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May 29, 1981

REPORT
CONCEPTUAL DESIGN AND COST ESTIMATE
TAILINGS PILE RECLAMATION
MOAB, UTAH
FOR ATLAS MINERALS

10223

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May 29, 1981

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Attention: Mr. Richard R. Weaver
President

Gentlemen:

Report
Conceptual Design and Cost Estimate
Tailings Pile Reclamation
Moab, Utah
For Atlas Minerals

Transmitted with this letter are 18 copies of our report containing conceptual design and cost estimate data for reclamation of the tailings pile located at the Atlas Mineral mill near Moab, Utah. Incorporated into this report are comments made by Atlas Minerals personnel who reviewed a draft copy issued on April 13, 1981.

Very truly yours,

Dames & Moore

George C. Toland

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

GCT:11

CONTENTS

Title — Page

INTRODUCTION 1
SUMMARY 2
PURPOSE AND SCOPE 3
DESCRIPTION OF THE TAILINGS DEPOSIT 4
  PRESENT CONFIGURATION 4
  FUTURE CONFIGURATION 4
  GENERAL SUBSURFACE CONDITIONS 6
RECLAMATION OBJECTIVES 8
RECOMMENDED RECLAMATION DESIGN 8
  GENERAL 8
  SLOPE CUTBACK 9
  SOIL COVER 11
  EROSION PROTECTION 14
    VEGETATIVE COVER 15
    ROCK COVER 16
  SETTLEMENT 18
    SOURCES 18
    MAGNITUDES 19
    RATE 20
    FIELD MONITORING 21
  CONSTRUCTION PHASING 21
    INITIAL CONDITIONS 22
    PHASE I RECLAMATION 22
    PHASE II RECLAMATION 22
    PHASE III RECLAMATION 23
CONSTRUCTION CONSIDERATIONS 23
  GENERAL 23
  SETTLEMENTS 24
  BORROW MATERIALS 24
    SOIL COVER 24
    ROCK COVER 27
REFERENCES 30
APPENDIX A - FIELD EXPLORATION AND LABORATORY TESTING . . . A-1
APPENDIX B - CONCEPTUAL PLANS AND SPECIFICATIONS B-1
APPENDIX C - COST ESTIMATE C-1

CONCEPTUAL DESIGN AND COST ESTIMATE
TAILINGS PILE RECLAMATION
MOAB, UTAH
FOR
ATLAS MINERALS

INTRODUCTION

Presented in this report are the results of our study for reclaiming the existing uranium tailings pile at the Atlas Minerals mill located near Moab, Utah (Pl :e 1, Vicinity Map). Although tailings slurry is still actively being discharged into it, the tailings pile will reach its maximum elevation licensed by the NRC in the reasonably near future. At that time discharge of tailings will be directed to another disposal location on the site and the existing tailings pond will be used for evaporation of decanted liquid. After termination of milling operations, any ponded water on the pile will be allowed to evaporate and the pile will be reclaimed to meet the intent of current NRC requirements. The purpose of this study is to outline reclamation methods, discuss construction-related requirements, and present estimated costs.

The results of our field exploration and laboratory testing are presented in Appendix A. Appendix B contains the conceptual plans and specifications; the cost estimate is presented in Appendix C.

SUMMARY

The conceptual design for reclamation of the tailings pile at the Atlas Minerals Moab, Utah, uranium mill is based on a phased sequence of construction intended to satisfy NRC criteria. Three phases of construction consist of 1) reshaping the pile to flatten the sideslopes and eliminate the pond in the center of the pile, 2) placing soil and rock cover on the reshaped pile to reduce radon emanation and promote surface stability, and 3) revegetating the pile top to promote surface stability. Phasing of construction operations is necessary because of the large magnitude of settlements anticipated to occur within the slimes tailings due to the weight of material placed on the pile top and lowering of the water table within the slimes.

Estimated costs associated with the recommended reclamation design are based on typical unit values and calculated quantities. The total estimated cost of the recommended reclamation is $3,230,700. Phase I construction is estimated to cost $338,400; Phase II is estimated to cost $2,859,300, and Phase III is estimated to cost $33,000.

PURPOSE AND SCOPE

The purpose and scope of this study were outlined in our proposal dated February 24, 1981, to Mr. Richard Weaver of Atlas Minerals. The purpose of the work has been to develop general reclamation plans intended to satisfy NRC requirements. While the plans are conceptual in nature, the intent of this study has been to identify major design and construction issues with sufficient accuracy to develop reasonable estimates of cost for surety bonding purposes.

The scope of our work has included the following:

1) A field program to sample potential on-site borrow areas for both soil cover and rock slope protection materials.

2) A modest laboratory testing program to establish the characteristics of the materials sampled.

3) An office program of preliminary design for the reclaimed pile, including:

   a) estimates of slope cutback requirements

   b) determination of final pile configuration

   c) estimates of settlement

   d) construction staging requirements

4) An assessment of material availability, suitability, and construction-related considerations.

5) Preparation of conceptual construction specifications, quantity estimates, and cost estimates.

DESCRIPTION OF THE TAILINGS DEPOSIT

PRESENT CONFIGURATION

At the present time, the Atlas tailings pile occupies roughly 130 acres with the top surface of the pile, exclusive of sideslopes, covering some 80 acres.

With the most recent (early 1980) raise of the perimeter embankments on the top of the tailings pile, the dike crest elevation has reached 4,058 feet. This results in an overall embankment height which varies from as little as 4 feet above the natural ground surface near the northwest corner, to approximately 100 feet along the east side. Present operating criteria call for a minimum 150-foot offset from the edge of the ponded water on top of the pile to the perimeter dike. This offset is maintained by peripheral spigotting of the tailings to develop a perimeter beach. Present estimates are that the ponded water has a maximum depth on the order of 17 feet near the center of the pile. Exposed above-water portions of the tailings beach have a surface slope of about two percent.

FUTURE CONFIGURATION

The tailings pile will reach its final elevation of 4,076 feet with construction of new perimeter dikes to this elevation scheduled for the 1982 construction season. Discharge of tailings will continue until the maximum level of the beach reaches this elevation around the entire perimeter of the pile, resulting in a pile height which will vary from about 20 to 120 feet above natural grade. Discharge of tailings onto the pile will cease at that time, and the mill tailings output will be directed to a new, below-grade impoundment currently being designed by others.

Liquid effluent decanted from the below-grade impoundment will be discharged onto the tailings pile for evaporation. Even though discharge of tailings onto the pile will cease when the pile reaches its maximum elevation, it will be necessary to use the pile for evaporation throughout the remaining life of the mill since it constitutes the sole possible evaporation area on or near the Atlas property.

Upon termination of milling operations, liquid discharge onto the tailings pond will end, and the ponded water will be allowed to evaporate. The exposed slimes tailings will be allowed to desiccate until a surface crust has formed. Reclamation efforts may commence after a surface crust of sufficient thickness has formed to permit equipment to move on it. It is anticipated that two years will be sufficient time for surface crust formation.

Reclamation of the tailings pile will be a time-phased process, with various fill placement operations conducted at different times to bring the pile to its ultimate abandonment configuration. This procedure is described in subsequent sections of this report.

GENERAL SUBSURFACE CONDITIONS

The tailings pile has been constructed by a series of perimeter dikes; the toe of each successive dike is located on or behind the crest of the next lower dike in the "upstream" method of raises. With the exception of the highest perimeter dikes, which in recent years have been constructed of native silty sand soils, the materials nearest the embankment face consist of sand-sized tailings which have been separated hydraulically from the finer slimes by being nearest the point of tailings slurry discharge.

Sand to silty sand tailings should be predominant up to 250 feet from the embankment face. At distances greater than 250 feet from the embankment face, typical tailings sediments of interlayered sand, silty sand, and silt gradation are likely to be present. Slime tailings m[illegible] be present near the embankment face at depth along the west edge of the pile.

In the central part of the pile, silt and possibly clay tailings (slimes) should be present. Slimes tailings have settled from the suspended sediment of the decant pond.

The coarse-to-fine segregation of tailings controls the engineering properties of the deposit. Of particular importance is the greater compressibility of the slimes tailings than the sand tailings.

Tailings along the periphery of the deposit beneath the intermediate dikes have been subjected to intensive subsurface exploration and testing (Dames & Moore, 1979). These tailings have been classified principally as SP to SM (Unified Soil Classification System). Laboratory tests results (Dames & Moore, 1979) have shown that these sand tailings are generally free-draining and relatively incompressible.

The interior areas of the pile were not accessible for subsurface exploration, but characteristics of the slimes tailings can be projected on the basis of tests performed on samples obtained from localized slimes layers encountered in borings around the periphery of the deposit. The slimes tailings have been classified as SM-ML, ML, and MH (Unified Soil Classification System). Laboratory test results (Dames & Moore, 1979) have shown that the compressibility of the slimes is moderate to high, ranging from about two to five times greater than the compressibility of the sand tailings.

The process of consolidation and settlement will occur almost immediately for the sand tailings. A significantly longer time period will be required for consolidation and settlement for the slimes because of their greater compressibility.

RECLAMATION OBJECTIVES

Two principal reclamation objectives stated by the NRC are:

1) Provide long-term protection of tailings against erosion

2) Provide long-term reduction of radon-222 emanation

The Final Environmental Statement (FES) related to operation of the Moab Uranium Mill (NRC, 1979) contains several license conditions intended to meet the reclamation objectives. The Final Generic Environmental Impact Statement (FGEIS) on uranium milling (NRC, 1980) contains regulatory requirements intended to meet the reclamation objectives. Some of the conditions in the FES differ slightly from the requirements of the FGEIS.

We believe that the recommended reclamation design discussed in this report meets the intent of the two principal reclamation objectives in the most economical way. Salient differences between FES and FGEIS affecting design are briefly mentioned at appropriate places in the report.

RECOMMENDED RECLAMATION DESIGN

GENERAL

Reclamation of the tailings pile must incorporate a number of elements to satisfy the intent of NRC requirements. These elements include: 1) cutting back existing pile slopes and depositing the excavated slope material on the pile top; 2) covering the pile with natural soil, and 3) establishing erosion protection on the soil cover.

Reclamation of the pile to incorporate elements 1 and 2 is complicated by the compressibility of the tailings; when subjected to load from the excavated materials placed on the pile top and from the soil cover, the tailings will undergo considerable settlement. This settlement must be accommodated in the design to prevent formation of depressions on the pile surface which could collect and pond water.

SLOPE CUTBACK

Tailings pile development and mill operations at the Atlas site have been constrained by limited space within the site boundaries; this constraint also governs cutback of the existing pile slopes. The pile slopes presently stand at about 3 horizontal to 1 vertical and will be constructed to 2 horizontal to 1 vertical along the southwest side when the pile reaches its maximum elevation of 4,076 feet. These slopes exceed the NRC regulations for long-term erosion stability and must be flattened.

The existing toe of the pile is constrained on all sides and cannot be extended. The north and east sides impinge on Moab Canyon Wash which already has limited area available for PMF flows. Extension to the north and northwest would reduce the limited area available for the planned below-grade tailings disposal scheme, and the southwest side of the pile is confined by existing State Highway 279. Therefore, flattening of the pile slopes must be done with the pile toe at its present location, and the excavated material must be deposited on the pile top.

