

TRANSPORTATION OF THE MOAB URANIUM MILL TAILINGS TO WHITE MESA MILL BY SLURRY PIPELINE

By:

Ron F. Hochstein
President and Chief Executive Officer
International Uranium (USA) Corporation

And

Rod Warner
Manager, Business Projects
Washington Group International

And

Terry V. Wetz, P.E.
Director of Project Development
International Uranium (USA) Corporation

ABSTRACT

The Moab uranium mill tailings pile, located at the former Atlas Minerals Corporation site approximately three miles north of Moab, Utah, is now under the control of the US Department of Energy ("DOE"). The location of the tailings pile adjacent to the Colorado River, and the ongoing contamination of groundwater and seepage of pollutants into the river, have lead to the investigation, as part of the final site remediation program, of alternatives to relocate the tailings to a qualified permanent disposal site.

This paper will describe the approach being taken by the team formed between International Uranium (USA) Corporation ("IUC") and Washington Group International ("WGINT") to develop an innovative technical proposal to relocate the Moab tailings to IUC's White Mesa Mill south of Blanding, Utah. The proposed approach for relocating the tailings involves using a slurry pipeline to transport the tailings to the White Mesa Mill. The White Mesa Mill is a fully licensed, active uranium mill site that is uniquely suited for permanent disposal of the Moab tailings. The tailings slurry would be dewatered at the White Mesa Mill, the slurry water would be recycled to the Moab site for reuse in slurry makeup, and the "dry" tailings would be permanently disposed of in an approved below grade cell at the mill site.

The Moab tailings pile contains an estimated 13 million tons of mill tailings and contaminated soils and cover material. One site closure alternative is to leave the tailings on-site and cap the tailings in-place. A number of federal and state agencies, local business interests, downstream water users, and environmental groups are objecting to this closure alternative and raising concerns about the risks of continued long-term contamination of site groundwater and the Colorado River.

Slurry pipeline transport of the tailings offers important advantages for final site closure - water can be supplied from the White Mesa Mill so that local resources are not further strained, contaminated ground water from the Moab site can be pumped and used for slurry makeup thus accelerating site groundwater cleanup, pipeline transport will be the least disruptive to local communities, relocation can

be completed faster than other alternatives, and the slurry pipeline alternative can be cost competitive with other tailings relocation alternatives. Relocating the tailings to the White Mesa Mill site, using proven pipeline slurry technology, will eliminate one permanent uranium mill tailings disposal site, while ensuring that the tailings are safely contained in a location (within permanent closure funds already in place) that ensures the highest degree of protection to public health, safety, and the environment.

This paper will discuss the material processing equipment needed to prepare the slurry for transport; the design, construction, and operation of dual pipelines for slurry transport and water recycle; the characteristics of the White Mesa Mill site which make it qualified for permanent tailings disposal; the steps involved in ongoing construction of tailings storage cells and placement of tailings; and the environmental and safety considerations of the slurry pipeline alternative.

INTRODUCTION

The Atlas Minerals Corporation uranium ore processing mill was located on the west bank of the Colorado River, about 3 miles northwest of Moab, Utah, (see Figure 1). Processing of over 10 million tons of ore at the Atlas mill generated the pile of tailings, which is now the object of final closure and remediation investigations by the U.S. Department of Energy ("DOE"). The pile covers approximately 130 acres, rises 90 feet above the river terrace and is approximately 750 feet from the river (see Figure 2). Based on a geotechnical study by Steffen, Robertson & Kirsten, Inc. (1999), the tailings materials are either fine-grained silty sands or clayey silts. The total volume of mill tailings is reported to be approximately 10.5 million tons of actual processed tailings, but the total volume of tailings, mill debris, embankment material, cover material and contaminated site soils which have been placed over the tailings is estimated to be in excess of 13 million tons.

