APPLICANT'S RESPONSE

TO

AGENCY COMMENTS ON DRAFT STATEMENT

ON

LISBON URANIUM MILL

DOCKET NO. 40-8084

BY

RIO ALGOM CORPORATION

MOAB, UTAH

NOVEMBER 1973

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1. Department of Housing and Urban Development
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PART I

ANSWERS TO A. E. C. QUESTIONS

I ENVIRONMENTAL MONITORING

The Environmental Monitoring Program may be separated into two categories, Preoperational and Operation.

1. PREOPERATIONAL

a. SOIL AND VEGETATION

The soil and vegetation sampling program consisted of a grid of sample points set on an approximate 2000 foot grid, Figure 1. At each grid point a composite soil sample was obtained in the immediate area. ne composite sample consisted of a set of nine 1-pound samples taken at a ten-foot spacing on a 30 x 30 foot grid adjacent to an identifiable point. Each nine pound sample was thoroughly mixed and a one pound sample analyzed for uranium, radium and thorium. Approximately two pounds were retained for future reference. Sample points are carefully identified and recorded so that additional samples may be obtained. These samples were taken in May and June 1972. At alternate soil sample stations, bulk vegetation samples were obtained, as shown on Figure 1. The succulent portion of these plants were analyzed for uranium, radium, thorium, copper, zinc and manganese.

Samples were also taken of soil in the drainage area below ore and waste dumps from other mining operations located south of the mine and immediately south of the county road. These soil samples indicate high soil radioactivity as compared to the original samples referred to above.

b. AIR

A baseline air sampling program consisted of four sets of air samples were taken at the following seven locations, La Sal Junction, La Sal, Wilcox Ranch, Redd Ranch at Rattlesnake Pond, Rio Algom well field in Section 19, mine service road entrance and on the county road in Section 27 wouthcast of the mine, as shown in Figure 2. This sampling was carried out in April and May 1972.

LISBON MINE SOIL AND VEGETATION SAMPLING GRID

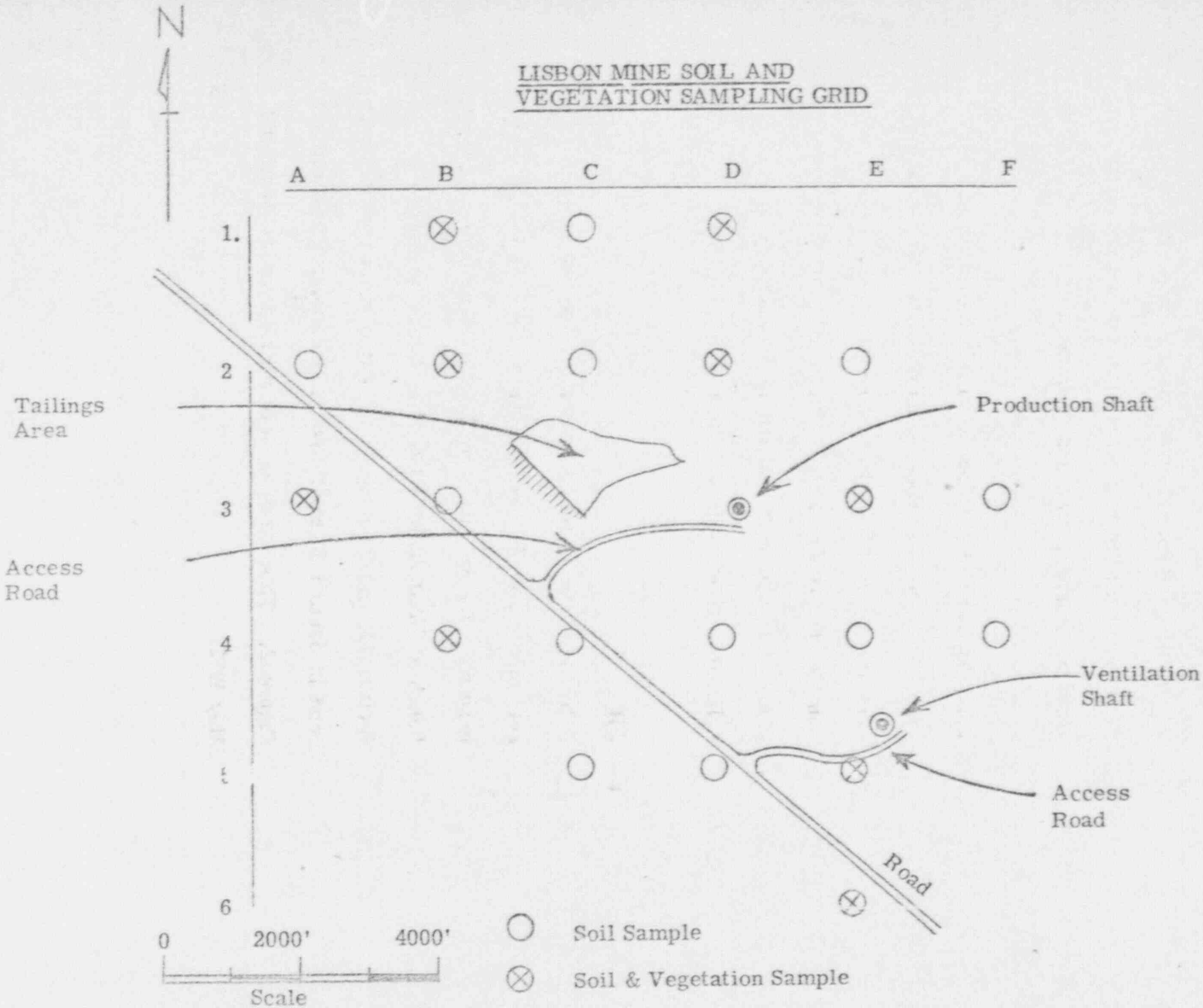


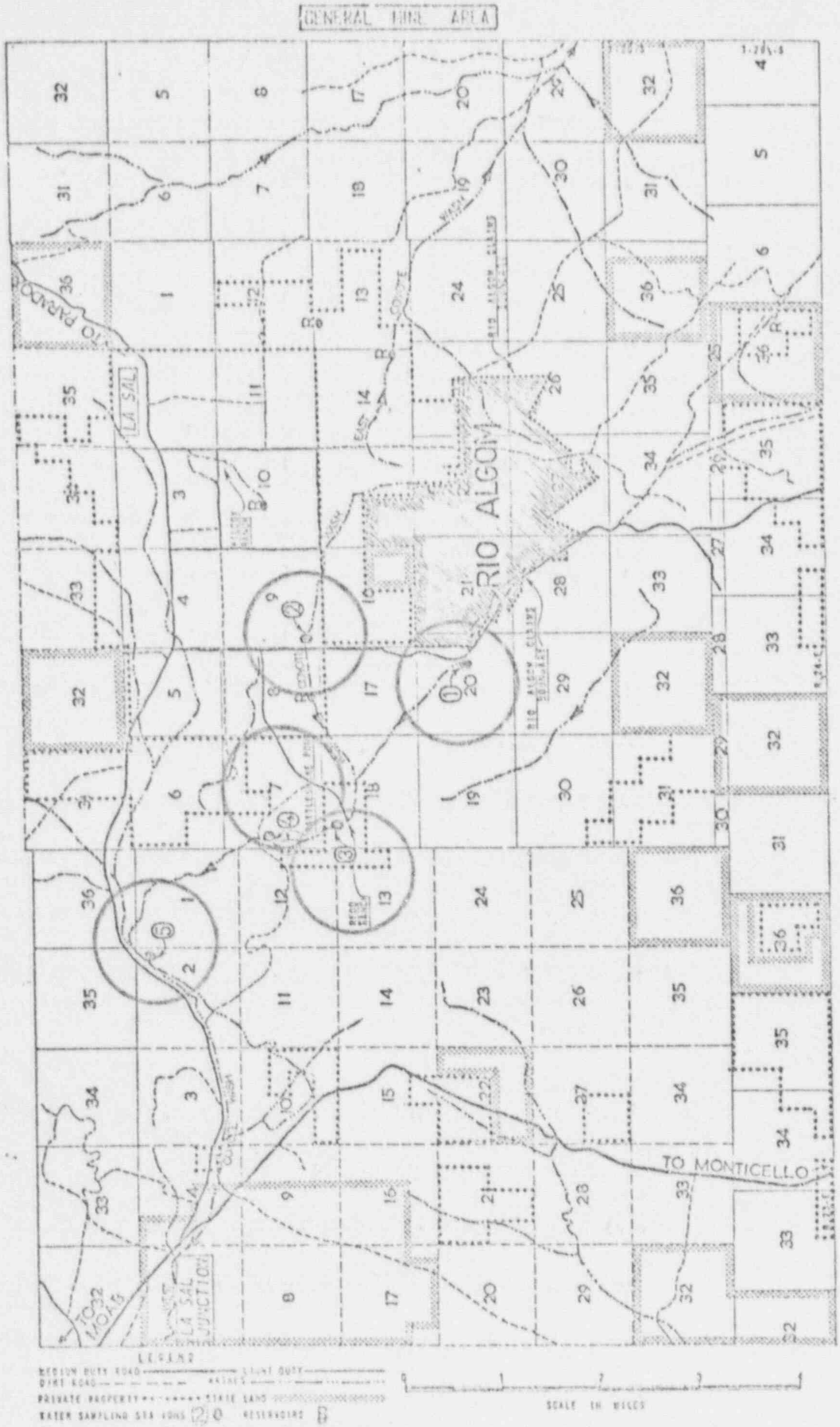
FIGURE 1

c. WATER

Five sampling stations on the West Coyote Wash drainage basin were established for the purpose of obtaining data for watershed contamination. Figure 2 shows this drainage basin located between the mine and La Sal with sample stations marked 1 through 5. Sample station No. 4 is a fresh water pond with a well established fish population. Station No. 2 is on the North Branch of West Coyote Wash and clear of any future effluents of the Rio Algom operations, and thus serve as a continuous base line reference point. These samples were analyzed for pH, dissolved solids, sulfate, nitrate, hardness, sodium, chloride, iron, uranium and total radioactivity. Samples were taken twice per month at all stations with extra samples taken at station No. 2. from July 1971 for one year.

Two sets of special water samples were obtained at the water sampling stations on West Coyote Wash and two of the water discharged by the production and ventilation shafts. These sets of special samples were analyzed for uranium, radium, thorium, polonium and lead.

FIGURE 2

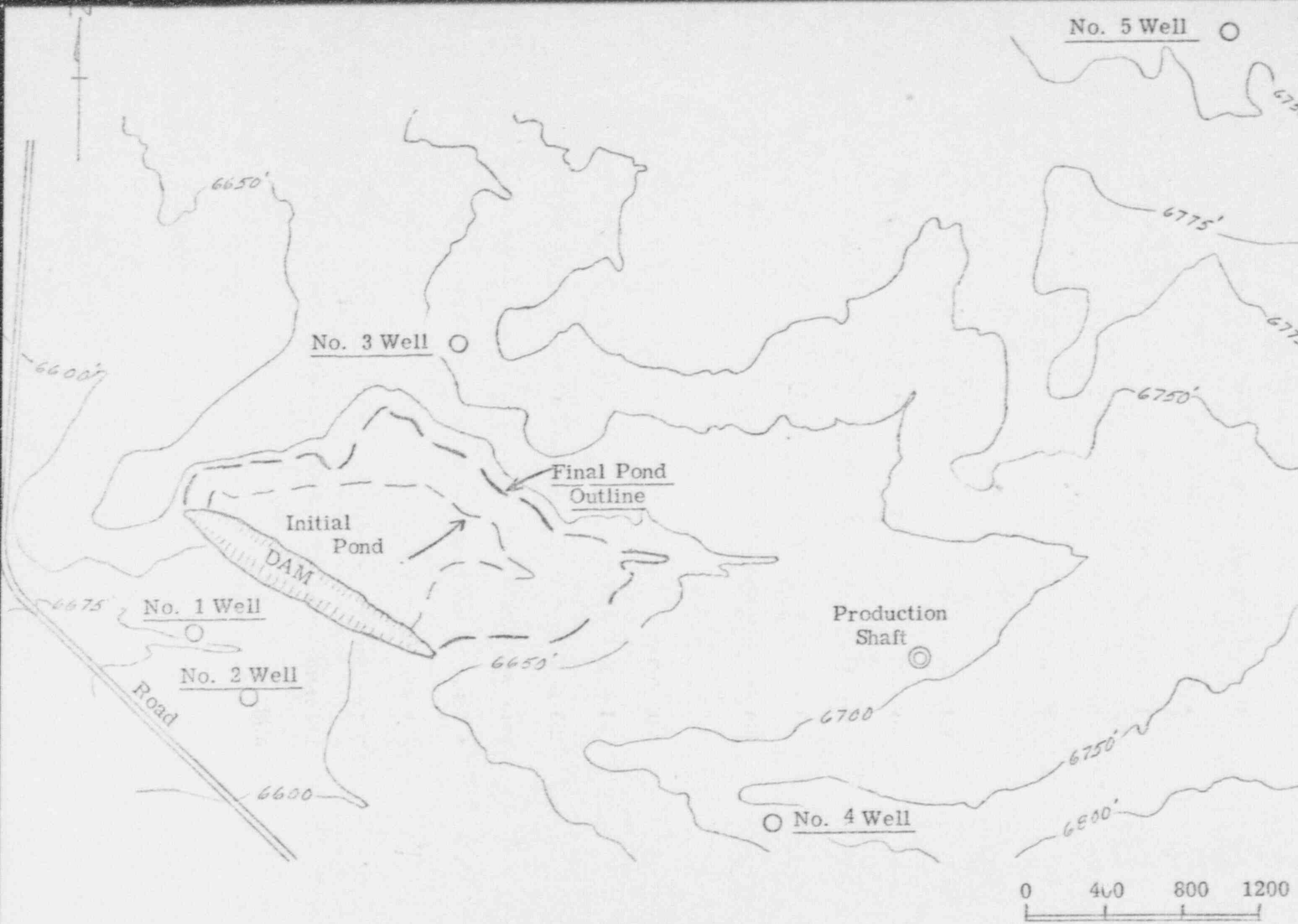


LAND OWNERSHIP, ROADS, DRAINAGE & WATER SAMPLING POINTS

Two of the three originally proposed monitor wells were installed below the dam. (Figure 3) The drilling of the third well was held off pending the determination of its most effective location relative to possible seepage from the tailings dam.

Due to delays in getting the contractor on site, only four samples were obtained from each monitor well before plant start-up. Two samples were lost in transit from each well about mill start-up time, but since then four samples per month have been obtained from each well.

The original four samples were analyzed for pH, sulphate, chloride and sodium. It was found that the commercial laboratory to which the samples were sent was not able to do analyses to the required low levels for the radionuclides. Since July 1972 all analyses have been carried out in our own laboratories for pH, sulphate, chloride, sodium, chloride, uranium, radium, thorium, polonium, lead and total alpha.



LISBON TAILINGS AREA AND
AND MONITOR WELL LOCATIONS

FIGURE 3

Because of the pressure of other work the BLM have as yet been unable to carry out a benthic survey of Rattlesnake Pond.

2. OPERATIONAL MONITORING PROGRAM

a. SOIL AND VEGETATION

The original program has been amended based on the recommendations of Dr. R.C. Pendleton, Director, Radiological Health Department, The University of Utah. (See Appendix A).

(i) Soil Sampling

Twice per year soil samples will be taken as described in Sec. 4.1.9.3. of the Supplementary Environmental Report at points B-3, C-2, C-4, E-2 and E-5 as shown in Figure 1. Two control samples will also be taken at points 2 to 2-1/2 miles NW and NE of the mine. All will be analysed for uranium, radium and thorium.

If the samples indicate an upward trend in radioactivity, the points will be re-sampled. If the upward trend is confirmed, the sampling frequency will be increased and the cause determined and corrected.

(ii) Vegetation Sampling

Quarterly vegetation sampling will be conducted with samples collected adjacent to sampling stations B-2, D-2, D-3 (adjacent to Production Shaft) C-4, E-3 and E-5 as shown in Figure 1, plus two reference samples, taken about two miles from the operation.

At each sampling point 5-pound samples will be obtained of each of the following:

Sagebrush (Artemesia tridentata)

Juniper (Juniperus Utahensis)

Meadow Clippings (mixed grasses)

These will be analyzed for uranium, radium and thorium. Analyses for copper, zinc and manganese will be terminated at the end of 1 year unless high values are indicated due to Rio Algom operation.

b. AIR

From the time of start of the mill in June 1972 until September 1972, 8 to 10 ambient air samples were obtained monthly. For the months of October to December, 4 to 6 samples per month were obtained and since then two samples a month have been taken.

Samples are obtained at distances approximately 500, 1500 or 3500 feet downwind from the plant, the distance and direction depending on the strength and direction of the wind at the time the sampler is set out. While the samples are being obtained, readings of wind speed and direction are taken at the mine, and the averages recorded. A high-volume air sampler is used to collect a sample on an 8 x 10 inch filter over a period of 8 hours. All samples are weighed to determine the total dust per cubic meters of air and analyzed for the uranium.

Quarterly ambient air samples have been obtained over a 24 hour period at the Redd Ranch located 2-1/2 miles northwest of the mine, the Wilcox Ranch located 2-1/2 miles northeast of the mine, at La Sal and at La Sal Junction (Figure 2). Wind strength and direction are recorded at the mine while the samples are being taken. Methods of collection and analysis are as previously described in this section.

In addition, monthly isokenetic dust samples are being collected in the discharge from each filter system, i.e., transfer house stack, crusher house, headframe, yellowcake scrubber stack and yellowcake dust filter stack and the dust and uranium concentrations discharged are determined. Daily visual checks of the dust filter system are performed to ensure proper operations. Monthly radon daughter samples are taken in the mine air discharged from the ventilation shaft. Semi-annually radon daughter samples are taken approximately 2000 feet downwind from the ventilation shaft. Monthly samples have been taken to determine the concentration of dust radon daughters and uranium in the air discharged from the ventilation shaft.

c. WATER

Twice per month sampling of the West Coyote Wash monitoring stations, as shown in Figure 2 was continued until July 1972. Sampling was then reduced to quarterly with analyses reduced to sulphate, uranium, radium and thorium. These substances are considered to be good indicators of any escape of contaminants.

Water samples from the ventilation shaft have been taken every second month and analysed for:

pH	Uranium
Total Dissolved Solids	Radium
Hardness	Thorium
Sulphate	Polonium
Nitrate	Total Alpha
Chloride	
Iron	

The sampling program for the two monitor wells (Nos. 1 and 2 as shown on Figure 3) close to and below the tailings reservoir dam has continued on a weekly basis. Two exploratory drill holes (Monitor Wells Nos. 3 and 4) north and southeast of the tailings area are being sampled monthly. Monitor well No. 5, also an exploratory drill hole, is some distance northeast of the tailings area and has been selected to detect contamination should such tend to migrate towards existing surface springs. This monitor well is on the same monthly sampling schedule as wells 3 and 4.

Analyses for pH, sodium and uranium in wells 1 and 2 have been on a weekly basis with analyses of the composites done monthly for sulphate, uranium, radium and thorium. For the other 3 wells analyses for all the above constitutents will be done as sampled.

Monitoring frequency and analyses performed will be changed to conform to that proposed by our consultants (Appendix B, page II-23).

Monitor well analyses data is given in Appendix C.

d. ANIMAL

Based on the recommendations of Dr. R.C. Pendleton, Director, Radiological Health Department, The University of Utah, the blacktailed jackrabbit (lupis californicus) will be used to monitor the take-up of uranium and daughter products in the biologic chain. This animal is sufficiently abundant to make sampling relatively easy throughout the year.

On an annual basis 2 rabbits will be obtained downwind (SE as to the prevailing wind) of the plant and analyses made of the liver, kidney and femur for uranium radium and thorium. One additional animal will be taken in an area remote from the plant for control purposes.

II BENTHIC SURVEY OF RATTLESNAKE POND (SAMPLE STATION 4)

We now find that, due to the pressure of other commitments the Bureau of Land Management have been unable to have a benthic survey carried out at Rattlesnake Pond (Figure 2).

As an alternative to this, on a quarterly basis, in addition to the current chemical analyses, samples will be sent for a scan analyses of selected metals. It is believed that due to the topography of the area and known water flows that there is little chance of there being any sudden change in the quality of the water in this pond. Appendix D gives the results of the first two scan analyses.

III ACTION LEVELS FOR RADIOACTIVITY IN MONITOR WELLS

To date analyses of water from the seepage monitor wells around the tailings area indicate that uranium, polonium 210 and thorium 230 are about 1/100 of the AEC concentration limit or 1/30 of the State of Utah limit. Radium 226 is about 1/10 the AEC limit and approaching the state allowable. These radionuclides could originate in the tailings area or could be an indication of high natural ground water levels.

Radium will therefore be taken as the indicator radionuclide to start corrective action. Because the concentrations under consideration are approaching the limit of accuracy for the usual mining chemical laboratory, the value placed on a single determination should not be too high. Trends and averages are of greater value and therefore action will not be taken until such time as two out of three successive values exceed the Utah state limit for radium.

All monitor wells are an appreciable distance from the property boundary in which distance, should the contamination have originated in the tailings area, further dilution and adsorption will take place, thus providing time in which to take corrective action. For the decrease in Radium values with distance from the tailings area, see Section XVII of Part II of this report.

This corrective action to limit the dispersion of contaminants will be the installation of pumps in existing monitor wells or special pumping wells between the monitor well and the tailings area. Pumped water will be returned to the tailings pond. (Appendix B, pages II-14 & II-15).

Percolation tests on actual tailings give a rate of flow of 6 feet per year, which appears to be much less than that for the natural soils. Thus when the bottom of the tailings pond has been completely covered with a layer of tailings it is expected that the infiltration of contaminants into the ground will be greatly reduced. (Appendix B, pages II-9 & II-10).

IV DETERMINATION OF RADIOACTIVITY IN PLANTS & ANIMALS

Appendix A gives the recommendations of Dr. R.C. Pendleton, Director, Radiological Health Department, University of Utah, regarding the determination of radioactivity pick-up by plants and animals.

1. Quarterly sampling of vegetation at station B-2, D-2, D-3, C-4, E-3 and E-5 will be carried out for grass, sagebrush and juniper where available at each sampling station. In addition samples will be obtained from two sites remote from radioactive dust discharged from a uranium operation to determine a base level. Analyses will be made for uranium, radium, thorium, copper, zinc and manganese.

Should these samples indicate a significant upward trend in radioactivity then the stations will be re-sampled to determine if the analysis was valid. Should an upward trend still be indicated, adjacent stations will be sampled and the cause of any increase in contamination sought and corrected.

2. The accumulation of radioactivity in plants is limited by their life. All the plants in the area, including sagebrush, are deciduous except the juniper and pine. This radically limits the

amount of accumulation in the forage portions. Juniper and pinyon pine replace their leaves within 2 to 5 years, thus again limiting the accumulation. Only those plants that can grow near the tailings water may accumulate higher levels of radioactivity. Thus in the area of the mine the amount of radioactivity associated with forage is most likely to be due to splash-up of ground contamination.

3. Some contamination of plants in the area will continue after milling operations cease because the natural soils contain considerable radionuclides in addition to any fall-out of dust from the concentrator. However any effect upon animals is limited to the length of time the leaves stay on the plants and their closeness to the ground.

4. If analyses of the edible vegetation demonstrate that there is an appreciable buildup of radioactivity that is approaching those limits given in 10 CFR 20, action will be taken to further reduce the dust released to the atmosphere by the operation. This will be done by reducing general fugitive dust from the plant area and ensuring that the plant dust control equipment is operating efficiently. The need for such action is not considered likely.

5. On an annual basis two blacktail jackrabbits will be obtained in an area some 1000 feet downwind of the plant in relation to the prevailing wind. In order to establish a background level, an additional jackrabbit will be obtained in an area remote from contamination by a uranium milling operation.

These animals will be analysed for uranium, radium and thorium in the liver, kidneys and femur.

V. WATER DISCHARGE PERMIT APPLICATION

A copy of Part B of our discharge application to the Corps of Engineers may be found in Appendix H of the Supplementary Environmental Report. The E.P.A. who are now responsible for effluent discharge permits have stated that our application should be processed some time this Fall. The site was inspected by the E.P.A. in September 1972.

This application was submitted as a precautionary measure. Drainage from the East Coyote Wash disappears some 10 miles southeast of the mine, at the mouth of the Lisbon Canyon, due to evaporation and ground seepage. There is thus no direct connection to any navigable water.

VI LOCATION AND SAMPLING OF TAILINGS MONITOR WELLS

VII LOCATION OF ADDITIONAL TAILINGS MONITOR WELLS

Five monitor wells have been installed between the tailings pond and the property boundary as shown on Figure 3.

Well numbers 1 and 2 are about 500 feet southwest of the tailings dam and down-dip both as regards surface contours and sub-surface drainage. Wells 3 and 4 are north and east of the tailings pond some 500 and 1600 feet while number 5 is some 4000 feet to the northeast. The first two are specially drilled holes while the other three utilize previously drilled exploration holes. These holes are placed to detect seepage towards the boundary in all directions from the tailings pond. (Appendix B, page II-19 & II-20)

Wells 1 and 2 are sampled weekly to facilitate early detection of contaminant levels. The other 3 wells are sampled monthly as they are more remote from the tailings area and contaminant levels should thus change less rapidly.

Our consultant had a number of additional wells drilled and made recommendations for others (Appendix B, page II-20). Wells D-1, D-2 and D-4 were drilled on the dam centreline and penetrate some 10 to 15 feet into the Burro Canyon sandstone. The water table was penetrated only in holes D-1 and D-2. Monitoring on a monthly basis will be conducted on these holes.

Below the dam, holes D-3, D-9 and D-10 were drilled with only D-3 and D-10 penetrating into the Brushy Basin formation to enable the complete saturated portion of the pervious Burro Canyon formation to be sampled, and to possibly obtain an estimate of the rate of contaminant movement. It is proposed that these monitor wells be sampled on a weekly basis. Hole D-7, on the proposed upper dam centreline will be sampled when needed.

Three other monitor wells recommended by our consultant would be situated north of and parallel to the county road running southeasterly. Their purpose is to determine whether groundwater is being contaminated by surface run-off from two other mining operations. This proposal is being evaluated. (Appendix B, page II-20 & II-21)

Based on the tests that have been conducted, (Appendix E), it is estimated that the rate of percolation through the tailings will be much less (6 feet per year) than through some portions of the subsoil and porous portions of the bedrock. However, it is expected that water will continue to flow to the monitor wells. A negative pressure should not exist over an appreciable area because air can be drawn through the rock pores not occupied by water.

VIII ISOLATION OF SHAFT WATER FROM THE SURFACE AQUIFER

When the mining operation is terminated it is now proposed that a concrete seal be placed in the shafts just above the mining horizon. This will isolate the mine water with high radioactivity from the water now seeping into the shafts from the Navajo and Entrada, and limit the radioactive contamination of these formations.

The height to which water will rise in the shafts is not known, but will depend on the hydrostatic head in these formations. However it is not anticipated that water will rise to the elevation of the Burro Canyon formation. Should it do so, there should be practically no transfer of water into or out of the shaft because of its concrete lining. No leaks are known in the lining in the area of the Burro Canyon. (Appendix B, page II-7). The shaft will also be capped with a concrete slab at ground level.

IX EFFECT OF MINE DRAINAGE ON SURFACE WATERS

Water pumped from the mine now totals some 400 gallons per minute due to the rapid opening up of the mining horizon and hence increased drainage from a larger area than anticipated.

Currently some 190 gpm is being disposed of to Redd Ranch Reservoir, some is used in the concentrator and the balance disposed of to the tailings pond and to the spray field for evaporation.

Because evaporation will not dispose of sufficient water, it has become necessary to install a barium chloride treatment system to reduce the radium levels in the increased volume of mine water discharged. Design capacity will be 500 gpm. This plant will be in operation in 1973. Any overflow from the Redd Ranch Reservoir, after dilution from natural springs etc., flows down East Coyote Wash and finally disappears due to evaporation and ground absorption. There is not direct connection with Hatch Wash or the Colorado River.

No mine water discharge enters the water flowing in West Coyote Wash.

X IMPACT OF OPERATION ON SOCIAL AREAS

1. Employment of Native People

Since the start-up of the mine it has been an established policy to employ as many native people as practical. At present the Indians and Mexicans comprise about 9% (17 out of 190) of those employed at the mine, as compared to a reported 2 to 3% of native population in the general area.

2. Support for the Tourist Industry

Because the surface operations of the Lisbon Mine are a restricted area, our operation cannot be made available for public tours. However the company will be willing to support the tourist industry in the area by supplying information of a general nature to the appropriate tourist bodies in both Moab and Monticello.

3. Archeological Survey

An archeological survey was conducted by the Utah Department of Development Services and no historic sites are reported. (Appendix F)

Should an archeological site be inadvertently uncovered during operations the above agency will be notified.

XI IMPACT OF EARTHQUAKES ON TAILINGS DAM STRUCTURE

Based on test borings through the existing dam and an evaluation of the soil parameters that have been determined it was calculated by our consultants that the dam would have adequate stability under a seismic shock of 0.05 times gravity. The minimum factor of safety was found to be 1.3 for the maximum pool elevation. This meets the requirements of the A.E.C. published in June 1973. (Appendix B, page I-4 & I-5).

XII CONTAINMENT OF CHEMICAL SPILLS

All tanks containing harmful chemicals meet state or federal inspections. In addition routine mechanical inspections and checks are carried out by the plant department on a routine preventative maintenance basis in order to forestall any possible escape of chemicals. Should a rupture occur, the contents of those tanks inside the mill will be contained within the mill sumps. To contain spillage from tankage outside the mill a retaining sump has been installed. This will contain the volume of the largest tank. Plugging of the drainage culvert at the perimeter road will be a back-up for the retaining sump. Any liquid contaminant contained in surface run-off from the plant area and not retained as above will be deposited in the tailings basin.

XIII TAILINGS DRAINAGE BASIN AREA AND CHARACTERISTICS

The stated area of the tailings basin of 590 acres is based on aerial photo contours and the derivation of the area has been checked.

Appendix G gives the calculations used by the Bureau of Land Management in deriving the run-off characteristics of the watershed. Soil characteristics of the area are given in a report "Soil Survey" San Juan Area, Utah, U.S. Dept. of Agriculture, Series 1945, No. 3, August 1962.

XIV DOCUMENTATION OF PERMEABILITY AND PERCOLATION TESTS

A. The term "relatively impervious" used in Section 5.4.3.1 on page 102 of the Supplementary Environmental Report should be referred to "low seepage rate (1 to 100 feet per year)" as given in Section 7.4.3.2.1 on page 168 of the same report. This term brackets the first to degrees of permeability suggested by our consultants. (Appendix II-A of Appendix B).

Relative Impermeable	Less than 10 feet per year
Slightly Permeable	10 to 100 feet per year

Woodward-Clyde and Associates investigated soil and foundation conditions for our tailings area and plant in 1969. This included the drilling of some 21 test holes in the area and an analyses of the soil data obtained. Appendix H shows page 6 of this report which states:

> "The natural soil in the reservoir area possesses sufficient fines (- #200) to be relatively impervious."

B. As stated on page 166 of the Supplementary Environmental Report, laboratory tests done on existing ground ore samples from a neighbouring mine gave low percolation rates.

Further tests on Lisbon ore freshly ground in the laboratory was reported on 2nd March 1972 to give a percolation rate of about six feet a year after one week.

Additional tests were done and reported on 16th October 1973 on fresh whole tailings as produced by the Lisbon mill. Again the percolation rate stabilized at about six feet a year after seven days. See Appendix E.

XV SOIL TESTS & DESIGN PARAMETERS FOR TAILINGS DAM

Our consultants have evaluated the stability of the current tailings dam by drilling three test holes along the centre line to obtain soil strength data. By use of the ordinary method of slices technique the factor of safety for various conditions of fluid level and for seismic shock was deter.nined. For the tests done the minimum factor of safety was 1.3, which meets the A.E.C. requirements published in June 1973. (Appendix B, page I-2 to I-5 and Appendix I-A)

The proposed upper tailings dam to provide storage capacity in excess of that given by the existing dam was designed based on an evaluation of samples of soil to be used in its construction and a slope analyses using the same method of slices. The recommended slopes are 3 to 1 for the downstream face and 2.5 to 1 for the upstream face. The minimum factor of safety for the conditions tested was found to be 1.2 which also meets the June 1973 A.E.C. requirements. (Appendix B, pages I-7 - I-10).

XVI DISPOSAL OF TAILINGS DAM SEEPAGE

The monitor well drilling conducted by our consultants indicates that seepage from the tailings pond probably percolates downward in stages until it reaches the zone of saturation lying on the Burro Canyon - Brushy Basin contact. Here the seepage is diluted by groundwater and moves down-dip along the contact.

Should they be needed to control seepage, our consultants have proposed the installation of two recovery wells on the centreline of the dam (as shown on Plate 8 of Appendix B) and extending some 15 feet into the Brushy Basin to form a sump intake for each pump, which would discharge back into the tailings pond. The effect of this seepage removal will be monitored in wells number 1 and 2 as well as D-3 and D-10.

XVII ADSORPTIVE CAPACITY OF TAILINGS AREA SOILS

According to our consultants the soils and rocks in the tailings area have the capacity to adsorb effluent constitutents such as radium and uranium by ion exchange. (Appendix B, page II-11).

Analysis for cation exchange capacity was done on seven soil and four rock samples. The values obtained ranged from 11 to 16 Mev/100 gms. Time precluded a complete study of the effectiveness of this mechanism, but the adsorptive capacity of any soil has limitations. Montmorillonite has a high cation exchange capacity but in the samples examined was present only in trace quantities.

A measure of the change in contaminant concentration will be obtained by monitoring wells 1 and 2 and comparing with values obtained from D-3 and D-10. September analyses give the following results which indicate a considerable reduction of radium with increasing distance from the tailings pond:

Monitor Well	Radium x 10^{-9}	Dates Sampled
D-1	6.9 µc/ml	8-13-73
D-3	2.3 µc/ml	8-13-73
D-10	1.7 µc/ml	8-13-73
No. 1	1.8 µc/ml composite	from 8-28-73 to 9-18-73
No. 2	2.4 µc/ml composite	from 8-28-73 to 9-18-73

XVIII ACTION ON DETECTION OF HIGH LEVELS OF SEEPAGE CONTAMINATION

In line with the recommendations in Section II of this part, when two out of three consecutive analyses from any of the monitor wells indicate that a radioactive contaminant is in excess of the allowable set by the State of Utah then action will be taken to control this contaminant. (Appendix B, page II-15).

When action is required it is proposed to install pumps in wells drilled on the centreline of the dam to capture the contaminant before excessive dilution occurs. The effluent will be discharged to the tailings pond.

By monitoring wells numbers 1 and 2 in addition to D-3 and D-10 an assessment of the rate of contaminant flow may be obtained if the source is the tailings pond.

PART II

ANSWERS TO A.E.C. QUESTIONS

I TAILINGS DAM

A. CONSTRUCTION & STABILITY OF EXISTING DAM

This section deals with the method of construction and stability of the tailings dam as it now is. Refer to:

E.P.A. - p. 10, item 3
- p. 11, para. 1

H.E.W. - item 2

Interior - p. 5, para. 4
- p. 7, para. 2

Agriculture (Forestry) - item 1, item 2 last 2 sentences

University of Utah - item 3, para. 3

The tailings dam was designed using accepted engineering and construction principles. Based on test borings through the actual dam and an evaluation of the soil parameters that were determined, it was calculated by our consultants that the minimum safety factor under all conditions evaluated (including earthquake loading of 0.05 g) was 1.3. This meets the A.E.C. requirements of June 1973. (Appendix B, pages I-2 to I-6).

The three drill holes D-1, D-2 and D-3 (Appendix B, page II-20) put down on the tailings dam centreline by our consultants in August 1973 did not detect water in the dam core itself. Water in the strata under the dam was detected in only 2 of these holes. Piezometers are installed in boreholes D-1 through D-7 to determine water table levels.

On completion of the milling operation the tailings areas will be dried up by evaporation, graded to prevent the collection of water, covered with soil and seeded. If necessary the face of the dams may be graded to a slope lower than at present. However even the exceptionally heavy precipitation in the winter of 1972-73 and with only some 20% grass cover, erosion of the dam face during storms has not been a problem. As the vegatative cover increases in the future the problem will be further minimized.

Based on calculations by the Bureau of Land Management and in discussions with them, the 10 foot minimum surge capacity between the tailings pond and the top of the existing dam at elevation 6630 will provide a factor of safety of 2.8 for a 100-year 10-day storm in the 590 acre drainage basin. This is described on pages 110-111 of the Supplementary Environmental Report. The upper tailings basin now proposed with an area (27 acres) estimated to be considerably larger than the existing pond, will provide some additional surge capacity. Our consultants confirm that a diversion channel is not needed during operations (Appendix B, page I-10) as all run-off from the plant area should go to and be retained in the tailings basin.

I TAILINGS DAM

B. PROVISION OF INCREASED STORAGE CAPACITY

This section deals with methods of obtaining increased tailings storage capacity in excess of that provided by the original tailings dam as now installed. Refer to:

E.P.A. - p. 10, para. 1

University of Utah - item 3, paras. 2 and 3

It was originally proposed to incrementally raise the existing dam using the "up-stream" method and using a facing of local material on coarse spigotted tailings to increase the storage capacity of the area. This was based on the pre-operational assumption that the tailings would have only 50% of the solid material finer than 200 mesh and 95% finer than 50 mesh. The tailings as now produced average as much as 70% finer than 325 mesh. This change in consistency makes the "up-stream" method of raising the dam impractical.

It is now proposed by our consultants that a second similar tailings dam be constructed some 700 to 1000 feet up-stream of the existing dam, using local compacted material.

It is proposed that this upper tailings dam will have a crest elevation of 6680 feet, a maximum pool elevation of 6675 feet and a continually operating decant system discharging clarified effluent to the existing pond, from which there shall be no decant. Estimated surface area will be about 27 acres.

This upper dam, with a maximum height of 45 feet, will be similar to the lower dam, but with the downstream slope increased to 1 in 3 from 1 in 2.5 and the up-stream increased from 1 in 2 to 1 in 2.5. For these conditions, including seismic shock, the minimum factor of safety is calculated to be 1.2, which meets the 1973 A.E.C. requirements. (Appendix B, pages I-7 to I-11).

On completion of the operation the removal of any supernatant liquid from both tailings areas by evaporation and filling will mean that should a dam be eroded by a storm, there will be no sudden release of contaminants to flood the valley below. Thus the quantity of contaminants that would escape during one storm should be minimal and could quite readily be cleaned up or buried.

The Utah State Department of Highways have been consulted and anticipate no appreciable damage to the state highway system in the unlikely event there is a dam failure. (Appendix I).

At close-down a diversion ditch is to be installed to take storm run-off past the tailings areas. Thus with no liquids on the surface of tailings areas and with the addition of the diversion ditch, the chance of a dam collapse at this time will be remote, and the area should be stable much beyond the 50 years referred to.

II TAILINGS AREA

A. GEOLOGY AND HYDROLOGY

This section deals with the general and local hydrology of the mine area. Refer to:

Interior - page 3, para. 5

Because the subject is fully covered in Appendix B it will not be repeated here. Reference should be made to the following:

Site Geology	Part I page 2
Regional Geohydrology	Part II page 2
Site Geohydrology	Part II page 6
Movement of Seepage	Part II page 9
Affect of Ground Water Withdrawals	Part II page 21

II TAILINGS AREA

B. REHABILITATION AND PERPETUAL CARE

This section deals with tailings area stabilization and revegetation, provision of a diversion channel and need for continued maintenance. Refers to:

E.P.A. - p. 9, paras. 1 and 2
- p. 11, para. 1
- p. 12

Interior - p. 2, para. 3
- p. 5, para. 5
- p. 6, para. 1, last 2 sentences
- p. 7, para. 1

University of Utah - item 4
- item 6, sentence 4 to end

Agriculture (Forestry) - item 1
- item 2, sentences 1 to 3

Agriculture (Soil Service) - items 6 and 9

The downstream face of the dam has been re-seeded and as of August 1973 there was estimated to be about a 15 to 20% coverage of grasses plus annual weeds for a total coverage of about 80 - 90%. Because of the high precipitation this year, and the higher water level in the dam it is hoped that the vegetation roots will be able to penetrate deep enough to gain access to moisture at all seasons and so become well established.

On cessation of operations, the tailings area will be dried up, graded if necessary, covered with soil and seeded. The seed mixture selected will be based on the advice of the Bureau of Land Management or the Department of Agriculture as being most suitable for the area and conditions. The science of revegetation of mine tailings will hopefully be much advanced by that time. Spray irrigation of the seeded area is not now contemplated. If vegetation has not become sufficiently well established on the dam face to stop erosion at time of shut-down, the slope of the dam will be lowered to a more stable angle before re-seeding. Any regulations in force at that time regarding stabilization of tailings areas will be complied with.

In order to reduce radiation from the tailings to acceptable limits it is estimated that about 1-1/2 feet of soil will be required. The thickness required will have to be determined by tests made at that time.

Depending on the depth of soil used and the depth of the root systems of the vegetation planted, the use of a fence after stabilization may be uncalled for. Based on the tests carried out by Dr. R.C. Pendleton, Radiological Health Department, University of Utah, the accumulation of radiation in plants from the soil in Utah is minimal. The posting of the area with permanent markers warning against occupancy or the use of any tailings may be all that is required. Further protective measures will be effected if the regulatory agencies so require.

All plant buildings will eventually be removed and the foundations levelled or buried and the area seeded.

It is considered that the factor of safety of 2.8 for a 100-year - 10-day storm, plus some additional surge capacity in the upper tailings area provides adequate insurance against over-topping the lower dam during its operating life. At shut-down, a storm diversion channel will be installed as described on page 112 and shown on page 30, Figure 7 of the Supplementary Environmental Report. The diversion ditch will be designed to accommodate the second tailings area.

To ensure the performance of this work to the satisfaction of both by the A.E.C. and the Bureau of Land Management, to whom the land will eventually return, a bond of $201,000 is to be posted by Rio Algom Corp. This amount includes escalation at 5% to 1980. It is not now the intention of Rio Algom to patent this land.

II TAILINGS AREA

C. SEEPAGE CONTROL

This section deals with the control of seepage from the tailings area: Refer to:

E.P.A. - p. 9, paras. 3 and 4

Interior - p. 3, para. 4
- p. 6, paras. 2 and 3
- p. 8, paras. 1, 2 and 4

Agriculture (Forestry) - item 3

Transportation - para. 3

At present the up-stream face of the dam and most of the north side of the pond have received a tailings cover by spigotting about two feet above the water line, and distribution in in progress around the basin to effectively minimize seepage of water into the ground.

Tests of Lisbon tailings (Appendix E) have indicated a percolation rate of six feet per year, thus providing a much better seal than the soil and rock in some portions of the area. (Appendix B, plate 7).

If seepage contamination ever reaches "action levels" recovery wells will be installed from which seepage will be pumped and returned to the tailings pond. An "action level" may be considered to be when any two out of three consecutive analyses in a monitor well exceed the allowable concentration. (Appendix B, pages II-15 to II-16).

When the tailings area becomes inactive and is covered with soil and vegetation, the downward migration of contaminants will be greatly reduced because there will be no remaining body of water to cause leaching of precipitated salts. The only water available will be that from the small amount of precipitation in the area, some 11 inches per year.

II TAILINGS AREA

D. MONITOR WELLS AND SAMPLE RESULTS

This section deals with monitor well location and sample results. Refers to:

E.P.A. - p. 7, para. 2
- p. 10, para 3, item 1
- p. 8, para. 3

The location of the 5 monitor wells around the tailings area is shown in Figure 3. Wells numbers 1 and 2 are situated close to and below the tailings pond and dam, to detect significant contamination from the pond through and below the dam should it occur. These are specially drilled wells some 95 to 110 feet deep drilled through the Burro Canyon (or Dakota) formation and some fifteen feet into relatively impervious Brushy Basin (or Morrison) formation.

The other three wells are placed at a greater distance to the southeast, northeast and north of the tailings area. These monitor wells are old exploration holes that are open through the Burro Canyon and that do contain water. (Appendix B, pages II-19, and II-20, and plates 5, 7 and 8).

The Burro Canyon - Brushy Basin contact elevations for the original 5 monitor wells are:

Monitor Well Number	Contact Elevation, feet
1	6480
2	6462
3	6571
4	6562
5	6432

Data for monitor wells D-1 to D-8, drilled by the consultant, is given in Appendix B, plates A-1A to A-1C.

Monitor well analyses to date are tabulated in Appendix C and graphed in Appendix B plates 9A, 9B and 9C. An examination of these data indicates that there has been an increase in some contaminants, whereas others have decreased. It would appear that the radium level may have passed its peak. It is anticipated that this trend will be confirmed by future analyses as the sealing of the basin by tailings progresses. These contaminant levels could originate from the tailings area or could be variations in the natural ground water levels.

Monitor wells D-1, D-2 and D-4 on the dam tailings centreline indicate no seepage passing through the dam. However water is indicated in the strata below the dam (Appendix B, plate 8).

It would appear that seepage from the pond will go either directly or by stages through the soil and rock, moving down gradient beneath the dam to the water-table resting on the Brushy Basin formation.