A major factor in the cost of reclamation is the pile sideslope angle used in slope-flattening efforts. FGEIS requirements express a preference for sideslopes as flat as 10 horizontal to 1 vertical to minimize erosion and provide long-term stability. However, if the Atlas pile were regraded to this slope, our preliminary calculations indicate that the pile would assume very nearly the configuration of a cone with no flat area on the pile top. Deposition of excavated material in such a manner would increase the pile height by over 100 feet and create slope lengths in excess of 2,000 feet.

FES reclamation conditions indicate that the slopes should be cut back to 10 horizontal to 3 vertical; this is three times steeper than the FGEIS preference. Regrading the Atlas pile to 10 horizontal to 3 vertical and depositing the excavated material on the pile top will increase the pile height by 5 feet. The maximum length of the 10 horizontal to 3 vertical slope segment will be about 415 feet.

Cutback slope angles of 10 horizontal to 3 vertical are feasible for reclamation of the Atlas pile and form the basis for subsequent design recommendations. Conceptual plans and section reflecting this cutback slope angle are presented in Appendix B.

Cutback of the existing slopes to 10 horizontal to 3 vertical will generate about 0.3 million cubic yards of sand tailings and natural soil (dike) material. In addition, we estimate that 0.1 million cubic yards of contaminated soil on the mill site (the upper 1 foot) and other debris would result from mill decommissioning. Thus, the total estimated volume of material to be placed on the pile top would be roughly 0.4 million cubic yards.

The material cut back from the sideslopes will be placed on the desiccated surface crust of the pile increasing from the perimeter (elevation 4,070) to an estimated depth of about 17.5 feet (elevation 4,076.5) over the slimes at the center of the pile. The resulting configuration is a very gently sloping, cone-shaped cap on the pile top. Settlement of the pile surface will occur as the slimes compress under the weight of the material excavated from the sideslopes. The significance of the settlement is discussed in subsequent sections.

SOIL COVER

The chief purpose of the soil cover is to reduce the emanation of radon-222 from the tailings material. Thicknesses of cover soils presented in the FES reflect the requirement that radon-222 emanation be restricted to a rate equal to approximately twice the background rate. According to the FES, the NRC considers the background rate in the vicinity of the tailings pile to be 1.6 $pCi/m^2/sec$.

Because radium-226 concentrations (which generate radon-222) are significantly higher in slimes tailings than in sand tailings, thicknesses of soil cover required to restrict radon-222 emanation are different over the two types of tailings material. Thickness values calculated by the NRC as reported in the FES are tabulated below. For the purposes of their calculations, the NRC assumed that the slimes tailings would be covered by five feet of non-slimes.

	TAILINGS TYPE	
Cover Material	Non-Slimes	Slimes Covered By 5 feet of Non-Slimes
Clay	2.0'	2.0'
Silty Sand	3.35'	6.7'
Topsoil	1.0'	1.0'
TOTAL COVER	6.35'	9.7'

The FGEIS requires that soil covers be sufficiently thick that radon-222 emanation is less than 2 $pCi/m^2/sec$. The FGEIS further stipulates that the minimum soil cover thickness is 10 feet.

Because high moisture content has been found to be effective in reducing radon emanation, soils with high moisture holding capacity (clay) may be more desirable for use as soil cover than soils with low moisture holding capacity. However, there is no NRC requirement that clay be used as a soil cover material to restrict radon-222 emanation.

It appears that the FGEIS minimum thickness of silty sand soil placed on the reshaped tailings pile will be sufficient to restrict radon-222 emanation to approximately the required rate, although no calculations have been performed to verify that this is true. The 10-foot minimum thickness is 3.65 feet (57 percent) greater than the FES value calculated by the NRC for the non-slimes portion of the reshaped pile. The FES value includes 2 feet of clay which will be replaced by 5.65 feet of local silty sand. This increased thickness of silty sand is probably sufficient to accommodate the reduction in the permissible radon emanation rate as well as the greater effectiveness of a thinner layer of clay.

The 10-foot minimum thickness is 0.3 feet greater than the FES value calculated by the NRC for the portion of the reshaped pile where slimes are covered by 5 feet of non-slimes. By cutting back the pile slopes to 10 horizontal to 3 vertical, a substantial volume (0.3 million cubic yards) of non-slimes will be deposited on the slimes. The minimum thickness of non-slimes overlying slimes on the reshaped pile will be 5 feet; the average thickness of non-slimes over slimes will be 11 feet. Such a thickness of non-slimes probably will mitigate the higher radium-226 concentration in the slimes. It appears that the FGEIS minimum thickness of silty sand soil will be sufficient to restrict radon-222 emanation to approximately the required rate, although no calculations have been performed to verify that this is true. We understand that Battelle Laboratories will address the radon-222 emanation rate from the reclaimed pile.

The FES considered that the clay at the base of the soil cover was essential to prevent infiltrating rainfall from percolating through the tailings pile. The FGEIS states that seepage is not expected to be a long-term consideration in areas where evaporation far exceeds precipitation. Such is the case at the Atlas Minerals site. Consequently, a clay liner is not considered to be necessary for reclamation.

Considering the discussions of the soil cover materials and thicknesses presented above, the recommended reclamation design is based on a 10-foot thickness of local silty sand soil. The availability of this material is discussed in the report section dealing with construction considerations. The estimated quantity required for a uniform 10-foot thickness over the 130-acre pile is 2.1 million cubic yards.

EROSION PROTECTION

Long-term protection of tailings against erosion can be provided by self-sustaining vegetative covers or by rock covers. The intent is to reduce wind and water erosion to negligible levels.

The FES considered that the thickness of soil cover might be inadequate to prevent the penetration of plant roots into the tailings. Consequently, the FES required that durable sandy gravel be substituted for vegetation as a means of surface stabilization. The thickness of gravel required by the FES was 4 inches on the gently sloping pile top and 12 inches on the steeper sideslopes.

Although the FGEIS apparently does not state that 10 feet of soil cover is adequate to prevent plant roots from penetrating into the tailings, it does suggest that the minimum thickness of soil cover will reduce the likelihood and potentially disruptive effects of root penetration. Additionally, the FGEIS requires that rock covers be used for erosion protection on the slopes of reclaimed tailings piles in arid regions because they believe that full vegetative covers are not likely to be self-sustaining on slopes. It appears that vegetative covers would be permitted on gently sloping pile tops in arid regions.

Considering the discussion presented above regarding erosion protection, the recommended reclamation design is based on a vegetative cover on the gently sloping pile top and rock cover on the steeper sideslopes. The two types of erosion protection are discussed below.

VEGETATION COVER

Natural soil, similar to the silty sand anticipated for use as soil cover, was evaluated to assess its agronomic suitability for establishing a self-sustaining vegetative cover (Dames & Moore, 1977). It was determined that with the addition of soil amendments, such as municipal sludge and fertilizer, to the upper three inches of soil, a self-sustaining cover of Siberian wheatgrass and sand dropseed could be established with only initial short-term irrigation.

The area of the gently sloping pile top on which the vegetative cover will be established is about 90 acres.

ROCK COVER

The FES discusses gravel cover materials only as "durable sandy gravel" and specifies a thickness of 12 inches on the slopes. The FGEIS applies soundness and quality specifications to rock cover materials that are almost as strict as those for concrete aggregate. Thicknesses are not specified in the FGEIS, but the values from a typical example are presented. The example thicknesses are 6 inches of coarse aggregate over 6 inches of medium aggregate.

The coarse aggregate, according to the FGEIS, should have a median grain size of three inches and be well graded. The medium aggregate should consist of grain sizes about one-fifth the diameter of the coarse aggregate, have a uniformity coefficient of at least 6, and contain less than 5 percent passing the No. 16 sieve. The purpose of the medium aggregate is to act as a filter in preventing piping.

The soundness and quality specifications from the FGEIS are summarized below:

1. ASTM C-88; loss not to exceed 10 percent with sodium sulfate, when subjected to 5 cycles of the soundness test.

2. ASTM C-127; bulk specific gravity not less than 2.5.

3. ASTM C-131; abrasion loss not to exceed 50 percent of weight after 500 revolutions.

4. ASTM C-33 for coarse aggregate, except that blast furnace slag is not to be used.

5. AASHTO T-103; loss from freezing and thawing not to exceed 10 percent after 25 cycles.

As discussed in Appendix A, representative samples of material selected from the only potential on-site rock borrow area were subjected to sodium sulfate soundness (ASTM C-88) and L.A. abrasion (ASTM C-131) testing. The five-cycle sodium sulfate test losses ranged from about 33 percent to about 80 percent, all considerably in excess of the 10 percent specification. The abrasion losses ranged from about 34 percent to 86 percent.

To compensate for the soundness and quality of the on-site material, the recommended design includes a two-foot thickness of rock cover material in lieu of the one-foot thickness suggested in the FGEIS. In the long term, weathering and breakdown of some of the rock cover material should result in a layer of sufficient thickness to provide adequate erosion protection.

Considerable processing of on-site material would be required to produce aggregate of the specified gradation. We expect that rock quarrying and crushing will be required to generate the anticipated volume. The area of the sideslopes is about 40 acres. The volume of a layer 2 feet thick will be about 0.13 million cubic yards.

SETTLEMENT

SOURCES

Settlement will be a major factor in reclamation design and construction. To avoid re-filling settlement depressions with scarce and expensive soil cover material and to avoid the need for long-term maintenance and regrading of the pile cover, anticipated settlements must be accommodated. This can be accomplished by phasing construction activities.

Settlement will vary greatly across the surface of the pile because of the differences in compressibility of the sand tailings and the slimes tailings. Near the pile periphery where sand tailings predominate, settlements probably will be less than a few feet. For central portions of the pile underlain by slimes, settlements may be as much as 8 feet.

Settlements will arise from a number of sources:

1) initial (often called "elastic") settlement of the tailings which occurs immediately in response to applied loads.

2) consolidation (primary) settlement in the tailings which occurs over a longer period as pore pressures generated by the applied load in the compressible materials dissipate.

3) longer-term settlements, principally in the slimes, which occurs as the water table gradually drops due to drainage.

4) secondary compression settlement in the tailings which occurs over very long periods.

5) relatively minor amounts of long-term settlement on wetting of the cover material and excavated tailings due to shallow infiltration of water from the pile surface.

Of these sources, consolidation settlement under load and due to water table drop constitute most of the settlement; the other sources contribute only minor amounts which have been neglected in our analysis.

MAGNITUDES

A graph of estimated settlements in sands and slimes tailings is shown on Plate 2. These settlements are based on thicknesses of slimes up to 60 feet and compressibility properties developed during previous studies (Dames & Moore, 1979). The extreme variability in the tailings properties precludes accurate estimates of settlements; actual settlements could vary considerably from those estimated.

