Appendix E

Evaluation of Disposal of Moab Tailings in Salt Caverns Within the Paradox Formation

E1.0 Introduction

In late 2003, the U.S. Department of Energy (DOE) considered an option to dispose of the Moab mill tailings in solution-mined salt caverns either at the DOE-owned Moab site or off-site at two potential locations. From the initial analysis, disposal of uranium mill tailings in solution mined salt caverns appeared to have potential advantages in terms of long-term risk reduction over the more conventional methods of capping tailings or disposal at off-site locations. Consequently, DOE took a closer look at this option. Potential advantages of salt cavern disposal might include greater long-term isolation, reduced long-term commitment of surface acreage, and dual usage of injection wells for contaminated ground water disposal. Further analysis shows that this option's advantages do not outweigh the disadvantages. Technical uncertainty, cost, schedule, and the demand on river water are among disadvantages for this option as compared to the other alternatives in this EIS.

Conceptually, solution-mining techniques would be used to create disposal caverns in the salt beds of the Paradox Formation beneath the Moab site or at other potential locations, such as the commercial potash mine site approximately 6 air miles downstream from Moab or in the area of Sevenmile Canyon; both areas are controlled by private entities. The use of off-site locations would entail DOE acquiring the necessary lands, leases, mineral rights, and associated permits for Federal ownership in perpetuity.

This option would involve withdrawal of significant quantities of Colorado River water, on the order of 1,700 gallons per minute (gpm) for 20 years (880 million gallons per year, or 73 million gallons per month). The water would be used as part of the solution mining process and would become saturated with salt, generating brine that would require disposal by deep well injection or solar evaporation or perhaps could be used in the future by commercial potash mining operations.

Other disadvantages of this option include:

- The potential need to purchase water rights and pay water depletion fees associated with compensation of existing water right holders because of impairment;
- Uncertainties of implementing a complex, first-of-a-kind disposal technique for radioactive waste;
- The long projected completion time of surface remediation under this alternative that could be 3 or 4 times as long as all other alternatives (up to a few decades to go operational with a 20-year operations time frame, culminating in a project life cycle range of multiple decades);
- Life-cycle cost range for this salt cavern alternative ranges from $892 million to $1.3 billion;
- The potential for substantial schedule and cost growth over the estimates generated in this evaluation based on the existing technical, geological, hydrological, seismological, legal, economic, and operational uncertainties;
- DOE would need to invest several years and millions of dollars to study this option to resolve uncertainties with no guarantee of success;
- Lease or purchase fees for extractive resource rights, land, and infrastructure;

- Uncertainty in obtaining multiple leases from the State of Utah and drilling multiple wells to determine the presence of oil, gas, potash, and mineral resources;
- Processing of brine and acquisition of specialty materials necessary to work in a highly corrosive environment.

Section E2.0 of this appendix further defines the conceptual approach to this option and identifies uncertainties relevant to the ability to execute this option. Section E3.0 provides a preliminary estimate of the potential cost of this option and compares that cost to the other alternatives evaluated in this EIS. Section E4.0 describes advantages and disadvantages of salt cavern disposal. Section E5.0 evaluates this option in the context of its viability and resonableness or lack thereof under NEPA.

E2.0 Conceptual Approach

Three potentially geologically suitable sites in the Moab area where the Paradox Formation is several thousand feet thick were examined. The sites include the following options: (1) the on-site option using the DOE-owned Moab millsite, (2) the off-site option near the potash mine site that is privately owned by Intrepid Mining, LLC (Intrepid) and located approximately 6 air miles southwest of the Moab millsite, and (3) the off-site option of using the Sevenmile Canyon site that is also privately owned by Intrepid and located approximately 7 air miles northwest of the Moab millsite. The two off-site locations considered might not be available to DOE. Consultation with the Army Corp of Engineers would be needed to estimate the magnitude of the site acquisition process A location and land ownership map, geologic cross sections, and brief descriptions of each of the three potential disposal sites are presented in Attachment 1, Figures 1 through 7.

The Paradox Formation consists of a sequence of salt beds several thousand feet thick in the Moab area (see geologic cross sections in Attachment 1, Figure 3). Caverns within the salt formation would be created by solution-mining techniques similar to those used extensively in the United States to store liquid and gas products. Solution mining would consist of injecting fresh water into the Paradox Formation to dissolve the salt until each of the multiple caverns is developed to the required size (about 200 feet in diameter by 2,000 feet in height). The mining solutions would become saturated with dissolved salts (brine) and would be pumped to the surface for disposal (880 million gallons per year, or 73 million gallons per month) by any one or a combination of methods, including (1) deep underground injection into the underlying Leadville Limestone; (2) multiple solar evaporation ponds up to 500 acres in size; and (3) consumption by the Intrepid potash mining operation. Tailings would be slurried several thousand feet below ground surface into the caverns for disposal and geologic isolation. Issues examined in the evaluation of this conceptual approach include constructing the caverns, disposal of the brine solution, slurrying the tailings into the salt caverns for disposal; relationship to oil, gas, and potash resources; property ownership; and permitting. The existing underground workings at the potash mine (large rooms with pillars) are not available for tailings disposal because of ongoing solution-mining operations in the old workings to prolong mine life.

E2.1 Cavern Construction

Both solution mining and conventional mining techniques have been used to create disposal caverns in nonradioactive environments. Conventional underground mining to develop disposal caverns was not considered further because those costs would be substantially higher than solution-mining methods.

Solution mining is a proven technology that has been used by DOE as part of the Strategic Petroleum Reserve (SPR) to create caverns for the storage of 700 million barrels of petroleum. Solution mining to create salt caverns is also used extensively in the United States by private industry to store liquid and gas products. Ferrell Gas Company developed a relatively small (about 267,000 cubic feet; considerably smaller cavern than those required for tailings disposal) salt cavern for natural gas storage in the Paradox Formation approximately 1.5 miles southeast of the Moab site in the 1960s.

The conceptual approach for disposal of approximately 8.9 million cubic yards of Moab tailings (equivalent to 11.9 million tons, assuming 101 pounds per cubic foot of moist tailings) presumes 6 caverns are created during a 20year period. Assuming the waste volume will bulk by 20 percent, an estimated 10.5 million cubic yards of salt would be mined to create the caverns. The caverns would need to be filled with brine or gas (a volume equivalent of 10.5 million cubic yards) to keep them open until the tailings are deposited. Caverns would be mined sequentially with each cavern being developed in 3 years then filled with mill tailings during the following 3 years. The total life of the project would depend on the permitting, initial cavern startup, and the time to fill the last cavern with the last of the mill tailings. This schedule from obtaining approvals and regulatory permits to the end of tailings disposal could be up to multiple decades with the associated technical, legal, economic, and regulatory uncertainties.

Each cavern would be approximately 200 feet in diameter and 2,000 feet in height, similar to the dimensions of the caverns used at the SPR. The top of the caverns would be encased at least 500 feet beneath the top of the salt formation and at least 2,000 feet beneath ground surface. The conceptual cavern locations would be (1) on-site, underneath the DOE Moab millsite or (2) on privately owned land (Sevenmile Canyon site or Intrepid potash mine area), where adequate thickness of the Paradox Formation is assumed to exist at reasonable depths beneath the ground surface. An illustration of the caverns for this conceptual approach is shown in the geologic cross sections provided in Attachment 1, Figures 3, 5 and 7, for each of the three potential disposal sites. Characterization of the geological, hydrological, seismological, biological, and climate change conditions would be required.

E2.2 Brine Disposal

According to the solution-mining engineers with whom DOE consulted, brine disposal is considered one of the most significant technical challenges to this concept. The estimated rate of brine production from solution mining the caverns would be approximately 1,700 gpm for a 20-year production period. This amounts to an estimated total water consumption of 15 billon gallons over the life of the project. Deep-sea disposal of the brine was the option selected for expansion of the SPR program, but that disposal option is not available for this project. Because salt is generally in oversupply, it is not easily marketable without significant disruption of markets for existing commercial producers. Other sites in the United States use underground injection wells as the option for brine disposal. The U.S. Bureau of Reclamation (USBR) is currently using deep well injection for disposal of brine at its Paradox Valley, Colorado, site adjacent to the Dolores River. USBR operating costs are high; injection pressures are also high and lead to some technical and operational difficulties. The design life of the wells is 100 years, the injection depth is 16,000 feet below ground surface and cost is $2 million per year to inject 230 gpm through one well screened at 16,000 feet below ground surface.

Because of the limited options for brine disposal, deep well injection into a permeable geologic formation is the primary method of choice to dispose of the brine solutions for this conceptual approach. The option of brine disposal solely by injection into the Leadville Limestone offers the possibility of minimizing overall costs, but this option has a higher technical uncertainty associated with (1) locating the desirable aquifer characteristics (no hydraulic connection to ground water or surface water and high porosity); (2) inherent possibilities of generating micro-seismicity; (3) potentially high surface wellhead pressures; (4) corrosivity to wells and equipment; (5) a relatively large subsurface footprint (see Attachment 1, Figures 3, 5, and 7); and (6) potential impacts to oil, gas, or potash resources that may be present in the injection horizon (Leadville Formation).

Other brine disposal methods available include (1) evaporation of the brine solution at multiple ponds constructed (up to 500 acres in size) at on-site or off-site locations; (2) transport and surface storage of the salt at the Intrepid potash site for future mining operations, and (3) consumption of the brine solution by ongoing Intrepid mining operations. Intrepid's potash site includes a salt storage area that once stored 4 to 5 million tons of salt. The company is consuming the remaining stockpiled salt at a rate of 650 gpm of brine that will be depleted in 2 to 3 years. The salt storage facility is nearly empty but could be reused for long-term storage of salt from the evaporation ponds. The opportunity exists for Intrepid to consume approximately the equivalent amount of brine (650 gpm) developed during solution mining of the disposal caverns. This consumption rate is optimally only one-third the total rate that would be required and may not be constant during the year; therefore, the alternate disposal options of deep aquifer injection and pond storage together would be necessary to potentially allow management of the brines developed during cavern growth.

Brine disposal cost based on evaporation and storage is higher than for deep aquifer disposal or for consumption by the ongoing potash mining operations. The cost for disposal via consumption by the ongoing Intrepid mining operation appears attractive but may be unreliable if Intrepid should curtail potash production or transfer ownership to an uncooperative owner. In addition, developing appropriate and durable contractual commitments with Intrepid for storage and/or consumption of salt and/or brine may be problematic because this model is untried and unproven.

The availability of three brine disposal options—(1) deep injection, (2) evaporation and storage, and (3) consumptive use, each with the potential to accept a third or more of the brine stream—provides flexibility to optimize the approach both during design and operations. Likely, DOE would have to implement all three options. Costs for brine disposal are, therefore, based on a combination of the three disposal options. For example, sole reliance on deep well injection and reduced ability of subsurface formations to accept the requisite flow rates could substantially increase the operational life of the project and increase the cost of brine disposal. The uncertainties could only be evaluated through extensive field studies.

E2.3 Tailings Slurry

The slurry system would involve screens, ball mill, thickener, and a pumping station and is assumed to require essentially the same site infrastructure for both on-site and off-site salt-cavern tailings disposal. Slurry transport is detailed in the EIS as a transportation mode for the conventional off-site disposal alternatives. The tailings would be conveyed through a slurry pipeline to the off-site locations, only nominal pipeline lengths would be required for on-site disposal. The pipeline to the Intrepid site or Sevenmile Canyon site is assumed to be above ground along the railroad bed. A pipeline would have to be constructed at least 8 miles to transport contaminated slurry to the off-site locations. If this pipeline route is not acceptable to the railroad and/or State of Utah, the other option is to bury the pipeline in State Highway 279 or Highway 191 right-of-way at a higher capital cost of installation and decommissioning. A leak-detection system would have to be installed to isolate the system if a leak or line break occurs. For the on-site salt cavern option, the same tailings preparation system is required, but only a short pipeline would be required on-site to convey tailings to the injection points.

For the purpose of estimating cost, the oversized material is assumed to be trucked and disposed of at a licensed disposal cell. Cost estimate for this scope is the same as that identified in the EIS for the off-site alternatives using the slurry pipeline method of transportation.

E2.4 Tailings Disposal

This concept proposes that the Moab site tailings would be slurry injected into the caverns. The multiple cavern volumes (approximately 8.9 million cubic yards is based on the known quantities of tailings plus a 20 percent bulk addition to make the slurry) assume the mill tailings will settle in the cavern and separate out from the water used to slurry the tailings. If tailings do not settle out and separate from the water, a larger cavern volume will be required to accommodate the tailings and slurry water. Studies would have to be completed to characterize the ability of slurry water to separate from the tailings. Brine displaced during injection of the mill tailings slurry into the caverns would be radioactively contaminated with fine uranium mill tailings. This overflow could be recycled back to the slurry plant by constructing an additional return 8-mile pipeline or could be permanently disposed of in a dedicated well permitted for deep injection of the radioactive contaminated brine. The return pipeline would be co-located with the pipeline discussed in Section E2.3. Because the brine-disposal injection well would be underutilized once cavern mining is completed, the well could be used to dispose of radioactively contaminated ground water from the Moab site. For both the on-site and off-site options, it is assumed that radioactively contaminated ground water would be mixed with slurry material during tailings placement and then later disposed of by deep well injection for the remainder of the 75 to 80 years of pumping the contaminant plume in the alluvial aquifer.

E2.5 Oil, Gas, Potash, and other Mineral Resources

Oil, gas, potash, and other minerals are known to exist in the vicinity of the two off-site locations. Studies and well drilling would have to be completed to characterize and verify mineral occurrences. Whether or not these mineral resources exist in the vicinity area, State of Utah well drilling permits and mineral lease tracts would be required. Potash ore has been produced by underground and solution mining since 1964 at the Intrepid site from a large block of land under active potash leases. Unlike the other site options, small amounts of oil and gas have been produced from the Long Canyon and Cane Creek fields near the Intrepid site. Production at these fields has been from the Cane Creek zone near the base of the Paradox Formation. This zone is approximately 1,000 feet below the bottom of solution-mined caverns in the Paradox Formation that are proposed for the Intrepid site. The Cane Creek zone is also present in the subsurface at the Sevenmile Canyon site and is in a similar position in relation to solution-mined caverns proposed at that site.

Issuance of oil and gas leases in areas that have active potash leases has been a concern in the Intrepid area where commercial mining is ongoing. To avoid conflict, the State of Utah Division of Oil, Gas, and Mining, has allowed oil and gas leases in potash-leased areas to occur with precautionary stipulations if they otherwise meet Utah's applicable requirements. Specific oil and gas well locations are considered on a case-by-case basis to determine horizontal and vertical buffer zones and appropriate fluid injection pressures that would prevent fluid communication and seismic effects to the solution-mining operation. Similar regulations and stipulations would need to be formulated to allow exploration for oil and gas at the sites where solution-mined caverns and deep injection into Leadville Limestone are proposed. Establishment of horizontal and vertical buffer zones and appropriate restrictions for oil and gas leases that may be required could alter the locations and costs of the solution-mined caverns as currently conceptualized. A large cost contingency would have to be estimated to cover this uncertainty.

In the Moab Valley, several caverns in the Paradox Formation have been created by salt dissolution for storage of natural gas. These operations are at least 1.5 miles southeast of the solution-mined caverns proposed for the Moab millsite and are assumed to be located a sufficient distance from the millsite so that storage of natural gas would not be affected. However, geologic, hydrological, biological, and seismic studies would have to be completed to support this assumption.

E2.6 Property Ownership

Approximately 1,700 gpm of fresh water (880 million gallons per year, or 73 million gallons per month) would be required for a 20-year period to perform solution-mining activities. In addition, state and privately owned lands exist in the immediate vicinity of the proposed operations. Obstacles associated with this approach include:

- Transfer existing 1,360 gpm of surface water rights (currently owned by DOE for the millsite, with a current consumption of 50 gpm annually) to a different intended use;
- Acquire the existing additional 340 gpm of water rights (solution mining would require 25 instead of 20 years if additional water rights were unavailable);
- Demonstrate maintenance of sufficient stream flow in the Colorado River to comply with Threatened and Endangered Species Act requirements; and
- Purchase private property (from Intrepid and potentially other private parties) to develop required infrastructure.

E2.7 Permitting

This conceptual approach would require State of Utah Class IV underground injection permits for the tailings, contaminated ground water, and disposal of brine solutions. Rights-of-way and various Federal and State permits would be required for access to and use of the potential disposal sites. A legal agreement would be required with the railroad and/or State of Utah to permit DOE placement of the aboveground slurry line on its property or right-of-way and with Intrepid for the off-site disposal options.

Potential additional environmental permits that would be required include, but may not be limited to,

- Air emission permit (NSR, NESHAPS);
- State wastewater disposal permit (evaporative lagoons);
- State solid waste permit (salt disposal);
- State mining permit;
- Federal storm water permit; and
- Pollution prevention permit.

Concurrence and/or approval from the U.S. Nuclear Regulatory Commission (NRC) would be required for disposal of the Moab tailings in the salt caverns and for the underground injection of contaminated brine and ground water. NRC concurrence and/or approval would also be required for disposal of the 35,000 cubic yards of contaminated solid debris that would not be disposed of in the salt cavern.

E3.0 Cost Estimates

This section provides a preliminary estimate of cost for the salt cavern disposal option and compares that cost to the other alternatives analyzed in this EIS. Several assumptions and tasks are not included in the preliminary cost estimate. Items omitted from the preliminary cost estimate because of the difficulty in estimating costs, but accounted for in contingency include, but may not be limited to:

- Site characterization requirements to demonstrate feasibility of this option;
- Lease or purchase fees for extractive resource rights, land, and infrastructure;
- Access fees;
- Processing of brine and acquisition of specialty materials necessary to work in a highly corrosive environment;
- Purchase of water rights and fees associated with compensation of existing water right holders related to impairment;
- Identification of suitable geologic and hydrologic locations for activities;
- Special design requirements;
- Permitting requirements;
- Cavern construction;

- Brine disposal; and
- Cost impacts related to adjacent extractive industry leases.

The cost estimates included are based on the same basic assumptions used in the EIS for the analyzed alternatives. The basic cost components include

- Infrastructure;
- Excavation of tailings;
- Slurry system;
- Solution mining;
- Disposal of brine; and
- Project management/oversight.

The range of costs is presented in Table E−1. Table E–2 provides the major components of the salt cavern scenario. The life-cycle cost range for the salt cavern alternative is $892 million to $1.3 billion. The low end reflects the simplest method of injecting the tailings into salt caverns below the Moab millsite and injecting the uncontaminated brine and radioactive contaminated brine into the Leadville Limestone below the salt caverns. The higher cost reflects conveying the tailings by slurry pipeline approximately 8 miles to an off-site location and a worse-case scenario of building multiple evaporation ponds (500 acres) to dispose of the salt brine on site or off site. Both on-site and off-site tailings disposal options require approximately 75 to 80 years of active ground water restoration. It is assumed that contaminated ground water will be mixed with slurry during tailings placement and then later injected into the deep disposal wells for the necessary 75 to 80 years of pumping the contaminant plume in the alluvial aquifer.