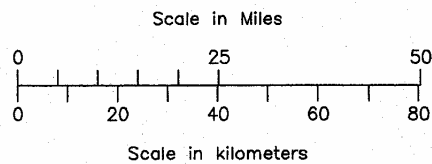
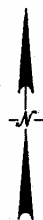
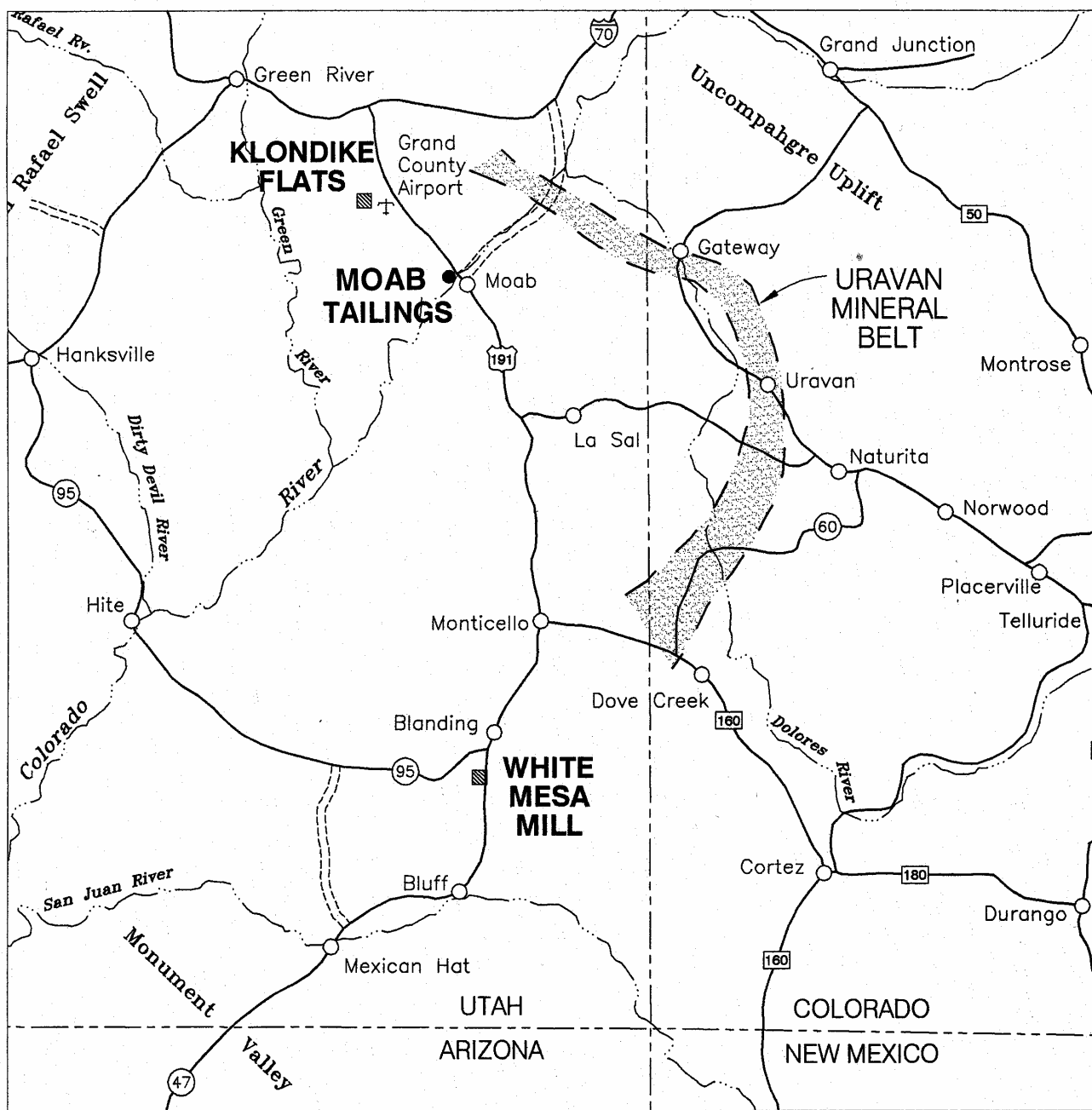
The transfer of site responsibility to DOE took place on October 31, 2001. At the present, the DOE is evaluating several closure options for the Moab site including: leave the tailings on-site and capping the pile in-place; or, relocation of the tailings to a new site by a combination of conveyor/rail/truck transport to a disposal site. The undeveloped sites that are being evaluated by the DOE include: Klondike Flats, which is about 18 miles north of the current Moab tailings location; a site at Crescent Junction, which is about 30 miles north of the site, and a site north of Green River, Utah, about 120 highway miles northwest of the Moab site. For these tailings relocation alternatives, the tailings would be moved by elevated conveyor from the pile up to a new siding on the existing rail line on the side of Poison Spider Mesa. The tailings would be loaded into railroad gondola or container cars and hauled to a transfer facility located at the terminus of a new rail spur. The tailings would then be transferred to trucks and transported to the final disposal facility.

