PDR WM-24

Summary Evaluation of Tailings
Disposal Methods

HANSEN PROJECT

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I. INTRODUCTION

A. OBJECTIVE OF REPORT

This report has been prepared for Cyprus Mines Corporation to summarize the results of the Hansen Project alternative tailings disposal studies, and to compare the various alternative disposal methods. Additional geologic and hydrologic information has been obtained during recent investigations required to respond to various issues and questions raised by state and federal regulatory agencies. This additional information is used in the comparison of the alternatives.

This report only discusses tailings disposal alternatives for Salt Creek Valley. It has been previously agreed by the regulatory agencies that this is the best site available for tailings disposal in the Hansen Project area.

In order to keep this report brief, it does not contain detailed discussions or descriptions of the site, project geology, hydrology, or the tailings disposal alternatives, all of which are covered in previous reports. This report discusses and summarizes the salient features of the site geology and hydrology as they relate to the tailings disposal alternatives under consideration. Several of the statements and conclusions made in this report are based on data and information developed during previous studies. An understanding of the geologic and hydrologic conditions at the site, the geotechnical implications of these conditions, and the effects of these conditions on the earthworks involved in tailings disposal facilities construction and operation is imperative. This data and information and detailed discriptions of the various alternatives are provided in the following reports and documents:

- Environmental Report, Hansen Project, Fremont County, Colorado, June 1979.

- W. A. Wahler & Associates, "Tailings Impoundment Site Selection Study-Tallahassee Creek Project," June 1978.

- W. A. Wahler & Associates, "Site and Laboratory Investigation and Definitive Design Report - Hansen Project - Tailings Impoundment and Raffinate Pond," May 1979.

- Wahler Associates, "Hansen Project - Evaluation of Alternative Tailings Management Methods," December 1979.

- Wahler Associates - Response to NRC Action Items 1, 2, 3, 4, 7, 8, 9, 10, 13, 14, 15, and 17, May 1980.

B. CRITERIA FOR TAILINGS MANAGEMENT

The proposed Hansen mill will process approximately 20,000,000 tons of ore during the planned 13 year life of the project, at a presently planned production rate of 1.54 million tons of ore per year. Based on the planned tailings tonnages and anticipated tailings densities, approximately 10,800 acre-feet are required for tailings storage.

The purpose of the tailings disposal facilities is to permanently contain and dispose of all of the tailings produced by the mill. The selection of a tailings disposal system that can best meet short and long term containment objectives in an environmentally acceptable manner at a reasonable cost is of great importance to the project.

The NRC has established several performance objectives for tailings management. These objectives include:

- The tailings disposal area should be sited to be isolated from present and future populations.

- The tailings disposal system should be sited so that disruption and dispersion of the tailings are eliminated or reduced to the maximum extent reasonably achievable.

- The tailings disposal system should be sited and designed to control seepage of toxic materials into the groundwater.

- During operations, the blowing of dried tailings should be controlled.

- After reclamation, the gamma radiation from the disposal area should be reduced to essentially background.

- The radon emanation rate from the disposal area should be reduced to about twice background after reclamation.

- The need for ongoing maintenance and monitoring programs after reclamation should be eliminated.

Pursuant to these performance objectives, the NRC has established below grade disposal as the prime option. In addition to the published NRC performance objectives, the NRC staff has enumerated other objectives for tailings management. These other objectives include:

- Tailings retention embankment heights should be minimized.

- The quantity of tailings disposed of below grade should be maximized.

- Contributory drainage area to the tailings disposal facilities should be minimized.

- Disposal facilities should allow for staged reclamation, i.e., commencement of reclamation while mill operations are still in progress.

Besides the above stated objectives, tailings disposal facilities must meet two other criteria.

- The tailings disposal system must be technically feasible. The technical feasibility of a tailings disposal system is based on site specific conditions. It is not appropriate to transfer a disposal system design from site to site or project to project. A tailings disposal facility that best meets the stated performance objectives for one site, may be technically infeasible at another site.

- The cost of the tailings disposal facilities must be considered in the cost and benefits of the whole project.