Contaminants in the seepage from the tailings basin are reduced to some degree along the seepage path by dilution by groundwater, by dispersion, and by some ionic exchange. A measure of this decrease in radium along a seepage path has been indicated in Section XVII of Part I of this report.

I' TAILINGS AREA

E. ANALYSES OF DISCHARGE TO TAILINGS POND

This section covers the analysis of a composite sample of tailings liquid and solid currently discharged to the tailings pond. Refer to:

Interior - p. 5, para. 3

Solution Analyses

Substance	Parts per million
SO_4	6500
$Na_2\ CO_3$	7740
$Na\ HCO_3$	3780
Na	11,700
Mn	0.44
Cu	0.11
Zn	0.09
Fe	0.5
Uranium	46300 pc/liter
Radium - 226	240 pc/liter
Thorium	110 pc/liter
pH	10.2

Solids Analyses	Parts per million
Mn	0.078
Cu	0.46
Zn	0.60
Fe	10,000
Uranium	7 pc/gram
Radium	21 pc/gram
Thorium	8 pc/gram

II TAILINGS AREA

F. TAILINGS DEPOSITION

This section deals with the description of the deposition of the tailings and changes some terminology. Refer to:

E.P.A. - p. 10, para. 2
- p. 10, para. 3, item 2

Tailings have been deposited at a number of points across the upstream face of the dam to reduce any seepage through it. The tailings line is laid on the upstream crest of the dam and the tailings are discharged at a number of points just above the water line. Because the tailings material is so finely ground very little "beach" of coarser fraction has as yet built up above the pond level of the liquid fraction of the tailings slurry, but the beach will gradually increase with time.

In order to seal the apparently more pervious rock and soil areas on the north and south sides of the dam, the tailings line has been extended along the north side to deposit a blanket of tailings by spigotting. On completion of this the tailings will then be spigotted along the south side. As the pond level rises the tailings will be discharged at various points around the perimeter of the pond to keep the liquid fraction of the tailings from direct contact with the bare rock and soil, unprotected by a layer of tailings with low permeability.

Because the discharge point for the tailings is moved fairly frequently, and the tailings are discharged well below the dam crest, slimes pockets if formed, will not adversely affect the dam stability as it is not now proposed to raise the present dam.

The formation of ice lenses is not anticipated to be any problem at the point of discharge. Should some ice be covered by tailings during the winte[illegible] will melt with the advent of warm weather and b[illegible]re it becomes buried to any great depth. Lisbon is a small tonnage operation, and any ice that is covered will not be buried to any great depth.

II TAILINGS AREA

G. DUST CONTROL

This section covers dust control and the use of water sprays. Refers to:

E.P.A. - p. 11, para. 2, sentence 3 to end

Interior - p. 6, para. 1

To date and for some time in the future there will be insufficient dry tailings exposed to the wind to constitute a dust hazard.

Because the tailings basin is situated in a shallow valley and behind the crest of the dam the full force of the wind blowing up the valley will be broken. Thus if any appreciable area of tailings becomes exposed in the future, the effect of wind will be minimal.

Should dust control be required, possible methods are outlined on page 155 of the Supplementary Environmental Report.

These methods include:

a) spraying

b) use of snow fencing

c) covering with mine waste

d) chemical stabilization

These are interim methods to use before final stabilization.

The spray irrigation system that has been installed within the tailings basin is used for the disposal of excess mine water and not for tailings dust control.

III MINING

A. MINING CLAIMS AND LEASES

This section deals with mining leases held by Rio Algom. Refers to:

Interior - p. 2, para. 3

The area for which Rio Algom Corp. holds mining claims and leases is held by the Bureau of Land Management except for one parcel covered by a State lease. The areas so held were obtained by lease from the original holders of the mineral claims or leases.

III MINING

B. MINING METHODS

This section deals with the isolation of completed mining areas by bulkheads. Refers to:

E.P.A. - p. 4, last para.

At the time the Supplementary Environmental Report was written tentative mining and ventilation methods were described, based on the limited information gained from the original exploratory drilling. However when development and mining in the ore horizon was started, ore grade and ground conditions required modification of original plans, and current plans may be further altered to meet changing conditions from time to time, consistent with safe practice.

After initial development, the basic mining system now in use is to extract the ore by mining from the exhaust towards the fresh air supply. Bulkheading is currently used mainly to direct the fresh air to the active mining area. A flow of vitiated air is maintained through mined-out areas towards the exhaust. It is this slow flow of air towards the exhaust that minimizes the contamination of fresh air.

Because of changes in mining methods it has not yet proved practical to isolate a mined out area with permanent bulkheads and maintain it under negative pressure. Contamination of fresh air by radiation from mined out areas is minimized by causing a slow flow of air through these abandoned areas towards the exhaust. Regular monitoring for radiation and determination of air flows is carried out by the staff to ensure that adequate supplies of good quality of air are provided each working place.

On completion of mining, groundwater seepage will flood the mine workings and shafts. The proposed bulkheads will prevent the escape of radon from the ore going to the surface.

III MINING

C. MINE SOLID WASTE DISPOSAL

This section deals with methods of trash disposal and uranium values in mine waste rock. Refers to:

E.P.A - p. 5, para. 1

Interior - p. 5, para. 2

Agriculture (Soil Service) - item 5

As indicated on page 127 of the Supplementary Environmental Report, solid trash waste such as mine timber, cable, chemical containers, shop waste, etc. will be disposed of at the rock dump and periodically covered by mine waste rock. If there is drainage from this area due to excess precipitation, it will be into the tailings area. The disposal of solid waste will be made to conform to applicable federal, state and local regulations.

There are no economically recoverable values in the estimated 400,000 tons of mine waste rock. (Not 4,000 as shown on page 49 of Draft Detailed Statement).

III MINING

D. MINE WATER

1. Source and Quantity

This section deals with the rock formations from which the mine water comes, its volume and effect on surface flows. Refer to:

E.P.A. - p. 3, para. 2
- p. 4, para. 1, sentences 1 to 4

Interior - p. 8, para. 5

The source of most of the mine water is believed to be the Navajo, Kayenta and Wingate formations some 1500 to 2000 feet below surface. It is not believed that there is any direct connection with surface aquifers in the immediate mine area other than by slow seepage through fault zones. The relatively impervious Brushy Basin formation lies between the surface aquifers and the Navajo, Kayenta & Wingate formations. (See Figure 9, page 34 of the Supplementary Environmental Report and Appendix B, Part II, plates 2 and 3).

It was originally expected that the drainage of water from the strata would decrease with time. However, since the development of new mining areas has been more rapid than originally planned the volume pumped from the mine has increased from 265,000 to 565,000 gallons per day in March 1973. The volume discharged through the ventilation shaft averages about 290 gpm. The balance of the mine water is pumped up the production shaft and averages about 150 gpm.

It is considered that the mine dewatering operations will not have a detectable effect on the surface ground water table as evidenced by a change in the discharge of springs in the area or on the vegetation. Surface springs in the area of Coyote Wash are recharged by precipitation run-off from the La Sal mountains to the north, also north of the East Coyote syncline. The mine lies to the south of this wash and also south of the syncline. (Appendix B, pages II-22 to II-24).

2. Use and Disposal

This section deals with water use, conservation of fresh water and disposal of excess water after treatment for radium. Refer to:

E.P.A. - p. 3, para. 1
- p. 4, para. 1, sentences 5 to end

Interior - p. 3, para. 3

University of Utah - item 5

Department of Army - item a.

Water from the ventilation shaft is currently being discharged to a cattle water reservoir on Redd Ranch. The water pumped up the production shaft is used in the mill to replace fresh water from the well field as far as possible. At present the total water from the well field amounts to about 80 gallons per minute, of which only 30 gpm is used for process water. The balance, about 50 gpm, is used for boiler feed, showers and drinking. This is a major reduction from the field capacity of 200 gpm. and the consumption of 56 gpm. indicated in the water balance diagram shown in Figure 15 on page 98 of the Supplementary Environmental Report. To further reduce fresh water consumption in the mill a recl[illegible]n system is now in operation sending tailings pond water back to the mill for re-use.

Deep well disposal of any excess liquid from our tailings pond is not contemplated at any time in the future.

The effluent discharge application of 10 August 1971 to the Corps of Engineers covering the discharge of water from the ventilation shaft has been transferred to the Environmental Protection Agency, Denver, and the site was inspected in September 1972. A ruling on the application is expected in the fall of 1973.

It is now planned to pump all mine seepage water up the production shaft because it has been found impractical to maintain low radiation levels in the total ventilation shaft water.

Excess mine water not required in the mill operation will be clarified in a settling pond and then treated with barium chloride. The clarified effluent from the second pond will readily meet the State of Utah standards of less than 3.3 pc/l (3.3 x 10^{-9} uc/ml) of radium when discharged to Redd Ranch reservoir. The treatment step will not remove the dissolved solids as frequently found in well waters; but these do not exceed the limits for cattle or irrigation in this case. The water discharged to Redd Ranch reservoir is diluted by water from other sources and meets drinking water standards at point of use, except for total dissolved solids.

3. Sampling and Analyses

This section refers to sampling of the water pumped from the ventilation shaft and discharged to Redd Ranch reservoir and also the production shaft discharge. Refer to:

E.P.A. - p. 7, para. 1

University of Utah - item 2

Mine water discharged from the ventilation shaft has been sampled every second month and analysed for the following:

pH	
total dissolved solids	uranium
hardness	radium - 226
sulphate	thorium - 230
chloride	polonium - 210
iron	total alpha

Because the source of this water is directly from the deep water-bearing strata by seepage or drainage from drill holes no sudden change in analyses has been expected, and the above sampling frequency has been deemed adequate.

Production shaft water is likewise sampled every two months and analysed for:

pH	sodium
total dissolved solids	uranium
sulphate	

Every six months analyses for the following are made:

radium

thorium

polonium

The frequency of analyses for the production shaft water are lower than that for the ventilation shaft because this water is currently maintained inside the restricted plant area.

The analyses to date were available to the A.E.C. Compliance Division on their inspection visit.

When the treatment facility for radium removal is in operation samples will be taken weekly from the discharge and analysed for radium. Every two months complete analyses will be made as at present for the ventilation shaft.

IV MILLING

A. FLOWSHEET

This section deals with pressure vessel venting to atmosphere. Refers to:

<u>Interior</u> - p. 4, paras. 4 and 5

The mill flowsheet has been amended to include the present discharge to atmosphere from the series of 10 autoclaves through the pre-heat tank to atmosphere, and directly to atmosphere from the caustic precipitation tanks. (Figure 4)

The bleed-off valves on the autoclaves vent continuously to the pre-heat tank as required by the pressure in each autoclave. In passing through the water in the pre-heat tank the discharge is scrubbed of most of the chemicals and particulates.

The seven precipitation tanks are vented to atmosphere through a common header to carry any steam and chemical vapours to the outside of the building to maintain comfortable working conditions. The volume vented is small.

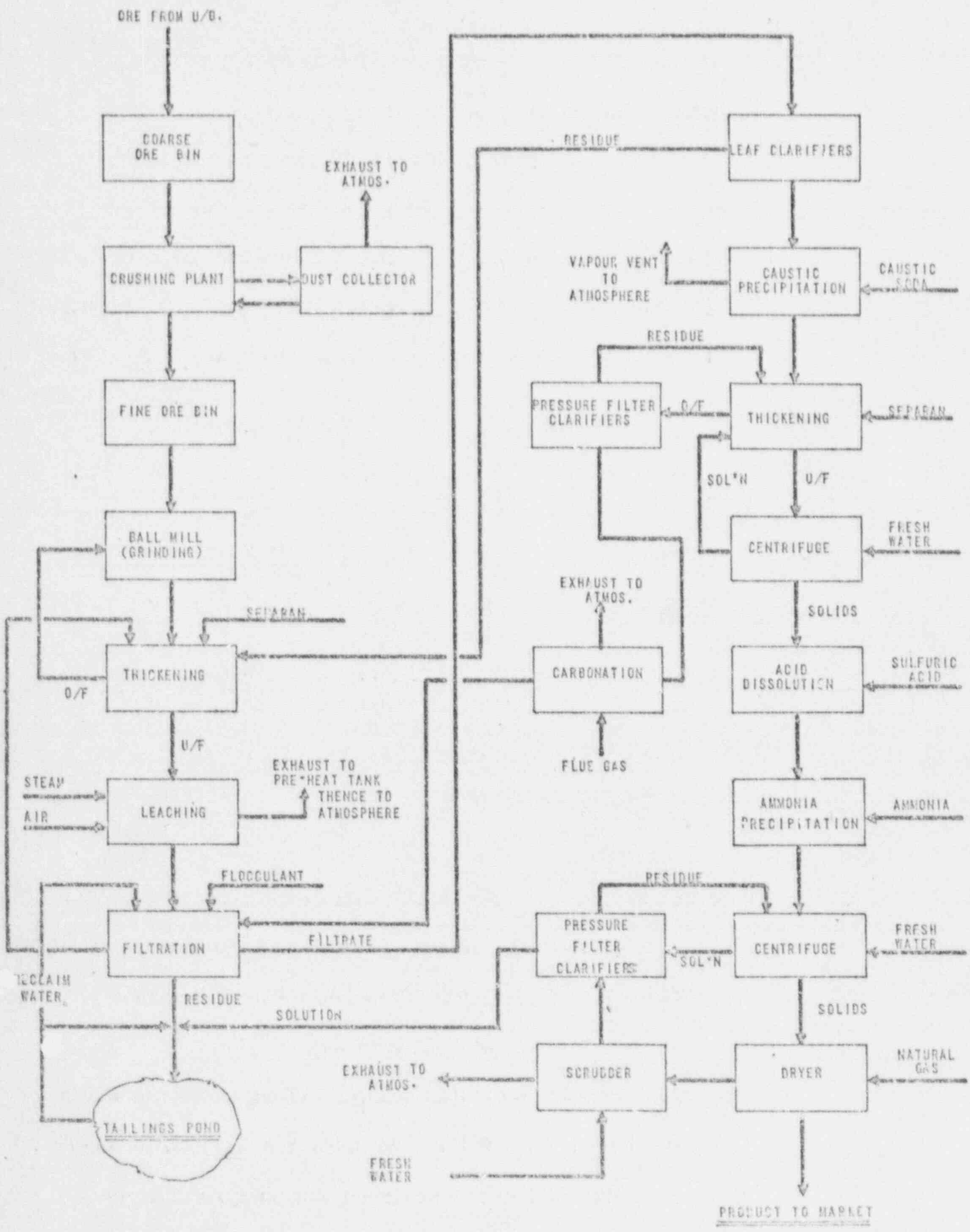
IV MILLING

B. OUTSIDE ORE STORAGE

This section deals with dust from ore storage piles. Refers to:

Interior - p. 4, para. 6

To date the outside ore storage pile has been used to a minor extent for both grade control and for drying of wet ore before crushing. For the first six months of this year the average


ORE FROM U/G.
COARSE ORE BIN
EXHAUST TO ATMOS.
CRUSHING PLANT
DUST COLLECTOR
FINE ORE BIN
BALL MILL (GRINDING)
SEPARAN
THICKENING
O/F
U/F
STEAM
AIR
LEACHING
EXHAUST TO PRE-HEAT TANK THENCE TO ATMOSPHERE
FLOCCULANT
FILTRATION
FILTRATE
RECLAIM WATER
RESIDUE
SOLUTION
TAILINGS POND
RESIDUE
LEAF CLARIFIERS
VAPOUR VENT TO ATMOSPHERE
CAUSTIC PRECIPITATION
CAUSTIC SODA
RESIDUE
PRESSURE FILTER CLARIFIERS
O/F
THICKENING
SEPARAN
SOL'N
U/F
CENTRIFUGE
FRESH WATER
EXHAUST TO ATMOS.
CARBONATION
FLUE GAS
SOLIDS
ACID DISSOLUTION
SULFURIC ACID
AMMONIA PRECIPITATION
AMMONIA
RESIDUE
PRESSURE FILTER CLARIFIERS
SOL'N
CENTRIFUGE
FRESH WATER
SOLIDS
EXHAUST TO ATMOS.
SCRUBBER
DRYER
NATURAL GAS
FRESH WATER
PRODUCT TO MARKET

monthly tonnage placed on the stockpile has been 2400 tons. Dust production has not been a problem because of the high moisture content in the ore.

The piled wet ore when it dries out tends to form a cake on the exposed surface due to the high clay content. Because of this caked surface normal wind velocities have little erosion effect.

IV MILLING

C. STACK DISCHARGE AND AMBIENT AIR SAMPLING

This section deals with procedures to determine dust discharged to the atmosphere. Refers to:

E.P.A. - p. 7, para. 3

Interior - p. 8, para. 6

In order to ensure the proper operation of the dust control systems the following procedures are called for:

1. Daily visual inspection of the dust filters and the attendant static pressure gauges.
2. Monthly isokenetic dust samples taken in the discharge stack from each filter. Samples are weighed to determine the total dust discharged and analyzed for the uranium content.

Figure 5

RIO ALGOM CORPORATION

LISBON MINE

URANIUM & DUST IN PLANT STACK DISCHARGE QUANTITIES

U_{nat}: 10^{-11} uc/ml　　　　Dust: mg/M^3

DATE	CRUSHER HOUSE STACK		TRANSFER HOUSE STACK		YELLOWCAKE SCRUBBER STACK		YELLOWCAKE DUST FILTER STACK		VACUUM PUMP STACK		HEADFRAME	
1972	U_{nat}	Dust	U_{nat}	Dust	U_{nat}	Dust	U_{nat}	Dust	U_{nat}	Dust	U_{nat}	Dust
JULY	.287	-	Bag Loose		.012	-	.118	-	.000	-	-	-
AUGUST	.256	-	.195	-	.020	-	.123	-	.000	-	-	-
SEPTEMBER	.240	-	.200	-	.003	-	.019	-	.000	-	-	-
OCTOBER	.284	-	.240	-	.005	-	.102	-	Discontinued		-	-
NOVEMBER	.317	-	.206	-	.009	-	.091	-			-	-
DECEMBER	.301	-	.263	-	.013	-	.052	-			-	-
AVERAGE	.28	-	.22	-	.01	-	.08	-	.00	-	-	-
1973												
JANUARY	.241	-	.200	-	.010	-	.102	-			-	-
FEBRUARY	.300	-	.187	-	.012	-	.110	-			-	-
MARCH	.011	1.00	.008	1.00	.760	1.00	.212	1.00			-	-
APRIL	.392	1.00	.668	2.00	1.021	1.00	.475	1.00			-	-
MAY	.543	1.56	.712	2.49	2.290	1.76	.386	.87			.024	.091
JUNE	6.62	*265.	.630	2.05	4.41	1.86	.288	.57			.054	.20
JULY	-	-	-	-	-	-	-	-			-	-
AUGUST	17.5	*345.	Nil	.06	27.59	.02	2.41	.0004			-	-
SEPTEMBER	65.0	*121.	.24	0.0	4.0	.007	.14	.07			.13	0.0

* Bags developed holes and are now replaced. Not in average.

Should any of the inspections or samples indicate that abnormal quantities of dust are being discharged, the system is examined to find the fault and corrective action taken.

Isokenetic samples have indicated that under normal conditions the discharge from the 5 dust discharge stacks runs between 0.9 and 2.5 mg/M^3, averaging below about 1.0 mg/M^3 which is much below the visible limit. The sampling results are given in Figure 5.

Ambient air samples were originally taken on a twice per week basis which has been reduced to twice per month in the vicinity of the plant. Baseline samples taken at surrounding points before mill start-up in June 1972 gave an average of 139 μg/M^3. (This happened to be a very windy period.) This may be compared to an average of about 20 μg/M^3 for a year of operation. The state ambient air standard is 90 μg/M^3 and the federal primary standard is 75 μg/M^3, annual geometric mean.

Ambient air samples are taken down-wind from the plant at distances of 500 to 3500 feet depending on the strength and direction of the wind at the time the samplers are set out.

The sample is obtained over approximately a 7 to 8 hour period on an 8 x 10 glass-fibre filter using a standard high volume sampler in an approved housing. The weight of the collected dust is then determined and the uranium content obtained by analysis.

Should any of the above samples indicate abnormally high values, or values over the MPC, the reason will be determined and corrective action taken.

IV MILLING

D. AMBIENT AND EMISSION STANDARDS FOR UTAH

This section comments on use of correct ambient air standards. Refers to:

E.P.A. - p. 5, para. 3

The ambient air standards effective 29 November, 1969 in Utah are:

	Pollutant	Concentration	Sample
State	Particulate	90 $\mu g/M^3$	Annual geometric mean
Federal (primary)	Particulate	75 $\mu g/M^3$	Annual geometric mean
Federal (primary)	Sulphur Oxides	.03 ppm	Annual arithmetic mean
Federal (primary)	Carbon Monoxide	9 ppm	8-hour average, not to be exceeded once per year

Emission standards for new installations require that the density of the visible emission shall be no greater than No. 1 Ringlemann Chart (20% black).

IV E DOWNWIND DUST CONCENTRATIONS

This section deals with actual dust emissions at the ventilation shaft discharge and at the operating plant stacks. Refer to:

E.P.A. - p. 2, para. 3
p. 5, para. 2
- p. 6, para. 2

Dust is emitted in the breaking of rock underground, and in its subsequent handling underground or on the surface until it comes to rest in the fine ore bin or on the waste pile, as the case may be. Subsequent treatment of the ore is a wet process, from which minimal dust is emitted until the drying and packing stages of the final yellowcake product are reached.

Ventilation of the underground workings extracts the dust and radon produced there and discharges them at the surface through the exhaust-fan stack. Dust-producing operations on the surface are also ventilated by exhausting the air from the locations where these are performed; the exhaust-fan discharges pass through filters and are then discharged to atmosphere through stacks of varying heights.

Some dust might be produced at the tailings pond, but as the tailings in the active tailings area will be under liquid cover most of the time during the lifetime of the mining operation, there should be a minimum fugitive dust from this source, and only towards the end of the operation.

Calculations of dust discharges in the Supplementary Environmental Report predated actual operations and were based on an assumed dust content of 1.5 milligrams per cubic meter in the case of the ventilation shaft discharges and of 0.03 grains per cubic foot (= 68.3 mg/M^3) for the surface plant discharges to atmosphere. The latter figure was based on the Company's specifications for the filter equipment on order.

Actual operating figures are now available, and revised calculations are based on these.

It is expected that the dust discharge by the ventilation shaft will decrease with time as the workings progress further from the return airway, allowing more time for the dust to settle out and to be removed by impingement. Recent sample results indicate this to be true.

Dust emissions from the various sources have been calculated as follows:

1. VENTILATION SHAFT DISCHARGE

Volume of air discharged		253,000 CFM
	=	7,160 M^3/min.
Average measured dust content		2.2 mg/M^3
Emission rate		15,750 mg per minute
Total dust emitted in 24 hours		22,700 grams
	=	50.1 pounds

2. SURFACE PLANT AIR DISCHARGES

The actual performance of the surface plant stack discharge dust filters has been considerably better than the specified emission rate of 0.03 grains per cubic foot or 68.3 mg/M^3, as shown below.

	Specification	Actual		Dust Emitted
	Airflow CFM	Airflow CFM	Dust mg/M^3	in 24 hours grams
Crusher house	13,000	13,000	1.19	315
Headframe	11,000	11,000	.097	21.7
Transfer Tower	2,500	2,200	1.27	57.0
Yellowcake scrubber	1,000	960	.941	30.7
Yellowcake dust filter	2,400	1,300	.585	25.9

Total emission 450.3 grams in 24 hours - under 1 lb.

Detailed calculations are shown in Table I, Appendix J.

ENVIRONMENTAL EFFECTS OF DUST EMITTED

The State of Utah's Ambient Air Standards limit particulate matter to an annual geometric mean of 90 ug/M^3 or 0.09 mg/M^3. All actual discharge concentrations from the operating stacks are higher than this during the period each particular unit is in operation, but diminish rapidly downwind from the stacks due to dispersion.

The ventilation shaft is located outside the plant fence, and it is improbable that there will be many people entering the area between this shaft and a minor road, on which travel is highly occasional, mainly by ranchers. The point on this road nearest the ventilation shaft is approximately 325 feet from it. Calculations of the dust content of the air at this point have been made according to Equation 3.3 (p. 6) in D. Bruce Turner's "Workbook of Atmospheric Dispersion Estimates" (published by the U.S. Department of Health, Education, and Welfare.)

The nearest point outside the property fence from any of the plant dust emitters is located about 250 feet from these sources. The concentration of dust at this distance from each of these emitters has also been calculated as well as the total emission from all the plant stacks.

Calculations of downwind concentrations from all these emitters at the points mentioned are reported in Tables 2a through 2c. Some anomalous results are apparent, and the results at these short distances must be treated with reserve.

The calculation used is: -

$$C = \frac{Q}{\pi u \sigma_y \sigma_z} \exp -\frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2$$

where C is the ground-level centre-line concentration (in g/M^3) of dust in the plume,

Q is the emission rate (g/sec) at the stack,

u is the wind velocity (M/sec),

σ_y, σ_z ar[illegible] he horizontal and [illegible]ertical dispersion coefficie[illegible], in meters, as a fu[illegible]ction of the downwind distance from source to point of measurement. These are obtainable from curves (Figures 3-2 and 3-3) in the Workbook.

H is the effective stack height, in meters.

The dispersion coefficients are naturally affected by the wind strength and by its directional stability. For the calculations, (Tables 2a through 2c, Appendix J) an average velocity of 5 mph (= 2.24 M/sec) has been taken, together with the most, least, and average stable conditions (Stability Classes F, A, and D respectively in the Workbook).

The effective height H of the stacks has been taken as the actual height in making these calculations. In the case of the ventilation shaft the discharge is horizontal; in the other cases discharge velocities are low, so that the plume would not rise very much above the actual stack. It is considered that no serious error is introduced by making this assumption.

Actual stack heights are:-

	Feet	=Meters
Ventilation shaft	6	2
Crusher	45	14
Headframe	75	23
Transfer	55	17
Scrubber	50	15
Filter	32	10

In making these calculations, average emission rates over 24 hours have been used for the individual surface plant stacks. Figures are also given for the total concentrations when all units are in operation simultaneously and for the totals over the 24 hour average emission rate.

To compare with the Utah ambient air standard of 0.09 (= 9×10^{-2}) mg/M^3, these concentrations, at the plume centre-line and at the nearest access points are summarized as follows:-

	mg/M^3		
	Stability A	Stability F	Stability D
Ventilation Shaft	9.4×10^{-2}	2.8	9.1×10^{-1}
Crusher	1.9×10^{-3}	1.3×10^{-14}	6.6×10^{-5}
Headframe	2.8×10^{-5}	9.9×10^{-38}	4.4×10^{-11}
Transfer House	2.2×10^{-4}	1.5×10^{-21}	4.7×10^{-7}
Scrubber	9.4×10^{-5}	9.0×10^{-18}	1.4×10^{-6}
Filter	1.4×10^{-4}	1.7×10^{-9}	8.9×10^{-5}
Total surface plant -	not including ventilation shaft		
1. all units in operation simultaneously	1.9×10^{-3}	1.7×10^{-18}	1.1×10^{-5}
2. 24-hour average	1.0×10^{-3}	8.9×10^{-19}	5.8×10^{-6}

With the exception of the ventilation shaft discharge when it reaches the road, all these discharges would meet Utah ambient air standards at any point of public access. Normally, with increasing stability however, that is from Class A towards Class F, concentrations would be expected to increase, but only in the case of the ventilation shaft do they do so. The method of calculation is generally considered to lose accuracy at the shorter distances, and this appears to be the case here.

IV MILLING

F. MAINTENANCE OF DUST CONTROL EQUIPMENT

This section deals with control of emissions during maintenance work. Refers to:

E.P.A. - p. 6, last sentence

Maintenance work is carried out on dust control equipment only when the process being controlled is itself shut down. While the overall milling process itself is on a full 24-hour a day basis various units in the process can be shut down for scheduled maintenance or because of temporary lack of ore.

V RADIATION

A. RADON DAUGHTER SAMPLING - CRUSHER AND MILL

This section deals with the requirements for a bi-weekly radon daughter sampling program. Refers to:

University of Utah - item 6, first half

A bi-weekly radon daughter sampling program has been instituted to demonstrate that radon daughters are below a significant level in the mill and crusher house. To date the readings have varied from 0.00 to 0.09 WL in about a dozen different areas in the two buildings.

V. B <u>AIR-BORNE RADIOACTIVITY</u>

This section deals with radioactive discharge resulting from the mining and processing operations. Refer to:-

<u>H.E.W.</u> - item 1

<u>E.P.A.</u> - p. 2, item 3
- p. 5, para. 2
- p. 6, para. 2, sentence 1
- p. 11, para. 2
- p. 13, items 1 & 2

<u>D.O.I.</u> - p. 7, para. 3

All the rock handled in the Lisbon operation contains some uranium and its daughter products, so the dust produced in handling also carries some radioactivity. Breaking of the rock releases gaseous radon, one of the daugnter products, into the atmosphere; further decay of the radon produces solid elements once again.

Ventilation of the underground workings extracts the dust and radon produced there and discharges them at the surface through the exhaust-fan. Dust-producing operations on the surface are also ventilated by extracting air from the locations where these are carried out by an exhaust fan; the discharge to atmosphere is through a dust filter or scrubber with release through stacks at varying heights.

V B 1. RADIOACTIVE EMISSIONS FROM DUST

The figures for radionuclide release in Appendix G of the Supplemental Environmental Report were based on the assumption that the dust discharged from the plant stacks would have the same uranium content as the ore, which had been assessed at 8 lb/ton of $U_3 O_8$, and that the radioactive disintegration products of the uranium would be in equilibrium with it.

Figures measured during actual operations (Figure 5, Section IV C, Part 2) are used in the following calculations.

a. Uranium (natural) emissions

	Volume of Air Discharged in 24 hours (M^3 x 1000) (From Table 1, Section IV E)	Radioactive Release		
		μCi/ml x 10^{-11}	μCi/day	Average μCi/Sec
Ventilation Shaft	10316	.07	7.22	8.36 x 10^{-5}
Crusher	265	.299	.792	9.17 x 10^{-6}
Headframe	224	.0527	.118	1.37 x 10^{-6}
Transfer House	44.9	.267	.120	1.39 x 10^{-6}
Scrubber	32.6	6.68	2.18	2.52 x 10^{-5}
Filter	44.2	.652	.288	3.33 x 10^{-6}

Total emission from the surface plant stacks is thus 3.5 μCi/day.

b. Thorium - 230, Radium - 226, and Radon - 222 from the surface Plant

At secular equilibrium in the ore, the radioactivity of natural uranium is equal to that of the associated Th-230, Ra-226, and Rn-222. These elements are not carried through to the yellowcake final product.

Thorium - 230

From the crusher, transfer house and headframe dust collectors only, Th-230 released

= .792 + .118 + .120 = 1.03 μCi/day

Radium - 226

From the crusher, transfer house and headframe dust collectors only, Ra-226 released

= 1.03 μCi/day from Ra-226 also.

Radon - 222

The radon emitted from the plant stacks will be that emitted while the ore is being handled on the surface. Once more therefore, radioactivity due to Rn-222, from the crusher, transfer house, and headframe collectors,

= 1.03 μCi/day from Rn-222.

V B 2A RADON - 222 EMISSIONS FROM THE VENTILATION SHAFT

The original calculations of radon and radon daughters in the mine air discharged at surface gave an estimated radon daughter figure of 1.0 WL from 3.9×10^{-7} μCi/ml of radon. Frequent tests of the air as discharged at surface indicate an average of about 0.58 WL of radon daughters. No radon readings have been taken, but on the assumption that the radon is reduced in the same ratio as the radon daughters, a value of about 2.25×10^{-7} μCi/ml of radon is derived.

$$2.25 \times 10^{-7} \text{ uCi/ml} = 2.32 \times 10^{-6} \text{ uCi/day}$$

V B 2B RADIATION DOSAGE FROM RADON - 222 RELEASED AT THE TAILINGS POND

The calculations in Appendix M of the Supplemental Environmental Report are valid up to the point where the diffussion of radon at the surface of tailings is calculated at 3.58×10^{-5} μCi/M^2/second. Further calculations are based on the fact that it is now proposed to build a second tailings pond upstream from the original one, which has not been filled, but will be used as a settling pond for decant liquid from the new pond before such liquid is recycled to the plant.

It has been calculated that 15 acres of the old pond will be covered with tailings before additions cease, and that the new pond will be covered to an area of 27 acres before the termination of operations.

The two ponds must be considered separately.

1. Original Tailings Pond - 15 acres

$$15 \text{ acres} = \frac{15 \times 4840 \times 36^2}{39.37^2} \text{ M}^2$$

$$= 60700 \text{ M}^2$$

Total Rn emission = $6.07 \times 10^4 \times 3.58 \times 10^{-5}$

= 2.17 µCi/sec or 1.87×10^5 µCi/day

2. New Tailings Pond - 27 acres (when completely filled)

$$27 \text{ acres} = \frac{27 \times 4840 \times 36^2}{39.37^2} \text{ M}^2$$

$$= 109,000 \text{ M}^2$$

Total Rn emission = $1.09 \times 10^5 \times 3.58 \times 10^{-5}$

= 3.90 µCi/sec or 3.37×10^5 µCi/day.

Final total emissions from both ponds will thus be $(1.87 + 3.37) \times 10^5$ = 5.24×10^5 µCi/day.

Rn-222 emissions from all sources will be:-

Ventilation Shaft	2.3×10^6 µCi/day or
Surface plant stacks	1.03×10^6 " " "
Tailings ponds	5.24×10^5 " " "
Total	2.82×10^6 " " "

The ventilation shaft discharge is thus in excess of 80% of the total.

V B 3 DOWNWIND RADIOACTIVE CONCENTRATIONS

Downwind calculations of radioactivity have been made, using the method also described for dust (Section IV E). In addition to concentrations at the nearest property boundary for each stability (A, F, and D), (Tables 1a through 1c, Appendix K), concentrations at 8,000 feet from the ventilation shaft and at $2\frac{1}{2}$ miles, the distance of the Redd Ranch from the mine, have been made, and are reported in Tables 2a through 2c and 3a through 3c, Appendix K, respectively.

Because information is not available from which a wind rose may be derived, calculations have been made on the basis that in each case the wind will blow steadily for 100% of the time towards the point of measurement, which is taken as lying on the centre-line of the discharge plume.

Where a number of stacks are emitting simultaneously, only if they were all in line could the receptor be on the centre-line of every plume. At the nearest property boundary, emissions from each source are considered separately, except the plant stacks, which are close together and have been taken as a single source. At the greater receptor distances, all emissions from the distant emitter are considered additive.

Calculation: -

In all cases, wind velocity u is taken at 5 mph, = 2.24 m/sec, and wind direction directly towards the receptor.

The calculation in this instance is (Compare p.40, Section IV E)

$$C = \frac{Q}{\pi\, u\, \sigma_y\, \sigma_z} \exp -\tfrac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$$

C = curies/M^3 or µCi/ml - downwind centre-line ground-level concentration.

Q = curies emitted per second

Type A stability has been assumed in Tables 1a, 2a, and 3a, Appendix K, as giving the lowest plume centre-line ground-level concentrations, Type F stability for Tables 1b, 2b, and 3b, as giving the opposite effect, while Type D, average stability, has been used in calculating Tables 1c, 2c, and 3c. The results for Type D only were used for derivation of radiation exposure calculations, pages 61&62. As in the case of the dust calculations, Section IV E, anomalous results (very low concentrations) were obtained for Stability F at the nearest distances.

Emission Rates: -

a. Stack Discharges. For these the emission rates shown on page 32 have been taken; total average emissions when all surface units are in operation at the same time, and total 24-hour average emissions have been calculated.

b. Tailings Ponds. The emission rates from two tailings ponds are shown on page 49 .

Tailings Ponds Calculations:-

For the purposes of calculation, downwind concentrations from an area source such as a pond, are assumed to originate in a virtual point source.

The distance of such a virtual source from the downwind edge of the pond, is found by dividing the side of the pond, taken as square, by 2 x the standard deviation of 2.15 for the downwind dispersion of an area source, taking the result as the horizontal dispersion coefficient from the virtual source, and deriving the distance from this. The downwind distance to the receptor is then the sum of the virtual source distance and the distance from the pond edge to the receptor.

The concentration downwind from an area source is given (Workbook) by

$$C = \frac{Q}{\pi \sigma_y \sigma_z u}$$

Where C = Concentration at downwind point in µCi/ml

Q = Quantity discharged by area source in µCi/sec

u = Wind speed in meters/sec

σ_y, σ_z are the horizontal and vertical dispersion coefficients in meters.

Virtual Source Calculations

1. Original Pond

Area = 60, 700 M^2; if square, side would be 245 M.

245 ÷ (2 x 2. 15) = 57 M;

a. At the nearest property boundary, 1000 feet = 305 M from pond edge: -

	Stability A	Stability F	Stability D
Virtual source distance giving horizontal dispersion coefficient of 57 M (From Fig. 3-2 in the Workbook)	260 M	2000 M	820 M
Distance from pond edge to boundary	305 M	305 M	305 M
Total Distance	565 M	2305 M	1125 M

For the total distances:-

σ_y	130	72	78
σ_z	180	23	34

b. At a boundary point, 8000 feet = 2500 M from mine operations:-

	Stability A	Stability F	Stability D
Virtual source distance	260 M	2000 M	820 M
Distance, mine to receptor point	2500 M	2500 M	2500 M
Total	2760 M	4500 M	3320 M

	Stability A	Stability F	Stability D
For the total distances:-			
σ_y	500 M	140	210
σ_z	3700	33	78

c. At the Redd Ranch, $2\frac{1}{2}$ miles = 4000 M from the mine:-

	Stability A	Stability F	Stability D
Virtual source distance	260 M	2000 M	820 M
Distance, mine to receptor point	4000 M	4000 M	4000 M
Total	4260 M	6000 M	4820 M
For the total distances:-			
σ_y	750	175	290
σ_z	8000	37	86

2. New Pond (when completed)

Area = 109,000 M^2, if square would have sides of 330 M.

The virtual distance of the source is found by dividing the pond side by 2 x 2.15 = 4.30 as before

$$330 \div 4.30 = 77 \text{ M}$$

a. The new pond is nearer the property boundary than the original pond. The nearest boundary is assumed to be at 500 feet or say 150 M.

	Stability A	Stability F	Stability D
Virtual source distance giving horizontal dispersion coefficient of 77 M (From Fig. 3-2 in Workbook)	330 M	2400 M	1090 M
Distance from pond edge to boundary	150 M	150 M	150 M
Total	480 M	2550 M	1240 M
For the total distances:-			
σ_y	115	80	65
σ_z	102	24.5	37

b. At a boundary point 8000 feet = 2500 M from operations:-

	Stability A	Stability F	Stability D
Virtual source distance	330 M	2400 M	1090 M
Pond edge to receptor point	2500 M	2500 M	2500 M
Total	2830 M	4900 M	3590 M
For the total distance:-			
σ_y	520	145	220
σ_z	4200	34	73

c. At the Redd Ranch, $2\frac{1}{2}$ miles = 4000 M from the mine:-

	Stability A	Stability F	Stability D
Virtual source distance	330 M	2400 M	1090 M
Distance, mine to receptor point	4000 M	4000 M	4000 M
Total	4330 M	6400 M	5090 M

For the total distances:-

σ_y	760	185	205
σ_z	9000	38	90

Calculations of downwind concentrations from both ponds are shown on Tables 1a through 1c, 2a through 2c, and 3a through 3c, Appendix K.

V B 4 RADIATION EXPOSURES

Additive Downwind Concentrations of Radioactivity

When a number of emitters are discharging simultaneously, only if they were all in line could the receptor ever be located on the centre-line of every plume. Additive figures for other cases can be obtained in a number of ways, but if it is assumed that all plumes are in a straight line, regardless of the wind direction at any moment, and that the downwind concentrations are additive, this would be the worst possible case. Such an assumption is not unreasonable for distances greater than 1 mile when the emitters are within a relatively short distance of one another, and this assumption has therefore been made in respect of the total emissions reported in Tables 2a through 3c. Additive figures for stability Class D emissions are given on p. 60.

For the short distances, -- from the emitter to the nearest access point - concentrations are considered individually, except in the cases of the surface plant stacks, these are sufficiently close together that they may by considered a single source; the total uranium emission from all five is only 1.36 times that of the highest single source, that of the crusher.

Radiation Exposures

The A.E.C. has laid down maximum permissible concentrations in air for radionuclides to limit the exposure of the whole body and certain critical organs to 1500 mrem per annum, in both restricted areas, which in general are those where people are exposed to radioactivity in the course of their employment, when exposure time is limited to a maximum of 40 hours weekly, as well as in unrestricted areas, where the general public moves freely for 168 hours per week.

MPC limits applicable to the Lisbon operation are as follows (μCi/ml).

Isotope	Restricted Areas (Exposure Limited to 40 hours/week)		Unrestricted Area 168 Hours/week	Critical Organ
Uranium (natural)	8×10^{-10}		3×10^{-10}	Whole body
	6×10^{-11}		3×10^{-12}	Kidney
Thorium - 230	2×10^{-11}	Soluble	5×10^{-12}	Whole body
	2×10^{-12}	Insoluble	3×10^{-13}	Lung
	2×10^{-11}	Soluble	8×10^{-14}	Bone
Radium - 226	5×10^{-11}		2×10^{-11}	Whole body
	3×10^{-11}		3×10^{-12}	Bone
Radon - 222	1×10^{-7}		3×10^{-9}	Lung

Unrestricted Areas

Additive Radioactivity, μCi/ml, at Stability D
at the Longer Distances
(From Tables 2c and 3c)

Emitter	At 2500 M	At 4000 M
URANIUM		
Ventilation Shaft	1.30×10^{-15}	8.57×10^{-16}
Surface Plant, at max. emission rate	8.71×10^{-16}	5.83×10^{-16}
Tailings Ponds	NIL	NIL
Total	2.17×10^{-15}	1.44×10^{-15}
RADON - 222		
Ventilation Shaft	4.14×10^{-10}	2.73×10^{-10}
Surface Plant, at max. emission rate	3.53×10^{-16}	2.37×10^{-16}
Tailings Pond, Old	1.89×10^{-11}	1.23×10^{-11}
Tailings Pond, New	3.45×10^{-11}	2.02×10^{-11}
Total	4.67×10^{-10}	3.06×10^{-10}
THORIUM - 230 and RADIUM - 226		
Ventilation Shaft	1.30×10^{-15}	8.57×10^{-10}
Surface Plant, at max. emission rate	3.53×10^{-16}	2.37×10^{-10}
Tailings Ponds	NIL	NIL
Total	1.65×10^{-15}	1.09×10^{-15}

Only the average stability (Class D) has been considered, since the extreme Classes A and F will not often occur.

In the further calculations it is assumed that 50% of the Thorium - 230 is in the soluble and 50% in the insoluble form.

EXPOSURE RATES AT NEAREST ACCESS POINTS (from Table 1 C)

1. Ventilation Shaft Discharge

Radionuclide	Uranium	Thorium-230	Radium-226	Radon-222	Total
μCi/ml	2.88×10^{-13}	2.88×10^{-13}	2.88×10^{-13}	9.14×10^{-8}	
Exposure, mrem/year for 100% occupancy					
Kidney - U	145	--	--	--	145
Lung - Th	--	2160	--	--	--
- Rn	--	--	--	4.59×10^{7}	--
Total Lung					4.59×10^{7}
Bone - Th	--	2700	--	--	--
- Ra	--	--	144	--	--
Total Bone					2840
Whole Body	1.44	432	21.6	--	455

2. Plant Discharge

Radionuclide	Uranium	Thorium-230	Radium-226	Radon-222	Total
μCi/ml	6.45×10^{-17}	6.45×10^{-17}	2.45×10^{-17}	2.45×10^{-17}	
Exposure, mrem/year for 100% occupancy					
Kidney - U	3.23×10^{-2}	--	--	--	3.23×10^{-2}
Lung - Th	--	6.16×10^{-3}	--	--	--
- Rn	--	--	--	1.23×10^{-6}	--
Total Lung					6.16×10^{-3}
Bone - Th	--	2.30×10^{-2}	--	--	--
- Ra	--	--	1.23×10^{-3}	--	--
Total Bone					2.42×10^{-3}
Whole Body	3.23×10^{-4}	3.68×10^{-3}	1.84×10^{-3}	--	5.84×10^{-3}

3. Tailings Ponds

	Old Pond	New Pond	Total
Radionuclide, Radon-μCi/ml	1.16×10^{-10}	1.76×10^{-10}	
Exposure mrem/year for 100% occupancy			
Lung	5800	8800	14,600

TOTAL EXPOSURE RATES AT THE FURTHER POINTS (See Table p60)

Distance		2500 M		4000 M	
		Total Concentration µCi/ml	Exposure mrem/year	Total Concentration µCi/ml	Exposure mrem/year
Organ	Radionuclide				
Kidney	- Uranium	2.17×10^{-15}	1.09	1.44×10^{-15}	7.2×10^{-1}
Lung	- Thorium	8.25×10^{-16}	4.13	5.45×10^{-16}	2.73
	- Radon	4.67×10^{-10}	233.	3.06×10^{-10}	153.
	- Total		2.37×10^{2}		1.56×10^{2}
Bone	- Thorium	8.25×10^{-16}	15.5	5.45×10^{-16}	10.2
	- Radium	1.65×10^{-15}	.825	1.09×10^{-15}	.545
	- Total		16.3		10.7
Whole Body	- Uranium	2.17×10^{-15}	.010	1.44×10^{-15}	.0072
	- Thorium	8.25×10^{-16}	.25	5.45×10^{-16}	.164
	- Radium	1.65×10^{-15}	.12	1.09×10^{-15}	.082
	- Total		0.38		0.253

Actual Exposure Rates To The General Public

The calculated concentrations and exposures have been based on a constant wind speed and a constant wind direction, directly towards the acceptor, and as these are improbable conditions actual exposures at a given point will not be the same as those calculated.

