UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

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WM-26

MAY 1 6 1980

Mr. Thomas E. Baca, Director
Environmental Improvement Division
Department of Health & Environment
P.O. Box 968, Crown Building
Santa Fe, New Mexico 87503

Dear Mr. Baca:

Enclosed is the report of the tailings management evaluation performed by the NRC staff of the Mt. Taylor Uranium Mill Project proposed by Gulf Mineral Resources Company. As was agreed in our meeting on March 3, 1980, this report of the tailings management evaluation, including conclusions and recommendations of NRC staff made in connection with its review, essentially completes the NRC assistance which was requested for this project.

Please feel free to contact me concerning any questions or comments on this matter.

Sincerely,

Ross A. Scarano

Ross A. Scarano, Chief
Uranium Recovery Licensing Branch
Division of Waste Management

Enclosure:
Rpt of the Tailings Management
Evaluation of the Proposed
Mt. Taylor Project

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REPORT OF THE TAILINGS MANAGEMENT EVALUATION OF THE PROPOSED MT. TAYLOR PROJECT

1.0 INTRODUCTION

The New Mexico Environmental Improvement Division (NMEID) requested technical assistance from the NRC in the review of the Mt. Taylor Uranium Mill Project proposed by Gulf Mineral Resources Company ("Gulf"), a division of the Gulf Oil Corporation. The most recent version of that proposed project was submitted in the Groundwater Discharge Plan dated February 1980[1]. In a March 3, 1980 meeting between the NMEID and the NRC concerning technical assistance on the proposed project, it was agreed that the NRC would provide (1) a report on the radiological assessment, and (2) a report on the tailings management system evaluation and comments and recommended license conditions resulting from the NRC review. The radiological assessment was forwarded by letter dated April 4, 1980. This tailings management evaluation report is intended to be independent, but also to supplement information provided in the radiological assessment report.

1.1 BACKGROUND

1.1.1 Description of proposal

The Mt. Taylor Project is to be located near San Mateo, New Mexico, which is approximately 16 miles northeast of Grants, New Mexico. The project has as its major components a deep underground mine, a processing mill with a capacity of approximately 1.5 million tons of ore per year, and tailings disposal facilities. The mine is located 1/2 mile north of San Mateo and the proposed mill is to be located in lower San Lucas Canyon, approximately 3 miles north of the mine site.

Gulf proposes to dispose of tailings waste from the Mt. Taylor Uranium Mill in La Polvadera Canyon in an area approximately 4 miles north-northwest of the mill site. A parallel series of dragline excavated trenches for burial of tailings solids located in the E 1/2 of Section 15, T14N, R8W, a slimes settling pond(s), and an evaporation pond would comprise the La Polvadera Canyon tailings facilities. During the planned project life from 1982 through year 2003, approximately 12.6 million tons of tailings would be buried. This tonnage represents one-half of the mine ore production minus five percent for dissolution during processing. The remaining 50 percent of the mill tailings would be used for mine backfill (review of the proposed mine backfill operation will involve a separate licensing action).

The proposed La Polvadera Canyon tailings facilities and operations would be as follows:

Note: Figures and tables from the Groundwater Discharge Plan which are referred to in the text of this report have been reproduced and included as an attachment.

(1) Tailings Trenches

Excavation of the parallel burial trenches would be accomplished with a dragline. The first trench or "box cut" would be excavated the approximately one-half mile length within the trench area boundary and the excavated material (spoil) would be stockpiled beside the cut. Each trench would be approximately 75 feet wide at the bottom, 125 feet wide at the surface, and 50 feet deep, and would have a gradual slope at the bottom of less than one percent. 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 and which have low permeabilities. Based on field measurements these units were estimated to have an average vertical permeability of one ft/year (10^{-6} cm/sec) and an average horizontal permeability of two ft/year (2 x 10^{-6} cm/sec). The depth of excavation would be to within no less than 10 feet of the Gallup Sandstone, although it was estimated by Gulf that the average thickness of the Dilco beneath the trench bottoms would be 75 feet. The overburden in the trenches would generally be prepared for removal by blasting, 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. The final trench bottom would be shaped with a bulldozer using rippers where necessary.

The tailings would be transported to the burial site by a pipeline at approximately 20 to 40 percent solids by weight. Initially, the tailings slurry would be discharged at the elevated end of a trench and gravity separation of the sands and slimes would occur. Berms would be constructed at intervals along the trench bottom to promote settling of slimes. In this manner, sand beaches would eventually cover and consolidate the slimes. The slimes would be concentrated at or near the bottom of the trench and would tend to seal more permeable areas on the bottom and sides of the trenches. The pooled raffinate behind the berms would be pumped to the intermediate slimes settling pond. When the area behind the berm is filled, tailings deposition would continue in the same manner behind the new berm constructed downstream within the trench.

As each succeeding parallel trench cut is made, the spoil would be deposited on top of the drained tailings placed in the previously filled trench to a level five feet below the existing ground level. A one-foot thick clay cap is proposed between the tailings and soil cover. Figure II-3 (of Ref. 1) illustrates the trench section, spoil height, tailings level and the final level of the cover surface after reclamation.

An open trench drain would be provided along the periphery of the disposal trench area to intercept horizontal seepage, if any is to occur, along bedding planes, sandstone layers and shallow fractures. Similarly, adjacent trenches would act as drains as they are opened next to an active trench. Sump pumps would be used to collect waste water if it appeared in the open drains or adjacent trenches and would route it to the settling pond to separate suspended solids from the waste water.

The computed values of seepage out of the impoundment are less than that which is available for retention in the foundation rocks,* i.e., the seepage water would be physically held in the pore spaces of the foundation rocks directly beneath the trench area. This is based primarily on the use of a model which assumes that the underlying geologic units are homogeneous and isotropic. This is evaluated in Section 2.2.3.1, below.

Figure II-1 (of Ref. 1) is an "artist's conception" illustration showing the tailings burial system described above. Figure II-2 (of Ref. 1) shows the location and orientation of the burial trenches in La Polvadera Canyon. The most recent studies by Gulf showed that the evaporation pond required may encroach on the southeast corner of the trench area and some minor adjustments in the trench system layout may need to be proposed as a result of final design studies. Table II-1 (of Ref. 1) contains the liquid and solid waste production rates used by Gulf in developing the proposal.

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*The available retained storage in the foundation rocks above the Mancos Shale, i.e., the volume of water which can be retained by the rock or soil against the pull of gravity minus the in-situ moisture content, directly beneath the trenches was calculated by Gulf to be greater than total estimated seepage losses during project life. For the Gallup geologic unit the specific retention and in-situ moisture content were found to be 20 and 5 percent by volume, respectively, and for the Dilco/Mulatto unit they were found to be 19 and 14 percent by volume, respectively. These values were obtained through the laboratory testing of samples obtained on site.

(2) Settling Pond

The intermediate settling pond would intercept suspended slimes in the tailings waste water and the clear water would be transported to an evaporation pond for disposal.

Like the trenches, the sedimentation pond would be excavated with a dragline into the Dilco Coal Member. The depth of excavation would be to within no less than 10 feet of the Gallup Sandstone, although it was estimated by Gulf that the average thickness of Dilco beneath the pond bottom would be 23 feet. The pond would be 30 feet deep, 75 feet wide at the bottom and would have 4:1 side slopes. The length of the initial pond would be such that two years slimes could be retained if one-third of all slimes were carried into the pond. The final pond size (total trench length) would be determined after an evaluation of the initial two years operating results. The bottom and sides of the pond would be lined with a three-foot thick, compacted clay liner, with an installed permeability which Gulf considers would be 0.05 ft/yr (5×10^{-8} cm/sec).

In the proposed site reclamation plan, the pond would be covered after slimes consolidate and dry. No specific plan for reclamation including details such as thickness of cover and final contouring and the like was presented by Gulf specifically for these ponds.

(3) Evaporation Pond

The evaporation pond would have sufficient capacity to store and evaporate all liquid wastes.

The evaporation pond would be contained by an embankment (constructed in stages using the downstream embankment construction method) with an initial height of about 40 feet and an ultimate height of about 80 feet (with final crest elevation of approximately 7145 feet). The final required pond would contain approximately 5400 acre-feet volume, would cover a suface area of about 200 acres, and would have a maximum surface elevation of about 7,135 feet. (It should be noted that the evaporation pond area which Gulf predicts would be required encroaches upon the tailings trench area). The entire pond area would be stripped to bedrock (Dilco Coal Member and Gallup Sandstone) and lined with a minimum layer of three feet of clay, with a permeability which Gulf considers would be 0.05 ft/yr (5×10^{-8} cm/sec), in areas not underlain by a minimum of 10 feet of the Dilco Coal Member. The clay liner material would be taken from soils stripped from the embankment foundation and pond areas.

In the tentative reclamation plan liquids would be allowed to evaporate at the end of project life and the residual salts would be disposed of in dragline trenches similar to those used for burial of tailings.

1.1.2 NRC technical assistance

In May 1978, the NMEID received an application for a Radioactive Material License from Gulf for the proposed Mt. Taylor Uranium Mill Project. In August 1978, NMEID requested NRC assistance in reviewing the Gulf proposal.[2] In October 1978, NRC provided questions on the Gulf application and attended a site visit with the NMEID and continued to provide assistance during subsequent months of the NMEID acceptance review of the application. NMEID accepted the Gulf application in February 1979.[3]

The tailings management system proposed initially involved the construction of a large, single unsegmented impoundment by construction of a dam (with a 2.5:1 downstream slope) across a subdrainage in La Polvadera Canyon. The impoundment would be unlined with seepage being impeded by the low permeability Dilco Coal Member which underlies the site. The ultimate impoundment after 20 years of operation would have a dam approximately 110 feet high and an area behind the dam of approximately 300 acres.

In May 1979, Gulf submitted the required Groundwater Discharge Plan to the NMEID Water Quality Section, and in June 1979, NMEID proposed a Gulf/NRC/NMEID meeting in Sante Fe, to discuss tailings management and radiological aspects of Gulf's proposal. At that meeting which was held on June 19-20, 1979, the NRC expressed concern that Gulf had not adequately addressed tailings management alternatives, particularly burial of tailings below-grade. Gulf agreed to investigate below-grade storage alternatives and other alternatives such as staged impoundment plans that would be more stable in the long-term. It was agreed that La Polvadera would be the most acceptable siting alternative with respect to remoteness from people.

In a meeting on August 14, 1979,[5] to discuss ongoing studies by Gulf, NRC reiterated the need for Gulf to consider modifying the tailings management system proposal to include a multicell/segmented design involving excavation of and construction of a series of smaller embankments. This modification would result in a tailings disposal system with characteristics more similar to those of below-grade systems, e.g., the tailings would be better protected from erosional forces by natural ground contours. Concern was also expressed that the proposal (and alternatives) involved the use of an unlined impoundment and that steps would need to be taken to reduce seepage to the maximum extent reasonably achievable. Gulf was requested to examine methods of reducing system head (e.g., shallower impoundment(s) and/or filtering (system underdrain)) and lining systems.