International Uranium (USA) Corporation ("IUC") and Washington Group International ("WGINT") have formed a team to develop an innovative technical proposal to relocate the Moab tailings to IUC's White Mesa Mill south of Blanding, Utah (see Figure 1).

IUC is the licensee and operator of the White Mesa uranium mill, located six miles south of Blanding, Utah. IUC's White Mesa mill has over 20 years of operating uranium recovery operating history, as well as experience in construction and maintenance of mill tailings facilities and planning for long-term mill tailings disposal. The White Mesa facility is located at a site that has ideal geologic and hydrologic conditions for permanent disposal and isolation of uranium mill tailings.

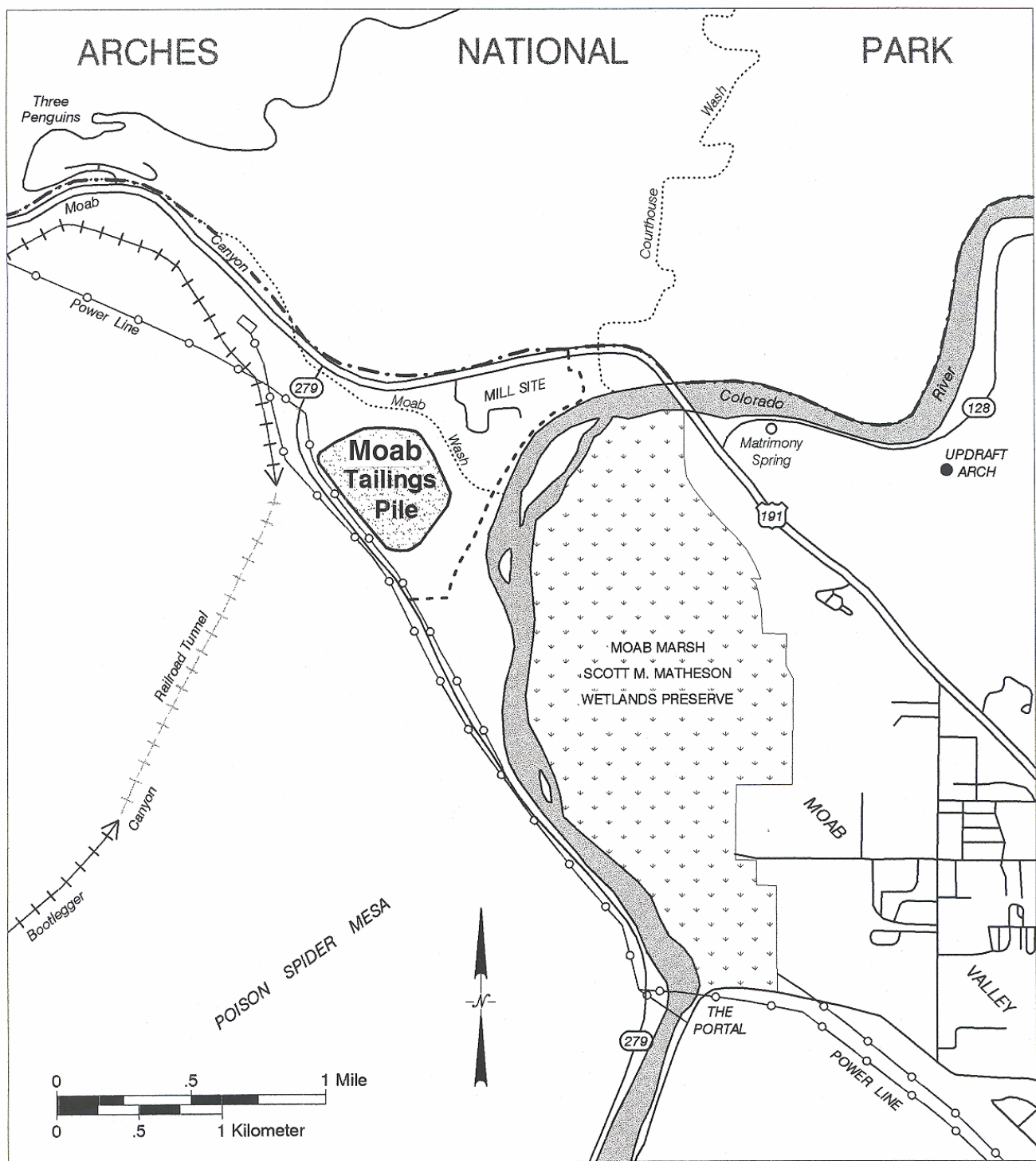
WGINT was formed by the consolidation of Morrison Knudsen Corporation, Westinghouse Government Services Group, and Raytheon Engineers & Constructors. WGINT (through Morrison Knudsen) brings extensive experience in uranium mill tailings remediation programs through its role as construction manager from 1983 through 1999 for the DOE UMTRA Title 1 projects. This involved a contract of over \$780 million, which included stabilization and control of tailings at 22 sites and 800 vicinity properties totaling 52 million tons of contaminated material.