The assumption that all emissions at the mine are additive in the case of the more distant acceptor points, has been made to present the least favourable case, so even at constant conditions actual exposures would be lower than those reported.

In the case of wind speed, other factors being constant, exposures will vary inversely as the speed, taken as 5 mph for the calculations. Varying speeds will of course have some effect on the plume stability also, but the combined effect of small variations is not easy to determine.

Wind direction is a more important variable. The reported figures are based on a constant wind direction, day and night, and give the concentrations at the plume centre-line. Concentrations to either side of the centre-line fall off quite rapidly.

Wind records from the minesite show the following percentages for each direction under daytime conditions:-

Wind Direction From	%
North	2-1/2
Northwest	32
West	8
Southwest	20
South	4-1/2
Southeast	22
East	6
Northeast	5

The Redd Ranch at 2-1/2 miles distance, is the point of greatest interest, as being the nearest point inhabited by members of the general public. Located roughly to the northwest of the mine, it would be exposed to downwind concentrations a maximum of perhaps 25% of the time, reducing lung exposures to a maximum of 39 mrem per year and bone exposure to 2.7 mrem/year.

The 8000 feet (= 2500 M) point at the nearest boundary, and also in the direction of the wind of second highest daytime frequency, would also not be exposed to downwind concentrations more than 25% of the time.

The prevailing wind, from the northwest, blows in the direction of uninhabited areas; it can however be assumed that at the distances stated human exposures would be limited to one third of the calculated amounts.

V C RADIOACTIVITY IN TAILINGS DAM SEEPAGE

This section gives the radionuclide concentrations in tailings dam solutions.

Some seepage under the existing tailings dam is taking place, and measurements of contaminants are being made in the monitor wells, but the actual flow rate has not been established. For the present the previously used figure of 5 gpm (SEP, Appendix G, etc) has been taken.

Seepage in the monitor wells are being sampled on a regular basis and are analysed for uranium, thorium, and radium, as well as soluble salts. All constituents appeared to peak in June-July, before settling back to slightly lower levels, (Appendix B, plates 9a, 9b and 9c). Concentrations appear to be of the same order as naturally-occurring groundwaters in the area.

Average concentrations of radionuclides in the solution in the tailings pond are of the following order:

Uranium 2×10^{-5}	µCi/ml
Thorium 230 $< 2 \times 10^{-8}$	µCi/ml
Radium 226 2×10^{-7}	µCi/ml

Assuming 5 gpm seepage of this solution, radioactive releases are as follows:-

(Volume/day - $5 \times 1440 \times 3785 = 2.73 \times 10^7$ ml)

Uranium	$2.73 \times 10^7 \times 2 \times 10^{-5} =$ 550 µCi/day
Thorium - 230	$2.73 \times 10^7 \times$ (say) 2×10^{-8} µCi/day = 0.55 µCi/day
Radium - 226	$2.73 \times 10^7 \times 2 \times 10^{-7} =$ 5.5 µCi/day

Releases from higher or lower actual seepage rates can be calculated proportionately. As the uranium is the desired saleable product of the operation, efforts are constantly made to reduce the amount going to tailings, in solution or otherwise, and as much as possible of the solution is recycled to the process for further recovery of values.

VI. ECOLOGY

A. ACCESS TO TAILINGS POND SOLUTION

This section discusses the reduction of use of the tailings pond by birds and animals. Refers to:

<u>Interior</u> - p. 1, last para.
- p. 2, para. 1

<u>Agriculture (Soil Service)</u> - items 1 and 7

It is recognized that the type of fencing installed around the tailings area will not keep out small animals or deer. However from observations to date it is not expected that the number of animals entering the fenced area will be significant. Other than the water in the tailings pond, there is considered to be no particular attraction in the area. Forage should be as good or better outside as inside. There are now four reservoirs of fresh water in Coyote Wash within 2 to 4 miles of the tailings area plus water in irrigation ditches. With these good water sources available it is not expected that wild animals or birds will linger for long around a very unpalatable water source.

Because of the evaporation of water from the pond, the concentration of salts will gradually make the water more unattractive to wild life and will also tend to inhibit the growth of succulent forage around the edge of the pond.

The temperature of the pond in winter will probably not be much different from that of other ponds in the area, except near the point of discharge of tailings. There was ice on the pond for a considerable portion of last winter.

VI ECOLOGY

B. POWER LINE

This section refers to the design used for the feeder power line. Refer to:

Interior - p. 4, para. 2

The standard wood pole lines supplying the mine and the distribution lines around the mine site are all of a generally similar construction to that used by the local utility in the area. The conductors are in a triangular formation, using either one horizontal cross-arm or two inclined arms on wooden poles.

Because of the traffic in and around the mine and the noise from the highway few hawks or eagles are observed in the vicinity of the plant.

VI ECOLOGY

C. PLANT & ANIMAL INVENTORY & IMPACT

This section deals with an inventory of plant and animal life in the area. Refer to:

Department of the Army - item (d) 1

Interior - p. 4, para. 1

Agriculture (Soil Service) - items 2, 3 & 4

The Supplementary Environmental Report, Section 4.1.5, "Area Wildlife" and Appendix B, contains an inventory of the area wildlife and plants by the Bureau of Land Management for the area around the Lisbon mine.

The use of "understory density" in place of "forage density" would be more appropriate.

The total annual yield of forage for livestock ranges from 300 down to 150 pounds per acre per year of air-dried material, depending on soil fertility and moisture available.

The warm water fishery in the area is in Rattlesnake Pond.

The spelling of the technical name for the prairie dog has been corrected as has that of mourning dove.

VI ECOLOGY

D. SOIL & VEGETATION SAMPLING

This section refers to the soil and vegetation monitoring program being conducted. Refer to:

E.P.A. - p. 8, para. 1

1. Pre-Operational Program

The soil and vegetation sampling program consisted of a grid of 21 sample points set on an approximate 2000 foot grid, as shown in Figure 1. At each grid point a composite soil sample was obtained in the immediate area. The composite sample consisted of a set of nine 1-pound samples taken at a ten-foot spacing on a 30 x 30 foot grid adjacent to an identifiable point. Each nine pound sample was thoroughly mixed and a one pound sample analysed for uranium, .adium and thorium. Approximately two pounds were retained for future reference. Sample points are carefully identified and recorded so that additional samples may be obtained at the same location. At alternate soil sample stations, bulk vegetation samples were obtained. The succulent portion of these plants were analyzed for uranium, radium, thorium, copper, zinc and manganese.

A total of nine pre-operational vegetation samples were obtained.

No close-in vegetation samples were taken in the baseline program because:

1. Vegetation was rather scarce.
2. Animals are unlikely to be close to the plant to eat the vegetation due to noise and the presence of people.

2. Operational Sampling

(i) Soil Sampling

Twice per year soil samples will be taken as described in Section 4.1.9.3. of the Supplementary Environmental Report at points B-3, C-2, C-4, E-2 and E-5 as shown in Figure 1. Two control samples will also be taken at points 2 to 2-1/2 miles NW and NE of the mine. All will be analysed for uranium, radium and thorium.

If the samples indicate an upward trend in radioactivity, the points will be re-sampled. If the upward trend is confirmed, the sampling frequency will be increased and the cause determined and corrected.

(ii) Vegetation Sampling

Based on the recommendations of Dr. R.C. Pendleton, Director, Radiological Health Department, University of Utah, a set of 6 samples were obtained at B-2, C-4, D-2, D-3, E-3 and E-5 in June. (Figure 1). In future quarterly samples will be taken, plus two reference samples at sites remote from contamination from a uranium concentrator. Analyses will be for uranium, radium and thorium, copper, zinc and manganese.

If a significant upward trend in radioactivity is indicated, then the station will be re-sampled to determine whether the analysis was valid. Should an upward trend still be indicated, adjacent stations will be sampled and the cause of any increase in radioactivity sought and corrected.

VII HISTORIC SITES AND ARCHEOLOGICAL SURVEY

A. HISTORIC SITES

This section deals with adjacent historic sites and national monuments. Refer to:

Interior - p. 2, para. 4

The nearest national site is Canyonlands National Park which is located 25 miles west of the mine site, as is

Glen Canyon National Recreation Area. Natural Bridges and Hovenweep are National Monuments and Alkali Ridge is a National Historic Landmark, and are over 50 miles south of the mine.

VII HISTORIC SITES AND ARCHEOLOGICAL SURVEY

B. ARCHEOLOGICAL SURVEY

This section deals with an archeological survey and inventory of the plant environs. Refer to:

Interior - p. 3, paras. 1 and 2

Army - item d (2)

The Utah Department of Development Services conducted a survey of the plant environs at our request and found no historic sites that would be adversely affected by our operations.

This statement is given in Appendix F.

VIII WATER SUPPLY

A. RADIOLOGICAL ANALYSES

This section covers radiological analyses of the fresh water supply. Refers to:

University of Utah - item 1

Radiological analyses on the well field water have been performed as follows:

By the AEC Jan. 1973	U_{Nat}	7×10^{-10} µc/ml
	Gross Alpha	2×10^{-9} "
	Gross Beta	1×10^{-8} "
By Utah Div. of Health		
Jan. 1972:	Total Alpha	5.02pc/1
	Total Beta	4.79 "
June 1972:	Total Alpha	2.11pc/1
	Total Beta	4.04 "
By Eberline Laboratories		
July 1972:	Total Alpha	0.0 ± 2.5pc/1
Jan. 1973:	Total Alpha	0.0 ± 2.5pc/1 (2 samples)

IX ACCIDENTS, REPORTING AND RECORDS

A. ACCIDENTS

This section deals with transportation accidents, accidental in-plant chemical spills and operational controls. Refers to:

<u>E.P.A.</u> - p. 13, item 3
- p. 14, item 4

<u>Interior</u> - p. 5, para. 1

1. Transportation

The impact of an accident during shipment of yellowcake in steel drums by truck or rail is expected to be minimal. The accident rate for yellowcake shipments in truck or carload lots should be no greater than for shipment of any other substance of low chemical toxicity shipped in sealed steel drums.

In the event of an accident, only a relatively small percentage of the drums are expected to be ruptured, and not all the material from a ruptured drum will be dispersed to the evironment. If the accident occurs on land, most of this low specific activity material will be capable of being collected and returned to the plant for reprocessing. Only if there should be an accident adjacent to a body of water into which yellowcake becomes dispersed, would there be an apprciable hazard to aquatic life. The chance of such an accident occurring is statistically minute. However should such an accident occur every effort will be made to remove this heavy material from pockets in which it will settle in the waterway. Monitoring of the waterway will be conducted to ensure that the clean-up has been effective in reducing the impact of a spill as far as practical.

The exact method of transport and routing have not been worked out as yet because the shipment date for our main contact is about one year distant.

In September to November this year some 8 cars will be shipped on a minor contract. This will involve trucking some 60 miles to the nearest rail siding, at which point the purchaser assumes responsibility. During truck shipment the only water crossed, other than drainage ditches which are normally dry at that time of year, is the Colorado River on a standard steel highway bridge just north of Moab on Highway 160. The first shipment has arrived without incident.

2. Chemicals

The tanks used for storage of sulphuric acid, caustic soda and anhydrous ammonia all conform to state and federal specifications for their specific uses. Should a rupture occur in any tank or line the discharged chemical will be contained within a spillage basin immediately below the mill. All liquids not retained at the plant will eventually drain to and be contained in tailings basin, where storage capacity is many times the possible spill.

Routine mechanical checks are maintained on the system and drenching showers are provided in all areas where personnel might become contaminated. All personnel handling corrosive substances are warned of potential hazards and if necessary are required to wear protective clothing.

3. Operational

Automatic alarms are not used to any great extent in the milling process, their primary purpose being protection of personnel and equipment. The major automatic control and alarm system installed is one to guard against failure of water used to control the temperature of the yellowcake dryer discharge gas. Should the water volume drop too low, the high temperature could cause the fibreglass scrubber to fail with resultant release of yellowcake. The control automatically shuts down the furnace exhaust fan and sounds an alarm, when an excess temperature is recorded.

IX ACCIDENTS, REPORTING AND RECORDS

B. REPORTING AND RECORDS

This section deals with reporting of accidents and maintenance of monitoring results. Refer to:

E.P.A. - p. 8, last para.

Should there be an uncontrolled discharge of tailings or effluent or release of chemicals or radioactivity this will be reported to the A.E.C. etc. as given on page 115 of the Supplementary Environmental Report.

Results of all monitoring sample analyses and data are recorded and available for inspection at the mine site by the agencies concerned.

X IMPACT OF THE OPERATION

A. SOCIAL, ECONOMIC AND HUMAN

This section deals with the inter-relationship between the social, economic and human values. Refer to:

Interior - p. 1, para. 3

The operation over the estimated 7-years of its duration offers employment at a relatively uniform level, summer and winter, and under a carefully controlled environment in respect to safety and health. In a region where employment is limited, the work force will be drawn from the established communities of Moab and Monticello and surrounding areas, employing the native Hispanic population to a considerable extent. No temporary townsite is involved in the operation and no inhabited area will be left abandoned when the deposit has been worked out. During the years of mining activity the local economic benefit is apparent, and the employment being offered at a uniform level, can only contribute to social welfare. At present the total payroll runs at about 200 persons.

The operation is in no way characterized by such detractions as area defacement, noise, dust, or odours, so as to downgrade the area and make it unattractive for the local population or the tourists, either during its life or after shutdown. (Appendix L)

X IMPACT OF THE OPERATION

B. NATIONAL ENERGY SUPPLY

This section covers the importance of this operation in the total uranium supply. Refer to:

Agriculture (Research) - item 1

At its current and planned level of production of 1,200,000 pounds of U_3O_8 in uranium concentrates per year the Lisbon mine and mill, brought into production at an initial capital cost of some $24 million, is contributing some 4 to 5 percent of the total national supply of uranium concentrates at the current national level of production. This production also constitutes about 50 percent of the total current annual production in the State of Utah.

A tonnage increase is planned which is expected to produce about 1,600,000 pounds of U_3O_8 of concentrates per year after 1973. There is now no expected change in the anticipated life of the operation.

Virtually all the production from Lisbon is dedicated, under long-term contract to 1980, to the Duke Power Company of Charlotte, North Carolina, one of the largest investor-owned electrical utilities in the U.S.A. The Duke Power Company has one of the largest nuclear power plant construction programs in the country, and although its uranium requirements will be much in excess of its purchases from Lisbon, the latter constitutes for Duke Power a quite meaningful supply source. In the supply/procurement sense, production from Lisbon is virtually "captive" to the Duke Power Company.

Because of the major, and constantly growing, commitment of the electric utility industry in U.S.A. to nuclear power plants as a prime source of heat for the generation of electricity, national requirements of uranium are growing very rapidly, and annual requirements are generally fore-cast to double every 5 years. In terms of requirement and use uranium is probably the fastest growing of any mineral commodity. The current level of demand in the U.S.A. is about 8,300 tons of U_3O_8 in uranium concentrates per annum. U.S.A.E.C. (and industry generally) forecast that this requirement will rise to 31,600 tons by 1980, and to 58,800 tons by 1985.

There is broad national consensus that every viable economic source of uranium now known to exist will be vitally needed in the near future, and considerable concern is being expressed now about the inadequacy of current exploration efforts to discover new reserves to meet the quite enormous national requirements of this commodity in future years. If the rapidly growing requirements cannot be met economically from domestic U.S. sources, large imports of foreign-produced uranium, currently excluded by embargo, will have to be made, subject to availability of such foreign uranium. From the viewpoint of balance of payments, it is of course desirable to maximize production of this vital energy source from economic deposits, such as Lisbon, known to exist within the U.S.A.

Being a small underground mine, Lisbon is a labour intensive source of uranium. Such deposits may be expected to be of less interest to operators in later years due to rising costs.

X IMPACT OF THE OPERATION

C. LOCAL POWER SUPPLY

This section deals with the impact of the facility on the local power supply system. Refer to:

Federal Power Commission Letter

The Utah Power and Light Company have stated that estimated future maximum demand of 4,000 KW and monthly consumption of 2.5 million KW Hr. will have a negligible impact on their system in view of their planned plant increases.

The final comment by the Federal Power Commission is given in Appendix M.

X IMPACT OF THE OPERATION

D. WITHDRAWAL OF ACREAGE

This section deals with withdrawal of some acreage from certain usages because of the operation. Refer to:

Agriculture (Soils Service) - item 8

After the completion of the mining operation, and after monitoring of the area has been carried out, the 120 acres lying outside the estimated 45 acre tailings area should be open to the public.

The tailings area will have to remain under certain restraints for at least 50 years, or, until declared free from radiation hazard by the A.E.C. or other competent authority.

XI ALTERNATIVES

A. ALTERNATIVE MILL SITES

This section deals with alternative mill sites. Refers to:

Agriculture (Forestry) - item 4

The nearest available operating mill that could treat the ore being mined is some 34 miles distant. Apart from the dollar cost to the company of transportation, there are a number of intangible costs:

1. Cost to the state for increased highway maintenance due to heavy trucks.
2. Danger of increased highway accidents due to increased traffic.
3. Interference with tourist traffic in a scenic area.
4. Spreading of radioactive contamination along a public highway from dust blown from the ore trucks.
5. Annoyance to citizens of Moab due to increased truck traffic through the city centre.
6. Increased total weight of pollutants being discharged from the existing mill at the Colorado River due to the increased tonnage.

If the mill for the Lisbon Mine were to have been constructed at some site other than at the mine, the following are some of the disadvantages other than costs to the company.

1. If trucking is involved to any other site, items 1, 2, 3 and 4 above apply.
2. An adequate fresh water supply probably will have to be developed.
3. A tailings pond would still have to be constructed using land of the same or higher value.
4. A larger total area would be used with separate mine and concentrator than with a combined operation.

The alternative employed is a self-contained operation, separate from the public and from built-up areas, and away from surface waterways. Some 120 acres of low value land are used for 8 - 10 years and 45 acres of this area will have restrictions as to use for a further period.

XI <u>ALTERNATIVES</u>

B. <u>NO ACTION</u>

This section deals with "no action" alternatives. Refers to:

<u>Army</u> - item d(3)

If the mining and milling operations had not been started the following adverse effects would have been avoided:

1. The energy potential of 8.4 million pounds of uranium would have remained in the ground for the future.
2. 120 acres would not be temporarily withdrawn from grazing, etc. for 8 - 10 years. This acreage represents grazing for only 2 head of cattle for six months, the usual winter range period for this area.
3. 45 acres in the tailings area would not be withdrawn from use for 50 years or more.
4. The topography would have remained unchanged by not constructing the tailings dam and pond and depositing 400,000 tons of waste rock.
5. No additional low levels of radioactivity would have been released to the environment.

The following benefits would also not have been gained:

1. Stable employment for some 200 people would not have been provided in an area of high unemployment.
2. Local, state and federal governments would not receive increased tax revenue from this operation.

3. The national power shortage which Duke Power hopes to assist in relieving by supplying by means of nuclear generation would have to be supplied by other energy sources, such as fossil fuels, with their attendant higher pollution levels in high population areas.
4. The 200 gpm fresh water source would not have been provided to the water-scarce area.

XII BENEFIT - COST ANALYSES

A. BALANCE OF BENEFITS AND COSTS

This section deals with additional benefit - cost factors. Refer to:

Agriculture (Research) - item 2

Regarding Rio Algom's mining and milling operation some 200 full time jobs are now being provided and are expected to last at least another 8 years. These assist in building a relatively stable economy for the area with resultant tax benefit to the municipality, state and country. The uranium fuel provided will produce power that would otherwise be generated by use of fossil fuels in areas with already high air pollution. By using nuclear power generation the fossil fuels are preserved for use by the petrochemical industry for a higher return in other applications. Balanced against these short-term benefits are some degree of air and water pollution and the withdrawal of some 120 acres from grazing.

The long-term benefits are an assured water supply of 200 gpm for cattle watering as balanced against the removal of 8 million pounds of uranium and the probable withdrawal of 45 acres from grazing for over 50 years.

In summary, the benefits are immediate, obvious and substantial as compared to trivial and speculative costs.

APPENDIX A

THE UNIVERSITY OF UTAH

SALT LAKE CITY 84112

RADIOLOGICAL HEALTH DEPARTMENT
100 Orson Spencer Hall

July 18, 1973

Mr. P. F. Pullen
Chief Environmental Engineer
Rio Algom Mines, Limited
120 Adelaide Street West
Toronto, Canada

Dear Mr. Pullen:

Per your request I have re-done my replies to your questions.

I have also found uptake of radium in organisms grow on soils heavily contaminated with tailings from a uranium extraction plant. However, such uptake by plants from any materials in your plant site could only be expected to occur after the tailings pile has been established and covered. If the cover is insufficient there should be some plant uptake over a protracted time. This could be especially serious if there were breaks in the soil mantle as a result of erosion.

Plants grown in such a situation would give a characteristic spectrum of radionuclides associated with the makeup of the tailings materials below. However, the quantity of radium in the plants would be a direct giveaway since this would be higher than the levels in the parent soils and would be presumptive evidence that the plant roots had reached the zone of relatively high concentration and were transferring the radium from that source. However, the uptake of radium by plants growing over the very small area of your tailings plant would not make a significant contribution to game animals or livestock grazing through the area when compared with the general level of radioactivity in the soils of San Juan County, and particularly the area surrounding your plant.

I regret that it has taken so long for me to reply to your original request.

Sincerely yours,

Robert C. Pendleton, Director
Radiological Health Department

ts

Enclosure

RIO ALGOM

1. How will a determination be made as to whether any radioactivity found in plants is the result of dry deposition or uptake from the soil?

Results of sampling of many thousands of plants in the intermountain area show very low or nonexistent levels of natural radioactive materials of the kinds that would be associated with your operation. However, the soils surrounding the Rio Algom Mine all contain appreciable quantities of uranium, radium, thorium, and the associated daughter products. Accordingly, low levels of all these materials could be expected to be present in plants but would be represented in direct proportion to the amount of radioactive materials in the soils. With this situation, it would be very difficult to separate radioactivity found in or on the plants from that taken up from the soil, since all the elements named have been observed to be transportable as wind-borne dust and a considerable amount of contamination of low-growing plants results from splash-up of surface soil during the intense rainfall associated with thundershowers, ~~which is~~ the predominant source of summer precipitation. Sampling performed in this laboratory indicated that whenever a significant quantity of radioactivity from the natural emitters (other than potassium) is found, it has originated from direct deposition of soil or dust. More important than attempting to determine whether the radioactivity has its origin in plant uptake or dust is the determination of a base level which can then be used to determine whether or not an increase in the vicinity of the mine can be demonstrated. This can be done by sampling representative species of plants adjacent to and distant from the operation and in sufficient numbers to act as a statistically valid level from which all future sampling can be compared. Following this, sampling on a specified schedule can be used to determine what build up, if any, has occurred.

Determination of changes can be made as follows:

Sample three plant types on a schedule of at least once each calendar quarter: sagebrush (Artemesia tridentata), juniper (Juniperus Utahensis), and meadow clippings (mixed grasses from the improved grazing areas).

Sample sagebrush by plucking off the new growth-leaves and new, succulent stems.

Sample juniper by pulling off the leaves.

Sample grasses by cutting the stems with grass clippers. Take great care to cut above any evidence of rain splash-up. This will show as dry mud on the lower stems and leaves.

Each sample should be at least two kilograms (2.2. lbs/kg) and one sample of each type should be taken from each of your sampling sites, and from many different shrubs and trees within the area of the sampling site.

Analyses should be made for U_3O_8 by methods developed in your laboratory. In addition, analyses using gamma spectrometry should be performed on an aliquot of each sample. The gamma-ray spectrometry analyses will show the presence of fallout nuclides, but will demonstrate the presence of very low levels of Th and Rn daughters (Bi-214 and Pb-214).

separated from plant fragments. (Microscopic examination of the dust would provide conclusive identification of the material.) Only if an increase in Po-210 or U_3O_8 above the recorded quantity in soil is found on the plants would corrective ac ion be indicated.

4. At what concentration in soil, vegetation, water or animal, will actions be taken to prevent a further increase in contamination?

Action to reduce release of uranium oxide will be taken if any demonstrable increase of this nature is detected. Since the quantity of U_3O_8 required to make a demonstrable contamination exceeds the quantity normally released by the plant by many thousand-fold, it is inconceivable that such a serious loss of product could occur. However, levels applicable to this problem will be those given in Paragraph B, Title 10, Part 20, Code of Federal Regulations, for air pertaining to uranium and daughter products in unknown mix.

Action involved in stopping the contamination would involve tightening procedures for limiting loss of U_3O_8 in the production system and limiting of releases of dust.

5. What biological organism will be used to set the limit?

Determination of accumulation of uranium, thorium, or daughter products should be made using the liver, kidneys and femur of the blacktail jackrabbit (Lepus californicus). This animal is sufficiently abundant in the vicinity of the plant to be obtained in sufficient numbers for sampling throughout the year and has the advantage over all other species in the area of having broad food selection habits, thus acting as an integrator of any contamination levels that might be encountered on plants.

Other rodent forms are too seasonal and too few for use in this operation, there are no deer present in sufficient numbers to be used for samples, and cattle spend so little time in this area as to be useless from the standpoint of sampling specimens.

During a thorough ecological surveillance of the area surrounding your plant, I noted a very rich fauna of songbirds, cottontail rabbits, and jackrabbits. I observed tracks of a resident herd of deer comprised of two does, one fawn, and one yearling buck. There were no game birds nor were there sites for their breeding. The resident organisms do not obtain and cannot obtain enough uranium, thorium or uranium daughters from any source to have a demonstrable effect on the health of the organisms nor their reproductive potential. The only effect on wildlife will be the reduction of available juniper pygmy forest as the tailings pond deepens. Although winter populations of deer may be larger than the resident herd, it is highly doubtful that any significant numbers will remain in the vicinity of the plant, and the total ingestion under the conditions that are being maintained could not have a demonstrable effect on these animals. This is also true of the occasional livestock grazing the area.

So long as the materials found in the plants show essentially the same ratio of radioactive materials as found in the soils one can assume that the accumulation stems from soil splash-up or wind transported dust.

2. If radionuclides are found in plants, what will be the equilibrium concentrations of the radionuclides in plants?

Except for plants growing at the edges of the tailings ponds that might have root access to seepage, no long-term buildup of radionuclides in plants is possible. The toxic properties of the tailings water precludes growth that might accumulate nuclides.

All plants growing in the area, excepting juniper and pinyon (Pinus edulis), are deciduous. Sagebrush retains leaves over winter, but drops all old leaves when the new crop appears in the spring.

Juniper and pinyon replace needles and leaves progressively, but a complete replacement is usually accomplished in two to five years. These species are only minor foods for deer in winter and are not cropped by cattle. The juniper has been proved to be efficient in retaining fallout radionuclides, however, and should prove to be a valuable species for analysis of any buildup of airborne effluents.

Because the only significant route of accumulation in plants is via airborne dusts, the dropping of edible leaves and die-back of grasses and annuals each year precludes accumulations greater than could be deposited in a single growing season. The sampling methods outlined above will show any increases during the growing season, and annual mean values can be compared for determining changes in subsequent years.

3. How long will radionuclides, if found on plants, persist after operations have ceased?

Annual die-back of grasses, loss of deciduous foliage, and gradual loss of leaves from evergreen species precludes persistence beyond five years. Because the soils in this area are uraniferous, some transfer from surface soil (not via roots) may always be expected on some plants in the same amounts as were found before the mine was built.

Because the quantity of U_3O_8 released by your plant is so small, it is doubtful that a demonstrable build-up of this material can be expected, but the sequential sampling-analysis procedure I have described will show any changes associated with time.

The soils of this region are high in uranium, radium, thorium and associated daughter products. Wind-borne dust and rain splash-up are the principle ways that vegetation in this area could become contaminated with isotopes that might be construed as having origins in your plant. Surface contamination of plants as a result of soil transfers (splash-up or dust - secondary aerosols) can be easily identified by simple mechanical separation of the dust by shaking dried material in a plastic bag and sampling the dust

APPENDIX B

REPORT OF CONSULTING SERVICES
TAILINGS POND EMBANKMENT STABILITY
AND
GROUND WATER GEOHYDROLOGY SEEPAGE EVALUATION
LISBON VALLEY MINE TAILIN. /ISPOSAL SYSTEM
NEAR LA SAL, UTAH
FOR RIO ALGOM CORPORATION

Dames & Moore Job No. 7144-002-06

October 2, 1973

Rio Algom Corporation
120 Adelaide Street West
Toronto 1, Canada

Attention: Dr. R. D. Lord, Vice President
Research and Development

Gentlemen:

Six copies of our report "Consulting Services, Tailings Pond Embankment Stability and Ground Water Geohydrology and Seepage Evaluation, Lisbon Valley Mine Tailings Disposal System, Near La Sal, Utah, For Rio Algom Corporation," are herewith submitted.

The purpose and scope of our consulting services were described in our letter of May 17, 1973. This scope was altered to meet existing conditions and requirements during numerous discussions between Dr. R. D. Lord, Messrs. J. E. Moyle, P. F. Pullen and M. D. Lawton of Rio Algom Corporation and Messrs. George Toland, William Mead and George Lamb of Dames & Moore. A draft of our report was reviewed by your engineering staff prior to this final submittal.

The results of our evaluations indicate that adequate safety factors for embankment stability and flood control exist in the present tailings pond system and that by following the recommendations provided in this report, a satisfactory continuing disposal system can be developed. Off-site ground water contamination from the tailings system can be avoided by implementation of the control measures proposed herein.

oOo

We appreciate the opportunity of performing this service for you. If you have any questions concerning this report, or if you desire additional information, please contact us.

Yours very truly,

DAMES & MOORE

George C. Toland

George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

William E. Mead

William E. Mead
Consulting Partner
Professional Geologist No. 939
State of California

GCT/WEM:ab

Enclosures

REPORT OF CONSULTING SERVICES
TAILINGS POND EMBANKMENT STABILITY
AND
GROUND WATER GEOHYDROLOGY AND SEEPAGE EVALUATION
LISBON VALLEY MINE TAILINGS DISPOSAL SYSTEM
NEAR LA SAL, UTAH
FOR RIO ALGOM CORPORATION

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INTRODUCTION

GENERAL

This report presents the results of our consulting services for Rio Algom's tailings disposal system at the Lisbon Valley Mine near La Sal, Utah. The location of the mine with respect to major roadways and towns in southeastern Utah is presented on Plate 1, Location Map. Detailed maps of the system and the surrounding area are presented in Part I and Part II sections of this report.

PURPOSE AND SCOPE

The extent of our services was planned and subsequently altered during numerous discussions between Dr. R. D. Lord, Messrs. J. E. Moyle, P. F. Pullen and M. D. Lawton of Rio Algom Corporation and Messrs. George Toland, William Mead and George Lamb of Dames & Moore. The purposes and scope of our services as developed are presented as introductory sections in the Part I and Part II sections of this report.

SITE CONDITIONS

SURFACE:

The plant site is located approximately four miles south of La Sal, Utah and seven miles southeast of La Sal Junction. The Rio Algom mine tailings disposal area is located in a small west-trending drainage area, approximately one-half mile west of the main mine shaft.

Overburden soils cover the flatter slopes of the site. Weathered sandstone bedrock outcrops on the valley flank. A sparse growth of grass, weeds and sagebrush is found on the flatter slopes. Pinon pine and juniper trees are the predominant vegetation in the steeper areas adjacent to bedrock outcrops.

SEISMICITY:

The seismicity of the Lisbon Valley Mine was provided in our report of February 24, 1972 to Rio Algom. The site was placed in a Zone 2 seismic area with a horizontal force of 0.05 times gravity recommended for design.

SITE GEOLOGY:

The surficial geologic materials in the site vicinity consist of overburden soils and outcrops of Burro Canyon (Dakota) sandstone.

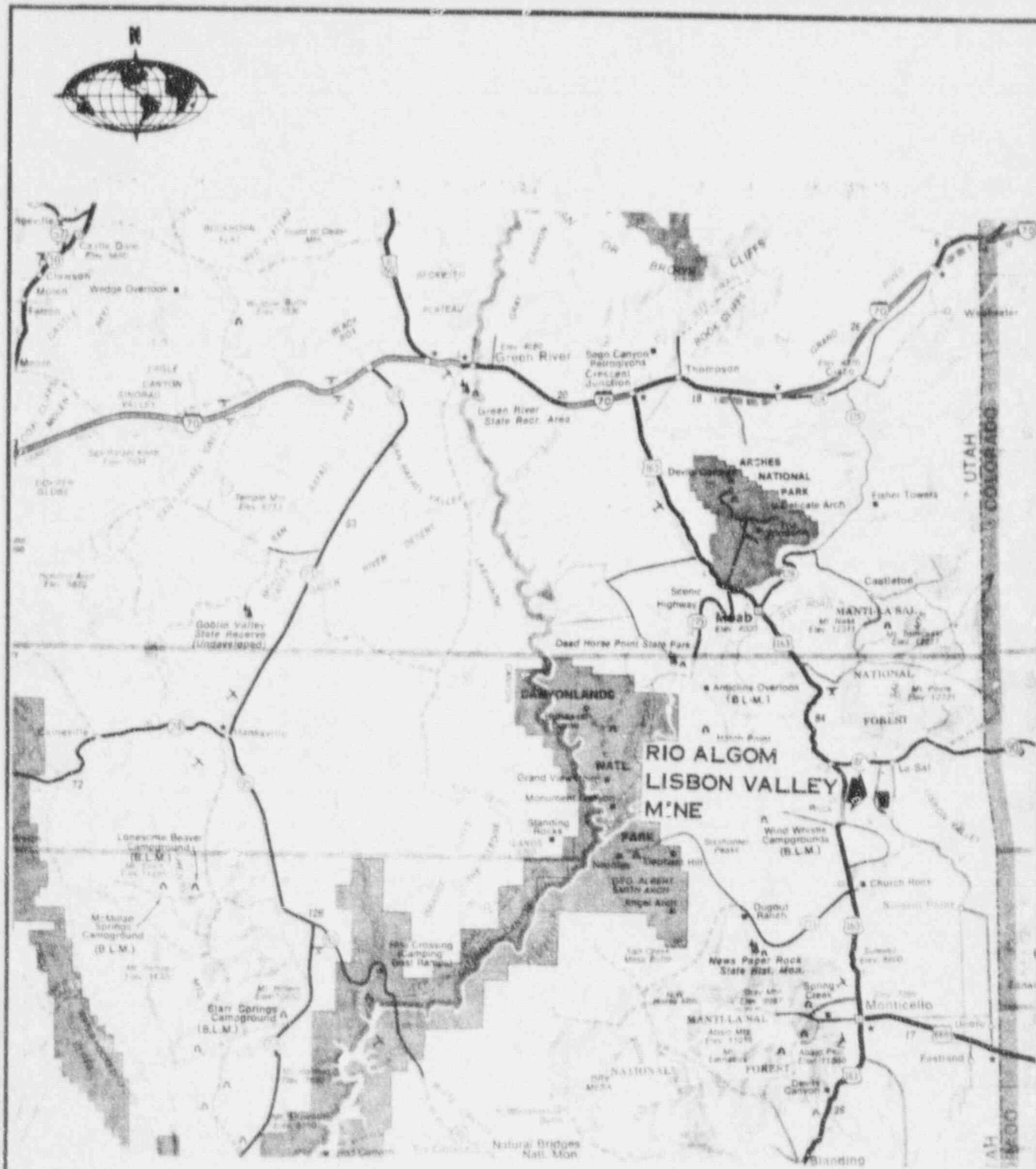
Residual soils, slope wash and alluvium comprise the overburden. The residual soils and slope wash occupy the flanks of valleys and rarely exceed 10 feet in thickness. They consist of sandy clays and clayey to silty sands. The alluvium varies from 5 to 60 feet thick and is composed of sandy silts containing abundant gravel.

The Burro Canyon sandstone is on the order of 280 feet thick where not eroded, as on the Norma claims in the north extremity of the property. In the vicinity of the tailings dam, this formation is over 100 feet thick, except in the buried channel beneath the dam, where erosion has reduced its thickness to 35 or 40 feet. In outcrops the Burro Canyon sandstone is highly weathered and fractured.

Beneath the Burro Canyon beds is a thick series of impervious shales and mudstones comprising the Brushy Basin Member of the Morrison Formation.

Local bedrock folding is extensive and conforms to the regional pattern. The East Coyote Syncline, a major structure, lies less than a mile northeast of the site. The Lisbon Valley Anticline enters the property from the southeast and merges with an unnamed syncline along the same structural trend. All of these folds have a northwesterly axial orientation. One-quarter mile southwest of the site boundary lies the Lisbon Valley Fault, which also strikes northwest, parallel to the folding.

Formations as deep as the Permian Cutler beds have been penetrated at the site. Detailed maps in Part II of this report relating to ground water and seepage show the general structural relationships of the area.



REFERENCE
STATE OF UTAH ROAD MAP

Scale: One inch: approximately 17.4 miles

LOCATION MAP

DAMES & MOORE

PLATE 1

BY H.D.T. DATE 9-26-73 FILE 7144-00- RIO ALGOM- MOAB REVISIONS BY ____ DATE ____
CHECKED BY ____

PART I
TAILINGS POND EMBANKMENT STABILITY

PURPOSE AND SCOPE

As described previously, the purpose and scope of our studies were developed progressively as the needs and design options became evident.

The purpose of our Tailings Pond Embankment Stability Studies (Part I), as developed and presented in this section of our report, was to:

1. Determine the stability of the existing tailings pond embankment.
2. Define requirements for a continuing tailings storage system.
3. Provide answers to questions of stability and tailings pond development posed by the agencies which reviewed Rio Algom's "Supplemental Environmental Report."

In accomplishing the above purposes we performed the following scope:

1. A field investigation under the direction of an experienced geological engineer from our staff consisting of:
   a. A general site reconnaissance.
   b. The drilling of 8 test borings.
   c. The excavation of 6 test pits.
   d. The drilling and installing of two monitor wells.
   e. The installation of 7 piezometers in Borings 1 to 7.
   f. A field survey.

2. A laboratory testing program to determine the engineering properties of the soils encountered.
3. Technical and analytical evaluations of the existing and future tailings system. The analytical approach used in determining the overall stability analysis was the ordinary method of slices (Fellenius Method). The analysis was performed on a Univac 1108 electronic computer utilizing a program developed by Dames & Moore.
4. Presenting our data, analyses, conclusions and recommendations in the Part I Report.

EVALUATION OF EXISTING TAILINGS POND EMBANKMENT

BASIS OF DESIGN:

The embankment location and maximum pool elevation are shown on Plate 1, Plot Plan. The configuration and physical characteristics of the existing tailings pond embankment presented herein is based on a general site reconnaissance of the area, verbal discussion with personnel familiar with the construction of the embankment, a review of reports by others, and the results of our field exploration program.

Field exploration data and laboratory test results pertinent to the embankment and foundation soils are presented in the appendix of this Part I Report. The soils encountered in Boring D1, D2 and D4 overlying the sandstone bedrock were found to be medium-stiff to very stiff, reddish-brown to brown, fine, sandy silty clay to fine, sandy clayey silt. These materials are considered typical of the natural soils and compacted embankment fills. The geometry of the embankment is shown on Plate 2, Typical Section Existing Embankment.

EMBANKMENT SECTION:

The existing embankment was constructed during 1970 to elevation 6630* with a crest length of 1,450 feet.

The construction plans specified that the embankment be constructed utilizing engineered fill, consisting of the natural surface soils located in the proposed pond area, compacted in 8-inch layers to 95 percent maximum density, in accordance with the A.A.S.H.O.** T90, Method of Compaction. The embankment was to have a 20-foot-wide crest with the upstream slope at two horizontal to one vertical, the downstream slope at two and one-half horizontal to one vertical. The geometry of the embankment is shown on Plate 2.

DISCHARGE SYSTEM:

The tailings from the mill are pumped in a slurry to the tailings pond and discharged into the pond from a spigot line established on the upstream face of the embankment approximately two feet above the pond water level. The amount of discharge at the present time is approximately 200-250 gallons per minute. The average total output of tailings from the mill is presently 600-700 tons per day. The tailings slurry contains approximately 40 percent of tailings by weight. The grind is approximately 97 percent

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*Elevations furnished by Rio Algom Corporation.

**American Association of State Highway Officials.

passing the No. 80 mesh and 70 percent passing the No. 325 mesh, as shown on Plate A-2A, Gradation Curve, in the appendix.

STABILITY ANALYSES:

In determining the factor of safety of the embankment, procedures defined by the ordinary method of slices (Fellenius Method) were utilized. The ordinary method of slices technique, which assumes a circular failure surface, was analyzed on an electronic computer utilizing a program developed by Dames & Moore. The soil parameters utilized in our analyses were based on the results of laboratory tests performed on undisturbed samples obtained from the embankment and underlying foundation soils.

Three different time-related storage pond configurations were analyzed. The different conditions are shown on Plate 2. The first condition analyzed was the end of the construction prior to tailings storage. Both the upstream and downstream slopes were analyzed. The factors of safety were found to be 1.7 and 1.9, respectively. The second and third conditions were selected as an intermediate and maximum storage pond pool elevation. Although no seepage was evident on the downstream face, the maximum theoretical top flow line for long-term seepage was assumed. The downstream slope was analyzed in conjunction with the maximum pool elevation and the upstream slope was analyzed in conjunction with the intermediate pool elevation, as recommended by the Atomic Energy Commission. The factors of safety were found to be 1.5 and 2.0, respectively.

The three conditions also analyzed were with a maximum anticipated earthquake loading of 0.05g*. For this condition, the factors of safety

*This value was recommended in our February, 1972 seismicity study for Rio Algom Corporation.

were found to be 1.5 and 1.7 for the end of construction cases, 1.3 for the maximum pool elevation and 1.7 for the intermediate pool elevation. These factors of safety meet the limits of the A.E.C. requirements published in June 1973.

FLOOD CONTROL:

As previously reported by Rio Algom Corporation, the natural watershed area above the tailings basin is 590 acres, including the plant area. The runoff water from a 100-year frequency rainstorm on this watershed was predicted by the Monticello office of the Bureau of Land Management as follows:

100-year, 2-day - 4.0 inches - 47 acre-feet

100-year, 4-day - 4.2 inches - 49 acre-feet

100-year, 7-day - 4.5 inches - 52 acre-feet

100-year, 10-day - 5.0 inches - 58 acre-feet

In the tailings pond, the normal water level will be maintained at least 10 feet below the crest of the dam (6620 maximum storage pond pool elevation), and therefore the upper portion of the storage may be assumed to be available for surge or flood capacity. From this capacity must be deducted the volume of tailings that are calculated to be above the pond elevation to obtain the net storage capacity.

The following figures have been reported by Rio Algom Corporation as the capacity available for flood control:

Capacity of basin above planned water level	194 acre-feet
Estimated volume of tailings above water level	27 acre-feet
Net storage of basin	167 acre-feet (above pond water level)

For the maximum calculated runoff of 58 acre-feet, the factor of safety against overtopping of the dam is $\frac{167}{58}$ or 2.9.

CONCLUSIONS:

Stability. Our stability studies indicate that the existing embankment under static loading and long-term seepage has factors of safety for the end of construction, prior to tailings storage, of 1.7 and 1.9 against deep-seated failure of the upstream and downstream slopes, respectively. Factors of safety against deep-seated failure of the downstream slope with a maximum pool elevation and the upstream slope with an intermediate pool elevation were found to be at least 1.5 and 2.0, respectively. Therefore, adequate stability safety exists for normal operation of this pond.

Flood Control. Based on the computed overtopping safety factor of the pond and from discussions by Rio Algom Corporation with the Bureau of Land Management, it is our opinion that a channel to divert possible flood water around the tailings pond is not necessary at this time. At the end of the mining and milling operation, the tailings pond area and the waste rock piles will be covered with a layer of soil. A diversion channel around the south side of the tailings pond should then be constructed to bypass drainage around the tailings pond area.

CONTINUING TAILINGS POND SYSTEM

EVALUATION OF ORIGINAL DESIGN:

The design storage capacity of the existing tailings pond at its present crest elevation, as provided by Rio Algom Corporation, is 605,000 tons. The estimated 1,550,000 total tons of ore would then require an additional storage area for the remaining 945,000 tons.

The original proposed design for capacity increases, as furnished by Rio Algom Corporation, indicated that the existing dam was to be raised in 5-foot increments as the pond surface raised, to a final crest elevation of 6655 feet. A beach, created by the coarse fraction of the tailings as they were discharged from the line, was to provide the base for this construction.