The sand tailings will undergo an estimated 2 feet of settlement under the 10 feet of soil cover. The slimes tailings in the central portion of the pile will be initially loaded with a maximum of about 17.5 feet of material excavated from the pile slopes. As shown on Plate 2, this initial load will produce an estimated 5-1/2 feet of settlement. Subsequent placement of the 10 feet of soil cover will result in another foot of settlement. Finally, over a number of years as the water table falls within the slimes, an additional foot of settlement could result. The cumulative maximum settlement near the center of the reclaimed pile could be about 8 feet. Sources of minor settlement not considered in the analyses and variability of the tailings properties make this value highly approximate.

RATE

The rate at which primary consolidation settlement occurs is also subject to considerable uncertainty. Coefficients of consolidation for slimes tailings derived from time-rate laboratory consolidation curves vary by a factor of greater than 10 (Dames & Moore, 1979). We believe that most of the primary settlement of slimes tailings under applied load will occur within 6 to 24 months after load application. It is our judgment that the required time will be about one year. Primary consolidation settlement of sand tailings will occur rapidly and should take place largely within the loading period.

It should be noted that the time required for primary settlement to occur is independent of the magnitude of the load causing the settlement. Thus, primary settlements due to placement of excavated material would require 6 to 24 months to be essentially complete, and primary settlements due to placement of the soil cover, although smaller in magnitude, would require an additional 6 to 24 months. As previously indicated, smaller secondary compression and settlements due to water table drop would continue over a number of years.

FIELD MONITORING

While settlements can be predicted in an approximate way by calculations based on laboratory test results, the only reasonably accurate prediction method for a situation of this type is field monitoring. It is therefore recommended that settlement time and magnitude under each applied load increment be determined by field monitoring in the sands and slimes throughout reclamation construction. Additionally, pore pressures in the slimes should be measured to permit determination of the end of primary consolidation.

CONSTRUCTION PHASING

A phased approach to reclamation construction is recommended because of the large magnitudes of settlement likely to be experienced during reclamation, and the difficulty in accurately estimating these magnitudes in advance of construction. By allowing settlements to occur between the various phases of reclamation, material quantities can be minimized and the need for post-reclamation regrading, reconstruction, and maintenance can be eliminated. Recommended sequencing of reclamation construction is outlined below. This sequence is also presented in Appendix B on conceptual plans and sections.

INITIAL CONDITIONS

Prior to commencing reclamation, the following should occur:

1) terminate milling operations

2) allow ponded water to evaporate

3) allow desiccation of the surface of the slimes to form a crust of sufficient competence to support equipment

PHASE I RECLAMATION

1) install pore-pressure monitoring devices in the slimes.

2) decommission mill site, place contaminated material on top of desiccated slimes

3) cut slopes back to 10 horizontal to 3 vertical

4) deposit material on pile top to approximate configuration shown

5) apply dust-suppressant chemicals to pile surface

6) install settlement monitoring devices and piezometers

7) monitor settlements, water levels and pore pressures until primary consolidation in the slimes is essentially complete.

PHASE II RECLAMATION

1) regrade pile top to eliminate settlement depressions or severe irregularities

2) place 10-foot soil cover

3) place 2-foot rock slope protection

4) apply dust-suppressant chemicals to top pile surface

5) reinstall settlement monitoring devices

6) monitor settlements, water levels and pore pressures until primary consolidation in the slimes is essentially complete.

PHASE III RECLAMATION

1) regrade pile top to eliminate settlement depressions or severe irregularities

2) condition soil on pile top and establish appropriate vegetation.

The estimated final configuration of the pile top would have an approximate average one-half percent slope. This is considered to be sufficiently flat to reduce erosion potential, but sufficiently steep to prevent substantial ponding. The final reclamation configuration shown in Appendix B is believed to be adequate to meet the intent of NRC reclamation criteria.

CONSTRUCTION CONSIDERATIONS

GENERAL

Principal construction considerations for reclaiming the tailings pile pertain to 1) accommodating large-magnitude settlements over periods of several months to more than a year and 2) locations and quantities of borrow materials (soil cover and rock cover).

SETTLEMENTS

Sources, magnitudes, and rates of settlement have been discussed in previous sections of the report. Reclaimed pile configurations shown in Appendix B have incorporated into them the anticipated magnitudes of settlement. Rates of settlement must be accommodated by allowing time for settlements to occur between successive reclamation phases. Regrading to eliminate depressions or severe irregularities should precede each reclamation phase.

Major uncertainties in the uniformity of material properties (chiefly compressibility) preclude totally reliable prediction of settlement magnitudes and rates on the basis of laboratory test results. Consequently, we strongly recommend instrumentation and monitoring of 1) settlement magnitudes and rates 2) pore pressures in the slimes, and 3) water levels in the tailings pile to provide a means for determining when sufficient settlement has occurred that the next construction phase may be started.

Instruments for measurement of settlements, pore pressures and water levels are readily available, and the monitoring techniques are conventional.

BORROW MATERIALS

SOIL COVER

The availability of soil cover material from within the site boundaries is severely limited for the same reasons that the toes of the embankment slopes cannot be extended from their present positions. Consequently, only one 25-acre area exists within the site boundaries where soil cover material could be obtained. This area is located between the tailings pile and the Colorado River.

The 25-acre area is on the flood plain of the Colorado River; the depth to ground water is about seven to nine feet. Subsurface information is this area has been developed during past studies by Dames & Moore; additionally, a number of surface samples were obtained specifically for this study. The locations of the surface samples are indicated on Plate A-1, Engineering Geology Map; the results of laboratory tests performed on these samples are described in Appendix A. Typically, surface soils from this area have 60 percent (numerical average of lab data) passing the No. 200 sieve.

The volume of material which would be available from this area is approximately 0.3 million cubic yards. This volume is based on excavation to the water table at slopes of five horizontal to one vertical from the toe of the tailings pile and from the property boundary. It can be seen clearly that substantial excavation below the water table would be required to generate from this area the 2.1 million cubic yards of required soil cover.

A near-site alternative to the potential on-site borrow area would be the banks and bottom of the Colorao River adjacent to the site. As shown on Plate 1, a small island near the west bank of the river is located approximately one-quarter mile from the tailings pond. The dimension of this island is approximately 3,200 feet by 1,050 feet (measured on a 1978 aerial photograph). The required 2.1 million cubic yards of soil cover could be obtained by dredging this island to a depth of 17 feet. Silty fine to coarse sand with some clay and gravel suitable for excavation by dredging is expected to be present to this depth.

Because of the extremely limited available quantity of soil cover material available within the site boundaries, and because of the economical way which large volumes of material can be moved with dredges, the Colorado River adjacent to the site is assumed to be the source of the entire 2.1 million cubic yards of soil cover material required for reclamation of the tailings pile.

The use of material dredged from the Colorado River as soil cover on the reshaped tailings pile will require the construction of a small dike around the perimeter of the gently sloping pile top. This perimeter dike will confine the dredged material while it dries sufficiently to be spread over the pile surface.

The maximum volume of dredge material which can be accommodated at any single time on the pile top is about 0.75 million cubic yards. Therefore, the required 2.1 million cubic yards of soil cover will require three dredging efforts separated by sufficient time for the material to dry and be spread.

ROCK COVER

Only one potential area of rock borrow exists within the property boundaries. This area is located southwest of State Highway 279 and is characterized by natural slopes ranging from 30 to 45 percent. Southwest of the property boundary, the slope steepens to about 100 percent at the base of a nearly vertical 300-foot high cliff. An engineering geologic map of this area prepared as part of this study is presented on Plate A-1 in Appendix A. Material in this area consists generally of colluvial deposits overlying bedrock. Local minor eolian silty sand and alluvial sandy and silty gravel are present. The colluvial deposits are typically sandstone fragments in a matrix of silt, sand and gravel.

The engineering geologic map, Plate A-1, shows that most of the southwest corner of the site is underlain by interbedded sandstone and siltstone of the Chinle Formation; the Chinle Formation is underlain by claystone and siltstone of the Moenkopi Formation. As much as 25 feet of colluvial deposits consisting of boulders and cobbles of sandstone in a matrix of gravel, sand and silt covers most of the slope.

Excavation of the colluvial deposits may be made with conventional heavy earthmoving equipment. Many boulders will be sufficiently large that 1) they will exceed the allowable size for use as rock cover and 2) they will exceed the equipment capacity. These boulders will have to be wasted or blasted individually. Excavation of the siltstone and claystone bedrock probably can be accomplished with heavy ripping; it is our opinion that blasting will be required to excavate the sandstone bedrock.

Based on the gradation data presented in Appendix A and on the FGEIS gradation requirements, it is clear that considerable processing of the rock borrow material will be required to yield suitable rock cover. Secondary and probably tertiary crushing and screening will be required to meet the gradations specified in the FGEIS regulations.

Based on the results of sodium sulfate soundness tests presented in Appendix A, it appears that no material from the site meets the FGEIS soundness specifications for rock fragments. In order to compensate for this deficiency with on-site rock material, either 1) thickness of durable rock cover specified in the FGEIS regulations should be exceeded, or 2) durable rock material should be imported.

As discussed in a previous section of this report, the recommended reclamation design includes a two-foot thickness of rock cover material obtained from the on-site source. The volume of rock cover required has been calculated to be 0.13 million cubic yards. Based on the gradation requirements of the rock cover and the nature of the on-site material, it is estimated that the waste factor will be 50 percent. Consequently, excavation of 0.26 million cubic yards will be required to yield 0.13 million cubic yards of rock cover.

Our preliminary calculations indicate that a total volume exceeding 5 million cubic yards is available from the southwest corner of the site. This calculated volume is based on excavation at continuous slopes of 1 horizontal to 1 vertical (100 percent) from the property boundaries to a base elevation of 4,050 feet. Consequently, it is clear that ample volume is available from the on-site rock borrow area.