II. TECHNICAL CONSIDERATIONS

A. GENERAL

As discussed previously, uranium tailings disposal is very site specific. Topography, hydrology, and site geology must be carefully considered. The evaluation and selection of the most suitable tailings disposal method must take into account these site specific conditions. These conditions in the Hansen Project area, and specifically in Salt Creek Valley, are somewhat unique, and are significantly different from conditions that are found in most of the uranium regions in this country.

B. TOPOGRAPHY

The terrain in Salt Creek Valley, like most of the project area, is very rugged. The valley is small, with the valley bottom about 1/3 of a mile wide. The gradient of the valley bottom is between about 3 and 5 percent, with the valley sides slopes as steep as 25 percent.

The topography makes the valley unsuitable for total below grade disposal because there is insufficient area in the valley.

Valley size and topography also place limitations on the depth of excavations associated with multiple cell disposal alternatives and the number of cells that "fit" within the valley.

C. GEOLOGY

Large, ancient landslides and slump block deposits exist on the sides of the Salt Creek Valley. Some of the alternatives being compared and evaluated in this report involve excavations of considerable depth. Large, deep excavations with steep excavation slopes for tailings disposal facilities will destabilize these landslide masses which border the valley. This destablization would be caused by removing lateral support at the toe(s) of the slide(s), with the strong potential for resumption of movement of these landslides. Excavations with slopes steeper than 4:1 (horizontal to vertical) would increase the potential for resumption of movement of the landslide mass(es) because more of the lateral support at the toe(s) of the slide(s) would be removed and the same amount of materials would be left in-place at the top or head of the slide(s).

The potential for reactivation of these landslides could be decreased by limiting the depth of any excavation in the valley and flattening excavation cut slopes.

D. HYDROLOGY

Groundwater under artesian pressure exists beneath the Salt Creek Valley. Disposal alternatives involving significant excavations in the valley would decrease the existing confining pressures over these water bearing zones.

The water bearing zones within the Echo Park Formation, and at the contact of the Echo Park and Precambrian basement complex, occur randomly, with no apparent physical or hydraulic connection between zones. These zones exhibit very low permeability and are under considerable artesian pressure. Because of the erratic nature and the low permeability of these water-bearing zones, a conventional dewatering program prior to deep excavation at the site, to dewater or depressurize the water bearing zones, would be impractical. Therefore, heaving of impoundment-cell bottoms due to artesian pressures would be anticipated for relatively deep excavations. Because of the low permeability of the water bearing zones, it is not anticipated that significant flooding of the excavations would occur, however, some water would enter the excavations due to the heaving and relieving of the artesian pressures. In addition, it should be noted that significant excavations within the valley would intercept some of these water bearing zones. The deeper the excavations, the greater the potential for more of these water bearing zones being intercepted.

The inability to dewater or depressurize these water bearing zones will significantly increase excavation difficulties. These difficulties will mostly be associated with the following items:

- Some heaving is expected to occur in the bottoms and/or sides of deeper excavations. This would tend to destroy the integrity of the more impervious portions of the Echo Park Formation which would otherwise act as a seal for the reservoir bottom.

- Some excavation will have to take place in saturated areas, which will slow progress.

- Some slope sloughing and ravelling would be anticipated where water bearing zones are exposed on excavation cut slopes.

- Control of seepage by channels, sumps, and pumps would be required.

- Because of the difficulties associated with wet ground excavation, it is anticipated that the unit cost for deep excavations would be 20 to 25 percent higher than those previously estimated.

The existence of the separate, discontinuous, artesian water bearing zones at the site provides excellent evidence, in a qualitative way, of the generally impervious nature of the Echo Park Formation. Thus, most of the site is provided with an excellent natural liner, since the artesian water-bearing zones are apparently of limited extent.

III. TAILINGS DISPOSAL ALTERNATIVES

A. SINGLE HEAD OF VALLEY IMPOUNDMENT

This alternative (Alternative B2 as proposed in the Environmental Report), would involve the construction of a zoned earthfill embankment at the head of the Salt Creek Valley. The embankment would be constructed in stages. The first stage of the dam would be 110 feet high (measured from the downstream toe), with the ultimate dam height 179 feet. The ultimate dam would be 160 feet high as measured vertically from the dam centerline. The dam would have a sloping upstream clay core, a continuous chimney drain, several horizontal drains connected to the chimney drain, and a downstream shell zone. Any pervious areas of the impoundment would be lined with compacted clay.