In a subsequent meeting in September 1979, Gulf presented studies of conceptual multicell/segmented tailings impoundment designs being considered. Generally, the alternatives were systems employing multiple dams/embankments to be located in La Polvadera Canyon at the site proposed initially. All options were sized to store 9,100 acre-feet of tailings, based on the assumption that 50 percent of the tailings by weight, as sands, would be returned to the mine as backfill. The designs involved minimal excavation, were unlined and did not consider the means of providing additional evaporation capacity, e.g., evaporation pond(s). The NRC position was restated that, when tailings impoundments requiring embankments are found to be necessary, embankments be kept as small as possible. In addition, consideration should be given to eliminating seepage through the use of dewatering and/or liner systems. In summary, although the multicell design seemed to be a good concept for the La Polvadera site, there was a need to provide (1) further excavation of the impoundment cells and (2) methods of minimizing/eliminating seepage.

Gulf, NMEID and NRC again visited the site on October 22, 1979 to discuss the proposed tailings management system. In an associated public meeting on October 23, 1979,[7] Gulf gave a presentation of the then-preferred tailings management alternative. The alternative plan consisted of a staged multicell impoundment in the upper reaches of La Polvadera Canyon. The plan would provide for sequential excavation and embankment construction and for staged reclamation. The cell areas would be approximately 20-30 acres each and the embankments would range in height up to about 50 feet. A separate evaporation pond of 120 acres would be provided (Alternative 5B of Ref. 8; see Fig. 1, attached).

The cells would be built down a gradual slope in the Canyon floor. As one cell was being used for tailings disposal, the previously used cell would by drying and the next cell downgradient would serve as an emergency catchment basin. The tailings would be buried as deep as possible, considering practical pit side slopes and isolation from groundwater. The bottom of each cell would be lined with clay to minimize seepage to groundwater and an under-drain would be provided in each cell to allow excess water to be pumped to a lined evaporation pond.

Reclamation would be accomplished in stages. When the cells were filled with tailings and dried out sufficiently, they would be covered with clay, overburden, and topsoil. Exposed embankments would be contoured to gradual slopes and rip rapped to maintain stability and control erosion. Gulf also stated that a dragline burial scheme (the alternative ultimately proposed) was under consideration.

In December 1979, Gulf submitted to the NMEID a radically different tailings management system proposal and a tailings management alternative study. The revised and current proposal is essentially the dragline burial scheme under consideration. The most recent version of that proposal is described in the revised Groundwater Discharge Plan.[1] (See Fig. II-2 of Ref. 1)

Throughout the course of NRC involvement in the review of the Mt. Taylor Uranium Mill Project proposal, the adequacy of the proposed La Polvadera site for disposal of tailings has been thoroughly analyzed. As a result of this analysis which included inspections by NRC of all alternative sites considered by Gulf it is concluded that there is no site which is as good as or superior to the Polvadera site based primarily on the criteria of (1) remoteness from people, (2) protection from disruption and dispersion by natural forces, and (3) protection of groundwater.

A NRC staff radiological assessment of the proposed plan was forwarded to the NMEID by letter dated April 4, 1980. This tailings management evaluation report is being provided to complete the technical assistance to be provided in review of this project as agreed with the NMEID.

1.2 CONTENTS OF REPORT

This report presents the results of an evaluation by the NRC staff of the adequacy of the tailings management system proposed by Gulf for the Mt. Taylor Uranium Mill Project. The major report components include (1) a comparison of the proposed tailings management system with NRC's performance objectives, and (2) conclusions and recommendations resulting from the NRC review.

2.0 EVALUATION OF PROPOSED FACILITY

2.1 TAILINGS MANAGEMENT PERFORMANCE OBJECTIVES

For the purposes of this section, tailings management is defined as the control of the tailings and waste solutions following removal of the uranium values. Engineering techniques to control pollutants from tailings, both during operational and postoperational stages of a milling project, have been proposed. The proposed tailings management system for the Mt. Taylor Mill facility has been evaluated against the following set of performance objectives developed by the NRC staff:

<u>Siting and design</u>

1. Locate the tailings impoundment area remote from people so that population exposures will be reduced to maximum extent reasonably achievable.

2. Locate the tailings isolation area so that disruption and dispersion by natural forces is eliminated or reduced to the maximum extent reasonably achievable.

3. Design the isolation area so that seepage of toxic materials into the groundwater system will be eliminated or reduced to the maximum extent reasonably achievable.

During operations and drying period

4. Eliminate the blowing of tailings to unrestricted areas during normal operating conditions (including a program of chemical spraying and wetting of tailings surfaces).

Postreclamation

5. Reduce direct gamma radiation from the impoundment area to essentially background.

6. Reduce the radon emanation rate from the impoundment area to about twice the emanation rate in the surrounding environs.

7. Eliminate the need for an ongoing monitoring and maintenance program following successful reclamation.

8. Provide surety arrangements to ensure that sufficient funds are available to complete the full reclamation plan.

2.2 COMPARISON OF PROPOSAL WITH PERFORMANCE OBJECTIVES

The proposed tailings management plan has been evaluated against the performance objectives listed in Section 2.1. The following evaluation will refer to each performance objective specifically.

2.2.1 Siting and design to ensure remoteness from people

The proposed La Polvadera Canyon tailings disposal area is located greater than seven (7) miles from San Mateo which is the nearest population center (current population approximately 700) and greater than 4.2 miles (6.8 km) from the San Miguel Ranch which is the nearest residence. It is considered adequately remote from people.

As was indicated in the Report of the Radiological Assessment of the Proposed Mt. Taylor Project, it is concluded that effluents from the entire Mt. Taylor Mill facility can be controlled to meet the limits imposed by 10 CFR 20 and 40 CFR 190 for effluent release concentrations and for maximum doses to individuals, respectively.

2.2.2 Location to minimize disruption and dispersion by natural forces

The proposed plan to dispose of tailings (1) below-grade in excavated trenches, (2) under a very thick rock cover (approximately 50 feet) having very gentle final slopes, and (3) at a site sheltered from wind by the surrounding terrain and with a small tributary watershed, provides very good long-term isolation of the tailings. The thick cover, which is well above the minimum needed to achieve an acceptable attenuation of radon flux, provides a strong measure of conservatism which is desireable and appropriate considering uncertainties concerning differential settlement of the tailings as they dry and consolidate, and other long-term failure mechanisms. This is particularly prudent given the large proportion of the tailings slimes that would be disposed of at the La Polvadera site (while the tailings sands would be used as backfill in the deep Mt. Taylor mine), as the slimes would tend to hold moisture and be less amenable to covering without stability problems than tailings with a higher sands fraction.

The tailings would be impounded below the natural grade in trenches excavated into bedrock. Because the reclaimed tailings trenches would be sheltered by the San Mateo Mesa on the south and west from the prevailing winds (generally from the southwest), the potential for long-term wind erosion is reduced.

Within the La Polvadera Canyon the tailings trench area would be located on the side of the basin on gently sloping terrain (natural slopes are from 10:1 to 8:1, horizontal to vertical). Because the upstream watershed tributary to this area is small (approximately 300 acres as compared to the approximately 300 areas of the trench area) and is mostly gently sloping, the potential for disruption of the reclaimed tailings from water sheet erosion and/or from flooding in the long-term is small. During the operational period any runoff from the upstream drainage areas would be diverted around the trench area.

During excavation of the trenches most of the overburden would be loosened by blasting and removed with a dragline. The material removed would be used to cover the adjacent, filled tailings trench. The proposed tailings cover would be composed of relatively large, well-sorted, angular fragments and thus would tend to be inherently resistant to both wind and water erosion. The final cover surface would be gently sloping (approximately 8:1, horizontal to vertical, but which could be further reduced considering the mass of the cover) and contoured to eliminate points at which surface water runoff might concentrate. In fact, since only the finer particles in the outer surface of the cover would be removed by wind and water and the large particles would settle and consolidate, the final result should be much the same, i.e., "armoring" of the surface. The cover could be safely revegetated with indigenous plant species without chance of intrusion by plant roots or animals down into the tailings because of the thickness and physical characteristics of the cover. In addition, although it is not likely that the vegetative cover would be full and self-sustaining, the thickness and physical characteristics of the cover along with the shape of the cover surface would be such that the vegetation would not have to be relied on as a stabilizing factor.

Because of the location of the trenches below-grade in bedrock, dispersion of the tailings due to earthquake loading is not considered possible. Also, the thickness of the cover ensures that the cover would not be damaged under earthquake conditions.

The siting together with the design of this tailings impoundment ensure that the chance of disruption and dispersion by natural forces would be virtually eliminated.

2.2.3 Siting and Design to Eliminate/Minimize Seepage

In the proposed tailings management system the tailings would be transported in slurry form from the mill and discharged in trenches at the La Polvadera impoundment site. Tailings liquids would be decanted from the trenches and routed through an intermediate settling pond(s) to an evaporation pond. In this proposed system, tailings liquids, if not adequately controlled, might be available for seepage from the La Polvadera impoundment site (the trenches, slimes sedimentation pond and the evaporation pond) and/or from the six-mile long, tailings transport and decant return lines. Seepage from the tailings transport system could only result from an accident.

2.2.3.1 La Polvadera Site

The staff has found the program for seepage control at the Gulf La Polvadera dragline trench burial facilities to be acceptable subject to incorporation of modifications discussed below. This is based upon the fact that there is no groundwater at the La Polvadera site except below an isolating, massive Mancos Shale formation. The nearest groundwater above the Mancos Shale is approximately one mile north of the site.

Seepage from the trenches would be limited by gravity draining and removal of solutions and likely formation of a low permeability slimes layer on the trench bottom. What seepage did occur would be retained in the foundation rocks immediately below the tailings trenches.

Seepage in the sedimentation pond would be limited by a three foot low permeability clay liner placed on bottom and sidewalls. As with seepage from tailings trenches, any seepage from this impoundment would also be retained in rock immediately underlying the pond.

On the basis of seepage calculations, the evaporation pond clearly poses the largest potential seepage impact. Mounding and lateral spreading of contaminated solutions on the Mancos Shale is expected based on Gulf's calculations. While the extent of spreading predicted by Gulf is no greater than several thousand feet, the calculations do not account for high hydraulic conductivity measurements made in the Gallup Sandstone or the presence or extent of subsurface features such as buried channels (eroded through the Gallup Sandstone to the Mancos Shale.) The staff considers that an additional degree of seepage control is warranted in view of this fact and that it would be prudent to require a greater factor of safety with regard to seepage migration than is currently proposed. Seepage from the evaporation ponds is most problematical because, unlike the tailings trenches in which operations are staged and seepage would occur for a limited time (approximately one year), seepage will continue from the evaporation pond during the entire operations and drying period. Furthermore, because operations in the trenches are staged, remedial action could be taken if seepage problems develop, whereas this would not be possible in the evaporation pond.