The IUC/WGINT proposal involves using a slurry pipeline to transport the tailings to the White Mesa Mill. The tailings slurry would be dewatered at the White Mesa Mill, the slurry water would be recycled to the Moab site, and the “dry” tailings would be permanently disposed of in an approved below grade cell at the mill site. Utilization of proven pipeline technology, which has a long history of safe operations, will be the least disruptive to the local communities, environmentally superior to other final closure alternatives and cost competitive with other transportation methods.



Regional Location Map

Figure 1



The Atlas Corporation Site and Uranium Mill Tailings Pile at Moab, Utah

Figure 2

HISTORY OF SLURRY PIPELINE OPERATIONS

Slurry pipelines are in common use throughout the minerals industry and other industries requiring transport of large volumes of bulk materials. Most pipelines are constructed in anticipation of several decades of use and the ultimate transport of hundreds of millions of tons of material.

Slurry pipelines are becoming an increasingly common means of moving large volumes of materials. Slurry pipelines offer advantages by not competing with other surface transportation corridors, and therefore do not interfere with ongoing commerce on existing highways and rail lines. Pipelines require minimal surface disturbance for construction and thus can be located to accommodate existing land uses. Slurry pipelines are also a “green” transportation method as large volumes of fuels are not needed to power transport equipment, thus air quality impacts are minimized by using slurry pipelines.

Transport of solids via slurry pipelines has over a 50-year commercial operating history. Commodities commonly being transported by slurry pipelines include coal, iron ore (very hard and abrasive), metal ore concentrates, limestone, phosphates, and ore processing tailings. The specific physical and chemical properties of the media to be transported are evaluated on a case basis to ensure that pipelines are properly constructed and operated for the specific commodity being transported. The density, size distribution, abrasiveness, and chemical reactivity or corrosiveness of the slurry are all important design criteria that go into the final selection of a slurry transport system.

WHITE MESA MILL SLURRY PIPELINE SYSTEM

Several options for transport of the tailings to the White Mesa Mill were evaluated by IUC and WGINT. The most efficient alternative for relocation of the tailings to the White Mesa Mill was determined to be by slurry pipeline. The slurry pipeline system will employ a slurry preparation and blending facility at the Moab site. Water for slurry preparation will be provided from the White Mesa Mill’s existing water sources. Drying of tailings at the Moab site, such as might be required to move wet tailings by the conveyors/rail/truck transportation method, with resultant radon emanation and dust problems, will not be required.