Table E−1. Preliminary Estimated Costs for Disposal of the Moab Tailings in Salt Caverns and Comparison to On-Site and Off-Site Alternatives in the EIS

	On-Site Cap-In-Place	**IUC White Mesa Mill**		**Crescent Junction**		**Klondike Flats**		**Salt Cavern**	
		Truck	**Slurry**	**Truck**	**Slurry**	**Truck**	**Slurry**	**On-Site**	**Off-Site**
Construction Costs									
	$151M	$382M	$423M	$304M	$366M	$300M	$359M	$445M[a]	$683M[a]
Long-Term Costs (Long-Term Surveillance and Maintenance, Ground Water Construction and Operations)									
	$75M[b]	$70M[b]	$70M[b]	$70M[b]	$70M[b]	$70M[b]	$70M[b]	$60M[b,c]	$60M[b,c]
Subtotal	**$226M**	**$452M**	**$493M**	**$374M**	**$436M**	**$370M**	**$429M**	**$505M**	**$743M**
Contingency	10%	10%	10%	10%	10%	10%	10%	[d]	[d]
Subtotal	**$22.6M**	**$45.2M**	**$49.3M**	**$37.4M**	**$43.6M**	**$37.0M**	**$42.9M**	**$387M**	**$578M**
Total	**$249M**	**$497M**	**$542M**	**$411M**	**$480M**	**$407M**	**$472M**	**$892M**	**$1,321M**

[a] Represents all pre-contingency costs minus surveillance and maintenance costs from Table E–2, below.

[b] Cap-in-place ground water remediation costs are slightly greater than off-site alternatives due to an estimated 5 additional years of ground water restoration efforts. Ground water remediation costs for the salt cavern disposal scenario are less than the other alternatives due to dual usage of injection wells for brine and contaminated ground water disposal.

[c] Represents surveillance and maintenance costs from Table E–2, below

[d] Salt cavern approach cost contingencies developed as per Table E–2, below.

Table E−2. Major Cost Components for Disposal of the Moab Tailings in Salt Caverns

Major Cost Components	**Costs ($ Millions)**		**Comments**
	On-site	**Off-site**	
Site characterization	$4	$15	Test cavern and brine disposal wells
Environmental H&S/NEPA	$16	$35	UIC Permit
Remedial action design	$3	$5	
Site acquisition	$1	$4	For brine/tailings disposal areas
Remedial action field management	$70	$81	Double shift for 20 years
Site preparation	$6	$20	Temp facilities, electricity
Tailings handling	$73	$170	Slurry Prep, Disposal
Cover material	N/A	N/A	
Erosion protection	N/A	N/A	
Site restoration	$12	$30	Reclaim millsite, Moab Wash, wells
All other construction costs	$237	$300	Well stimulation, salt transport
Surveillance and maintenance	$60	$60	Includes long-term ground water costs
Subtotal	**$482**	**$720**	
Contingency (80%)	$385	$576	
Vicinity property design	$1	$1	
Vicinity property construction	$10	$10	
TAC project management	$12	$12	For 6-year period - pre-remediation
Subtotal	$**23**	$**23**	
Contingency (10%)	$2	$2	
Grand Total	$**892**	$**1,321**	

Note: Vicinity property (VP) design, VP construction, and project management have lower uncertainty and, therefore, lower contingency values (10 percent). Eighty percent contingency for other costs based on guidance in DOE Order 413.3. Costs for this approach are pre-conceptual and represent rough order of magnitude.

Preliminary cost estimates for tailings disposal in salt caverns mined beneath the Moab millsite and for off-site disposal in salt caverns mined beneath the Intrepid site or beneath the Sevenmile Canyon site are significantly higher than for the alternatives presented in the EIS because of high capital costs, high operations and maintenance requirements, and high risk contingency. Risk management principles are applied in this case as a major input cost factor for predicting the probability of successfully defining and implementing the disposal concept of slurrying the Moab uranium tailings into salt caverns. Life-cycle costs of remediating and disposing of remaining waste, both uncontaminated and contaminated, in the ponds and with the slurry pipeline will increase the cost of the off-site options. The application of risk management increases the estimated costs and schedule significantly to the $892 million to $1.3 billion range.

E4.0 Advantages and Disadvantages of Salt Cavern Disposal

Relative advantages and disadvantages of tailings disposal in solution-mined salt caverns as compared to the on-site and off-site alternatives presented in the EIS are summarized below.

Advantages of salt cavern disposal include the following points:

- Provides the potential for longer term isolation and more protection than other alternatives;

- Offers the least long-term environmental impact because no surface footprint would remain at the conclusion of the disposal period;
- Provides disposal option for contaminated ground water for 50 of the 75 to 80 years of required ground water remediation.

Disadvantages of salt cavern disposal include the following points:

- Withdrawal of large quantities of Colorado River water that could impact the river and protected aquatic species;
- Technical uncertainties associated with both the uncontaminated brine and radioactively contaminated brine disposal are greater;
- Remediation time frame to complete the tailings disposal phase of the project is greater;
- Potential contractual uncertainty for use of privately owned sites and operations;
- Substantial technical, legal, operational, and life-cycle cleanup cost uncertainties.

E5.0 Conclusions

Disposal of uranium mill tailings in underground salt formations has never been attempted in the United States or elsewhere.

Because of the unproven concept, a large contingency factor must be applied to the total estimated cost. This contingency may not sufficiently account for the uncertainties and unknowns. Resolving these uncertainties sufficiently so that the decision-makers could be sure that this concept can be validated as technically feasible and implementable would require a considerable investment in time and money for additional studies, including injection well testing, subsurface characterization, salt cavern performance assessment, and permitting, all of which are required for a proof of concept. Such studies could require millions of dollars and years to complete, with no guarantee that the investment would demonstrate that this alternative is viable.

DOE has considered the salt cavern disposal option in view of guidance on evaluating alternatives in the Council on Environmental Quality’s NEPA regulations (40 CFR 1500–1508). Given the technical, legal, and economic uncertainties associated with this approach, the time and cost needed to resolve the uncertainties and the potential disadvantages, DOE has concluded that this option is not “practical or feasible” and, therefore, is not a reasonable alternative that should be analyzed in detail in this EIS.

Attachment 1

Characterization of Potential Salt Cavern Disposal Sites

Attachment 1

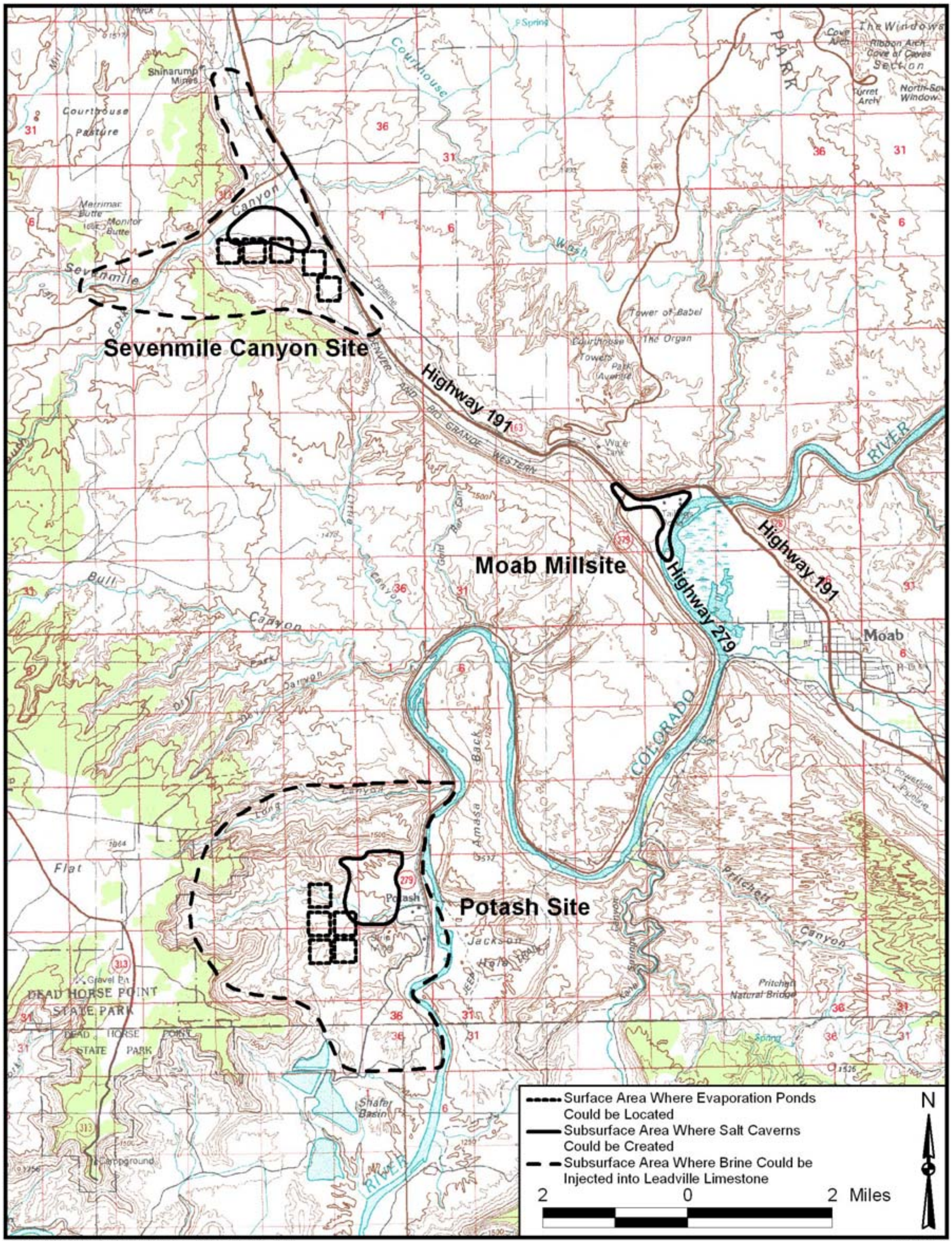

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Figure 1. Location Map of Three Geologically Potential Sites

Attachment 1

Description of the Moab Millsite

The thick Paradox Formation composing the Moab Valley salt diapir beneath the Moab millsite might provide solution-mined caverns for tailings disposal. Original beds in the Paradox Formation have been disturbed by salt flowage during creation of the salt diapir. Because of this, beds in the Paradox Formation below the site are expected to be highly contorted or indistinct, or both. This salt flowage and its creation of indistinct or contorted beds in the formation is analogous to conditions in salt domes along the U.S. Gulf of Mexico coastal area, where numerous solution-mined caverns have been developed for storage of liquid and gas products but never for radioactive waste.

The thickness of the Paradox Formation decreases from southwest to northeast across the project site (Figures 2 and 3). At the southwest end of the site (Figure 3), the formation thickness is estimated at 6,000 to 7,000 feet and at the northeast end of the site along the Colorado River; the formation thickness may reach up to 9,000 feet. The northwest-striking Moab normal fault (Figure 3) with a displacement of approximately 2,500 feet is in the northwest end of the site; a larger thickness of the Paradox Formation is on the southwest, or upthrown, side of the fault. The Moab Fault disappears to the southeast, in the area northeast and east of the tailings pile, in the main part of the thick diapir forming the Moab Valley salt-cored anticline.

Multiple solution-mined caverns at the Moab millsite would potentially be situated in an arc-shaped area starting east of the tailings pile and extending north and northwest near State Highway 279 (Figure 2). Spacing of approximately 1,000 feet between each cavern would allow enough area for six caverns. The top of each cavern would be at depths of between 2,000 and 3,000 feet. In the northwest part of the millsite, approximately 1,000 feet of bedrock overlying the Paradox Formation occurs southwest of the Moab Fault. In the southeast part of the millsite (and in all locations), approximately 500 feet of cap rock, the insoluble residue on top of the leached salt diapir, occurs at the top of the Paradox Formation. With these conditions, the base of the 2,000-foot-high caverns would be at depths of between 4,000 and 5,000 feet across the millsite.

Brine disposal at the Moab millsite could be achieved by deep well injection into the Leadville Limestone or sent to large multiple evaporation ponds. The Leadville is approximately 400 feet thick in this area and at a depth below the effects of salt movement. The estimated depths to Leadville Limestone vary across the Moab millsite from 8,000 feet at the northwest end of the site to 9,000 to 10,000 feet in the southeast part of the site. However, the surface area at the Moab site is sufficiently large to allow only one or two brine injection wells. These injection wells would be used for disposal of brine contaminated with fine-grained mill tailings or contaminated ground water. The majority of brine solutions from cavern development could be disposed of by deep well injection into the Leadville Limestone at the potash site or the Sevenmile Canyon site or by evaporation in large evaporation ponds up to 500 acres in size.

Attachment 1

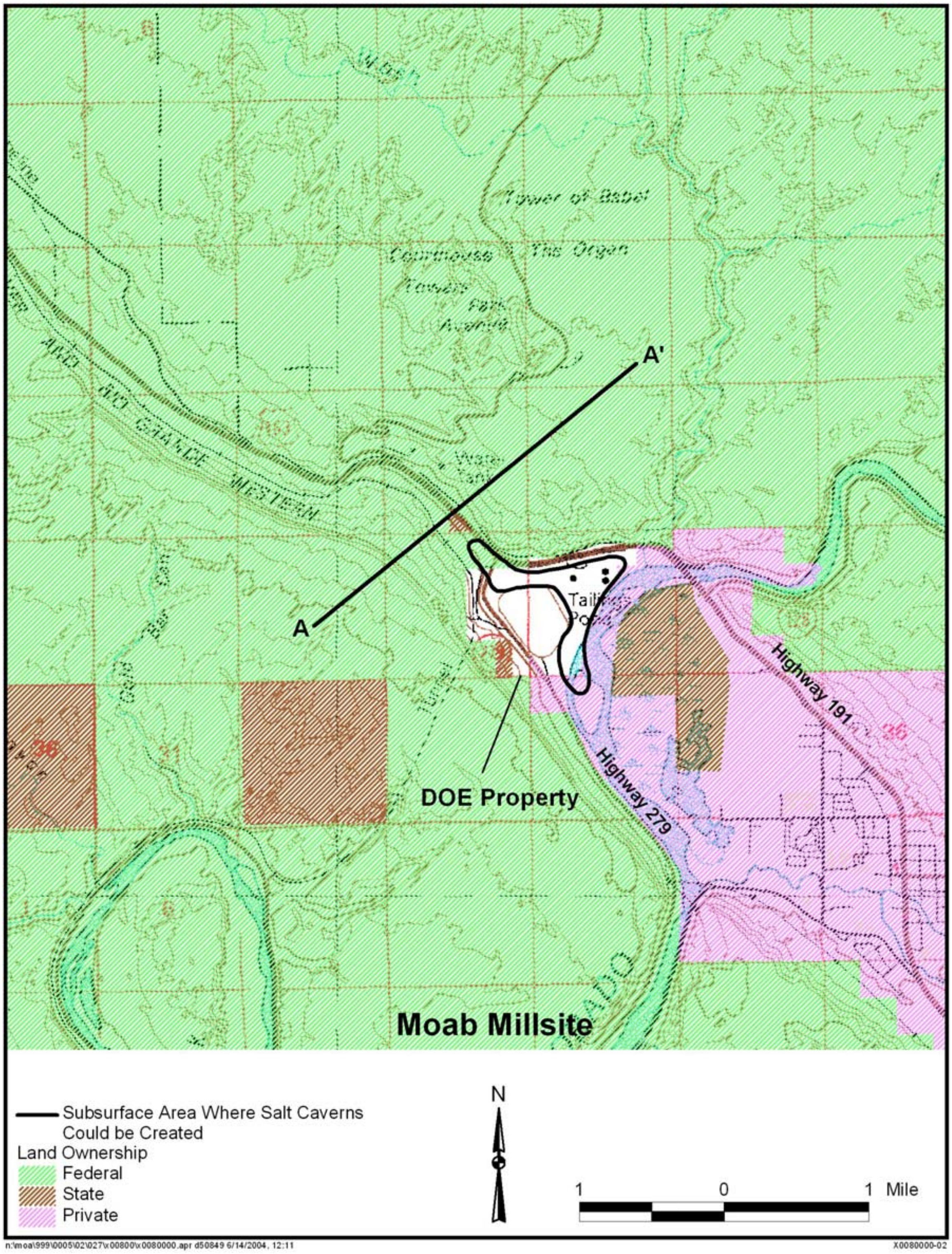

Figure 2. Property Ownership and Location of the Geologic Cross Section for the Moab Millsite

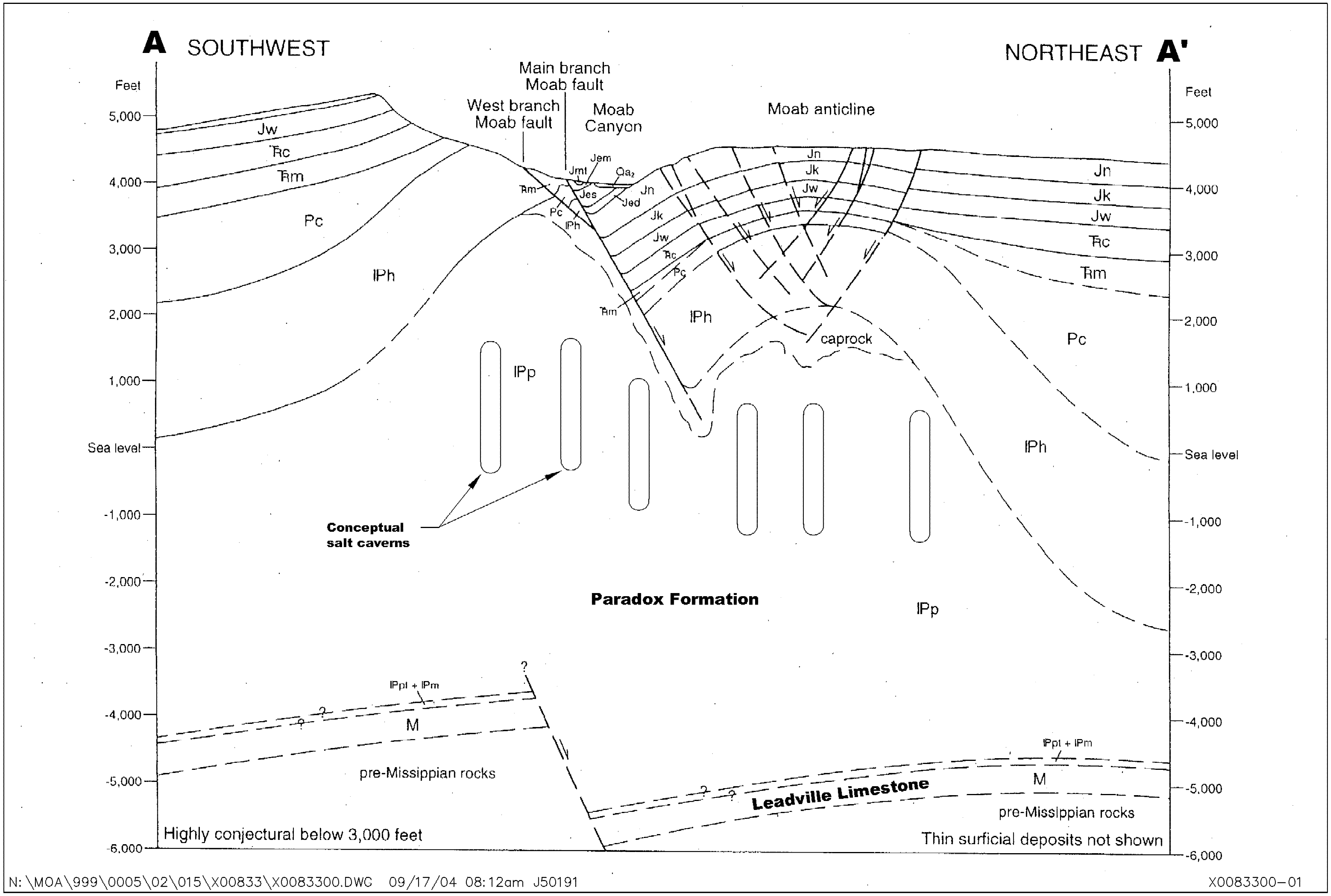

Figure 3. Geologic Cross Section for the Moab Millsite

Attachment 1

Attachment 1

Description of the Potash Site

The thick Paradox Formation underlying the Intrepid potash site could provide solution-mined caverns for tailings disposal. The proposed disposal area under which the caverns could be situated is on the northeast flank of the northwest-striking Cane Creek Anticline (Figure 4) approximately 6 air miles southwest of the Moab millsite. This area is about 0.5 to 1 mile north to northwest of the offices and loading facilities of Intrepid Mining, LLC, the present solution-mining and evaporation operator at the Intrepid potash site. Also, the area is at least 0.5 mile north of the underground potash mine workings.