A basic assumption in the initial analysis that the tailings would have only 50 percent of the material finer than the No. 200 sieve and 95 percent finer than the No 50 sieve was incorrect. Actually, the tailings are now averaging as much as 70 percent finer than the No. 325 sieve. With such fine material, the "upstream" method of construction described above would be impractical.

SUGGESTED ALTERNATE DESIGNS:

As an alternate, we suggested raising the existing embankment 25 feet to the maximum elevation of 6555 feet by maintaining the 20-foot crest width and two and one-half horizontal to one vertical downstream slope angle, with all new fill being placed downstream of the existing embankment. We suggested that a second alternate would be to construct a new embankment and create a second pond upstream from the existing embankment. With the second alternate, the existing embankment would act as a secondary dam in case of spillage or leakage from the upstream dam, and provide additional safety and flexibility to the operation.

After examination of the two alternatives, Rio Algom Corporation determined that the new embankment would provide the best method for increasing storage volume. Therefore, only the proposed upstream pond has been analyzed in detail.

EVALUATION OF UPSTREAM TAILINGS POND:

Basis of Design. Evaluation of the upper pond embankment has been based on design requirements provided by Rio Algom Corporation. These requirements were as follows:

1. A crest level at elevation 6680.
2. A maximum pool elevation of 6675.
3. Flood control for a drainage area similar to the existing dam.
4. A continually operated decant system.

Use of Material. The location of the proposed upper tailings pond area is shown on Plate 1, Plot Plan. The natural soil, reddish-brown to brown, fine, sandy silty-clay mixture encountered in the test pits located within the future proposed ponded area, may be used for embankment fill (see attached appendix). The fill material should be placed in layers not to exceed eight inches in loose thickness and compacted to 90 percent of the maximum density determined in accordance with the A.A.S.H.O. T180, Method of Compaction. No segregation or zoning of materials during construction will be required.

The loose foundation soils below the embankment within the area shown on Plate 3, Typical Section Proposed Upstream Embankment, should be removed and conditioned and replaced to the density standard specified.

Stability Analyses. To meet topographic and design requirements the proposed pond embankment will be a maximum of 45 feet high and have a 20-foot-wide crest. The soil parameters utilized in our analyses were based on the results of laboratory tests on remolded samples compacted to the previously mentioned specifications, and the results of laboratory tests performed on undisturbed samples obtained from Borings D5, D6 and D7 (see appendix). A series of slopes were analyzed to select the recommended slopes shown on Plate 3. These recommended slopes are two and one-half horizontal to one vertical upstream and three horizontal to one vertical downstream. As for the existing embankment, factors of safety of the embankments were defined by utilizing the ordinary method of slices (Fellenius Method) computer program.

Three different time-related storage pond configurations were analyzed. The different conditions are shown on Plate 3. The first condition analyzed was the end of construction prior to tailings storage for both the upstream and downstream slopes. The factors of safety were found to be 1.4 and 1.8, respectively. The second and third conditions were selected as an intermediate and maximum storage pond pool elevation. Although a decant system should be installed to remove the majority of the water from the pond, the maximum theoretical top flowline for long-term seepage was assumed. The downstream slope was analyzed in conjunction with the maximum pool elevation and the upstream slope was analyzed in conjunction with the intermediate pool elevation, as recommended by the Atomic Energy Commission. The factors of safety were found to be 1.6 and 1.7, respectively. The three conditions were also analyzed with a maximum anticipated earthquake loading of 0.05g. For this condition, the factors of safety were found to be 1.2 and 1.6 for the end of construction cases, 1.3 for the maximum pool elevation, and 1.4 for the intermediate pool elevation.

Flood Control. Although the maximum theoretical top flowline was assumed for the stability analysis, we recommend a continuous operating decant system be installed in the proposed upstream storage pond. This decant system will remove the water by gravity to the downstream existing pond for recycling to the mill and/or for evaporation. This will permit a greater storage capacity behind the upstream embankment.

Since the downstream pond embankment will be maintained at the designed 10-foot freeboard level and as the upstream embankment with a 5-foot minimum tailings surface freeboard will have more storage volume than the downstream pond, the flood control factor of safety previously determined by Rio Algom Corporation (2.9) will remain the minimum factor against overtopping of the system. Therefore, as discussed for the downstream embankment, a diversion channel would not be required until the end of the mining operations.

ANSWERS TO REVIEW QUESTIONS

A list of review questions, and where in the text of the Part II Report the answers to seepage questions may be found, is presented in Appendix II-D of the Part II Report. Answers to the Tailings Pond Embankment Stability questions are not indexed in Appendix II-D; however, we feel that these questions are answered in this report as follows:

1. Our field exploration program, soil test data and stability analyses confirm the existing dam to have an adequate safety factor for embankment stability.
2. Surface hydrology and runoff evaluations confirm that the proposed freeboard requirements for the existing and proposed upper tailings pond will provide an adequate safety factor against overtopping without a spillway or bypass canal.
3. Construction of the proposed upstream tailings pond to the design requirements presented in this report will resolve the questions regarding future tailings disposal.

Respectfully submitted,

DAMES & MOORE

George C. Toland

George C. Toland
Consulting Partner
Professional Engineer No. 2311
State of Utah

GCT:ab

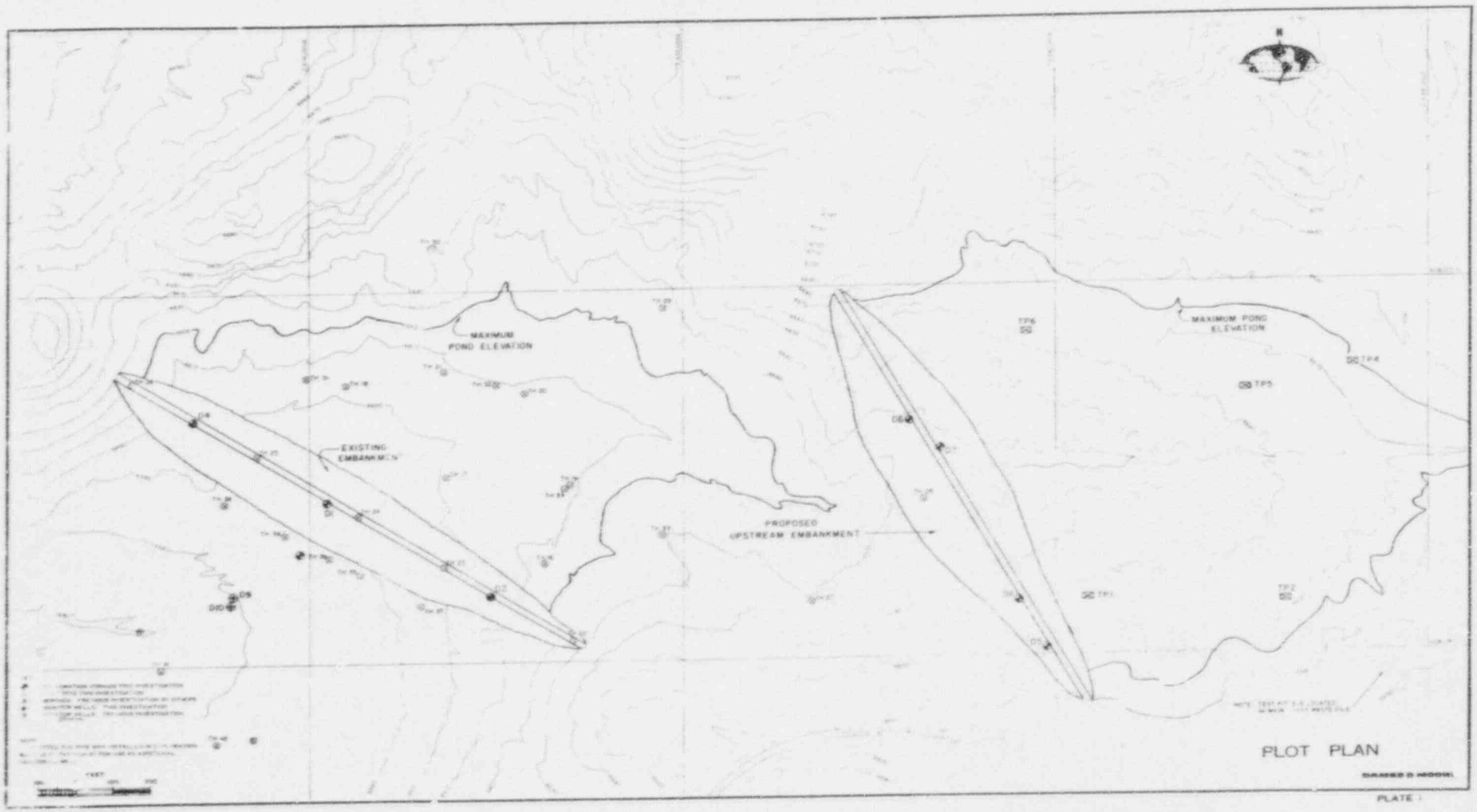
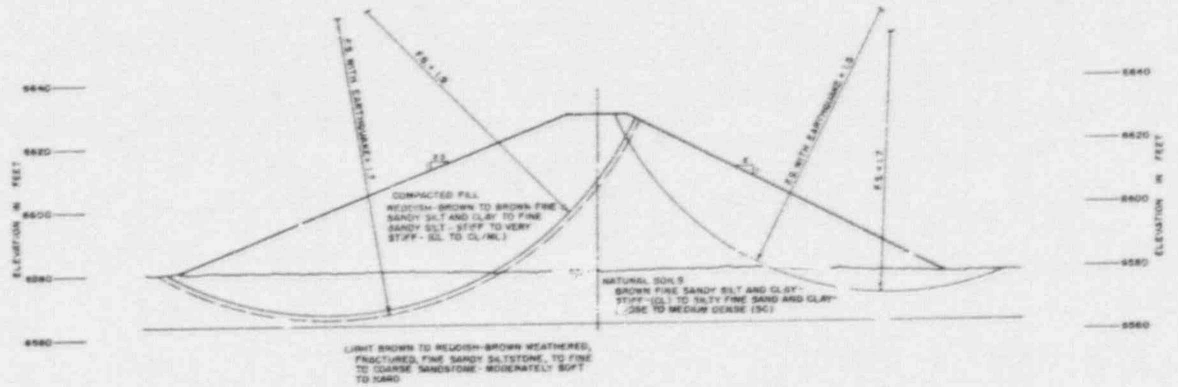
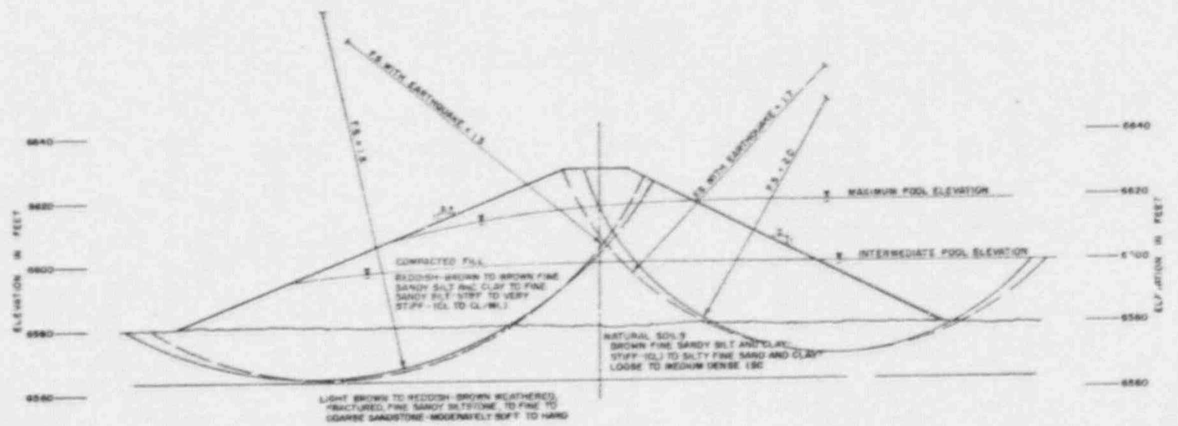

MAXIMUM
POND ELEVATION
EXISTING
EMBANKMENT
PROPOSED
UPSTREAM EMBANKMENT
MAXIMUM POND
ELEVATION
TP6
TP4
TP5
TP1
TP2
D6
D7
D5
D1
D2
D8
D9
D10
N
PLOT PLAN
DAMES & MOORE

PLATE I



END OF CONSTRUCTION



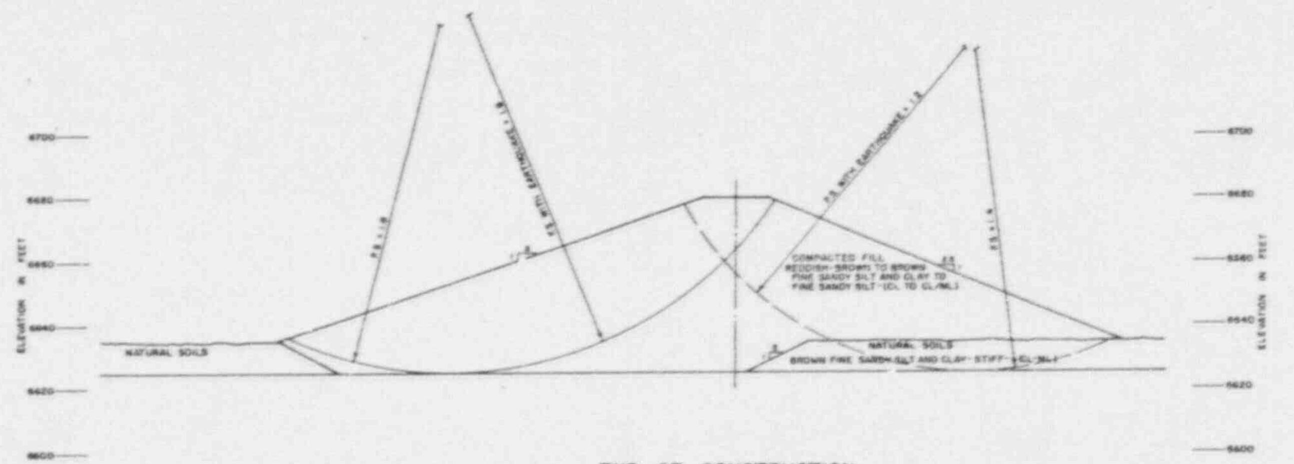
POOL ELEVATION

FEET
10 5 0 10 20 30 40 50

TYPICAL SECTION
EXISTING EMBANKMENT

DAMES & MOORE

PLATE 2



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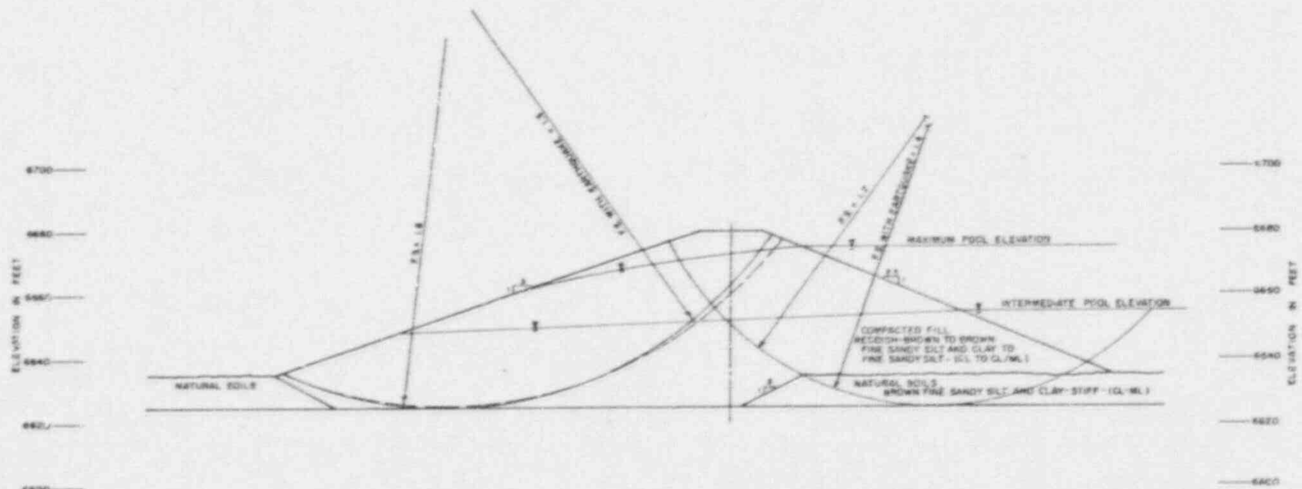


POOL ELEVATION

FEET
10 5 0 10 20 30 40 50

TYPICAL SECTION
PROPOSED UPSTREAM
EMBANKMENT

DAMES & MOORE

PLATE 3

APPENDIX I-A

FIELD STUDIES AND LABORATORY TESTING

FIELD STUDIES:

General. The field portion of our investigation included a reconnaissance of the site area, drilling of test borings, excavation of test pits, and the installation of monitor wells. The field studies were directed by engineers from our staff.

Site Reconnaissance. Prior to and during our field exploration program a general reconnaissance of the site was performed. The reconnaissance study was performed to aid in evaluating the geology of the site and the performance of the existing tailings pond system. In addition, the reconnaissance information was utilized in selecting the number, locations and depths of the test pits and borings.

Field Exploration. Subsurface soil and ground water conditions at the site were investigated by drilling eight exploration borings, excavating six test pits and installing nine monitor wells. The locations of the borings, test pits and monitor wells are presented on Plate 1, Plot Plan, in the text of this section of the report.

The borings were drilled with a truck-mounted rotary rig and extended to depths ranging from 24.0 to 71.3 feet. The backhoe pits extended to depths ranging from 6.0 to 13.0 feet. The test pits were excavated to determine the extent of the natural surface soils suitable for construction of the proposed upstream dam.

The following table gives details of the six test pits excavated:

TABLE A-1

Test Pit Number	Depth To Bedrock (Feet)	Total Depth Excavated (Feet)
1	Not encountered	12
2	4.5	6
3*	Not encountered	13
4	Not encountered	12
5	Not encountered	9
6	5.0	6

*Located in main shaft waste pile.

The soils encountered in all test pits can be classified as CL-ML material, reddish-brown to brown, fine, sandy silty clay to clayey silts.

Undisturbed soil samples were obtained from exploration borings by utilizing a Type U Dames & Moore sampler, as illustrated on Plate A-3. The soils were classified by visual and textural examination in the field and a complete log was maintained of each boring. These classifications were supplemented by inspection and testing in our laboratory. The nomenclature utilized in describing the soil types appears on Plate A-4, Unified Soil Classification System. Graphical representation of the soils encountered in the exploration borings is shown on Plates A-1A through A-1C, Log of Borings.

In order to monitor the ground water gradient and provide a means of sampling the ground water, a series of nine monitor wells were installed. Seven of the wells, which consist of slotted three-inch-diameter PVC pipe, were installed in borings D1 to D7. Two monitor wells, denoted as D9 and

D10 were drilled and installed downstream of the existing embankment. The following table gives details of these monitoring wells:

TABLE A-2

	Monitor Well No. D9	Monitor Well No. D10
Soil Overburden	0-55 feet	0- 55 feet
Burro Canyon Sandstone	57-67 feet	57- 93 feet
Brushy Basin Shale	-	93-103 feet
Monitor Well Casing	0-67 feet	0-103 feet
Casing Perforations	57-67 feet	93-103 feet

Monitoring of the ground water levels and water sampling and analyses is being performed by representatives of Rio Algom Corporation. This data is transmitted on a periodic basis to our office for our review.

Surveying. The location and elevations of all borings and test pits was done by Rio Algom Corporation. The locations are shown on Plate 2, Plot Plan. The following Table A-3 provides numerical data based on Rio Algom Plant datum:

TABLE A-3

Station (Boring Number)	Rio Algom Plant Coordinates North	East	Rio Algom Plant Elevations
D1	608441	636048	6629.4
D2	608182	636483	6630.0
D3	608299	635975	6588.0
D4	608661	635687	6628.0
D5	608018	637972	6675.0
D6	608150	637898	6657.0

TABLE A-3 (Cont.)

Station (Boring Number)	Rio Algom Plant Coordinates North	East	Rio Algom Plant Elevations
D7	608565	637683	6639.0
D8	608638	637606	6639.0
D9	608180	635798	6579.0
D10	608161	635792	6580.0
(Test Pit Number)			
TP1	608125	638081	6663.0
TP2	608140	638622	6664.0
TP3	608608	639644	6701.0
TP4	608760	638787	6675.0
TP6	608865	637922	6661.0

LABORATORY TESTING:

General. Our laboratory testing program included moisture and density tests, gradation tests, Atterberg Limits and direct shear tests. A description plus the results of the tests are presented in subsequent sections.

Moisture and Density. To aid in classifying and correlating the soils, moisture and density determinations were conducted on selected samples. The moisture and density test data obtained are presented to the left of the boring logs on Plates A-1A through A-1C.

Gradation Tests. Additional classification data was obtained by performing partial gradation tests on selected soil samples. The results of the gradation tests are shown on Plates A-2A through A-2C.

Atterberg Limits. Additional classification data was obtained on selected soil samples. The results of the Atterberg Limits tests are presented in tabular form below:

Boring No.	Depth In Feet	Soil Classification	Liquid Limit In Percent	Plasticity Index In Percent
D1	6.5	CL	19.8	2.6
D1	12.5	CL-ML	19.5	5.4
D1	30.5	CL	23.6	7.3
D1	39.5	CL	17.2	0.8
D2	6.5	CL-ML	16.3	3.5
D2	15.5	CL-ML	24.8	6.8
D4	6.0	SM	Non-Plastic	
D4	14.5	CL-ML	21.5	5.6
Tailings Pond	Bulk	CL-ML	21.1	4.6

Direct Shear Tests. To provide additional strength data, a series of direct and double direct shear tests were performed on selected undisturbed samples. The tests were performed in accordance with the method described on Plate A-5, Method of Performing Direct Shear and Friction Tests.

The tests were run at a strain rate of 0.005 inches per minute. At this rate, the samples were assumed to be able to drain without building up excess pore pressures. Therefore, the tests have been classified as "drained."

The results of the tests are tabulated on the following page.

Boring No.	Depth In Feet	Soil Type	Normal Pressure In PSF	Peak Shearing Strength In PSF	Yield Shearing Strength In PSF
D1	10.0	CL-ML	500	1,500	700
D1	12.5	CL-ML	1,000	1,760	600
D1	18.5	CL	500	1,650	950
D1	24.5	CL	1,000	2,380	1,400
D1	30.5	CL	1,500	3,340	1,250
D1	39.5	CL	1,000	2,030	1,150
D1	45.5	CL-ML	2,000	2,000	800
D1	48.5	CL	2,500	2,380	1,550
D1	51.5	CL	3,000	2,460	900
D1	54.5	CL	3,500	2,875	1,175
D2	6.5	CL-ML	500	2,240	1,820
D2	9.5	CL-ML	1,000	2,500	1,050
D2	15.5	CL-ML	1,500	2,780	1,300
D2	21.5	CL-ML	2,000	2,220	1,100
D2	24.5	CL-ML	2,500	3,390	1,100
D4	6.0	SM	3,500	3,880	2,050
D4	6.0	SM	4,000	4,150	1,950
D4	14.5	CL-ML	4,500	4,800	1,700
D4	24.5	CL-ML	3,000	3,200	1,520
D4	24.5	CL-ML	4,500	4,720	1,430
D4	29.5	CL-ML	3,500	4,000	1,030
D4	29.5	CL-ML	4,000	2,550	1,250
D5	5.5	CL-ML	2,000	2,950	1,720
D6	2.5	CL-ML	1,000	2,800	2,050

Boring No.	Depth In Feet	Soil Type	Normal Pressure In PSF	Peak Shearing Strength In PSF	Yield Shearing Strength In PSF
D6	5.5	CL-ML	500	1,050	675
D6	8.5	SM	1,500	1,975	925
D7	2.5	CL-ML	3,000	2,300	1,080
D7	2.5	CL-ML	4,000	2,890	1,100
D7	8.5	ML	3,500	2,140	770
D7	8.5	ML	3,500	2,590	930

The following plates are attached and complete this appendix:

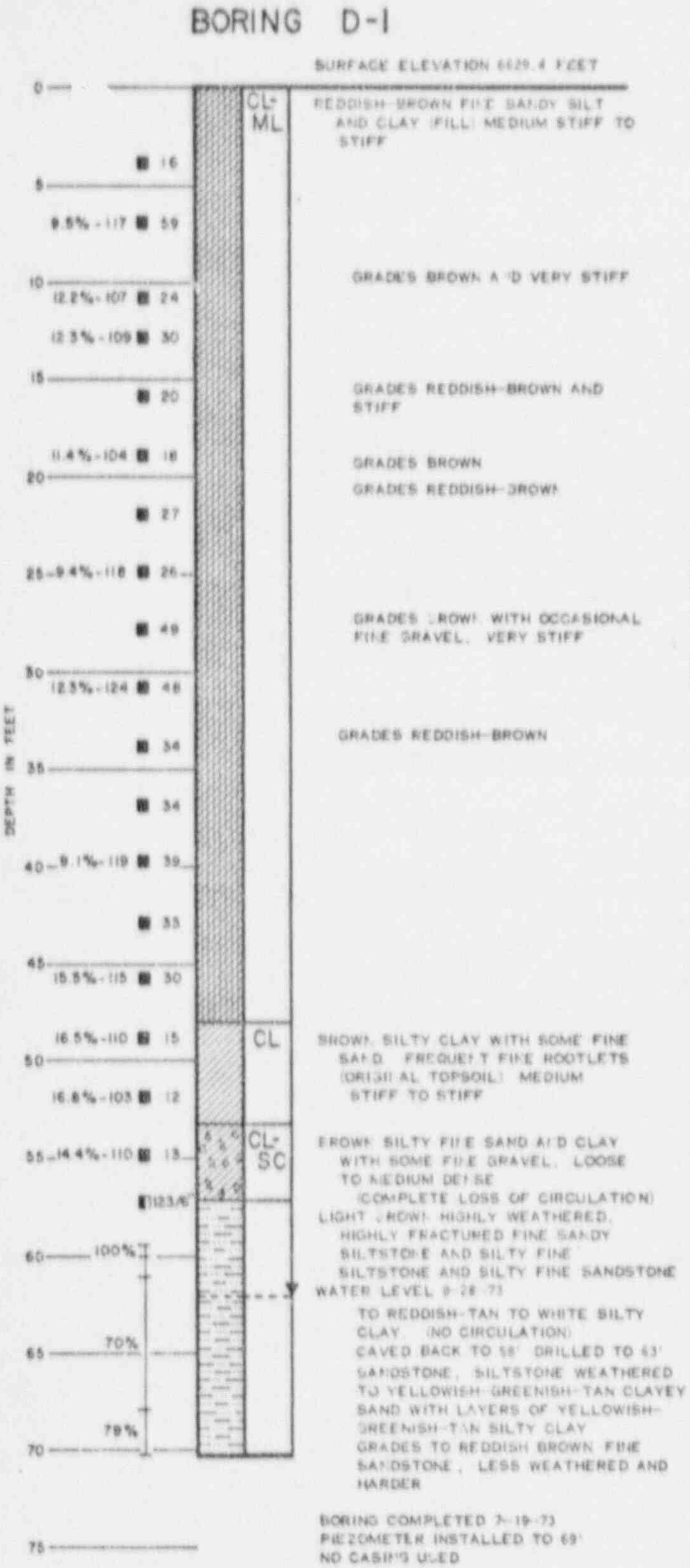
Plates A-1A through A-1C - Log of Borings (Borings 1 through 8)

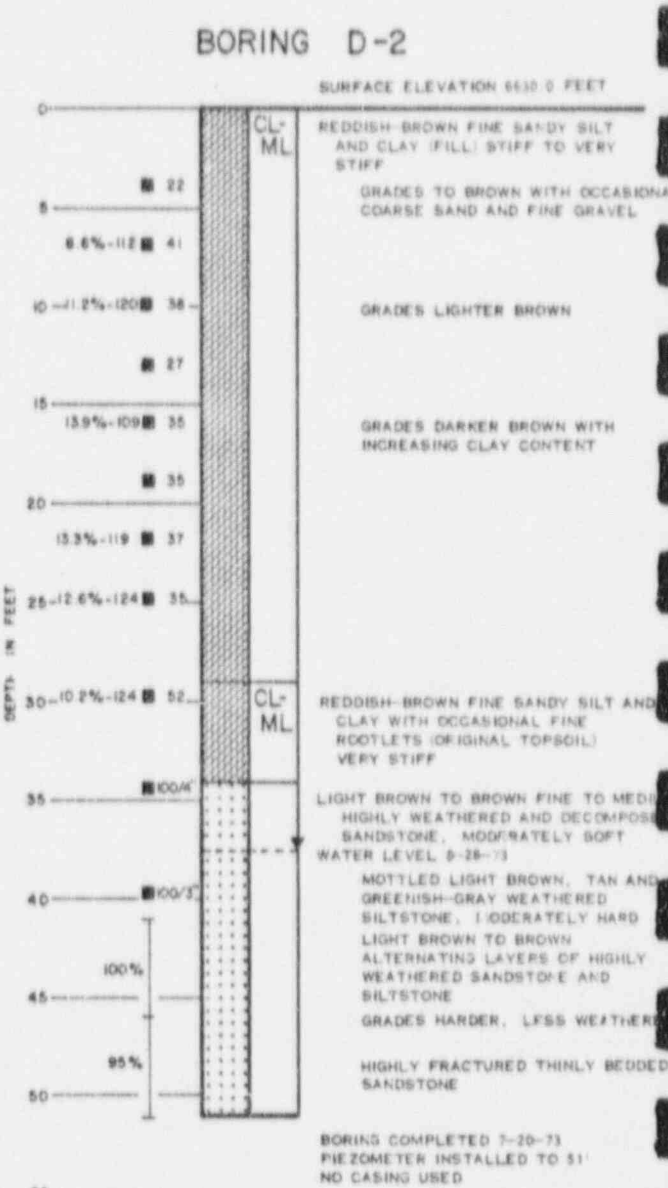
Plates A-2A through A-2C - Gradation Curves

Plate A-3 - Soil Sampler Type U

Plate A-4 - Unified Soil Classification System

Plate A-5 - Method of Performing Direct Shear and Friction Tests





NOTES

GROUND WATER WAS NOT ENCOUNTERED, TO THE DEPTHS EXPLORED, IN ANY OF THE TEST PITS AT THIS SITE.

THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED, "SITE CONDITIONS, SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

KEY

A - B ■

A FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL

B DRY DENSITY EXPRESSED IN LBS. PER CUBIC FOOT

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED

⊠ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED

□ SAMPLING ATTEMPT WITH NO RECOVERY

⊠ BULK SAMPLE

ELEVATIONS FURNISHED BY RIO ALGOM CORPORATION

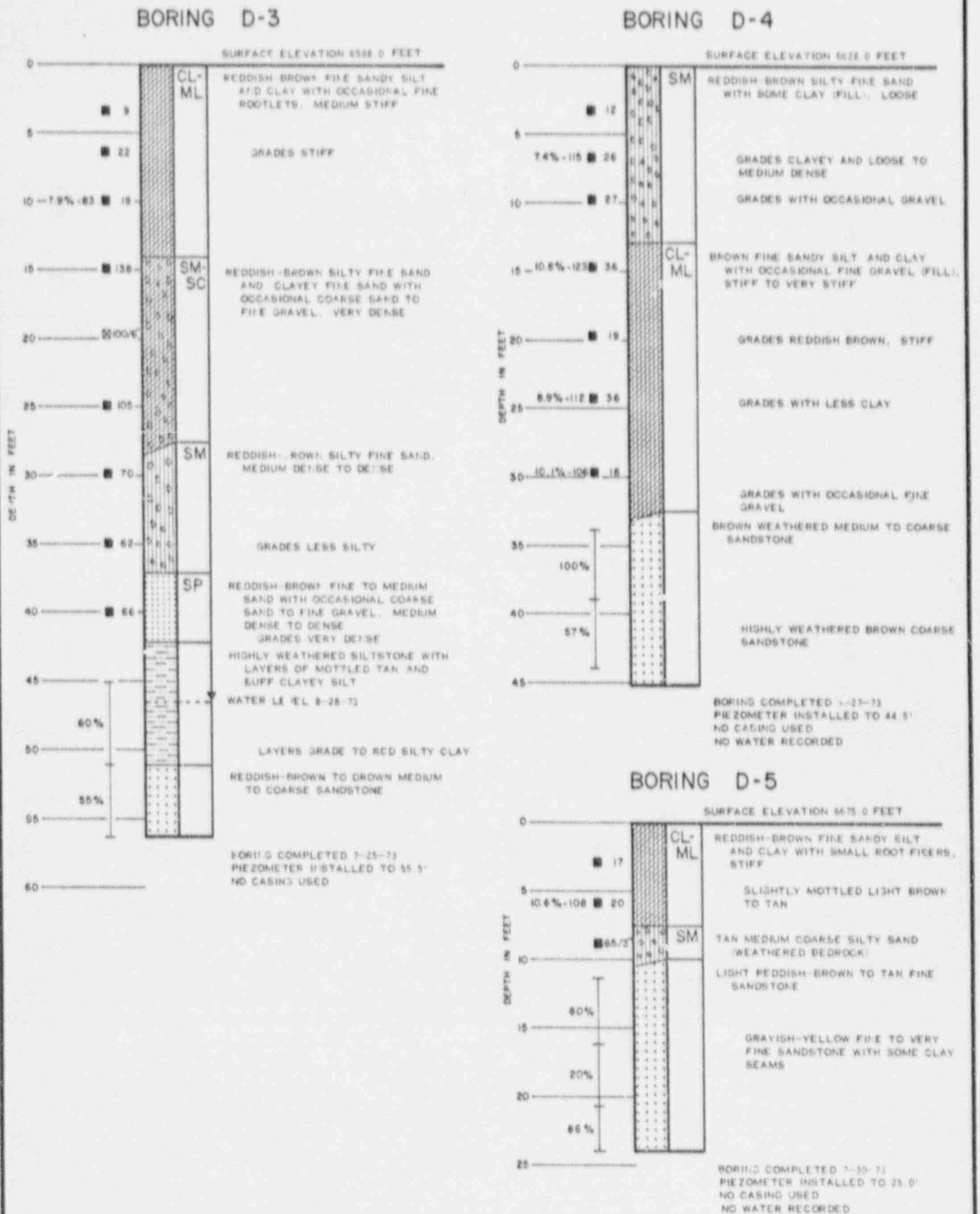
A — INDICATES DEPTH AND LENGTH OF CORE RUN

— PERCENT OF CORE RUN RECOVERED

LOG OF BORINGS

DAMES & MOORE

PLATE A-1A

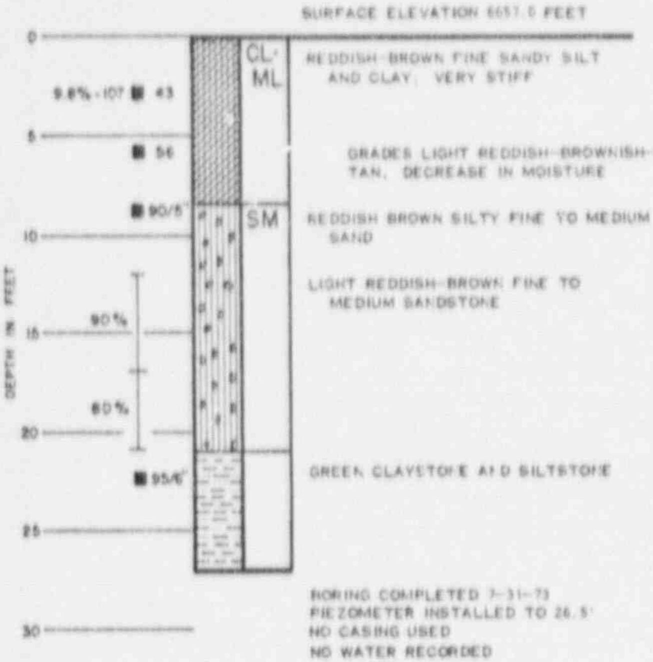


LOG OF BORINGS

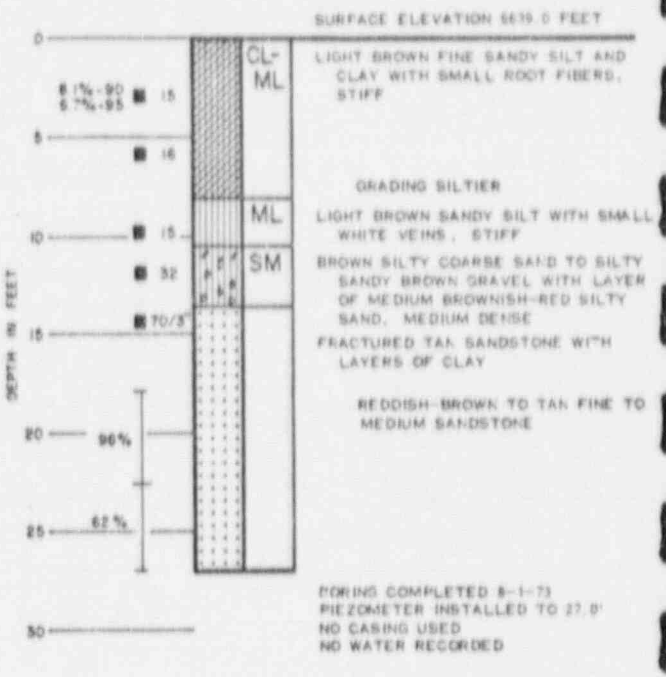
DAMES & MOORE

PLATE A-1B

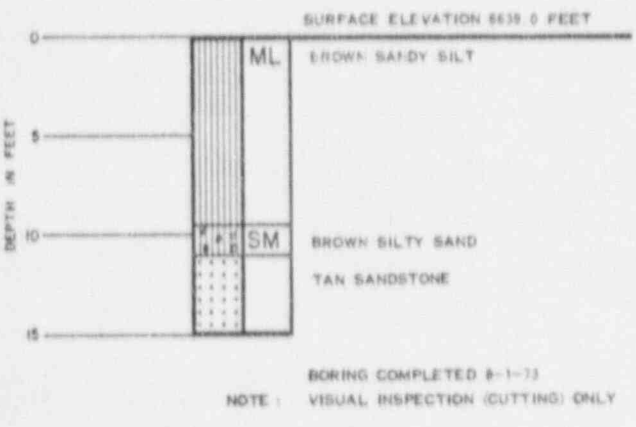
BORING D-6



BORING D-7



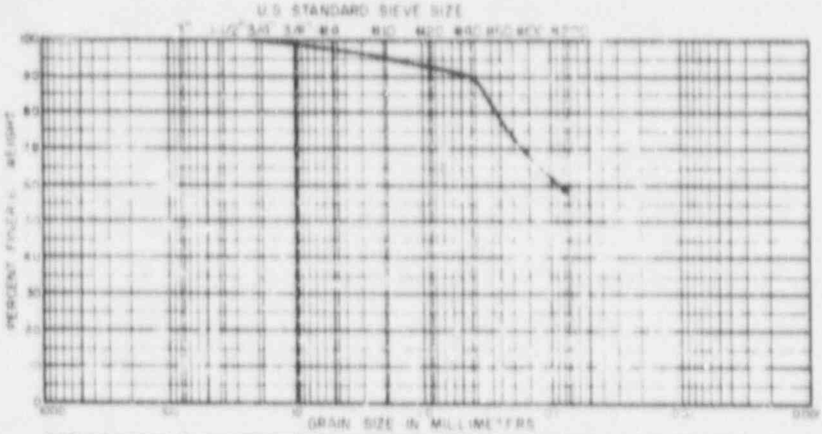
BORING D-8



LOG OF BORINGS

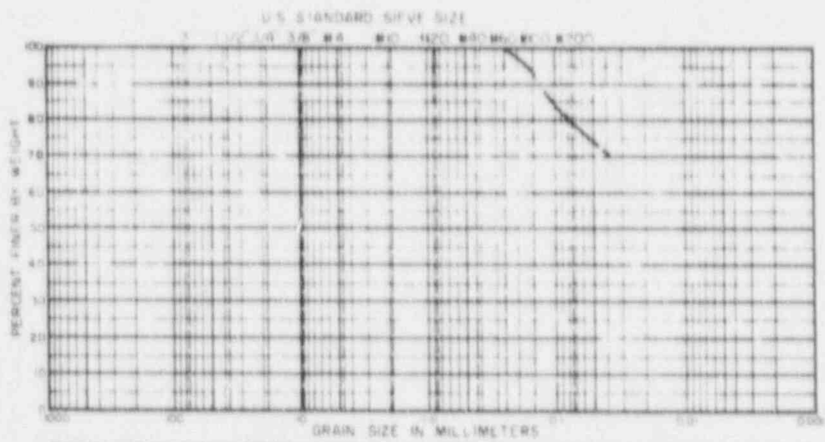
DAMES & MOORE

PLATE A-1C



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
EXISTING EMBANKMENT	BULK	CL-ML REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
EXISTING POND	BULK	TAILINGS

GRADATION CURVES

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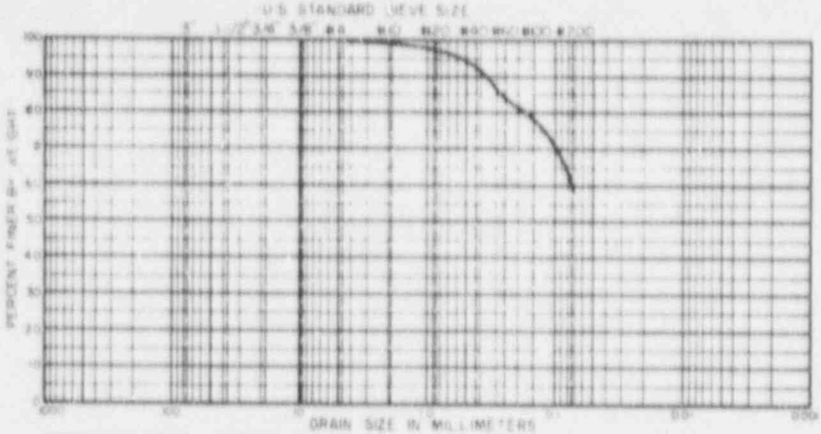
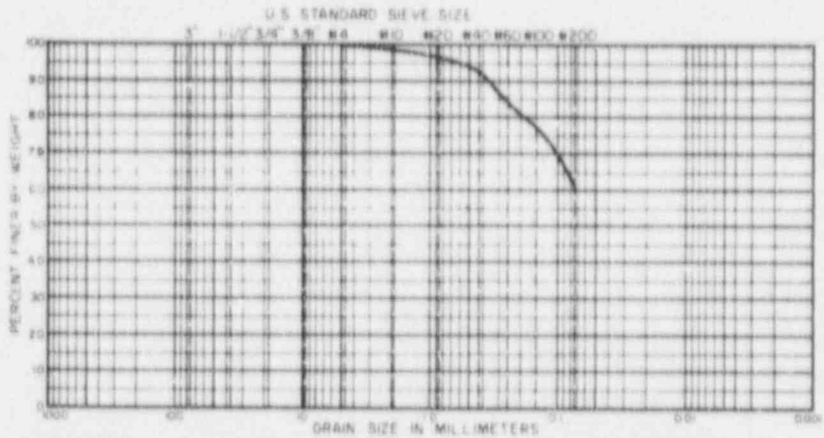
PLATE A-2A



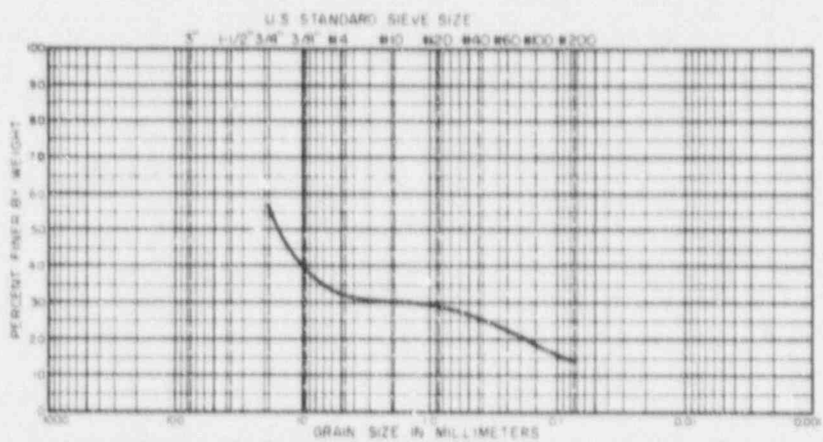
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 1	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 2	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



