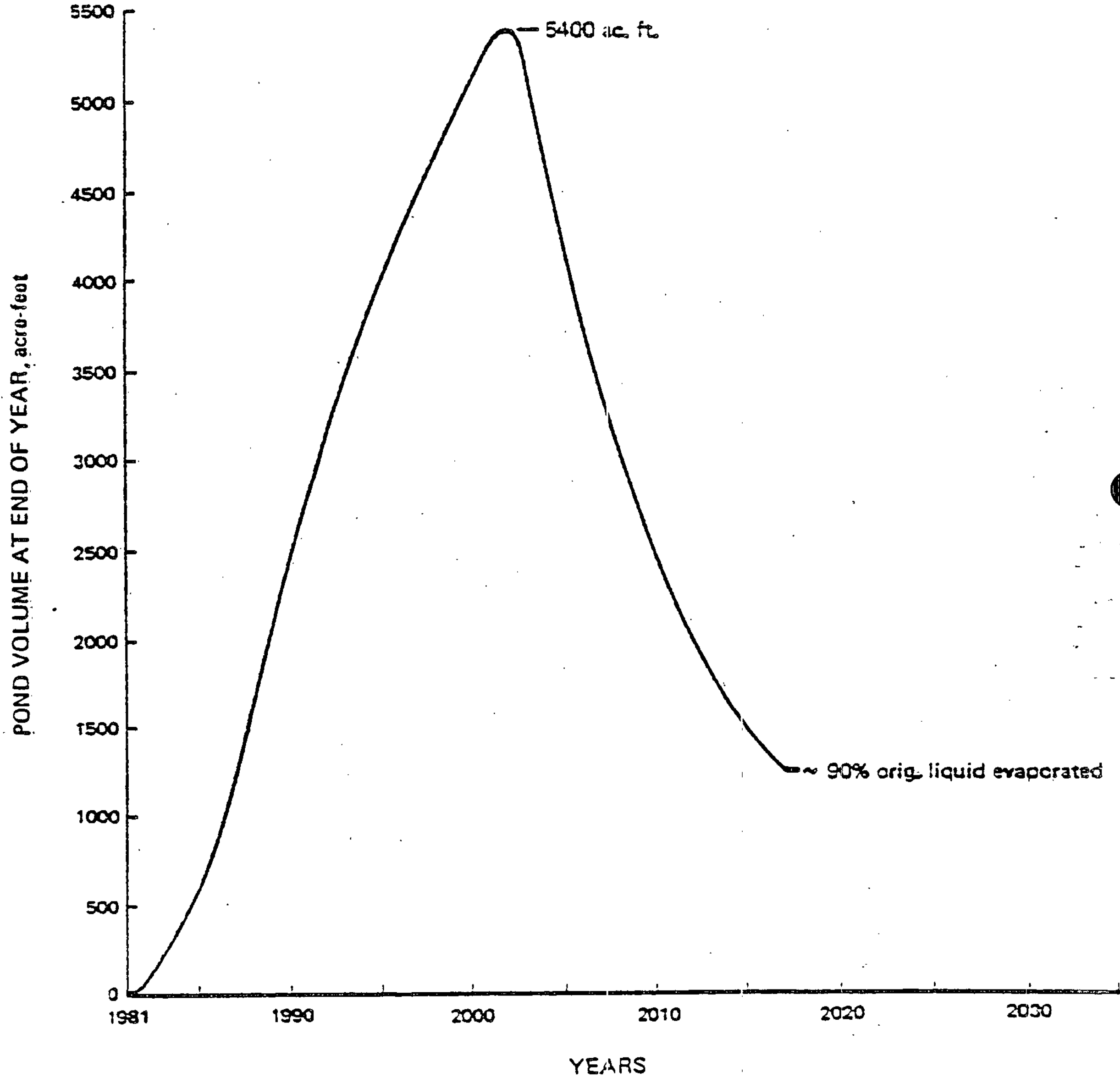


TYPICAL CROSS SECTION
Scale: 1"≈70'

GULF MINERAL RESOURCES CO. Mt. Taylor Uranium Mill Project		
Earth Sciences Associates Palo Alto, California		
SEEPAGE MODEL— SETTLING POND		
Checked by [signature] Date 2/4/79 Approved by [signature] Date 2/10/79	Project No. 2150	Fig 8



GULF MINERAL RESOURCES CO. Mt. Taylor Uranium Mill Project
Earth Sciences Associates Palo Alto, California
AREA CAPACITY CURVE LA POLVADERA EVAPORATION POND
Checked by ________ Dated ________ Project No. 2150 — Fig 9 Approved by ________ Date 2/14/79



GULF MINERAL RESOURCES CO.

Mt. Taylor Uranium Mill Project

Earth Sciences Associates

Palo Alto, California

TIME–VOLUME RELATIONS

LA POLVADERA EVAPORATION POND

Checked by	Date	Project No. 2150	Fig 10
Approved by	Date 12/14/79		

The entire pond area will be stripped to bedrock and a liner will be placed on this surface, as needed, to control seepage. The lining system will consist of a compacted clay liner three feet thick over less than 200 acres of pond bottom, and will have an estimated permeability of 5 x 10^{-8} cm/sec (0.05 feet/year). The liner will completely cover that portion of the pond underlain by the Gallup Sandstone and areas of Dilco having a thickness of less than 10 feet. Field conditions permitting, where the Dilco is exposed, scarification and recompaction of clay shales in the Dilco may be substituted for a borrowed clay liner.

The dam and pond lining will be constructed in stages using a downstream embankment construction method. Upstream diversion facilities will be provided that will prevent runoff into the pond. This will minimize the amount of water to be evaporated and minimize the interception of natural run-off in the watershed. Suitable clay lining and embankment materials are available in La Polvadera Canyon. Soils stripped from the embankment foundation and pond areas will be used for dam construction, clay lining and/or reclamation.

Analysis of Potential Discharges to Ground Water by Seepage

Gulf's Calculations

The La Polvadera evaporation pond was designed to take advantage of the available pore storage in the extremely dry native foundation materials which underlie the La Polvadera Canyon area. Laboratory analysis of core samples from both the Gallup Sandstone and Dilco Coal Member indicate water contents far below specific retention for these foundation materials. Therefore, the excessively dry porous media has the potential to store water and bind it by capillary forces which are strong enough to prevent significant free drainage. This retained storage capacity is measured by the difference between the water content at specific retention and the natural in-situ water content. Laboratory testing and field observations suggest that this difference is up to 20 percent by volume for the native materials in La Polvadera Canyon.

Evaporation pond seepage calculations were performed by the applicant which depict vertical seepage from the reservoir through a low permeability liner to the underlying unsaturated foundation material, with subsequent spread of the seepage. Two separate calculational methods were employed for this analysis. The initial seepage analysis was performed using the McWhorter and Nelson one-dimensional empirical mathematical method designed to analytically approximate the complex seepage phenomena. That analysis was subsequently complimented by a more rigorous method using two-dimensional computer numerical simulation. The results of both modeling efforts are presented below.