Road distance from the Moab millsite to the potash site along State Highway 279, which is mostly along the bank of the Colorado River, is 15.4 miles (from the junction of U.S. Highway 191). Distance along the railroad spur to the potash site, starting from the road west of the tailings pile that goes to the railroad tunnel entrance, is much shorter at 8.4 miles. The elevation at the proposed disposal area is about 4,000 feet, the same as at the Moab millsite. Elevation difference along the railroad varies from about 4,220 feet at the north end of the tunnel (west of the Moab millsite) to approximately 3,950 feet about 0.5 mile north of the potash site.

A 3,500-foot thickness is estimated for the Paradox Formation in the proposed disposal area (Figure 5) where the formation consists of cyclically interbedded evaporite and clastic beds; 29 cycles of paired evaporite and clastic sequences have been identified. These evaporite/clastic beds are expected to be distinct and underformed or only slightly deformed.

The six solution-mined caverns, spaced approximately 1,000 feet apart, could be situated (in the subsurface) in the low, amphitheatre-like area extending from the railroad westward for about 0.75 mile (Figure 4). The top of the Paradox Formation in this area is at a depth of about 2,500 feet. The top of each cavern would be well within the Paradox at a depth of about 3,500 feet. The base of the 2,000-foot-high caverns would then be at a depth of about 5,500 feet (Figure 5).

Brine disposal at the potash site would be through deep well injection into the Leadville Limestone, estimated to be about 400 feet thick in this area and/or send to large multiple evaporation ponds about 500 acres in size. The depth to the top of the Leadville is approximately 6,500 feet at its shallowest point (where the surface elevation in the area is lowest). Depths for injection could range to about 8,000 feet.

Attachment 1

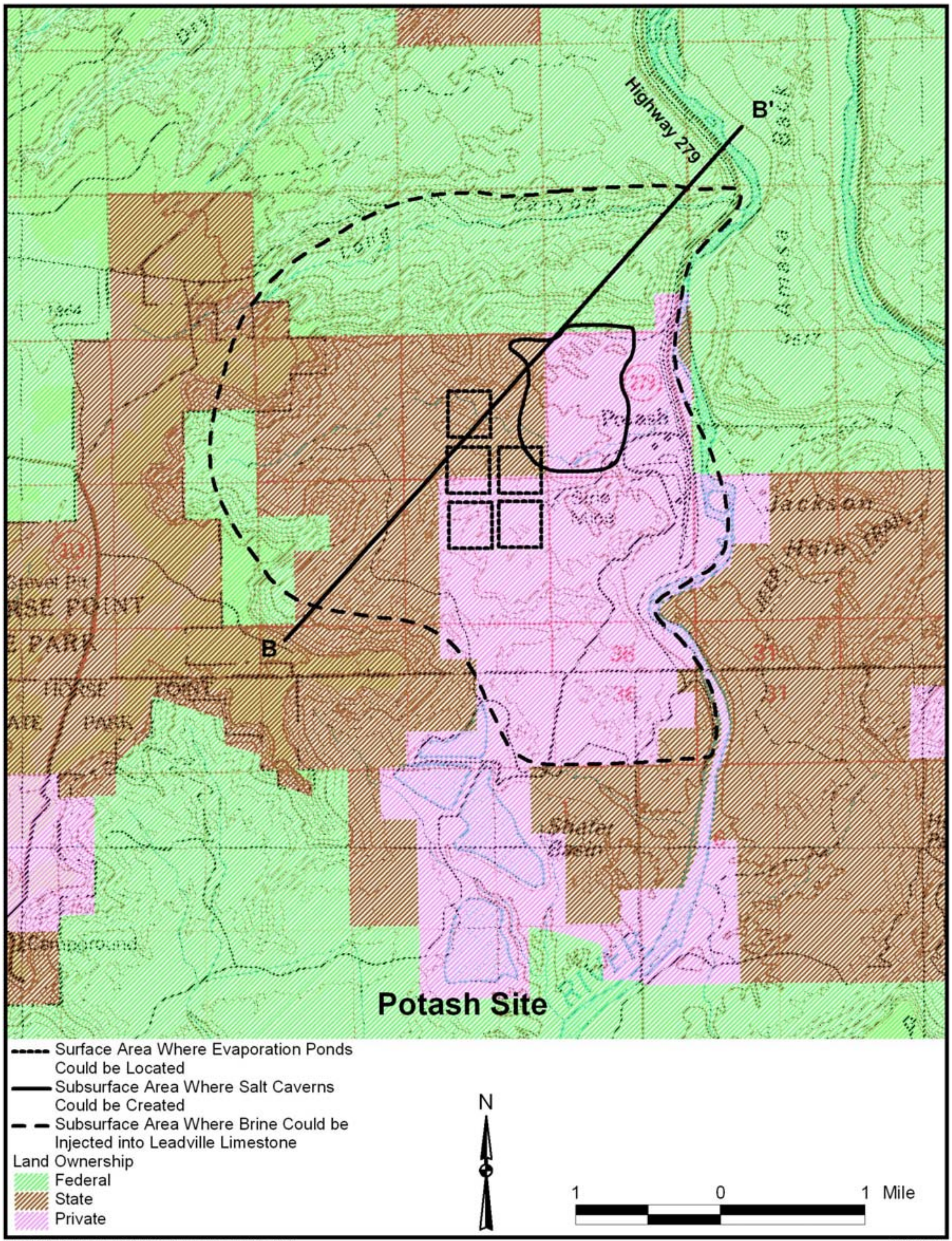

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Figure 4. Property Ownership and Location of the Geologic Cross Section for the Potash Site

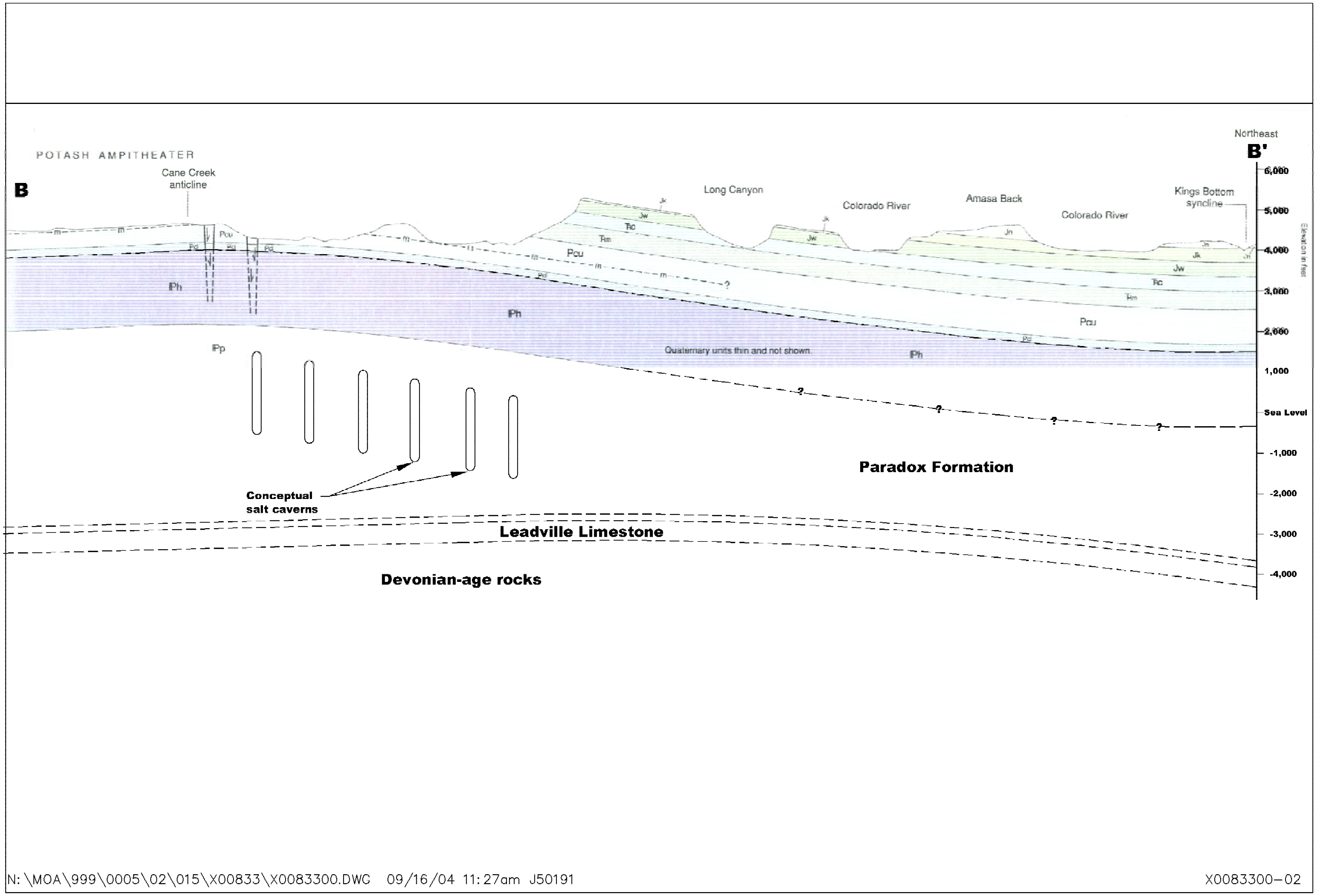

Figure 5. Geologic Cross Section for the Potash Site

Attachment 1

Description of the Sevenmile Canyon Site

The greatly thickened section of Paradox Formation underlying the Sevenmile Canyon area could provide solution-mined caverns for tailings disposal. This area is at the mouth of Sevenmile Canyon, south of the junction of U.S. Highway 191 and State Highway 313 (Figure 6), approximately 7 miles northwest of the Moab millsite. Elevation of this area is approximately 4,500 feet; U.S. Highway 191 rises northwest through Moab Canyon to about 4,600 feet en route to this area from the millsite, which is at an elevation of about 4,000 feet.

The Sevenmile Canyon area is 0.5 to 1.5 miles southwest (on the upthrown side) of the northwest-striking Moab normal fault, which has approximately 3,000 feet of displacement (Figure 7). In this area southwest of the Moab Fault where beds dip gently to the southwest, the Paradox Formation is estimated to be as much as 7,000 feet thick. Because this area is northwest of the Moab Valley salt diapir, original evaporite beds in the Paradox Formation are expected to be distinct and underformed or only slightly deformed.

Spaced approximately 1,000 feet apart, six solution-mined caverns could be situated (in the subsurface) in the flat area south of the junction of the two highways. Here, the top of the Paradox Formation is at a depth of approximately 2,500 feet. The caverns would be situated below any cap rock that might occur in the uppermost Paradox Formation, and the top of each cavern would be at a depth of about 4,500 feet. The base of the 2,000-foot-high caverns would be at a depth of about 6,500 feet (Figure 7).

Brine disposal at the Sevenmile Canyon area would be through deep well injection into the Leadville Limestone or large multiple evaporation ponds approximately 500 acres in size. The depth to the top of the approximately 500-foot-thick Leadville Limestone in this area is about 8,000 feet.

Attachment 1

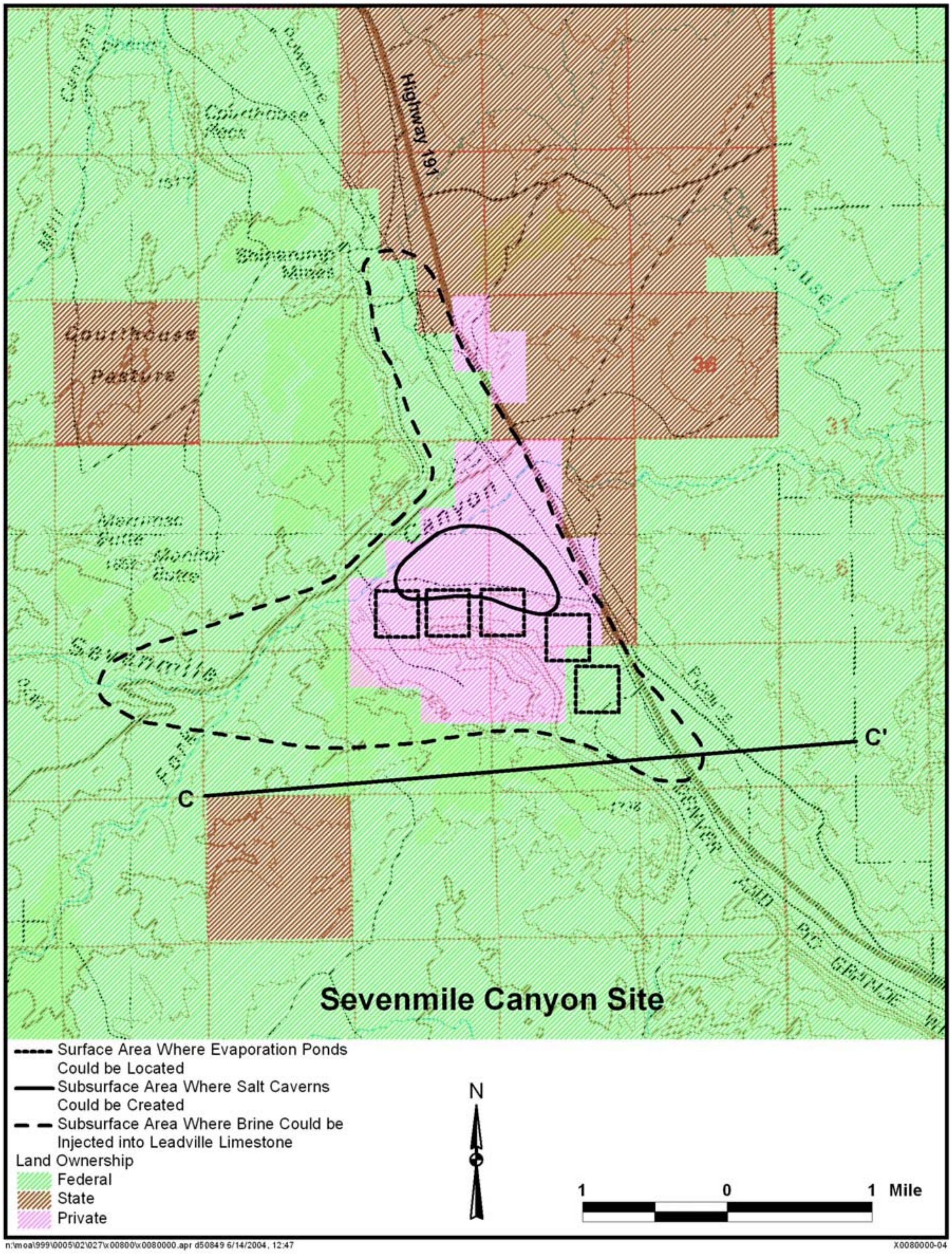

Figure 6. Property Ownership and Location of the Geologic Cross Section for the Sevenmile Canyon Site

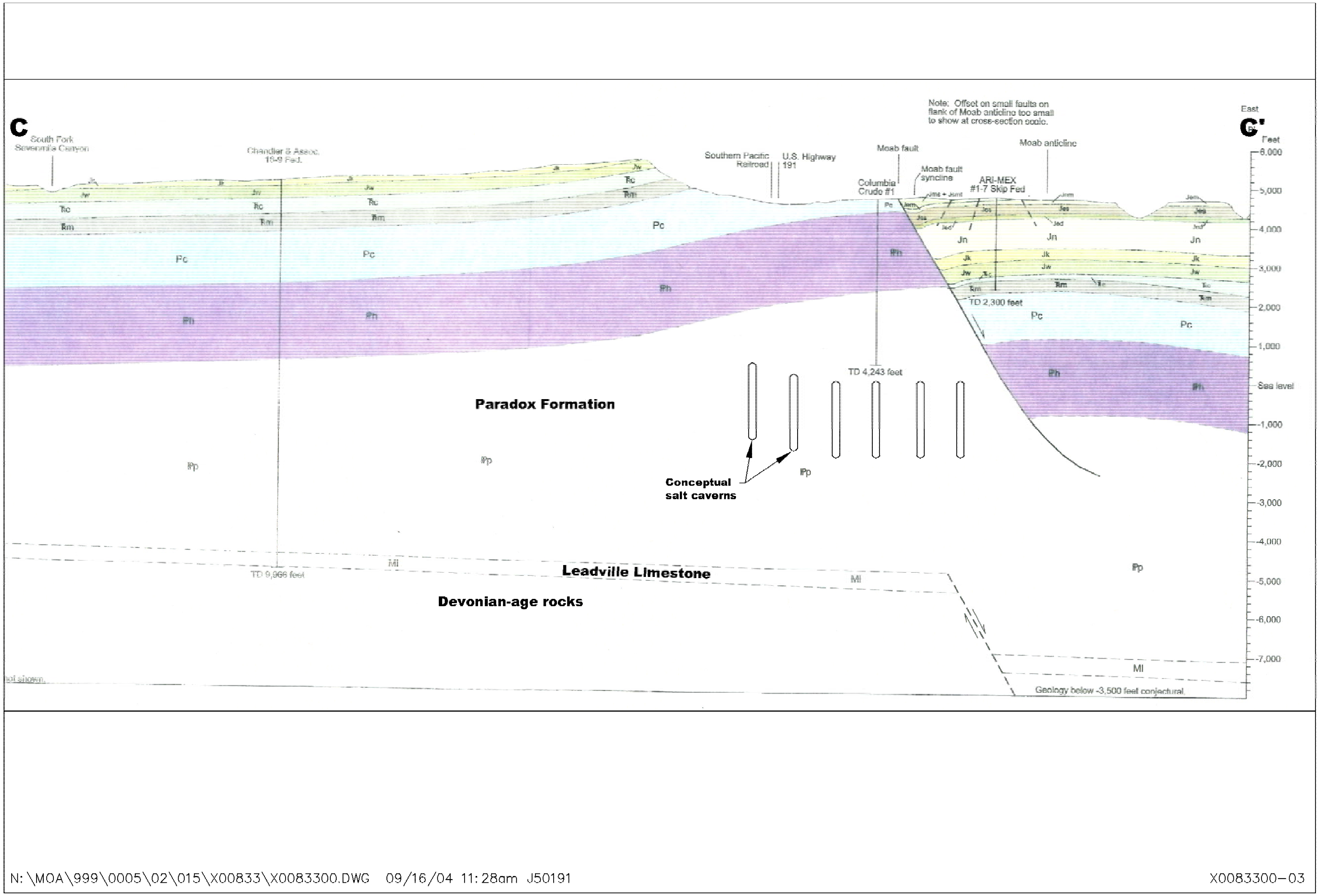

Figure 7. Geologic Cross Section for the Sevenmile Canyon Site

Appendix F

Floodplain and Wetlands Assessment and Floodplain Statement of Findings for Remedial Action at the Moab Site

F1.0 Introduction

The Moab uranium mill tailings site (Moab site) is located 3 miles northwest of Moab, Utah, on the west bank of the Colorado River. Historical processing of uranium ore at the site has resulted in a 130-acre mill tailings pile and contamination of surface water and ground water. The entire site covers approximately 439 acres, 150 of which are in the 100-year floodplains of the Colorado River and Moab Wash (an ephemeral stream that bisects the site) and the 500-year floodplain of the Colorado River. The site also contains wetlands along the border of the Colorado River (Figure F–1).