Flood control for the small (1.2 square mile) drainage area would be provided by maintaining sufficient freeboard to retain the Probable Maximum Flood Series as specified by the NRC. About 60 percent of the dam borrow would be obtained from within the impoundment, with the depth of excavation limited and excavation cut slopes at 5:1 (horizontal to vertical) in recognition of the ancient landslides and artesian groundwater conditions. The dam slopes would be provided with rock slope protection. The stage 1 construction of the dam would provide for approximately 2 years of mill production.

By borrowing from the impoundment area, approximately 20 percent of the tailings would be disposed of below the existing ground surface. Dust control during operations would be provided by selective operation of the tailings discharge system in order to keep the tailings beaches wet and with chemical sprays when necessary.

The impoundment would be reclaimed with 10 feet of earth and rock cover. After reclamation, the impoundment would be in a depositional mode where sedimentation from runoff would add to the tailings cover. An open cut spillway, through a natural saddle in the valley, would be provided to pass extreme flood flows after reclamation, to prevent flow over the downstream face of the dam.

With this alternative, tailings would be disposed of at the head of a small valley with a small drainage area. The tailings would be surrounded on 3 sides by the valley ridges and contained on the downstream side by a zoned earth fill embankment.

The stage 1 construction would require approximately 1.8 million cubic yards of stripping and excavation and about 1.6 million cubic yards of embankment construction. Ultimately, this alternative would require about 5.0 million cubic yards of stripping and excavation, approximately 4.9 million yards of embankment construction, and about 2.5 million cubic yards for reclamation.

B. <u>TAILINGS DISPOSAL IN 3 DEEP CELLS IN SALT CREEK VALLEY</u>

This alternative (Alternative 1) involves the construction of three dams and deep cells in Salt Creek Valley. These facilities would require nearly the whole valley for tailings disposal. The first cell would be located at the southern end of the valley, near the drainage divide. The other two cells would be located downstream of the first cell, with the last cell located just upstream of the Taylor Soda Spring.

The three dams, all founded on prepared soil or soft rock foundation, would be between 66 and 78 feet high. The dams would be zoned earthfill structures. The dams would be constructed from materials obtained from the cell excavations. Individual cells and dams would be constructed when the tailings storage was needed. With this alternative, cell excavation is maximized, recognizing the geometric, geotechnical, and hydrologic limitations at the site. The cell excavations would be on the order of 150 feet deep (from the top of the cut slope). The cells would be excavated with

4:1 (horizontal to vertical) cut slopes in consideration of valley side slope stability and to facilitate clay lining placement where necessary. The relatively flat excavation slopes would also remove material from the head of the slides while the toes of the slides were being excavated. However, the cell excavations would destabilize the ancient landslides.

It is anticipated that most of the cell surface will be impervious clay and claystone. However, parts of the east side of the valley will require lining. Those areas requiring lining can best be delineated during construction. Pervious areas would be lined with 3 feet of compacted clay.

Both embankment borrow and cell reclamation materials would be obtained from the cell excavations. In addition, because of the large volume of cell excavation, there will be approximately 6.2 million cubic yards of excess excavation material that will have to be disposed of. This excess material could be disposed of in Section 34 just north of the tailings disposal area. The ridges immediately adjacent to the cells should not be used for this overburden disposal because disposal in these areas would add a surcharge load to the top of the slumpblock deposits while the toe of these deposits was being removed in the cell excavation process.

During operations, flood control would be provided for the tailings disposal cells by diversion facilities sized to pass the Probable Maximum Flood (PMF). These facilities could be constructed with some of the excess excavation materials obtained from the cells. In addition, a minimum of 10 feet of freeboard would be maintained between the dam crest and maximum tailings level in each cell.

Dust control during operations can be provided by selective operation of the tailings discharge system in order to keep tailings beaches wet and with chemical sprays when necessary. The three-cell tailings disposal system in this alternative would allow for multi-staged construction and reclamation. Reclamation of filled cells could commence while tailings disposal operations were taking place in other cells. It is anticipated that with proper surface management techniques, cell reclamation could commence as early as two years after the cell had filled. Reclamation construction activities for some of the cells could coincide with the excavation of other cells. However, the placement of the reclamation cover would have to be closely controlled and may need to be relatively slow to prevent the development of excess pore pressures within the tailings and shearing failures of the tailings and cover. The tailings cover would consist of 3 feet of compacted clay, 6.5 feet of random earthfill, topped by 1/2 foot of topsoil. All exposed embankment slopes would be flattened to 6:1 (horizontal to vertical) during reclamation. To provide for flood control after reclamation and to prevent overtopping of the embankments, the dam crests would be provided with a nominal 3 foot raise and open cut spillways would be provided to pass flood flows.