The mounding of seepage beneath the pond which would result from the current proposal has been found to be due primarily to the topography of the evaporation pond site itself; that is, the difference in elevation across the final pond causes lower areas on the pond bottom to be subject to a large hydrostatic head and inundation period. Changes to the proposal which would accomplish the necessary additional seepage control include modifying the liner by substituting a synthetic liner or increasing clay liner thickness as a function of hydrostatic head. In the latter case the staff considers that an increase of thickness to 10% of final hydrostatic head would be appropriate. In this regard, it is considered that a greater overall benefit would be obtained from increasing the thickness of the clay liner in the evaporation pond than from installing the clay cap which is currently proposed for use in the tailings trench cover. Presumeably such a cap was proposed to minimize infiltration of rainfall through the cover. However, seepage is not considered a potential problem in the long term for the reclaimed tailings impoundment (trench area). The high net evaporation rate helps ensure that there is very little moisture that would infiltrate and be available for migration down through the cover. Although there would be periods in which minor infiltration could occur, this would not be available for seepage through the tailings, because of the capillary rise of moisture during dry periods and evapotransportation due to vegetation in the proposed cover.

Other modifications which might be considered to reduce seepage include (1) changing the mill process to reduce the volume of tailings waste liquids, and/or (2) relocation of the pond to a site having smaller elevation differences.

It should be noted that the model[9] used by Gulf to predict the movement of seepage to and retention in the pores of underlying rock, assumes foundation materials are homogeneous and isotropic having properties equal to the average of those actually observed. Such model averages do not account for the real complexity of geologic units which are comprised of widely varying materials with widely varying properties. That this variability occurs is evidenced by the range in permeabilities obtained by Gulf by field testing at the La Polvadera site. The averaging of these values is useful in estimating the total quantity of seepage that would occur. For evaluating seepage and associated contaminant migration, however, not only total seepage but also the potential for "channeling" such as may occur through interconnected zones of materials with higher permeability must be given careful consideration. In the independent evaluation of seepage performed by the NRC staff, consideration was given to the probability of seepage through such high permeability zones. Appendix A includes brief descriptions of the Gulf seepage model(s) and calculations, the independent evaluation performed by the NRC staff, and the results of the evaluation.

2.2.3.2 Tailings Pipeline

The six-mile tailings pipeline would parallel the San Lucas Canyon from the millsite to the La Polvadera tailings disposal area. The major features of the system would include a diked and lined pipeway elevated to above the 100-year floodplain, nine spill containment basins located at low points along the pipeway, and a service route immediately adjacent to the pipeway. 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. Pipeline integrity would be ensured by the "Control and Interlock/Shutdown" system, a round trip visual inspection of the pipeline twice per shift, and a maintenance and inspection program. The layout of the pipeway and catchment system is illustrated in Fig. III-1 (of Ref. 1).

The tailings pipeline should not be a source of seepage except under accident conditions. As an accident analysis is beyond the scope of this evaluation report, only a general recommendation is made that all the details of the design and construction and the written procedures for operation, inspection, and maintenance of the pipeline system be reviewed and approved by the New Mexico Environmental Improvement Division (NMEID) prior to pipeline construction.

2.2.4 Elimination of the blowing of tailings during operation

The tailings surface will be protected from the wind because of its location no less than five feet below-grade in the trenches. Gulf's plan to develop tailings disposal areas in stages and reclaim them as soon as possible after tailings are deposited is positive in that it minimizes the area available for dusting. During operations, the tailings ahead of the advancing discharge point can be kept moist with tailings liquids and the surface of the filled tailings trench behind the discharge point can be covered with spoil or otherwise stabilized by wetting or chemical spraying to prevent dusting. It is recommended that a license condition be included that requires a formal interim stabilization program to control dusting during the operational and post-operational (reclamation) periods.

2.2.5 Reduction of radon exhalation rate and gamma radiation

The results of the evaluation of the adequacy of the proposed tailings cover were provided in Report of the Radiological Assessment of the Proposed Mt. Taylor Project, dated April 4, 1980. In that document calculations indicate that the net exhalation of radon from the tailings would be less than 2 pCi/m^2-sec (Appendix D) and that net gamma radiation from the tailings would be a small fraction of natural background (Appendix C).

2.2.6 Provisions for surety arrangements to complete reclamation

Financial surety arrangement provisions to assure complete decommissioning and reclamation after facility operation have not been reviewed by the NRC staff. The NRC staff, nevertheless, recommends that such arrangements be required.

2.2.7 Other considerations

As stated in the Groundwater Discharge Plan, reclamation of the tailings trench area will include spreading topsoil, which was previously stripped from the area and stockpiled, over the surface of the graded spoil cover. Plowing and revegetation would then be performed in accordance with current regulatory standards. However, a more detailed reclamation plan is required at this time in order to develop adequate surety arrangements.

Gulf's proposal did not address reclamation of the sedimentation and evaporation ponds in sufficient detail; this should be done before operations are authorized to ensure surety arrangements are adequate to complete full site cleanup and decommissioning. It is stated that the sedimentation pond would be covered after slimes consolidate and dry, and that in the tentative reclamation plan for the evaporation pond, liquids would be allowed to evaporate at the end of project life and the residual salts would be disposed of in dragline trenches similar to those used for burial of tailings. Because of the highly toxic nature of the slimes and the potential long drying period and because of the need to limit the amount of land lost to storage of tailings wastes, the slimes pond reclamation plan should require that the slimes be allowed to dry and consolidate to a moist state and be transported along with contaminated liner material to the tailings trenches for final disposal. Similarly, the reclamation plan for the evaporation pond should also require that radioactively contaminated liner material be disposed of in the tailings trenches.

Although radionuclides in the tailings liquids should not migrate far into the liner but should be adsorbed onto the liner material, this could be a significant part/cost of the reclamation effort. Consideration of this cost would be important in evaluating the clay versus synthetic liners required for seepage control as addressed in Section 2.2.3.1, above.

3.0 RECOMMENDATIONS

Based upon its evaluation, as documented in this report and in the report of the radiological assessment previously submitted to NMEID, the NRC staff recommends that the applicant be required to take steps to ensure that the proposed operation is conducted in a way that assures public health and safety and protection of the environment. License conditions concerning the radiological assessment are included for completeness. These general recommendations and specific conditions should be incorporated into the license.

3.1 RADIOLOGICAL

The radiological assessment clearly indicated the need for strict effluent controls in order to ensure compliance with regulatory limits. Measurements to be taken as part of the radiological monitoring program must be used to confirm that effluents from the mill facility operation meet the limits of 10 CFR Part 20 and 40 CFR Part 190. If operational results show that regulatory limits are exceeded, further review will be necessary to determine whether operational procedures or design modifications to increase emission control will have to be instituted or whether the restricted area boundary needs to be further extended so that compliance with 10 CFR Part 20 can be achieved.

As a result of calculations which indicated that the MPC for Th-230 would be exceeded at the proposed exclusion area boundary S-SE-E of the mill at a throughput of 4200 tpd, it is recommended that (1) the exclusion area boundary be extended to near the property boundary southeast of the mill and (2) monitoring results for the initial first four years of operations at 2100 tpd be used to project effluent concentrations which would be expected at 4200 tpd.

Specific license conditions should be included concerning the following:

1. In addition to the planned program of staged covering and reclamation of tailings, a formal documented program of fugitive dust control at the tailing trenches and the ore handling and storage areas should be developed and followed. This program should include the use of written operating procedures that specify the use of specific control methods for all conditions. The effectiveness of the control methods used should be evaluated weekly by means of a documented inspection.

2. Frequent checks of yellowcake stack emission control equipment performance should be made. Specifically, checks should be made and logged at least twice per operating shift of all parameters (e.g., differential pressures and scrubber water flow rates) which determine the efficiency of control equipment operation. It should be determined that conditions are within a range prescribed to ensure that the equipment is operating consistently near peak efficiency. Effluent control devices should be operative at all times during drying and packaging operations and whenever air is exhausting from the yellowcake stack. Drying and packaging operations should terminate when controls are inoperative or not operating within the range prescribed for peak efficiency.

3. A radiological environmental monitoring program based on that which is outlined in Generic Environmental Impact Statement on Uranium Milling (GEIS) should be established. Additionally, the guidance presented in NRC Staff Technical Position on Operational Radiological Monitoring Programs should be used in developing the program. Specific details of the program should be firmly established and made a license condition prior to authorizing the proposed operations. For example, there is a clear need to sample air particulates at the restricted area boundaries immediately west and southeast of the mill to enable measurements of radionuclide concentrations at those critical locations. As part of the program to ensure compliance with 40 CFR 190 exposure limits, Gulf should be required by license condition to conduct an annual survey of land use (grazing, inhabited residences, wells, etc.) in the area within 8 km (5 miles) of the

mill and submit a report to the State. The report should describe any differences in land use from that assumed in support of the first radiological assessment.

4. The applicant should institute, and maintain a management program to control the development, periodic review and enforcement of written procedures governing all aspects of the environmental monitoring and effluent control program. Such a management control program could be combined with the in-plant radiation safety program, and it should assure that all license conditions are met. The institution of such a program is consistent with the ALARA concept (controlling emissions and exposures to as low as reasonably achievable) and should itself be made a license condition.

3.2 TAILINGS MANAGEMENT

In connection with its review of the tailings management system proposed by Gulf the NRC staff has developed certain recommendations and recommended license conditions as follows:

1. The applicant should be committed by license conditions to a firm tailings management program as described in the Gulf application and submittals, subject to revisions based on the conclusions of the final Generic Environmental Impact Statement on Uranium Milling and any related rulemaking.

2. To ensure the probability of adverse impacts to groundwater is minimized, Gulf should be required by license condition(s) to provide detailed technical specifications and procedures concerning all aspects of programs for construction and operation of the La Polvadera facilities. These technical specifications and procedures should be reviewed and approved by the NMEID, and NMEID approval should be incorporated into the license by amendment, but, in any case, should be required prior to construction of the La Polvadera facilities.

   (a) Procedures to be followed during preparation of unlined areas within the trenches and evaporation pond. This should include a thorough inspection of impoundment bottoms 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 specifications should be used to control installation of the liners to ensure installed properties are as specified. These should include:

(1) Specification of inspections and tests which should be performed. For example, procedures to be followed to ensure that there is a 10-foot minimum thickness of the Dilco Coal Member beneath the tailings trenches, and that excavation operations, e.g., blasting, are adequately controlled.

(2) Supervision of installation by a professional engineer or other equivalently qualified person.

(c) Procedure which establishes the method of tailings deposition which ensures:

- The tailings drain to the maximum extent practible by removal of solutions from the trenches to lined ponds and, in general, to ensure that the phreatic surface in the trenches is lowered to the maximum practicable extent.

- Formation of a slimes barrier in the bottom of the trenches.

This procedure could be combined with that recommended for control of tailings dusting in section 3.1.1, above.

(d) Procedure to enable a determination that the system is behaving as predicted with respect to seepage. This would include checks of the overall water balance, of seepage collected in cutoff trenches and in monitor wells, of drainage of and moisture content in deposited tailings, of slimes settlement, and so on. This should include a periodic (for example, 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 procedures, and/or changes in monitoring programs.

(e) The seepage cutoff trench should be excavated to a depth which, based upon careful evaluation of stratigraphy, would intercept laterally spreading seepage mounded on the relatively impermeable strata observed at the site.

(f) There should be a comprehensive groundwater monitoring program having the following features as a minimum:

- Location of monitor wells as operations progress to provide monitoring of trenches adjacent to the active trench; the seepage cutoff trench on the outer perimeter of the entire tailings disposal area will not be effective in identifying and intercepting seepage from inner trenches.