Remediation of the Moab site is mandated by the Floyd D. Spence National Defense Authorization Act, which transferred the title for the site and responsibility for cleanup to the U.S. Department of Energy (DOE). The Act also specified that the site be remediated in accordance with Title I of the Uranium Mill Tailings Radiation Control Act of 1978. Custody of the site was transferred to DOE in 2001 for remediation and long-term stewardship. Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*, requires that each federal agency evaluate the impacts of proposed actions on floodplains and wetlands and consider flood hazards and floodplain management. Regulations in 10 CFR 1022 mandate this assessment, which includes a description of the proposed action for remediation, a description of floodplains and wetlands, a discussion of the effects on floodplains and wetlands, and a consideration of alternatives.

Pursuant to the National Environmental Policy Act of 1969 (NEPA), DOE announced its intent to prepare this environmental impact statement and published a Notice of Floodplain and Wetlands Involvement for remediation of the Moab site (67 FR 77969, December 20, 2002). This notice requested comments from the public regarding potential impacts on floodplains and wetlands associated with remediation of the Moab site.

In 10 CFR 1022.4, a floodplain is defined as "…lowlands adjoining inland or coastal waters …including at a minimum, that area inundated by a 1.0 percent or greater chance flood in any given year." The area meeting this definition is referred to as the base floodplain or the 100-year floodplain. The *critical action floodplain*, also referred to as the 500-year floodplain, is the area inundated by a flood having a 0.2 percent chance of occurring in any given year. Within this floodplain, any activity for which even a slight chance of flooding would be too great (a *critical action*) is prohibited. Because petroleum, lubricants, and other hazardous materials would be used during the construction phase of this project, both the base floodplain and the critical action floodplain are considered in this assessment.

National Flood Insurance maps have not been updated recently, do not reflect current site conditions, and do not include the 500-year floodplain boundary, so they were not used for floodplain boundaries for this assessment. Therefore, flood and rainfall data, including an extensive backwater analysis (Mussetter and Harvey 1994) were used with the U.S. Army Corps of Engineers (USACE) HEC-2 model to determine the current 100-year and 500-year floodplains at the site.

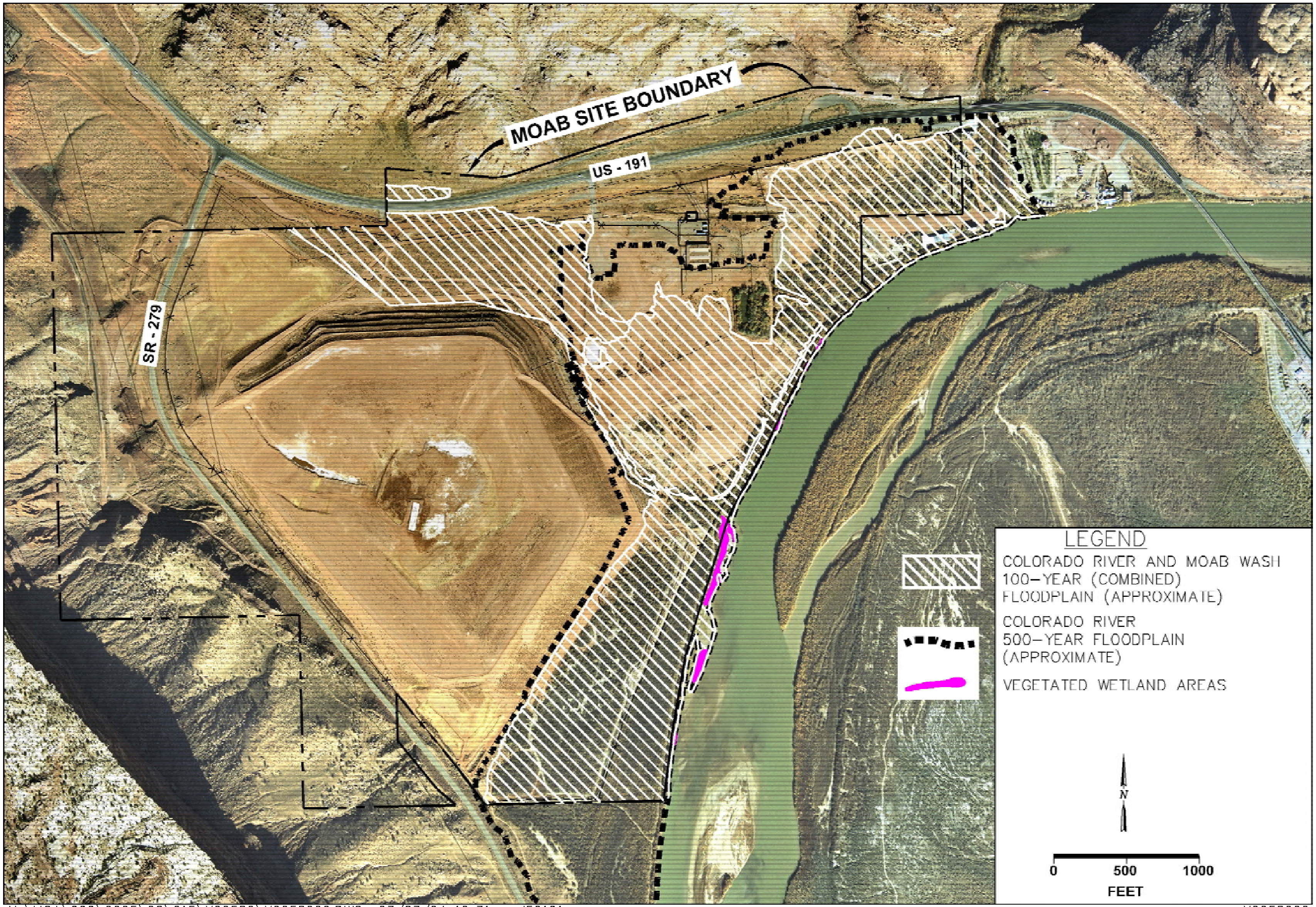

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Figure F–1. Colorado River, Floodplains, and Potential Wetlands at the Moab Site

A wetland is defined in 10 CFR 1022.4 as "an area that is saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to life in saturated soil conditions." Wetlands can serve a variety of functions in an ecosystem, including water quality preservation, flood protection, erosion control, biological productivity, and wildlife habitat. The presence of riparian vegetation such as cottonwood (*Populus* spp.), willow (*Salix* spp.), and tamarisk (*Tamarix ramosissima*) does not necessarily indicate the presence of wetlands because such plants have deep root systems that enable them also to grow in upland areas with a sufficient water table.

To gather information about other possible floodplains and wetlands in the project areas, several resources were examined:

- *U.S. Fish and Wildlife Service National Wetlands Inventory.* The inventory contained no information on wetlands in or near the sites.
- *U.S. Department of Agriculture, Natural Resources Conservation Service* (NRCS). Local offices of the NRCS have not conducted any wetland delineations near any of the sites. Current soil surveys did not indicate hydric soils at any of the locations being considered.
- *U.S. Geological Survey Topographic Maps.* Topographic maps of the areas involved were examined for evidence of springs and streams in the project area. These areas were further investigated by contacting local, state, and federal agency personnel and by making site visits when possible.

F2.0 Project Description

This section briefly describes the proposed project. For more detailed descriptions, see Chapter 2.0 of the *Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah, Final Environmental Impact Statement* (DOE/EIS-0355). Both on-site and off-site disposal alternatives are under consideration; in either case, ground water remedial action would take place at the Moab site for an estimated 75 to 80 years after remediation. The on-site disposal alternative would be completed in 7 to 8 years and would involve stabilizing the existing tailings, along with contaminated materials to be identified and removed from the remainder of the Moab site and any affected vicinity properties, at the Moab site. Alternatively, the tailings and all other contaminated materials could be transported and disposed of in an off-site cell. This alternative would be completed in an estimated 5 years and would include transportation methods of truck, rail, or slurry pipeline.

This section is divided into two parts. Section F2.1 describes the proposed on-site disposal alternative at the Moab site, including ground water remediation and vicinity properties. Section F2.2 discusses off-site disposal alternatives at Klondike Flats (approximately 18 miles northwest of Moab), Crescent Junction (approximately 30 miles northwest of Moab), and White Mesa Mill (approximately 80 miles south of Moab).

F2.1. Proposed Actions at the Moab Site—On-Site Disposal Alternative

F2.1.1 Remediation of Contaminated Materials

In areas with surface contamination, large earth-moving equipment would be used to excavate soil from the top layer. Existing contaminated vegetation, consisting mostly of tamarisk, would be cleared and chipped for disposal in the cell. Disturbed areas would be revegetated with native species.

Remediation of vicinity properties in the Moab area would include excavating and transporting contaminated materials from affected properties. Disturbed areas would be reclaimed.

F2.1.2 On-Site Disposal Cell

Construction of an on-site disposal cell would involve stabilizing and capping the tailings pile in place. The activities would take place outside wetlands and floodplains with the following exceptions. Interim storage of uncontaminated borrow materials for the disposal cell would occur within the 100-year floodplain. Storm water management measures, including the construction of berms, drainage ditches and basins, hay bales, sediment traps, and silt fence fabric, would also occur on the floodplain. Under the on-site disposal alternative, Moab Wash would be rechanneled. The wash would be moved north of its current location, away from the base of the tailings pile. It would be designed to carry runoff for an approximate 200-year flood and would discharge into the Colorado River at its historical (pre-millsite) location. To further protect the disposal cell, a buried riprap wall would be installed in the Colorado River floodplain. The wall would protect the stabilized tailings pile from river migration and erosion to meet the design life of the disposal cell. DOE would also perform additional flood analyses at Courthouse Wash to determine the best alignment and design requirements.

Long-term maintenance and monitoring of the disposal cell would include inspecting the floodplain and river boundary and the buried riprap wall.

F2.1.3 Ground Water Remediation

Ground water remediation could involve installation of up to 50 wells or 1,500 to 2,000 linear feet (ft) of shallow trenches in the floodplain to intercept contaminated ground water before discharge to the river. The wells or trenches would be installed in areas already disturbed by surface remediation.

There are several options for treating collected ground water. Evaporation ponds could be installed in the floodplain and isolated by berms from the 100-year flood level to evaporate the water, resulting in a concentrated brine or sludge for disposal. Injection of the water into a hydrologically separate deep saline aquifer is another possibility. Currently, tamarisk on the site is removing a significant quantity of ground water and plays a phytoremediation role. Similar deep-rooted plants could be placed on the floodplain after remediation. Alternatively, salt-tolerant native or agricultural plants could be irrigated for uptake.

F2.1.4 Borrow Areas

Seven proposed borrow areas for soil, sand, gravel, and rock are being investigated for the on-site disposal alternative. LeGrand Johnson and Papoose Quarry are existing commercial quarries. Floy Wash, Crescent Junction, Tenmile, Courthouse Syncline, and Blue Hills Road borrow areas would be new excavations, requiring new transportation routes. Disturbed areas would be reclaimed with native vegetation.

F2.2. Off-Site Disposal Alternative

Construction, vicinity properties remediation, and ground water remediation activities at the Moab site would be similar to those described in Section F2.1, with several changes:

- Moab Wash would not be rechanneled. It could be reconfigured with meanders to slow the water velocity and erosion potential of high flows. It would be lined with riprap and designed to carry a 200-year flood.
- Storm water management structures would be removed when remediation was complete.
- There would not be a buried riprap wall in the floodplain.
- Storage of borrow materials at the Moab site would not be necessary.
- Maintenance and monitoring of an alternative disposal cell would occur off-site.

All of the off-site alternatives would involve constructing a new disposal cell; preparing tailings for transport; transporting the tailings to the cell by rail, truck, or slurry pipeline; excavating borrow areas; and constructing borrow material transportation routes. All transportation options would require activity within the floodplain at the Moab site. Rail and truck options would require processing and/or drying areas within the floodplain. The slurry pipeline option would require the construction of temporary facilities to mix the slurry. All processing areas would be protected by berms against a 100-year flood event.

The White Mesa Mill alternative does not include rail transport because no rail lines go to that disposal location. This alternative also proposes the use of two additional borrow areas, Blanding and White Mesa Mill. If the White Mesa Mill option were chosen and a slurry pipeline were used, the pipeline would cross the 100-year floodplain at the Moab site. It would also cross the Colorado River, Matheson Wetlands Preserve, and numerous streams and dry washes. Under the Klondike Flats and Crescent Junction disposal alternatives, a slurry pipeline would not cross these areas. Floodplains and wetlands associated with individual borrow areas or transportation routes are described in Sections F3.0 and F4.0.

F3.0 Floodplain and Wetlands Descriptions

F3.1. Moab Site

The 100-year and 500-year floodplains for Moab Wash and the Colorado River occupy 150 acres, or the easternmost third of the Moab site (see Figure F–1). Floodplain alluvium consists of shallow sandy sediments and deeper gravelly sediments. Thickness of the shallow alluvium ranges from 8 to 30 ft. Coarse sand and gravel with occasional silt and clay pockets make up the deeper alluvium layer. The water table is within 5 feet of the surface in the floodplain through most of the year (SMI 2001).

Base flow for the river ranges from 3,000 to 4,000 cubic feet per second (cfs); the average peak between April and July (based on flows from 1914 to 1999) is 22,000 cfs. The river stage increases by approximately 7 feet during average peak flow. Currently, the river accesses the floodplain at the Moab site when it reaches 48,900 cfs. Because tamarisk has stabilized the soils and flow has been altered by upstream water diversions, the floodplain is not accessed by a 5-year or less flood event. Therefore, it is not considered an active floodplain. During a 100-year flood, flow would reach 99,500 cfs (NRC 1997). The 500-year flood discharge for the river was estimated by the U.S. Geological Survey to be 123,500 cfs (Jacoby and Gonzales 1993). These discharges are based on flows at the Cisco gaging station, which is 35 miles upstream from Moab; the flows at the Cisco station are considered representative of the flows at the Moab site because there are no significant tributaries between the gage and the site. One of the highest recorded discharges of the river was in 1984, when the flow reached 70,300 cfs. This flow flooded part of Moab and rose about 4 ft above the toe of the tailings pile (NRC 1999). The U.S. Nuclear Regulatory Commission (NRC) calculated a 300,000-cfs discharge applicable to the Moab site during the probable maximum flood (PMF). This flow would correspond to a water depth of 29 feet above the toe of the tailings pile (Mussetter and Harvey 1994).

Moab Wash runs through the middle of the site to the Colorado River. The wash drains approximately 5 square miles and is located north and east of the tailings pile (NRC 1997). Its original configuration was altered during milling operations. It is an ephemeral stream with infrequent, brief runoff periods during rainstorms and snowmelt. The 100-year flow for Moab Wash is 9,480 cfs, based on precipitation of 2.6 inches in 24 hours (USACE 1995). The PMF flow for Moab Wash was estimated at approximately 16,000 cfs (NRC 1997). Practices implemented as a result of the *Moab Project Site Storm Water Pollution Prevention Plan* (DOE 2002) limit the amount of runoff entering the wash from the millsite.

Vegetation on the floodplain is dominated by tamarisk, which is dense in the areas adjacent to the river and sparse or patchy in other areas. There are approximately 50 acres of mature tamarisk, with patches of cottonwood and Russian olive at the Moab site. Milling operations and remedial activities have disturbed much of the floodplain in recent years and have limited its use by wildlife. The tamarisk areas on the floodplain are not jurisdictional wetlands.

Several areas below the tamarisk next to the Colorado River were investigated in February 2002 and were found to contain wetland plants and soils. These areas include sandbars downstream of Moab Wash that are critical habitat for sensitive fish species. Seedling tamarisk is the predominant plant in these wetland areas; other wetland plants include saltgrass *(Distichlis spicata)*, cattail *(Typha* sp.), rush (*Juncus* sp.), bulrush *(Scirpus* sp*.)*, spikerush (*Eleocharis* sp.), redroot flat sedge (*Cyperus erythrorhizos*), and sandbar willow (*Salix exigua*). Formal wetlands delineations indicate that 4.7 acres of USACE jurisdictional wetlands exist immediately adjacent to the Colorado River, at the Moab Site's eastern boundary. Although wetland vegetation exists on the margins of an on-site holding pond for irrigation water, this area is not a jurisdictional wetland because the water source is artificial.

The Matheson Wetlands Preserve is an 875-acre conservation area that occupies the floodplain across the river from the site. The preserve has a variety of wetland types that include emergent wetlands, shrub wetlands, cottonwood stands, and ponds. It is the only sizable wetland remaining on the Colorado River in Utah and is important in serving multiple functions, including water quality preservation, flood protection, erosion control, and biological productivity and diversity. A levee along the northwest edge of the wetland failed in 1984 and now allows water into the wetland when the flow reaches 40,000 cfs (Mussetter and Harvey 1994). This levee possibly affects flooding potential at the Moab site; if the entire levee were removed, floodwaters would inundate the Matheson Wetlands Preserve in a shorter time. Currently, floodwaters inundate the Matheson Wetlands Preserve at a lower stage than at the DOE site (40,000 cfs vs. 48,900 cfs).

In the desert environment, it is common for very small wetlands to occur at numerous seeps, springs, and areas of rainfall collection. The presence of riparian vegetation such as tamarisk, willow, or cottonwood may indicate the presence of such small wetlands, but because riparian trees and shrubs have very deep roots, they usually occur alone, without associated wetlands. Because it is difficult to locate all the small emergent wetlands throughout large geographical areas, there is incomplete knowledge regarding their location and size. Although they are very small, these wetlands have ecological importance. It is known that no such wetlands occur on the Moab site. All other areas to be remediated or disturbed by construction, including vicinity properties, would be examined thoroughly for small wetlands prior to construction. If such wetlands were found, they would be protected (Section F4.1.2).

F3.2. Klondike Flats Site

No perennial streams or rivers exist at the Klondike Flats site (Figure F–2). The site contains numerous ephemeral washes in which surface flooding occurs, but these areas are not floodplains. Northern portions of the Klondike Flats site drain into the Green River (approximately 23 river miles) via tributaries to Tenmile Wash. Southern portions of the site drain into the Colorado River (approximately 15 river miles) via Courthouse Wash. Several areas of wetland riparian vegetation are present in or near the southern portion of the Klondike Flats site. Two occur near small ephemeral reservoirs north of the site and are vegetated primarily by tamarisk. In all, 66 acres of land containing some riparian vegetation exist in five locations near the site (BLM 2003).

No wetland areas are known to exist at the Klondike Flats site. However, if the Klondike Flats disposal alternative were chosen, areas vegetated with riparian species would be investigated for any small, isolated wetlands.

F3.3. Crescent Junction Site

Although no floodplains exist at the Crescent Junction site, due to its location at the base of the Book Cliffs and adjacent to Crescent Wash, it is subject to extreme surface water flooding potential (BLM 2003).