In the one-dimensional approach, seepage is divided into four stages: Stage I - vertical seepage to the existing water table or to an impervious boundary (in this case, the Mancos Shale); Stage II - buildup of a seepage mound beneath the pond; Stage III - mound spreading; and Stage IV - mound dissipation. Figure 11 illustrates the seepage model used for the analysis. Seepage computations were performed for each of seven zones based on proposed pond excavation contours. The steps used in estimating liner requirements were as follows:

1. Pond zones were established between 10-foot contours, for purposes of simplifying the calculations.

2. For each zone, the following were determined:

   * Thickness of underlying rock units.

   * Safe pore water storage capacity = (water content at specific retention - present water content) x (zone area) x (average thickness between pond bottom and base of Gallup Sandstone).

   * Using time-volume and area-capacity relations for the pond, the mean head for each zone was determined for two-year periods throughout the project life.

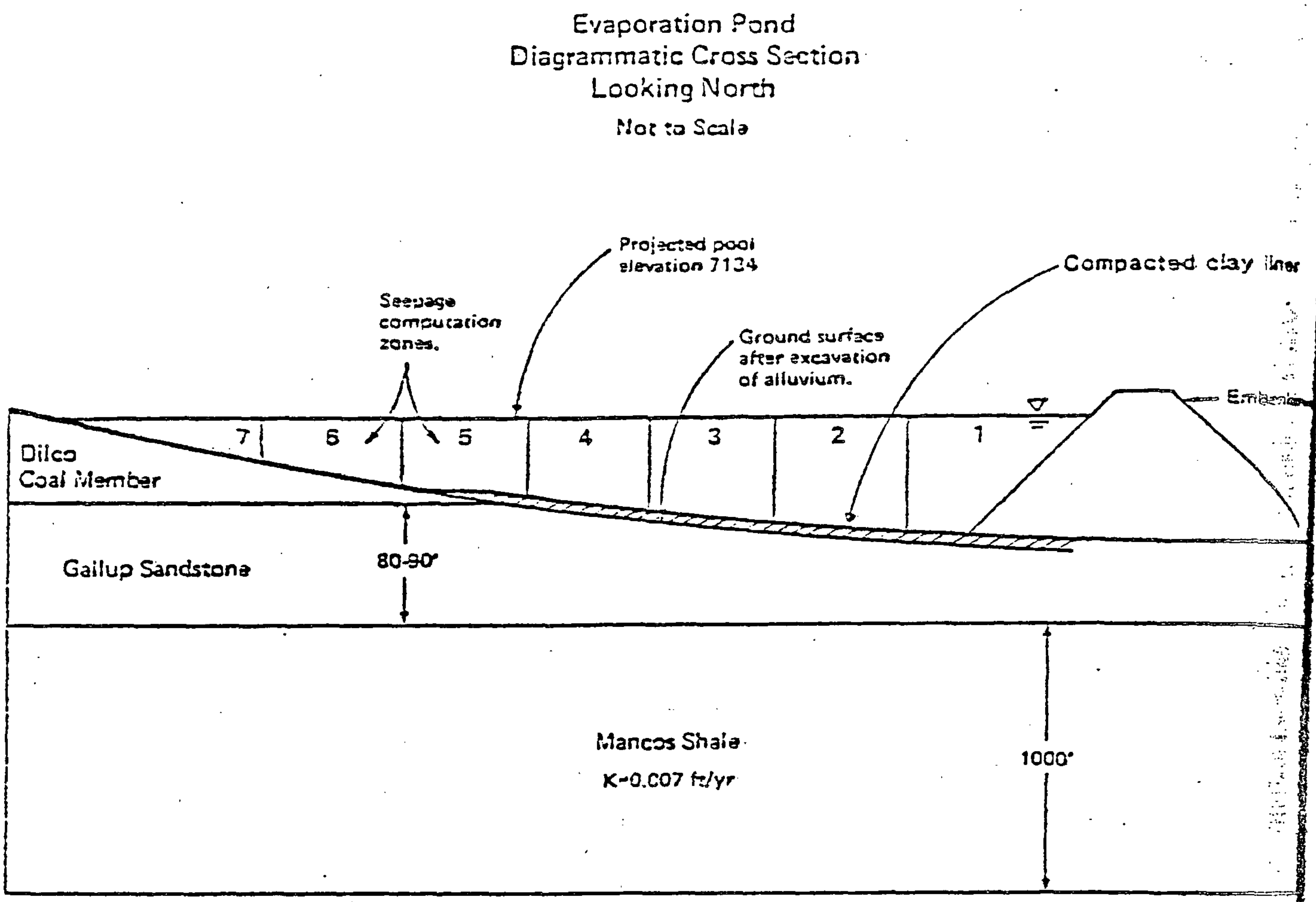
   * Seepage through each zone was calculated using the proposed clay lining and appropriate thickness of Gallup Sandstones or Dilco. Table 1 shows the results of these calculations.

As shown in Table 1, saturation of the Gallup Sandstone beneath the pond is calculated to occur in Zones 1 through 5, where the heads are greatest, and inundation periods are longest. Seepage in Zones 6 through 7 will be less than available retained storage in the Dilco and Gallup rocks underlying these zones. In practice, lateral spreading of the seepage will cause partial saturation of other zones as well. However, because of the low natural moisture of the bedrock materials, movement of a saturation front to the saturated zone of the Gallup (more than a mile distant) should not occur.

Gulf's analyses indicate that Stage I will not be complete until 13 years of pond operation, and Stage II will take an additional 1.5 years to complete. Assuming behavior according to the model, a saturation mound will start to develop after 13 years and will reach the pond bottom after 14.5 years. As soon as the mount starts developing, it will slowly spread laterally, but it probably will not reach the pond margin before 16 to 18 years or more.

The applicant's calculations show total seepage of 3,167 acre-feet would occur over 204 acres versus 2,673.4 acre-feet retained storage capacity, and that this is due to seepage exceeding storage capacity by 1,049 acre-feet in the 118 acres closest to the embankment. Because seepage from the evaporation pond is controlled by the compacted-clay liner, increasing the assumed permeability of the Dilco unit would not have a significant effect on seepage estimates.

The one-dimensional approach used in this initial analysis is felt to provide a reasonable initial estimate of vertical seepage volumes and rates. This calculational procedure, however, has limitations in its ability to estimate lateral seepage components or long-term water movement characteristics.



Hydraulic Parameters

Dilco	Clay liner	Gallup
K_v = 1 ft/yr	K = .05 ft/yr	K_v = 5 ft/yr
n = .22		n = .28
θ_r = .19		θ_r = .20
θ_i = .14		θ_i = .05

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Mt. Taylor Uranium Mill Project

Earth Sciences Associates

Palo Alto, California

SEEPAGE MODEL-
EVAPORATION POND

Checked by ______ Date ______

Approved by ______ Date ______

Project No. 2150

Fig 1

TABLE 1

EVAPORATION POND SEEPAGE

Zone	Zone Elevation Boundaries (feet)	Retained Storage Capacity (acre-feet)	Inundation Period (years)	Approximate Area (acres)	Total Zonal Seepage (acre-feet)
1	7,060-7,075	126.0	36	14	314
2	7,075-7,085	178.5	34	17	418
3	7,085-7,095	216.0	32	18	448
4	7,095-7105	337.9	30.5	27	573
5	7,105-7115	556.5	25	42	711
6	7,115-7125	696.0	17	48	530
7	7,125-7234	562.5	7.5	38	173
Totals		2,673.4		204	3,167

Note: Seepage from Zones 1 through 5 exceed the retained storage capacities by 1,049 acre-feet.