- Point in the underlying strata where wells are screened off should be determined based on a careful evaluation of information on stratigraphy. Monitoring should be conducted in zones where seepage would likely be mounding on impervious strata and moving laterally. For example, as a minimum, strata immediately above the Mancos Shale should be monitored.

3. The applicant should be required to submit changes to the design of the evaporation pond which will provide greater control of seepage than is currently proposed by either of the following:

   (a) Increase in the thickness of the clay liner on the floor of the pond as a function of ultimate tailings liquid depth to account for increased hydrostatic head and inundation periods with increased depth; staff considers that increasing the liner thickness to 10% of final hydrostatic head would be appropriate; or

   (b) Substition of a synthetic liner for the clay liner.

   Other changes which should be considered are (a) changes to the mill mill process that will result in generation of a smaller quantity of waste liquid that must be disposed of, or (b) relocation of the evaporation pond to an area with better topographic characteristics, i.e., where the surface area to volume ratio is increased and maximum hydrostatic head is reduced.

4. The applicant should be required to submit detailed plans for reclamation of the evaporation and sedimentation ponds during final site cleanup and decommissioning. The plans should include procedures for removing and ultimately disposing of contaminated pond and liner materials in the tailings trenches.

5. Prior to the initiation of mill activities and the associated generation of tailings, the licensee shall submit to the NMEID documentation that ownership of lands (both surface and subsurface) to be used for tailings disposal has been acquired, or that, if not acquired, the owner and any subsequent owner is aware that such lands (which have been committed to the disposal of tailings wastes) will have to be maintained subject to a perpetual NRC license which will likely include conditions concerning the restriction of future site land uses (after the final site cleanup and decommissioning).

6. Before mill operations begin, Gulf should be required to submit proposed financial surety arrangements, as well as supporting documentation showing a cost breakdown, sufficient to cover the expense of mill and site decommissioning. The amount of the surety should be sufficient to cover the expense of reclaiming those areas of the site which are unreclaimed at any given time. The amount of the surety should be reviewed periodically to adjust for changing factors such as the condition of the site and inflation.

7. Construction of evaporation pond embankment should not begin until the system design has been reviewed and approved in accordance with Regulatory Guide 3.11. NMEID approval should be incorporated into the license by amendment and should be required prior to embankment construction. Required freeboard and other operating requirements should be determined during the review.

8. The licensee should conduct and document at least one inspection of the tailings transport, distribution and retention systems per day and should immediately notify the NMEID by telephone and telegraph of any failure in the systems which results in a release of radioactive material and/or of any unusual conditions which if not corrected could lead to such a failure.

Finally, the NRC staff did not evaluate the proposed plan to dispose of 50% of the tailings by weight, as sands, in the deep Mt. Taylor mine, primarily because the details of this part of the Gulf proposal have not yet been submitted (the review of this part of the proposal would require a separate licensing action). However, as this will be an important part of the proposed Mt. Taylor Project activities, it is noted that, from the standpoint of long-term isolation of tailings, such an operation would be very desireable. In addition, prevention of mine subsidence and the subsequent cross-connection of aquifers in overlying geologic units would be positive. However, as this would involve placing tailings in groundwater formations, the impacts from this aspect of the propos Gulf operations must be thoroughly examined.

REFERENCES

1. Gulf Mineral Resources Company, Ground Water Discharge Plan, Mt. Taylor Uranium Mill Project, New Mexico, February 1980. Docket WM-26.

2. Ltr from NMEID to NRC, dated 10-23-78.

3. Ltr from NMEID to GMRC, dated 2-26-79.

4. Ltr from NMEID to NRC, dated 6-12-79.

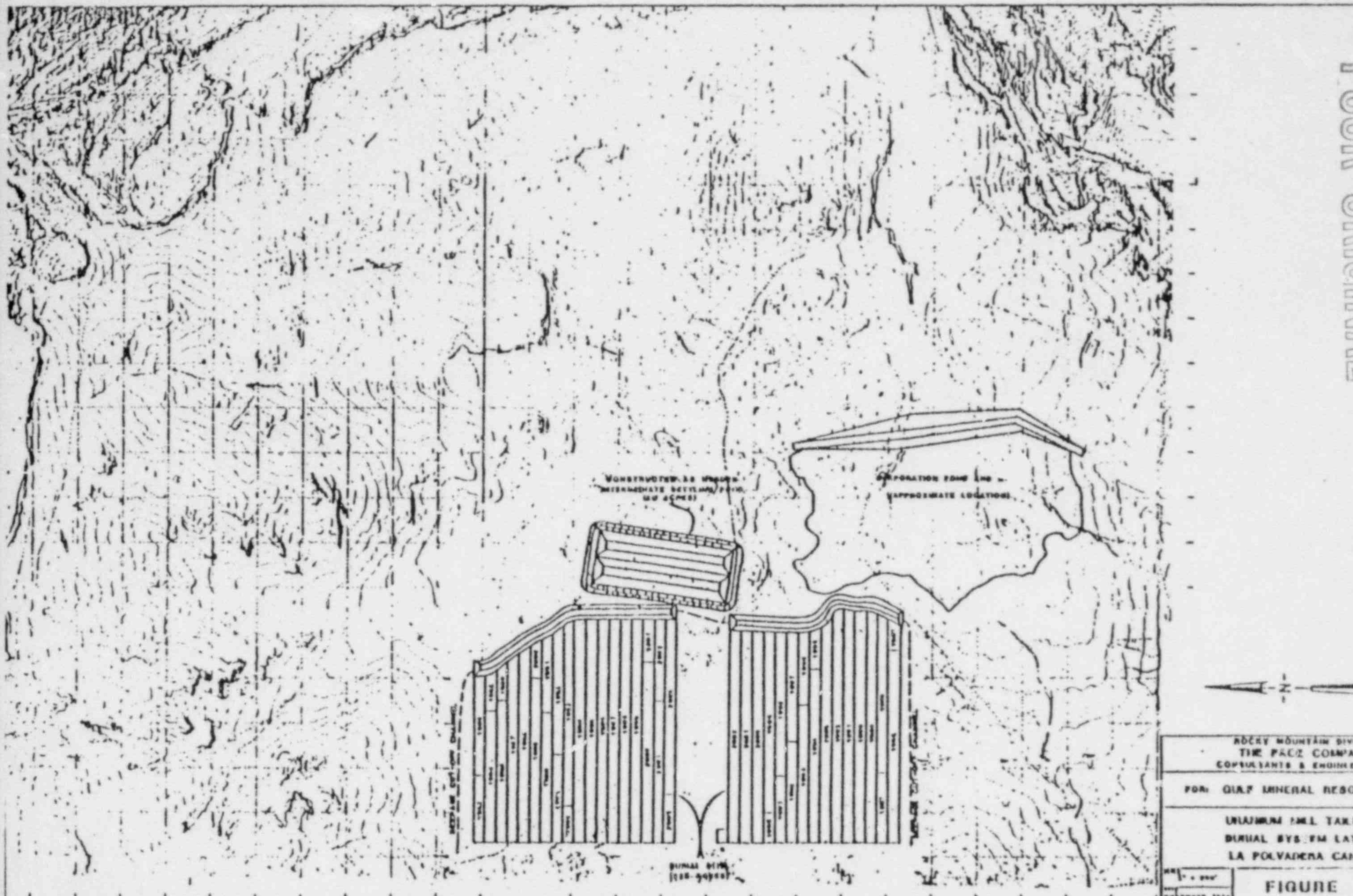
5. NRC meeting minutes, dated 8-27-79. Docket 40-8725 (WM-26)

6. NRC meeting minutes, dated 9-12-79. Docket 40-8725 (WM-26)

7. NRC meeting minutes, dated 11-16-79. Docket 40-8725 (WM-26)

8. Gulf Mineral Resources Company, Tailings Management Alternatives, Mt. Taylor Uranium Mill Project, December 1979. Docket WM-26 (as supplemented by a W. A. Wahler and Associates report, dated November 1979, on the same subject).

9. McWhorter, D. B., and J. D. Nelson, Unsaturated Flow Beneath Tailings Impoundments, J. Geot. Engr. Div., ASCE, Vol. 105, No. 9T11, Nov. 1979.



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

FOR: GULF MINERAL RESOURCES Co.