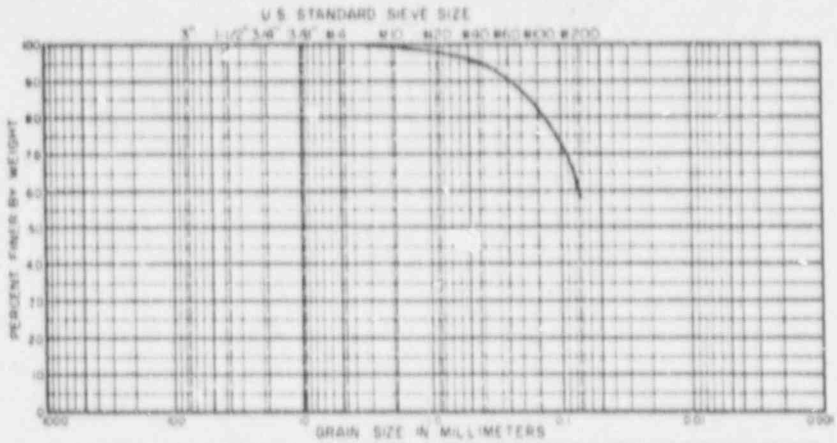
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 3	BULK-WASTE PILE	MIXTURE OF SANDS, SILTS AND CLAYS FROM MAIN SHAFT UNDERGROUND MINE WASTE

GRADATION CURVES

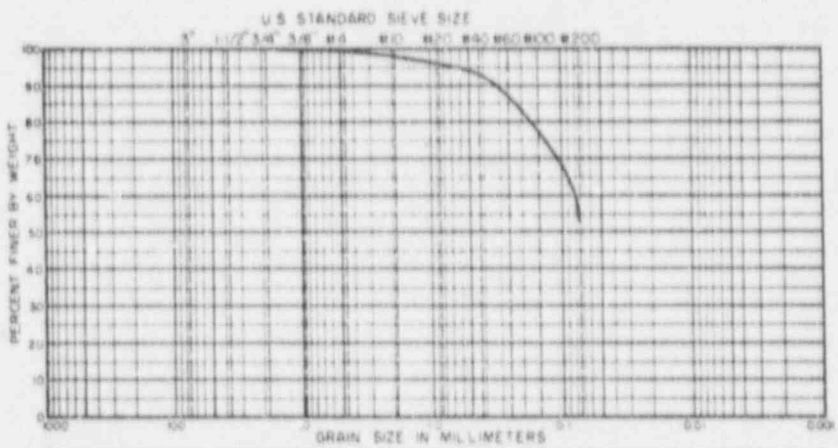
DAMES & MOORE

PLATE A-2B



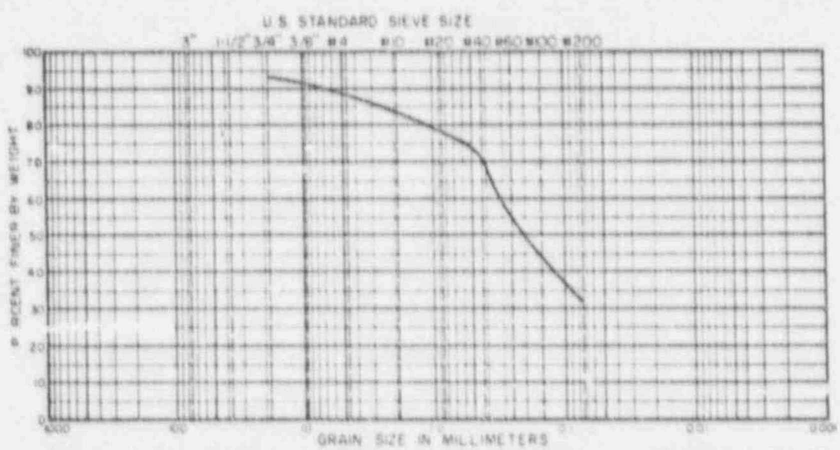
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 4	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 5	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS



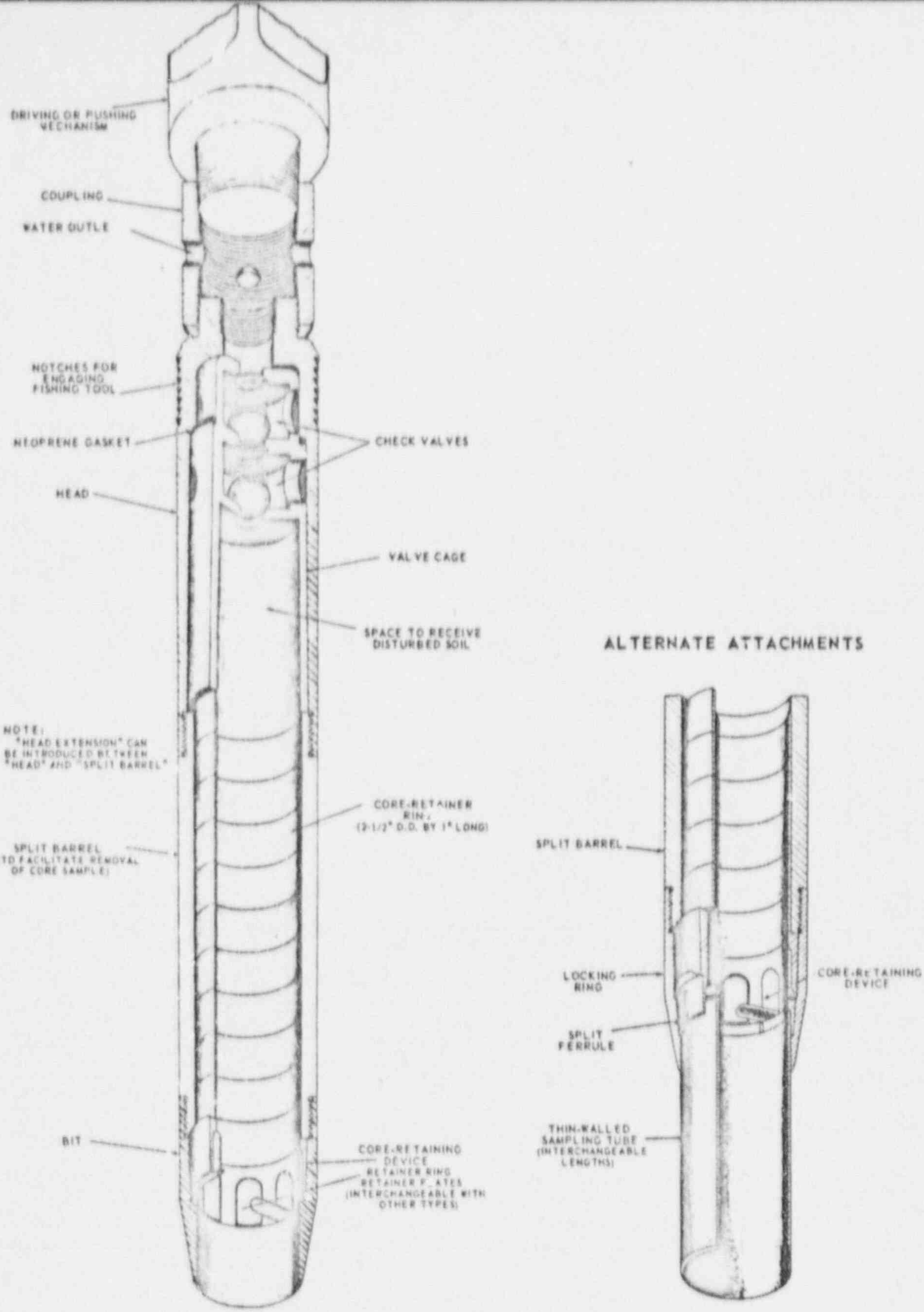
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LOCATION	DEPTH	CLASSIFICATION
TEST PIT 6	BULK	CL-ML - REDDISH BROWN TO BROWN FINE SANDY SILT AND CLAY TO CLAYEY SILTS WITH OCCASIONAL THIN LAYERS OF LIGHT TAN TO WHITE FINE SAND

GRADATION CURVES

DAMES & MOORE

PLATE A-2C



SOIL SAMPLER TYPE U

U. S. PATENT NO. 2,318,062

DAMES & MOORE

BY ____ DATE ____ CHECKED BY ____ DATE ____ FILE ____ REVISIONS BY ____ DATE ____

PLATE A-3

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

DAMES & MOORE

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL RESISTANCES BETWEEN SOILS AND VARIOUS OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.

DIRECT SHEAP TESTING & RECORDING APPARATUS

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

Direct Shear Tests

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

Friction Tests

IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DAMES & MOORE

PART II
GROUND WATER GEOHYDROLOGY AND SEEPAGE EVALUATION

PURPOSE AND SCOPE

The purpose of Part II of this investigation was to provide:

1. A full discussion of the regional and local geologic conditions, particularly as they relate to ground water flow.
2. An evaluation of the mode of seepage loss from the tailings pond and the means for its control.
3. A report which is sufficiently comprehensive to answer questions relating to geology, ground water and reservoir seepage raised by the agencies which reviewed Rio Algom's "Supplemental Environmental Report."

With these objectives in mind, the following scope of work was undertaken:

1. All published data of relevance was reviewed, and earlier studies performed by others for Rio Algom were evaluated.
2. A simple bailer test was performed in one of the monitor wells.
3. The borings drilled by Dames & Moore in conjunction with the Part I studies relating to dam stability and siting of a new pond were utilized to obtain further information on seepage characteristics below the reservoir. Several of these borings were established as new monitoring points.
4. Representative samples of soil and rock core were analyzed for petrographic information, solubility and cation exchange capacity.

REGIONAL GEOHYDROLOGY

REGIONAL GEOLOGY:

The site is located in the Colorado Plateau physiographic province approximately 12 miles south of the La Sal Mountains and some 40 miles southwest of the Uncompahgre structural uplift. The region surrounding the site is underlain by sedimentary strata of Cretaceous, Jurassic, Triassic, and older ages which are folded into a series of broad, northwest-trending anticlines and synclines. Tertiary intrusives outcrop as domes 8 to 20 miles north of the site.

The undulating bedrock folds are expressed topographically as low hill ranges and intervening valleys trending generally northwest. The principal surface drainages parallel the valleys.

Faults are common in the region and the more important structures trend northwest, similar to the folding and topography. Both normal and reverse faults have been identified.

The sedimentary deposits consist of continental and shallow marine beds, including sandstone, conglomerate, shale, mudstone, and lesser amounts of limestone and evaporites (gypsum, salt and anhydrite). Uranium deposits occur widely throughout the region and are most commonly associated with the sandstone and conglomerate formations.

Plate 1, Regional Geology, shows the principal geologic features. Plate 2, Regional Stratigraphic Description, provides general information as to bedrock lithologies, formational sequence and water bearing characteristics. Plate 3, Regional Geologic Structure Profile, shows a typical cross section.

GROUND WATER MOVEMENT:

Surface runoff and ground water movement in the site region are influenced strongly by the La Sal Mountains, which rise to an elevation of 12,700 feet. These highlands act as a ground water recharge area to permeable formations. Infiltration from rain and snowmelt in the La Sal Mountains enters Quaternary alluvium or permeable bedrock strata (generally sandstone or conglomerate) and moves to lower topographic or structural elevations. Some of this recharge flows toward the site, and thence to the west and northwest in the direction of the Colorado River. Plates 1 and 3 show the general paths of ground water flow toward the site and beyond. The interpretation is based upon topography and geologic structure in the absence of good water table data from well records.

Faults in the region trending across the path of ground water movement may or may not serve as barriers, depending on the inherent permeability of the fault material and the character of the formations opposite the fault.

Artesian pressures exist in some wells of the region where ground water moves through aquifers to lower elevations beneath confining layers (aquicludes) such as the Morrison shale or mudstone tongues in the Dakota sandstone. No flowing wells are known to occur.

The rate of ground water movement through the bedrock aquifers is believed to be on the order of several hundred feet per year. Where the flow gradient has been steepened near wells due to high drawdown, the rate of movement is greater.

Ground water in the alluvium or in shallow bedrock aquifers such as the Burro Canyon sandstone discharges as springs or directly into streams.

A few springs having this origin occur northeast and east of the site. Direct ground water recharge to the surface waterways is believed to occur mostly downstream several miles from the property, where the drainage channels have eroded through the aquifers.

GROUND WATER USE:

Good information on well characteristics in the region is lacking. Table 1 gives a summary of wells within a radius of several miles, but the specific aquifer in most cases can only be inferred. Many of the wells appear to be developed in the Dakota or Burro Canyon sandstone. Wells less than 80 or 90 feet in depth probably produce from the Quaternary alluvium. Wells deeper than 300 feet are believed to withdraw ground water from the Entrada, Navajo, or Wingate sandstones. Plate 1 and Plate 4, Vicinity Map, show the recorded wells in the region referred to in Table 1.

GROUND WATER QUALITY:

Data on the quality of ground water in the region is limited. Values for selected constituents in typical wells are provided on Table 1. In the Burro Canyon (Dakota) sandstone, the ground water is generally of potable quality. Many of the listed wells are suspected or known to be in the Burro Canyon formation and indicate fair to good potability. Analyses of the ground water from the production shaft show much higher mineralization in the Wingate and Navajo sandstones. The dissolved constituents in these two aquifers range as follows:

Wingate Sandstone:	2500-4500 ppm	total dissolved solids
	475- 500 ppm	sulfates
	760-1876 ppm	chlorides
Navajo Sandstone:	1200-1700 ppm	total dissolved solids
	22- 62 ppm	sulfates
	465- 690 ppm	chlorides

TABLE 1

GROUND WATER USE

Well[1] (Serial Number)	Yield Reported[2] (Sec-Feet)	Depth[3] Of Well (Feet)	Aquifer[4]	Rad.[5]	TDS	SO_4	Cl	U_3O_8
05-213	0.015	90						
05-360	1.5	600-1,000		IAB[8]	618	235	27	0.001
05-623	0.045	150						
05-204	0.014	109						
05-784	0.010	50-150						
05-105	3.0	100-300						
05-376	1.5	80-300						
05- 79	0.0506	60						
05-779	0.1	100-150						
05-306	0.5	3 wells: 70, 78, 86	Alluvium					
05-203	0.015	78-80						
05-780	0.1	2 wells: 100, 200						
05-321	0.1	140		IAB	788	275	43	0.002
05-320	0.017	?		IAB	682	221	28	0.001
05-800	0.5	200-300						
05-791	0.5	300-500						
05-154	0.556	3 wells: Depths?						
05-426	0.02	828		IAB	246	33	23	0.002
Rio Algom 2	0.10	275	B.C.[7]	?	277	118	16	No U_3O_8
Rio Algom 3	0.075	322	B.C.	?	345	135	22	assays
Rio Algom M-1	0.20	230	B.C.	?	598	160	24	in ppm
Rio Algom M-2	0.12	270	B.C.	?	to	to	to	
Rio Algom M-4	0.18	235	B.C.	?	806	286	36	
Rio Algom M-5	0.16	230	B.C.	?				

1. Serial Number, Utah Division of Water Rights
2. At time of completion
3. Where given as range, depth applied for
4. Where data omitted, none available
5. Rad. = radioactivity in gross alpha pico-Curies per ml
6. All constituents except radioactivity given in ppm
7. B.C. = Burro Canyon sandstone
8. IAB = Insignificant above background

in geographic or stratigraphic proximity to uranium deposits, some contamination by radionuclides may occur, particularly if shafts or open borings permit the mingling of ground water from various formations.

SITE GEOHYDROLOGY

SITE GEOLOGY:

The surficial geologic materials in the site vicinity consist of overburden soils and outcrops of Dakota or Burro Canyon sandstone. These materials are further described in the introductory section of this report. Plate 5, Vicinity Geology, and Plate 6, Vicinity Ground Water Flow, show the general structural relationships of the area.

A contour map drawn on the top of the Brushy Basin shale in the vicinity of the early exploration borings shows considerably more complexity in local bedrock structure than would be inferred from published data. Among these small local features are several shallow domes and troughs. Because the top of the shale acts as a bottoming layer for shallow percolation, these irregularities exert some localized influence upon ground water flow, as discussed in the next section of the report.

GROUND WATER MOVEMENT:

Deep Ground Water. Ground water is present in several formations beneath the site; namely, the Burro Canyon, the Navajo, and the Wingate sandstones. Some ground water was also reported in the Kayenta formation during the shaft sinking. In all cases, ground water movement into the area is believed to occur principally from the northeast, although increments of this flow are probably diverted to the northwest or southeast along synclinal depressions. A smaller component of flow may enter the site from the southeast, following the north side of the Lisbon Valley fault and the nose of the Lisbon Valley Anticline.

Local recharge within a few miles of the site does not penetrate significantly into the impermeable Brushy Basin shale. Deeper aquifers are isolated from the shallower water bearing zones by these shale beds and by the lower aquicludes, unless interconnection is provided by faults, borings, shafts, or underground workings. In pumped workings, mixing between aquifers is largely prevented due to the break in hydraulic continuity at the cone of depression. In flooded workings or open borings, contamination of the shallow aquifers from deeper confined sources is possible. At Rio Algom, however, this will be prevented when the operations are abandoned by sealing off the mineralized workings from the shallower formations.

Based upon present information, the ultimate flooding level in the shafts subsequent to mine closure cannot be anticipated with certainty. Ground water will rise in the shafts to a level which is in hydrostatic equilibrium with the formation having the highest piezometric head. This head has not been measured for the deeper aquifers. If it were sufficient to reach the Burro Canyon sandstone, we believe that no significant contamination could move either into this formation, or from it into the shaft, because of the shaft linings.

Shallow Ground Water. Infiltration of surface waters occurs through the soils in the drainage depressions and through fractured and weathered Burro Canyon sandstone, both where it outcrops and where covered by overburden.

Percolation rates have been measured in the soils and the Burro Canyon sandstone by field permeability tests conducted by others. These test results are shown on Plate 7, Map of Bedrock Surface, and are summarized in Appendix II-A.

Shallow ground water probably moves off the site through the lower Burro Canyon formation, remaining perched on the Brushy Basin shale, and enters the shallow synclinal trough southwest of the property. Flow which reaches the Lisbon Valley fault either penetrates through it into the upthrown Wingate sandstone on the opposite fault block, or is diverted northwestward along the fault, perhaps eventually to discharge into the south branch of West Coyote Wash.

The low anticlinal divide northeast of the mine, as shown in Plate 6, may affect slightly the directions of ground water movement. Because of this structural feature, any ground water entering the Burro Canyon sandstone or deeper aquifers at the production shaft would probably flow southwest, which is the apparent slope of the hydraulic gradient. The divide, aided by shaft pumpage, may help to prevent pond seepage from flowing northeast or east toward wells.

In the immediate vicinity of the operations, local irregularities in the Brushy Basin surface as discussed in the previous section would be expected to impose a variety of directional components in the flow by ground water. For example, the axis of the proposed upstream tailings dam coincides with a local ground water divide. Seepage from the proposed reservoir could enter a northwesterly ground water flow pattern, whereas any seepage beneath the proposed dam might join the southwesterly flow system that passes beneath the existing tailings pond. Infiltration from the spray field, which also straddles this divide, could similarly move either northeast or southwest.

Any seepage entering the Burro Canyon sandstone from the production shaft, which appears to occupy a saddle in the Brushy Basin shale, would tend to flow southwest after encountering the main ground water zone, although movement into troughs extending eastward and northwestward from the shaft is also possible.

The proposed site for construction of barium treatment ponds is also situated on a saddle between troughs in the Brushy Basin shale. These troughs extend roughly eastward and northwestward from the contemplated pond site and will influence the movement of any seepage from the ponds.

Plate 8, Geologic Cross-Sections-Tailings Pond, shows the interpreted paths of seepage and ground water movement in the vicinity of the existing impoundment.

SEEPAGE FROM TAILINGS POND

MOVEMENT OF SEEPAGE:

It has been anticipated that seepage from the tailings pond will reduce to negligible amounts as sealing of the bottom progresses with the emplacement of tailings fines. Rio Algom has determined from field tests that the permeability of the tailings is about 6 feet per year.

Until this tailings blanket effectively seals all of the ponded area, effluent will percolate through the more permeable natural soils and into the underlying fractured Burro Canyon sandstone or it will infiltrate directly into the sandstone where this rock is in contact with the effluent.

Some seepage, though probably negligible, can be expected even after the tailings blanket is essentially complete.

Seepage from the pond percolates to the natural ground water zone in the lower Burro Canyon formation, either directly or by stages via perching layers in the soil or rock and then moves downgradient beneath the dam, past the monitor wells and eventually off-site. Dilution, dispersion, and cation exchange occur along this seepage path with attendant reduction in the concentration levels of radionuclides and other constituents.

At its present elevation, the outer portions of the pond on the north side are in direct contact with fractured Burro Canyon sandstone, or separated from it by only two or three feet of overburden. Percolation through the bedrock fractures can be many times the rate estimated from field permeability tests of the soils or unfractured sandstone. This is borne out by the range of permeabilities determined for the in-place sandstone as shown on Plate 7.

RADIONUCLIDE LEVELS:

Plates 9A, 9B, and 9C show the variations in concentration of the principal radionuclides in the monitor wells and shafts at the site. These curves show the effects of dilution by the natural ground water beneath the site and indicate a time lag between fluctuations of radionuclide levels in the pond and response in the monitor wells.

The Utah standards pertaining to radioactive effluent limitations which are shown on these plates are based on one-thirtieth of the maximum permissible concentrations for the critical body organ as defined in the National Bureau of Standards Handbook No. 69. These standards are much stricter than the limits stipulated by the Atomic Energy Commission.

In general, the uranium levels have diminished in the monitor wells since mill startup and are currently well below the Utah standard. Radium, on the other hand, has increased somewhat over this same period with a few of the analyses exceeding the standard. The trend suggests that ground water contamination from pond seepage may reach objectionable levels unless control measures are undertaken.

The radium concentration in monitor wells MW-1 and MW-2 probably results from their close proximity to the tailings pond, coupled with their downstream and "downdip" position relative to the pond. The radium increase in monitor well MW-4, located about 2000 feet southeast of the tailings dam, is more difficult to interpret. The latest recorded water level, in July, 1973, was at elevation 6577 feet, or about 20 feet below the lowest pond bottom elevation. The site for MW-4 is slightly "up-dip" from the pond along the Brushy Basin contact but otherwise does not lie along a feasible flow path from this body of water. Any contaminants infiltrating from the production shaft might move in this direction, however. MW-4 is situated in the drainage area downstream from other uranium mines southeast of Rio Algom, which opens the possibility of contaminants reaching MW-4 from that direction. Contradicting this assumption, however, is the fact that the increase in radium content in MW-4 appears to coincide roughly with the radium increase in the Rio Algom tailings pond and in monitor wells MW-1 and MW-2.

CATION EXCHANGE:

The soil and rock materials beneath the reservoir and along seepage flow paths have the capacity of adsorbing effluent constituents such as radium by the process of cation exchange. An adequate evaluation of this process requires detailed knowledge as to the chemical content of each radionuclide and principal non-radioactive constituent in the effluent. The greatest difficulty, however, lies in conceptualizing quantitatively the physical environment in which cation exchange takes place. With time, the adsorptive capacity of the soil and rock materials at a given location is fully consumed by prolonged contact with the effluent so that the constituents are required to migrate further downgradient where unused exchange capacity is still available. This advancing front of contaminant is affected by radioactive decay and normal dilution as well as by cation exchange. The net result is observable in monitor wells, but differentiating each process and its relative influence is exceedingly complex.

It is probable that cation exchange has already proceeded to completion in the vicinity of the tailings pond though it may still be an active process at some distance from the pond. Cation exchange by itself, however, would not be capable of fixing a sufficient amount of radionuclide, such as radium, to reduce its concentration below permissible limits.

Present techniques of cation exchange analysis utilize a diffusion model computer program and require several months to complete. A detailed evaluation of this phenomenon lies outside the scope of the present study.

However, seven samples of soil and four rock core samples from the site were analyzed for cation exchange capacity (CEC) by the calcium carbonate exchange method. The results are given in Table 2, in milliequivalents per 100 grams of soil or rock.

TABLE 2

CATION EXCHANGE CAPACITY

Boring	Depth (ft)	Description	% Cations Available	CEC (Mev/100 gms)
D-1	51.5-54.5	SM	28.6	15.6
D-3	24.5	SP-GP	24.7	13.5
D-3	39.5	SP	29.1	16.0
D-4	19.5	CL-ML	28.3	15.5
D-4	29.5	CL-ML	29.4	16.1
D-3	9.5	CL-ML	25.4	13.9
D-3	34.5	SM	27.3	15.0
D-1	60.5	Sandstone	26.1	14.3
D-2	42.5	Sandstone	19.3	10.6
D-3	46.5	Sandstone	19.8	10.9
D-4	34.5	Sandstone	21.3	11.7

SOLVENT EFFECTS OF EFFLUENT:

Some attempt was made to determine the susceptibility of the soil and rock materials beneath the dam to solution when exposed to the seepage effluent. Appendix II-B describes the results of petrographic analysis to identify soluble minerals, and solubility testing in solutions of various compositions. The generalized conclusions which can be drawn from these analyses is that one percent or less of the typical soils would be subject to solution in a pH 9.0 environment. The rock would be still less soluble.

Quartz is abundant in most of the samples. When the effluent becomes more alkaline than pH 10.0, as occasionally shown by the records, silica in the earth materials may be affected. Although tests were not run under these conditions, the possibility exists that high ph seepage below the tailings pond and above the zone of saturation may be capable of dissolving some of the quartz in the soils and rock with a resultant increase in permeability.

OTHER DILUTING EFFECTS:

Seepage which reaches the zone of ground water saturation undergoes rapid dilution. A measure of this dilution rate is indicated by monitor well MW-1 in which the radium concentration during July, 1973 was only two to five percent of that recorded in the pond over the previous two months. Monitor well MW-1 is 725 feet from the nearest approach of the pond.

Recently completed monitor well D-10 is located about midway between the pond and monitor well MW-1. Radium in this well from the one assay thus far obtained (in August, 1973) was 3.0×10^{-9} uC/ml lower than MW-1, suggesting an even higher rate of dilution.

CONTROL OF OFF-SITE CONTAMINATION

GENERAL:

The Burro Canyon formation supplies numerous wells in the region with potable water, including those maintained by Rio Algom. This aquifer is also the uppermost bedrock unit near the tailings pond. Monitor wells in the vicinity of the pond have shown that seepage is occurring. Among the radioactive constituents, radium has most closely approached acceptable state limits, indicating that seepage control measures may be necessary to insure that off-site contamination does not occur. Such measures will be undertaken in the near future.

An "action level" of radioactivity in the monitor wells should be established and it is proposed that wells MW-1 and MW-2 below the tailings dam be used to identify this level. These wells are 320 feet and 170 feet, respectively, from the nearest property boundary and are downgradient from the pond. In view of the probable dilution rate versus distance, an action level in the monitor wells should be selected which is sufficiently below the Utah standard to allow time for implementation of effective control measures before concentrations exceed acceptable limits at the property boundary.

Based upon the present concentrations of radioactive constituents in the monitor wells, it is proposed that radium serve as the index constituent governing the action level. A reasonable action level, in our opinion, would be indicated when two out of three consecutive monthly composite radium analyses exceed the Utah standard in either of these wells.

Two general methods for achieving control are seepage recovery by pumping wells and total containment by reservoir sealing. Effective sealing of the reservoir may take several months to accomplish, and it therefore seems advisable that a well recovery system be activated in the near future. These wells will then serve as a backup system after the reservoir has been sealed.

RESERVOIR SEALING:

Sealing of the reservoir is clearly the most positive way of controlling the seepage of contaminants. Though such a method is not likely to eliminate seepage entirely, it should be capable of reducing these losses to an acceptable maximum.

It is the intent of the tailings placement plan to accomplish sealing of the reservoir. Identification and treatment of the areas having the highest seepage potential should be of first priority. However, sealing of the entire reservoir should be the ultimate goal and will require that a tailings blanket at least six inches thick be placed under all areas occupied by water, so that at no point does this effluent come in direct contact with the natural ground surface. As the pond level rises, additional layers of tailings must be deposited on the newly inundated banks around the periphery of the reservoir. This recommendation applies both to the existing pond and the proposed second tailings containment area. Sealing of these basins is essential regardless of any recovery well system contemplated.

The north side of the reservoir is believed to be one of the principal areas of high seepage loss. In this locality, a tailings seal should be emplaced which blankets all zones having less than three feet of natural soils and which extends to the maximum pool elevation. The area within the reservoir basin from which embankment material was excavated may require similar treatment. The areas recommended for placement of tailings are shown on Plate 7.

RECOVERY WELLS:

Recovery of contaminant seepage will be necessary until the reservoir sealing process has become effective. Seepage percolates downward some 40 to 50 feet below the reservoir before reaching the zone of saturation at the ground water table. Some portion of the seepage is intercepted by discontinuous mudstone layers in the sandstone. In the zone of saturation, the seepage moves laterally downgradient. Recovery is possible only after the seepage enters this zone. Wells pumped to extract the contaminants will also withdraw some ground water which is not contaminated.

The primary objectives of the well recovery system would be to remove contaminants and to create a cone of depression which induces flow toward the wells by reversing the natural gradient. This has proven to be an effective technique in other instances for lowering the ground water table and restricting the movement of contaminants.

A pumping test should be conducted in the proposed recovery area to determine the local hydraulic characteristics of the sandstone. From these data, the number, arrangement and discharge capacity of the recovery wells can be prescribed which will provide an appropriate drawdown configuration. Although supply wells of 30 to 40 gallons per minute capacity have been developed elsewhere in the Burro Canyon formation, as at the Maple Leaf claims, seepage recovery wells at the tailings pond probably will not require pumping at these rates to form an effective seepage barrier.

A crude bailer-type pumping test was conducted in monitor well MW-1 to gain some impression as to the feasibility of pumping as a seepage recovery measure. Approximately five gallons per minute were bailed over a 30-minute period without producing a significant drawdown. The results suggest that there is sufficient transmissivity in the sandstone to warrant the use of submersible or vertical turbine pumps.

As an alternative to test pumping prior to designing a recovery well system, wells could be installed on a trial and error basis according to our present limited knowledge of the aquifer hydraulics at the site. These wells should be located so as to intercept seepage as close as possible to its confluence with the ground water system, in order to recover the highest concentrations. The crest of the tailings dam would be an effective and convenient area for the recovery wells. It is proposed that two wells be installed initially, one near each zone of suspected maximum seepage in the pond, as indicated on Plate 5. Each well should extend at least 15 feet into the Brushy Basin shale, to provide a sump for the pump intake. We estimate that these wells should be fitted with a pump capable of lifting 10 to 20 gallons per minute against a head of 120 to 130 feet. This would require a 1 to 1-1/2 horsepower pump and a minimum well diameter of four inches.

Existing monitor wells MW-1 and MW-2 would continue to be monitored and could also be pumped, if necessary, as backup to the proposed recovery system.

Discharge from the recovery wells would be returned to the reservoir and pumpage should be kept to the minimum required for an effective barrier. Depression of the water table as a consequence of recovery well operation will have no adverse affect upon dam stability. The permeability of neither the soils nor bedrock beneath the tailings pond will be increased, although the velocity of present ground water flow from the northeast (upgradient) will be greater.

TREATMENT:

The radium concentration in the ventilation shaft currently exceeds Utah standards for effluent discharge, due principally to the fact that some contaminated mine water is pumped through this shaft. Plans for exporting water from the vent shaft to off-site users therefore cannot be implemented until the radium content is reduced. This will be accomplished by pumping mine water only through the production shaft in the future and treating the unused excess volume with barium chloride to remove the radium. The treated water will then be combined with the improved vent shaft water for discharge to the Redd Ranch Reservoir.

MONITORING

EXISTING MONITOR WELLS:

Five monitor wells are currently used to maintain surveillance of the ground water quality in the site vicinity. Their locations are shown on Plate 5. The well sites were placed a sufficient distance inside the Rio Algom property line to insure early detection of undesirable contaminant levels and trends and to permit corrective action to be taken before excessive concentrations are able to move off-site. Two of these wells, MW-1 and MW-2, are approximately 500 feet southwest of the tailings dam. MW-1 reportedly encountered bedrock at a depth of 15 feet rather than at 70 feet in a bedrock depression as predicted by the seismic refraction survey. MW-2 penetrated 60 feet of sandy overburden above the Burro Canyon contact in a bedrock depression. Both wells were drilled 15 feet into the Brushy Basin shale, cased the full length, and perforated from the lower 10 feet of overburden to the bottom of the well.

The other three monitor wells are former deep exploration borings which have been cased in the upper portion and plugged below the Burro Canyon sandstone. The sites for these wells were chosen north, northeast and southeast of the site on the premise that movement of seepage from the tailings pond would be omnidirectional above the main ground water table. Movement would also be more responsive to bedrock structure in this zone, which slopes generally northeastward into the East Coyote Syncline from the northern sector of the property, with local variations in flow as described on page 8. The radionuclide levels in these wells were discussed earlier.

During the course of the prevent investigation, additional monitor wells were installed, two below the present dam (D-9, D-10) and three (D-5, D-6 and D-7) at the proposed upstream site. In addition, three of the recent borings (D-1, D-2 and D-4) along the existing dam axis and one boring (D-3) at the toe of the dam were cased and will be used to monitor the phreatic line.

Monitor well D-9 was drilled 10 feet into the Burro Canyon sandstone to observe whether seepage was flowing in the overburden or upper fractured bedrock, possibly perched on a mudstone layer in the sandstone. No water has been recorded in D-4 or D-9, indicating that seepage is penetrating deeper into the Burro Canyon beds before reaching monitor wells MW-1 and MW-2.

Monitor well D-10 was drilled within 20 feet of D-9 and taken through the Burro Canyon sandstone approximately 10 feet into the Brushy Basin shale. The overburden and upper bedrock region were sealed off to isolate possible seepage in this zone from ground water flowing in the lower Burro Canyon formation. The lower 15 feet of sandstone is saturated.

PROPOSED MONITOR WELLS:

The possibility of ground water contamination originating from sources other than Rio Algom has been considered. Mining operations southeast of the property and northeast of the Lisbon Valley fault are suspect. This area is up-dip from Rio Algom, on the nose of the Lisbon Valley anticline, and ground water movement toward Rio Algom within the Burro Canyon sandstone is conceivable. In order to confirm possible contamination of the Rio Algom monitor wells from this region, two additional monitor wells are proposed, one in the northwest corner of Audrey 19 claim and one in the northwest portion of Audrey 2 claim.

A third site might be considered on the Susan Jean 20 claim, to monitor possible sources from the upper portion of the watershed. Each of the proposed monitor wells should extend five feet into the Brushy Basin shale, and be sealed above 10 feet of depth in the Burro Canyon formation.

MONITORING SCHEDULE:

A rather large number of existing and proposed new monitor wells at the site makes it practical to limit the frequency of sampling and the extent of analysis. Table 3 presents our recommendations as to a future schedule for sampling in these wells. The program should be reviewed every two or three months and modified as appropriate.

AFFECT OF GROUND WATER WITHDRAWALS

SUPPLY WELLS:

The water supply well system on the Maple Leaf claims has been designed for a capacity of 200 gallons per minute. Subsequent reassessment of the operational needs has reduced the foreseeable requirement to approximately 80 gpm. Review of the pump test analyses performed by others indicates a probable drawdown per well of 10 feet in 10 years at a distance of two miles, assuming a pumping rate of 40 gallons per minute and no recharge. Accepting these calculations, 80 gallons per minute of pumpage for plant use would produce 20 feet of drawdown at two miles in 10 years, without making allowance for recharge. Recharge of the Burro Canyon aquifer is an actuality, however, as proven by the existence of several springs emanating from this formation in the region. These overflows indicate an excess of recharge over storage capacity. Pumpage at the planned rate may possibly diminish springflow within 1500 or 2000 feet of the supply wells and affect forage near any local springs. Beyond one mile, the influence on existing springs should be minor. The nearest known well to the Maple Leaf well field is over one mile distant to the northwest.

MINE SHAFTS:

Combined pumpage from the two shafts on the property has increased from about 250 gallons per minute in July, 1972, to nearly 400 gallons per minute in September, 1973. Approximately equal amounts are discharged currently from each shaft. Most of this water originates from the Navajo and Wingate sandstones, which range in depth, respectively, from 1150 to 1540 feet and from 1749 to 2051 feet in the region northeast of the Lisbon Valley fault. These aquifers are deeper than any well of record within five miles of the mine. The other principal aquifer, the Burro Canyon sandstone, is lined with concrete in the shafts and hence sealed against leakage into them.

Due to the foregoing circumstances, mine pumpage will have no adverse affect upon present aquifer use in the region.

Among the aquifers penetrated by the shafts, only the Burro Canyon sandstone outcrops in the vicinity or is the source of springs. There are no springs known to be present within one mile of the shafts and those which

TABLE 3

MONITOR WELL PROGRAM

	Water Level	pH	U(nat)	RA226	Th230	Na	SO_4
MW 1	M	W	W,M_c	M_c	M_c	W	M_c
MW 2	M	W	W,M_c	M_c	M_c	W	M_c
MW 3	M	M	M	M	M	M	M
MW 4	M	M	M	M	M	M	M
MW 5	M	M	M	M	M	M	M
D 1	M		M	M			M
D 2	M		M_c	M_c			M_c
D 3	M	M_c	M_c	M_c			M_c
D 4	M	Now dry; check weekly for water level, then monthly for Ra.					
D 5			No sampling				
D 6			No sampling				
D 7	M		M_c	M_c			M_c
D 9	M	Now dry; check weekly for water level, then monthly for Ra.					
D 10	M		M_c	M_c			M_c
"Outside Sources" Monitor Wells		initially, two samples one week apart, then monthly composites thereafter, on Uranium, Radium and SO_4					

W = Weekly

M = Monthly

M_c = Monthly composite of weekly samples are nearest have shown no change in flow which might be attributed to mine drainage operations.

Imported high quality water from the Maple Leaf well field is now being used primarily for culinary purposes, while most other needs are met by pumpage from the shafts.

The ventilation shaft water is relatively low in radionuclide contamination, whereas water from the production shaft is highly contaminated. It is planned that the production shaft water in excess of on-site requirements will be treated to acceptable standards and exported from the site.

In our view, present or planned schemes for water use of the Rio Algom operations reflect due regard for the need of conserving this resource.

Respectfully submitted,

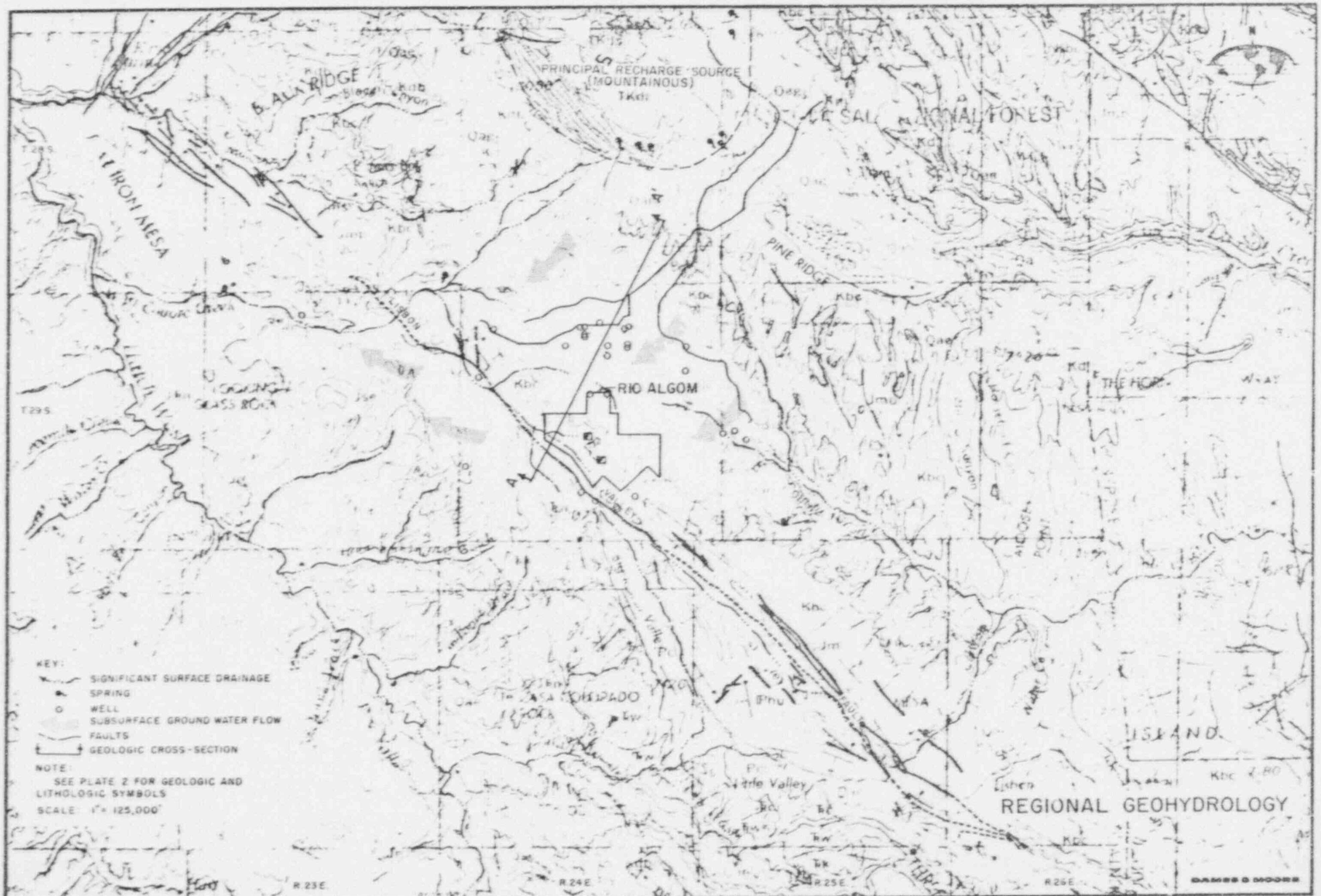
DAMES & MOORE

William E. Mead

William E. Mead
Consulting Partner

WEM:ab

Attachments



PRINCIPAL RECHARGE SOURCE
(MOUNTAINOUS)
LA SAL NATIONAL FOREST
IRON MESA
PINE RIDGE
RIO ALGOM
LISBON
GLASS ROCK
THE HOOK
ISLAND
KEY:
SIGNIFICANT SURFACE DRAINAGE
SPRING
WELL
SUBSURFACE GROUND WATER FLOW
FAULTS
GEOLOGIC CROSS-SECTION
NOTE:
SEE PLATE 2 FOR GEOLOGIC AND
LITHOLOGIC SYMBOLS
SCALE 1" = 125,000'
R.23E.
R.24E.
R.25E.
R.26E.
T.29S.
REGIONAL GEOHYDROLOGY
DAMES & MOORE

PLATE I

Period	Symbol		General Description	Thickness in Ft.	General Water-Bearing Characteristics
Quaternary	Qaf		ALLUVIAL FAN GRAVELS		AQUIFER
	Qag		ALLUVIAL GRAVELS, MOSTLY GLACIAL OUTWASH		AQUIFER
	Qae Qa Qap		ALLUVIUM AND WIND BLOWN DEPOSITS, UNDIFFERENTIATED		AQUIFER (SEVERAL OFF-SITE WELLS ARE IN THIS FORMATION)
	Qc		COLLUVIAL DEPOSITS		MINIMAL
Tertiary	TKds	TKdi	DIORITE PORPHRY (IGNEOUS INTRUSIVE)		MINIMAL
Cretaceous	Kd		DAKOTA (CEDAR MOUNTAIN) SANDSTONE, INTERBEDDED CONGLOMERATE SANDSTONE, CARBONACEOUS SHALE	5 TO 200	AQUIFER
	Kbc		BURRO CANYON FORMATION: SANDSTONE AND CONGLOMERATE INTERBEDDED WITH SILTSTONE, SHALE, MUDSTONE, THIN BEDDED LIMESTONE (OUTCROPS AT SITE)	0 TO 200	*AQUIFER SUPPLIES WELLS FOR SITE. FEEDS SPRINGS NEAR SITE. SEVERAL OFF-SITE WELLS APPEAR TO BE IN THIS FORMATION
Jurassic	Jm	Jmb	MORRISON FORMATION: SHALE, MUDSTONE, AND SANDSTONE. SOME THIN LIMESTONE		AQUICLUDE
			Jmb BRUSHY BASIN SHALE MEMBER: CHIEFLY MUDSTONE, LESSER SANDSTONE AND CONGLOMERATE	250 TO 500	AQUICLUDE
		Jms	Jms SALTWASH SANDSTONE MEMBER: SANDSTONE, LESSER MUDSTONE, THIN LIMESTONE	190 TO 490	MINIMAL
	Js		SUMMERVILLE FORMATION: SANDY SHALE AND MUDSTONE	60 TO 150	AQUICLUDE
	Je		ENTRADA SANDSTONE	180 TO 350	MODERATE (1 OR 2 OFF-SITE WELLS MAY BE IN THIS FORMATION)
	Jc		CARMEL FORMATION: SILTSTONE, LESSER SANDSTONE	35	AQUICLUDE
	JTRn		NAVAJO SANDSTONE	400	*MODERATE PRODUCES SOME WATER IN RIO ALGOM SHAFTS
Triassic	TRk		KAYENTA FORMATION: SHALE, SILTSTONE AND SANDSTONE	0 TO 240	AQUICLUDE (CONTAINS SOME WATER AT SITE)
	TRw		WINGATE SANDSTONE	0 TO 350	*MODERATE PRODUCES WATER IN RIO ALGOM SHAFTS
	TRcu / TRcb	TRc	CHINLE FORMATION: SILTSTONE, SANDSTONE, SHALE, CONGLOMERATE	0 TO 600	AQUICLUDE (ORE BEARING AT SITE)
			TRcu UPPER CHINLE		
			TRcb MOSS BACK MEMBER: SANDSTONE, LESSER MUDSTONE		
	TRm		MOENKOPI FORMATION: CHIEFLY SHALE AND MUDSTONE, LESSER SANDSTONE AND CONGLOMERATE	0 TO 1000	AQUICLUDE MISSING AT SITE
Permian	Pc		CUTLER FORMATION: ARKOSIC CONGLOMERATE	0 TO 8000	UNKNOWN
Pennsylvanian	IPh	IPhu	HERMOSA FORMATION		
			IPhu UPPER HERMOSA: LIMESTONE, LESSER SANDSTONE, SILTSTONE, SHALE	0 TO 1000	UNKNOWN
		IPhp	IPhp PARADOX MEMBER: SALT, GYPSUM, ANHYDRITE, SHALE, SANDSTONE, LIMESTONE	0 TO 11,000	UNKNOWN