To more precisely examine these seepage characteristics, the applicant chose to perform a two-dimensional water movement simulation, via computer. The model mathematically simulates two-phase, gas-water, flow through the porous medium. Gravity and capillarity effects are considered in both the vertical and radial directions. Special features of the model that make it suitable for predicting water movement from the evaporation pond area are:

* The model can mathematically consider the heterogeneous and anisotropic geologic features of the pond area,

* The simulator is a two-phase model; it provides a consideration of the effect of saturation of each phase on their flow properties through the use of relative permeability data,

* The mathematical consideration of gravity and capillary forces is particularly important in this application where the water from the pond seeps into the underlying moisture-deficient rocks.

Figure 12 illustrates the evaporation pond configuration and cross-section of the surrounding rocks assumed for the initial two-dimensional modeling effort and illustrates the calculated seepage front movement. The total 204 acres of the pond bottom was assumed to overlie the Gallup Sandstone with only a three-feet thick liner between them. In reality, only 118 acres of the Gallup form part of the pond base with the remainder being formed by the less permeable Dilco unit. Other assumptions which should favor a high seepage, compared to the actual physical system, included: the assumption of a constant water depth throughout the year, as specified for the end of the year; and the assumption of a flat bottom for the pond, instead of the actual sloping bottom which would increase the seepage area and the potential difference between the pond and the underlying formations. Rock properties assumed for the simulation are presented in Table 2.

Using those properties and assumptions, the simulator calculated that approximately 7,254 acre-feet of water would seep into the formations from the pond, more than double the volume predicted by the one-dimensional model. In Figure 12, the seepage front movement is tracked by plotting the zero saturation-change contours. The right-hand side of the seepage front contours represent rock formations that undergo no change in water saturation or no contamination by seepage water at the time indicated on the contour. These contours indicate that the rate of advance of the seepage fronts significantly decreases after about 400 years of simulation and is essentially stationary at the end of 1,000 years. The calculated seepage front has become essentially immobile 3,800 feet radially from the center of the pond and thus should not impact ground water.

To provide for a more thorough consideration of the wide range in physical properties naturally found within rock units, the applicant performed additional two-dimensional seepage simulations wherein the representative coefficients were accordingly adjusted. Those simulations produced generally similar results and support the conclusions derived from the initial simulation presented above. They will be examined further in the next section of this paper.

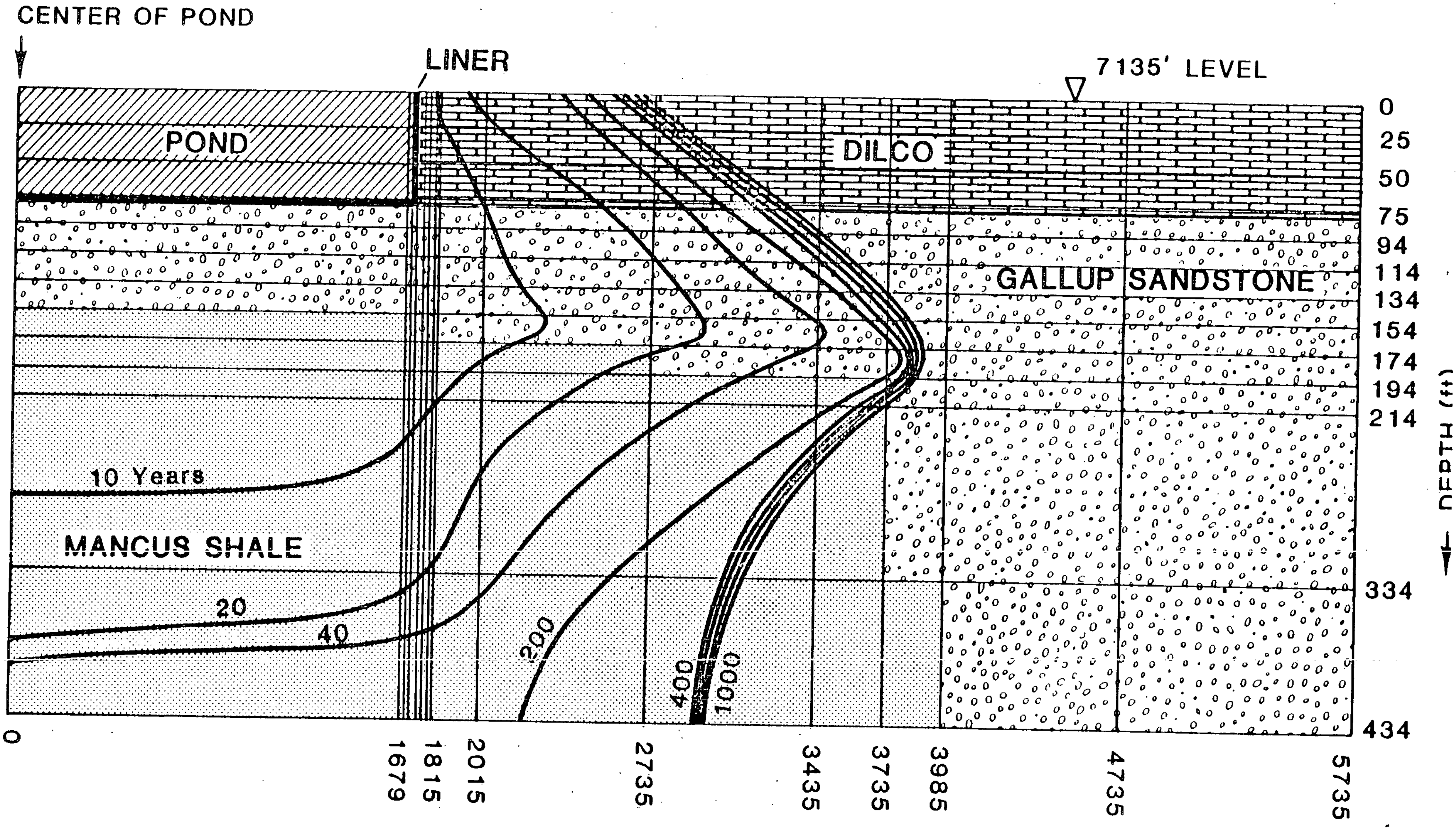


FIGURE 12

CONTOUR MAP OF SEEPAGE FRONTS WITH TIME

TABLE 2

PROPERTIES OF ROCKS UNDERLYING EVAPORATION POND
ASSUMED FOR INITIAL COMPUTER SIMULATION

Geol. Unit	Porosity Ø	Specific Retention S_r (%)	In-Situ Water Sat. S_w (%)	Permeability K_h (ft/yr)	K_v
Liner	0.34	97.00	72.00	0.050	0.050
Dilco	0.22	86.4	63.6	2.000	1.000
Gallup (SST)	0.28	71.4	17.9	10.000	5.000
Mancos Sh	0.13	97.0	60.0	0.007	0.007

Independent Evaluation

Predicting the potential magnitude of ground water pollution associated with the land disposal of wastes (solid or liquid) is a complex technological undertaking. The simultaneous presence of numerous interactive mechanisms (physical, chemical, and biological) makes it difficult to obtain a description in advance of a potential pollution by a given waste for a specific hydrogeological setting. Consequently, many investigators have resorted to the construction of "models" for evaluating the performance of a certain waste disposal site. A waste disposal model may be considered to be a simplified representation of a real system. Proper care must be employed during a modeling effort to consider what are conservative, but reasonable, parameters to represent the real system.