In this alternative, the tailings would be disposed of in a series of deep cells. This alternative would provide for reasonable assurance of both short and long term containment of the tailings. The tailings and cover would be below the ridges bounding the cells, except for the downstream (northern) end. During operations, the tailings would be either below ground or retained by engineered zoned earthfill embankments. With this alternative, approximately 65 percent of the tailings would be disposed of below the existing ground. At the presently planned production rates and anticipated tailings densities, individual cells would provide storage for approximately 3.5 to 5.5 years of mill production.

The stage 1 construction of this alternative, utilizing the most upstream cell initially, would require 4.0 million cubic yards of excavation and 0.92 million cubic yards of embankment construction. Ultimately, this alternative would require 13.7 million cubic yards of excavation, 2.78 million cubic yards of embankment construction, and 4.1 million cubic yards for reclamation.

C. <u>TAILINGS DISPOSAL IN 3 CELLS IN SALT CREEK VALLEY</u>

This alternative (Alternative 2) is similar to Alternative 1, where 3 cells are utilized for tailings disposal. The cells, located in Salt Creek

Valley, would be similar to the other multicell alternative, but the depth of the cell excavation would be limited to about 110 feet (from the top of the cut slope). In order to provide the required tailings storage, the retention embankments would have to be approximately 10 feet higher than the other multi-cell alternative. With this alternative, approximately 50 percent of the tailings would be disposed of below the existing ground. The three dams, between 77 feet and 87 feet high, would be zoned earthfill structures founded on prepared soil or soft rock foundations. The flood control facilities, construction staging, tailings disposal operations, cell linings, dust control, and reclamation of the cells would be similar to those discussed in Alternative 1. Since there is less excavation and more embankment construction involved in this alternative than in Alternative 1, there is significantly less excess excavation material to be disposed of. This alternative is nearly a balanced cut and fill operation with approximately 1.3 million cubic yards of excess material remaining after reclamation.

In this alternative, the tailings would be disposed of in a series of three cells of moderate depth. This alternative would provide for reasonable assurance of both short and long term containment of the tailings, with fewer problems in controlling groundwater during construction. The tailings and cover would be below the ridges bounding the cells, except for the downstream (northern) end. During operations, the tailings would be either below ground or retained by engineered zoned earthfill embankments.

The stage 1 construction of this alternative, utilizing the most upstream cell initially, would require 3.0 million cubic yards of excavation and 1.28 million cubic yards of embankment construction. Ultimately, this alternative would require 10.2 million cubic yards of excavation, 3.59 million cubic yards of embankment construction, and 4.5 million cubic yards for reclamation.

D. TAILINGS DISPOSAL IN 3 CELLS WITH TAILINGS EMBANKMENTS

This disposal system would be similar to Alternative 2 with 3 cells of moderate depth, but the two most upstream zoned earthfill embankments in Alternative 2 would be replaced with cycloned tailings embankments. The same geotechnical concerns regarding cell excavations would apply to this alternative. In addition, since there is some additional excavation with this scheme, under the tailings embankments, there would be additional risk associated with the landslide potential.

Dust control, flood control, and reclamation would be similar to the other multicell alternatives. This alternative would provide for disposal of approximately 56 percent of the tailings below the existing ground level. This alternative has a lower ultimate cost than either of the other two multicell alternatives but has a higher initial cost. The higher initial cost is due to the greater quantity of stage 1 excavation and the larger earthfill embankment.

E. TAILINGS DISPOSAL IN A SINGLE IMPOUNDMENT WITH MAXIMUM BELOW GRADE

This alternative would be similar to the Single Head of Valley Impoundment (Alternative B2), except that the amount of reservoir excavation would be maximized. Using 5:1 (horizontal to vertical) excavation slopes, the maximum depth of excavation would be about to Elevation 8060. Based on preliminary layouts and evaluations, maximizing the excavation would result in lowering the ultimate dam height about 20 feet (from 160 feet to about 140 feet) and would result in about 35 to 40 percent of the tailings below the existing ground.