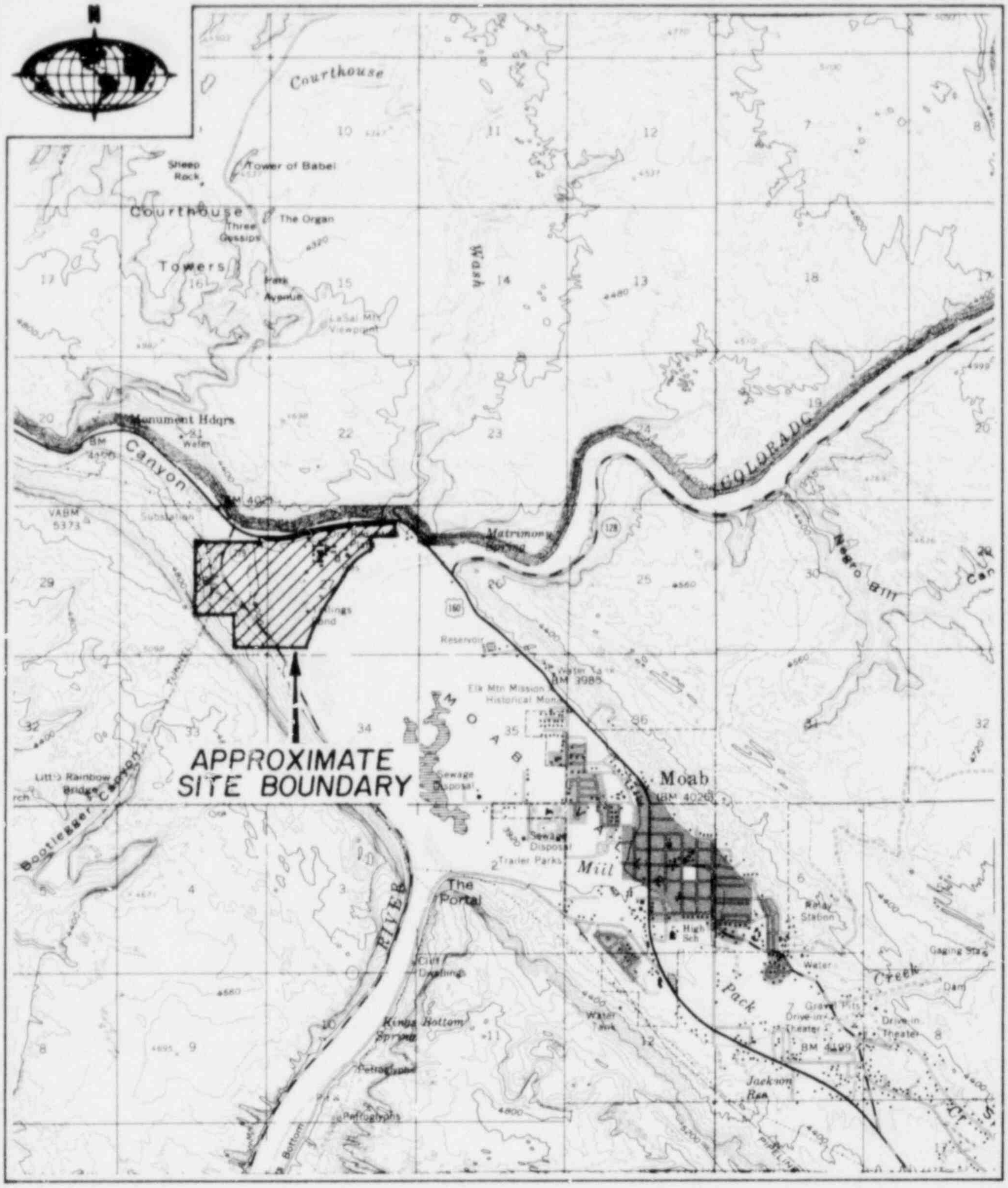
REFERENCES

Dames & Moore, 1977, Tailings management and reclamation alternatives study, for Atlas Minerals Mill at Moab, Utah, revised: unpublished consultant's report, Job No. 05467-019-06, dated October 14, 1977.

______, 1979, Report of supplementary study, geotechnical evaluation of tailings pond - embankment system, Moab, Utah, for Atlas Minerals: unpublished consultant's report, Job No. 05467-023-06, dated February 16, 1979.

NRC, 1979, Final environmental statement related to operation of Moab uranium mill, Atlas Minerals Division, Atlas Corporation: Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, NUREG-0453, Docket No. 40-3454, January, 1979.

______, 1980, Final generic environmental impact statement on uranium milling, Project M-25: Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, NUREG-0706, 3 volumes, September, 1980.



SCALE IN FEET

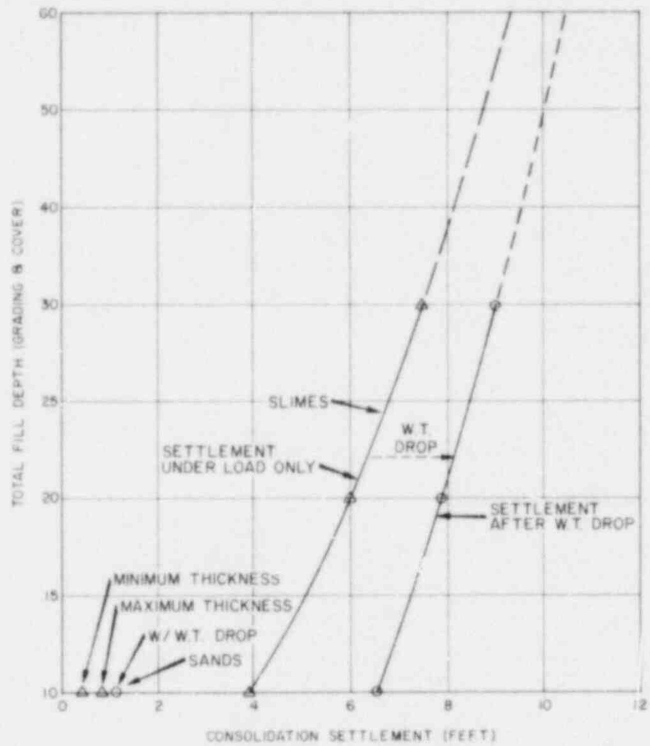
3000 0 3000 6000

VICINITY MAP

REFERENCE
U.S.G.S. QUADRANGLE SHEET ENTITLED
"MOAB, UTAH" DATED 1959 (PR 1968).

DAMES & MOORE

PLATE 1



NOTES

1) DISCUSSIONS IN THE TEXT ARE NECESSARY FOR A PROPER UNDERSTANDING OF THE DATA SHOWN.
2) ALL SETTLEMENTS SHOWN ARE VERY APPROXIMATE AND COULD VARY WIDELY FROM THE INDICATED VALUES.
3) SETTLEMENTS SHOWN ARE DUE ONLY TO PRIMARY CONSOLIDATION, AND SETTLEMENT DUE TO OTHER MECHANISMS IS NOT ACCOUNTED FOR.
4) FOR CONSTRUCTION PURPOSES, SETTLEMENT SHOULD BE BASED ON FIELD MONITORING.
5) W.T. = WATER TABLE.

ESTIMATED SETTLEMENTS IN SANDS AND SLIMES TAILINGS

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APPENDIX A

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

INTRODUCTION

Our previous investigations at the Atlas Minerals mill at Moab have been restricted principally to the area northeast of State Highway 279, south of U.S. Highway 163, and northwest of the Colorado River, although our study dated October 14, 1977, included a regional reconnaissance. The field work for this study was restricted principally to the area between the tailings pile and the Colorado River and to the area southwest of State Highway 279.

The field work for this study consisted of engineering geology mapping and collection of representative samples of on-site surficial and bedrock materials. The engineering geology mapping was performed on March 9 and 10, 1981 by an experienced engineering geologist from our staff. Stereoscopic aerial photographs (1:8640 approximate scale) of the mill and tailings facilities were obtained from Aero-graphics, Inc. of Salt Lake City. These photographs were taken on April 11, 1978 and used by Aero-graphics to compile a topographic map of the tailings pile for our use on a project conducted in 1978. Frame numbers 28-01 and 28-02 were used in the field as the base for engineering geology notes.

The engineering geology information recorded in the field was then transferred to a base map at the scale of 1 inch to 400 feet. The base map was constructed from photography dated March 12, 1977. Our interpretation of the engineering geology at the site is presented on Plate A-1.

NOMENCLATURE AND MAPPING SYMBOLS

Surficial and bedrock materials at the site have been classified in general accordance with the system proposed by Galster (1977) and subsequently modified by Keaton (1980). This system utilizes capital letters followed by one or more lower case letters. For surficial materials, the capital letters signify material genesis (A for alluvial, C for colluvial, F for fill); the lower case letters signify material texture in a manner derived from the Unified Soil Classification System (c for clay, m for silt, s for sand, g for gravel, k for cobbles, b for boulders). The thickness of surficial materials is indicated by a number in parentheses at the right end of the symbol. Conventional geologic "shorthand" is used for bedrock units (SS for sandstone, ST for siltstone, CS for claystone); interbedded deposits are signified by a lower case "i" preceding the bedrock symbol. Surficial deposits overlying bedrock material are indicated by stacking the appropriate symbols.

EXPOSURES

Bedrock within the site boundaries is poorly exposed with the exception of the most resistant sandstones of the Chinle

Formation. Southwest of the site boundaries, the cliff-forming Wingate Sandstone is well exposed. Most of the bedrock visible within the site boundaries has been exposed by grading for access roads to the railroad tunnel and power poles and for State Highway 279 road cuts.

LABORATORY TESTING

INTRODUCTION

Samples obtained in the field were brought to our Salt Lake City laboratory for testing. The tests consisted principally of classfication tests (grain-size distribution and Atterberg limits). Additionally, tests commonly performed for concrete aggregate (specific gravity, freeze-thaw, soundness and durability tests) were conducted on three samples. Pertinent test data from our previous studies were reviewed but have not been reproduced in this appendix.

GRAIN-SIZE DISTRIBUTION

These tests were performed on all samples collected for this study. The sieve sizes selected for the tests (basically No. 4, No. 10, No. 40, and No. 200) permit classification of the samples by the Unified Soil Classification System (Plate A-2); hydrometer analyses were not performed on any samples.

The results of the grain-size distribution tests are tabulated on the following page:

GRAIN-SIZE DISTRIBUTION

Sample Number	Soil Type	Percent Finer By Weight #4	#10	#40	#200	*Indicates Atterberg Limits Run
1	ML	100	99.9	99.7	67.9	*
2	ML-SM	100	100	99.9	50.8	*
3	ML	100	100	99.8	79.9	*
4	CH	100	100	100	98.8	*
5	SP-SM	85.5	74.8	58.5	11.8	
6	SM	99.6	98.9	90.6	29.2	
7	MH-CH	100	100	100	98.8	*
8	MH	100	100	100	99.9	*
9	CH	100	100	100	99.7	*
10	SP	100	100	85.2	9.4	
11	SP	99.5	98.9	89.9	4.1	
12	SP	100	99.6	97.4	9.6	
13	SP	100	100	96.9	6.1	
14	SM	94.3	92.2	81.2	28.1	
15	SM	89.0	85.6	81.2	16.2	
16	GP	39.7	37.6	36.0	6.6	
17	SW-GW	58.1	54.2	18.9	7.4	
18	GP	5.7	2.7	1.3	0.6	

ATTERBERG LIMITS

The Atterberg limits of four samples were determined; additionally, three samples were found to be non-plastic. The samples selected for Atterberg limits determinations were those with more than 50 percent by weight passing the No. 200 sieve.

The results of the Atterberg limits determinations are tabulated below:

ATTERBERG LIMITS

Sample Number	Liquid Limit	Plasticity Index	Classification
1	--	Non-Plastic	ML
2	--	Non-Plastic	ML-SM
3	--	Non-Plastic	ML
4	52.3	25.2	CH
7	53.5	24.9	MH-CH
8	73.1	29.3	MH
9	67.0	49.4	CH

SPECIFIC GRAVITY

Specific gravity tests were performed on samples 16, 17 and 18. The results of these tests are tabulated on the following page:

SPECIFIC GRAVITY

Sample Number	Gs
16	2.67
17	2.80
18	2.76

FREEZE-THAW

One representative cobble-sized piece of material from samples 16, 17, and 18 was immersed in tap water and subjected to 25 freeze-thaw cycles; visual observations only were made. The cobble from sample 16 showed no visible change after 25 cycles. The cobble from sample 17 slaked completely after the second cycle. The cobble from sample 18 showed minor slaking after 25 cycles of freezing and thawing.