An extensive staff review of the applicant's seepage modeling effort evaluated the conservatism of the simulated results. We have attempted to evaluate whether the model selected for the simulations and associated input coefficients can be relied upon as a reasonable representation of the physical system at La Polvadera Canyon. The review focused on the accuracy of the particular computer model used (e.g., whether the model had been verified to accurately simulate actual field or laboratory data), the reliability of the hydrogeologic data input into the model, and the conclusions drawn from the simulated results.

Accuracy of the Model

Data supplied by the Gulf Research and Development Company has supported the validity of the two-dimensional, two-phase simulator. Water content data collected during an experiment in which a 13-foot high core was drained to gravity-capillary pressure equilibrium, were accurately predicted by the simulator. The mathematical veracity of the computer code is therefore judged to be reliable for saturated-unsaturated flow system simulation.

An important consideration in the use of a two-dimensional computer model is how one discretizes the area of condern. The discretized cross-section of the pond and of the surrounding rocks used in the initial simulation is shown in Figure 12. Each of the rectangular blocks shown in this figure are ring-shaped and are extended over 360° around the vertical axis through the center of the pond. The rings are assumed to have uniform rock and fluid properties. However, each of these blocks are assigned a fixed value for porosity and permeability according to the geologic formations they represent. Considering the complexities in mathematical simulations and in the variabilities in rock properties, it follows that the finer the discretization (mesh) used, the more accurate will be the results.

Our review of the initial simulation raised questions regarding the mesh size chosen, and regarding the dimensions of the cross-section chosen for discretization. Our particular concerns were:

* Gulf arbitrarily placed an impermeable boundary beneath the pond at a depth of 434 feet. It is believed that this may have induced water to flow horizontally which otherwise may

have percolated downward. The staff felt that it would have been much more realistic to lower this boundary to the top of the first aquifer beneath the site. By doing so, the lateral spread would have been more limited, but would have been more physically representative.

* For the complexity of the problem, Gulf may have chosen too coarse a mesh to represent the critical areas for seepage, e.g., near the clay liner. Subsequent seepage simulations by Gulf incorporated revisions in the mesh dimensions and have greatly reduced our concerns in this area.

The accuracy of the model is judged to be sufficient, given the revised grid mesh.

Reliability of the Hydrogeologic Input Data

Hydraulic conductivity data obtained from field tests conducted by the applicant showed a significant range of values for both the Dilco and Gallup formations. Hydraulic conductivity data obtained from field tests in the Dilco (29 values from 10 drill holes) varied from 0.0 to 69.4 feet/year with a log normal mean of 1.3 feet/year from which average vertical and horizontal hydraulic conductivities of 1 foot/year and 2 feet/year, respctively, were estimated. Similarly, hydraulic conductivity data obtained from field tests in the Gallup (38 values from 14 drill holes) varied from 0.0 feet/year to 3,580 feet/year with a log normal mean of 6.6 feet/year from which average vertical and horizontal hydraulic conductivities of 5 feet/year and 10 feet/year were estimated. The Mancos Shale was found to have a mean hydraulic conductivity of 0.007 feet/year based on field tests (7 values from 5 drill holes).

The range in hydraulic conductivity values obtained from the testing, in itself, is not particularly surprising. By the nature of the processes by which such sedimentary formations are laid down, these zones are unlikely to be uniform throughout. The coefficient of hydraulic conductivity found in natural soil deposits ranges from millions of feet per year to less than one-thousandth of a foot per year. In many soil deposits, the hydraulic conductivity parallel to the bedding planes may be 100 or even 1,000 times larger than the permeability perpendicular to the bedding plane. Hydraulic conductivity in some soils is very sensitive to small changes in density, water content, or gradation. In certain ranges, a few percent variation in any one of these factors may result in a thousand percent variation in hydraulic conductivity. Because of the wide variation in hydraulic conductivity that is possible, measurement of great accuracy is not required for most engineering designs; rather, the order of magnitude of the hydraulic conductivity is of importance.

Methods used to compute saturated hydraulic conductivities above the water table (in unsaturated material) are approximate. For the different types of tests in the same material, computed values could differ by perhaps 25 to 100%. None of these borehole methods, however, may be reliable in fractured rock, as they are based on assumptions of flow through homogeneous, isotropic porous media. A major deficiency in the applicant's discharge plan and initial seepage simulation is the lack of information on fracture location, density, or related hydraulic conductivities.

The staff examined available literature and conducted on-site investigations to more fully analyze the fracture related permeability displayed in the Cretaceous rocks found at the site. Our review highlighted the following critical points:

1. The Gallup sandstone contains well-defined joints with a spacing of 30 centimeters to 3 meters or more. These joints are preferential pathways for fluid movement in the sandstone. It is clear from outcrop studies in the area that joint planes have been the locus of fluid movement in the Gallup (and in other Cretaceous rocks of the region) in the past and are presently the site of differential weathering. Similar features are observed in core samples.

2. Joint patterns apparently control faulting at the proposed site. East-, northeast- and north-trending joint sets are characteristic of this area; similar trends are seen in the faults mapped by Santos (USGS, GQ-516) and Gulf. According to Gulf, faults are characterized by zones of high permeability and structural distortion.

3. Where the Gallup sandstone is exposed at the surface, joints are opened by stress release at the free surface. This is clearly demonstrated in the outcrops of Cretaceous sandstone bounding the site and specifically in outcrops of Gallup and Dilco at or very near the site. Where the overburden has been stripped and Gallup exposed, this phenomenon yields zones of fissuring; subsequent alluvial cover may hide the fissured Gallup, but does not change its character. Therefore, Gallup below alluvium can be expected to have significantly higher permeability than that buried within the Cretaceous stratigraphic section.

4. An east-trending joint set is pervasive in the Gallup of this region. This joint set parallels the direction of expected subsurface water movement from the tailings disposal area to potential aquifers.

It was concluded from this data that fracture permeability may exist in the Gallup sandstone beneath the site and that possibility exists in which underground fluids may move eastward at relatively higher rates than assumed for the seepage analyses along pathways formed by joints and fractures in the Gallup sandstone. In situ measurements of permeability at the site did not test the potnetial for fracture permeability in the Gallup. Without these tests, a conservative estimate of rates of underground fluid flow can not be considered to have been made. On this basis, the staff believed that the values assigned to the permeability of the Gallup sandstone in the initial simulation were too low.