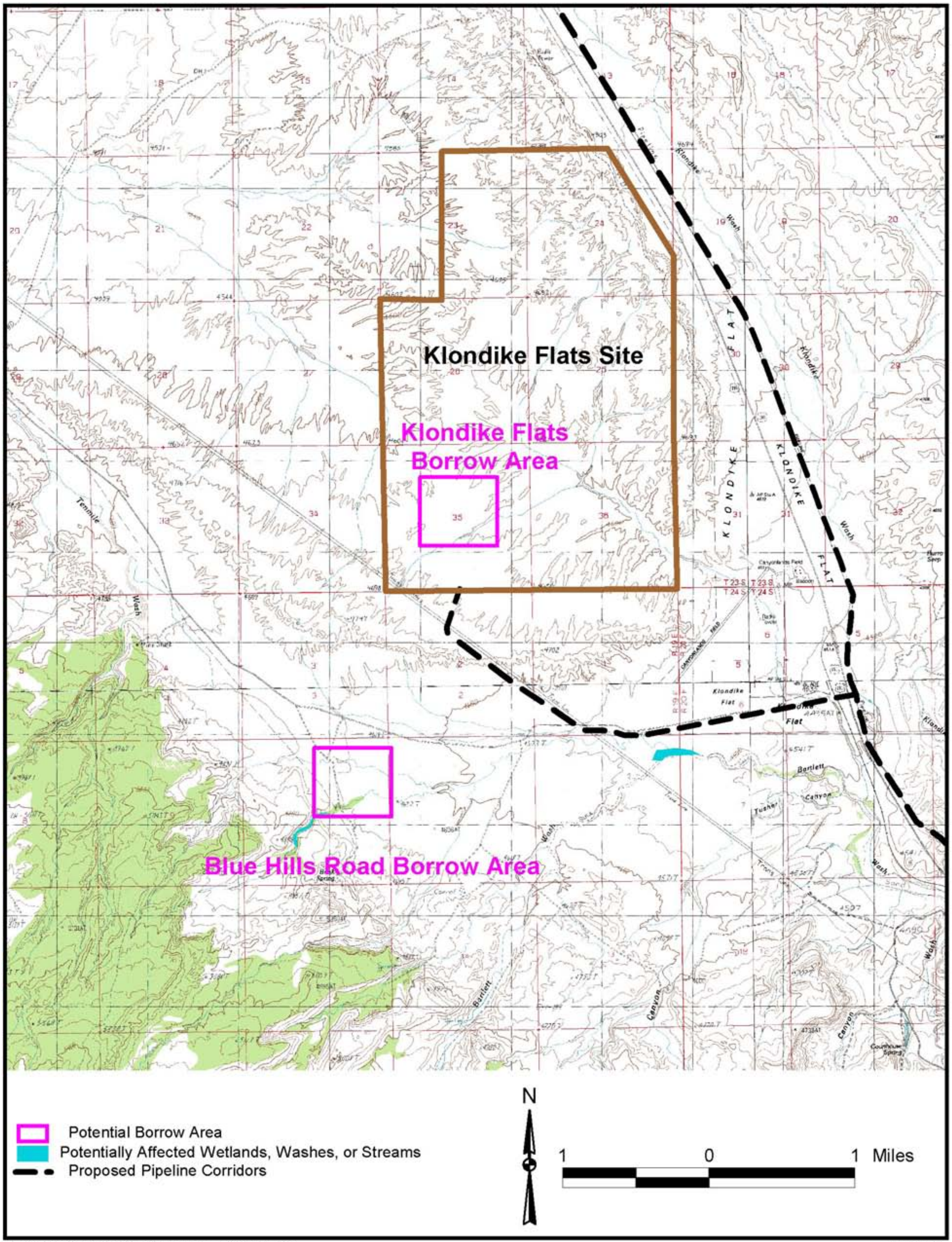

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Figure F–2. Klondike Flats Site and Location of Spring Near the Blue Hills Road Borrow Area

There are no known wetlands on or near the Crescent Junction site; therefore, a map of the site is not included in this document. Three small water collection structures exist on the site, but they have no associated riparian vegetation (BLM 2003). Two other collection structures near the site are vegetated by tamarisk and grasses. Although it is unlikely that wetland areas occur in these areas or along the proposed transportation and pipeline routes, they would be thoroughly investigated for small, isolated wetlands.

F3.4. White Mesa Mill Site

The White Mesa Mill site is situated near four intermittent streams, all of which contain cottonwood and tamarisk, valuable riparian resources. Corral Creek, to the east, has a 5-square-mile drainage and is a tributary to Recapture Creek. Westwater Creek to the west drains 27 square miles into Cottonwood Creek. Both Cottonwood and Recapture Creeks flow into the San Juan River. PMF estimates for Cottonwood Creek, Westwater Creek, and Corral Creek are 66,000 cfs, 18,000 cfs, and 14,000 cfs, respectively (Dames and Moore 1978). The existing watercourses for these creeks have capacities that exceed their PMF values. The White Mesa Mill site is located beyond the floodplains of these creeks.

Water resources in and near the White Mesa Mill site have not been assessed in detail; such an assessment would be required if this alternative were chosen. Topographic maps of the area potentially indicate 10 riparian or wetland areas within the boundaries of the site, 2 of which occur within the borrow area. The following resources are known to exist:

- Perched ground water discharges in springs and seeps along Westwater Creek Canyon, Cottonwood Creek, and Corral Canyon where the Burro Canyon Formation crops out.
- Ruin Spring, approximately 2 miles southwest of the millsite, flows on a consistent basis, and riparian species (including cottonwood and tamarisk) grow near the discharge. The other springs and seeps have not been known to flow year-round, although plants such as cattails have been observed around a seep in Cottonwood Canyon.
- Two small, ephemeral catch basins are located near the millsite; these ponds are filled by the mill to provide water and habitat for local wildlife, and it is assumed that they have associated wetland vegetation.

Figure F−3 shows potential wetland and riparian areas on and near the White Mesa Mill site.

The White Mesa Mill pipeline would cross 11 perennial streams and at least 21 intermittent drainages. The perennial streams contain riparian and wetland vegetation such as cottonwoods, willows, tamarisk, and bulrush. Some of the intermittent washes also have wetland vegetation and could be considered valuable riparian resources. The pipeline would also cross the Colorado River and the Matheson Wetlands Preserve.

F3.5. Borrow Areas

F3.5.1 Areas with No Floodplains or Wetlands

Of the 10 proposed borrow areas, 5 have no associated floodplain or wetland areas: the commercial quarries (LeGrand Johnson and Papoose Quarry), and the Klondike Flats, Crescent Junction, and Blanding borrow areas. Some transportation routes to these areas may cross dry washes, and though no wetlands are known to exist, the areas would be investigated for small, isolated wetlands.

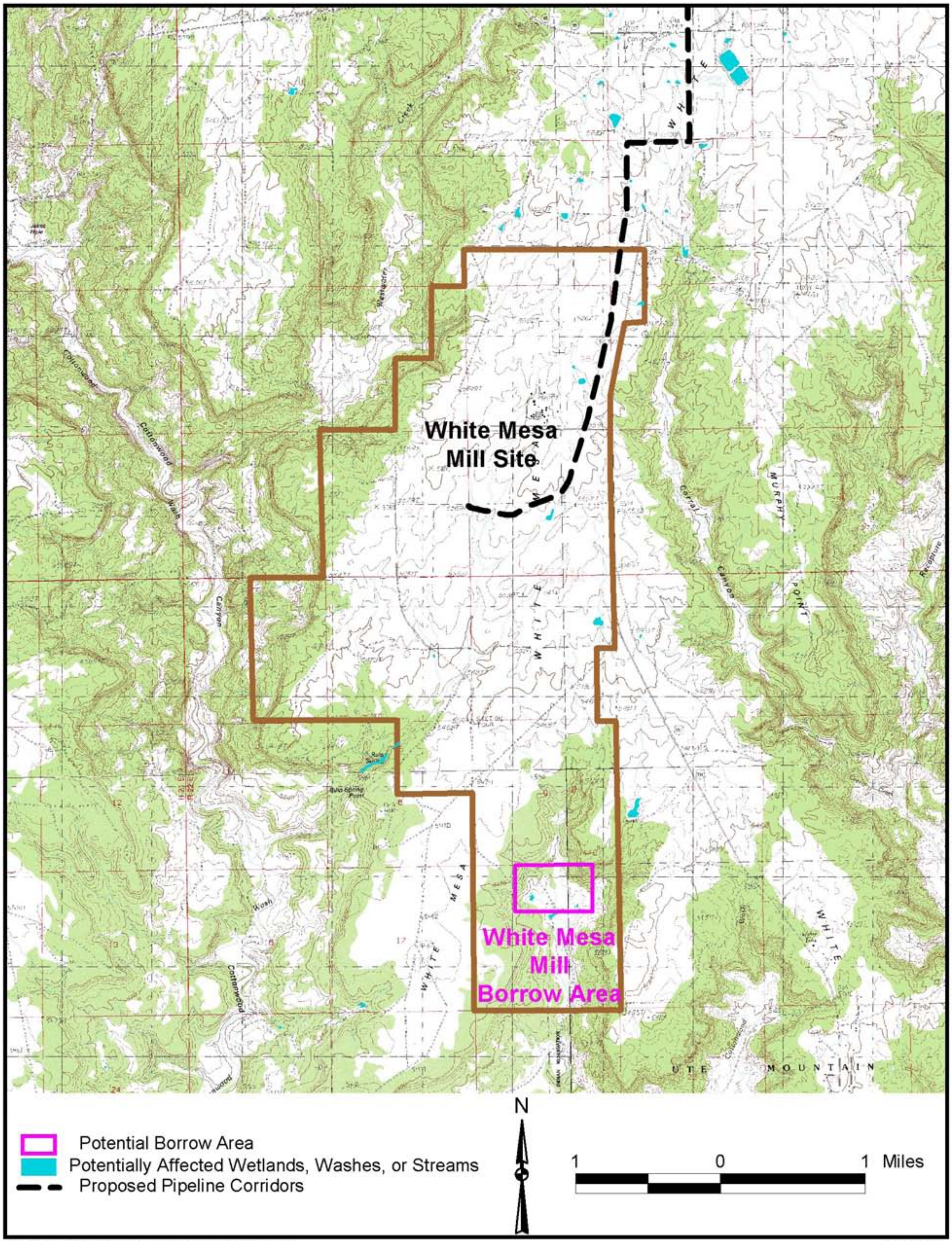

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Figure F–3. Drainages That May Contain Riparian Vegetation and Possible Wetlands Near the White Mesa Mill Borrow Area

F3.5.2 Blue Hills Road Borrow Area

Near the southwest corner of this site, a small spring provides water to maintain cottonwoods and bulrush. As this small potential wetland area approaches the edge of the borrow area, the vegetation changes to more drought-tolerant species such as skunkbush and serviceberry, reflecting the drier, nonriparian conditions. Figure F–2 shows the location of the spring relative to the proposed borrow area.

F3.5.3 Courthouse Syncline Borrow Area

Courthouse Syncline borrow area contains portions of Thompson Wash and Crescent Wash. Both washes are intermittent streams that contain potential wetlands. It is unlikely that any wetlands occur in the area, but because they contain some tamarisk populations, these areas would be investigated for small, isolated wetlands.

F3.5.4 Floy Wash Borrow Area

The Floy Wash borrow area is bordered by Floy Wash, an intermittent stream that lies to the west of the proposed borrow area (Figure F–4). Though not located within a floodplain, this wash is prone to extreme surface flooding (BLM 2003).

The whole of Floy Wash has 80 acres of native and exotic riparian and wetland resources, including lentic wetlands, tamarisk, and willow areas (BLM 2003). Farther downstream, the wash supports additional riparian areas containing cottonwood, willow, bulrush, and tamarisk. The wash has been rated by BLM as a “functioning at risk” system, meaning that it fulfills some, but not all, of the definitions of a properly functioning riparian system (BLM 2002). Known lentic wetlands lie approximately 0.5 mile north and 1 mile south of the borrow area. Portions of Floy Wash and a small water impoundment structure in the southeast corner of the area contain tamarisk, but they are not likely to contain jurisdictional wetlands. However, they would be investigated for small, isolated wetlands.

F3.5.5 Tenmile Borrow Area

The Tenmile borrow area is within one-quarter mile of Tenmile Wash, an ephemeral wash system dominated by tamarisk. BLM has rated it as a non-functioning riparian system, meaning that improvements must be made to restore the riparian values of this system (BLM 2002). The channel is deeply incised with bank collapse and gullying. There are a total of 99 acres of wetland areas in the whole of Tenmile Wash, and its drainage also supports a network of 125 acres of developed cattail and bulrush wetlands downstream (BLM 2003). Such lentic wetlands are rare in desert environments. Figure F−5 shows the location of Tenmile Wash relative to the borrow area.

F3.5.6 White Mesa Borrow Area

The borrow areas associated with the White Mesa Mill site contain some drainages with riparian vegetation that may also contain associated wetlands (see Figure F−3). These would need a more detailed water resource inventory should this alternative be chosen.

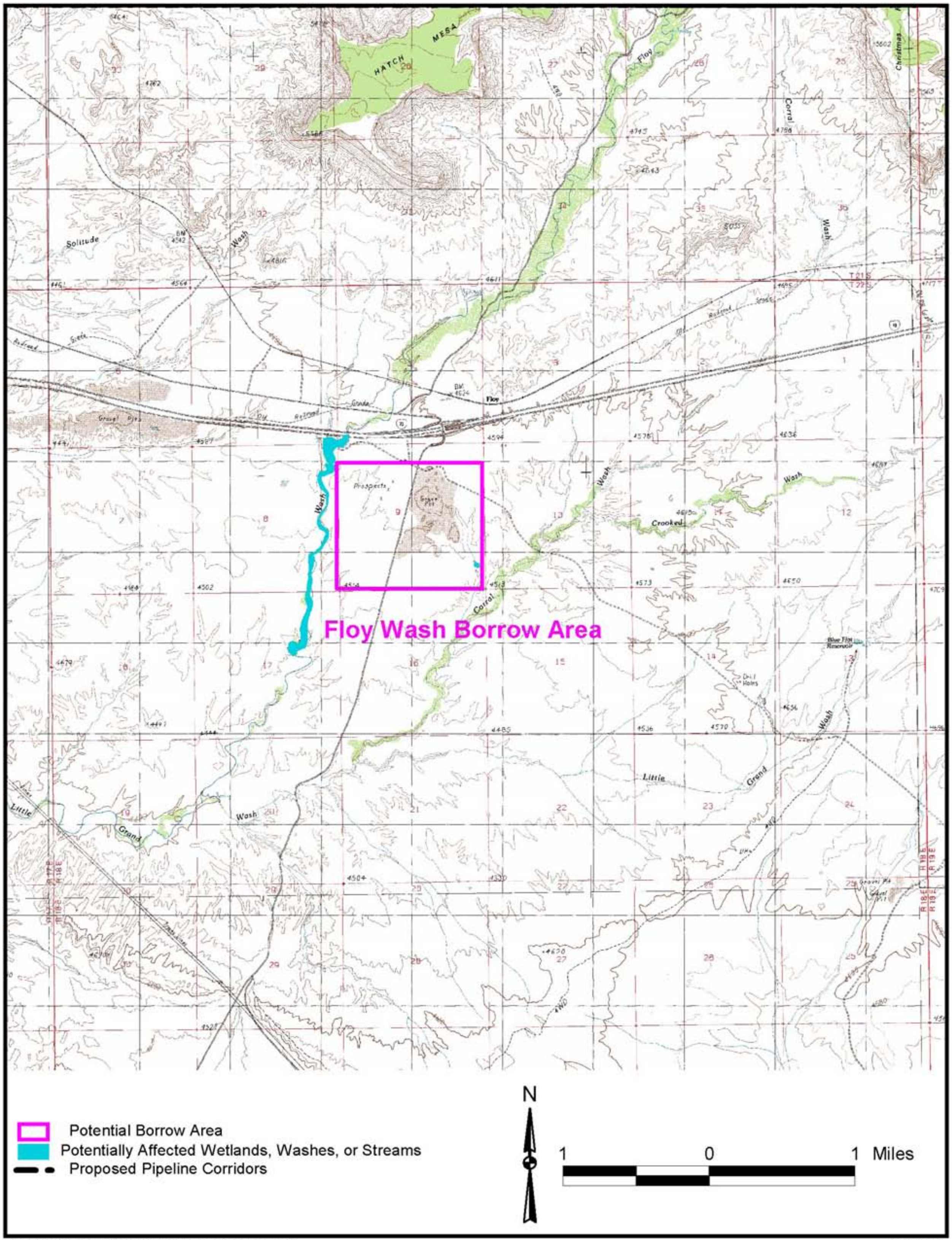

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Figure F–4. Potential Wetland Near the Floy Wash Borrow Area

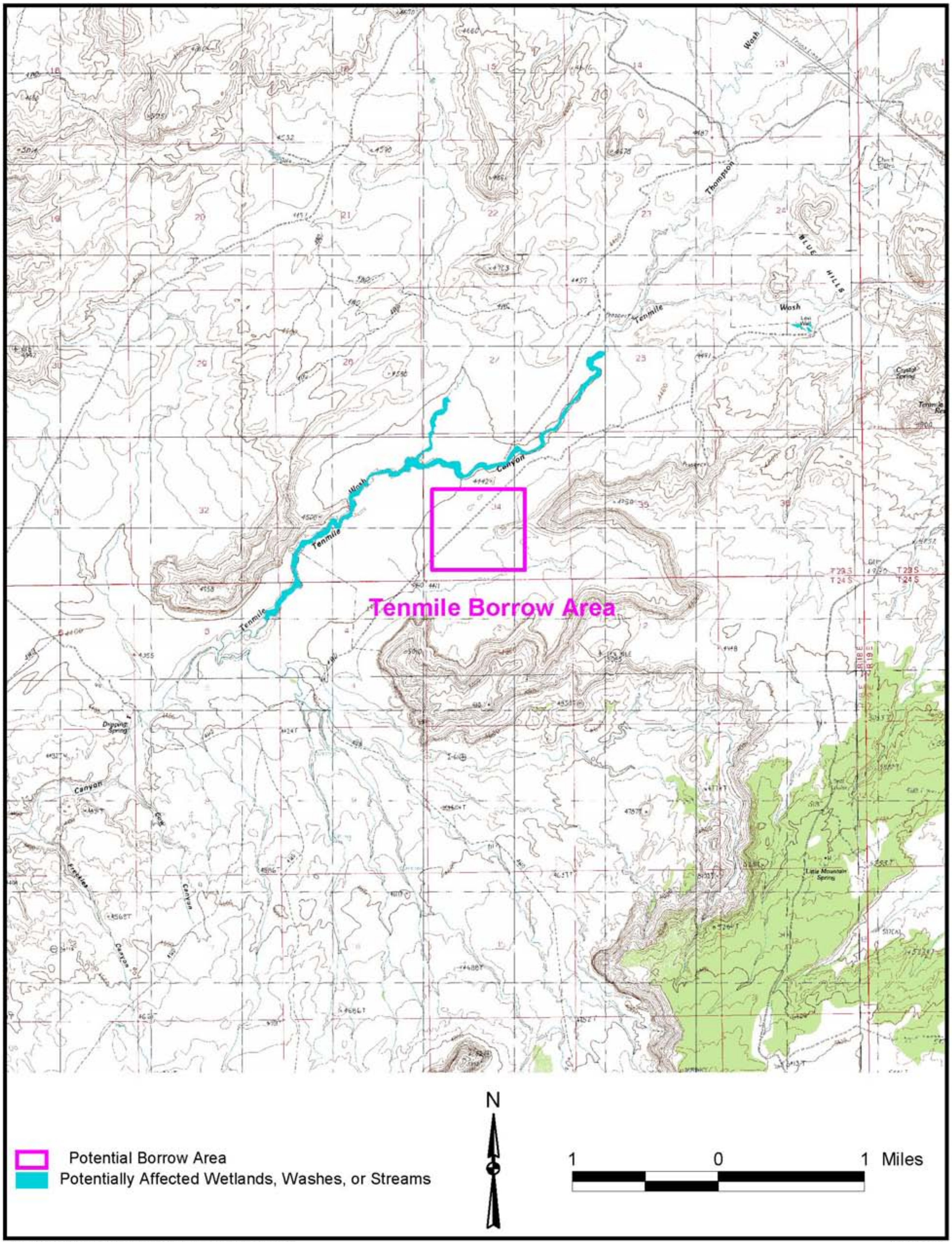

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Figure F–5. Location of Wash Near the Tenmile Borrow Area

F4.0 Floodplain and Wetlands Impacts

F4.1. Moab Site—On-Site Disposal Alternative

F4.1.1 Floodplains

Removal of contaminated materials during surface remediation at the Moab site may permanently lower the base elevation of the floodplain. The depth of soil removed may be greater than the 6 inches of topsoil proposed for reclamation. This would result in flooding of the site at a slightly lower river stage, increasing the capacity of the floodplain, and possibly minimally affecting flooding patterns at the Matheson Wetlands Preserve. Although the capacity of the floodplain would increase, the boundary would not change significantly.