SODIUM SULFATE SOUNDNESS

Bulk samples coarser than the No. 4 sieve were submitted to Pittsburgh Testing Laboratories for sodium sulfate soundness testing. The tests were conducted in the manner described as ASTM test designated C-88. The results are tabulated below:

Sample Number	Weighted Loss (%)
16	33.3
17	79.5
18	51.4

ABRASION DURABILITY

Bulk samples coarser than the No. 4 sieve were submitted to Pittsburgh Testing Laboratories for abrasion durability testing. The tests were conducted in the manner described as ASTM test designated C-131, Method A, 500 revolutions, 12 steel balls. The results are tabulated below:

Sample Number	Percent Loss
16	86.1
17	34.1
18	36.3

oOo

The following are attached and complete this appendix:

References

Plate A-1 - Engineering Geology

Plate A-2 - Unified Soil Classification System

REFERENCES

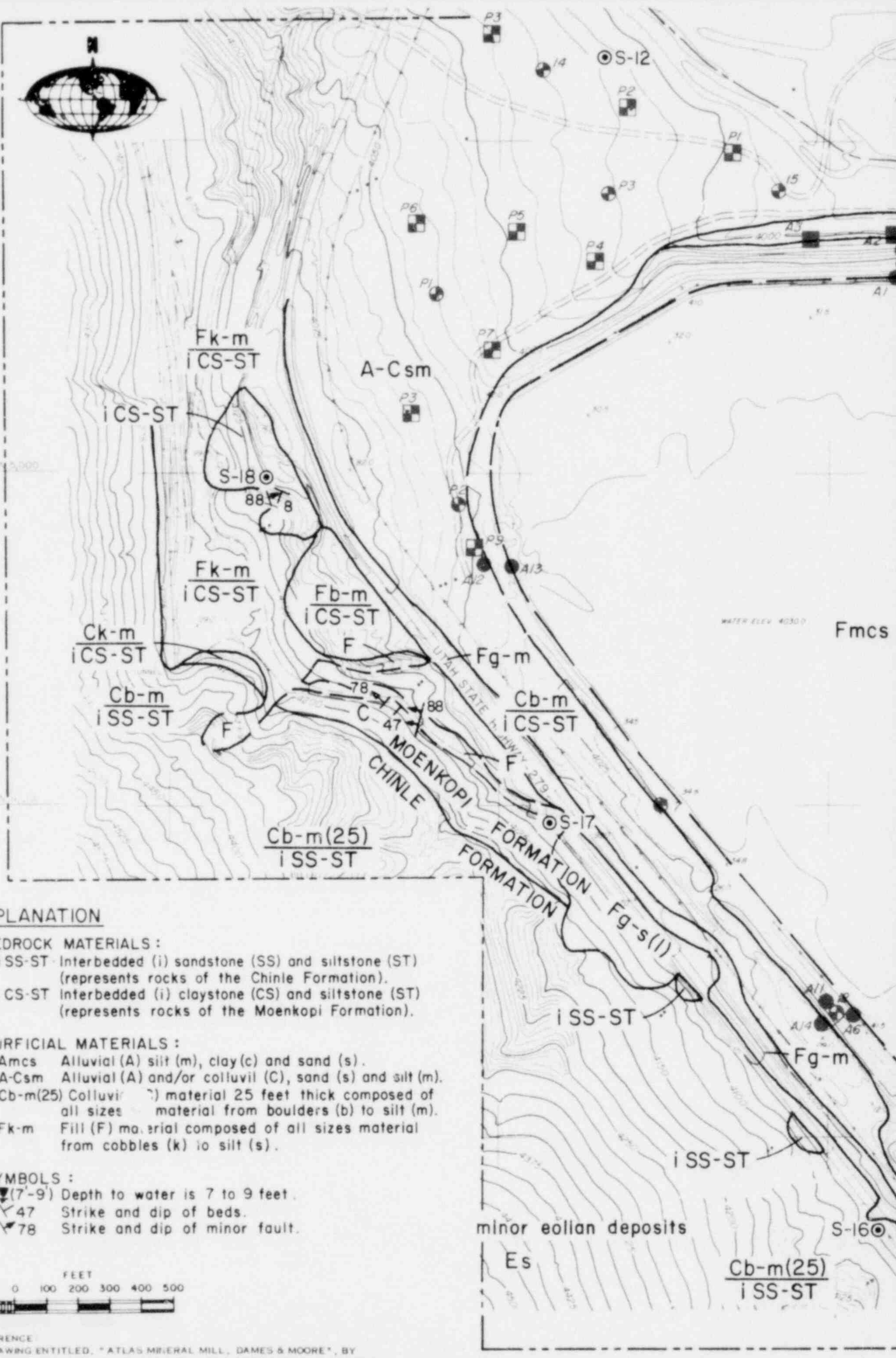
Galster, R.W., 1977, A system of engineering geology mapping symbols: Association of Engineering Geologists, Bulletin, Vol. XIV, No. 1 p. 39-47.

Keaton, J.R., 1980, Genesis-Lithology-Qualifier (GLQ) system of engineering geology mapping symbols--review and update: Association of Engineering Geologists, Program and abstracts, 23rd annual meeting, Dallas, Texas p. 47.

REVISIONS
BY ______ DATE ______ TO EO ______
BY ______ DATE ______ TO EO ______

BY ______ DATE ______
CHECKED BY ______
COPY TO EO ______

466 12 (4-64)



EXPLANATION

BEDROCK MATERIALS:

- iSS-ST Interbedded (i) sandstone (SS) and siltstone (ST) (represents rocks of the Chinle Formation).
- iCS-ST Interbedded (i) claystone (CS) and siltstone (ST) (represents rocks of the Moenkopi Formation).

SURFICIAL MATERIALS:

- Amcs Alluvial (A) silt (m), clay (c) and sand (s).
- A-Csm Alluvial (A) and/or colluvil (C), sand (s) and silt (m).
- Cb-m(25) Colluvi(C) material 25 feet thick composed of all sizes material from boulders (b) to silt (m).
- Fk-m Fill (F) material composed of all sizes material from cobbles (k) to silt (s).

SYMBOLS:

- (7'-9') Depth to water is 7 to 9 feet.
- 47 Strike and dip of beds.
- 78 Strike and dip of minor fault.

FEET
100 0 100 200 300 400 500

REFERENCE
DRAWING ENTITLED, "ATLAS MINERAL MILL, DAMES & MOORE", BY AERO GRAPHICS, INC., SALT LAKE CITY, UTAH, FROM PHOTOGRAMMETRIC METHODS, DATE FLOWN 3-12-77.

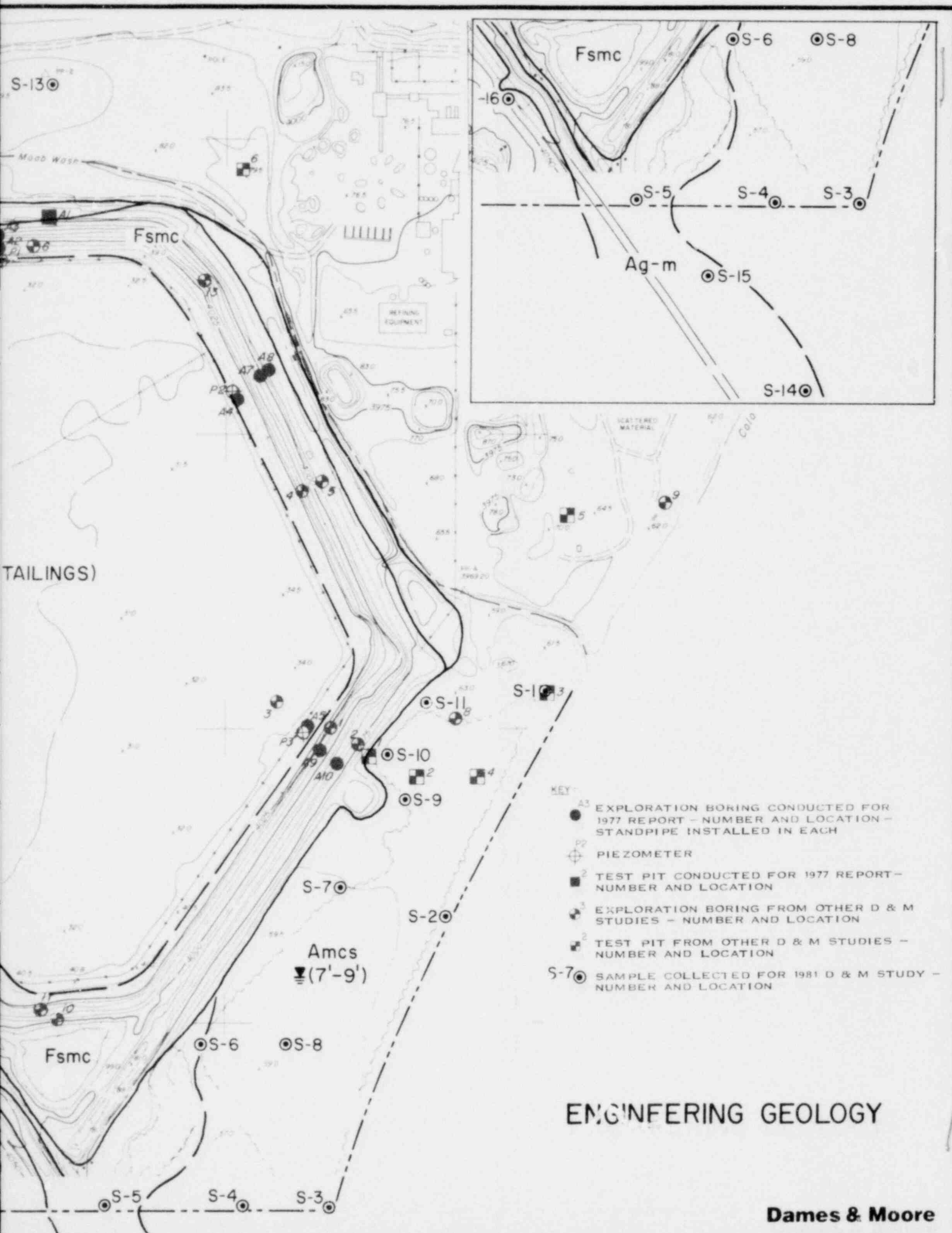

Fsmc
S-6
S-8
-16
S-5
S-4
S-3
Ag-m
S-15
S-14
S-13
Moab Wash
A1
Fsmc
REFINING EQUIPMENT
A8
A7
P2
A4
SCATTERED MATERIAL
TAILINGS)
S-11
S-1
S-10
S-9
A9
A10
P3
S-7
S-2
Amcs
(7'-9')
Fsmc
S-6
S-8
S-5
S-4
S-3
KEY:
EXPLORATION BORING CONDUCTED FOR 1977 REPORT – NUMBER AND LOCATION – STANDPIPE INSTALLED IN EACH
PIEZOMETER
TEST PIT CONDUCTED FOR 1977 REPORT – NUMBER AND LOCATION
EXPLORATION BORING FROM OTHER D & M STUDIES – NUMBER AND LOCATION
TEST PIT FROM OTHER D & M STUDIES – NUMBER AND LOCATION
S-7 SAMPLE COLLECTED FOR 1981 D & M STUDY – NUMBER AND LOCATION
ENGINEERING GEOLOGY
Dames & Moore

PLATE A-1

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 <u>RETAINED</u> 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 <u>LARGER</u> THAN NO. 200 SIEVE SIZE				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION <u>PASSING</u> 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 <u>LESS</u> 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 <u>SMALLER</u> THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT <u>GREATER</u> 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

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APPENDIX B

TAILINGS PILE RECLAMATION
CONCEPTUAL PLANS AND SPECIFICATIONS

INTRODUCTION

The reclamation of the tailings pile shall be accomplished in accordance with the conceptual plans and specifications presented in this appendix. Reclamation shall be performed in phases to permit settlements associated with one phase to occur prior to commencement of the subsequent phase.