URANIUM MILL TAILINGS
BURIAL SYSTEM LAYOUT
LA POLVADERA CANYON

FIGURE II-2

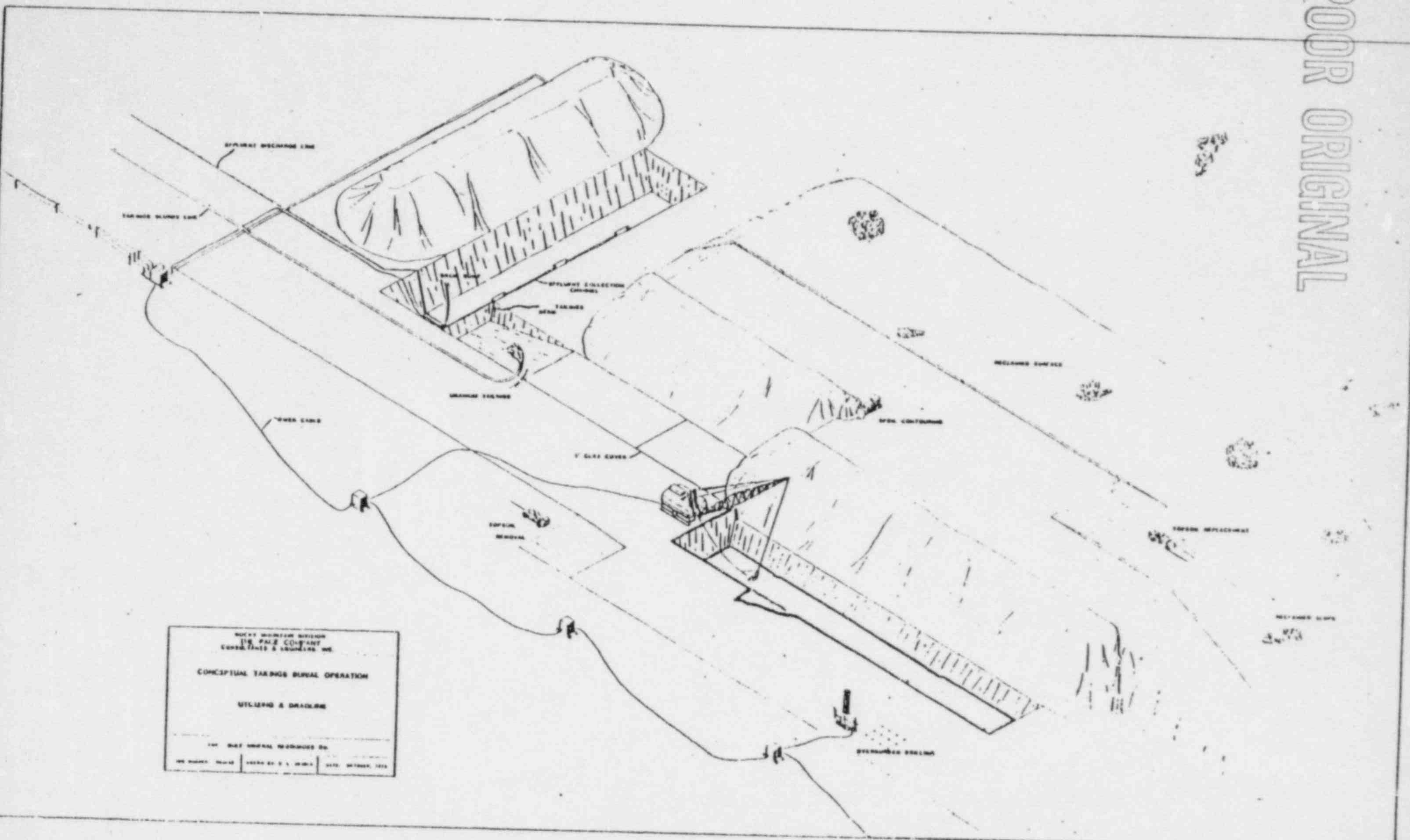
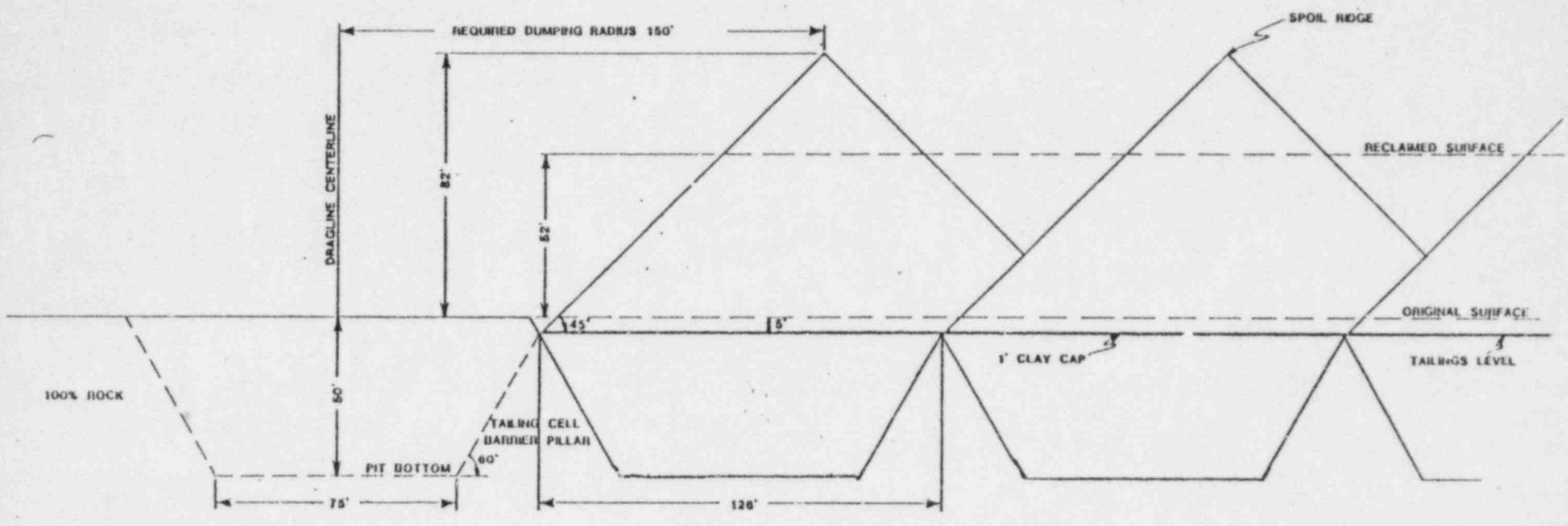

CONCEPTUAL TAILINGS BURIAL OPERATION
UTILIZING A DRAGLINE

FIGURE II-1



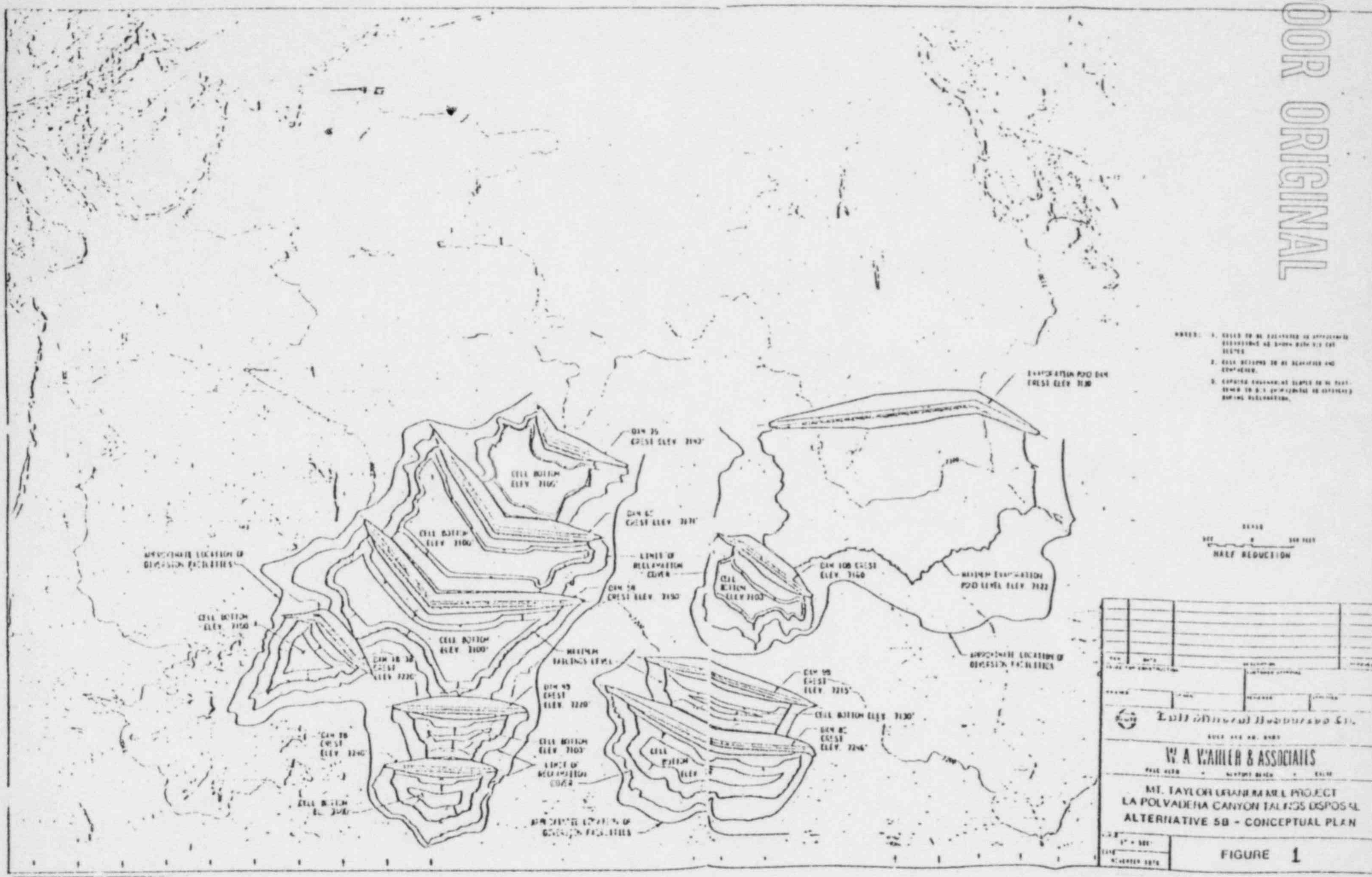
DRAGLINE RANGE DIAGRAM
BURIAL DEPTH 50'