* WATER BEARING AT SITE

CONTACT

FAULT

STRIKE AND DIP OF BEDS

HORIZONTAL BEDS

REFERENCE:
MODIFIED FROM WILLIAMS (1964)

REGIONAL STRATIGRAPHIC DESCRIPTION

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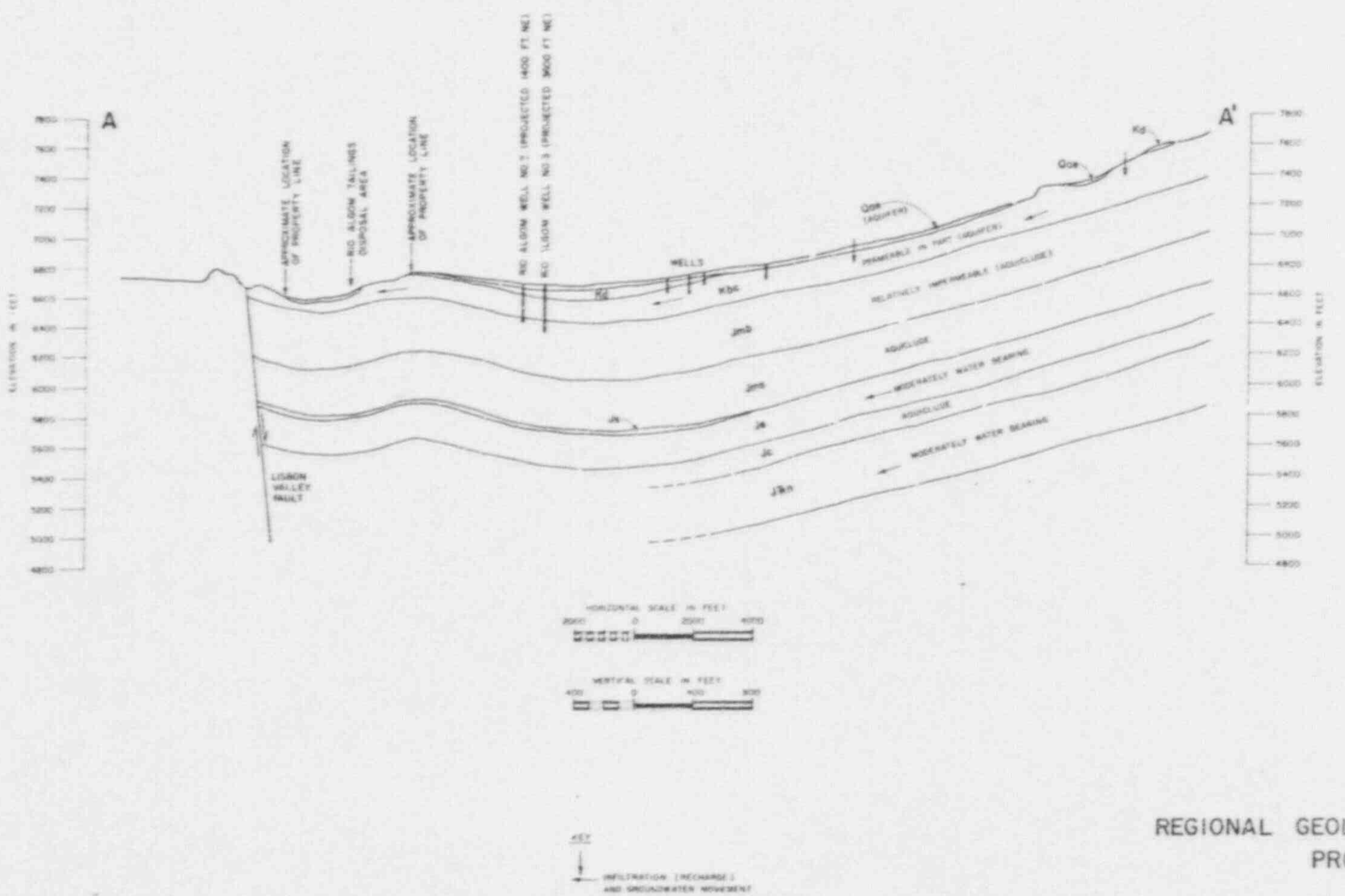

REGIONAL GEOLOGIC STRUCTURE PROFILE

CROSS SECTION A - A'

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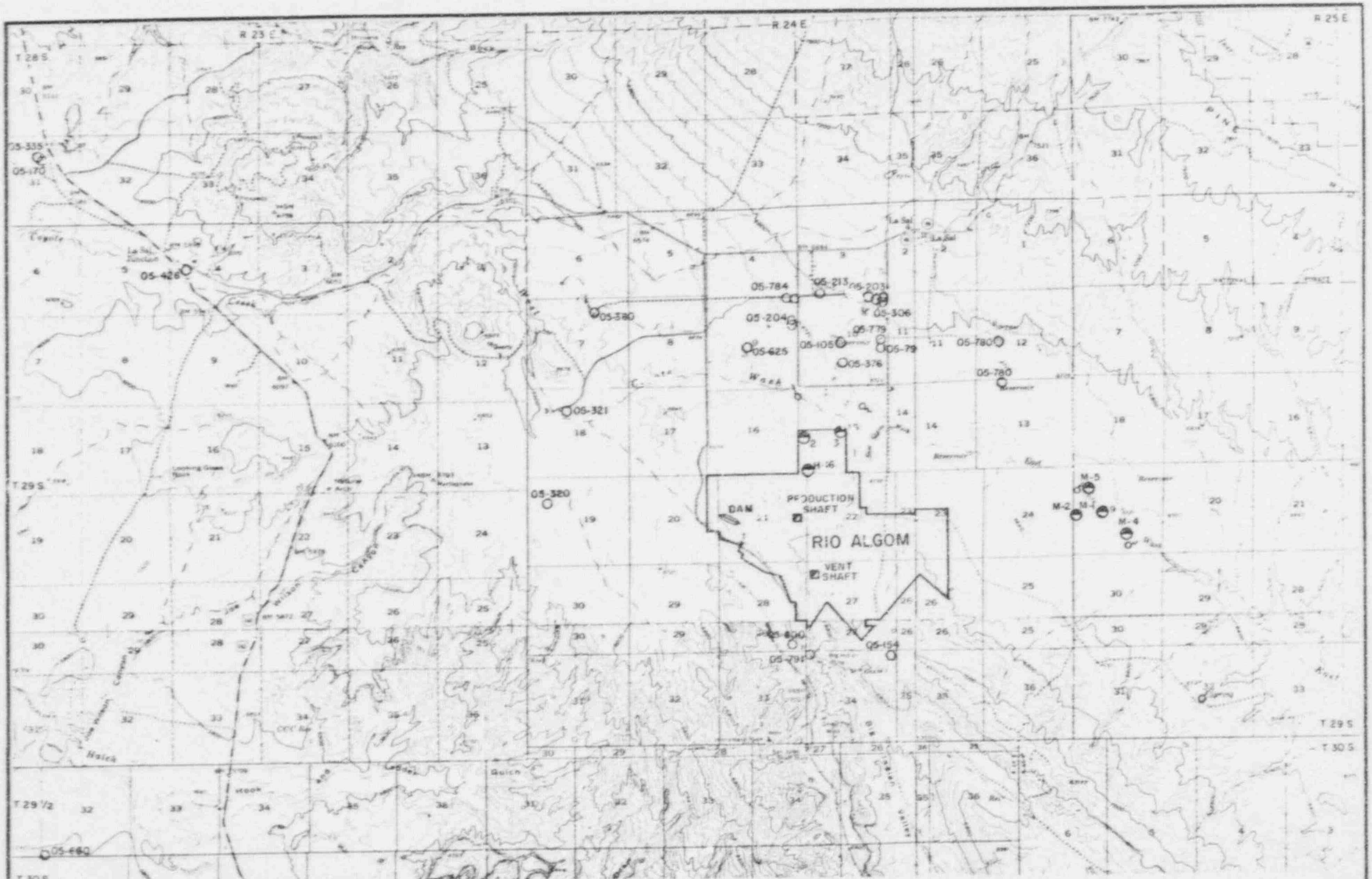
PLATE 3



REFERENCE:
U.S.G.S. QUADRANGLE MAPS TITLED, "LA SAL JUNCTION," "LA SAL," "HATCH ROCK," AND "LISBON VALLEY".

KEY:
SPRING
WATER SUPPLY WELL AND SERIAL NUMBER
RIO ALGOM WELLS AND NUMBER

VICINITY MAP

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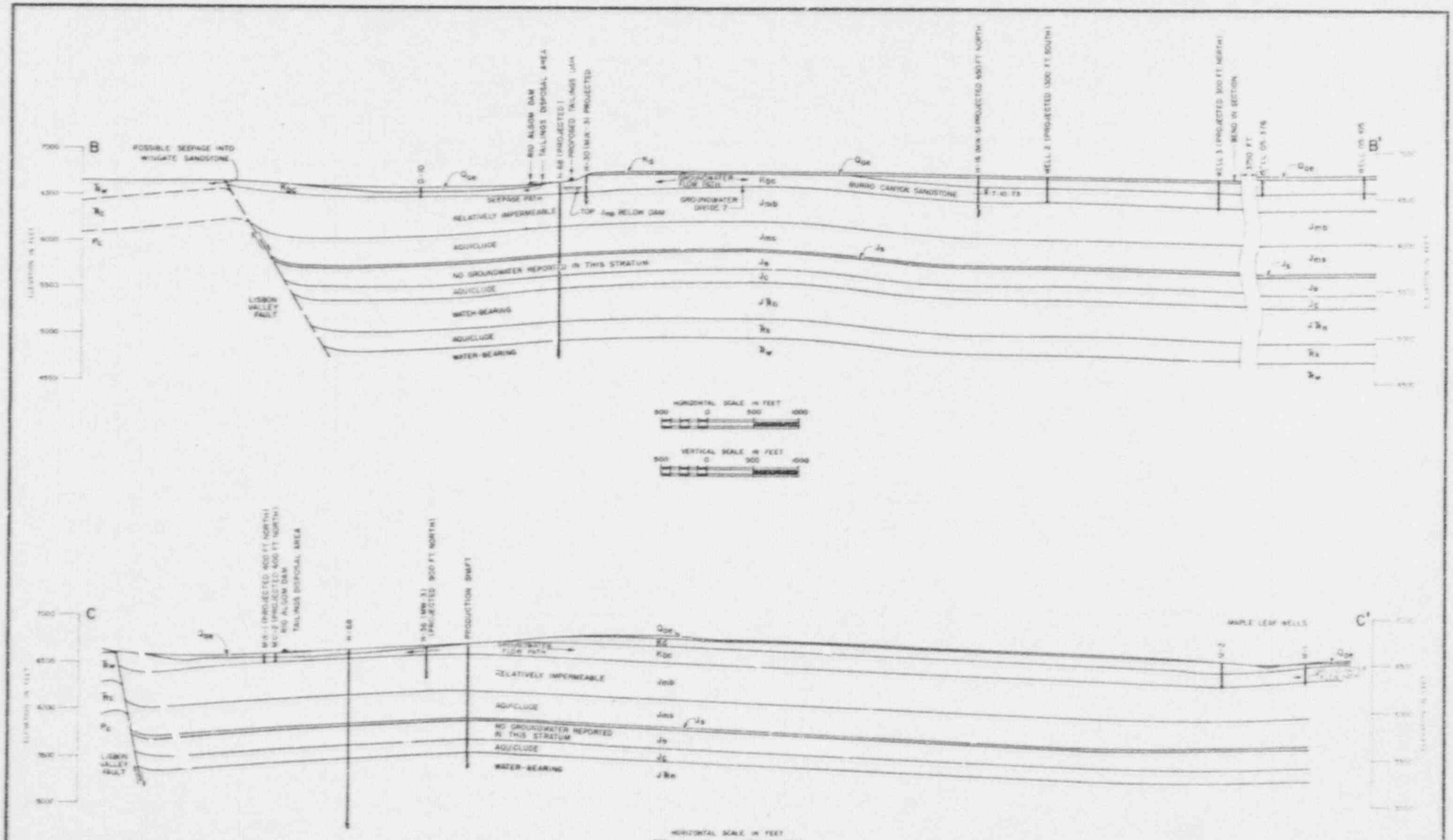
PLATE 4

REFERENCE:
PRELIMINARY GEOLOGIC MAPS TITLED:
"MOUNT PEALE 1 SW QUADRANGLE, 1957,"
"MOUNT PEALE 2 SE QUADRANGLE, 1960,"
"MOUNT PEALE 3 NE QUADRANGLE, 1958,"
"MOUNT PEALE 4 NW QUADRANGLE, 1961,"
LOCATED IN SAN JUAN COUNTY, UTAH.

VICINITY GEOLOGY

DAMES & MOORE

PLATE 5



VICINITY GROUND WATER FLOW CROSS SECTIONS B-B' AND C-C'

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PLATE 6

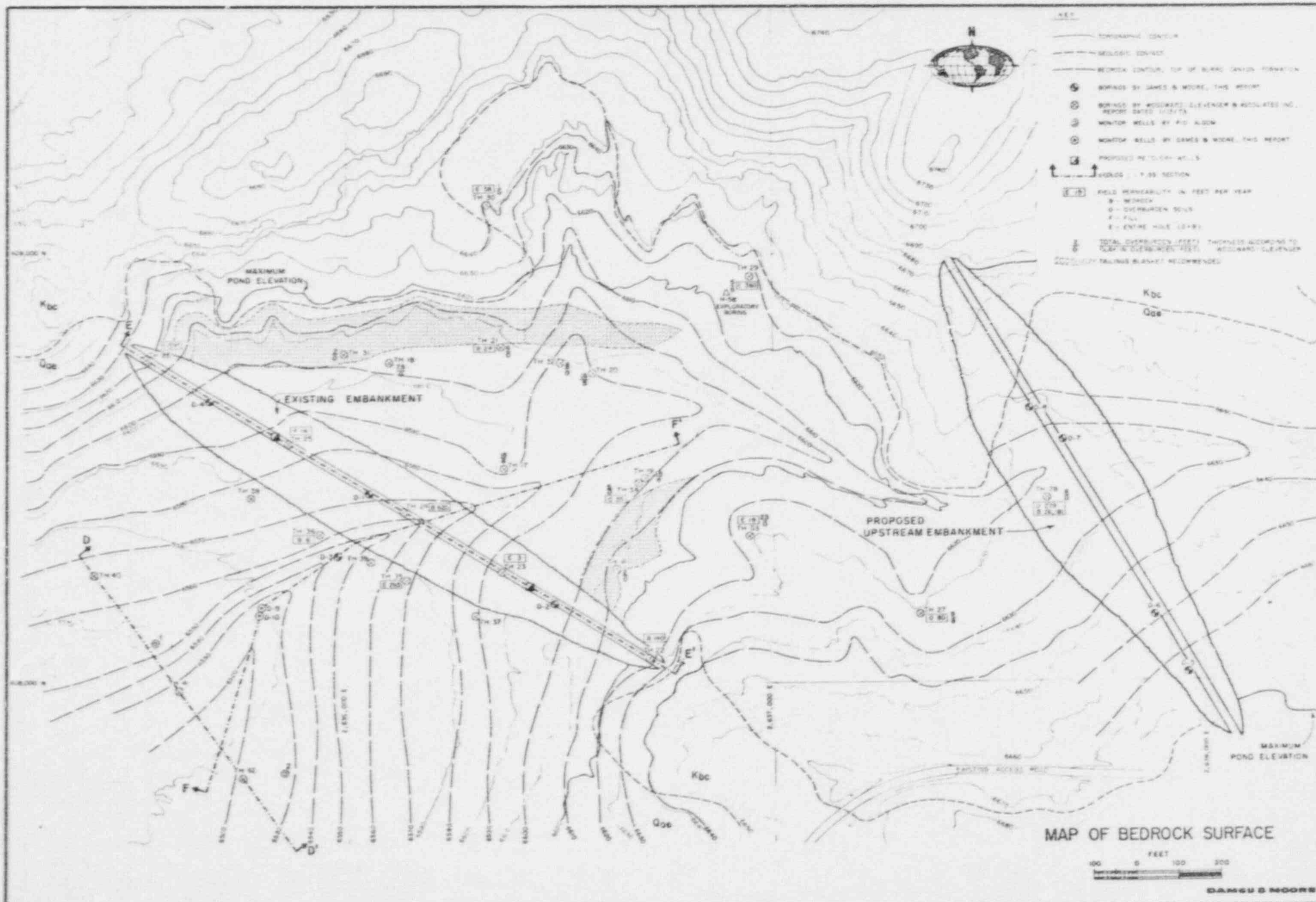
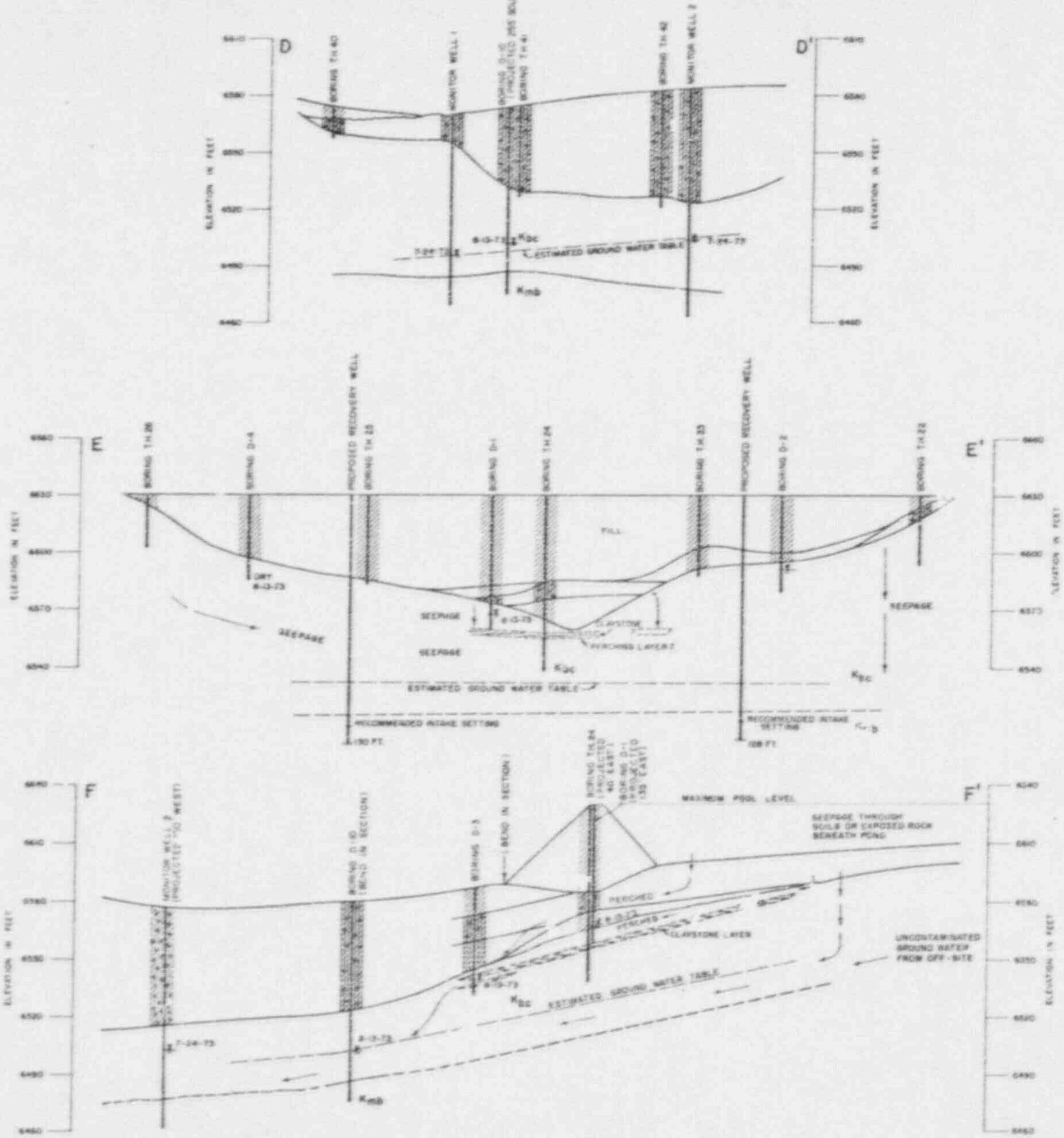

MAP OF BEDROCK SURFACE
EXISTING EMBANKMENT
PROPOSED UPSTREAM EMBANKMENT
MAXIMUM POND ELEVATION
MAXIMUM POND ELEVATION
EXPLORATORY BORING
Kbc
Qae
N
FEET
100 0 100 200
DAMES & MOORE

PLATE 7



GEOLOGIC CROSS SECTIONS
TAILINGS POND
CROSS SECTIONS D-D', E-E', AND F-F'

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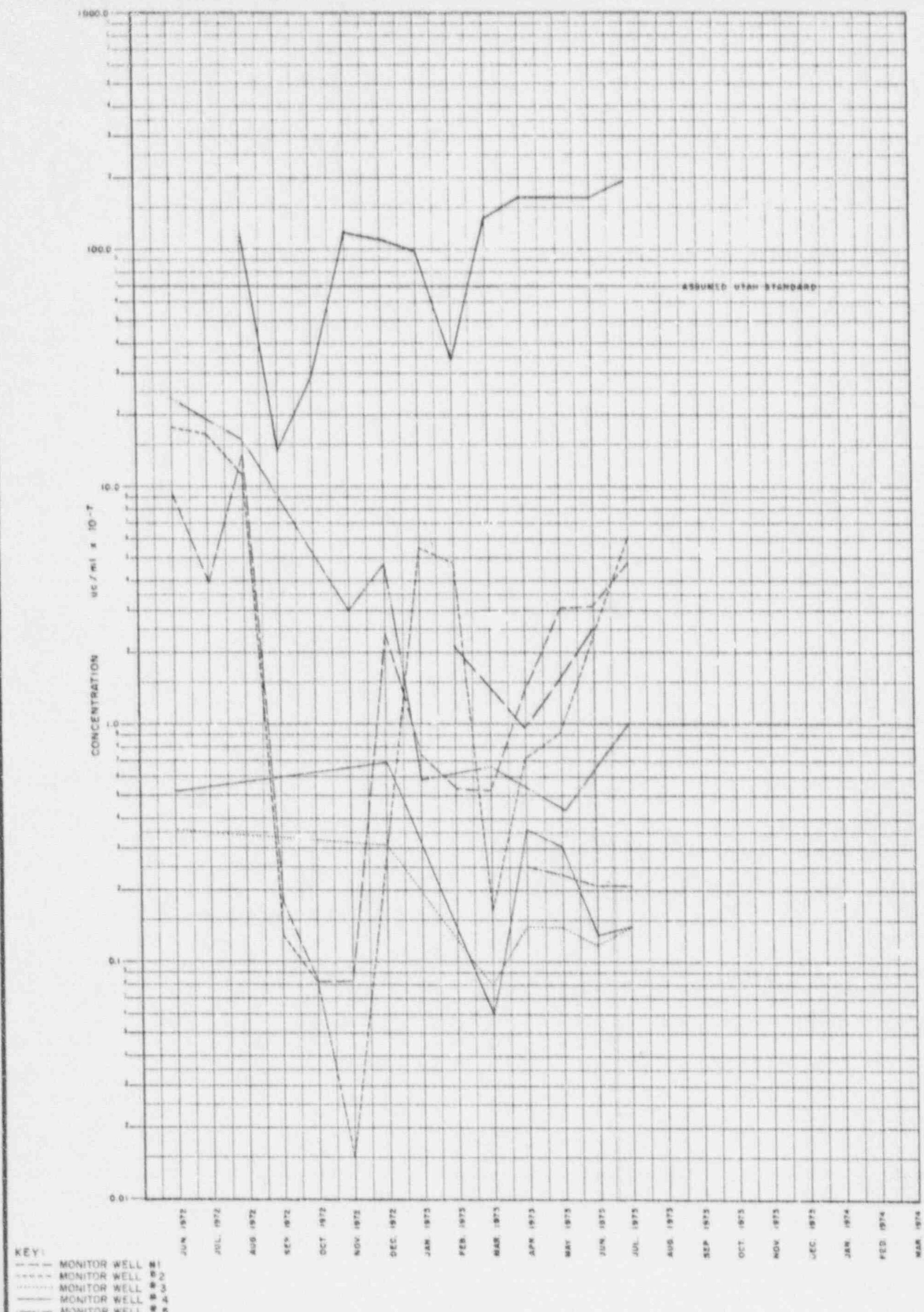
PLATE 8



NATURAL URANIUM CONCENTRATION
GROUND WATER IN OPERATIONS AREA

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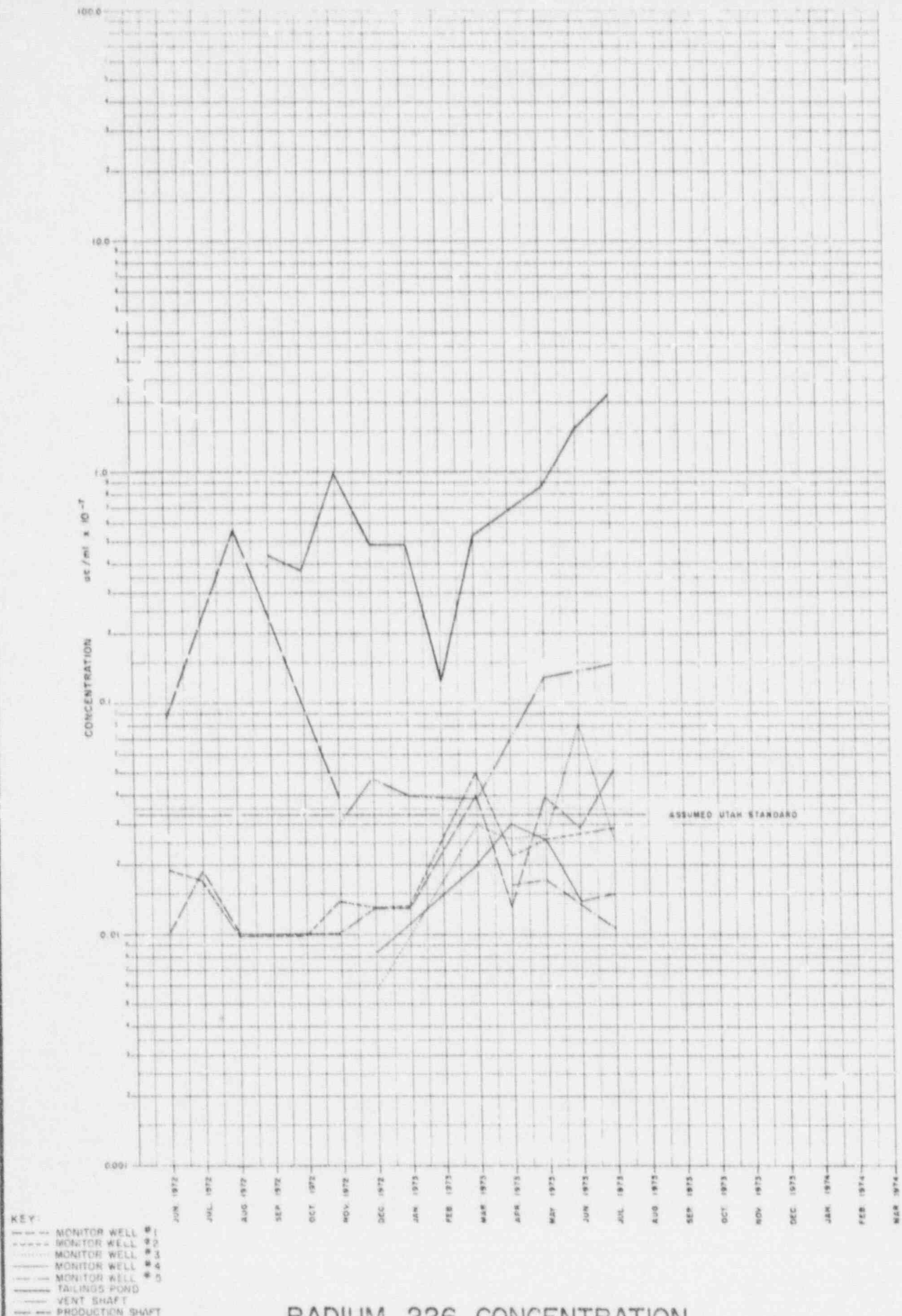
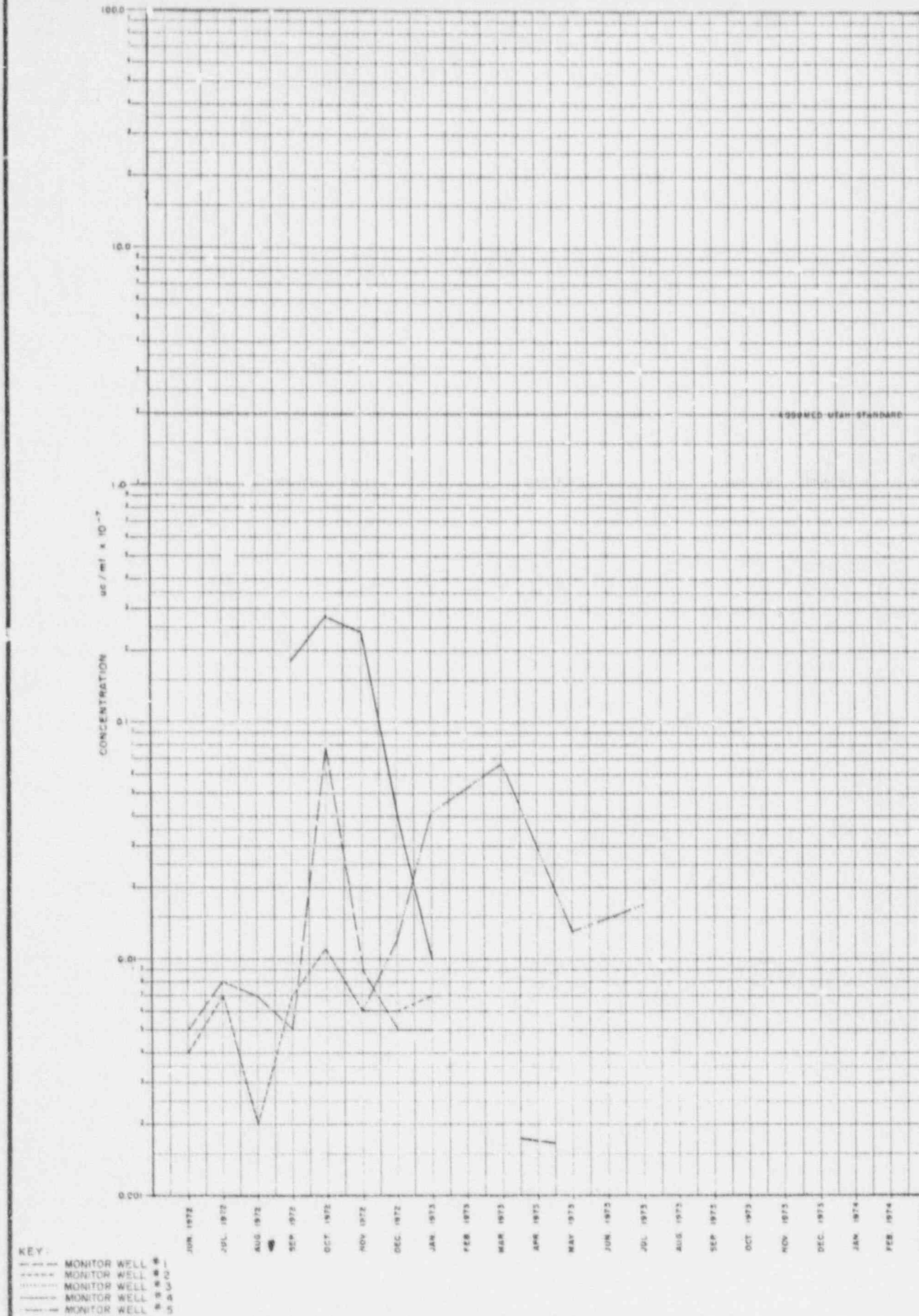
PLATE 9A



RADIUM 226 CONCENTRATION
GROUND WATER IN OPERATIONS AREA

DAMES & MOORE

PLATE 9B



POLONIUM 210 CONCENTRATION
GROUND WATER IN OPERATIONS AREA

DAMES & MOORE

PLATE 9C

APPENDIX II-A

PERMEABILITY TESTING

Field tests were conducted in January, 1972 by others to determine the permeability of the soils and bedrock in the vicinity of the tailings pond and along the axis of the starter dam. These tests were made at 14 separate locations by falling head or constant head permeameter techniques in an open, uncased boring or by single packer method. The procedures used are standard methods established by the U. S. Bureau of Reclamation. Under adequately controlled conditions, these tests indicate approximate ranges and orders of magnitude for permeability.

The results of the field testing are presented in Table II-A1. Based on these results, the following average permeabilities were assumed for the natural soil and rock materials:

	Permeability Range (Ft/yr)	Average Permeability (Ft/yr)
Overburden soils and shallow, weathered bedrock	19 to 340	150
Burro Canyon sandstone	0 to 1595	400

A general qualitative guide to degree of permeability, expressed in feet per year, is as follows:

Relatively Impermeable	-	Less than 10 feet per year
Slightly Permeable	-	10 to 100 feet per year
Moderately Permeable	-	100 to 1000 feet per year
Highly Permeable	-	Over 1000 feet per year

TABLE II-A1

FIELD PERMEABILITY TESTS

Boring	Depth (Ft)	Test Type	Material	Permeability (Ft/yr)
22	11.3	1	B	14
	9.3	1	B	33
	7.4	1	B	71
23	43.3	1	E	2.6
	43.3	1	E	3.4
	43.3	1	E	2.4
25	35.3	1	C	1.4
27	11.0	1	D	98
	9.5	1	D	83
	9.9	1	D	58
28	14.0	2	B	380
	14.5	1	B	350
	11.5	1	B	108
29	8.0	2	E	360
30	4.1	1	A	63
	3.0	1	A	66
	3.0	1	A	46

1. Open Hole - Falling Head, Uncased
2. Open Hole - Constant Head, Uncased
3. Packer - Constant Head

   A. Sandstone
   B. Sand: dense, clayey or silty
   C. Clay Fill
   D. Clay: stiff
   E. Combined overburden and sandstone

TABLE II-A1 (Cont.)

FIELD PERMEABILITY TESTS

Boring	Depth (Ft)	Test Type	Material	Permeability (Ft/yr)
33	5.7	1	E	11
	5.0	1	E	26
	2.3	1	E	20
34	9.2	1	E	53
	9.4	1	E	16
35	24.0	2	F	420
	24.0	2	E	147
36	49.0	2	D	180
22	16-37	3	A	139
	16-37	3	A	141
24	69-92	3	A	620
26	12-28	3	A	1780
	12-28	3	A	1410
28	18-35	3	A	26.5
	18-35	3	A	181
32	14-34	3	A	24
36	33-49	3	A	6

1. Open Hole - Falling Head, Uncased
2. Open Hole - Constant Head, Uncased
3. Packer - Constant Head

    A. Sandstone
    B. Sand: dense, clayey or silty
    C. Clay Fill
    D. Clay: stiff
    E. Combined overburden and sandstone

APPENDIX II-B

PETROGRAPHIC AND SOLUBILITY ANALYSES

Several soil and rock samples were analyzed petrographically, primarily to ascertain the presence of soluble constituents such as gypsum or calcite. Removal of soluble minerals by the tailings pond effluent, which frequently has a pH exceeding 10, would increase the permeability of the soil or rock so affected and would promote seepage loss.

The results of petrographic analysis are as follows:

Boring D-1; Sample depth 54.5 feet; Soil-SM

Percent moisture: 15 (as percentage of oven-dried weight)

Percent clay size fraction: 7

Composition of clay size fraction: quartz, 4 percent; kaolin, 2 percent; illite, 1 percent

Overall description: A soil. Coarse fraction consists of euhedral quartz crystals less than 0.5 mm in size, in a matrix of silt and clay. The matrix is predominantly quartz.

Boring D-2; Sample depth 29.5 feet; Soil-SM

Percent moisture: 10

Percent clay size fraction: 11

Composition of clay size fraction: quartz, 5 percent; calcite, 4 percent; kaolin, 1 percent; other, 1 percent

Overall description: Mostly quartz cemented by calcite. The quartz is euhedral to subhedral, with one half percent quartz rounded.

Boring D-3; Sample depth 39.5 feet; Soil-SP

Percent moisture: 9

Percent clay size fraction: 12

Composition of clay size fraction: quartz, 8 percent; calcite, 2 percent; kaolin, 2 percent

Overall description: Poorly sorted with pebbles up to one-inch (left out in moisture determination). Euhedral quartz and rounded calcite fragments occur in the silt and clay fraction.

Boring D-3; Sample depth 47.0 feet; Rock core-sandy mudstone

Percent moisture: 3

Percent clay size fraction: 16

Composition of clay size fraction: kaolin, 12 percent; halloysite, 4 percent

Overall description: Rounded quartz and calcite grains in a matrix of silt and clay. Occasional gypsum grains. Friable, breaks in the hand.

Boring D-4; Sample depth 34.0 feet; Rock core-sandstone

Percent moisture: 2

Percent clay size fraction: Less than one percent

Composition of clay size fraction:

Major: An unidentified mineral with a strong 3.3 Å line - very possibly an iron mica - glauconite, celedonite, or biotite and quarts.

Minor: Kaolin. Trace of montmorillonite.

Overall description: Many of the quartz grains are sharp and doubly terminated. A few are rounded. Cement is calcite. Visual estimate of porosity is 20 percent. The clay sized fraction occurs as inclusions up to 1/4-inch across.

In addition to the foregoing petrographic studies, the samples were evaluated for solubility in distilled water at 88° C, in water of pH = 9 and in weak acid solution. In each case, the sample was agitated in the solution and allowed to stand for 24 hours before determining the percentage of dissolved solids. The results are on the following page.

Sample No.	Solubility Neutral Water	pH 9.0 (%)	Acid (%)
D-1, 54.5 feet	Nil	1.0	2.0
D-2, 29.5 feet	Nil	0.9	0.9
D-3, 39.5 feet	Nil	Nil	5.7
D-3, 47.0 feet	Nil	Nil	3.1
D-4, 34.0 feet	Nil	0.2	0.7

TAILINGS SEEPAGE

E. P. A. QUESTION

	Reference Page or Plate No.
Page 38 of the draft statement indicates that a set of sampling wells for the tailings retention system has been established. However, page 56 (Section 6.6.3) of the applicant's environmental report mentions only "a monitoring well". The final statement should clarify how many wells will be used.	
The draft statement also indicates that samples from these wells around the tailings retention system will initially be taken weekly and later monthly, if results indicate the need. Since the mill has been operating since June, the final statement should contain actual sampling information relating to the occurrence of seepage prior to sealing, as is predicted for the bottom and side walls of the system.	Pg. 19-21
	Plate 9
In addition to the above data, the location of the monitoring wells should be indicated as well as depth and strata sampled. This information is necessary to insure that the points are representative.	Pg. 19 Plates 5,7,8

TAILINGS DAM

E. P. A. QUESTIONS

The EPA has considerable concerns relating to the proposed method for lifting the tailings retention dam. As a result of a meeting with the Bureau of Reclamation, Earth Dams Division, it was verified that the method of raising the tailings dam is not acceptable. Generally the Corps of Engineers review and subsequent license stipulations should prove adequate, but the proposed stipulations should be explicitly incorporated in the final statement to prevent omission of them in future licenses. In addition, the Bureau of Reclamation - Earth Dams Division, and the Bureau of Mines should also be directly consulted prior to additional lifting of the present retention dam.	X
The reference on page 31 of the draft statement to the spigotting technique is misleading with respect to the term "surface water". The final statement should refer to the liquid tailings solution, rather than surface water.	X
Other questions concerning tailings retention which are not resolved in the draft statement and which should be addressed in the final statement are:	X

1) Is the underlying silty sand and clay, into which the dam is keyed, impermeable to the tailings seepage? Plate 8 Pg. 10

2) What provisions have been made to prevent formation of ice lenses or slime pockets near the crest of the dam and near other critical structural points in the dam? X

3) Does the applicant intend to monitor the position of the phraetic line during deposition of tailings? Pg. 20

TAILINGS SEEPAGE

E. P. A. QUESTION

As has been the case with other uranium mills, it is optimistically predicted that seepage from the tailings pond will be minimal with the seal provided by depos..ed sand tailings. However, experience indicates that this mechanism may be far less effective than anticipated and liquid loss by seepage will most likely be significant and require additional control procedures. X

It is stated that the p..mping of seepage back to the system will be initiated, when and if necessary, but the method of collection and return is unspecified. This should be outlined in greater detail. It is also recommended that necessary equipment and facilities (e.g., collection basin at foot of dam), for such events should be available. Pg. 16-18

TAILINGS SEEPAGE

D. O. I. COMMENT

The impacts of eventually allowing the industrial wastes in the pond to seep into the ground water should be identified. In the milling process, approximately 60% of the milling solution is sent to the tailings pond. Based on the concentrations stated, concentrations in the tailing pond will be nearly 4,500 ppm of sulfate and 4,300 ppm of sodium. Although the 2 feet per year of milling solution could all evaporate, there will be periods of surface-water runoff into the tailings pond which will result in significant percolation of water to the ground water. X

An adequate basis has not been provided in the draft statement for assessing the potential effects on ground water from seepage of radioactive or chemical wastes from the tailings pond. The statement briefly specified that tailings will be deposited around the pond as a "perimeter sealing process" and specifies that should seepage appear in monitor wells around the dam it will be collected and pumped back. However, without further description of the physical features, and without any description, discussion or documentation of the geology and hydrology of the site of the pond and its vicinity, it is not possible to judge (1) whether the "perimeter sealing process" or other (unspecified) sealing agents will be useful, (2) whether the monitoring wells will be properly located, sufficiently deep, and properly designed to detect the seepage, or (3) whether the seepage can be collected efficaciously and returned to the pond. Pg. 10, 11 Pg. 6-10

It is stated on page 33 that liquid losses will occur principally by evaporation is misleading. The soluble salts introduced will be available for leaching and downward percolation until depleted. Artificial lining of the floor of the pond was rejected because laboratory tests conducted by the applicant on tailings from a mine adjacent to Rio Algom indicated that tailings of a high solid to liquid ratio have a very slow percolation rate. However, it should be recognized that if the rock underlying the floor of the tailings pond is highly fractured or jointed and has a thin natural lining of silt and clay, the rate of percolation might be greatly enhanced -- especially as the hydraulic head is increased by filling of the pond, or in the event the solid to liquid ratio of the tailings is reduced by storm runoff into the pond. Regardless of the evaporation potential, there will be downward percolation of water unless the bed is absolutely impermeable. With present conditions there is enough permeability so that a more concentrated solution will flow to the ground water. Losses by both mechanisms will occur and there is little basis to assume that evaporation will be the principal mechanism. X

Environmental Monitoring

This section of the statement should be expanded to document the validity of the assumption that these processes will limit migration of contaminants. The documentation should include discussions of (1) the chemical and radioactive substances that might be expected to seep from the pond, (2) the lithology, sorptive and exchange capacities, and the thickness and distribution of the earth materials through which the seepage fluids might move, and (3) the natural ground water chemistry and paths and rates of movement of water in these materials. Pg. 6-14 Table 1

The Environmental Monitoring section also specifies that the applicant will perform periodic sampling from wells to confirm that migration by seepage is not occurring, and that the AEC will periodically audit the applicant's monitoring program. Therefore, it would be appropriate to describe the AEC criteria for determining when corrective action or changes would be required and explain how the specified regulatory action would be taken. R.A.