Since a large portion of the excavation would take place during stage 1 construction, it is anticipated that the stage 1 cost for this alternative would be greater than the B2 alternative.

F. TAILINGS DISPOSAL IN A SINGLE IMPOUNDMENT WITH FLAT RECLAIMED SLOPE

This alternative would be similar to Alternative B2, except that during reclamation the 2.5:1 downstream slope of the embankment would be flattened to increase the long term erosion resistance. Because of the steep terrain of the valley, extremely flat slopes such as 6:1 or 10:1 require extremely large reclamation quantities. For example, flattening the slopes to 6:1 (horizontal to vertical) would require nearly 5 million cubic yards of the fill. This quantity is approximately the same as the original retention embankment volume. Flattening the downstream slope to 3.5:1 (horizontal to vertical) with a large rockfill section of hard rock would provide excellent long-term erosion resistance. The thick hard rock section on the embankment downstream slope, composed of coarse rock and boulders, will resist gullying and watersheet erosion as well as wind erosion. The hard rock could be obtained from quarry operations in the welded tuff or andesite located near the disposal area, or from andesite overburden from the mine. This rockfill section would add approximately 1 million cubic yards to the Alternative B2 reclamation quantity.

G. OTHER TAILINGS DISPOSAL ALTERNATIVES

During these evaluations and studies, several other alternatives were considered and rejected for tailings disposal in Salt Creek Valley. These alternatives included total below grade and other multi-cell, small dam alternatives.

As discussed previously, the site is unsuitable for total below grade disposal. In addition, because of the geometric constraints of the valley, disposal in more than 3 cells would not lower the required embankment heights or increase the percentage of tailings disposed of below the existing ground. The valley would be filled with embankments rather than tailings.

Tailings disposal in a series of cells with steep excavation slopes is not a suitable alternative for the Hansen Project. Deep cell excavation with steep cut slopes within the valley would have a high probability of reactivation of the ancient landslides on either side of the valley. In addition, cut slopes much steeper than 4:1 (horizontal to vertical) would be difficult to line with 3 feet of compacted clay.

IV. COMPARISON OF TAILINGS DISPOSAL METHODS

A. QUALITATIVE COMPARISON OF ALTERNATIVES

To aid in the evaluation of tailings disposal alternatives, the alternatives wi' be compared on a qualitative basis. In addition, the alternatives ..i.l be briefly compared on a quantitative basis, as relating to relative amounts of required construction earthworks and estimated construction costs.

Two of the alternatives, the 3 cell altern..tive with tailings embankments and the single impoundment with maximum excavation, have been considered and rejected because they may not fully meet the NRC performance objectives and/or they offer no significant advantages over the other alternatives.

The 3 cell alternative with tailings embankments was rejec:ed because it would be impractical to meet the seismic stability requirements specified in NRC Reg. Guide 3.11. Historically, tailings embankments have had greater problems with operational stability than properly designed and constructed earthfill embankments. I addition, this scheme would have slime ponds located on both sides of the tailings embankments, thus the zone of saturation within the embankments would be higher than for conventional tailings dams. Therefore, there would be a greater risk factor for instability during operations with this alternative. Furthermore, the cycloned tailings embankments could be subject to liquefaction due to earthquake shaking. This liquefaction potential could be overcome if sufficient compactive effort were used in the construction to increase the density of the tailings embankments or if special embankment drainage features were included in the tailings embankments to maintain the zone of saturation at a very low level within the cycloned embankments. Another potential solution would be to increase the height of the downstream compacted earthfill embankment to provide additional storage for containment of solids and liquids which might be released in the event of upstream tailings dike distress. All of the measures described above to reduce risk would increase the total cost substantially.

The single impoundment with maximum excavation was rejected because the large excavation would still destabilize the ancient landslides, even with the 5:1 (horizontal to vertical) cut slopes. This alternative would also encounter more problems with the artesian groundwater than would the multicell alternatives, because of the great depth of excavation. In addition, the large amount of excavation would only lower the height of the required retention embankment by about 20 feet.