The applicant subsequently performed additional computer seepage simulations to investigate the sensitivity of the water saturation profile advancement to the presence of fractures and zones of relative high hydraulic conductivity in the underlying formations. Figure 13 shows the results of the fracture sensitivity study. A single vertical fracture occurring in the Gallup sandstone is assumed in the simulation to extend from the center of the pond to the top of the Mancos Shale. A single horizontal fracture intersects the vertical fracture at a 124 foot depth and extends from the pond center to the outside radius of the system. The fractures are 1/8-inch thick and have a 100 darcy (81,433 feet/year) hydraulic conductivity. This resulted in an equivalent horizontal hydraulic conductivity for the blocks surrounding the fractures of 115 md (94 feet/year). Comparing the results from this simulation to those on Figure 12 suggests that the presence of the fractures effects the advance of the wetting front for the first 40 years, but the ultimate advance of the front has not dramatically changed. The fracture induced advanced position of the seepage front is dispersed via capillary and gravity forces, indicating the presence of minor fractures beneath the pond should not dramatically alter the initial simulation results.

An additional computer simulation considered staff-suggested saturated and unsaturated hydraulic conductivity values. Table 3 shows the saturated hydraulic conductivities employed for this simulation. Adjustments in both horizontal and vertical hydraulic conductivities were made to consider probable vertical stratification in hydraulic conductivities and bedding plane induced anisotropy (horizontal hydraulic conductivity: vertical hydraulic conductivity = 20:1). Hydraulic conductivities of the liner were increased by a factor of 10. Figure 14 shows the results of the later simulation. The seepage front has not advanced as far as the front in the original work at a comparable time.

The staff feels that the hydrogeologic data considered in the later simulations to be of adequate reliability for the long term seepage analysis.

<u>Conclusions Drawn From the Simulated Results</u>

Based upon the information referenced above, the staff supports Gulf's conclusion that the seepage front will not invade the water table. This interpretation, of course, must be predicated upon proper quantification of the hydrologic properties of the site. Upon implementation of construction and monitoring activities, additional field data will become available for consideration. If site conditions are then found to be significantly different than present data suggests, the seepage projectsions should be revised.

The following are judged to be the most critical data which should be collected during these activities:

1. The applicant will remove all alluvium from the evaporation pond bottom, exposing the underlying Gallup formation. On-site inspections of the rock material should be conducted; specifically, a

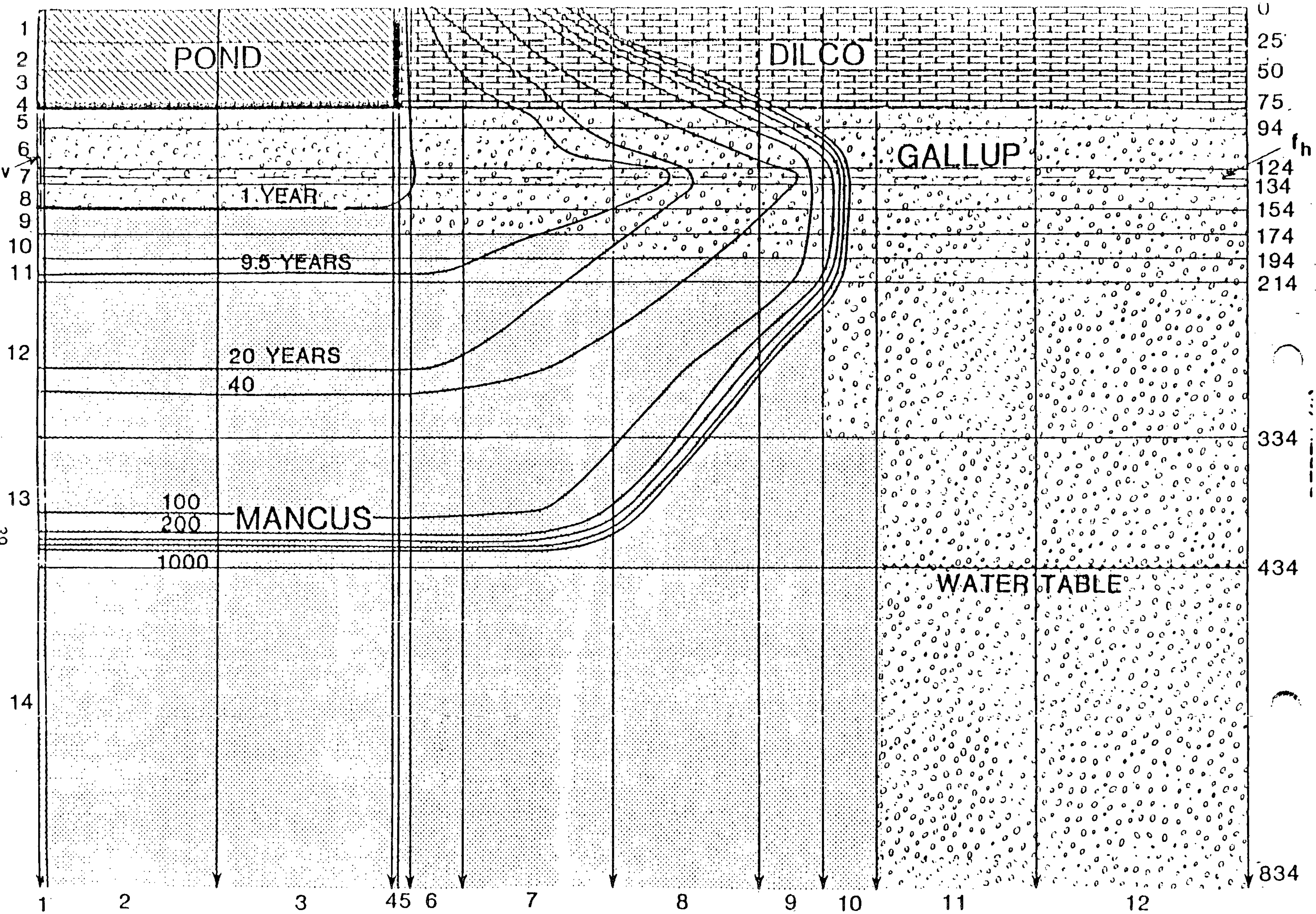


FIGURE 13

REVISED RADIAL GRID SYSTEM - MT. TAYLOR POND SEEPAGE STUDY
(Note Presence of Vertical and Horizontal Fractures Imposed On Grid)

TABLE 3

EID SUGGESTED PHYSICAL PROPERTIES OF ROCK AND FLUIDS
USED IN FINAL SEEPAGE SIMULATION

ROCK FORMATION	POROSITY ϕ	PERMEABILITY	
		K_h ft/yr	K_v ft/yr
Liner	0.34	0.5	0.5
Gallup			
Upper 30ft	0.28	100	5
Lower Part	0.28	20	1
Dilco	0.22	4.0	0.2
Mancos Shale	0.13	0.007	0.007