It is recognized on page 38 that the principal ionic form of radioactive wastes will be complex anions. We think that due to the anions and salt concentrations expected in the tailing pond the result of the retention mechanisms will be much less than the maximum implied. It can be expected that a volume of ground water will be contaminated with sulfate-rich wastes and some radiochemical constituents. X

Normally regulatory action is after the fact and therefore is noncorrective since little corrective action is possible except to recycle pumped water. This section should not consider migration to be negligible. It will occur, although it is unlikely to be hazardous. X

No impervious lining is planned for the tailings pond. Only a small amount of seepage is anticipated, and the soil beneath should tie up the alkaline ions before they contaminate the ground water. There should be adequate insurance against the possibility of this seepage contaminating underground aquifers that supply water wells to the south. Pg. 7 Pg. 14-18

DIVERSION DITCH

D. O. I. COMMENT

The initial dam which will be approximately 40 feet high, will be raised to a final height of 65 feet and have a minimum freeboard of 10 feet. The freeboard for dam heights of less than 65 feet is not given. The size of the drainage area above the dam is not given in the statement, but according to figure 3 on page 10 the drainage area seems large enough to produce cloudburst-flood runoff that might endanger a 40 foot high dam with only a 10 foot freeboard. The minimum freeboard of 10 feet at the maximum dam height of 65 feet seems adequate for storm runoff. It is stated on page 33 that a channel will be constructed to divert floodwaters around the tailing pond. It appears to us that if this channel is constructed prior to the milling operations as an added safety precaution, many of our concerns expressed in these comments would be satisfied. X

DIVERSION DITCH

E. P. A. COMMENT

The stated intention of constructing a flood control channel around the tailings pond should be accelerated in schedule and not delayed until cessation of the milling activity. This would provide protection from failure. Comments on this recommendation should be made in the final statement, along with an implementation schedule, if adopted. X

The draft environmental statement adequately documents the existing ecological and physical characteristics of the land and has recognized the major environmental impacts that may be created for one alternative. The major weaknesses of this statement are the superficial evaluation of the alternatives to the proposed action and the short time span (8-10 years) considered in evaluating the adverse impacts. X

We raise the following questions concerning the evaluation of impacts:

1. The tailing pond is being constructed in a drainage channel to take advantage of the storage capacity without excavation. This is hazardous even in this arid climate. Heavy intensity, local "cloud bursts" are common in this area. If the proposed site is developed, the channel diversion should be constructed before the pond is filled. X

CORPS OF ENGINEERS

NOTE

a. Rio Algom Corporation has complied with the requirements of Section 13 of the 1899 River and Harbors Act by filing an application for permit to discharge into a navigable waterway during construction and in event of accidental spills or discharges. All applications to the Corps of Engineers for such permits have been transferred to the Environmental Protection Agency as a result of the Federal Water Quality Act Amendments of 1972. X

E.P.A. COMMENT

Environmental Monitoring

No mention is made in the draft statement of the sampling of mine water discharge. It is recommended that this discharge be monitored until determinations have been made by cognizant agencies or authorities that all standards are being met. Plate 9

D. I. O. COMMENT

The proposal to discharge approximately 100 gpm of excess mine water containing 5.3 pCi of radium-226 per liter, without treatment, to the Redd Ranch and the Keystone-Wallace cooper leaching operation is not acceptable. Utah water quality standards require that radioactive substances shall not exceed 1/30th of the MPC values given for continuous occupational exposure in the National Bureau of Standards (NBS) Handbook #69. Application of this criteria leads to a maximum allowable radium-226 concentration of 3.3 pCi per liter. This water will drain essentially undiluted and freely across land not controlled by the applicant, and in drainages considered to be waters of the state. It appears therefore that the water quality standards of the State of Utah will be violated by this action. The final statement should indicate how compliance will be attained. Plate 9 Pg. 18,19

The draft statement indicates two water sources in the area. One is used by neighbouring ranchers and the mill as the primary source for potable water. The other is the water pumped from the mine. Since the average rainfall is less than 15 inches/year and the evaporation rate is 55 inches/year, all excess water used must come from precipitation in the La Sal mountains. This would indicate an overall shortage of water and a need for conservation. To assess the impact of the mining and mill operation upon the ground water, further information is required. The relative depths of the two sources should be shown on the Stratigraphic Section (Figure 6). The expected drawdown of the potable water aquifer should be shown and the effect of such drawdown upon the ranchers, wildlife and forage should be discussed. Plate 2 Pg. 21, 22

The draft statement indicates that the volume of mine water is decreasing, but fails to give any reason or rate of the decrease. There is no indication whether a direct connection exists between the mine water source and the potable water aquifer. This should be clarified in the final statement. The most efficient use of water should be required in all cases. It is assumed that the mine water comes from aquifers below those economically available for use by the ranchers in the area. Therefore, it would appear that the mine water should be used for industrial processes exclusively, leaving the well water for use by the ranchers who depend on these wells as their only source. Although the draft statement says that the volume does not appear adequate for the process requirements, the alternative of using waste mine water supplemented by well water when necessary should be discussed. The draft statement does not show how the Redd Ranch plans to use the mine water. This should be discussed. No alternatives involving possible reuse of any portion of the water have been shown. These items should be discussed in the final statement.

Pg. 22,23

R.A.

Pg. 24

Hydrology

The effect of discharging a significant fraction of the 100 gpm excess mine water was not covered. As this water has relatively high dissolved solids (2,962 ppm), sodium (1,335 ppm), and chloride (1,597 ppm), the effect on the aquifer underlying the Coyote Wash area may be detrimental to the water quality.

X
No regulating criteria

There is a remote possibility that the mine drainage operations would result in a detectable decrease in natural ground water discharge such as spring flow. If there are nearby springs discharging from the rocks dewatered by mine drainage operation, periodic discharge measurements of those springs are recommended as part of the monitoring program.

Pg. 22,24

STATE OF UTAH

COMMENT

2. According to the report, about one hundred gallons per minute of excess process or waste water pumped from the mine will be diverted for use at the Redd Ranch in the Keystone-Wallace heap leaching operations located about two miles south of the applicant's site. Initial testing of the mine water for radioactivity showed the radium content of some samples to be about one-sixth of the limit for release to an unrestricted area as set forth in the AEC's 10 CFR Part 20. The AEC is requiring the applicant to perform surveys to

Pg. 18,19

assure that the radioactivity in the water diverted to the Redd Ranch is within acceptable limits. We would like to be assured that this is done.

GEOLOGY AND HYDROLOGY

D. O. I. COMMENT

Geology

The sections on geology and hydrology are exceedingly brief and are inadequate to provide the background necessary for independently judging the AEC's assessment of the environmental impact of the proposed mill and its operations. These sections should be expanded to include a detailed description of the geology of the site and a general description of the geology of the region around the site. The expanded section should include discussions of the lithologic and hydrogeologic properties and the geographic distribution of stratigraphic units, and should be illustrated by geologic and hydrologic maps at scales appropriate to document the basis for various conclusions stated in other sections in the report. In particular, it will be necessary to define and discuss all aquifers potentially affected by the plant during and after its operational lifetime. Areas of recharge and discharge of aquifers, directions and rates of ground water movements, and present and potential use of water from these aquifers should be specified.

Full report

A. E. C. QUESTIONS

DOCKET NO. (40-8084)

3. Describe or state your action level for the total radioactivity measurements for water monitoring stations No. 1, 2, 3 and 4, i.e. at what concentrations of total activity will you identify and quantify the contaminent? When this action level is selected, how will you assure that it is a concentration that will not allow the concentrations of U, Ra-226 and Th-230 to exceed MPC's for unrestricted areas? Pg. 15

6. Seepage from the tailings pond is to be monitored by perforated wells (Section 7.4.2.4, Page 170). Because the filter cake of tailings material lining the pond bottom will restrict infiltration, it is quite likely that flow in the formations will occur at pressures less than atmospheric. If so, monitor wells will not detect the flow. Provide information about subsurface conditions and rationale for locating sample wells for monitoring for seepage from the tailings pond. Pg. 19,20

7. On page 170 of your Supplemental Report dated November 1971 and in your correspondence dated February 20, 1973, you state that two additional monitor wells have been selected and that a third is to be selected, total of 5. Provide the rationale for selecting these monitor wells and submit descriptions of all tests, and data from such tests, which supports the rationale for selecting these wells. Pg. 19,20

8. Ventilation and production shafts will produce water in a substantial amount from the Navajo and Entrada formations (Section 7.2.1.5, Page 138). Water quality is relatively poor (Table 11, Page 38) compared to that of the Dakota (Table IV, Page 134). When the shafts are abandoned, this water may fill the shafts and enter the Dakota where it would contaminate that source. Develop a plan for sealing all vertical shafts at the end of mining operations so that no deep water communication with shallow aquifers is possible. Pg. 7

9. Appendix H of the Supplemental Environmental Report (p. H-2) shows an estimated mine drainage discharge of 0.17 MGD. However, the average daily discharge is given as 150 GPM (p. H-5), the equivalent of 0.22 MGD. The preliminary Environmental Report states (p. 17) that any drainage from the mine area will travel via the south branch of West Coyote Creek to Hatch Wash and Cane Creek to join the Colorado River some five miles below Moab. Mine drainage is a subject of increasing concern to environmentalists. Greater attention should be given to this topic. — No mine drainage runoff will be allowed

Furnish a statement answering the following questions. What is the actual expected discharge rate to natural drainage? Does the value of 2900 mg/liter T.D.S. (p. H-7) apply to this discharge? What alternatives have been considered to prevent mine drainage water from entering and contaminating natural streams? — Zero, <u>including</u> max. flood

13. In the Environmental Report of August 1971, it is stated that the watershed area for this dam basin is 590 acres. What checks have been performed to verify this? In addition, provide information about the soil characteristics of the drainage basin and methods used to determine these characteristics. — X

14. Provide a definition of the term "relatively impervious" as used on page 102 of the Supplemental Environmental Report dated August 1971, and provide documentation of "permeability or percolation testing", referred to on page 166, Section 7.4.2.2.1 and page 168, Section 7.4.2.3.1, same report. — Appendix II-A

16. Provide a more explicit discussion on how seepage below the dam will be disposed of. — Pg. 16-18

17. Provide an analysis of the adsorptive capacity of the soils through which the tailings solution will seep, e.g., using the exchange capacity of the soil (milliequivalents per gram of soil) calculate the grams of radium adsorbed by a ton of soil through which the tailings may seep and thereby show that the soil is or is not an effective mechanism for fixing that radium that may seep. — Not answered yet

LIBSON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc.		
7-3-73	80'								
7-10-73	75'		385		5.1				
7-17-73	75'		385		3.9				
7-24-73	75'		385		4.8				
COMPOSITE			385		4.6				
				698	4.8	5.22	<2.0		
8-7-73	75'	7.2	295		2.9				
8-14-73	75'	7.6	333		3.3				
8-21-73	75'	7.4	335		3.6				
COMPOSITE				489		4.78	<2.0		
8-28-73	74'	7.4	386		2.4				
9-4-73	73'	7.5	330		1.6				
9-11-73	73'	7.6	340		1.4				
9-18-73	73'	7.3	315		1.4				
COMPOSITE				473	1.7	1.84	<2.0		
9-25-73	73'	7.4	330		2.4				
10-2-73	73'	7.5	325		1.5				
10-9-73	73'	7.6	328		1.4				

M = monthly
Mc = monthly composite
W = weekly

APPENDIX C

LIBSON MINE

TAILINGS MONITOR WELL #2

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
7-3-73	85'		394		5.8				
7-10-73	80'		393		6.4				
7-17-73	80'		394		5.6				
7-24-73	80'		393		6.6				
COMPOSITE				715	6.2	2.96	< 2.0		
8-7-73	80'	7.3	395		6.5				
8-13-73	80'	7.6	300		2.0				
8-20-73	80'	7.5	392		4.7				
COMPOSITE				481	4.4	1.14	< 2.0		
8-28-73	80'		410		4.2				
9-4-73	80'		360		3.9				
9-11-73	81'		370		4.2				
9-18-73	81'		365		2.8				
COMPOSITE				420	3.9	2.40	< 2.0		
9-25-73	82'	7.6	446		3.9				
10-2-73	82'	7.6	345		3.4				
10-9-73	82'	7.6	360		4.2				

M = monthly
Mc = monthly composite
W = weekly

LIBSON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN 73	SNOWBOUND								
FEB 73	SNOWBOUND								
3-13-73	155'	8.2	160	260	.08	3.0	<2.0		
4-13-73	150'	8.1	72	254	.16	2.6	<2.0		
4-25-73	150'	8.0	72	253	.12	2.6	<2.0		
5-1-73	150'	8.4	150	135	.15	2.6	<2.0		
5-8-73	145'	8.3	150	130	.15	2.8	<2.0		
5-15-73	145'	8.2	153	137	.14	2.8	<2.0		
5-22-73	145'	8.3	150	142	.14	2.5	<2.0		
6-12-73	145'	8.1	51	210	.12	8.3	<2.0		
7-10-73	145'	8.2	83	278	.14	2.6	<2.0		
8-14-73	145'	7.4	48	160	2.50	5.7	<2.0		
9-4-73	145'	7.6	40	167	2.30	3.75	<2.0		
10-2-73	145'	7.3	38	168	.20	1.56	<2.0		

M = monthly
Mc = monthly composite
W = weekly

LIBSON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN. 73	SNOWBOUND								
FEB. 73	SNOWBOUND								
3-13-73	155'	8.3	187	277	.06	2.0	2.0		
4-13-73	150'	8.1	158	253	.42	1.2	2.0		
4-25-73	150'	8.1	154	254	.31	4.9	2.0		
5- 1-73	150'	8.4	114	155	.30	2.6	2.0		
5- 8-73	145'	8.4	107	150	.30	2.7	2.0		
5-15-73	145'	8.4	114	153	.31	2.5	2.0		
5-22-73	145'	8.4	121	148	.29	2.6	2.0		
6-12-73	145'	8.4	100	301	.13	1.4	2.0		
7-10-73	145'	8.4	173	349	.14	1.5	2.0		
8-14-73		7.7	140	250	1.90	5.3	2.0		
9- 4-73	145'	7.9	130	310	1.00	3.25	2.0		
10-2-73	152'	7.6	130	213	.20	3.22	2.0		

M = monthly
Mc = monthly composite
W = weekly

LIBSON MINE

TAILINGS MONITOR WELL #5

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
JAN. 73------SNOWBOUND---------									
FEB. 73------SNOWBOUND---------									
MAR. 73 -----SNOWBOUND & MUD--									
4-13-73	205'	7.9	42	324	.28	1.81	2.0		
4-25-73	200'	7.8	42	264	.23	1.45	2.0		
5- 1-73	195'	8.4	29	215	.23	1.63	2.0		
5- 8-73	195'	8.4	29	210	.24	1.75	2.0		
5-15-73	195	8.3	29	219	.23	1.78	2.0		
5-22-73	195'	8.4	29	223	.23	1.78	2.0		
6-12-73	195	8.2	31	338	.21	1.39	2.0		
7-10-73	195'	8.2	50	424	.21	1.07	2.0		
8-14-73	195'	7.4	26	250	1.20	1.85	2.0		
9- 4-73	195'	7.5	20	301	1.40	1.65	2.0		
10-5-73	195'	7.2	19	182	.30	1.94	2.0		

M = monthly
Mc = monthly composite
W = weekly

LIBSON MINE

TAILINGS MONITOR WELLS D-1, D-2, D-3 & D-10

SAMPLE DATE	DEPTH TO WATER	ppm			uc/ml				REMARKS
		pH	Na	So^4	Unat	Ra 226	Th 230		
FREQUENCY	M	W	W	Mc	w Mc	Mc	Mc		
D-1									
8-13-73		7.6		261	.20	6.99			
9-26-73		7.4		381	.10				
D-2									
8-13-73		7.7		2688	84.1	3.40			
BEFORE BAILING									
D-2A 9-26-73		7.7		3135	121.3				
AFTER BAILING									
D-2B 9-26-73		7.8		3376	126.9				
10-8-73		7.8		3376	126.9				
D-3									
8-13-73		7.4		1705	50.4	2.35			
9-26-73		7.6		1915	5.3				
D-10									
8-13-73		7.5		350	.70	1.71			
9-26-73		10.5		923	.03				

M = monthly
Mc = monthly composite
W = weekly

LISBON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	PH	H2O LEVEL	DISSOLVED SOLIDS (PPM)	HARDNESS (PPM)	SO4 (PPM)	NO3 (PPM)	Na (PPM)	Cl (PPM)	Fe (PPM)	10^{-7} URANIUM (uc/ml)	10^{-9} RADIUM 226 (uc/ml)	10^{-8} THORIUM 230 (uc/ml)	10^{-9} POLONIUM 210 (uc/ml)	10^{-9} LEAD 210 (uc/ml)	10^{-9} TOTAL ALPHA (uc/ml)
1972															
1- 4-73	7.9					ND	293	525		.84					
1-24-73	8.0					2	286	536		.67					
1-31-73	8.0					4	289	543		.67					
COMPOSITE					383						1.3	< 2.0	0.5		
2- 5-73	8.0	85'					290			.46					
2-12-73	7.8	85'					290			.51					
2-19-73	7.8	85'					280			.48					
2-26-73	7.6	85'					280			.55					
COMPOSITE					458					.53		< 2.0			
3- 5-73	7.6	80'					305			.17					
3-13-73	8.0	80'					294			.75					
3-19-73	8.1	80'					293			.75					
3-26-73	8.1	80'					298			.42					
COMPOSITE					475					.52	4.0	< 2.0			
4- 3-73	7.3	80'					261			.71					
4-10-73	7.6	80'					261			1.06					
4-17-73	7.7	75'					261			2.26					
4-24-73	7.7	75'					261			1.78					
COMPOSITE					284.8					1.38	1.3	< 2.0			
5- 1-73	8.2	75'					300			4.29					
5- 8-73	8.2	75'					300			2.10					
5-15-73	8.3	75'					300			2.10					
5-22-73	8.2	75'					314			4.40					
COMPOSITE					251					3.24	4.02	< 2.0			
6-5-73	7.9	75					289			3.44					
6-12-73	7.9	75					322			3.69					
6-19-73	8.0	75					300			3.19					
6-26-73	8.0	75					311			3.05					
COMPOSITE					604					3.38	2.91	< 2.0			
MPC										$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL															
AVERAGE															

LISBON MINE

TAILINGS MONITOR WELL #2

SAMPLE DATE	PH	PPM							uc/ml					
		WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
1972														
1- 4-73	7.5				4	300	582		1.79					
1-24-73	7.4				2	293	571		1.51					
1-31-73	7.5				2	295	564		1.34					
COMPOSITE				343						1.3	< 2.0	.7		
2- 5-73	7.6	90'				356			3.02					
2-12-73	7.6	90'				367			6.09					
2-10-73	7.7	90'				344			5.33					
2-26-73	7.6	90'				333			4.12					
COMPOSITE				557					4.72		< 2.0			
3- 5-73	7.8	85'				396			.35					
3-12-73	8.2	85'				396			.10					
3-19-73	8.2	85'				394			.75					
3-26-73	8.3	85'				396			.10					
COMPOSITE				330					.16	5.0	< 2.0			
4- 3-73	7.9	85'				340			.26					
4-10-73	7.9	85'				340			.82					
4-17-73	7.9	80'				360			.98					
4-24-73	7.9	80'				360			1.14					
COMPOSITE				296					.72	2.2	< 2.0			
5- 1-73	8.3	80'				460			.96					
5- 8-73	8.3	80'				440			.96					
5-15-73	8.3	80'				420			.96					
5-22-73	8.3	80'				460			.79					
COMPOSITE				324					.92	2.6	< 2.0			
6-5-73	8.1	75'				389			.45					
6-12-73	8.0	75				378			.45					
6-19-73	8.0	75				378			.70					
6-26-73	8.0	75				367			.42					
COMPOSITE				695					.50	3.3	< 2.0			
MPC									2×10^{-5}	3×10^{-8}	2×10^{-6}	7×10^{-7}	1×10^{-7}	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	PH	WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
		PPM							uc/ml					
1972														
JAN 73----	SNOWBOUND	--------												
FEB 73----	SNOWBOUND	--------												
3-13-73	8.2	155'		260		160			.08	3.0	<2.0			
4-13-73	8.1	150'		254		72			.16	2.6	<2.0			
4-25-73	8.0	150'		253		72			.12	2.6	<2.0			
5- 1-73	8.4	150'		135		150			.15	2.6	<2.0			
5- 8-73	8.3	145'		130		150			.15	2.8	<2.0			
5-15-73	8.2	145'		137		153			.14	2.8	<2.0			
5-22-73	8.3	145'		142		150			.14	2.5	<2.0			
6-12-73	8.1	145'		210		51			.12	8.3	<2.0			
7-10-73	8.2	145'		278		83			.14	2.6	<2.0			
8-14-73	7.4	145'		160		48			2.50	5.7	<2.0			
MPC									$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	PH	PPM							uc/ml					
		WATER LEVEL	HARDNESS	SO4	NO3	Na	Cl	Fe	10^{-7} URANIUM	10^{-9} RADIUM 226	10^{-8} THORIUM 230	10^{-9} POLONIUM 210	10^{-9} LEAD 210	10^{-9} TOTAL ALPHA
1972														
JAN 73	SNOWBOUND													
FEB 73	SNOWBOUND													
3-13-73	8.3	155'		277		187			.06	2.0	< 2.0			
4-13-73	8.1	150'		253		158			.42	1.2	< 2.0			
4-25-73	8.1	150'		254		154			.31	4.9	< 2.0			
5- 1-73	8.4	150'		155		114			.30	2.6	< 2.0			
5- 8-73	8.4	145'		150		107			.30	2.7	< 2.0			
5-15-73	8.4	145'		153		114			.31	2.5	< 2.0			
5-22-73	8.4	145'		148		121			.29	2.6	< 2.0			
6-12-73	8.4	145'		301		100			.13	1.4	< 2.0			
7-10-73	8.4	145'		349		173			.14	1.5	< 2.0			
8-14-73	7.7			250		140			1.9	5.3	< 2.0			
MPC									2x10-5	3x10-8	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL														
AVERAGE														

LISBON MINE

TAILINGS MONITOR WELL #5

SAMPLE DATE 1972	PH	H2O DEPTH	DISSOLVED SOLIDS (PPM)	HARDNESS (PPM)	SO4 (PPM)	NO3 (PPM)	Na (PPM)	Cl (PPM)	Fe (PPM)	10^{-7} URANIUM (uc/ml)	10^{-9} RADIUM 226 (uc/ml)	10^{-8} THORIUM 230 (uc/ml)	10^{-9} POLONIUM 210 (uc/ml)	10^{-9} LEAD 210 (uc/ml)	10^{-9} TOTAL ALPHA (uc/ml)
JAN 73-----SNOWBOUND--------															
FEB 73-----SNOWBOUND---------															
MAR 73-----SNOWBOUND & MUDBOUND------															
4-13-73	7.9	205'			324		42			.28	1.81	< 2.0			
4-25-73	7.8	200'			264		42			.23	1.45	< 2.0			
5- 1-73	8.4	195			215		29			.23	1.63	< 2.0			
5- 8-73	8.4	195			210		29			.24	1.75	< 2.0			
5-15-73	8.3	195			219		29			.23	1.78	<2.0			
5-22-73	8.4	195			223		29			.23	1.78	<2.0			
6-12-73	8.2	195			338		31			.21	1.39	<2.0			
7-10-73	8.2	195			424		50			.21	1.07	<2.0			
8-14-73	7.4	195			250		26			1.20	1.85	<2.0			
MPC										$2x10^{-5}$	$3x10^{-8}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	
TOTAL															
AVERAGE															

LISBON MINE

TAILINGS MONITOR WELL #1

SAMPLE DATE	PH	PPM S04	PPM NO3	PPM Na	PPM CI	10-7 uc/ml URANIUM	10-9 uc/ml RADIUM	10-8 uc/ml THORIUM	10-9 uc/ml POLONIUM	10-9 TOTAL ALPHA uc/ml	10-9 uc/ml LEAD-210
4-6-72	7.7	310		230	430						
4-13-72	7.7	295		220	470						
4-19-72	7.65	340		220	480						
4-26-72	7.4	345		280	428						
---------MILL STARTUP--------											
6-13-72	7.5	279	22	270	511	6.63	< 1.0	< 2.0	0.6	0 ± 2.5	$5.0\pm.20$
6-19-72	7.6	291	25	270	539	14.1	1.14	2.99	0.5	0 ± 2.5	$3.03\pm.04$
6-26-72	7.3	291	20	264	546	7.97	< 1.0	1.76	0.5	0 ± 2.5	$.43\pm.01$
7-3-72	7.6	340	25	271	550	.811	2.96	3.16	0.7	0 ± 2.5	$1.73\pm.06$
7-10-72	7.3	350	25	292	518	1.84	< 1.0	3.45	0.8	0 ± 2.5	$.00\pm.11$
7-17-72	7.3	361	25	364	546		2.73	4.92	1.0	0 ± 2.5	$.43\pm.01$
7-23-72	7.3	319	25	336	681	8.96	< 1.0	< 2.0	0.7	14 ± 7	$0\pm.01$
8-8-72	7.4	153	22	289	737	5.26	< 1.0	< 2.0	0.1	0 ± 2.5	$.58\pm.01$
8-14-72	7.8	256	22	298	737	5.39	< 1.0	< 2.0	0.2	40 ± 17	$2.31\pm.07$
8-21-72	7.4	283	24	292	567	38.35	< 1.0	< 2.0	0.2	27 ± 15	$.86\pm.02$
8-28-72	7.6	251	27	202	629	7.67	< 1.0	< 2.0	2.2	41 ± 17	$1.29\pm.03$
9-6-72	7.8	288	52	265	600	N.D.					
9-11-72	8.2	171	47	257	603	.342					
-18-72	8.0	156	30	283	333	.013					
25-72	8.1	198	34	374	363	N.D.					
COMPOSITE							< 1.0	< 2.0	0.5	44 ± 2	$1.15\pm.02$
10-2-72	7.6	254	11	273	464	N.D.					
10-9-72	7.8	246	10	273	464	.005					
10-24-72	7.7	328	9	250	446	.157					
COMPOSITE							< 1.0	< 2.0	9.0		$28.8\pm.7$
11-7-72	7.6	165	10	[illegible]	[illegible]	.013					
11-13-72	7.7	184	14	258	593	.009					
11-20-72	7.9	209	15	258	582	.295					
11-27-72	7.8	228	10	235	593	.014					
COMPOSITE							< 1.0	< 2.0	0.9		$3.31\pm.10$
12-5-72	8.0	399	3	293	602	4.10					
12-15-72	7.9	383	3	280	588	1.37					
12-19-72	8.0	377	3	287	594	2.05					
12-26-72	8.1	394	3	293	594	2.05					
COMPOSITE							1.3	< 2.0	0.5		$4.42\pm.16$
TOTAL	229.75	844[illegible]	[illegible]16	8235	16370	107.399					
AVERAGE	7.66	281.5	[illegible].6	274.5	545.7	4.88					

LISBON MINE

TAILINGS MONITOR WELL NO. 2

SAMPLE DATE	PH	PPM SO4	PPM NO3	PPM Na	PPM Cl	10-7 uc/ml URANIUM	10-9 uc/ml RADIUM	10-8 uc/ml THORIUM	10-9 uc/ml POLONIUM	10-9 TOTAL ALPHA	10-9 uc/ml LEAD-210
4-6-72	7.6	200		210	580						
4-13-72	6.65	200		210	630						
4-19-72	7.7	225		220	600						
4-26-72	7.5	175		260	575						
--------MILL STARTUP----------											
6-13-72	7.5	178	98	240	610	10.6	<1.0	8.26	0.5	0±2.5	3.30±.20
6-19-72	7.5	198	92	270	638	25.6	3.63	4.04	0.1	0±2.5	8.36±.30
6-26-72	7.5	167	78	258	628	11.5	<1.0	1.05	0.5	0±2.5	1.58±.04
7-3-72	7.8	141	92	264	628	3.61	<1.0	3.16	0.7	0±2.5	.58±.01
7-10-72	7.5	354	92	271	599	1.38	3.17	3.16	0.8	0±2.5	4.76±.17
7-17-72	7.5	504	92	327	631	5.38	1.63	<2.0	0.8	17±14	.00±.01
7-23-72	7.5	198	73	309	738	55.6	<1.0	<2.0	0.5	27±15	.14±.01
8-8-72	7.1	289	96	298	751	20.64	<1.0	<2.0	0.2	17±14	1.58±.04
8-14-72	7.7	360	96	313	751	8.79	<1.0	<2.0	0.2	0±2.5	2.31±.06
8-21-72	7.3	369	95	298	524	4.26	<1.0	<2.0	0.2	15±13	.00±.01
8-28-72	7.8	362	75	326	562	6.82	<1.0	<2.0	0.3	32±16	1.30±.05
9-6-72	8.1	390	14	309	559	N.D.					
9-11-72	8.1	313	13	307	560	.383					
9-18-72	7.8	275	8	325	255	.013					
9-25-72	8.2	299	4	333	277	.005					
COMPOSITE							<1.0	<2.0	0.7	25±15	3.30±13
10-2-72	8.1	382	9	327	396	N.D.					
10-9-72	8.2	387	7	314	390	.006					
10-24-72	8.2	423	6	314	372	.157	<1.0	<2.0	1.1	OCT. COMPOSITE	14.4±.4
11-7-72	7.8	322	43	304	[illegible]	.009					
11-13-72	7.9	335	43	304	582	.007					
11-20-72	7.9	304	40	281	557	.028					
11-27-72	7.9	631	40	327	571	.014					
COMPOSITE							1.418	<2.0	0.6		2.45±.07
12-5-72	7.8	435	42	318	587	.21					
12-15-72	7.5	351	34	287	590	.41					
12-19-72	7.8	361	19	260	588	.24					
12-26-72	7.8	372	12	293	588	.29					
COMPOSITE							1.3	<2.0	0.6		4.48±.18
TOTAL	231.25	9500	1313	8677	16899	155.952					
AVERAGE	7.71	316.7	50.5	289.2	563.3	6.50					

LISBON MINE

TAILINGS MONITOR WELL #3

SAMPLE DATE	PH	PPM				10^{-7} uc/ml URANIUM	10^{-9} uc/ml RADIUM 226	10^{-8} uc/ml THORIUM 230	10^{-9} uc/ml POLONIUM 210	10^{-9} uc/ml TOTAL ALPHA	10^{-9} uc/ml LEAD-210
		SO4	NO3	Na	Cl						
6-1-72	7.9	1600	5	71	98	.36					
12-15-72	8.0	1520	3	68	115	.32	5.7	<2.0	.5		.32 ± .07
TOTAL	15.9	3120	8	139	213	.68					.32
AVERAGE	7.95	1560	4	69.5	106.5	.34					.32

LISBON MINE

TAILINGS MONITOR WELL #4

SAMPLE DATE	PH	PPM				10^{-7} uc/ml URANIUM	10^{-9} uc/ml RADIUM 226	10^{-8} uc/ml THORIUM 230	10^{-9} uc/ml POLONIUM 210	TOTAL ALPHA	10^{-9} uc/ml LEAD-210
		SO4	NO3	Na	Cl						
6-1-72	8.1	410	5	100	132	.52					
12-12-72	8.2	315	3	160	123	.68	.81	<2.0	.5		$14.6\pm.07$
TOTAL	16.3	725	8	260	255	1.20					
AVERAGE	8.15	362.5	4	130	127.5	.60					

SCAN ANALYSIS

RATTLESNAKE POND WATER

	31st August PPM	1st October PPM
Pb	.038	< .02
Zn	.037	.006
Ni	< .1	< .01
Co	< .1	< .01
Fe	.037	.08
Mn	.022	.015
Cu	.023	.02
Al	< .19	< .14
Na	59	65
K	6.1	5.5
Ca	102	116
V	< .1	< .1
Mo	< .3	< .3
Ba	< .4	< .2
N	2.4	4.0
NO_3	1.9	1.2
NH_3	2.0	2.0
Ra pc/l	< 1	< 1

Inter-Office Memorandum File No. ....

To: M. E. Grimes Date March 2, 1972

From: J. T. Mather c.c. J. W. Fisher

Subject: Seepage Tests on Utah Tailings

The current series of lab seepage tests are giving steady seepage rates of 6-8 ft./yr.(Fig. 1) for untreated tailings after one week under simulated field conditions. These rates are similar to the figures used by Clevenger & Ass. in their estimate of loss by seepage from the base of the tailings area (10 ft./yr for whole tailings).

If the seepage loss estimated by Clevenger & Ass. is considered to be excessive, we would recommend the use of sealing agents added to or sprayed on the tailings, with the qualification that outside advice be sought on the stability of the tailings embankment after the sealing treatment. The proposed tailings retaining structure consists of a starter dam backed up by coarser tailings deposited by conventional spigotting. Placing of an impermeable layer of sealant or treated tails immediately behind the starter dam might affect the stability of the retaining embankment by keeping the whole of the tailings behind the dam semi-fluid, rather than letting a layer of coarse material drain and consolidate and add to the strength of the starter dyke.

We are presently evaluating the effectiveness of two Dow sealing agents that may be sprayed on a prepared base, using methods supplied by Mr. E. K. Anderson of Dowell of Canada, Calgary. The costs range from $200 to $900 per acre for sealant only. We are also evaluating the use of one of these reagents mixed in with tailings before deposition, and the use of $FeSO_4 \cdot 7H_2O$ (Copperas) in like manner. The latter technique could save on sealant costs, but is not specifically recommended by Dowell.

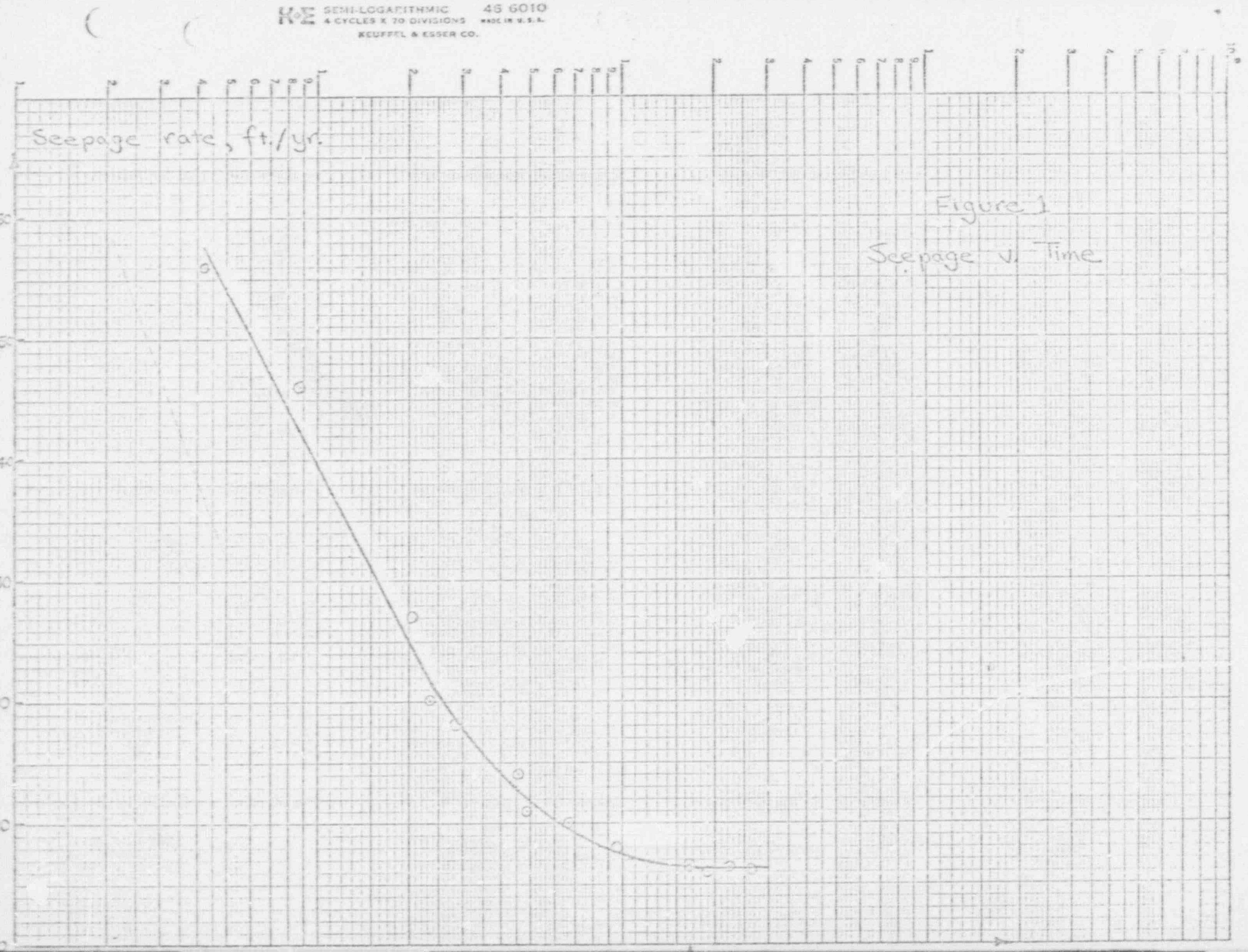
All these techniques for sealing require that the sealant or treated material be placed on a prepared base in order to minimise reagent cost. Since it is not intended to grade the tailings area to obtain a clean, uniform base, it will be necessary to lay down an initial layer of untreated tailings

..../2

over the area to be sealed, preferably to a minimum of 6" depth. This job might be simplified by some bulldozing of very rough areas and by brushing the entire area, depending on the topography.

Preliminary figures on the effectiveness of various sealing agents should be available in one week.

J. T. Mather


K&E SEMI-LOGARITHMIC 46 6010
4 CYCLES X 70 DIVISIONS MADE IN U.S.A.
KEUFFEL & ESSER CO.
Seepage rate, ft./yr.
Figure 1
Seepage v. Time

Inter-Office Memorandum File No. ....

To: E. Barnes Date Oct[illegible] 16, 1973

From: J. T. Mather

Subject: Seepage through Utah Tailings Test on fresh tailings from Lisbon, Utah

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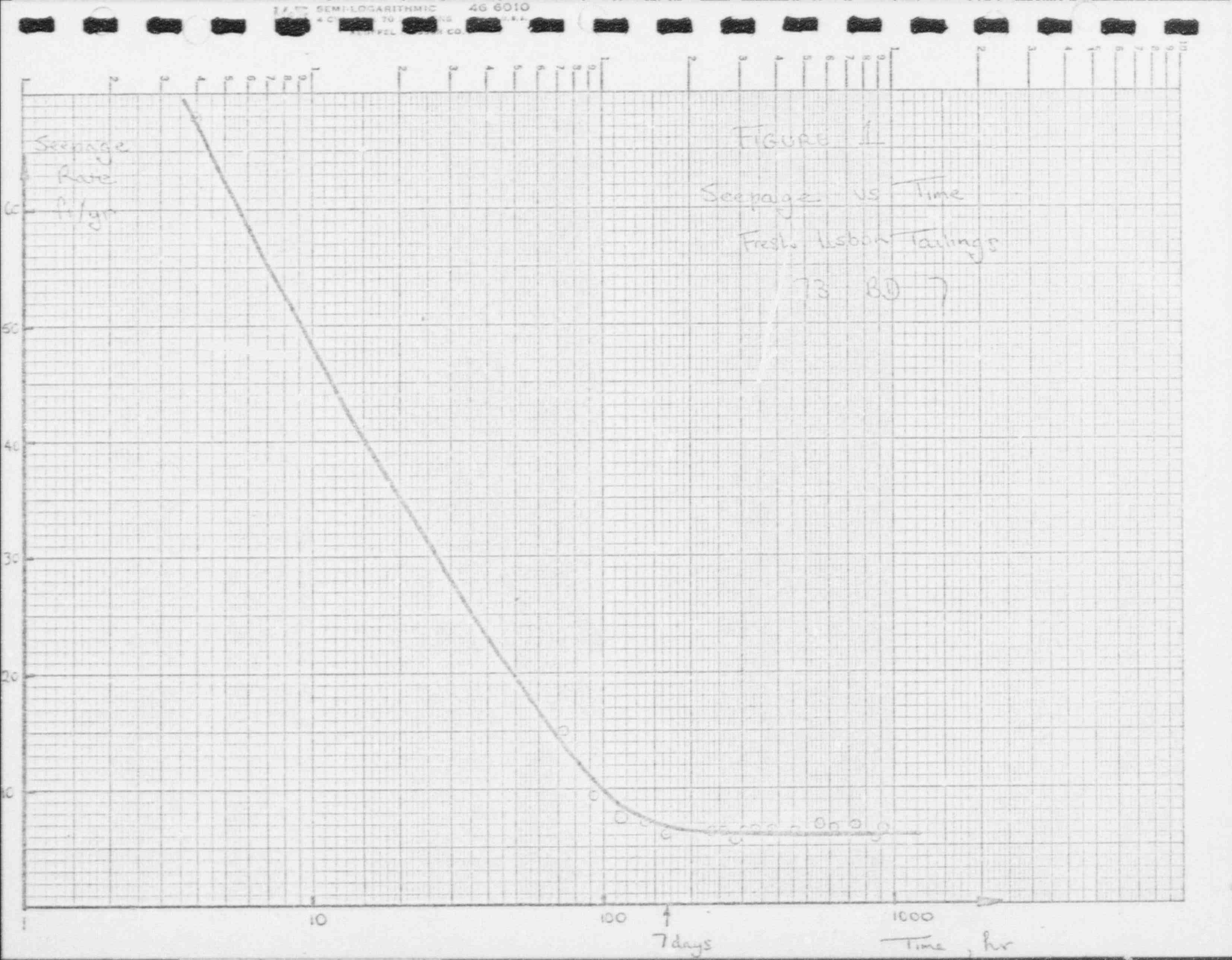
A fresh sample of whole tailings from the Lisbon treatment plant was received on August 3, 1973 and labelled 73BD7. The tailings slurry, of Sg 1.342, was mixed thoroughly and poured onto a base of washed clarifier sand in a 1½" i.d. glass column.

The Percolation rate was monitored over a period of 38 days, keeping the surface of the tailings just covered with water i.e. equivalent to a hydraulic gradient of 1 ft. water per ft. tailings. Results are shown graphically on Figure 1. The percolation dropped from an initial value around 100 ft/yr to a steady 6 ft/yr after 7 days. These results are virtually identical to those for the tailings prepared by leaching North Alice material in our laboratory autoclave, see memo J.T. Mather to M.E. Grimes dated March 2, 1972.

JTMather

JTM:kbc J. T. Mather


SEMI-LOGARITHMIC 46 6010
FIGURE 1
Seepage vs Time
Fresh Lisbon Tailings
Seepage Rate ft/yr
10
20
30
40
50
60
1
10
100
1000
7 days
Time, hr

Appendix F

STATE OF UTAH
Calvin L. Rampton, Governor
DEPARTMENT OF DEVELOPMENT SERVICES
Division of State History
Melvin T. Smith, Director
603 East South Temple
Salt Lake City, Utah 84102
Telephone: (801) 328-5755

May 7, 1973

Mr. R. D. Lord, Vice President
Research & Development
Rio Algam Mines Limited
120 Adelaide Street West
Toronto 110, Canada

Dear Mr. Lord:

Last Wednesday and Thursday, May 2-3, I traveled to LaSal to see if any historic sites would be affected by the uranium operation of the Rio Algam Corporation. After checking over the site, I found no historic sites that would be adversely affected by the operations of the Rio Algam Uranium Mine and Mill located approximately four miles south of LaSal.

I hope this is sufficient for the Environmental Impact Statement necessary in obtaining a license from the U. S. Atomic Energy Commission.

Sincerely yours,

Kent Powell

Kent Powell
Preservation Historian

KP:hm

IN REPLY REFER TO

United States Department of the Interior

2030

BUREAU OF LAND MANAGEMENT
Monticello, Utah 84535 801-587-2247
October 15, 1971

Mr. P. F. Pullen
Chief, Environmental Engineer
Rio Algom Mines Limited
120 Adelaide Street
West Toronto 110 Canada

Dear Mr. Pullen:

We have compiled some additional information in regards to your millsite proposals on precipitation, sprinkler systems, vegetation and soils. These items will be discussed individually.

To begin, the storm frequency used in calculating the run off on the attached hydrology sheet is for a six-hour storm on a 100 year frequency. The following data from the weather bureau records is also for a 100 year frequency. However, the time of measurement is from 2 to 10 day. This information is significant in that it indicates watershed runoff which would be impounded by the proposed tailings pond.

100 year, 2 day - 4.0 inches = 46.6 acre ft.
100 year, 4 day - 4.2 inches = 49.0 acre ft.
100 year, 7 day - 4.5 inches = 52.4 acre ft.
100 year, 10 day - 5.0 inches = 58.4 acre ft.

It can readily be seen by the above figures that the potential run off accumulation for say a 25 day period using a 1,500 year frequency would be far in excess of the capacity of the tailings pond. In view of these facts we would suggest that the tailings pond not be used to impound all runoff of the entire drainage, rather that some method, i.e. a diversion ditch, be constructed to divert runoff water to one of the adjacent drainages thus eliminating the threat of water breaching the tailings pond dam.

Soil types range from exposed sandstone parent material on the rocky knolls to very fine sandy loams in valley. Vegetation on shallow soils is basically pinion and juniper with some browse and forb understory. On the deeper soils in the bottoms, a sagebrush/grass composition dominates. This type is in fair condition, with as high as a 60% ground cover.