The remaining 4 alternatives, Alternatives B2, 1, 2, and B2 Modified, will be compared and evaluated on a qualitative basis to aid in the assessment of the alternative tailings disposal methods. In general, the alternatives meet the NRC performance objectives, with the main differences between the alternatives, on a qualitative basis, being the tradeoffs required between individual performance objectives and the problems associated with extensive excavations at the site.

Tailings distribution, dust control provision, and waste liquid decanting and recycle provisions would be essentially the same for all of the alternatives.

1. Alternative B2 - Tailings Disposal in a Single Head of Valley Impoundment

With this alternative the tailings would be disposed of in a single head of valley impoundment. The tailings and reclamation cover would be below the encompassing ridges on three sides. The tailings would be retained on the downstream side by a zoned earthfill embankment, constructed in stages. After reclamation, the impoundment would be in a depositional mode, where natural sedimentation would add to the tailings over. To prevent extreme flood events from overtopping the reclaimed embankment, an open cut spillway would be provided through a natural saddle on the east side of the impoundment, well away from the embankment.

During operations, positive flood control would be provided by maintaining sufficient freeboard to retain the NRC specified Probable Maximum Flood (PMF) series volume. Since the excavation within the valley with this alternative would be limited, the potential problems with valley side slope stability and groundwater are minimized. Since excavation would be limited in the disposal area, more of the natural clay and claystone would be left in place than either of the multicell alternatives. Pervious areas of the impoundment would be lined with 3 feet of compacted clay.

It is believed that this alternative, because of its location at the head of the valley, provides for excellent long term containment of the tailings. A smaller percentage, about 20 percent, of the tailings are disposed of below the existing ground than in the multicell alternatives, but the multicell alternatives require some tailings disposal at the mouth or downstream end of the valley where the natural contributory drainage area is greater.

This alternative would require less excavation and reclamation, but greater embankment construction than the multicell alternatives. The estimated cost for stage 1 construction and ultimate cost of this alternate are less than for the multicell alternatives.

2. Alternatives 1 and 2 - Tailings Disposal in a Series of 3 Cells

These alternatives would dispose of the tailings in a series of 3 cells in the Salt Creek Valley. The tailings and reclamation cover for these two alternatives would be below the surrounding ridges on three sides of the cells and be retained by zoned earthfill embankments on the downstream side. The exposed embankment slopes would be flattened to 6:1 (horizontal to vertical) during reclamation. Flood control during operation would be provided by diversion facilities sized to pass the PMF. The multicell disposal concept would allow reclamation activities to commence before mill operations cease. Pervious areas of the cells would be lined with 3 feet of compacted clay to control seepage.

Because of the extensive excavations associated with these alternatives, the cell excavations for either alternative would destabilize the ancient landslides on the valley sides. In addition, heaving and some wet ground excavation problems, due to the relieving of artesian pressures and interception of some of the water bearing zones by the cell excavations, would be anticipated with either alternative. Because of the extensive excavations associated with these alternatives, more of the impervious natural clay and claystone would be removed from beneath the disposal area.

Alternative 1, with the deeper cell excavations and smaller retention embankments would result in the disposal of about 65 percent of the tailings below the existing ground surface. The retention embankments would be between 66 and 78 feet high. Since the cell excavations would be deeper in this multicell alternative, it is anticipated that there would be greater problems associated with the artesian groundwater during excavation than with the other multicell alternative.

Alternative 2, with cells of moderate depth, would dispose of approximately 50 percent of the tailings below the existing ground surface. The retention embankments would be between 77 and 87 feet high.

The multicell alternatives would require less embankment construction but considerably more excavation and reclamation than the single head of valley impoundment. The estimated stage 1 and ultimate cost for both multicell alternatives would be greater than the head of valley impoundment. The estimated ultimate costs are 32 percent and 18 percent higher, for Alternatives 1 and 2 respectively, than the single head of valley impoundment.

3. Alternative B2 Modified - Tailings Disposal in a Single Head of Valley Impoundment with Flattened Downstream Slope

This alternative is the same as Alternative B2 except that, during reclamation, the downstream slope of the retention embankment would be flattened to 3.5:1 (horizontal to vertical) with coarse rock and boulders. It is believed that the location of the embankment (head of the valley) and the large rockfill section of this alternative will make the long term erosion resistance equal to or greater than either of the multicell alternatives.