Density of water = 67.40 lbm/ft^3 = 1.082 g/cc

Net evaporation rate = 34 inches/year

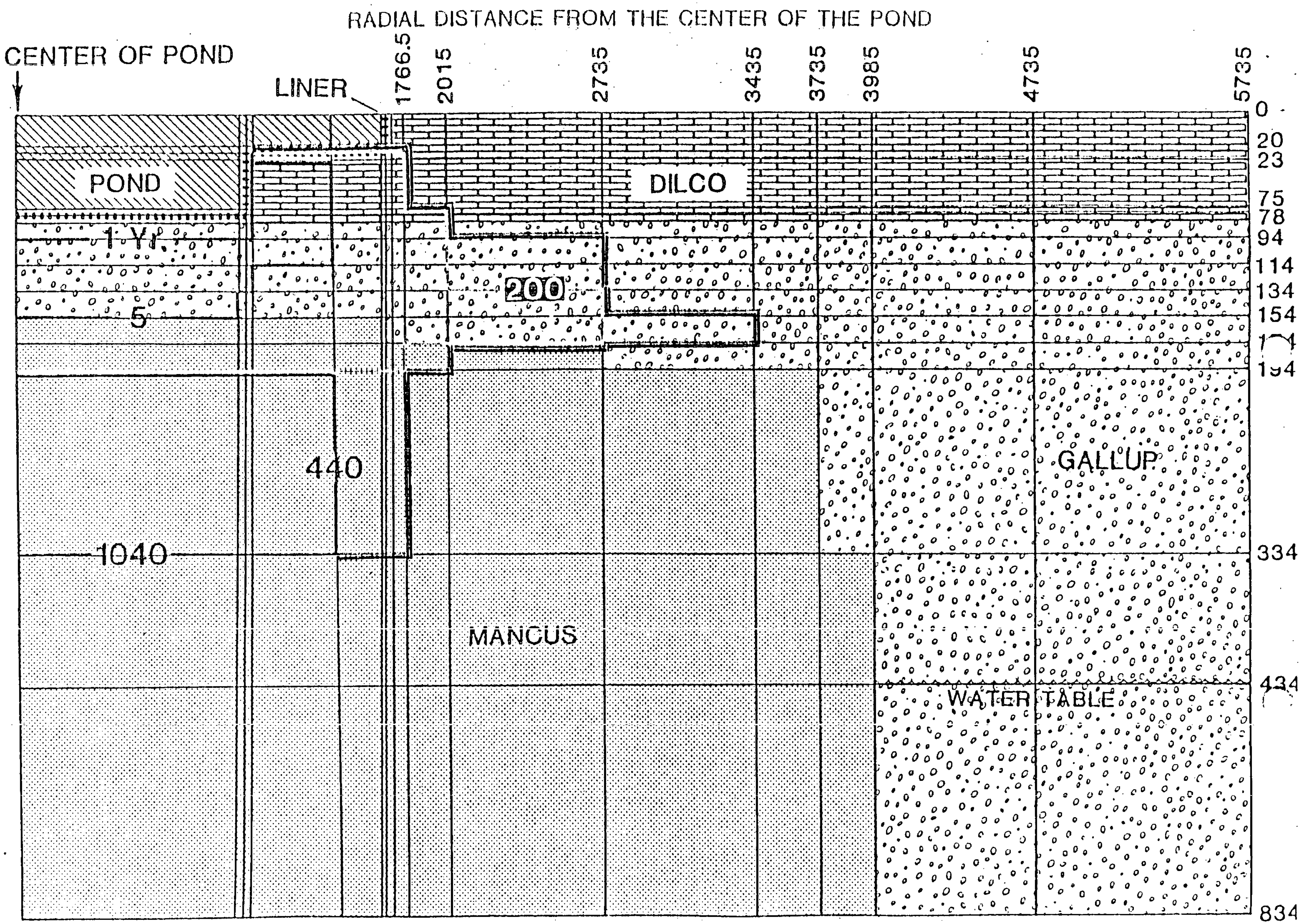


FIGURE 14

SEEPAGE-FRONT AT END OF TIMES LABELED
(Properties Used In Simulation Are Presented in Table 3)

detailed examination of the joint and fracture systems present on the exhumed rock surface. As discussed earlier, the Gallup below alluvium can be expected to have significantly higher permeability than that buried beneath the Dilco formation. If the examination reveals major fissure-type features, rather than typical minor fracturing (e.g., 1/8-inch width), the applicant should be obligated to quantify the effects of the enhanced permeabilities.

2. Shallow monitoring wells will be installed around the pond perimeter to allow for detection of seepage front advance. The bore holes will be air drilled and cored; in situ moisture content measurements of the cores will be performed. If the information from the tests suggest the presence of significantly higher rock moisture contents than considered in the seepage analyses, the applicant should be obligated to quantify the effects of the increased in situ moisture.

With the above concerns recognized, the applicant's seepage assessment for the evaporation pond is considered adequate to demonstrate that ground water should not be degraded beyond standards by evaporation pond seepage.

Evaporation Pond Dam Failure

The Mt. Taylor site is said to be in the Zone 2, "moderate damage," seismic risk category (intensity VII on the Modified Mercalli Scale). Available seismograph records for the project area were insufficient to permit the applicant from performing statistical forecasting of the occurrence of large-magnitude earthquakes. Based on the historical record, a Gulf analysis indicates that an earthquake of Intensity VIII could occur at the Rio Grande Rift Zone about 60 miles east of the site. This earthquake would probably be felt at the project site with an intensity of VI. An earthquake with a maximum intensity greater than VIII at the site cannot reasonably be expected. Such an earthquake is said to correspond to an effective acceleration of 0.07g. The evaporation pond dam is designed to be constructed to withstand an effective acceleration of 0.1 g.

The maximum liquor impounded by the dam will be 5,400 acre-feet. The peak rate of flow in the event of a failure cannot be reasonably estimated since this flow rate would be dependent upon the rate of failure of the dam. However, the drainage network downstream of the dam traverses approximately 100 miles through relatively unpopulated regions before reaching a major stream course (Rio Grande). Consequently, the peak outflow, although relevant, is not a major cause for concern. These areas concerned could be treated or removed once the degree of contamination was assessed. The closest community along the drainage system which could be affected by a tailings release is the small village of Guadalupe which is located approximately 40 miles below the dam. By the time the release reached that area, it would probably be contained within the natural channels due to channel storage and friction.

The consequences of such a failure, although difficult to quantify, potentially could be severe. It is the staff's opinion that local ground water contamination beyond the New Mexico Water Quality Control Commission Regulations standards probably would occur. The probability of such an event occurring, however, must be similarly considered. The applicant's proposed dam design must meet or exceed New Mexico State Engineer Office and Nuclear Regulatory Commission requirements prior to its construction. At the time of this writing, the dam is still under review by the State Engineer.

A deficiency in the applicant's proposed discharge plan is the lack of detailed emergency response procudures to be implemented in the event of a dam failure or a major tailings pipeline failure. The probabilities of such events transpiring are considered to be quite low. Nevertheless, with proper response procedures in effect, the ultimate insult of the failures could be greatly reduced. It is recommended that the applicant be required to develop a realistic response plan prior to any tailings discharge.

Disposal Facility Monitoring

Liquid and solid mill waste disposal facilities in La Polvadera Canyon are designed to minimize saturation of rock units in the vadose zone beneath the facilities and to preclude deep percolation to the saturated deeper units. Fluid is expected to seep beneath the evaporation pond, but this seepage water will be contained within the presently unsaturated Gallup Sandstone. A network of shallow and deep monitoring wells will be constructed to detect seepage amounts exceeding design values. The location of the applicant's proposed network of deep and shallow monitoring wells are shown on Figure 15.