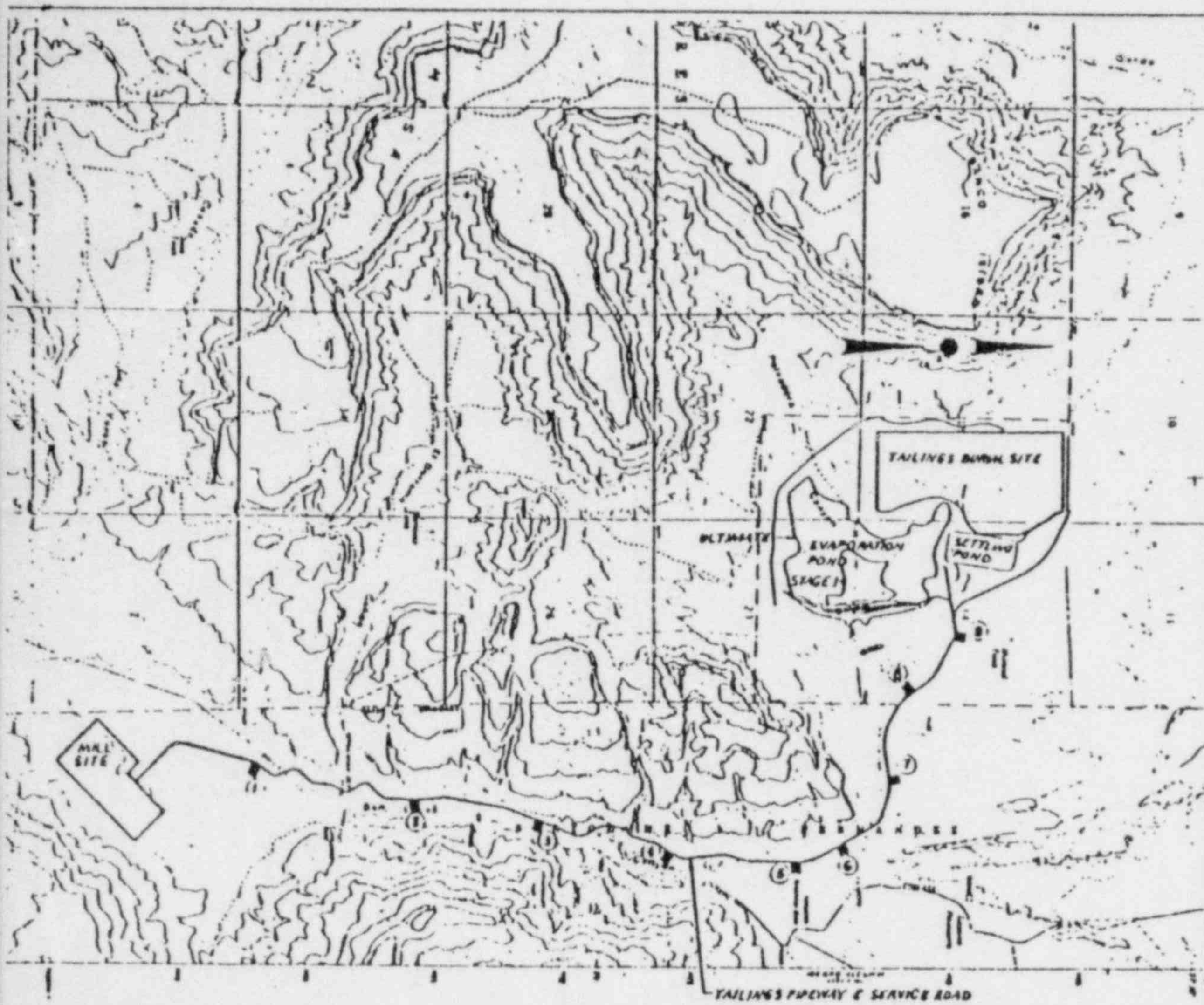
FIGURE II-3

TABLE II-1

PROJECTED LIQUID AND SOLID WASTE PRODUCTION RATES

			Waste Water		
Year	Mine Ore Production (tons)	Mill Tailings to Burial Trenches (tons-dry weight)	to Burial Trenches (ac-ft)	Estimated Retained Tailings Storage plus Net Evaporation Loss in Trenches (ac-ft)	Total to evaporation Pond (ac-ft)
1982	255,000	121,125	154	34	120
1983	391,000	185,725	235	49	186
1984	493,000	234,175	296	60	236
1985	663,000	314,925	401	78	323
1986	867,000	411,825	523	101	422
1987	1,071,000	508,725	646	123	523
1988	1,326,000	629,850	800	150	650
1989	1,496,000	710,600	904	169	735
1990	1,496,000	710,600	904	169	735
1991	1,496,000	710,600	904	169	735
1992	1,496,000	710,600	904	169	735
1993	1,496,000	710,600	904	169	735
1994	1,496,000	710,600	904	169	735
1995	1,496,000	710,600	904	169	735
1996	1,496,000	710,600	904	169	735
1997	1,496,000	710,600	904	169	735
1998	1,496,000	710,600	904	169	735
1999	1,496,000	710,600	904	169	735
2000	1,496,000	710,600	904	169	735
2001	1,496,000	710,600	904	169	735
2002	1,292,000	613,700	780	147	633
2003	709,000	336,775	428	83	345
Totals	26,515,000	12,594,625	16,015	3,022	12,993


EVAPORATION POND DAM
CREST ELEV. 7130
DAM 7S
CREST ELEV. 7192'
CELL BOTTOM
ELEV. 7165'
DAM 6C
CREST ELEV. 7171'
CELL BOTTOM
ELEV. 7100'
LIMIT OF
RECLAMATION
COVER
DAM 5B
CREST ELEV. 7152'
APPROXIMATE LOCATION OF
DIVERSION FACILITIES
CELL BOTTOM
ELEV. 7150
CELL BOTTOM
ELEV. 7100'
MAXIMUM
TAILINGS LEVEL
DAM 3B
CREST
ELEV. 7220'
DAM 4B
CREST
ELEV. 7220'
CELL BOTTOM
ELEV. 7103'
LIMIT OF
RECLAMATION
COVER
DAM 2B
CREST
ELEV. 7240'
CELL BOTTOM
EL. 7140
APPROXIMATE LOCATION OF
DIVERSION FACILITIES
DAM 10B CREST
ELEV. 7160
CELL
BOTTOM
ELEV. 7103
MAXIMUM EVAPORATION
POND LEVEL ELEV. 7122
APPROXIMATE LOCATION OF
DIVERSION FACILITIES
DAM 9B
CREST
ELEV. 7215'
CELL BOTTOM ELEV. 7130'
DAM 8C
CREST
ELEV. 7246'
HALF REDUCTION
Ltd Mineral Resources Co.
W. A. WAHLER & ASSOCIATES
MT. TAYLOR URANIUM MILL PROJECT
LA POLVADERA CANYON TAILINGS DISPOSAL
ALTERNATIVE 5B - CONCEPTUAL PLAN
FIGURE 1



TAILINGS PIPELINE CATCHMENT PONDS

Pond No.	SAG Length (Ft)	Pond Volume (Gal x 10^3)	Pond Surface Area (Sq Ft x 10^3)	100 Year Flood Impoundment (Gal x 10^3)	Free-board (Inches)
1	8800	575	30.7	486	18
2	5000	375	20.1	272	18
3	1810	210	11.3	105	18
4	3390	315	16.9	189	18
5	1080	180	9.7	61	18
6	2000	225	12.0	111	18
7	1800	215	11.5	100	18
8	1500	200	10.7	85	18
9	5000	1386	33.0	200	36

FIGURE III-1
TAILINGS PIPELINE CONTAINMENT BASINS

1613?

APPENDIX A

EVALUATION OF SEEPAGE TO GROUNDWATER PROPOSED MT. TAYLOR URANIUM MILL TAILINGS IMPOUNDMENT

A.1 Description of Gulf Evaluation - La Polvadera Site

The tailings trenches, slimes sedimentation pond and evaporation pond would be excavated into the Mulatto Tongue Member of the Mancos Shale and the Dilco Coal Member of the Crevasse Canyon Formation. These geologic units are located above the Gallup Sandstone which is separated from the lower Dakota Sandstone, which contains the only groundwater directly at the site, by approximately 1000 feet of the relatively impermeable Mancos Shale (estimated to have a secondary permeability of approximately 0.007 ft/yr).[1] The facilities would be located on the crest of the San Mateo Dome and bedding planes are essentially horizontal at this point. Any seepage through the Gallup Sandstone would spread above the Mancos Shale laterally and would follow the dip of the Mancos. Gulf assumed that any seepage not retained directly beneath the trenches or ponds would move uniformally and radially outward but would not reach the nearest saturated zone in the Gallup Sandstone which is located approximately one mile to the north (Fig. A.1).

Because of the importance of the foundation rocks in analyzing seepage potential, they were described[1] in order of age, from youngest to oldest, as follows:

Mulatto Tongue Member of the Mancos Shale (Kmm) - The Mulatto Tongue Member is the youngest bedrock unit in the La Polvadera Canyon area, where it occurs in conformable contact over, and in fault contact with, the Dilco Coal Member of the Crevasse Canyon Formation. The Mulatto Tongue crops out in the upper reaches of the main canyon and tributary washes. Approximately 3/4 mile west of the canyon mouth, the Mulatto is down-dropped against the Dilco along a north-south trending fault. The Mulatto is also cut by an east-west trending fault located about 1-1/4 miles north of the main canyon. The Mulatto Tongue unit consists of up to 100 feet of thinly-bedded, light tan, sandy shale and siltstone with a few thin beds of sandstone and dark gray shale. Gypsum occurs as infilling of fracture and bedding planes.

Dilco Coal Member of Crevasse Canyon Formation (Kcdi) - The Dilco Coal Member underlies the Mulatto Tongue Member of the Mancos Shale. The Dilco Member comprises the major bedrock type in the project area and forms the broad ridges in the central portion of La Polvadera Canyon, where it is about 120 feet thick in full section and consists of interbedded, white to brown sandstone, brown to light gray siltstone, and gray to black and purple shale beds, with minor, thin coal lenses. The sandstone is fine-to-medium-grained and poorly cemented, and contains carbonaceous partings and some iron-oxide stain. The majority of the sandstone beds range from six inches to five feet in thickness, although one massive sandstone bed in the upper part of the Dilco stratigraphic section attains a maximum aggregate thickness of 15 feet. The siltstone shows variegated colors from tan to yellow to gray and purple, with iron staining, and exhibits wavy bedding. The shale is gray to black, carbonaceous, fissile to flaky, and air-slakes readily. Most of the shale is found in the lower half of the stratigraphic section.

Gallup Sandstone (Kg) - The Gallup Sandstone underlies the Dilco Coal Member and for the most part occurs in the subsurface. In parts of the main washes it is present directly beneath alluvium where the Dilco Coal Member has been eroded. The only outcrop occurrence is in the area of Michael Tank, just over a mile northwest of the canyon mouth. As indicated by drilling, the Gallup Sandstone attains thickness ranging from 78 to 90 feet in the La Polvadera Canyon area, where it consists of a massive, crossbedded, white, light yellow to light gray, fine- to medium-grained, poorly cemented and friable sandstone. It contains a few inclusions and thin streaks of carbonaceous material. Joints, steeply dipping to vertical and spaced from two to 10 feet, were observed in outcrops. However, cores from drill holes revealed very few joints or fractures.

Main Body of the Mancos Shale (Km) - Although the main body of the Mancos Shale is not exposed in the canyon area, it is an important unit for seepage considerations forming a thick, relatively impervious stratum beneath the Gallup Sandstone. The upper part of the main body of the Mancos Shale is of Late Cretaceous age and is a thick lithologic unit composed predominantly of dark gray, calcareous, fissile clay shale of marine origin. In La Polvadera Canyon, the Mancos Shale is about 1000 feet thick, as indicated by geophysical logs of more than a dozen deep exploration holes. It is not exposed in the project area, but the upper 15 to 40 feet were penetrated by deep exploratory borings, which showed it to consist of interbedded, thin-bedded, tight, dark gray shale and siltstone with carbonaceous partings.

The hydraulic conductivities of the site foundation rocks are also of significance in analyzing seepage potential. Site suitability investigations by Gulf of hydrogeologic parameters showed a range of permeabilities for both the Dilco and the 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 ft/yr with a log normal mean of 1.3 ft/yr from which average vertical and horizontal permeabilities of 1 ft/yr and 2 ft/yr, respectively, were estimated. Similarly, hydraulic conductivity data obtained from field tests in the Gallup (38 values from 14 drillholes) varied from 0.0 ft/yr to 3580 ft/yr with a log normal mean of 6.6 ft/yr from which average vertical and horizontal permeabilities of 5 ft/yr and 10 ft/yr were estimated. The Mancos Shale was found to have a mean hydraulic conductivity of 0.007 ft/yr based on field tests (7 values from 5 drill holes).

A.2 Evaluation of Impacts to Groundwater

A.2.1 Gulf Calculations

To estimate the seepage potential of the La Polvadera dragline trench burial facilities Gulf used the computational procedure of McWhorter and Nelson,[2] which takes into account the effect of tailings, liner and foundation rocks.

(1) Tailings Trenches

Computations were done by 1/4 year periods, assuming the trenches would be sized for filling in one year. It was assumed that a two-foot layer of slimes would develop a permeability of 0.5 ft/yr ($5x10^{2}$ cm/sec) after 0.5 year. Hydrostatic head of liquid was taken as approximately 45 feet liquid + 20 feet suction (from Dilco) = 65 feet total. Figure II-12 (of Ref. 1) illustrates this model. A "worst case" condition was analyzed where 10 feet of the Dilco unit would be present under the trench bottom (an average of 75 feet of Dilco would actually be present). For the worst case, calculations indicated that seepage plus drainage would equal 798 ft^3 per lineal foot of trench, as compared with available retained pore water storage capacity of the underlying Gallup Sandstone, computed as (80 feet)(0.15)(126 feet wide trench) = 1512 ft^3 per lineal foot of trench, i.e., foundation rocks would not reach field capacity and saturation would not occur in the Gallup Sandstone.