In considering a sprinkler system to dispose of surplus water, the following factors should be considered:

Soil type - very fine sandy loam
Water holding capacity - 1.5" per feet of soil
Effective Root zone - 3'
Root Zone capacity (3 x 1.5") = 4.5" water
Net moisture to replace - 50% of 4.5" = 2.25"
Gross inches to replace - $\frac{2.25''}{70\%\ \text{efficiency}}$ = 3.22"
Irrigation frequency - $\frac{2.25''\ \text{net.}}{.30''\ \text{peak use}}$ = 7.5 or 8 days
Based on 150 gallon per minute water sourch
Acres = $\frac{8\ \text{days}\ (23\ \text{hrs.})\ (150\ \text{gpm})}{453\ (3.22''\ \text{gross})}$ = 12.1 acres or 730 feet square
Evaporation rate - 84" per year

The biological data on the Rattlesnake pond has not been completed, but we will forward such information as it becomes available.

As per our discussion, I feel that the techniques used in stabilization of tailings areas should remain open until the need for the area has ceased. Also seeding of the damsite could be deferred until early spring in order to take advantage of winter moisture.

I do want to impress upon you the importance of protecting the tailings both during the operation and after its completion. We feel that the best approach is to eliminate the need of your tailings pond as a watershed retention structure. A diversion canal above the tailings is one approach, others undoubtedly are available.

If additional questions arise, or assistance needed, feel free to contact us.

Sincerely yours,

Thomas A. Moore

Thomas A. Moore
Acting District Manager

Form 7120-2
(November 1966)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

HYDROLOGIC DATA SHEET

ESTIMATED PEAK RATE OF RUNOFF

1. Drainage basin

2. LOCATION

SECTION	TOWNSHIP	RANGE	MERIDIAN
21	29 S.	24 E.	SLB&M

3. Drainage area 556 acres = .869 sq. mi.

4. Watershed length (L) 10,032 ft.

5. Elevation change (Δh) 274 ft.

6. Watershed slope (S) = $\frac{\Delta h}{L} \times 100$ = 2.7 percent

7. Design frequency 100 yrs.

8. HYDROLOGIC SOIL COVER COMPLEXES (Illustrations 7-8)

HYDROLOGIC SOIL GROUP	LAND COVER	CLASS CONDITION	TREATMENT OR PRACTICE	CURVE NO.	ACRES	PERCENT OF AREA	CURVE NO. × PERCENT
D (Rock)	P.J.	Fair	None	89	193	35	3115
D	S.B.	Fair	None	66	363	65	4290
							7405
				TOTAL	556	100	7405

Weighted Curve Number = $\frac{7405}{100}$ = 74.05 use 74

9. Rainfall (P) 2.5 inches (illus. 1-6)

10. Runoff (Q) .63 inches (illus. 10)

11. Watershed runoff = Q × ac ÷ 12 = 29.2 ac. ft.

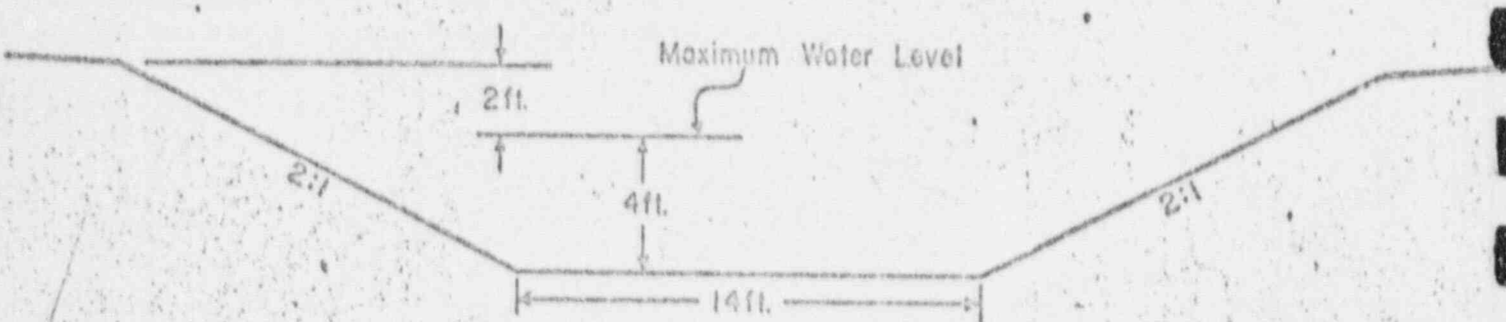
12. Time of concentration (T_c) .79 hrs. (illus. 11)

13. Hydrograph Family No. 3.75 (illus. 12)

14. Unit peak discharge 270 csm (illus. 13)

15. Watershed peak discharge rate (q) = csm × sq. mi. × Q = 147.8 cfs

DISCHARGE IS BASED ON HYDRCLOGY
FOR 100 yr. STORM FREQUENCY



CHANNEL CROSS-SECTION

Q = AV
Q = 88 x 1.86
Q = 163.7 c.f.s.

A = 88 sq. ft.
V = (1.486/n) r2/3 S1/2
n = 0.0225
r = 2.8
S = 0.00020
V = 1.86 f.p.s.

Diversion channels constructed to the above demensions and as shown on the area map, would give a safety factor of over 1.5.

USE CONCRETE DROP STRUCTURES TO PREVENT HEAD CUTTING
DRAINAGE AREA
DIVERSION CHANNEL
TAILINGS POND
EARTH FILL DAM
17
16
15
14
23
26
27
28
29
6720
6750
6800
38°15'
109°15'
17'30"
BIG INDIAN MINE
ROAD CLASSIFICATION
Improved
Unimproved
1 MILE
7000 FEET

Borrow

In our opinion, there is ample, suitable borrow soil within the tailing pond area to construct the proposed starter dam.

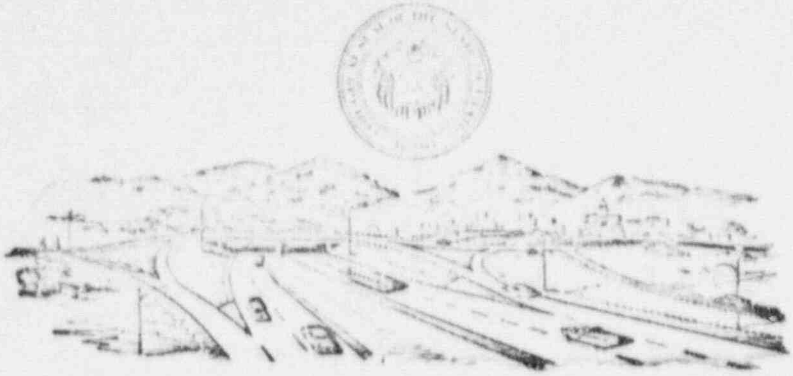
Underseepage

The natural soils in the reservoir area possess sufficient fines (-#200) to be relatively impervious. However, in view of the desire to minimize underseepage losses, we believe a cutoff trench of compacted earth will be appropriate beneath the tailing starter dam extending into the clay soils, and for the abutments, 5 feet into the sandstone bedrock. Final investigations may indicate the desirability of blanketing the sandstone outcrop on the right abutment for some distance upstream of the starter dam with compacted, impervious fill.

LIMITATIONS

Test holes for the headframe were closely spaced to give a reasonably accurate subsoil picture, and widely spaced in the plant site and tailing dam areas, typical of preliminary investigations. Variations in subsoils not indicated by the borings are always possible, particularly with widely spaced preliminary borings. We recommend that the excavations for the headframe be inspected by a competent soil specialist to assure that subsurface conditions are as indicated by the test holes. Final investigations should be performed in the plant and tailing dam areas prior to design to enable confirmation of our preliminary opinions and determination of design criteria. We will be happy to accomplish these inspections and investigations for you, if desired.

Appendix I



DIRECTOR
ENRY C. HELLAND

STATE HIGHWAY ENGINEER
BLAINE J. KAY

ADDRESS REPLY TO
DISTRICT ENGINEER

Utah State Department of Highways

Price, Utah

JAMES L. DEATON
DISTRICT ENGINEER

June 14, 1973

Mr. P. E. Pullen, P.E.
Chief Environmental Engineer
Rio Algom
Rio Tinto
120 Adelaide Street
West Toronto, Canada

Dear Mr. Pullen:

I am in the receipt of your May 30, 1973, letter pertinent to the proposed mining operations in San Juan County. I can see no problem that would impact the Highway system or the highway user.

The safety feature designed into the dam seem adequate in the event of leekage or a break, the present land contour would fan or spread the water over a wide area resulting in little or no damage to the State Highway system.

Yours truly,

James L. Deaton
District Engineer

JLD/ajs

cc: C. V. Anderson, P. E. State Highway Engineer
Sam Taylor, Commissioner
LaVar Hamilton, Design Engineer

"safe today - alive tomorrow"

TABLE I

CALCULATION OF DUST EMISSIONS (SURFACE PLANT)

	Crusher	Headframe	Transfer	Yellowcake Scrubber	Yellowcake Filter
Average actual operating time (hours/day)	12	12	12	20	20
CFM	13,000	11,000	2,200	960	1,300
= CF in 24 hours (x 1,000)	9,360	7,920	1,584	1,152	1,560
= M^3 in 24 hours (x 1,000)	265	224	44.9	32.6	44.2
Dust content (mg/M^3)	1.19	.097	1.27	.941	.585
Dust emitted in 24 hrs. (grams)	315.	21.7	57.0	30.7	25.9

Total dust emission 450.3 grams in 24 hours - under 1 lb.

APPENDIX J

TABLE 2A

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS
AT NEAREST ACCESS POINT
(Minimum Stability - Class A)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	$\frac{H}{\sigma_z}$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust Emitted g/day	$\frac{Q}{g/sec}$	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M^3)
Ventilation Shaft	99	28	2	14	.143	9.90×10^{-1}	22,000	.263	2760	9.53×10^{-5}	9.43×10^{-5}
Crusher (12 hours)	76	22	14	10.5	1.33	4.13×10^{-1}	315	7.29×10^{-3}	1625	4.49×10^{-6}	1.85×10^{-6}
Headframe (12 hours)	76	22	23	10.5	2.19	9.09×10^{-2}	21.7	5.02×10^{-4}	1625	3.09×10^{-7}	2.81×10^{-8}
Transfer (12 hours)	76	22	17	10.5	1.62	2.69×10^{-1}	57.0	1.32×10^{-3}	1625	8.12×10^{-7}	2.18×10^{-7}
Scrubber (20 hours)	76	22	15	10.5	1.43	3.60×10^{-1}	30.7	4.26×10^{-4}	1625	2.62×10^{-7}	9.43×10^{-8}
Filter (20 hours)	76	22	10	10.5	.953	6.35×10^{-1}	25.9	3.60×10^{-4}	1625	2.22×10^{-7}	1.41×10^{-7}
*Total Surface Plant Emissions	76	22	16 (Average)	10.5	1.52	3.15×10^{-1}		*9.90×10^{-3}	1625	6.09×10^{-6}	1.92×10^{-6}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	73	22	16 (Average)	10.5	1.52	3.15×10^{-1}	450.3	5.21×10^{-3}	1625	3.21×10^{-6}	1.01×10^{-6}

*When all surface plant units are in operation simultaneously.

Wind Speed u = 5 mph = 2.24 M/sec.

TABLE 2B

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS AT NEAREST ACCESS POINT

(Maximum Stability - Class F)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	H/σ_z	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust emitted g/day	Q g/sec	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M^3)
Ventilation Shaft	99	4.0	2	2.3	.870	6.85×10^{-1}	22,700	.263	64.7	4.06×10^{-3}	2.78×10^{-3}
Crusher (12 hours)	76	3.2	14	1.8	7.78	7.19×10^{-14}	315	7.29×10^{-3}	40.5	1.80×10^{-4}	1.29×10^{-17}
Headframe (12 hours)	76	3.2	23	1.8	12.8	8×10^{-36}	21.7	5.02×10^{-4}	40.5	1.24×10^{-5}	9.92×10^{-41}
Transfer (12 hours)	76	3.2	17	1.8	9.44	4.46×10^{-20}	57.0	1.32×10^{-3}	40.5	3.26×10^{-5}	1.45×10^{-24}
Scrubber (20 hours)	76	3.2	15	1.8	8.33	8.56×10^{-16}	30.7	4.26×10^{-4}	40.5	1.05×10^{-5}	8.98×10^{-21}
Filter (20 hours)	76	3.2	10	1.8	5.56	1.94×10^{-7}	25.9	3.60×10^{-4}	40.5	8.89×10^{-6}	1.72×10^{-12}
*Total surface plant Emissions	76	3.2	16 (Average)	1.8	8.89	6.89×10^{-18}		*9.90×10^{-3}	40.5	2.44×10^{-4}	1.68×10^{-21}
24-hour average total surface ore treatment plant emissions	76	3.2	16 (Average)	1.8	8.89	6.89×10^{-18}	450.3	5.21×10^{-3}	40.5	1.29×10^{-4}	8.86×10^{-22}

Wind Speed u = 5 m.p.h. = 2.24 M/sec

*When all surface plant units are operating simultaneously.

TABLE 2C

CALCULATION OF DOWNWIND CENTRE-LINE DUST CONCENTRATIONS AT NEAREST ACCESS POINT

(Average Stability - Class D)

Emitter	Receptor Distance (meters)	σ_y	H (meters)	σ_z	H/σ_z	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	Dust emitted g/day	Q g/sec	$\Pi u \sigma_y \sigma_z$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	Concentrations C (g/M^3)
Ventilation Shaft	99	8.0	2	4.7	.425	9.14×10^{-1}	22,700	.263	265	9.92×10^{-4}	9.06×10^{-4}
Crusher (12 hours)	76	4.8	14	3.8	3.68	1.15×10^{-3}	315	7.29×10^{-3}	128	5.70×10^{-5}	6.56×10^{-8}
Headframe (12 hours)	76	4.8	23	3.8	6.05	1.13×10^{-8}	21.7	5.02×10^{-4}	128	3.92×10^{-6}	4.43×10^{-14}
Transfer (12 hours)	76	4.8	17	3.8	4.47	4.58×10^{-5}	57.0	1.32×10^{-3}	128	1.03×10^{-5}	4.71×10^{-10}
Scrubber (20 hours)	76	4.8	15	3.8	3.95	4.09×10^{-4}	30.7	4.26×10^{-4}	128	3.33×10^{-6}	1.36×10^{-9}
Filter (20 hours)	76	4.8	10	3.8	2.63	3.15×10^{-2}	25.9	3.60×10^{-4}	128	2.81×10^{-6}	8.85×10^{-8}
*Total surface plant emissions	76	4.8	16 (Average)	3.8	4.21	1.42×10^{-4}		*9.90×10^{-3}	128	7.73×10^{-5}	1.10×10^{-8}
24-hour average total surface ore treatment plant emissions	76	4.8	16 (Average)	3.8	4.21	1.42×10^{-4}	450.3	5.21×10^{-3}	128	4.07×10^{-5}	5.78×10^{-9}

Wind Speed u = 5 m.p.h. = 2.24 M/sec

*When all surface plant units are operating simultaneously.

TABLE 1A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Minimum Stability - Class A)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
A. URANIUM										
Ventilation Shaft	100	2	8.36×10^{-11}	28	14	.143	2760	9.90×10^{-1}	3.03×10^{-14}	3.00×10^{-14}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	22	10.5	1.33	1625	4.13×10^{-1}	5.64×10^{-15}	2.33×10^{-15}
Headframe	76	23	1.37×10^{-12}	22	10.5	2.19	1625	9.09×10^{-2}	3.43×10^{-16}	7.66×10^{-17}
Transfer	76	17	1.39×10^{-12}	22	10.5	1.62	1625	2.69×10^{-1}	8.55×10^{-16}	2.30×10^{-16}
Scrubber	76	15	2.52×10^{-11}	22	10.5	1.43	1625	3.60×10^{-1}	1.55×10^{-14}	5.58×10^{-15}
Filter	76	10	3.33×10^{-12}	22	10.5	.953	1625	6.35×10^{-1}	2.04×10^{-15}	1.30×10^{-15}
Total Surface Plant Emissions*	76	16 Ave.	5.81×10^{-11}*	22	10.5	1.52	1625	3.15×10^{-1}	3.58×10^{-14}	1.13×10^{-14}
24-Hour Ave., total surface plant emissions	76	16 Ave.	4.05×10^{-11}	22	10.5	1.52	1625	3.15×10^{-1}	2.49×10^{-14}	7.84×10^{-15}
Tailings Ponds: -										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	100	2	2.66×10^{-5}	28	14	.143	2760	9.90×10^{-1}	9.64×10^{-9}	9.54×10^{-9}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	22	10.5	1.33	1625	4.13×10^{-1}	5.64×10^{-15}	2.33×10^{-15}
Headframe	76	23	1.37×10^{-12}	22	10.5	2.19	1625	9.09×10^{-1}	8.43×10^{-16}	7.66×10^{-17}
Transfer	76	17	1.39×10^{-12}	22	10.5	1.62	1625	2.69×10^{-1}	8.55×10^{-16}	2.30×10^{-16}
Total Emissions from ore Treatment Plant*	76	18 Ave.	2.38×10^{-11}*	22	10.5	1.71	1625	2.32×10^{-1}	1.46×10^{-14}	3.38×10^{-15}
24-Hour Ave., total surface ore treatment plant emissions	76	18 Ave.	1.19×10^{-11}	22	10.5	1.71	1625	2.32×10^{-1}	7.32×10^{-15}	1.69×10^{-15}
Tailings Ponds: -										
Original	305 Actual	-	2.17×10^{-6}	130	180	-	165,000	-	1.32×10^{-11}	1.32×10^{-11}
New	150 Actual	-	3.90×10^{-6}	115	102	-	82,500	-	4.72×10^{-11}	4.72×10^{-11}

C. THORIUM - 230 and RADIUM -226

At secular equilibrium in the ore the radioactivity of the natural uranium and the thorium, radium, and radon associated with it are equal to one another. Thorium, radium, and radon are not carried through to the yellowcake product and the individual as well as the total and average concentrations of the thorium and radium in the plant stacks are therefore equal to those reported for the radon in this instance.

*When all surface plant units are in operation simultaneously.

TABLE 1B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Maximum Stability - Class F)

$u = 2.24$ M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
A. URANIUM										
Ventilation Shaft	100	2	8.36×10^{-11}	4.0	2.3	.870	64.7	6.85×10^{-1}	1.29×10^{-12}	8.86×10^{-13}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	3.2	1.8	7.78	40.5	7.19×10^{-14}	2.26×10^{-13}	1.62×10^{-26}
Headframe	76	23	1.37×10^{-12}	3.2	1.8	12.8	40.5	8.00×10^{-36}	3.38×10^{-14}	2.70×10^{-49}
Transfer	76	17	1.39×10^{-12}	3.2	1.8	9.44	40.5	4.46×10^{-20}	3.43×10^{-14}	1.52×10^{-33}
Scrubber	76	15	2.52×10^{-11}	3.2	1.8	8.33	40.5	8.56×10^{-16}	6.22×10^{-13}	5.32×10^{-28}
Filter	76	10	3.33×10^{-12}	3.2	1.8	5.56	40.5	1.94×10^{-7}	8.22×10^{-14}	1.59×10^{-20}
Total Surface Plant Emissions*	76 (Ave.)	16	5.81×10^{-11}*	3.2	1.8	8.89	40.5	6.89×10^{-18}	1.43×10^{-12}	9.88×10^{-30}
24 Hr. Ave. total surface plant emissions	76 (Ave.)	16	4.05×10^{-11}	3.2	1.8	8.89	40.5	6.89×10^{-18}	1.00×10^{-12}	6.89×10^{-30}
Tailings Ponds: -										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	100	2	2.66×10^{-5}	4.0	2.3	.870	64.7	6.85×10^{-1}	4.11×10^{-7}	2.82×10^{-7}
Plant Stacks: -										
Crusher	76	14	9.17×10^{-12}	3.2	1.8	7.78	40.5	7.19×10^{-14}	2.26×10^{-13}	1.62×10^{-26}
Headframe	76	23	1.37×10^{-12}	3.2	1.8	12.8	40.5	8.00×10^{-36}	3.38×10^{-14}	2.70×10^{-49}
Transfer	76	17	1.39×10^{-12}	3.2	1.8	9.44	40.5	4.46×10^{-20}	3.43×10^{-14}	1.52×10^{-33}
Total Emissions from ore Treatment Plant	76	18 (Average)	2.38×10^{-11}*	3.2	1.8	10.0	40.5	1.90×10^{-22}	5.88×10^{-13}	1.12×10^{-34}
24 Hour Average Total Surface Ore Treatment Plant Emissions	76	18 (Average)	1.19×10^{-11}	3.2	1.8	10.0	40.5	1.90×10^{-22}	2.94×10^{-13}	5.59×10^{-35}
Tailings Ponds: -										
Original	305(Actual)	-	2.17×10^{-6}	72	23	-	11700	-	1.85×10^{-10}	1.85×10^{-10}
New	150	-	3.90×10^{-6}	80	24.5	-	13800	-	2.83×10^{-10}	2.83×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

Appendix K

TABLE 1C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT NEAREST ACCESS POINT

(Average Stability - Class D)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C μCi/ml
A. URANIUM										
Ventilation Shaft	100	2	8.36×10^{-11}	8	4.7	.425	265	9.14×10^{-1}	3.15×10^{-13}	2.88×10^{-13}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	4.8	3.8	3.68	128	1.15×10^{-3}	7.16×10^{-14}	8.23×10^{-17}
Headframe	76	23	1.37×10^{-12}	4.8	3.8	6.05	128	1.13×10^{-8}	1.07×10^{-14}	1.21×10^{-22}
Transfer	76	17	1.39×10^{-12}	4.8	3.8	4.47	128	4.58×10^{-5}	1.09×10^{-14}	4.99×10^{-19}
Scrubber	76	15	2.52×10^{-11}	4.8	3.8	3.95	128	4.09×10^{-4}	1.97×10^{-13}	8.05×10^{-17}
Filter	76	10	3.33×10^{-12}	4.8	3.8	2.63	128	3.15×10^{-2}	2.60×10^{-14}	8.19×10^{-16}
Total Surface Plant Emissions*	76	(Ave.) 16	5.81×10^{-11}*	4.8	3.8	4.21	128	1.42×10^{-4}	4.54×10^{-13}	6.45×10^{-17}
24-Hour Average, total Surface Plant Emissions	76	(Ave.) 16	4.05×10^{-11}	4.8	3.8	4.21	128	1.42×10^{-4}	3.16×10^{-13}	4.49×10^{-17}
Tailings Ponds:-										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	100	2	2.66×10^{-5}	8	4.7	.425	265	9.14×10^{-1}	1.00×10^{-7}	9.14×10^{-8}
Plant Stacks:-										
Crusher	76	14	9.17×10^{-12}	4.8	3.8	3.68	128	1.15×10^{-3}	7.16×10^{-14}	8.23×10^{-17}
Headframe	76	23	1.37×10^{-12}	4.8	3.8	6.05	128	1.13×10^{-8}	1.07×10^{-14}	1.21×10^{-22}
Transfer	76	17	1.39×10^{-12}	4.8	3.8	4.47	128	4.58×10^{-5}	1.09×10^{-14}	4.99×10^{-19}
Total Emissions from ore Treatment Plant*	76	18 (Average)	2.38×10^{-11}*	4.8	3.8	4.74	128	1.32×10^{-5}	1.86×10^{-13}	2.45×10^{-18}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	76	18 (Average)	1.19×10^{-11}	4.8	3.8	4.74	128	1.32×10^{-5}	9.30×10^{-14}	1.23×10^{-18}
Tailings Ponds:-										
Original	305 Actual	-	2.17×10^{-6}	78	34	-	18,700	-	1.16×10^{-10}	1.16×10^{-10}
New	150 Actual	-	3.90×10^{-6}	85	37	-	22,100	-	1.76×10^{-10}	1.76×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

TABLE 2A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8000 FEET (2500 M) FROM MINE OPERATIONS

(Minimum Stability - Class A)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
A. URANIUM										
Ventilation Shaft	2,500	2	8.36×10^{-11}	430	3300	.0006	9.98×10^6	1.0	8.38×10^{-16}	8.38×10^{-16}
Plant Stacks: -										
Crusher	2,500	14	9.17×10^{-12}	430	3300	.0042	9.98×10^6	1.0	9.18×10^{-17}	9.18×10^{-17}
Headframe	2,500	23	1.37×10^{-12}	430	3300	.0070	9.98×10^6	1.0	1.37×10^{-17}	1.37×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	430	3300	.0052	9.98×10^6	1.0	1.39×10^{-17}	1.39×10^{-17}
Scrubber	2,500	15	2.52×10^{-11}	430	3300	.0055	9.98×10^6	1.0	2.52×10^{-17}	2.52×10^{-17}
Filter	2,500	10	3.33×10^{-12}	430	3300	.0030	9.98×10^6	1.0	3.34×10^{-17}	3.34×10^{-17}
Total Surface Plant Emissions*	2,500	16(Ave.)	5.81×10^{-11}*	430	3300	.0048	9.98×10^6	1.0	5.82×10^{-16}	5.82×10^{-16}
24-Hour Average, Total Surface Plant Emissions	2,500	16(Ave.)	4.05×10^{-11}	430	3300	.0048	9.98×10^6	1.0	4.06×10^{-16}	4.06×10^{-16}
Tailings Ponds: -										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	2,500	2	2.66×10^{-5}	430	3300	.0006	9.98×10^6	1.0	2.67×10^{-10}	2.67×10^{-10}
Plant Stacks: -										
Crusher	2,500	14	9.17×10^{-12}	430	3300	.0042	9.98×10^6	1.0	9.19×10^{-17}	9.19×10^{-17}
Headframe	2,500	23	1.37×10^{-12}	430	3300	.0070	9.98×10^6	1.0	1.37×10^{-17}	1.37×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	430	3300	.0052	9.98×10^6	1.0	1.39×10^{-17}	1.39×10^{-17}
Total Emissions from Ore Treatment Plant*	2,500	18 (Average)	2.38×10^{-11}*	430	3300	.0055	9.98×10^6	1.0	2.38×10^{-16}	2.38×10^{-16}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	2,500	18 (Average)	1.19×10^{-11}	430	3300	.0055	9.98×10^6	1.0	1.19×10^{-16}	1.19×10^{-16}
Tailings Ponds: -										
Original	2,500 (Actual)	-	2.17×10^{-6}	500	3700	-	1.30×10^7	-	1.67×10^{-13}	1.67×10^{-13}
New	2,500 (Actual)	-	3.90×10^{-6}	520	4200	-	1.54×10^7	-	2.53×10^{-13}	2.53×10^{-13}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A

*When all surface plant units are in operation simultaneously.

Appendix K

TABLE 2B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8,000 FEET FROM MINE OPERATIONS

(Maximum Stability - Class F)

u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
A. URANIUM										
Ventilation Shaft	2,500	2	8.36×10^{-11}	77	24	.083	13,000	9.97×10^{-1}	6.43×10^{-15}	6.41×10^{-15}
Plant Stacks:-										
Crusher	2,500	14	9.17×10^{-12}	77	24	.583	13,000	8.44×10^{-1}	7.05×10^{-16}	5.95×10^{-16}
Headframe	2,500	23	1.37×10^{-12}	77	24	.958	13,000	6.31×10^{-1}	1.05×10^{-16}	6.62×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	77	24	.708	13,000	7.79×10^{-1}	1.07×10^{-16}	8.33×10^{-17}
Scrubber	2,500	15	2.52×10^{-11}	77	24	.625	13,000	8.23×10^{-1}	1.94×10^{-15}	1.60×10^{-15}
Filter	2,500	10	3.33×10^{-12}	77	24	.417	13,000	9.17×10^{-1}	2.56×10^{-16}	2.34×10^{-16}
Total Surface Plant Emissions*	2,500	16 (Average)	5.81×10^{-11}*	77	24	.667	13,000	8.01×10^{-1}	4.46×10^{-15}	3.75×10^{-15}
24-Hour Average, Total Surface Plant Emissions	2,500	16 (Average)	4.05×10^{-11}	77	24	.667	13,000	8.01×10^{-1}	3.12×10^{-15}	2.49×10^{-15}
Tailings Ponds:-										
Original			Nil							
New			Nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	2,500	2	2.66×10^{-5}	77	24	.083	13,000	9.97×10^{-1}	2.05×10^{-9}	2.04×10^{-9}
Plant Stacks:-										
Crusher	2,500	14	9.17×10^{-12}	77	24	.583	13,000	8.44×10^{-1}	7.05×10^{-16}	5.95×10^{-16}
Headframe	2,500	23	1.37×10^{-12}	77	24	.958	13,000	6.31×10^{-1}	1.05×10^{-16}	6.62×10^{-17}
Transfer	2,500	17	1.39×10^{-12}	77	24	.708	13,000	7.79×10^{-1}	1.07×10^{-16}	8.33×10^{-17}
Total Emissions From Ore Treatment Plant*	2,500	18 (Average)	2.38×10^{-11}*	77	24	.750	13,000	7.75×10^{-1}	1.83×10^{-15}	1.40×10^{-15}
24-Hour Average, Total Surface Ore Treatment Plant Emissions	2,500	18 (Average)	1.19×10^{-11}	77	24	.750	13,000	7.75×10^{-1}	9.15×10^{-16}	7.09×10^{-16}
Tailings Ponds:-										
Original	2,500(actual)	-	2.17×10^{-6}	140	33	-	32,500	-	6.67×10^{-11}	6.67×10^{-11}
New	2,500(actual)	-	3.90×10^{-6}	145	34	-	34,700	-	1.12×10^{-10}	1.12×10^{-10}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 2C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT 8000 FEET FROM MINE OPERATIONS

(Average Stability - Class D)
u = 2.24 M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -1/2 \left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C $\mu Ci/ml$
A. URANIUM										
Ventilation Shaft	2500	2	8.36×10^{-11}	160	57	.0351	64200	9.99×10^{-1}	1.30×10^{-15}	1.30×10^{-15}
Plant Stacks:-										
Crusher	2500	14	9.17×10^{-12}	160	57	.246	64200	9.70×10^{-1}	1.43×10^{-16}	1.39×10^{-16}
Headframe	2500	23	1.37×10^{-12}	160	57	.404	64200	9.21×10^{-1}	2.13×10^{-17}	1.96×10^{-17}
Transfer	2500	17	1.39×10^{-12}	160	57	.298	64200	9.56×10^{-1}	2.17×10^{-17}	2.07×10^{-17}
Scrubber	2500	15	2.52×10^{-11}	160	57	.263	64200	9.66×10^{-1}	3.93×10^{-16}	3.80×10^{-16}
Filter	2500	10	3.33×10^{-12}	160	57	.175	64200	9.85×10^{-1}	5.19×10^{-17}	5.11×10^{-17}
Total Surface Plant Emissions*	2500	16 (Average)	5.81×10^{-11}*	160	57	.281	64200	9.62×10^{-1}	9.05×10^{-16}	8.71×10^{-16}
24 Hr. Ave. total surface emissions	2500	16 (Average)	4.05×10^{-11}	160	57	.281	64200	9.62×10^{-1}	6.31×10^{-16}	6.07×10^{-16}
Tailings Ponds:-										
Original			NIL							
New			NIL							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	2500	2	2.66×10^{-5}	160	57	.0351	64200	9.99×10^{-1}	4.14×10^{-10}	4.14×10^{-10}
Plant Stacks:										
Crusher	2500	14	9.17×10^{-12}	160	57	.246	64200	9.70×10^{-1}	1.43×10^{-16}	1.39×10^{-16}
Headframe	2500	23	1.37×10^{-12}	160	57	.404	64200	9.21×10^{-1}	2.13×10^{-17}	1.96×10^{-17}
Transfer	2500	17	1.39×10^{-12}	160	57	.298	64200	9.56×10^{-1}	2.17×10^{-17}	2.07×10^{-17}
Total Emissions from ore Treatment Plant*	2500	18 (Average)	2.38×10^{-11}*	160	57	.316	64200	9.51×10^{-1}	3.71×10^{-16}	3.53×10^{-16}
24 Hour Average Total Surface Ore Treatment Plant Emissions	2500	18 (Average)	1.19×10^{-11}	160	57	.316	64200	9.51×10^{-1}	1.85×10^{-16}	1.76×10^{-16}
Tailings Ponds:-										
Original	2500 (Actual)	-	2.17×10^{-6}	210	78	-	115000	-	1.89×10^{-11}	1.89×10^{-11}
New	2500 (Actual)	-	3.90×10^{-6}	220	73	-	113000	-	3.45×10^{-11}	3.45×10^{-11}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

Appendix K

TABLE 3A

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH 2 1/2 MILES (=4,000 meters) FROM THE PROPERTY (MINIMUM STABILITY - CLASS A)

$u = 2.24$ M/sec.

A. URANIUM Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	4,000	2	8.36×10^{-11}	710	7,000	.0003	3.5×10^{7}	1.0	2.39×10^{-18}	2.39×10^{-18}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	710	7,000	.0020	3.5×10^{7}	1.0	2.62×10^{-19}	2.62×10^{-19}
Headframe	4,000	23	1.37×10^{-12}	710	7,000	.0033	3.5×10^{7}	1.0	3.91×10^{-20}	3.91×10^{-20}
Transfer	4,000	17	1.39×10^{-12}	710	7,000	.0024	3.5×10^{7}	1.0	3.97×10^{-20}	3.97×10^{-20}
Scrubber	4,000	15	2.52×10^{-11}	710	7,000	.0021	3.5×10^{7}	1.0	7.20×10^{-19}	7.20×10^{-19}
Filter	4,000	10	3.33×10^{-12}	710	7,000	.0014	3.5×10^{7}	1.0	9.51×10^{-20}	9.51×10^{-20}
Total Surface Plant Emissions*	4,000	16 (Average)	5.81×10^{-11}*	710	7,000	.0023	3.5×10^{7}	1.0	1.66×10^{-18}	1.66×10^{-18}
24-Hour Avg. Total Surface Plant Emissions		16 (Average)	4.05×10^{-11}	710	7,000	.0023	3.5×10^{7}	1.0	1.16×10^{-18}	1.16×10^{-18}
Tailings Ponds: -										
Original			nil							
New			nil							
B. RADON -222 (No allowance made for radon decay)										
Ventilation Shaft	4,000	2	2.66×10^{-5}	710	7,000	.0003	3.5×10^{7}	1.0	7.60×10^{-13}	7.60×10^{-13}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	710	7,000	.0020	3.5×10^{7}	1.0	2.62×10^{-19}	2.62×10^{-19}
Headframe	4,000	23	1.37×10^{-12}	710	7,000	.0033	3.5×10^{7}	1.0	3.91×10^{-20}	3.91×10^{-20}
Transfer	4,000	17	1.39×10^{-12}	710	7,000	.0024	3.5×10^{7}	1.0	3.97×10^{-20}	3.97×10^{-20}
Total Emissions from Ore Treatment Plant*	4,000	18 (Average)	2.38×10^{-11}*	710	7,000	.0026	3.5×10^{7}	1.0	6.80×10^{-19}	6.80×10^{-19}
24-Hour Avg., Total surface ore treatment plant emissions	4,000	18 (Average)	1.19×10^{-11}	710	7,000	.0026	3.5×10^{7}	1.0	3.40×10^{-19}	3.40×10^{-19}
Tailings Ponds: -										
Original	4,000(actual)	-	2.17×10^{-6}	750	8,000	-	4.22×10^{7}	-	5.14×10^{-14}	5.14×10^{-14}
New	4,000(actual)	-	3.90×10^{-6}	760	9,000	-	4.81×10^{7}	-	8.11×10^{-14}	8.11×10^{-14}

C. THORIUM -230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 3B

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH, 2½ MILES (=4,000 meters) FROM THE PROPERTY

(Maximum Stability - Class F)

u = 2.24 M/sec

A. URANIUM

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	4,000	2	8.36×10^{-11}	120	31	.0645	26,200	9.98×10^{-1}	3.19×10^{-15}	3.18×10^{-15}
Plant Stacks:-										
Crusher	4,000	14	9.17×10^{-12}	120	31	.452	26,200	9.03×10^{-1}	3.50×10^{-16}	3.16×10^{-16}
Headframe	4,000	23	1.37×10^{-12}	120	31	.742	26,200	7.60×10^{-1}	5.23×10^{-17}	3.97×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	120	31	.548	26,200	8.60×10^{-1}	5.31×10^{-17}	4.56×10^{-17}
Scrubber	4,000	15	2.52×10^{-11}	120	31	.483	26,200	8.90×10^{-1}	9.62×10^{-16}	8.56×10^{-16}
Filter	4,000	10	3.33×10^{-12}	120	31	.323	26,200	9.49×10^{-1}	1.27×10^{-16}	1.21×10^{-16}
Total Surface Plant Emissions*	4,000	16 (Average)	5.81×10^{-11}*	120	31	.516	26,200	8.76×10^{-1}	2.22×10^{-15}	1.94×10^{-15}
24-Hour Average, Total Surface Plant Emissions		16 (Average)	4.05×10^{-11}	120	31	.516	26,200	8.76×10^{-1}	1.55×10^{-15}	1.35×10^{-15}
Tailings Ponds:-										
Original			Nil							
New			Nil							

B. RADON - 222 (No allowance made for radon decay)

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\Pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\Pi u \sigma_y \sigma_z}$	C µCi/ml
Ventilation Shaft	4,000	2	2.66×10^{-5}	120	31	.0645	26,200	9.98×10^{-1}	1.02×10^{-9}	1.02×10^{-9}
Plant Stacks:-										
Crusher	4,000	14	9.17×10^{-12}	120	31	.452	26,200	9.03×10^{-1}	3.50×10^{-16}	3.16×10^{-16}
Headframe	4,000	23	1.37×10^{-12}	120	31	.742	26,200	7.60×10^{-1}	5.23×10^{-17}	3.97×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	120	31	.548	26,200	8.60×10^{-1}	5.31×10^{-17}	4.56×10^{-17}
Total Emissions from Ore Treatment Plant*	4,000 / 4,000	18 (Average)	2.38×10^{-11}*	120	31	.581	26,200	8.45×10^{-1}	9.08×10^{-16}	7.67×10^{-16}
24-Hour Average Total Surface Ore Treatment plant emissions	4,000	18 (Average)	1.19×10^{-11}	120	31	.581	26,200	8.45×10^{-1}	4.54×10^{-16}	3.84×10^{-1}[illegible]
Tailings Ponds:-										
Original	4,000(actual)	-	2.17×10^{-6}	175	37	-	45,500	-	4.76×10^{-11}	4.76×10^{-11}
New	4,000(actual)	-	3.90×10^{-6}	185	38	-	49,500	-	7.87×10^{-11}	7.87×10^{-11}

C. THORIUM -230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

TABLE 3C

RADIOACTIVITY: DOWNWIND CENTRE-LINE CONCENTRATIONS AT THE REDD RANCH (≈ 4000 METERS) FROM THE PROPERTY

(Average Stability - Class D)

$u = 2.24$ M/sec

Emitter	Receptor Distance (meters)	H (meters)	Emission Rate Q Curies/sec	σ_y	σ_z	$\frac{H}{\sigma_z}$	$\pi u \sigma_y \sigma_z$	$\exp -\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2$	$\frac{Q}{\pi u \sigma_y \sigma_z}$	C µCi/ml
A. URANIUM										
Ventilation Shaft	4,000	2	8.36×10^{-11}	180	77	.0260	97,500	1.0	8.57×10^{-16}	8.57×10^{-16}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	180	77	.182	97,500	9.84×10^{-1}	9.41×10^{-17}	9.26×10^{-17}
Headframe	4,000	23	1.37×10^{-12}	180	77	.299	97,500	9.56×10^{-1}	1.41×10^{-17}	1.35×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	180	77	.221	97,500	9.76×10^{-1}	1.43×10^{-17}	1.40×10^{-17}
Scrubber	4,000	15	2.5[illegible] $\times 10^{-11}$	180	77	.195	97,500	9.81×10^{-1}	2.58×10^{-16}	2.53×10^{-16}
Filter	4,000	10	3.33×10^{-12}	180	77	.130	97,500	9.92×10^{-1}	3.42×10^{-17}	3.39×10^{-17}
Total Surface Plant Emissions*	4,000	16 (Average)	5.81×10^{-11}*	180	77	.208	97,500	9.76×10^{-1}	5.96×10^{-16}	5.83×10^{-16}
24-Hour Avg. Total Surface Plant Emissions	4,000	16 (Average)	4.05×10^{-11}	180	77	.208	97,500	9.78×10^{-1}	4.15×10^{-16}	4.06×10^{-16}
Tailings Ponds: -										
Original			nil							
New			nil							
B. RADON - 222 (No allowance made for radon decay)										
Ventilation Shaft	4,000	2	2.66×10^{-5}	180	77	.0260	97,500	1.0	2.73×10^{-10}	2.73×10^{-10}
Plant Stacks: -										
Crusher	4,000	14	9.17×10^{-12}	180	77	.182	97,500	9.84×10^{-1}	9.41×10^{-17}	9.26×10^{-17}
Headframe	4,000	23	1.37×10^{-12}	180	77	.299	97,500	9.56×10^{-1}	1.41×10^{-17}	1.35×10^{-17}
Transfer	4,000	17	1.39×10^{-12}	180	77	.221	97,500	9.76×10^{-1}	1.43×10^{-17}	1.40×10^{-17}
Total Emissions from Ore Treatment Plant*	4,000	18 (Average)	2.38×10^{-11}*	180	77	.234	97,500	9.73×10^{-1}	2.44×10^{-16}	2.37×10^{-16}
24-Hour Avg. Total Surface Ore Treatment Plant Emissions	4,000	18 (Average)	1.19×10^{-11}	180	77	.234	97,500	9.73×10^{-1}	1.22×10^{-16}	1.19×10^{-16}
Tailings Ponds: -										
Original	4,000(actual)		2.17×10^{-6}	290	86	-	176,000	-	1.23×10^{-11}	1.23×10^{-11}
New	4,000(actual)		3.90×10^{-6}	305	90	-	193,000	-	2.02×10^{-11}	2.02×10^{-11}

C. THORIUM - 230 and RADIUM - 226

See Note on Table 1A.

*When all surface plant units are in operation simultaneously.

Appendix L

CITY OF MONTICELLO

Phone 587-2271

P.O. Box 847 MONTICELLO, UTAH 84535 35 West First North

June 6, 1973

RECEIVED JUN 6 1973 RIO ALGOM MOAB

RECEIVED JUN - 7 1973 RIO ALGOM MOAB

Rio Algom Corporation
Box 610
Moab, Utah 84532

Dear Mr. Lawton:

In your application for a license with the AEC, if it may be of assistance, we are pleased to make the following comment. In observing the activities of Rio Algom over the past year or so, there appears nothing in their operation at LaSal that in ourview would be detrimental to recreational activities or tourism in the County. We note that you are employing on your work force, Members of our Hispanic and Indian population which contributes to balanced employment in our District.

Sincerely,

CITY OF MONTICELLO

Gene W. Etherington

Mayor Gene W. Etherington

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

19 JUL 1973

Mr. Leland C. Rouse
Chief, Technical Support Branch
Directorate of Licensing
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Rouse:

This letter is supplementary to my letter of March 22, 1973, commenting on the AEC Draft Environmental Statement relating to Rio Algom Corporation's Humeca Uranium Mill in San Juan County, Utah.

The Applicant's letter of June 28, 1973, to the Utah Power and Light Company, advised that the estimated 1975-1980 power requirements for the Humeca Uranium Mill were as follows:

	Current Requirements	1975-1980 Estimated Requirements
Maximum Monthly Demand	3,400 kW	4,000 kW
Energy Requirements, Monthly	1,949,400 kWhr.	2,500,000 kWhr.

The Utah Power and Light Company's service line to the Applicant's facility is rated at 69 kilovolts. Problems of power supply adequacy are not anticipated in meeting the Applicant's capacity and energy requirements, in view of the Utah Power and Light Company's planned system expansion which appears to be keeping pace with the load growth.

Very truly yours,

T. A. Phillips
Chief, Bureau of Power

UTAH POWER & LIGHT COMPANY
1407 WEST NORTH TEMPLE STREET
P. O. BOX 899
SALT LAKE CITY, UTAH 84110

July 17, 1973

Mr. P. F. Pullen
Professional Engineer
Chief Environmental Engineer
Rio Algom Mines, Ltd.
120 Adelaide Street W
Toronto, Canada

Dear Mr. Pullen:

I have been asked to respond to your letter of June 28, 1973 regarding the impact on our service facilities and energy requirements in the area of an anticipated increase of capacity in your Southern Utah uranium milling plant.

The load increase expected from your plant addition will be approximately 600 kilowatts, and this amount will have negligible impact on our service facilities and the energy demand of the area. Inasmuch as new generating units either now being installed or scheduled for the foreseeable future are rated at 330,000 to 440,000 kilowatts, the load addition you plan will not have any measurable effect upon either the time schedule or sizes of new generating facilities planned for our system.

We are presently forecasting system firm peak loads in the neighborhood of 1,446,000 kilowatts in 1975, increasing to 2,094,000 kilowatts in 1980, and expect to have peaking capacity (including reserve) of 1,783,000 kilowatts in 1975 and 2,640,000 kilowatts in 1980. As you can see, we plan to have adequate capacity to serve all of our system loads throughout the 1975-1980 period.

We trust this information will satisfy your request.

Very truly yours,

A. R. Dunn

A. R. Dunn
Manager of Rates

cc: Mr. T. A. Phillips
Chief, Bureau of Power
Federal Power Commission