Rechanneling Moab Wash would permanently affect features within the floodplain by changing drainage patterns and the river discharge point. Fortification of the wash with riprap to withstand 200-year flows would make it less likely to overflow or to carry sediment into the river. More water could be discharged to the river, but this would be somewhat mitigated by storm water management measures that would decrease runoff to Moab Wash. The wash would enter the river farther upstream and could change flow patterns; this could alter fish habitat and possibly affect wetlands over time. Critical fish habitat is discussed in the Biological Assessment (Appendix A1).

The buried riprap wall would permanently alter the floodplain by stabilizing soils in the floodplain.

Vegetation loss would result from remedial action. Currently, the tamarisk located on the floodplain plays a significant role in reducing the amount of ground water reaching the river. Removal of the tamarisk could cause more contaminated ground water to migrate to the river unless additional interim actions were implemented. Another effect of vegetation removal is a greater potential for erosion from the floodplain. This short-term effect would be mitigated by storm water management measures, described in Section F2.1.2. Because the area would be revegetated, these effects would be temporary.

Wastes generated from construction activities would be evaluated and managed according to the site waste management plan to ensure protection of public health, safety, and the environment. The use of petroleum, oil, lubricants, and other hazardous materials during construction would be controlled, spills would be promptly cleaned up, and any affected surface would be remediated. Fuel storage and refueling facilities would not be located in the floodplain.

With some ground water remediation strategies, trenches and/or evaporation ponds would be constructed in the floodplain. These structures would be bermed for a 100-year flood event. No long-term negative effects would be expected as a result of ground water remediation. Disturbance would take place in areas already disturbed by surface remediation. Removal of contaminated surface soils and ground water would improve water quality in the Colorado River adjacent to and downstream of the site.

Impacts to floodplains caused by vicinity property remediation would likely be short-term. Vicinity property remediation would be on a much smaller scale than at the Moab site.

The proposed floodplain actions would result in no significant effects to lives or property.

F4.1.2 Wetlands

At the Moab site and on vicinity properties, impacts to wetlands would be avoided whenever possible. Unavoidable excavation of contaminated soils along waterways would result in a temporary increase in sedimentation downstream. A temporary loss of wetland soils and vegetation would occur in all excavated wetlands, but these would be replaced during reclamation. Reclamation of wetlands would be in accordance with USACE Section 404 permitting requirements. The USACE regulates activities in wetlands and issues permits that require mitigation for any temporary or permanent disturbances. Its permitting requirements, both general and site-specific, would ensure that the size, quality, and function of wetlands are preserved.

F4.2. Off-Site Disposal–Klondike Flats

Impacts from remediation at the Moab site would be similar under the Klondike Flats off-site disposal alternative, with several changes. Because there would be no rechanneling of Moab Wash to a new location, effects associated with rechanneling would not apply. There would not be a buried riprap wall in the floodplain, and storage of materials for disposal cell construction would not be necessary. Also, effects from storm water management measures would be temporary because storm water management structures would be removed after remediation.

At the Moab site, tailings processing areas would be constructed in several locations on the floodplain during remediation. Depending on the mode of transportation, these areas would be used to dry tailings for transport or to mix tailings with water to form slurry. The tailings processing areas would be bermed to protect against a 100-year event and removed after remediation.

If the Klondike Flats site alternative were chosen, a formal survey would be undertaken to identify any small, isolated wetlands that may exist in the area. All impacts to such wetlands, including disturbance or sedimentation due to runoff, would be avoided.

No impacts to floodplains and wetlands would be expected from monitoring and maintenance of this facility.

F4.3. Off-Site Disposal–Crescent Junction

Under the Crescent Junction off-site disposal alternative, impacts at the Moab site would be the same as those described in Section F4.2. The Crescent Junction site is more susceptible to surface flooding than the Klondike Flats site, and construction of a disposal cell could add more sediment to the Crescent Wash drainage. However, because of the distance between Crescent Wash and the Colorado River, impacts to distant floodplains and wetlands would be unlikely.

There are no floodplains at the Crescent Junction site. If this alternative were chosen, areas containing riparian vegetation would be surveyed to identify any small isolated wetlands that may exist in the area. All impacts to such wetlands, including disturbance or sedimentation due to runoff, would be avoided.

No impacts to floodplains and wetlands would be expected from monitoring and maintenance of this facility.

F4.4. Off-Site Disposal–White Mesa Mill

Under the White Mesa Mill off-site disposal alternative, impacts at the Moab site would be the same as those described in Section F4.2. If a slurry pipeline were installed, it would be within the 100-year floodplain.

Construction on the White Mesa Mill site has a potential for sediment loading or surface water runoff into adjacent streams and wetlands. This effect would be temporary and would be mitigated with a storm water management system and revegetation.

The slurry pipeline transportation option would involve crossing the Colorado River and the Matheson Wetlands Preserve, along with 11 perennial streams and at least 21 intermittent drainages. There have been previous utility crossings in the Matheson Wetlands Preserve, and the pipeline for this project would follow these as closely as possible. Construction of the pipeline would involve an estimated 3,500 ft of directional drilling under the streams and wetlands. A small potential exists for leakage of drilling fluids into the ground water beneath the wetlands. Up to 1 mile of open-cut buried crossings would introduce sediment into the stream during the period of construction. To reduce sediment impacts, crossings would be constructed during low-flow periods, and sediment control measures would be implemented. Unavoidable disturbance to wetlands along waterways would be mitigated in accordance with USACE Section 404 guidelines (see Section F4.1.2).

Some of the springs or seeps adjacent to the White Mesa Mill site may be hydrologically connected to the site, and there could be a potential for ground water contamination due to spills, pipeline rupture, or other accidents. Mitigation to minimize the possibility of exposure would be implemented.

No impacts to floodplains and wetlands would be expected from monitoring and maintenance of this facility.

F4.5. Borrow Area Impacts

Removal of materials from borrow areas would involve the use of large earth-moving equipment. Borrow areas and their associated transportation routes would be chosen to avoid any impacts to wetlands, including sedimentation.

F5.0 Summary

Disturbance to floodplains at the Moab site and on any potential vicinity properties would be unavoidable where soils within the floodplains are contaminated. The ground water treatment system described in Section F2.1.3 must be located in the floodplain at the Moab site. Because of space constraints, materials must be stored within the floodplain (Section F2.1.2), and tailings processing areas (Section F2.2), excluded by berms, must be located within the floodplain boundary.

Disturbance to wetlands would be unavoidable where wetland soils are contaminated. In all other areas except in construction of a slurry pipeline to White Mesa Mill, wetlands could be avoided. Disturbance to wetlands would be unavoidable if a slurry pipeline were constructed because there is no alternative route.

The only alternative to remediation is a No Action alternative. Under this alternative, DOE would not remediate contaminated materials or ground water. No short-term or long-term site controls to protect human health or the environment would be in place. This alternative is analyzed to provide a basis for comparison to the action alternatives and is required by NEPA regulations.

F6.0 References

10 CFR 1022. U.S. Department of Energy, “Compliance with Floodplain and Wetland Environmental Review Requirements.”

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Attachment 1

Floodplain and Wetland Statement of Findings

Floodplain and Wetland Statement of Findings

AGENCY: U.S. Department of Energy (DOE)

SUMMARY:

The Moab site is a Title I site under the Uranium Mill Tailings Radiation Control Act, as amended by the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001. A Floodplain and Wetlands Assessment was prepared to assess on-site and off-site alternatives to remediate residual radioactive material (RRM) in accordance with 10 CFR 1022.12 and Executive Orders 11988 and 11990; this assessment is included in the Moab site environmental impact statement (EIS) as Appendix F. On April 6, 2005, DOE announced its preferred alternatives for remediation of the Moab site: (1) offsite disposal of the tailings pile and other contaminated materials at the Crescent Junction site, and (2) active ground water remediation at the Moab site. This Statement of Findings is included in the final EIS in accordance with 10 CFR 1022.15 for the preferred alternatives only.

DESCRIPTION OF PROPOSED ACTION:

The major actions associated with implementing the preferred alternatives are briefly outlined below. For more detailed descriptions of the proposed actions, see Sections 2.2 and 2.3 of the EIS; for a floodplain map, see Figure 3–16 of the EIS.

- Construction and operations at the Moab site: Activities located within or adjacent to the base floodplain would include those associated with both surface and ground water remediation. Surface remediation activities would include constructing temporary staging areas, access roads, haul roads, and a conveyor system to transport tailings to a loadout station; enhancing and repairing the water pumping station, including piping and ponds; applying water for dust control; implementing a storm water management system; excavating contaminated soils; regrading and recontouring remediated areas; backfilling deep excavations; revegetating disturbed areas; and reconstructing Moab Wash. Activities located within or adjacent to wetlands would include excavating contaminated soils and enhancing the intake structure to the water pumping station. Fuel storage areas and tailings processing areas would be located outside the base floodplain with berms designed to protect against a 100-year flood.

  Active ground water remediation at the Moab site could include installing multiple extraction wells, injection wells, trenches, and/or evaporation ponds. If evaporation ponds were constructed within the floodplain, they would be bermed to protect against a 100-year flood.

- Characterization and remediation of vicinity properties could include excavating contaminated materials within floodplains or wetland areas, followed by reclamation.
- Construction and operations at the borrow areas would include excavating and transporting soils or other materials and reclaiming disturbed areas after excavation. Excavation would not be done within wetlands or floodplains, but floodplains and wetlands exist near several potential borrow areas.
- Activities associated with transporting contaminated materials to the proposed Crescent Junction site by rail and constructing and operating the proposed Crescent Junction disposal cell would not occur within floodplains or wetlands.

REASON FOR LOCATION WITHIN FLOODPLAIN AND WETLANDS:

As a result of historical ore processing activities, contaminated soils and ground water exist within the floodplain and wetlands at the Moab site and possibly at vicinity properties. Contamination that is affecting, or may affect, these resources must be remediated to protect human health and the environment. Therefore, remediation activities must be temporarily located, and must occur, within the 100-year floodplain, and possibly within the wetlands located along the eastern boundary of the site.

ALTERNATIVES CONSIDERED:

In the EIS, DOE considered (1) stabilizing and capping the tailings pile in place at the Moab site (the on-site disposal alternative), and (2) relocating and disposing of the tailings at one of three off-site locations (the off-site disposal alternative). Both alternatives would include remediating vicinity properties, remediating ground water, and transporting borrow materials for reclamation of disturbed areas. The on-site disposal alternative assessed consolidating on-site contaminated soils into the existing tailings pile before capping the pile in place. The off-site disposal alternative considered transporting (by rail, truck, or slurry pipeline) the unconsolidated contaminated soils and existing tailings pile to a newly constructed disposal cell at Klondike Flats, Crescent Junction, or White Mesa Mill. In addition, DOE assessed the No Action alternative. Detailed descriptions of all the alternatives considered for remediation of the Moab site are included in Chapter 2.0 of the EIS. .

CONFORMANCE WITH APPLICABLE STATE AND LOCAL FLOODPLAIN PROTECTION STANDARDS:

All activities associated with DOE’s preferred alternatives would conform to applicable state and local floodplain protection standards and would be coordinated with appropriate federal and state agencies.

STEPS TO MINIMIZE POTENTIAL HARM TO OR WITHIN THE FLOODPLAIN AND WETLANDS:

All remediation activities would be conducted in a manner that would minimize potential adverse impacts to the floodplain and wetlands. Activities would include removing unconsolidated RRM-contaminated soils from the floodplain and protecting wetlands that could be affected by remediation activities. Specific activities would include locating remediation activities, to the extent practical, outside the floodplain; constructing temporary berms to minimize the potential for floodwaters to come in contact with contaminated soils; implementing a storm water management plan; and implementing best management practices for soil remediation, control of invasive plant species, and native plant revegetation. Activities would also include ground water remediation to reduce the contaminant concentrations within the floodplain. Detailed actions to minimize potential effects on the floodplain and wetlands would be included in the remedial action plan and the mitigation action plan that would be developed following issuance of the Record of Decision for the EIS.

Appendix G

White Mesa Mill Operations

G1.0 Introduction

White Mesa Mill is a U.S. Nuclear Regulatory Commission (NRC)-licensed mill that produces uranium for commercial nuclear power plants. The White Mesa uranium/vanadium mill was developed in the late 1970s by Energy Fuels Nuclear, Inc. (EFN) as an outlet for the many small mines that are located in the Colorado Plateau and for the possibility of milling Arizona Strip ores. Although the White Mesa Mill facility is a candidate site for possible permanent disposal of the Moab tailings, the facility also operates periodically as an NRC-licensed mill under Source Material License SUA-1358. White Mesa Mill's Source Material License allows the mill to create and dispose of uranium by-product materials from mill operations. Because of the recent history of periodic operations, the continued operations of the mill into future years is considered a reasonably foreseeable action with respect to cumulative impact analysis for the Moab tailings project. Although it is not known how long into the future the mill will operate, it is reasonable to assume that continued operations similar to those of the past 10 years are possible, since the facility's license does not expire until March 31, 2007.

G2.0 Background

The Source Material License application for the White Mesa Mill was submitted to NRC on February 8, 1978. Construction on the tailings area began on August 1, 1978, with the removal of earth from the area of Cell 2. Cell 2 was completed on May 4, 1980, Cell 1 on June 29, 1981, and Cell 3 on September 2, 1982. In January 1990, an additional cell, designated 4A, was completed and placed into use solely for solution storage and evaporation. The first ore was fed to the mill grizzly on May 6, 1980 (IUC 2000).

At the time of the mill's construction, it was anticipated that high uranium prices would stimulate ore production. However, prices started to decline about the same time as mill operations commenced. As uranium prices fell, producers in the region were affected and mine output declined. After about two and one-half years, the White Mesa Mill ceased ore-processing operations altogether, began solution recycle, and entered a total shutdown phase. In 1984, a majority ownership interest was acquired by Union Carbide Corporation's (UCC) Metals Division, which later became UMETCO Minerals Corporation (UMETCO), a wholly-owned subsidiary of UCC. From 1985 through 1990, the mill was active again in receiving and processing uranium ores. The partnership between UMETCO and EFN continued until May 26, 1994, when EFN reassumed complete ownership. Beginning in the mid- to late- 1990s, the mill began to process uranium-bearing material other than natural ores from off-site locations. These "alternative feed materials" generally have consisted of uranium-bearing residues from uranium-ore processing facilities or other metal-processing facilities as well as soils contaminated with natural uranium, most of which has come from Formerly Utilized Sites Remedial Action Program sites managed by the Army Corps of Engineers (NRC 1999). In May 1997, International Uranium (USA) Corporation (IUC) purchased the assets of EFN and is the current owner of the facility.

G3.0 Facility

The White Mesa Mill is located in San Juan County, Utah, approximately 5 miles south of Blanding, Utah. Facilities consist of a mill, ore storage pad, and four lined tailings cells with leak detection systems and ground water monitor wells. The facilities are situated within a 5,415-acre private property mostly owned by IUC. The mill itself occupies approximately 50 acres, and the tailings disposal ponds occupy approximately 450 acres. A one-half-mile-long private road off US-191 provides access to the site.

The ore storage pad at the site covers an area of approximately 20 acres. The pad is underlain by compacted, mostly fine-grained material. Crushed limestone was reported to have been incorporated into the pad at the time of construction. The surface of the pad is sloped to promote drainage and prevent off-site movement of drainage.

The tailings facilities at White Mesa Mill consist of four cells:

- Cell 1, constructed with a 1.2-inch polyvinyl chloride (PVC) earthen-covered liner, is used to store the process solution.
- Cell 2, constructed with a 1.2-inch PVC earthen-covered liner, is used to store the barren tailings sands.
- Cell 3, constructed with a 1.2-inch PVC earthen-covered liner, is used to store the barren tailings sands and solutions.
- Cell 4A, constructed with a 1.6-inch high-density polyethylene liner, is currently not used.

Total estimated design capacity of Cells 2, 3, and 4A is approximately 6 million cubic yards (IUC 2000).

G4.0 Operations

Although originally designed for a capacity of 1,500 dry tons per day, the mill capacity was boosted to the present rated design of 1,980 dry tons per day prior to commissioning. Under current and recent operations, alternative feed materials are received at the site by truck and temporarily staged until a sufficient quantity is received to run the mill.

Feed materials for the mill are temporarily stockpiled on the ore pad. The period that materials are stockpiled varies but is typically about 2 years. Feeds currently stored on the site in piles typically cover an area of approximately 0.1 to 1.5 acres and often merge. Pile thicknesses vary but may exceed 30 feet (ft). Mill operations are periodic; when operations are under way, the mill typically employs between 70 and 100 full-time employees.

Once operations commence, the feed materials are either passed through the ore-receiving hopper and semiautogenous grinding mill or run through an existing trammel before being pumped into pulp storage tanks, where a leaching process is initiated by addition of sulfuric acid. The mill currently uses propane to fire all process and heating boilers.

The mill uses an atmospheric hot acid leach followed by countercurrent decantation (CCD). This in turn is followed by a clarification stage, then a solvent extraction (SX) circuit. Kerosene containing isodecanol and tertiary amines extracts the uranium and vanadium from the solution in the SX circuit. Salt and soda ash are then used to strip the uranium and vanadium from the organic phase.

After extraction from the SX solution, uranium is precipitated with anhydrous ammonia, dissolved, and reprecipitated to improve product quality. The resulting precipitate is then washed and dewatered using centrifuges to produce a final product called “yellowcake.” The yellowcake is dried in a multiple-hearth dryer and packaged in drums weighing approximately 800 pounds for shipping to conversion plants. The current NRC license for the facility specifies a maximum production rate of 4,380 tons of yellowcake per year.

After the uranium is stripped from the pregnant SX solution, the vanadium in the remaining solution is transferred to tertiary amines contained in kerosene and concentrated into an intermediate product called vanadium product liquor (VPL). An intermediate product, ammonium metavanadate (AMV), is precipitated from the VPL using ammonium sulfate in batch precipitators. The AMV is then filtered on a belt filter and, if necessary, dried. Normally, the AMV cake is fed to fusion furnaces where it is converted to the mill’s primary vanadium product, vanadium pentoxide (V_2O_5).

Tailings produced by the mill typically contain 30 percent moisture by weight, have an in-place dry density of 86.3 pounds per cubic foot (Cell 2), have a particle size distribution that is predominantly a −325 mesh size fraction, and have a high acid and flocculent content (IUC 2000).