Prior to commencement of Phase I, but after termination of milling operations, all water ponded on the tailings pile (which at that time will be used as an evaporation pond) shall be permitted to evaporate. A crust of sufficient competence to support construction equipment shall be allowed to form by desiccation on the surface of the slimes tailings. As much as two years may be required for such a crust to form.

Pore pressure monitoring devices, such as a Sinco Pore-Pressure Indicator Model 51421-A or equivalent, shall be installed at six locations in the central part of the pond. These locations shall be selected in the field by the owner's geotechnical representative. Installation shall be accomplished by drilling a boring at each of the six locations to depths specified in the field by the owner's geotechnical representative. Pore-pressure devices shall be installed in the manner prescribed by the manufacturer of the devices selected for use.

Care shall be taken that the electronic lead wires are not damaged by equipment at any time during reclamation operations. Should damage to the wires occur, such damage shall be repaired immediately.

PHASE I RECLAMATION

The initial task of Phase I shall be to decommission the mill site. Contaminated material (the upper 1 foot of soil and other debris) shall be placed on the desiccated crust formed on the slimes. The volume of this material is estimated to be 0.1 million cubic yards. Contaminated material shall be spread in lifts not exceeding 12 inches in loose thickness and compacted with at least 3 passes of heavy construction equipment.

The pile sideslopes shall be graded to slopes of 10 horizontal to 3 vertical beginning at the existing toe of the slope as shown on Plate B-1 and Section B on Plate B-3. Excavated material shall be spread on the pile top in lifts not exceeding 12 inches in loose thickness and compacted with at least 3 passes of heavy construction equipment.

The crest of the 10 horizontal to 3 vertical segment of the slope extending up from the toe shall be near elevation 4,070 feet. The elevation of the peak on the pile top shall be about 4,076.5 feet.

Dust suppressant chemicals, such as Coherex or equivalent, selected by the owner's representative shall be applied to the surface of the reshaped pile. The area of the reshaped pile is approximately 130 acres.

Settlement monitoring devices, such as pieces of reinforcing steel 5 feet in length embedded in concrete or equivalent, shall be installed at 12 locations on the pile top. These locations shall be selected in the field by the owner's geotechnical representative.

Piezometers, consisting of perforated PVC pipe or equivalent, shall be installed at six locations on the pile top. These locations shall be selected in the field by the owner's geotechnical representative. Installation shall be accomplished by drilling a boring at each of the six locations to depths specified in the field by the owner's geotechnical representative. Borings containing piezometer casings shall be backfilled in the manner prescribed by the owner's geotechnical representative.

Settlements, water levels, and pore pressures shall be monitored periodically, not less frequently than monthly until the owner's geotechnical representative has reason to believe that primary consolidation in the slimes is essentially complete. The magnitude of the anticipated settlements is shown schematically on Section C on Plate B-3.

PHASE II RECLAMATION

When the owner's geotechnical representative has determined that primary consolidation in the slimes is essentially complete, Phase II reclamation shall commence. The initial task of Phase II shall be to regrade, as necessary, the pile top.

A small dike shall be created on the pile top near the crest of the 5 horizontal to 1 vertical slope segment. The details of this dike shall be established in the field by the owner's geotechnical representative. In general, this dike shall be no greater than 10 feet in height and constructed of native (non-tailings) material compacted to at least 90 percent of the maximum dry density determined by AASHTO test designated T-180. The dike shall be constructed with sideslopes of 2 horizontal to 1 vertical; the width of the top shall be 10 feet. It is estimated that about 0.06 million cubic yards wll be compacted to form this dike.

A dredge operation shall be established after necessary permits have been obtained. Dredged materials shall be discharged onto the pile top inside the small dike. It is anticipated that 0.75 million cubic yards of dredged material can be placed inside the small dike. This material should be given sufficient time to dry to a workable consistency and spread over the slopes of the reshaped pile. The dried material should be spread in lifts not exceeding 12 inches in loose thickness and compacted with at least 3 passes of heavy construction equipment.

Compaction of material should be done first at the toe of the slope so that a nearly horizontal working surface may be maintained. The material shall be placed in such a manner that the thickness of material in a vertical plane is 10 feet and the slope of the out face does not exceed 10 horizontal to 3 vertical.

Dredged material shall be discharged onto the pile top and allowed to dry to a workable consistency about 3 times to create the 2.1 million cubic yards required for the soil cover. The contours of the pile after placement of the soil cover are shown on Plate B-2 and Section D on Plate B-3.

After the soil cover is in place, rock cover shall be applied to the 10 horizontal to 3 vertical slope segments. A quarry operation shall be established to produce graded aggregate suitable for use as rock cover. It is anticipated that 0.26 million cubic yards of material will have to be processed to yield 0.13 million cubic yards of suitable rock cover. The rock cover shall be placed in such a manner that the thickness of material in a vertical plane is two feet and the slope of the out face does not exceed 10 horizontal to 3 vertical. The rock cover is shown schematically on Section D on Plate B-3.

Dust suppressant chemicals, such as Coherex or equivalent, selected by the owner's representative shall be applied to the surface of the soil cover on the pile top. The area of the pile top is approximately 90 acres.

Settlement monitoring devices shall be reinstalled at 12 locations on the pile top. These locations shall be selected in the field by the owner's geotechnical representative.

The integrity of the six piezometers shall be preserved during Phase II reclamation. Settlements, water levels, and pore pressures shall be monitored periodically, not less frequently than monthly, until the owner's geotechnical representative has reason to believe that primary consolidation in the slimes is essentially complete.

PHASE III RECLAMATION

When the owner's geotechnical representative has determined that primary consolidation in the slimes is essentially complete. Phase III reclamation shall commence. The initial task of Phase III shall be to regrade, as necessary, the pile top to eliminate topographic depression or severe irregularities.

Revegetation of the pile top shall be done to complete the reclamation. The initial task of revegetation shall be to apply municipal sludge at the rate of 15 tons per acre to the 90-acre pile top. The sludge shall be worked into the upper three inches of soil cover material by discing or other suitable means.

Seeding shall be performed in two operations. In late fall (late-October to early-November) Siberian wheatgrass shall be sowed at a depth of three-quarters of an inch on 12-inch spacings at the rate of 8 pounds per acre. Sand dropseed shall be broadcast seeded in July following sowing of the Siberian wheatgrass. The sand dropseed shall be applied at the rate of two pounds per acre.

Fertilizer shall be applied after seeding at the rates of 25 pounds per acre of available nitrogen and 20 pounds per acre of available phosphorous. Irrigation shall be done as directed by the owner's agricultural representative. It is anticipated that the only irrigation required will be immediately following application of fertilizer. The configuration of the reclaimed pile is shown in Section E on Plate B-3.

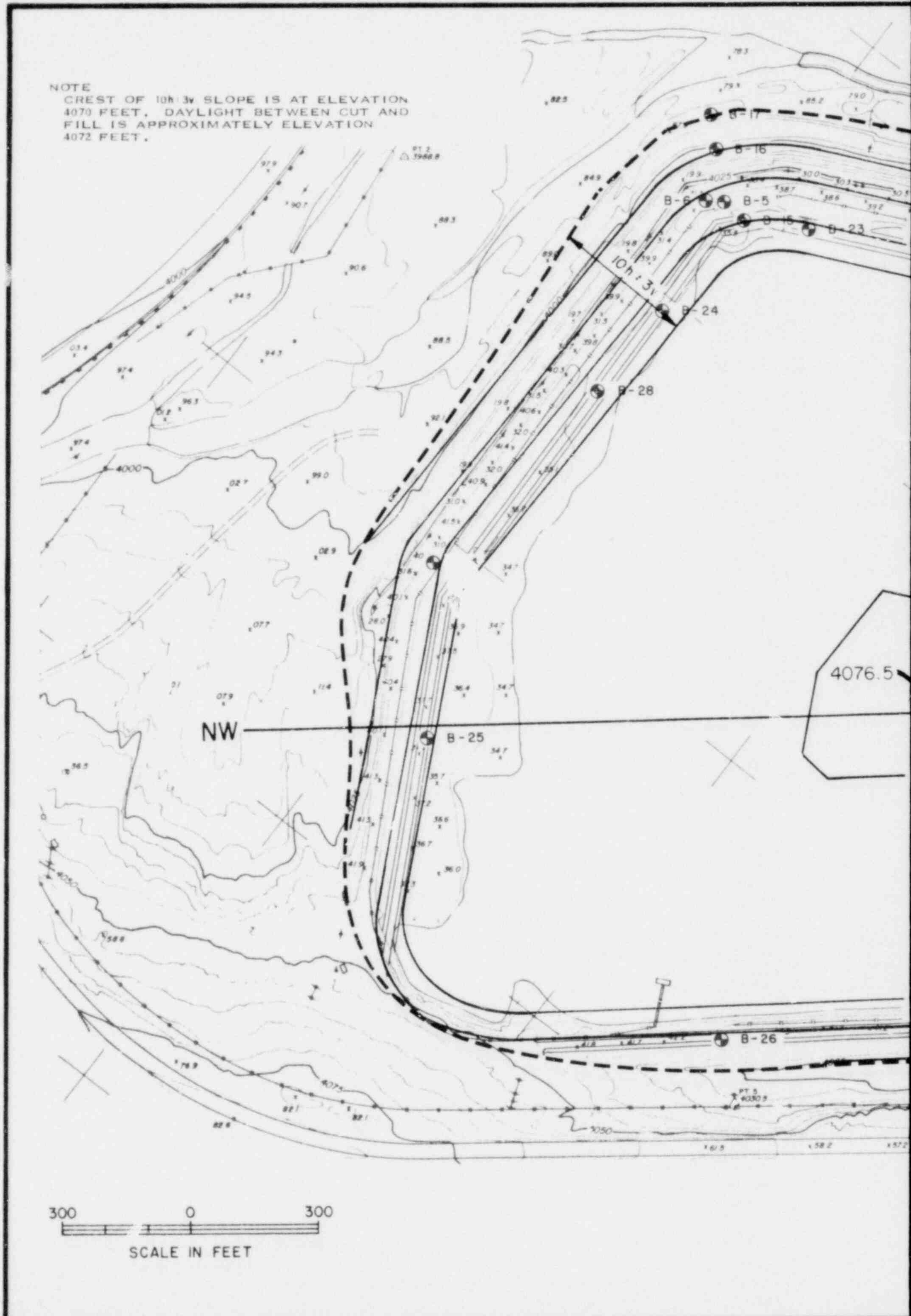
oOo

The following are attached and complete this appendix:

Plate B-1 - Phase I Reclamation

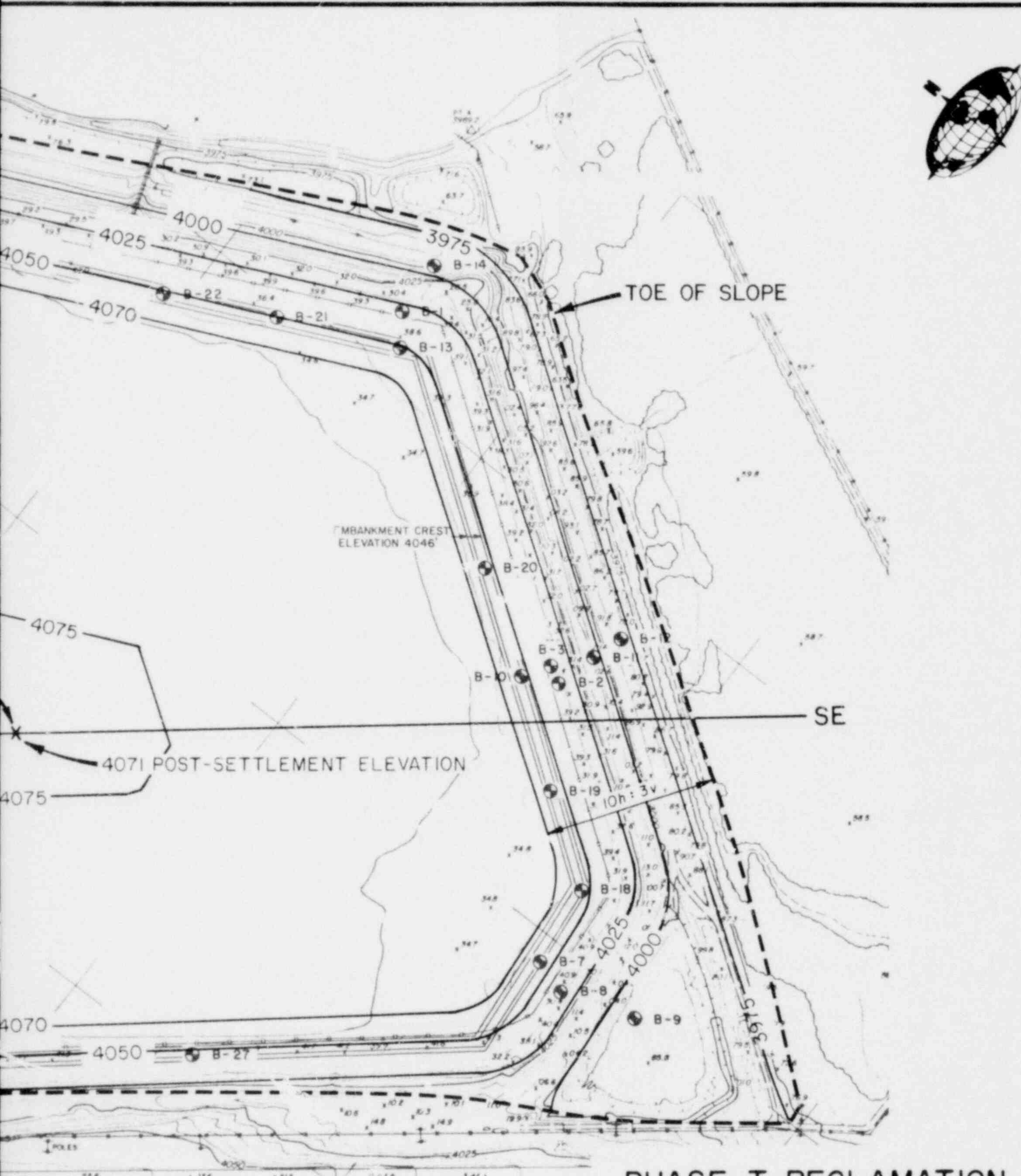
Plate B-2 - Phase II Reclamation

Plate B-3 - Pile Configuration and Reclamation Staging



NOTE
CREST OF 10h:3v SLOPE IS AT ELEVATION 4070 FEET. DAYLIGHT BETWEEN CUT AND FILL IS APPROXIMATELY ELEVATION 4072 FEET.
B-17
B-16
B-6
B-5
B-15
B-23
10h : 3v
B-24
B-28
4076.5
NW
B-25
B-26
4000
4050
300
0
300
SCALE IN FEET

466.12 (4-64)

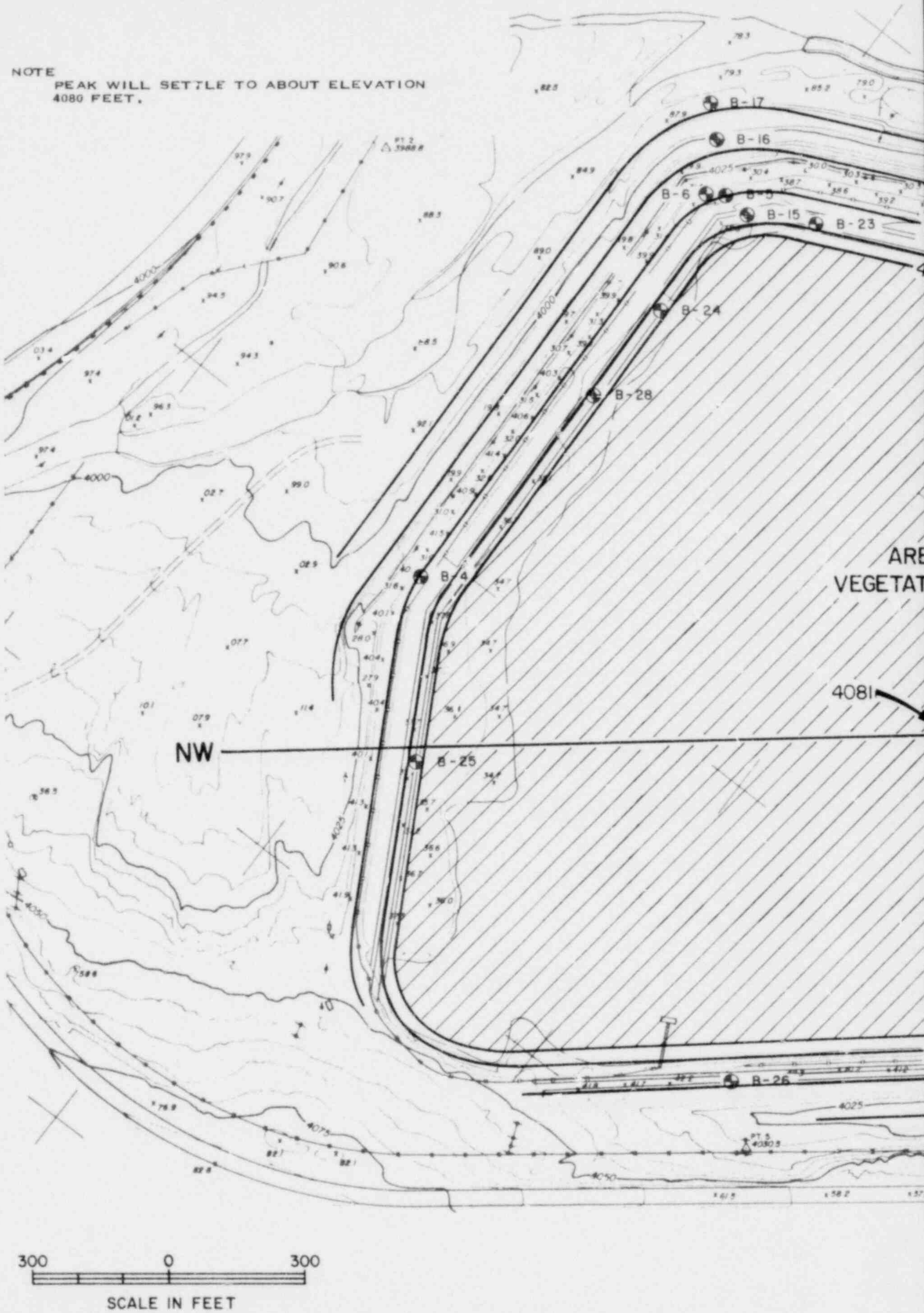


PHASE I RECLAMATION
RESHAPED CONTOURS

DAMES & MOORE

PLATE B-1

NOTE
PEAK WILL SETTLE TO ABOUT ELEVATION
4080 FEET.