Transport of the slurry from the Moab site to the White Mesa Mill will require two pump stations. The tailings slurry will be dewatered at the White Mesa Mill, and the water will be recycled back to the Moab site in a pipeline located alongside the slurry pipeline. The dewatered tailings will be disposed of in a “dry” cell, and a single “wet” cell will be provided for solution storage and to receive slurry if the dewatering plant is not operating.

System Description

Preparation Plant

Material excavation equipment and a slurry preparation and blending facility will be required at the Moab site to prepare slurried tailings for pipeline transport. The preparation plant is designed to re-pulp and re-grind the tailings to achieve the desired particle size distribution. The plant flowsheet includes a grizzly to separate debris from the mill tailings. The process of sizing material for slurry transport will minimize the amount of oversize material that will not be suitable for slurry transport. The oversize material, which was accumulated during operation of the mill and from the later demolition of the mill facilities, will be hauled by truck to White Mesa for disposal. The grizzly screen will be followed by a vibrating screen in closed circuit with a ball mill to grind the oversize material. The material passing the screen, minus 20 mesh, will flow to a high-capacity thickener which will produce a slurry at about 55% solids concentration.

Mainline Slurry System

The pipeline system will be designed to transport 400 tons per hour at a 55% solids concentration (dry basis). The material will be transported at a velocity of about 6 feet per second. The mainline slurry system will consist of:

- A primary pump station at the Moab tailings site designed for a flow rate of 2,070 gallons per minute (“gpm”) at a discharge pressure of 2,800 pounds per square inch (“psi”). The three mainline pumps (two operating, one standby) will be positive displacement piston diaphragm pumps with 2,100 horsepower variable speed motors. Feed to the mainline pumps will be from a storage tank that will provide about 8 hours of surge capacity between the preparation plant and the slurry mainline pumps.
- A booster pump station will be located approximately 31.5 miles from the Moab tailings site. It will be designed for a flow rate of 2,070 gpm and a discharge pressure of 2,800 psi. At the booster pump station there will also be three pumps (two operating, one stand-by) with 2,100 horsepower variable speed motors. No storage tanks are provided in the booster station.
- The main slurry pipeline will be a 12.75” outside diameter unlined steel pipe. The wall thicknesses will range from 0.312” to 0.625”. These wall thicknesses allow for the designed head pressures and are net of corrosion or erosion allowances. Based on previous experience, a combined corrosion/erosion rate of 60 mils per year was assumed; therefore, given the duration of the project and low corrosion/erosion rate, a protective liner will not be required.

Dewatering Plant

The slurry pipeline option involves disposal of dewatered tailings at the White Mesa Mill in a below-grade, lined cell extending south from the current tailings disposal cells. Slurry dewatering will be accomplished with four operating disc filters, which will produce a dried solid for disposal at approximately 15 to 20 percent moisture. The filtrate will be diverted to a lined storage pond for clarification, and the clarified water will be pumped back to the Moab

tailings site through the reclaim water line (see the following section). The pond will also function as an emergency slurry storage pond in the event that the dewatering system is not operable; therefore, pipeline operations can continue during periods when the dewatering plant is out of service.

Reclaim Water System

The reclaim (recycle) water system will be designed to return the required amount, approximately 1,500 gpm, of process water for re-pulping tailings at the preparation plant located at the Moab site. The reclaim water system will consist of:

- One water storage tank to provide about 8 hours of pipeline flow volume surge capacity.
- A reclaim/recycle water pipeline main pump station located at the White Mesa Mill and designed for a flow rate of 1,500 gpm and a discharge pressure of 940 psi. Only one pump station will be required to pump the reclaim water back to the Moab tailings site. The mainline pump (one operating) will be a multistage horizontal centrifugal pump with a 1,200 horsepower motor.
- The reclaim water pipeline will be 44 miles of 12.75" outside diameter carbon steel pipe and 44 miles of 10.75" outside diameter carbon steel pipe with wall thickness ranging from 0.25" to 0.312".

Instrumentation and Control

Pipeline systems operate on a continuous basis and are not subject to weather, surface use conflicts, or other delays that can affect other transport alternatives. In addition, because few operating components are involved (compared to fleets of trucks and railroad equipment), pipeline systems lend themselves extremely well to automated operation, monitoring, and control.