Constructed in shallow valleys or swale areas, the lined tailings cells provide storage below the existing grade and reduce potential exposure. Because the cells are separate, individual cells may be reclaimed as they are filled to capacity. This phased reclamation approach attempts to minimize the amount of tailings exposed at any time.

Slurry is disposed of in both Cells 2 and 3. Tailings in Cell 2 were placed using the perimeter discharge method. Perimeter discharge involves setting up discharge points around the east, north, and west boundaries of the cell. This method results in low-cost disposal at first, followed by higher disposal costs toward the end of the cell's life. In Cell 3, a process called the final grade method has been used, whereby the slurry is discharged until the tailings surface reaches final grade. The discharge points are set up in the east end of the cell, and the final grade surface is advanced to the slimes pool area. When the slimes pool is reached, the discharge points are then moved to the west end of the cell and worked back to the middle. As described by IUC in its reclamation plan, an advantage to using the final grade method is that maximum stability is achieved by (1) allowing water to drain from the sands to the maximum extent, and (2) allowing coarse sand deposition to help provide stable beaches. Another advantage is that radon release and dust prevention measures (through the placement of the initial layer of the final cover) are applied as expeditiously as possible.

As a zero-discharge facility, the White Mesa Mill must evaporate all of the liquids used during processing. This evaporation takes place in two areas: Cell 1, which is used for solutions only, and Cell 3, in which tailings and solutions exist.

The original engineering design indicated that a net water gain into the cells would occur during mill operations. In addition to natural evaporation, spray systems have been used occasionally to enhance evaporation rates and control dust. To minimize net water gain, solutions are recycled from the active tailings cells to the maximum extent possible. Solutions from Cells 1 and 3 are brought back to the CCD circuit, where additional extraction can be realized. Recycling to other parts of the mill circuit is not feasible due to the acid content of the solution.

G5.0 Air and Radioactive Emissions

Air emissions from the White Mesa Mill are regulated by the State of Utah in accordance with the mill's air quality permit issued in 1997 (Utah DAQE-884-97). The air quality permit establishes annual emissions limits for the yellowcake dryers and vanadium circuit scrubber. The permit also describes emission controls for sources in the mill and general procedures for controlling dust from roads and fugitive sources. Specifically, the permit requires that particulate (PM_{10}) emissions to the atmosphere shall not exceed 0.40 pound per hour for each yellowcake dryer and 2.50 pounds per hour for the vanadium circuit scrubber. The mill is also required to submit to the Utah Department of Environmental Quality an annual emissions inventory (Table G−1). Table G−1 is based on the 5 years of operation from 1997 through 2002 and shows the amounts of emissions that might be expected from future mill operations.

Table G–1. Air Emission Inventory for Key Criteria Emissions (tons per year)

Year	PM_{10}	Sulfur Dioxide	Nitrogen Dioxide	Volatile Organic Compounds	Carbon Monoxide
1997	0.775	0.255	3.859	2.120	7.257
1998[a]	–	–	–	–	–
1999	2.57	1.15	18.11	2.16	14.14
2000	1.9	1.47	14.61	2.76	11.78
2001[a]	–	–	–	–	–
2002	0.68	0.98	9.04	1.80	11.49

[a] IUC was not required to file an air emission inventory for these years because it was determined that the mill did not realize a change of 5 percent or more in emissions for any criteria pollutant reported in the previous year.
Source: IUC 2003
Note: PM_{10} = particulate matter less than 10 micrometers in diameter.

As required by 10 CFR 20.1101, the mill employs procedures and engineering controls, to the extent practicable, to achieve occupational radiological doses and doses to members of the public as low as reasonably achievable. Under 10 CFR 20.1301, NRC has adopted the U.S. Environmental Protection Agency's (EPA's) annual dose limit of 25 millirem (mrem) (exclusive of radon) for members of the public for doses attributable to licensed operations. Doses from natural background or medical radiation are excluded. In addition, the highest dose any individual member of the public should receive from direct air emissions of radioactive material to the environment should not exceed 10 mrem/year from plant emissions. On the basis of past analyses by NRC, the predicted total effective dose equivalent to a receptor at the potential nearest residence would have been a small fraction of the 25-mrem standard (IUC 2003).

G6.0 Past and Recent Production

From May 6, 1980, to February 4, 1983, the mill processed 1,511,544 tons of ore and other materials. During a second operational period from October 1, 1985, through December 7, 1987, 1,023,393 tons were processed. During a third operational period from July 1988 through November 1990, 1,015,032 tons were processed. During the fourth operational period from August 1995 through January 1996, 203,317 tons were processed. The fifth operational period from May 1996 through September 1996 processed 3,868 tons of calcium fluoride material. Since early 1997, the mill has processed over 100,000 tons from several additional feed stocks. The total amount of materials processed from the beginning of milling operations through 2002 is 4,083,144 tons. The highest annual production of yellowcake was 3.75 million pounds per year in the 1985−1990 period.

G7.0 Transportation

The original plan for the mill was to process up to 680,000 tons of ore per year, which, using 25-ton trucks, would be 27,500 truck loads per year (78 per day based on a 7-day work week, or 109 per day based on a 5-day work week). To serve the mill with process materials, it was anticipated there would be over 20 truck trips per day bringing loads of anhydrous ammonia, sulfuric acid, and other supplies.

Yellowcake refined at the mill is shipped in 55-gallon drums that weigh an average of 800 pounds. Drums are shipped an average of 1,300 miles to conversion plants, where the yellowcake is converted to uranium hexafluoride and then to enrichment-grade uranium suitable as a fuel source for nuclear power plants. An average truck shipment contains approximately 40 drums, or 17.5 tons of yellowcake. Based on licensed production capacity of 4,380 tons of yellowcake per year, a maximum of 8,760,000 pounds of yellowcake could require shipment from the mill in a given year, or 275 truck shipments per year.

A more typical recent mill operation can be characterized by the license amendments that allowed the mill to process materials from the Molycorp’s Lanthanide Division Facility in Mountain Pass, California. For the year 2002, it was estimated that the mill would receive and process up to 17,750 tons of alternative feed materials, in this case consisting of lead sulfide containing approximately 0.15 percent uranium. For this mill run, an estimated 60 to 70 trucks per week would bring the materials from California to the mill over a 60- to 90-day period, representing a 2-percent increase in truck traffic on regional roads for a 3-month period. Based on the recent past history of mill operations, it can be expected that the White Mesa Mill would undertake milling operations on a scale similar to the Molycorp project approximately every 3 years.

Each periodic operation of the mill can have adverse environmental consequences from mill operations, including transportation. These effects could be in the form of health effects for workers at the mill, air or ground water pollution, or a transportation accident resulting in the release of process chemicals or source materials into streams or other sensitive areas along the travel route to the mill. These potential adverse environmental effects would be in addition to environmental effects contributed from the permanent disposal of Moab uranium tailings at the White Mesa Mill facility. The direct, indirect, and cumulative effects of Moab tailings disposal at the White Mesa Mill site are discussed in Chapters 4.0 and 5.0.

G8.0 References

10 CFR 20. U.S. Nuclear Regulatory Commission, “Standards for Protection Against Radiation.”

IUC (International Uranium [USA] Corporation), 2000. *White Mesa Mill Reclamation Plan*, International Uranium (USA) Corporation, Revision 3, July 17, Denver.

IUC (International Uranium [USA] Corporation), 2003. *Description of the Affected Environment, White Mesa Mill, Blanding, Utah*, International Uranium (USA) Corporation, May 5, Denver.

NRC (U.S. Nuclear Regulatory Commission), 1999. *Environmental Assessment for International Uranium Corporation's Uranium Mill Site, White Mesa, San Juan County, Utah*, in consideration of an Amendment to Source Material License SUA-1358 for the Approval of the Proposed Reclamation Plan. U.S. Nuclear Regulatory Commission, Division of Waste Management, Office of Nuclear Safety and Safeguards, Washington, D.C., December 23.

Appendix H

Transportation Impact Analysis

H1.0 Introduction

This appendix summarizes the methods and results of analyses for determining the environmental impacts of shipping uranium mill tailings and borrow materials by truck and rail. The impacts are presented by alternative and include doses and health effects.

The transportation impacts of shipping contaminated materials from vicinity properties, mill tailings from the Moab site, and borrow material from the proposed borrow areas would be from two sources: radiological impacts and nonradiological impacts. Radiological impacts would be from incident-free transportation and from transportation accidents that released contaminated material or uranium mill tailings. There would be no radiological impacts from moving borrow material because it is not contaminated. Nonradiological impacts would be from the engine and fugitive dust emissions from the truck or train moving the contaminated material, uranium mill tailings, and the borrow material, and from fatalities from traffic accidents during the transport of these materials. The total transportation impacts would be the sum of the radiological and nonradiological impacts.

H1.1 Incident-Free Transportation Impacts

Radiological dose during normal, incident-free transportation of contaminated material or uranium mill tailings would result from exposure to the external radiation field that surrounds the truck or rail car containing the contaminated material or uranium mill tailings. The dose is a function of the number of people exposed, their proximity to the containers, their length of time of exposure, and the intensity of the radiation field surrounding the truck or rail car.

Radiological impacts were determined for workers and the general population during normal, incident-free transportation. For truck shipments, the workers were drivers of the trucks carrying the contaminated material or uranium mill tailings. The radiation dose rate for the driver of a truck carrying contaminated material from vicinity properties was estimated to be 0.13 millirem (mrem) per hour using the MICROSHIELD computer code (Grove Engineering 1996). The radiation dose rate for the driver of a truck carrying uranium mill tailings from the Moab site was estimated to be 0.22 mrem per hour. For rail shipments, the workers would be individuals who inspected the train carrying the uranium mill tailings. The radiation dose rate for the inspectors was estimated to be 0.44 mrem per hour.

For truck shipments, the general population consisted of those individuals within 2,625 feet (ft) of the road (off-link) and individuals sharing the road (on-link). Because the trucks would drive directly to the disposal sites, no individuals were assumed to be exposed at stops. For rail shipments, the general population consisted of those individuals within 2,625 ft of the road (off-link). Because the train would not share the track with other trains at the same time and would not be in a classification yard, no individuals were assumed to be exposed at stops or on-link. Radiation doses for the general population were calculated using the RADTRAN 5 computer code (Neuhauser and Kanipe 2000, Neuhauser et al. 2000). The radiation dose rate for the vicinity property truck was estimated to be 0.17 mrem per hour at 3 ft from the truck. For the truck carrying uranium mill tailings, the radiation dose rate was estimated to be 0.30 mrem per hour. The radiation dose rate for the rail cars was estimated to be 0.44 mrem per hour at 3 ft from a rail car.

H1.1.1 Incident-Free Collective Dose Scenarios

Calculating the collective doses is based on developing unit risk factors. Unit risk factors provide an estimate of the impact from transporting one shipment of radioactive material over a unit distance of travel in a given population density zone. The unit risk factors may be combined with routing information such as the shipment distances in various population density zones to estimate the risk for a single shipment (a shipment risk factor) between a given origin and destination. Cashwell et al. (1986) contains a detailed explanation of the use of unit risk factors. Table H–1 contains the unit risk factors for truck and rail shipments.

Table H–1. Incident-Free Unit Risk Factors

Receptor	Zone	Truck	Rail
General population (public)			
Vicinity property off-link (person-rem/km per persons/km^2)	Rural	1.92E-09	0
	Suburban	1.92E-09	0
	Urban	1.92E-09	0
Vicinity property on-link (person-rem/km)	Rural	9.11E-07	0
	Suburban	9.11E-07	0
	Urban	9.11E-07	0
Off-link (person-rem/km per persons/km^2)	Rural	1.85E-09	4.42E-09
	Suburban	6.38E-09	4.42E-09
	Urban	6.38E-09	4.42E-09
On-link (person-rem/km)	Rural	1.65E-07	0
	Suburban	4.56E-07	0
	Urban	2.14E-06	0
Workers			
Vicinity property truck drivers (person-rem/km)	Rural	3.34E-06	0
	Suburban	3.34E-06	0
	Urban	3.34E-06	0
Mill tailings truck drivers (person-rem/km)	Rural	2.50E-06	0
	Suburban	3.93E-06	0
	Urban	3.93E-06	0
Rail inspector (person-rem/shipment)	Rural	0	7.99E-04
	Suburban	0	7.99E-04
	Urban	0	7.99E-04

km = kilometer

Incident-free nonradiological fatalities (pollution health effects) were also evaluated using unit risk factors. These fatalities would result from exhaust and fugitive dust emissions from highway and rail traffic and are associated with 10-micrometer (μm) particles. The nonradiological unit risk factor for truck transport used in this analysis was 1.5×10^{-11} fatalities per kilometer per persons per square kilometer; for train transport, the nonradiological unit risk factor was 2.6×10^{-11} fatalities per kilometer per persons per square kilometer. These unit risk factors were estimated from the data in Biwer and Butler (1999) and have been adjusted to account for more current diesel exhaust emission factors, a fleet average fugitive dust emission factor for roads, an age-adjusted mortality rate, and an average 10-μm particle risk factor. The distances used in the nonradiological analyses were doubled to reflect the round-trip distances, because these impacts could occur whether or not the shipments contain radioactive material. In addition, the impacts from pollution health effects included shipments from borrow areas.

H1.1.2 Incident-Free Maximally Exposed Individual Exposure Scenarios

Maximum individual doses were calculated using the RISKIND computer code (Yuan et al. 1995). The maximum individual doses for the routine transport off-site were estimated for transportation workers and for members of the public. For truck shipments, two scenarios were evaluated for members of the public:

- A person caught in traffic next to a truck containing uranium mill tailings for 30 minutes. The distance between the two vehicles was assumed to be 3 ft.
- A resident living 98 ft from the highway used to transport the uranium mill tailings. For shipments from vicinity properties, the resident lived 26 ft from the road. This person was assumed to be exposed to all shipments over the course of a year.

For rail shipments, two scenarios were evaluated for members of the public:

- A resident living 98 ft from the railroad used to transport the uranium mill tailings. This person was assumed to be exposed to all shipments over the course of a year.
- A person in a car stopped at a railroad crossing while a 30-car train passes. This person was assumed to be 9 ft from the train.

For truck shipments of uranium mill tailings, the maximally exposed worker would be the driver, who would be exposed for 1,000 hours per year. The radiation dose rate for the driver was estimated to be 0.22 mrem per hour, or 0.13 mrem per hour for a vicinity property truck driver. For rail shipments, the maximally exposed worker would be an individual who inspected the loaded rail cars for 1,000 hours per year. This individual would be 3 ft from a railcar, and the radiation dose rate for this individual was estimated to be 0.44 mrem per hour. The inspector would inspect rail cars prior to departure from the Moab site or after arrival at the disposal site.

H2.0 Transportation Accident Impacts

The transportation accident analysis considers the impacts of accidents during the transportation of uranium mill tailings and contaminated material by truck or rail. Under accident conditions, impacts to human health and the environment may result from the release and dispersal of radioactive material. Transportation accident impacts have been assessed using accident analysis methods developed by the U.S. Nuclear Regulatory Commission (NRC 1977). In addition, the nonradiological impacts from transportation accidents involving traffic fatalities were evaluated.

Two types of analyses were performed for accidents involving the dispersal of uranium mill tailings and contaminated material. First, an accident risk assessment was performed that takes into account the probabilities and consequences of a spectrum of potential accident severities. For the spectrum of accidents considered in the analysis, accident consequences in terms of collective dose to the population within 50 miles were multiplied by the accident probabilities to yield collective dose risk using the RADTRAN 5 computer code (Neuhauser and Kanipe 2000, Neuhauser et al. 2000).

Second, to represent the maximum reasonably foreseeable impacts to individuals and populations should an accident occur, radiological consequences were calculated for an accident of maximum credible severity. An accident is considered credible if its probability of occurrence is greater than 1×10^{-7} per year (1 in 10 million per year). The accident consequence assessment for maximally exposed individuals and population groups was performed using the RISKIND computer code (Yuan et al. 1995).

The radiological impacts were calculated in units of dose (rem or person-rem). Impacts are further expressed as health risks in terms of estimated latent cancer fatalities in exposed populations.

H2.1 Transportation Accident Rates

Utah-specific accident rates and fatality rates taken from data provided in Saricks and Tompkins (1999) for rail and heavy combination trucks were used to estimate accident risks and consequences, and traffic fatalities. These rates are presented in Table H–2.

Table H–2. Utah-Specific Accident and Fatality Rates

Type	Mode	Accident Rate	Fatality Rate
State Highway	Truck	3.05×10^{-7} accidents/km	1.60×10^{-8} fatalities/km
Interstate	Truck	2.90×10^{-7} accidents/km	1.19×10^{-8} fatalities/km
Other	Truck	9.04×10^{-7} accidents/km	2.27×10^{-8} fatalities/km
Rail	Rail	5.87×10^{-8} accidents/railcar-km	2.54×10^{-8} fatalities/railcar-km

H2.1.1 Severity Categories, Conditional Probabilities, and Release Fractions

Transportation accidents have different severities and would result in the release of different amounts of uranium mill tailings or contaminated materials. Therefore, accidents are grouped into severity categories. Each severity category has a different conditional probability of occurrence and release fraction. In this analysis, the release fraction is the fraction of material released that is respirable. The respirable release fractions considered the large particle size of uranium mill tailings (45 to 75 µm for slimes and 75 to 500 µm for sands), with 10 µm as the upper bound for a respirable particle. The severity categories, conditional probabilities, and release fractions for truck and rail accidents are presented in Tables H–3 and H−4, respectively.

Table H–3. Severity Categories, Conditional Probabilities, and Respirable Release Fractions for Truck Accidents

Severity Category	Conditional Probability	Respirable Release Fraction
1	0.80	0.0
2	0.10	5.0×10^{-6}
3	0.05	2.5×10^{-5}
4	0.05	5.0×10^{-5}

Table H–4. Severity Categories, Conditional Probabilities, and Respirable Release Fractions for Rail Accidents

Severity Category	Conditional Probability	Respirable Release Fraction
1	0.60	0.0
2	0.20	5.0×10^{-6}
3	0.20	5.0×10^{-5}

H2.1.2 Shipment Inventories

Based on data from the Moab site, the average radium-226 (Ra-226) concentration in the uranium mill tailings was 516 picocuries per gram (pCi/g), and the density of the tailings was 1.6 grams per cubic centimeter (cm^3). In order to calculate the radionuclide inventory contained in a truck or train, it was assumed that Ra-226 was in secular equilibrium with its radioactive progeny. In addition, thorium-230 (Th-230) was assumed to be present in equilibrium with Ra-226. A 44-ton tandem truck was assumed to be used for truck shipments of uranium mill tailings. A 10-cubic-yard (yd^3) truck was assumed to be used for shipments from vicinity properties. A 100-ton gondola car was assumed to be used for rail shipments of uranium mill tailings. Table H–5 shows the estimated radionuclide inventories for truck and rail shipments.

Table H–5. Radionuclide Inventory in Uranium Mill Tailings Shipments

Radionuclide	Concentration (pCi/g)	Truck Inventory (Ci)	Railcar Inventory (Ci)	Vicinity Property Truck Inventory (Ci)
Th-230	516.00	0.021	0.047	0.0063
Ra-226	516.00	0.021	0.047	0.0063
Radon-222 (Rn-222)[a]	516.00	0.021	0.047	0.0063
Polonium-218 (Po-218)	516.00	0.021	0.047	0.0063
Lead-214 (Pb-214)	515.90	0.021	0.047	0.0063
Bismuth-214 (Bi-214)	516.00	0.021	0.047	0.0063
Polonium-214 (Po-214)	515.89	0.021	0.047	0.0063
Lead-210 (Pb-210)	516.00	0.021	0.047	0.0063
Bismuth-210 (Bi-210)	516.00	0.021	0.047	0.0063
Polonium-210 (Po-210)	516.00	0.021	0.047	0.0063

[a] Rn-222 through Po-210 are radioactive progeny of Ra-226.
Ci = curies; pCi/g = picocuries per gram.