This alternative would have the same earthwork quantities and costs as Alternative B2 except for greater reclamation costs. The estimated ultimate cost is approximately 11% greater than Alternative B2.

B. SUMMARY EVALUATION AND COMPARISON OF ALTERNATIVES

The four alternatives described above all meet the NRC performance objectives. There are significant qualitative and quantitative differences between the alternatives. The stage 1 and ultimate cost for the four alternatives vary considerably. The estimated stage 1 and ultimate costs are summarized in Table IV-1. It should be noted that estimated cost figures for the multicell disposal alternatives presented in Table IV-1 do not include the estimated 20 to 25 percent increased unit cost for excavation associated with wet ground excavation difficulties.

A rating of the four alternatives is presented in Table IV-2. The ratings of each alternative for eleven different considerations ranged between 5 (best or highly desirable) and 0 (unacceptable). The following considerations were used in the ratings.

- Required Embankment Heights
- Percent of Tailings Disposal Below Ground
- Groundwater Control
- Seepage Potential

TABLE IV-1

SUMMARY OF ESTIMATED COSTS FOR TAILINGS DISPOSAL ALTERNATIVES

Alternative	Stage 1 Cost	Ultimate Cost
B2	$7.31 Million	$27.07 Million
1	$9.66 Million*	$35.66 Million*
2	$8.31 Million*	$31.99 Million*
B2 Modified	$7.31 Million	$30.07 Million

* Cost do not include increase due to wet ground excavation at depth - Stage 1 and Ultimate costs may be increased on the order of 10 to 15 percent.

TABLE IV-2

RANKINGS SUMMARY OF ALTERNATIVES FOR TAILINGS DISPOSAL[1.)]

	Rating Consideration	B2	1	2	B2 Modified[2.)]
		Alternatives			
1.	Embankment Height	2	4	3	2
2.	Percent of Tailings Below Ground	1	4	3	1
3.	Ground Water Control	4	2	3	4
4.	Seepage Potential	4	2	3	4
5.	Construction Difficulties	5	2	3	5
6.	Flood Control	5	2	2	5
7.	Drainage Areas	4	2	2	4
8.	Potential for Valley Side Slope Instability	4	3	3	4
9.	Reclamation	3	5	5	3
10.	Long Term Erosion Resistance	2	5	5	5
11.	Costs	5	2	3	4
	Total	39	33	35	41

Notes:

1. Rating Scale: 5 (Best or Excellent) 0 (Unacceptable)

2. B2 Modified is the single head of valley impoundment (B2) with the reclaimed downstream slope flattened to 3.5:1 with a large hard rockfill section.

* Construction Difficulties
* Flood Control
* Drainage Areas
* Potential for Valley Side Slope Instability
* Reclamation
* Long Term Erosion Resistance
* Costs

Since the alternatives are located in the same area, several considerations for uranium tailings disposal such as location with respect to the mine or mill, availability of property, and remoteness from present and future populations are the same for all alternatives and were not included in the ratings.

Alternative B2 modified has the highest overall rating of the four alternatives. Based on a careful and objective evaluation of the alternatives, it is considered that this alternative, tailings disposal in a single head of valley impoundment with the massive rockfill downstream section, is the best method of tailings disposal for the Hansen Project. The B2 modified alternative best fulfills the NRC performance objectives, considering site specific conditions. It is recognized that this alternative has a lower percentage of below ground tailings disposal than the multicell alternatives. Perceived benefits of a greater percentage of tailings below ground are far overshadowed by the increased potential for massive valley slope instability, the increased construction problems associated with wet ground excavation, larger drainage area, location nearer to the canyon mouth, and substantially higher costs.

The modified B2 alternative is significantly more expensive than Alternative B2, because of additional earthworks involved with the addition of the large rockfill section to the embankment during reclamation. However, with this rockfill section, greater assurance of the long term erosion resistance of the tailings is obtained. This scheme provides as good or better erosion resistance than either of the multicell alternatives for two reasons:

- All of the tailings are at the head of the valley, away from the valley mouth and with a smaller contributory drainage area.

- The massive rockfill section is inherently resistant to both wind and water erosion.

For the above reasons it is recommended that Alternative B2 Modified be utilized for tailings disposal for the Hansen Project.