The tailings slurry pipeline system will include a fully integrated, continuously operating control and management system. This will include a System Communication And Data Acquisition (SCADA) network to continuously monitor all pumping and pipeline functions. System communications will be maintained through a fiber optic cable located along the pipeline route. A central control room at the main pump station at the Moab site will be continuously staffed. The pipeline control system will have the capability to evaluate system operating data and determine if any abnormal flow conditions exist. In addition, remote monitoring sites will be located along the pipeline route to measure pipeline operating parameters. Any upsets or abnormal operating values will trigger immediate system shut down until the cause of the alert can be determined and resolved. Cathodic protection will be utilized to minimize pipeline corrosion.

Reclamation

Final reclamation of the tailings disposal cells at the White Mesa Mill will be completed concurrently with the disposal operations. Following completion of tailings relocation to the White Mesa Mill, the Moab site facilities and slurry preparation and pumping equipment can be removed. Final site cleanup and closure of the Moab site will take place after tailings removal.

The pipelines can also be removed, although opportunities will be investigated for possible subsequent uses of the pipelines.

Since the slurry pipeline will operate on a continuous basis, the total time required for tailings removal will be less than for other relocation alternatives, as the pipeline is not subject to weather delays, interference with community and business activities, or other operating suspensions that might be required for alternatives that use surface transportation.

Preliminary Pipeline Route

Based on preliminary engineering, the entire length for the proposed tailings pipeline route is approximately 88 miles, of which 60 miles follows the rights-of-way of existing gas pipelines. The following table summarizes the proposed route. The pipelines will be buried to minimize interference with land surface uses. The return water line will use the same pipeline route and will be buried in the same trench from the White Mesa Mill to the Moab tailings pile.

Table I. Moab Tailings and Reclaim Water Pipeline route Characteristics

Moab Tailings and Reclaim Water Pipeline Route Characteristics		
Total Route Length	88	Miles
Rocky (Weathered Sandstone)	20	Miles
Soil (Sandy Loam and Sagebrush)	68	Miles
Major River Crossings	Length, ft	Crossing Type
Colorado River ¹	1,600	Directional Drill
West Coyote Creek	100	Buried
Spring Creek	200	Buried
Verdure Creek	200	Buried
Dodge Canyon	200	Buried
Long Canyon	200	Buried
Devil Canyon	300	Buried
Highway Crossings	Length, ft	Crossing Type
Highway #279	150	Directional Drill
Highway #191 - near Lopez Arch	150	Directional Drill
Highway #191 – Recapture Dam	300	Burial
Highway #191 – Blanding	150	Directional Drill

PRELIMINARY PIPELINE CAPITAL & OPERATING COST ESTIMATES

Based on a preliminary engineering study done by Pipeline Systems Incorporated, the capital cost of the slurry preparation plant, the dewatering facilities, and the pipeline system is estimated at approximately \$97 million. The break down of the capital is shown in the following table.

¹ Total length has to be greater to provide for curvature and depth.

Table II. Preliminary Pipeline Capital & Operating Cost Estimates

Area	\$ (Millions)
Preparation Plant	\$3.0
Pump Stations	\$10.2
Pipelines	\$48.2
Dewatering Plant	\$8.1
Control Systems	\$5.2
Indirects & Contingency	\$22.3
Total Estimated Capital Costs	\$97.0

The above costs exclude right-of-way and land use acquisition costs and owner's costs.

The slurry pipeline operating cost estimate, which includes labor, power and maintenance parts and supplies, were also estimated by Pipeline Systems Incorporated. On an annual basis the estimated operating costs are shown in the following table:

Table III. Slurry Pipeline Operating Cost Estimate

Area	\$ ('000's)
Labor	\$1,046
Power	\$1,784
Maintenance Parts and Supplies	\$650
Contingency	\$348
Total Estimated Annual Operating Costs	\$3,827

Based on transporting 400 tons of solids per hour, the unit operating cost is estimated at \$1.20 per ton.

The estimated pipeline total unit cost, including full capital depreciation and the costs of operations for slurry preparation, transportation, and dewatering, is estimated to be approximately \$9.40 per dry ton. This cost estimate excludes material excavation at the Moab site, final disposal of the tailings, and final remediation of the Moab site groundwater.