H2.1.3 Atmospheric Conditions

Because it is impossible to predict the specific location of a transportation accident, generic atmospheric conditions were selected for the risk and consequence assessments. For the accident risk assessment, neutral weather conditions (Pasquill Stability Class D) were assumed. Neutral weather conditions are typified by moderate wind speeds, vertical mixing within the atmosphere, and good dispersion of atmospheric contaminants. For the accident consequence assessment, doses were assessed under neutral (Class D with 14.67-ft-per-second wind speed) atmospheric conditions.

H2.1.4 Exposure Pathways

Radiological doses were calculated for an individual located near the scene of the accident and for populations within 50 miles of the accident. Rural, suburban, and urban population densities were assessed. Dose calculations considered a variety of exposure pathways, including inhalation and direct exposure from the passing cloud (cloudshine), direct exposure from radioactivity deposited on the ground (groundshine), and inhalation of resuspended radioactive particles from the ground.

H2.1.5 Health Risk Conversion Factors

The following health risk conversion factors used to estimate latent cancer fatalities from radiological exposures were from the Interagency Steering Committee on Radiation Standards (DOE 2002): 6×10^{-4} and 5×10^{-4} latent cancer fatalities per person-rem for members of the public and workers, respectively. Although latent cancer fatalities are the predominant health risk associated with low-level radiation doses (that is, doses below the thresholds for acute effects), they are not the only potential detrimental health effect. Risks of other delayed health effects such as nonfatal cancers and hereditary effects should also be acknowledged. International Commission on Radiological Protection Publication 60 (ICRP 1991) has estimated that the total risk of detrimental health effects are 7.3×10^{-4} and 5.6×10^{-4} total detrimental health effects per person-rem for members of the public and workers, respectively.

H3.0 Shipments

For each alternative, there would be shipments of contaminated material from vicinity properties, uranium mill tailings, and borrow material. The borrow material would consist of cover soils, radon barrier soils, sand and gravel, riprap, and Moab site reclamation soils. The numbers of shipments are listed for each alternative in Tables H−6 through H−9. The distances for the shipments are listed in Table H–10.

Table H–6. Number of Shipments for the On-Site Disposal Alternative

Material	Truck Shipments
Vicinity property material	2,940
Borrow material	
Cover soils[a]	25,030
Radon barrier soils[b]	11,200
Sand and gravel[c]	4,200
Riprap[d]	6,363
Moab site reclamation soils[a]	9,670
Total	**59,403**

[a] Cover soils and reclamation soils were assumed to be from the Floy Wash borrow area.
[b] Radon barrier soils were assumed to be from the Klondike Flats borrow area.
[c] Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[d] Riprap was assumed to be from the Papoose Quarry borrow area.

Table H–7. Shipments for Klondike Flats Disposal Alternative

Material	**Truck Option**		**Rail Option**		**Slurry Pipeline Option**	
	Shipments	**Mode**	**Shipments**	**Mode**	**Shipments**	**Mode**
Vicinity property material	2,940	Truck	2,940	Truck	2,940	Truck
Borrow material						
Cover soils[a]	37,800	Truck	37,800	Truck	37,800	Truck
Radon barrier soils[b]	0		0		0	Truck
Sand and gravel[c]	6,538	Truck	6,538	Truck	6,538	Truck
Riprap[d]	1,973	Truck	1,973	Truck	1,973	Truck
Moab site reclamation soils[a]	12,875	Truck	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	3,840 2,188	Rail[e] Truck	2,188	Truck
Total	**330,926**		**68,154**		**64,314**	

[a] Cover soils and reclamation soils were assumed to be from the Floy Wash borrow area.
[b] Radon barrier soils were assumed to be from the Klondike Flats borrow area.
[c] Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[d] Riprap was assumed to be from the Papoose Quarry borrow area.
[e] Each rail shipment would consist of 30 rail cars of uranium mill tailings.

Table H–8. Shipments for Crescent Junction Disposal Alternative

Material	**Truck Option**		**Rail Option**		**Slurry Pipeline Option**	
	Shipments	**Mode**	**Shipments**	**Mode**	**Shipments**	**Mode**
Vicinity property material	2,940	Truck	2,940	Truck	2,940	Truck
Borrow material						
Cover soils[a]	0		0		0	
Radon barrier soils[a]	0		0		0	
Sand and gravel[b]	6,300	Truck	6,300	Truck	6,300	Truck
Riprap[c]	1,973	Truck	1,973	Truck	1,973	Truck
Moab site reclamation soils[d]	12,875	Truck	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	3,840 2,188	Rail[e] Truck	2,188	Truck
Total	**292,888**		**30,116**		**26,276**	

[a] Cover soils and radon barrier soils were assumed to be from the Crescent Junction borrow area.
[b] Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[c] Riprap was assumed to be from the Papoose Quarry borrow area.
[d] Reclamation soils were assumed to be from the Floy Wash borrow area.
[e] Each rail shipment would consist of 30 rail cars of uranium mill tailings.

Table H–9. Shipments for White Mesa Mill Disposal Alternative

Material	Truck Option		Slurry Pipeline Option	
	Shipments	**Mode**	**Shipments**	**Mode**
Vicinity property material	2,940	Truck	2,940	Truck
Borrow material				
Cover soils[a]	0		0	
Radon barrier soils[a]	0		0	
Sand and gravel[b]	6,300	Truck	6,300	Truck
Riprap[c]	1,973	Truck	1,973	Truck
Moab site reclamation soils[d]	12,875	Truck	12,875	Truck
Uranium mill tailings	268,800	Truck	2,188	Truck
Total	**292,888**		**26,276**	

[a] Cover soils and radon barrier soils were assumed to be from the White Mesa borrow area.
[b] Sand and gravel was assumed to be from the LeGrand Johnson borrow area.
[c] Riprap was assumed to be from the Papoose Quarry borrow area.
[d] Reclamation soils were assumed to be from Floy Wash borrow area.

Table H–10. Shipment Distances

Origin	Destination	Truck Distance (miles)[a]	Rail Distance (miles)[a]
Vicinity Properties	Moab	5.0	N/A
Moab	Klondike Flats	19	16
Moab	Crescent Junction	31	30
Moab	White Mesa Mill	85	N/A
Floy Wash borrow area	Moab	35	N/A
Klondike Flats borrow area	Moab	18	N/A
LeGrand Johnson borrow area	Moab	6.0	N/A
Papoose Quarry borrow area	Moab	28	N/A
Floy Wash borrow area	Klondike Flats	25	N/A
LeGrand Johnson borrow area	Klondike Flats	24	N/A
Papoose Quarry borrow area	Klondike Flats	53	N/A
LeGrand Johnson borrow area	Crescent Junction	39	N/A
Papoose Quarry borrow area	Crescent Junction	68	N/A
LeGrand Johnson borrow area	White Mesa Mill	91	N/A
Papoose Quarry borrow area	White Mesa Mill	10	N/A

[a] All distances are one-way distances.

H4.0 Results

H4.1 Transportation Impacts

H4.1.1 On-Site Disposal Alternative

Table H–11 lists the transportation impacts for the on-site disposal alternative. The transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site and shipping borrow materials. Borrow materials would consist of cover soils and reclamation soils shipped from the Floy Wash borrow area, radon barrier soils shipped from the Klondike Flats borrow area, sand and gravel shipped from the LeGrand Johnson borrow area, and riprap shipped from the Papoose Quarry borrow area. For this alternative, there would less than one fatality.

Table H–11. Transportation Impacts for the On-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.1E-3	8.1E-2	8.2E-2
Mill tailings	0	0	0	0	0	0
Total	2.7E-5	3.9E-5	6.9E-9	1.5E-3	8.2E-2	8.4E-2

LCFs = latent cancer fatalities

H4.1.2 Klondike Flats Off-Site Disposal Alternative

Table H–12 lists the transportation impacts for the Klondike Flats off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to Klondike Flats, and shipping borrow materials. Borrow materials would consist of cover soils shipped from the Floy Wash borrow area to Klondike Flats, reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to Klondike Flats, and riprap shipped from Papoose Quarry borrow area to Klondike Flats. For this alternative, there would less than one fatality.

Table H–12. Transportation Impacts for the Klondike Flats Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.6E-3	1.0E-2	2.0E-9	9.6E-5	2.6E-1	2.7E-1
Total	1.6E-3	1.0E-2	8.9E-9	1.4E-3	3.4E-1	3.5E-1
Rail option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.6E-5	1.6E-3	3.5E-9	6.1E-5	1.5E-1	1.5E-1
Total	4.3E-5	1.6E-3	1.0E-8	1.4E-3	2.3E-1	2.3E-1
Slurry option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	9.3E-4	8.1E-2	8.2E-2
Mill tailings	1.3E-5	8.4E-5	1.6E-11	7.8E-7	2.1E-3	2.2E-3
Total	4.0E-5	1.2E-4	6.9E-9	1.3E-3	8.4E-2	8.6E-2

LCFs = latent cancer fatalities

H4.1.3 Crescent Junction Off-Site Disposal Alternative

Table H–13 lists the transportation impacts for the Crescent Junction off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to Crescent Junction, and shipping borrow materials. Borrow materials would consist of reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to Crescent Junction, and riprap shipped from the Papoose Quarry borrow area to Crescent Junction. For this alternative, there would less than one fatality.

Table H–13. Transportation Impacts for the Crescent Junction Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.7E-3	1.7E-2	3.3E-9	1.6E-4	4.3E-1	4.5E-1
Total	2.7E-3	1.7E-2	1.0E-8	1.4E-3	4.7E-1	4.9E-1
Rail Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.7E-5	1.7E-3	6.5E-9	1.1E-4	2.9E-1	2.9E-1
Total	5.4E-5	1.7E-3	1.3E-8	1.4E-3	3.3E-1	3.3E-1
Slurry Option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	8.9E-4	4.2E-2	4.3E-2
Mill tailings	2.2E-5	1.4E-4	2.7E-11	1.3E-6	3.5E-3	3.7E-3
Total	4.9E-5	1.8E-4	6.9E-9	1.3E-3	4.7E-2	4.8E-2

LCFs = latent cancer fatalities

H4.1.4 White Mesa Mill Off-Site Disposal Alternative

Table H–14 lists the transportation impacts for the White Mesa Mill off-site disposal alternative. Transportation impacts would be from shipping contaminated materials from vicinity properties to the Moab site, shipping uranium mill tailings and vicinity property material from the Moab site to White Mesa Mill, and shipping borrow materials. Borrow materials would consist of reclamation soils shipped from the Floy Wash borrow area to the Moab site, sand and gravel shipped from the LeGrand Johnson borrow area to White Mesa Mill, and riprap shipped from the Papoose Quarry borrow area to White Mesa Mill. For this alternative, there would be about one fatality.

Table H–14. Transportation Impacts for the White Mesa Mill Off-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Truck option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.2E-3	5.3E-2	5.4E-2
Mill tailings	2.6E-2	4.9E-2	1.4E-6	6.7E-2	1.2E+0	1.3E+0
Total	2.6E-2	4.9E-2	1.4E-6	6.9E-2	1.3E+0	1.4E+0
Slurry option						
Vicinity properties	2.7E-5	3.9E-5	6.9E-9	3.7E-4	1.1E-3	1.5E-3
Borrow material	0	0	0	1.2E-3	5.3E-2	5.4E-2
Mill tailings	2.1E-4	4.0E-4	1.1E-8	5.4E-4	9.6E-3	1.1E-2
Total	2.4E-4	4.4E-4	1.8E-8	2.1E-3	6.4E-2	6.7E-2

LCFs = latent cancer fatalities

H4.2 Incident-Free Radiation Doses to Maximally Exposed Individuals

H4.2.1 On-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the on-site disposal alternative. For truck shipments of contaminated materials from vicinity properties to the Moab site, the maximally exposed transportation worker would be the driver of the truck. This person would receive a radiation dose of 26 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.3×10^{-5}.

For truck shipments of contaminated materials from vicinity properties to the Moab site, the maximally exposed member of the public would be a person who happened to be stuck in a traffic jam next to a truck containing contaminated materials. This person would receive a radiation dose of 0.084 mrem, which is equivalent to a probability of a latent cancer fatality of about 5.0×10^{-8}.

H4.2.2 Klondike Flats Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the Klondike Flats off-site disposal alternative. For truck shipments of mill tailings from Moab to Klondike Flats, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For rail shipments of mill tailings from Moab to Klondike Flats, the maximally exposed transportation worker would be an individual who inspected the rail cars. This person would receive a radiation dose of 440 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 2.2×10^{-4}. This also represents an upper bound on potential radiation impacts, because it assumes that the individual inspects rail cars for 1,000 hours per year, and includes no wait times, training times, etc.

Table H–15. Incident-Free Radiation Doses for the Maximally Exposed Individual Scenarios

Scenario	On-Site Disposal	Klondike Flats Disposal	Crescent Junction Disposal	White Mesa Mill Disposal
Truck				
Nearby resident (member of the public)	0.0058 mrem/yr (3.5E-9 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)	1.0 mrem/yr (6.3E-7 LCFs)
Individual in traffic jam (member of the public)	0.084 mrem/yr (5.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)	0.15 mrem/yr (9.0E-8 LCFs)
Driver (occupational)	26 mrem/yr (1.3E-5 LCFs)	220 mrem/yr (1.1E-4 LCFs)	220 mrem/yr (1.1E-4 LCFs)	220 mrem/yr (1.1E-4 LCFs)
Rail				
Nearby resident (member of the public)	N/A	0.53 mrem/yr (3.2E-7 LCFs)	0.53 mrem/yr (3.2E-7 LCFs)	N/A
Individual at railroad crossing (member of the public)	N/A	1.4E-6 mrem/yr (8.5E-13 LCFs)	1.4E-6 mrem/yr (8.5E-13 LCFs)	N/A
Inspector (occupational)	N/A	440 mrem/yr (2.2E-4 LCFs)	440 mrem/yr (2.2E-4 LCFs)	N/A

LCFs = latent cancer fatalities

For truck shipments of mill tailings from Moab to Klondike Flats, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

For rail shipments of mill tailings from Moab to Klondike Flats, the maximally exposed member of the public would also be a resident who lived along the rail line on which the tailings were shipped. This person would receive a radiation dose of 0.53 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 3.2×10^{-7}.

H4.2.3 Crescent Junction Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the Crescent Junction off-site disposal alternative. For truck shipments of mill tailings from Moab to Crescent Junction, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For rail shipments of mill tailings from Moab to Crescent Junction, the maximally exposed transportation worker would be an individual who inspected the rail cars. This person would receive a radiation dose of 440 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 2.2×10^{-4}. This also represents an upper bound on potential radiation impacts, because it assumes that the individual inspects rail cars for 1,000 hours per year, and includes no wait times, training times, etc.

For truck shipments of mill tailings from Moab to Crescent Junction, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

For rail shipments of mill tailings from Moab to Crescent Junction, the maximally exposed member of the public would also be a resident who lived along the rail line on which the tailings were shipped. This person would receive a radiation dose of 0.53 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 3.2×10^{-7}.

H4.2.4 White Mesa Mill Off-Site Disposal Alternative

Table H–15 lists the incident-free radiation doses for the maximally exposed individual scenarios for the White Mesa Mill off-site disposal alternative. For truck shipments of mill tailings from Moab to White Mesa Mill, the maximally exposed transportation worker would be the driver of the truck. This person was assumed to drive the truck containing mill tailings for 1,000 hours per year. For the other 1,000 hours per year, the truck would be empty. This driver would receive a radiation dose of 220 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-4}. This represents an upper bound to potential radiation impacts, because it includes no wait times, training times, etc.

For truck shipments of mill tailings from Moab to White Mesa Mill, the maximally exposed member of the public would be a resident who lived along the road on which the tailings were shipped. This person would receive a radiation dose of 1.0 mrem per year, which is equivalent to a probability of a latent cancer fatality of about 6.3×10^{-7}.

H4.3 Impacts from Severe Transportation Accidents

In addition to analyzing the radiological and nonradiological risks of transporting contaminated material from vicinity properties, shipping uranium mill tailings and vicinity property material from the Moab site, and shipping borrow materials, DOE assessed the consequences of severe transportation accidents, known as maximum reasonably foreseeable transportation accidents. These severe accidents have a probability of about 1×10^{-7} per year. The consequences of these accidents were determined through the inhalation, groundshine, and immersion pathways.

The following assumptions were used to estimate the consequences of maximum reasonably foreseeable accidents:

- The release height of the plume is 3.3 ft.
- The breathing rate for individuals is assumed to be 10,500 yd^3 per year.
- The short-term exposure to airborne contaminants is assumed to be 2 hours.
- The long-term exposure to contamination deposited on the ground is assumed to be 1 year for the maximally exposed individual and the population, with no interdiction or cleanup.
- The accident was assumed to occur in either a rural area or near Moab, Monticello, or Blanding.
- Impacts were determined using moderate wind speeds and neutral atmospheric conditions (a wind speed of 14.67 ft per second and Class D stability).
- The release fractions used in the analysis were for Severity Category 4 truck accidents or Severity Category 3 rail accidents (see Tables H−3 and H−4).
- The shipment inventories used in the analysis are listed in Table H–5.

H4.3.1 On-Site Disposal Alternative

The maximally exposed individual would receive a radiation dose of 4.8×10^{-5} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings from a vicinity property to the Moab site. This is equivalent to a probability of a latent cancer fatality of about 2.9×10^{-8}. The probability of this accident is about 4×10^{-4} per year. The population would receive a collective radiation dose of 5.6×10^{-4} person-rem from this accident, which is equivalent to a probability of a latent cancer fatality of about 3.3×10^{-7}.

H4.3.2 Klondike Flats Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to Klondike Flats, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.06 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.0018 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

If rail were used to transport the mill tailings from Moab to Klondike Flats, the maximally exposed individual would receive a radiation dose of 0.0014 rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 8.5×10^{-7}. The probability of this accident is about 0.3 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.017 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-5}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.7×10^{-5} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.6×10^{-8}.

H4.3.3 Crescent Junction Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to Crescent Junction, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.1 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.0018 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

If rail were used to transport the mill tailings from Moab to Crescent Junction, the maximally exposed individual would receive a radiation dose of 0.0014 rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 8.5×10^{-7}. The probability of this accident is about 0.5 per year.

If this accident occurred near Moab, the population would receive a collective radiation dose of 0.017 person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.0×10^{-5}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.7×10^{-5} person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.6×10^{-8}.

H4.3.4 White Mesa Mill Off-Site Disposal Alternative

If trucks were used to transport the mill tailings from Moab to White Mesa Mill, the maximally exposed individual would receive a radiation dose of 1.6×10^{-4} rem from the maximum reasonably foreseeable transportation accident involving a shipment of mill tailings, which is equivalent to a probability of a latent cancer fatality of about 9.6×10^{-8}. The probability of this accident is about 0.3 per year.

If this accident occurred near Moab, Monticello, or Blanding, the population would receive a collective radiation dose of 0.0018 person-rem, which is equivalent to a probability of a latent cancer fatality of about 1.1×10^{-6}. If this accident occurred in a rural area, the population would receive a collective radiation dose of 2.9×10^{-6} person-rem. This is equivalent to a probability of a latent cancer fatality of about 1.7×10^{-9}.

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