(2) Sedimentation Pond

Again, available storage in the Dilco and the Gallup were taken as 5 and 15 percent by volume, respectively. The average thickness of the Dilco under the pond was taken as 23 feet. The hydrostatic head was taken as (30 feet water + 20 feet suction from the Dilco =) 50 feet on the bottom and (15 + 20 =) 35 feet on the sidewalls. Figure II-13 (of Ref. 1) illustrates this model. Total seepage for a 22 year operating life was calculated to be 33.38 acre-feet storage versus total available storage of 35.56 acre-feet. This calculation did not take into account the effect of slimes deposited on the pond bottom and sides.

(3) Evaporation Pond

The seepage model used for the evaporation pond utilized 7 zones bounded by 10-foot contour intervals to account for the effect of elevation differences in the area, i.e., zones nearest the embankment would be subjected to the largest hydrostatic heads and inundation periods. Figure II-14 (of Ref. 1) illustrates the model and Table II-9 the results of the calculations. Total seepage was calculated to be 3167 acre-feet versus 2673.4 acre-feet retained storage capacity over 204 acres. It is noted that seepage from zones 1 through 5 (118 total acres nearest the embankment) exceeds retained storage capacity by 1049 acre-feet. The seepage model predicts that the excess seepage would cause a saturation mound to start to develop and spread laterally on top of the Mancos. Gulf predicts that the saturation mound would spread uniformly and radially outward to a distance of several thousand feet before it is bound as pore moisture in the Gallup Sandstone and underlying Mancos Shale.

Gulf claims that factors which would tend to reduce seepage or act as safety factors are (1) storage of seepage in the Mancos Shale was not considered, and (2) sizing of the evaporation pond was based on zero seepage from the tailings trenches and evaporation pond.

A.2.2 <u>Independent Evaluation</u>

The seepage model used by Gulf assumes seepage occurs thru homogeneous, isotropic materials having properties which are an average of those actually observed and does not account for more complex system behavior. For example, the model does not account for the possibility of "channeling," i.e., accelerated flow through interconnected zones of higher permeability. However it is necessary to consider the degree to which zones of higher permeability materials might be interconnected to permit accelerated flow of seepage through channels to groundwater. Although the simplified, "averaged" model might be used to obtain a reasonable estimate of total seepage, it cannot predict the maximum rate of movement of seepage which is of greatest concern.

(1) Tailings Trenches

An independent evaluation of seepage from the unlined trenches was performed considering higher permeability values than the values used by Gulf. This is appropriate given that the rate of seepage migration will normally be controlled by fractures and zones of materials with high permeabilities. In the calculations which were performed, permeabilities 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 permeabilities of 10 and 25 ft/yr for the Dilco and Gallup units, respectively (and horizontal permeabilities of 20 and 50 ft/yr, respectively).

Less than the highest permeabilities were used because the geology is such that it is unlikely that the zones of measured higher permeabilities will be completely interconnected. It appears as though the higher observed permeabilities are horizontal permeabilities occuring 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 Gulf's prediction that the quantity of seepage from the trenches would be no greater than that which could be stored in the retained storage volume directly beneath the trench area. These calculations used a vertical permeability of 10 ft/yr (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 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 tailings in a filled trench. The driving force for seepage also realistically 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.

Gulf'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.

(2) Sedimentation Pond

The sedimentation pond is not 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 Gulf because it should take into account the drying period following operations.

Gulf'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.

(3) Evaporation Pond

Gulf calculations (see sect. A.2.1, above) show total seepage of 3167 acre-feet would occur over 204 acres versus 2673.4 acre-feet retained storage capacity, and that this is due to seepage exceeding storage capacity by 1049 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 permeability of the Dilco unit would not have a significant effect on seepage.

In estimating the actual quantity of liquid that would be available for seepage from the evaporation pond Gulf estimated the net rate of evaporation of liquid from the pond would be 34 inches per year although the mean annual lake evaporation in the area is approximately 57 inches per year and the annual precipitation is approximately 10 to 12 inches per year (per Ref. 1). The 34 inch/year figure is considered appropriate because it takes into account uncertainties concerning actual evaporation from tailings liquids having a low pH and high salt concentration.

Because of Gulf's mill process and relatively high ore processing rate, there is a large volume of tailings waste liquid generated. The proposed site for the evaporation pond is not optimum with respect to evaporative capacity because of the large elevation difference across final pond, i.e., the evaporative capacity (surface area) for a given storage volume is not large. In addition, the evaporation pond zones with the largest hydrostatic head and longest inundation periods are underlain by the smallest, available retained storage volume capacities, i.e., the smallest thickness of Gallup Sandstone. (By way of contrast, seepage from a given tailings trench is expected to occur over a one year period into an 80-foot average thickness of the Gallup Sandstone, while there are zones in the evaporation pond which are underlain by less than a 60-foot thickness of the Gallup and which are expected to be inundated and subject to seepage for periods up to 36 years).

Calculations indicate that seepage would be reduced if the thickness of the compacted clay liner were uniformly increased as a function of hydrostatic head and inundation period. For example, liner thickness could be increased in thickness to 10% of ultimate hydrostatic head. A feasible liner alternative would be to substitute a synthetic liner which would ensure a seepage mound is not formed. Other changes to the proposed program which might be considered to reduce seepage include (1) process modifications to reduce the quantities of tailings waste liquids, and (2) relocating the evaporation pond to achieve a better ratio of surface area to storage volume.

Although a review of the groundwater monitoring plan was outside the scope of this assessment, it is a critical element of the seepage control program. The monitoring program should provide not only quantities of and the contaminants in seepage but also action levels and the associated remedial actions.

APPENDIX A REFERENCES

1. Gulf Mineral Resources Company, Ground Water Discharge Plan, Mt. Taylor Uranium Mill Project, New Mexicc, February 1980. Docket WM-26

2. McWhorter, D. B., and J. D. Nelson, Unsaturated Flow Beneath Tailings Impoundments, J. Geot, Engr. Div., ASCE, Vol. 105, No. 9T11, Nov. 1979.

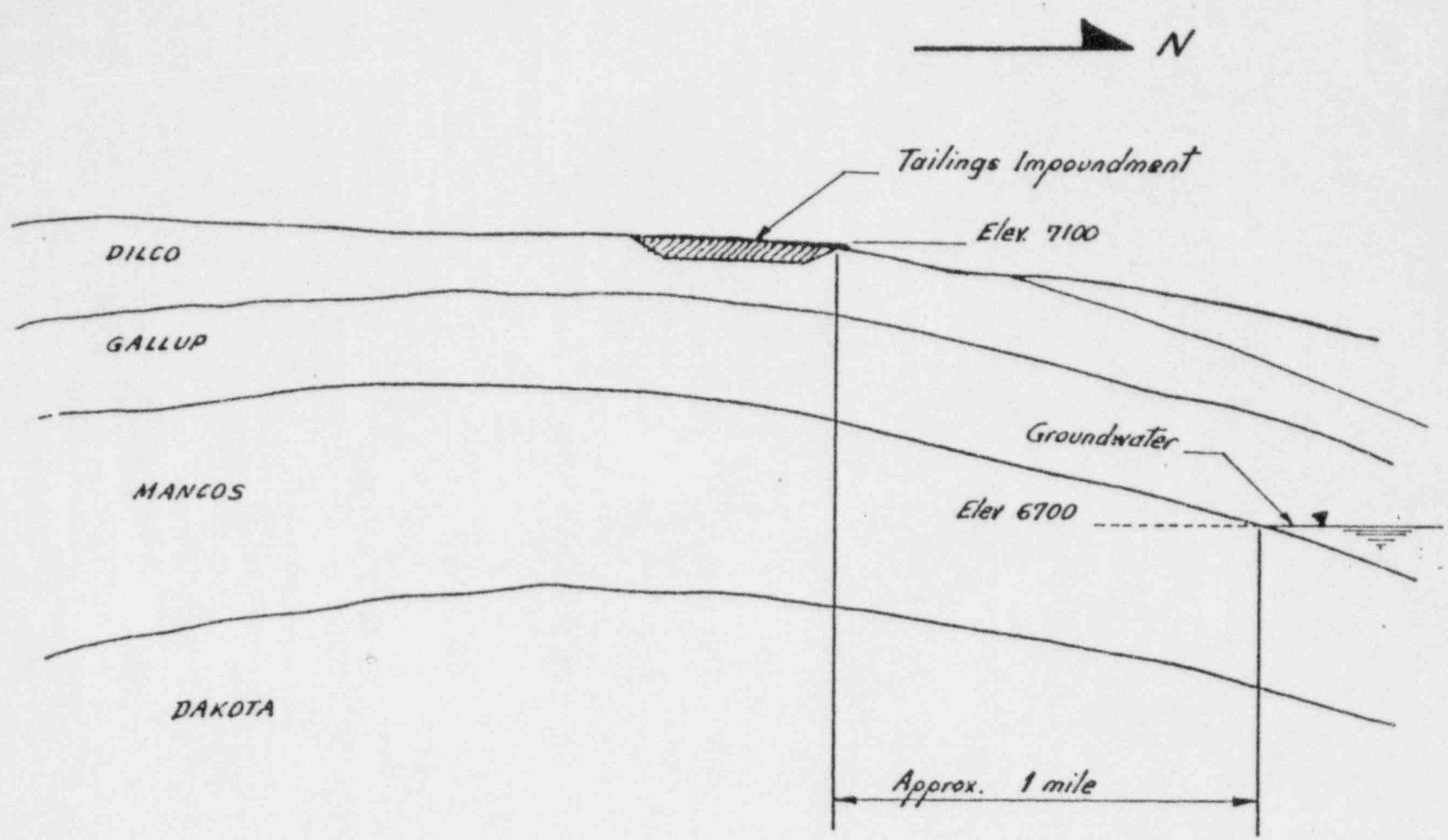
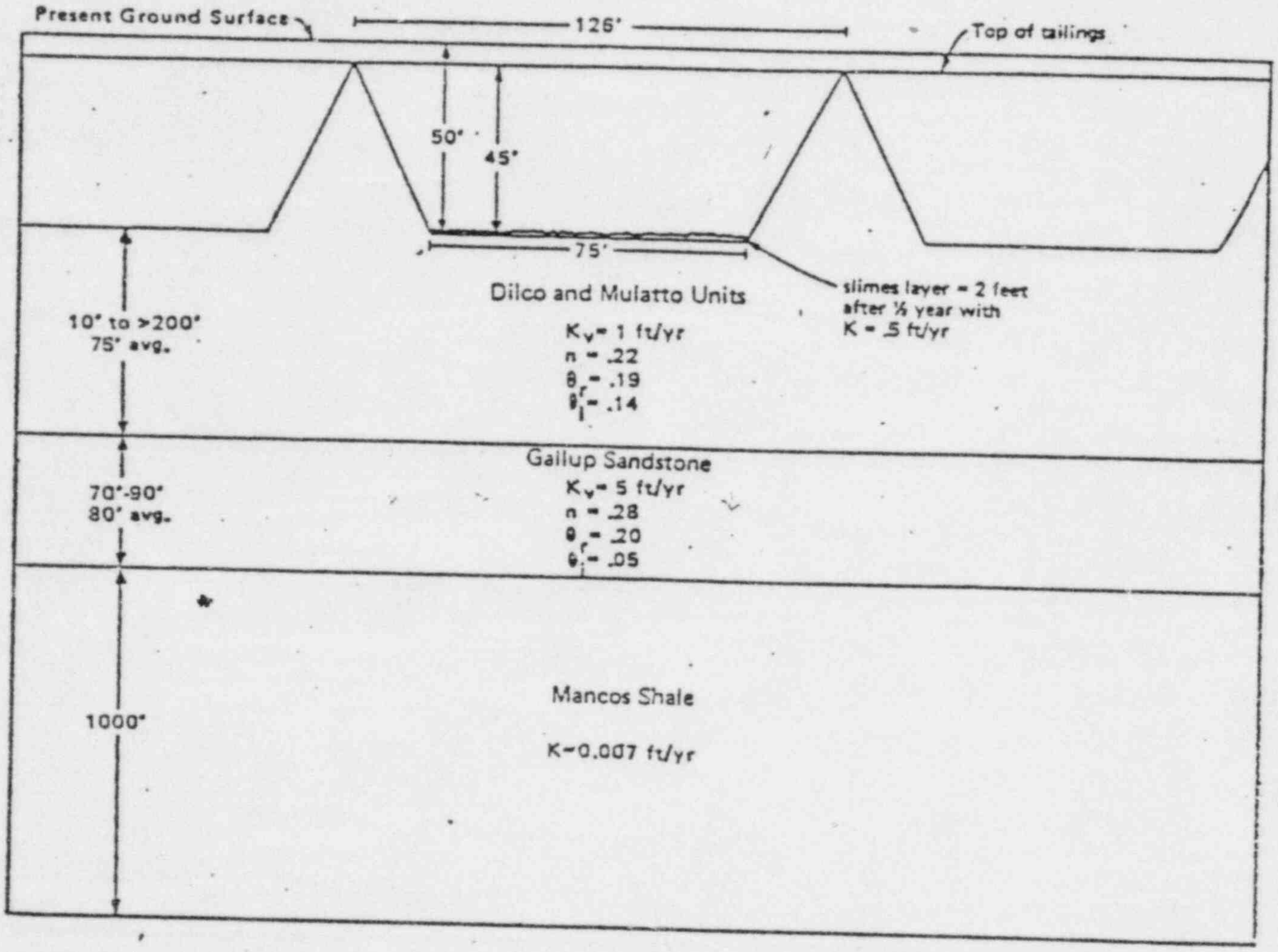