Shallow Monitoring System

The proposed shallow monitoring system consists of a series of wells designed to detect development of saturated zones within the Gallup Sandstone and Dilco-Mulatto units. Only minor saturation is expected beneath the disposal trenches in the Dilco Unit and beneath the evaporation pond. Monitoring the rates of in situ moisture change along with water quality if saturation occurs, will provide data to determine if existing aquifers are threatened.

The shallow monitoring system will consist of two groups of neutron-moisture monitoring wells. One group will consist of clusters of two wells each: one well penetrating only the Dilco Unit and another well drilled to the base of the Gallup Sandstone with the overlying Dilco Unit sealed off. The other group of shallow monitoring wells will consist of single wells open only to the Gallup Sandstone or alluvium. All of the cluster wells and the single wells will be air-drilled wells.

Deep Monitoring System (Saturated Zone)

The deep groundwater monitoring network will include two wells that will penetrate to the base of the Dakota Sandstone beneath the main body of the Mancos Shale. The wells will have a minimum five-inch diameter conductor casing, extending through the Mancos Shale, grouted in place to form a seal so that only water from the Dakota Sandstone is sampled. The locations of these wells are shown on Figure

The two deep wells are designed to detect degradation of existing groundwater from deep seepage (if any) through the Mancos Shale aquiclude. If deep seepage to the Dakota Sandstone occurs, it will have to move downward through the Mancos Shale along fracture zones. No faults were detected in the areas occupied by disposal facilities. The nearest detected fault zones are a north-south fault to the east and an east-west fault to the north of the facilities. A long, slow seepage path would be required to reach these faults. Also, evidence indicates that fracturing does not persist through the Mancos Shale.

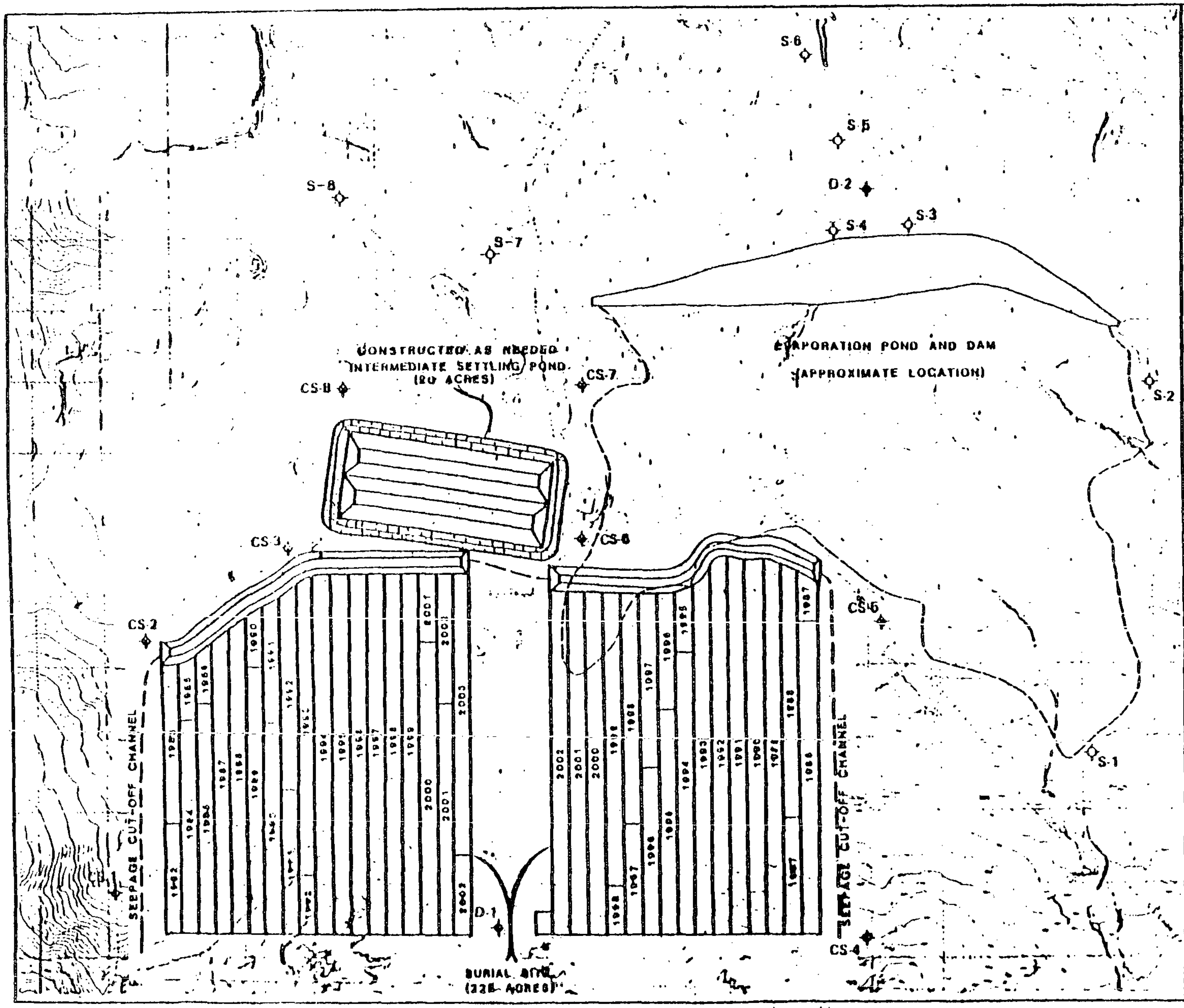
The two deep wells will have permanent pumps installed for ease of sampling and can be used as a replacement stock water supply after the Polvadera Well has been abandoned. The Polvadera Well, along with two other old oil and gas test wells, will be sealed with cement and bentonite grout to the surface to prevent these wells from transmitting seepage water downward to degrade existing groundwater.

Monitoring Procedures

The monitoring well network will be constructed prior to the start of disposal operations, and baseline water level and moisture measurements will be made and samples will be collected for chemical analysis from the two deep wells (the shallow well system will be dry). After the start of operations, monthly water level measurements in the two deep wells and monthly moisture determinations in all shallow wells will be made. Water samples from the deep wells will be collected and analyzed quarterly. The results of the monitoring program will be evaluated annually and submitted to the New Mexico Environmental Improvement Division. Sampling and water level measurement frequency will be reviewed annually and adjusted to reflect monitoring requirements. Sampling and analytical techniques will conform with Subsection 3-107.B. of the amended Water Quality Control Commission Regulations dated January 11, 1977. Chemical analyses will include constituents listed under Section 3-103 for baseline monitoring and initial operational monitoring. With the review and concurrence of New Mexico Environmental Improvement Division (NMEID), analyses will be adjusted later during operations to include only constituents of concern.

Threshold Levels

The criteria for setting threshold levels for corrective action in the event of degradation of existing groundwater will conform with Section 3-103 of the amended Water Quality Control Commission Regulations dated January 11, 1977. If seepage could penetrate the Mancos Shale, the first principal



EXPLANATION

CS-6 — Cluster of 2 shallow Monitoring Wells: constructed so that 1 well is open only to the Dilco unit and 1 well is open only to the Gallup Sandstone.