When compared to other surface transportation alternatives, such as highway trucks or railroad, the slurry pipeline will have an overall cost advantage for tailings transport. A slurry pipeline will likely have higher initial capital costs than truck or rail alternatives, but the slurry system offers very favorable unit operating costs during material transport. A pipeline system is not susceptible to costly disruptions due to inclement weather, ongoing construction and maintenance of roadways and railways, and conflicts with other surface uses, such as tourism, recreation, and local business and community activities. Furthermore, a pipeline system will have a considerable unit cost advantage if the final volume of material to be transported increases beyond the amount presently assumed (volume increases have always been experienced in past tailings cleanup projects).

WHITE MESA MILL

The White Mesa Mill was commissioned and licensed by the Nuclear Regulatory Commission ("NRC") in 1980. The White Mesa Mill was sited following extensive regional and local investigations to locate a site with characteristics most suitable for processing operations, tailings disposal, and permanent storage and isolation of uranium mill tailings.

The White Mesa Mill operates under a Source Material License issued by NRC. The White Mesa has dual circuits to process natural ores to recover both uranium and vanadium. The Mill also is capable of processing other feedstocks (referred to as “alternate feeds”) to recover uranium or other valuable metals.

The natural hydrogeologic setting at the White Mesa Mill site is ideal for groundwater protection and isolation of tailings from the environment. A thin, perched zone of poor quality water, occurring at a depth of 110 to 150 feet, sits atop 1,200 feet of dense shale, which separates this perched zone from the regional aquifer. The Mill follows an NRC-approved groundwater monitoring program using the perched zone as a means of ensuring early detection of seepage, if any, from the tailings cells. After over 20 years of continuous monitoring, there is no evidence that there have been any releases from the tailings cells to the perched zone, much less to the regional aquifer.

The near surface lithology at the White Mesa Mill is comprised of shale and claystone of the Burro Canyon Formation and extremely dense sandstone of the Dakota Formation. The natural clay formations provide sources of construction material for building the initial layer of liner material under the tailings cells. The site materials are also suitable for capping and closure of tailings disposal cells, and materials for the final rock cover are available nearby.

Tailings Disposal

The dewatered tailings from the dewatering plant will be moved the short distance to the disposal cell at the White Mesa Mill and immediately placed for final disposal. The tailings will be covered in a progressive manner as new cell area is excavated, and the excavated material is used for final cover on the tailings being deposited. Disposal of the Moab tailings will result in no significant change in the area currently licensed for tailings disposal at the White Mesa Mill.

The tailings disposal cells at the White Mesa Mill are located between two low ridgelines. This topographic setting isolates the cells from surface water sources that might cause erosion of the tailings cell embankments. This setting also allows the tailings cells to be blended into the topography so the final configuration is essentially at or below the surrounding land surface. This configuration is ideally suited to ensure permanent site integrity, as well as practically eliminating any long-term visual impacts.

To prepare the necessary disposal cell volume for tailings storage, low dikes will be constructed between parallel ridgelines. Additional soil and rock material will then be excavated from the interior of the cell, and this material will either be used to increase the dike height or stockpiled for final reclamation cover.

The original tailings cells on the White Mesa Mill site were lined with PVC synthetic liners, but newer cells are lined with a combination of natural clay materials, available on-site, and double layers of high density polyethylene. Final reclamation of the cells is accomplished by placement of approximately 7 feet of re-compacted native materials, which includes a one-foot thick clay layer for reduction of radon emanation from the tailings material. The cell area, as well as the final reclaimed slopes, will be covered with riprap materials available from a source near the site.

Potential Recycling Opportunities

The opportunity may also exist to recycle a portion of the Moab tailings at the White Mesa Mill to recover uranium and vanadium. Alternatives such as selectively isolating higher grade zones in the tailings pile, processing solids at the White Mesa Mill, or processing solution used in slurry transport are being investigated.

ADVANTAGE OF SLURRY PIPELINE SYSTEMS

The slurry pipeline option has several important advantages compared to moving the tailings by road or rail transport systems.