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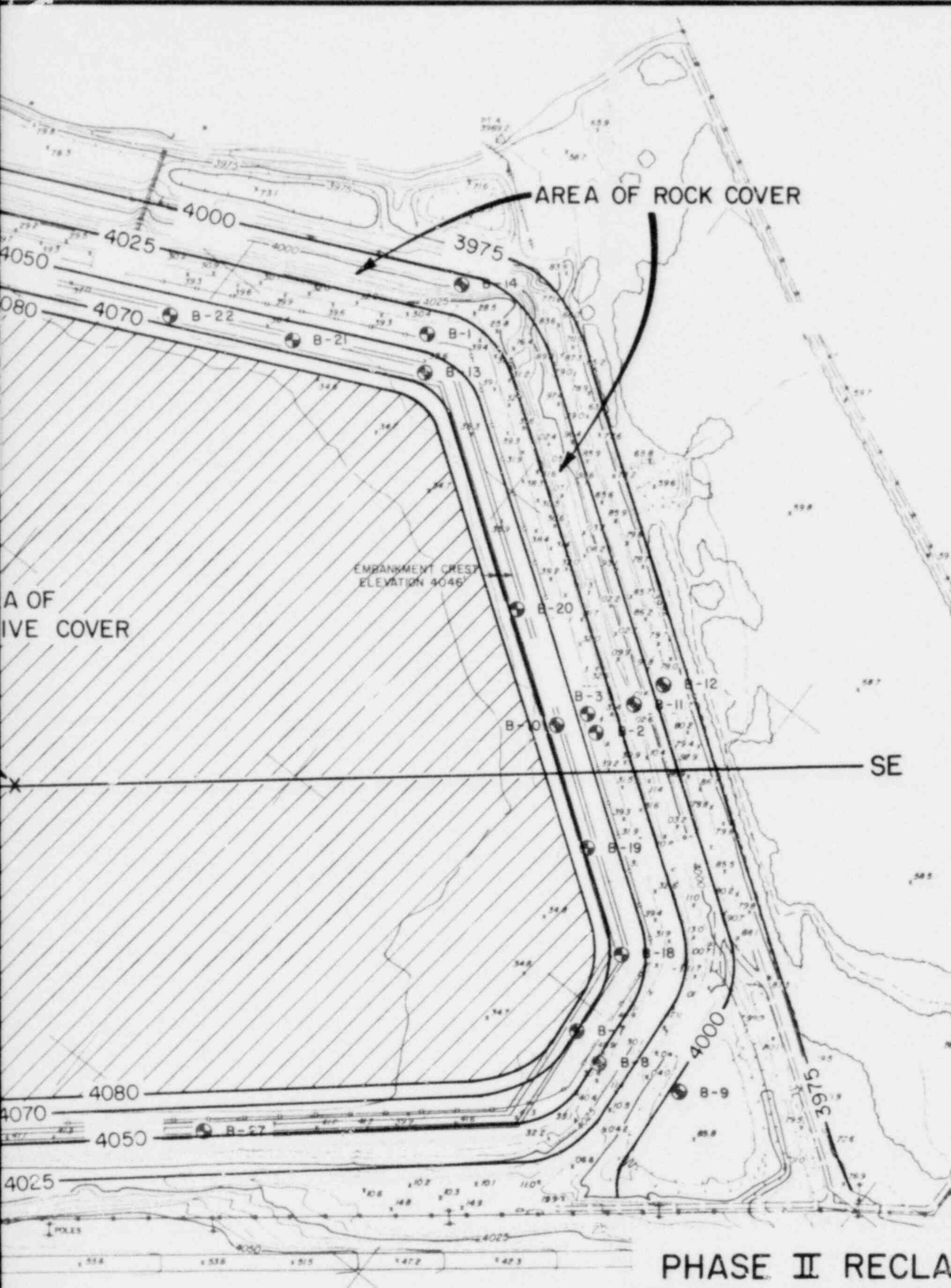
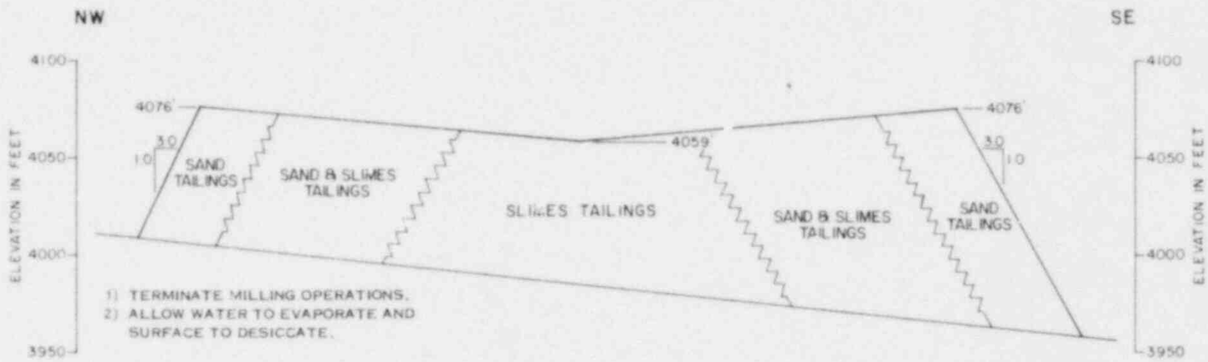
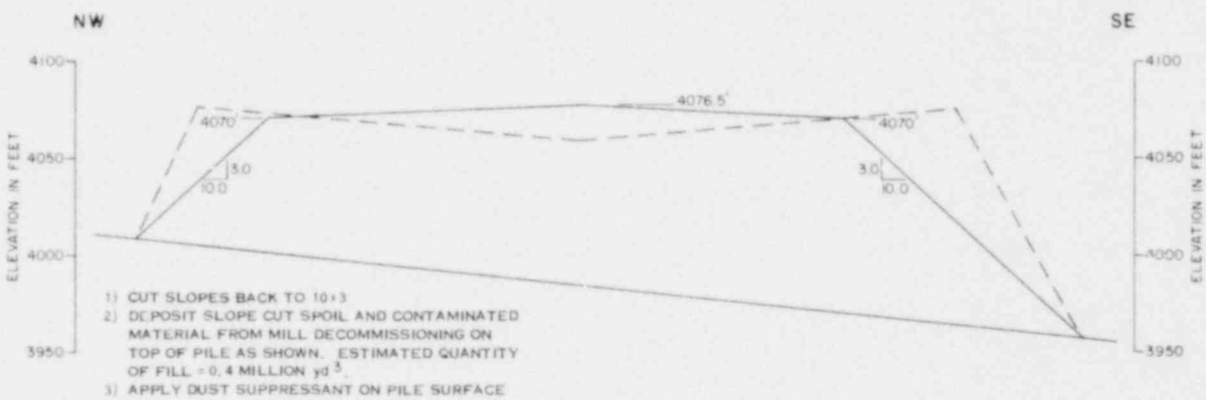


PHASE II RECLAMATION
INCLUDING 10 FEET OF SOIL COVER

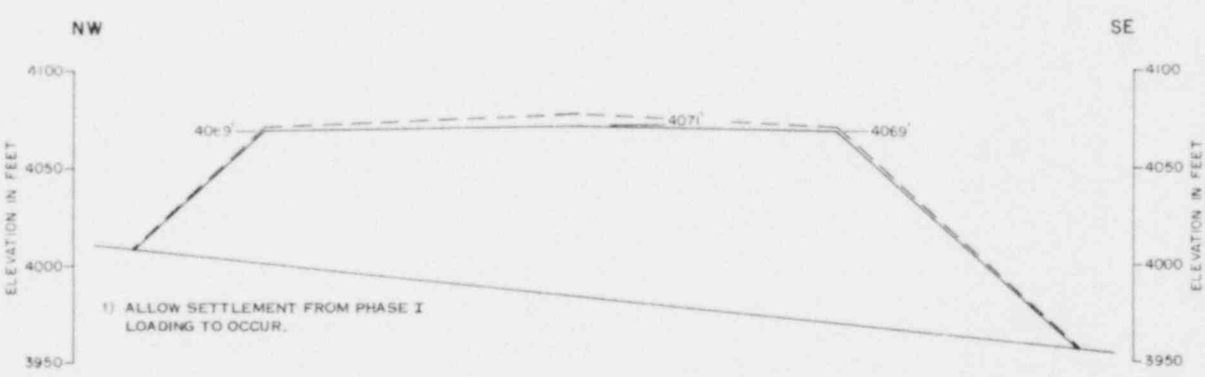
DAMES & MOORE



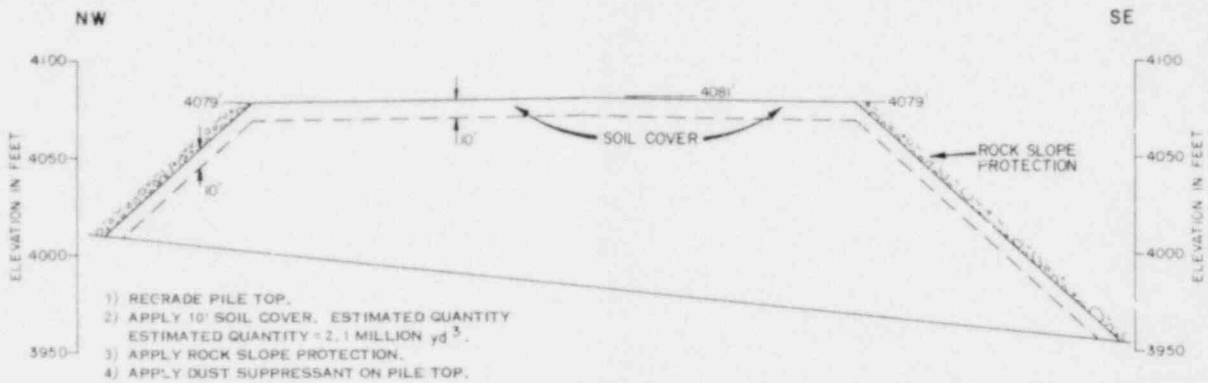
SECTION A
ABANDONMENT CONFIGURATION



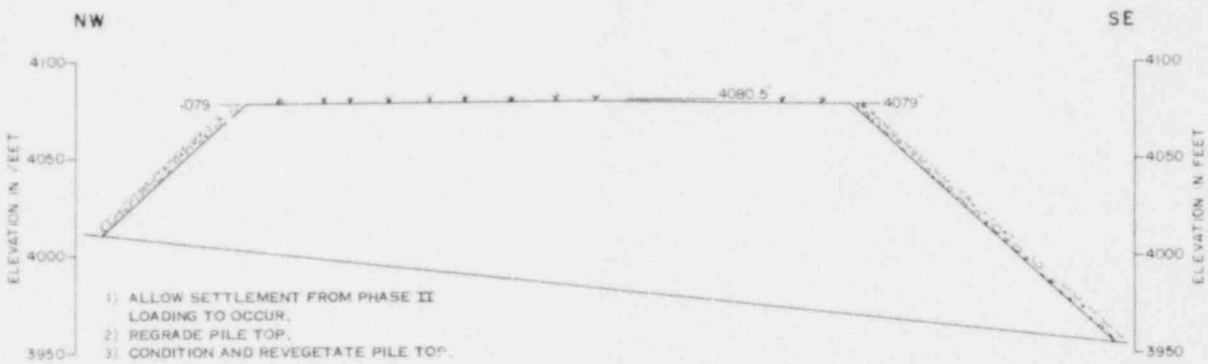
SECTION B
PHASE I RECLAMATION



SECTION C
SETTLEMENT DUE TO PHASE I LOADING



SECTION D
PHASE II RECLAMATION
10 FOOT THICK SOIL COVER
PLUS ROCK SLOPE PROTECTION



SECTION E
PHASE III RECLAMATION
VEGETATION ON TOP SURFACE

6 X VERTICAL EXAGGERATION

PILE CONFIGURATION
AND RECLAMATION STAGING

DAMES & MOORE

PLATE B-3

APPENDIX C

COST ESTIMATE

The cost estimate presented in this appendix is based on the quantities discussed in the text and Appendix B and cost values considered to be reasonable. The costs are identified by item and phase of construction. Costs associated with mill decommissioning are not included in this estimate.

PHASE I

Pore pressure devices	
6 devices at $350/device =	$2,100
6 installation at $500/device =	$3,000
Cutback slopes	
0.3 million cubic yards at $1.00/yard =	$300,000
Dust suppressant	
130 acres at $180/acre =	$23,400
Settlement devices	
12 installed at $50/device =	$600
Piezometers	
6 devices at $50/device =	$300
6 installations at $500/device =	$3,000
Monitoring settlements, water levels, and pore pressures	
15 times at $400/time =	$6,000
Phase I subtotal	$ 338,400

PHASE II

Regrade pile top	
$1,500 total cost	$1,500
Construct small dike	
0.06 million cubic yards at $1.50/yard =	$90,000

Dredged material	
2.1 million cubic yards at $0.75/yard =	$1,575,000
Rock cover	
Excavate and screen 0.26 million yards at $4/yard =	$1,040,000
Place 0.13 million cubic yards at $1.00/yard =	$130,000
Dust suppressant	
90 acres at $180/acre =	$16,200
Settlement devices	
12 installed at $50/device =	$600
Monitor settlements, water levels, and pore pressures	
15 times at $400/time =	$6,000
Phase II subtotal	$2,859,300

PHASE III

Regrade pile top	
$1,500 total cost	$1,500
Revegetate pile top	
90 acres at $350/acre =	$31,500
Phase III subtotal	$33,000
Total estimated cost	$3,230,700