S-3 — Single shallow Monitoring Well: constructed to the top of the Mancos Shale and open only to the Gallup Sandstone.

D-1 — Deep Monitoring Well: constructed to the base of the Dakota Sandstone and open to the Dakota and lower Mancos Shale.

SCALE

0 — 1000

feet

GULF MINERAL RESOURCES CO.

Mt. Taylor Uranium Mill Project

Earth Sciences Associates

MONITORING WELL SYSTEM

LA POLVADERA CANYON

Checked by [illegible] Date [illegible]		Project No
Approved by [illegible]	Date [illegible]	2160

FIGURE 15

aquifer that seepage water could reach would be the Dakota Sandstone. This aquifer occurs more than 1,000 feet below the lowest part of the disposal area. Baseline samples will be collected and analyzed prior to start of operations and will be used as more definitive critieria for threshold values. This, and additional analyses from deep monitoring wells, will establish threshold levesl.

A realistic threshold for seepage and lateral spreading of perched groundwater is established by the seepage analysis. Saturation, and perched mound development and spreading should not occur in the Gallup Sandstone. Therefore, if seepage water is detected in monitoring wells open to this unit after the start of pond operations, then design threshold levels will have been exceeded. The detection of saturation in the Gallup Sandstone beneath the disposal trenches does not mean that groundwater degradation will occur, but it would indicate that seepage estimates have been exceeded and serves as an alert to this fact. If saturation in the Gallup Unit is detected beneath the disposal trenches or beneath the evaporation pond, seepage conditions will be re-analyzed using monitoring data to make the appropriate adjustments to provide better accuracy for seepage predictions. The monitoring program will be flexible so that additional wells can be added to fill data gaps as information is developed. The extremely long periods of time required for perched mound development and spreading provides an abundance of time to make adjustments. If the seepage rates indicated by monitoring appear to threaten the quality of existing aquifers, then preparation would be made for corrective actions. The rate of seepage movement and configuration of a seepage mound would provide information for design of corrective measures, if needed.

Detection of development of perched saturated zones within the Dilco Unit would not indicate excessive seepage. It is reasonable to expect this to occur to some extent and it would indicate beneficial barriers against downward seepage to the more permeable Gallup Sandstone. Perched saturated zones within the Dilco Unit will be monitored closely to determine the extent and rate of seepage. Additional monitoring wells will be provided, if needed. If necessary, corrective measures will be formulated to contain lateral spreading beyond the area of the facility.

Contingency Plans

The primary contingency plan is to periodically evaluate monitoring data to verify seepage estimates. If seepage predictions are exceeded, conditions will be reanalyzed to determine if existing aquifers are threatened with contamination. These updated analyses based on observed moisture contents and water quality will then be used to design remedial measures, if needed.

Corrective measures will be initiated if it appears that the quality of groundwater in the saturated zone of the Gallup Sandstone, which may, or could conceivably be used as a domestic or agricultural water supply in the reasonably foreseeable future, could be degraded beyond the standards of Section 3-103 of the Regulations. Corrective measures could include, for instance, hydraulic barriers and/or grout curtain.

Perched saturated zones within the Dilco Unit will probably be relatively easy to intercept with open drainage trenches. Open drains will be constructed around the perimeter of the tailings burial trenches. Additional trenches will be added downslope from the planned drains if monitoring data indicates they are needed.

If deep percolation to the Dakota Sandstone is detected, then pumping the two deep monitoring wells could contain contaminants in the immediate area. However. additional deep pumping and monitoring wells would be considered, depending on the hydraulic characteristics of this aquifer and the degree of degradation. Direct contamination of the Dakota Sandstone would require an undetected fracture zone penetrating the Mancos Shale in the disposal area and failure of the pond lining systems. This is considered to be the most improbably scenario for ground water degradation.

If seepage discharges from the Gallup Sandstone to the recent alluvium to the east, then dewatering wells would be constructed in the alluvium along the buried channels. This system will take full advantage of the buried channels which will act as natural drains.

Post Operational Monitoring

After waste disposal operations cease, monitoring of both shallow and deep wells will continue until the seepage flow system can be predicted with reasonable confidence. Tentatively, monitoring will continue at least five years after operations cease. By this time, the seepage predictions should be so well validated that monitoring can cease or at least be reduced to a few key wells monitored at extended intervals of time. Emphasis should be placed on periodic reevaluation of monitoring data and upgrading seepage analyses so that flexibility is maintained throughout the program. A fixed, inflexible routine should be avoided so that any unpredictable conditions can be handled easily and in a timely manner. Rates of movement of any saturated flow should be very slow, providing ample time to adjust the monitoring program and to activate contingency plans if needed, after careful analysis of monitoring data.

Evaluation of the Proposed Monitoring Program

Gulf's proposal to monitor shallow subsurface seepage migration with the use of neutron-moisture moderation techniques is felt to be appropriate. The staff believes, and Gulf's model indicates, that seepage beneath the pond liner will occur mostly at water contents much less than saturation, provided the integrity of the three-foot thick liner is maintained. Conventional open-hole piezometers are generally useful for monitoring saturated flow conditions; substantial volumes of fluid moving under unsaturated flow conditions could, therefore, remain undected by such a well design.

As these monitoring holes are drilled, moisture determinations on samples of recovered rock will be made by Gulf. This data will be used to establish a baseline condition of in situ moisture content. In addition, Gulf will examine the rock structure under the evaporation pond upon excavation. If this examination indicates a significant difference from the presently assumed conditions, Gulf will consider additional monitoring wells as may be agreed upon by Gulf and the New Mexico Environmental Improvement Division.

Given the uncertainties regarding rock conditions at the pond site, the staff does not feel that a final monitoring array can be established prior to pond-bottom exhumation. In general, the proposed shallow array shown in Figure 15 seems acceptable; it is considered prudent, however, to hold in abeyance recommendations regarding the monitoring configuration and design until this additional on-site data can be incorporated.

Given the structural deformation which has occurred at the San Mateo dome, monitoring of deep water bearing units is appropriate. Gulf proposes installing two deep wells into the Dakota formation for water quality testing. Available drilling information, however, suggests that sandstone units within the overlying Mancos Shale have been developed in the past for livestock supply. Gulf should prepare discussion for presentation at the forthcoming hearing regarding historical use and known hydrogeologic conditions of the Mancos sandstone units at the site. Upon hearing the discussion, the staff will then make a recommendation regarding the need for monitoring in the Mancos formation.

Witnesses for the Environmental Improvement Division Concerning the Gulf Mineral Resources Company Proposed Ground Water Discharge Plan for the Mt. Taylor Uranium Mill Project

WITNESS	TESTIMONY
Jonathan F. Callender, Professor University of New Mexico	Structural Geology
Bruce M. Gallaher, Geohydrologist Ground Water Section	Overall summary of staff review of Gulf Proposal
David L. Schreiber, Consulting Hydraulic Engineer	Engineering Design Features of the Waste Pipeline System
Daniel B. Stephens, Professor New Mexico Tech	Seepage Assessments
Stephen G. Wells, Professor University of New Mexico	Long Term Stability of the Tailings Disposal Area