A slurry pipeline system is the least-risk alternative. Slurry pipelines are proven technology used worldwide in the mining industry. Currently there are over 45 slurry pipeline systems operating throughout the world transporting iron ore, coal, limestone, phosphate concentrate, and base metal concentrates. Some systems have been operating for over fifty years. Slurry pipelines have a well-established operating history and safety record. Finally, the risk to workers, the public, and the environment from traffic incidents is minimized. In fact, the proposed Moab slurry pipeline system is very similar to two phosphate concentrate pipelines currently operating in Idaho and Utah. Comparison of the Moab system and the two phosphate systems is shown in the following table.

Table IV. Pipeline Comparisons

	Moab	SF Phosphates, Utah	Simplot, Idaho
Initial operation	??	1986	1982
Pipeline length	88 miles	92 miles	83 miles
Pipeline diameter	12-inch	10-inch	9-inch
Pipeline material	Bare steel	Bare steel	Bare steel
Throughput	3.5 Mt/yr	2.9 Mt/yr	1.9 Mt/yr
No. of pump stations	2	2	2
Maximum pressure	2,800 psi	2,200 psi	3,500 psi

With the slurry operation, the potential exists to withdraw contaminated groundwater from the Moab site to use in slurry makeup. By withdrawing the groundwater, this would avoid costly treatment and/or disposal of contaminated groundwater at the Moab site, and the cost of the groundwater remediation program at the Moab site could be greatly reduced. The excess water will be evaporated at the White Mesa Mill in the “wet” tailings cell.

Finally, experience at nearly all of the previous tailing relocation projects has shown that the final volume of contaminated material to be disposed of increased significantly from the original estimate, at times by a factor of 1.5 to 2. With a truck and/or rail system, the incremental costs associated with increased volumes are linear, that is, there are no economies of scale. Whereas with the slurry pipeline system, the incremental cost of moving the additional contaminated materials declines as the volume increases, which can result in an overall cost benefit and reduces the potential risk of increased volumes.

In addition to the advantages of the proposed slurry pipeline system, disposing the Moab tailings at the White Mesa Mill versus construction of a new disposal site has the following benefits:

- Utilizing the White Mesa site helps fulfill the objectives of non-proliferation of permanent disposal sites.
 - No additional Title I disposal site will be required.
 - The disturbance of a new site in a remote tourist recreation area will be avoided.
- Water for slurry, dust control, and final tailings placement can be provided under the White Mesa Mill's existing water rights.
 - Using existing White Mesa Mill water supply avoids straining local Moab and Colorado River water resources.
- The opportunity exists to recover uranium, a valuable energy resource, and vanadium by recycling the tailings or slurry water at the White Mesa Mill.

The projected costs for the slurry pipeline system are competitive with or less than the alternatives of locating and constructing a new, dedicated disposal facility at Klondike Flats or other locations.

CONCLUSION

IUC and WGINT have formed a team to develop an innovative technical proposal for the relocation of the Moab tailings to IUC's White Mesa Mill south of Blanding, Utah.

Relocation of the Moab tailings basically involves three activity "centers": 1) excavation and loading of the tailings and related debris, 2) transportation of the material to a disposal facility, and 3) final disposal of the material. IUC and WGINT have conducted studies of each of these components of the project to determine the technical feasibility of the slurry pipeline option. An independent engineering firm has prepared a conceptual engineering study for the construction and operation of the slurry pipeline. While this study was preliminary, it was based on actual costs and experience for pipeline projects of similar magnitude, and demonstrates that the concept is sound and well within the current technical envelope for construction and operation of slurry pipelines.

Relocation of the Moab tailings to the White Mesa Mill via slurry pipeline has many advantages over relocation to a new, as yet unqualified, disposal site. Aside from being far less disruptive to the local communities and highway traffic, this alternative also presents the possibility for completing the relocation faster and at a competitive or lower cost than other options under consideration, while also providing the opportunity to recycle a valuable energy resource. Relocation of the Moab tailings to the White Mesa Mill makes the most technical and commercial sense, and is the environmentally superior alternative for ensuring the highest degree of protection for public health, safety, and the environment.