Fig. A.1 Schematic Diagram of Existing Groundwater Conditions.

Dragline Disposal Trench
Diagrammatic Cross Section
Not to Scale



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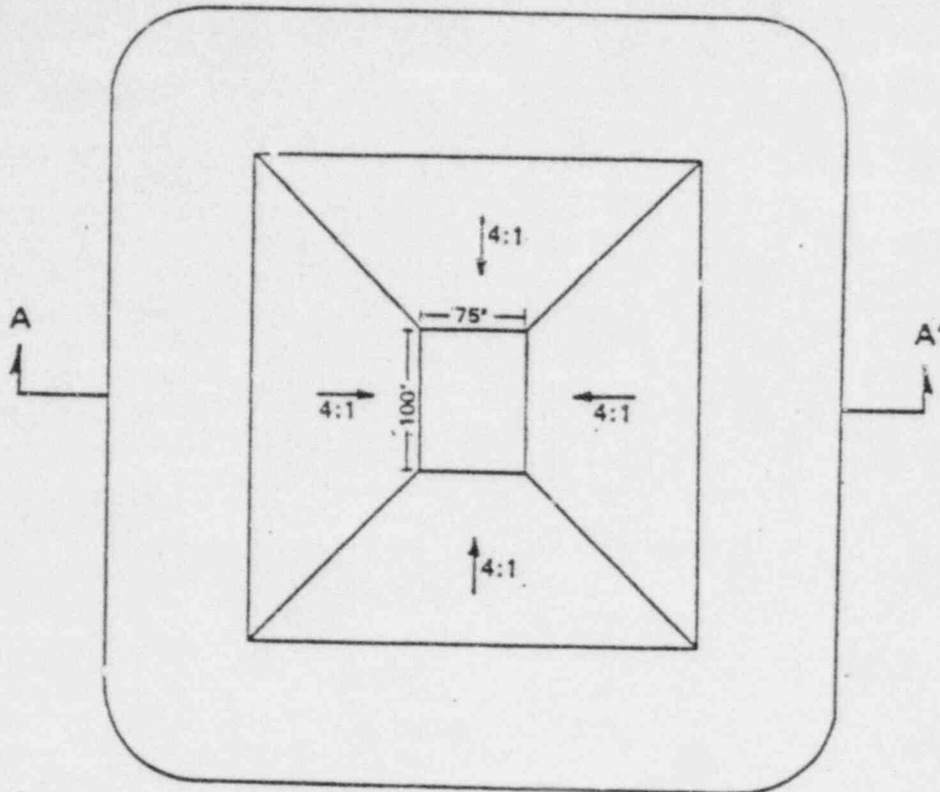
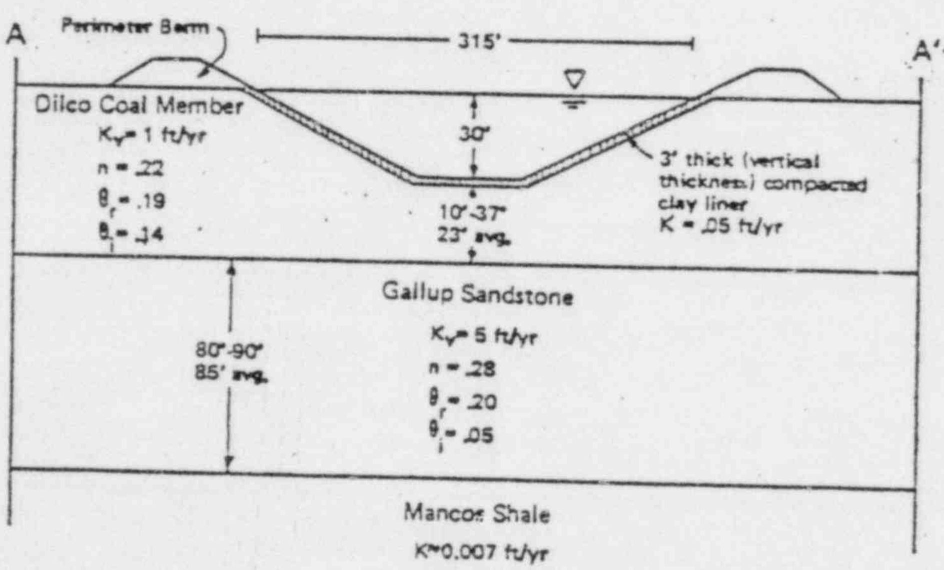
SEEPAGE MODEL –
DRAGLINE TRENCH TAILINGS DISPOSAL

Checked by B. L. Turner	Date [illegible]	Project No. 2150	Figure No. [illegible]
Approved by [illegible]	Date [illegible]		



PLAN VIEW
Scale: 1"=70'



TYPICAL CROSS SECTION
Scale: 1"=70'

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SEEPAGE MODEL—
SETTLING POND

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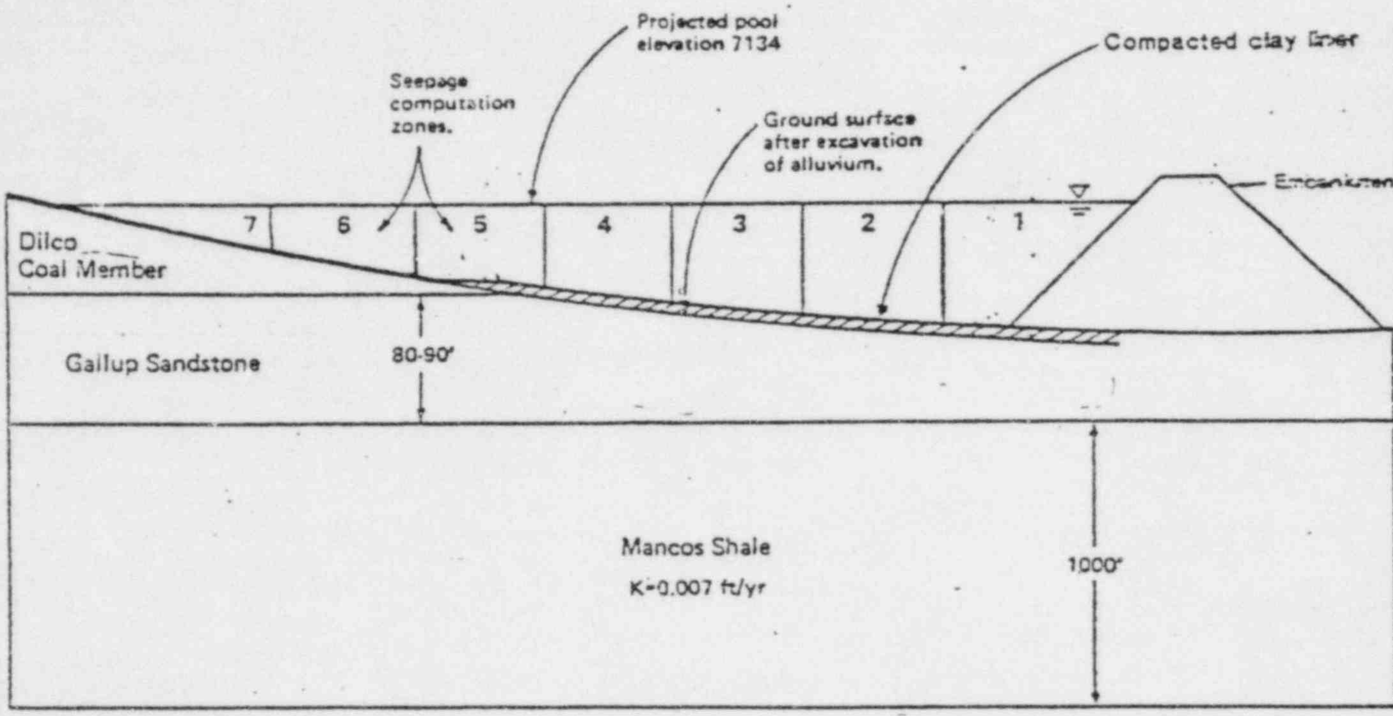
Evaporation Pond
Diagrammatic Cross Section
Looking North

Not to Scale



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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SEEPAGE MODEL-
EVAPORATION POND

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Approved by ______ Date ______	2150	II-14

TABLE II-9

EVAPORATION POND SEEPAGE

Zone	Zone Elevation Boundaries (ft)	Retained Storage Capacity (ac-ft)	Inundation Period (yrs)	Approximate Area (ac)	Total Zonal Seepage (ac-ft)
1	7060-7075	126.0	36	14	314
2	7075-7085	178.5	34	17	418
3	7085-7095	216.0	32	18	448
4	7095-7105	337.9	30.5	27	573
5	7105-7115	556.5	25	42	711
6	7115-7125	696.0	17	48	530
7	7125-7234	562.5	7.5	38	173
Totals		2673.4		204	3167

Note: Seepage from Zones 1 through 5 exceed the retained storage capacities by 1049 ac-ft.