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Moab Site Project

Preliminary Plan For Remediation

DRAFT

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Acronyms

ACL	alternate concentration limit
Atlas	Atlas Minerals Corporation
BLM	Bureau of Land Management
CFR	Code of Federal Regulation
cfs	cubic feet per second
COPC	constituents of potential concern
DOE	U.S. Department of Energy
ECDC	East Carbon Development Corporation
EPA	U.S. Environmental Protection Agency
FEIS	Final Environmental Impact Statement
FTER	Final Technical Evaluation Report
ft	feet
ft^3	cubic feet
gal/min	gallons per minute
HLA	Harding Lawson Associates
in.	inches
LTSM	long-term surveillance and maintenance
MCL	maximum concentration limit
mg/L	milligrams per liter
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
pCi/L	picocuries per liter
pCi/g	picocuries per gram
PEIS	Programmatic Environmental Impact Statement
PMF	probable maximum flood
PSD	prevention of significant
RCRA	Resource Conservation and Recovery Act
SDWA	safe drinking water act
T&E	threatened and endangered
TDS	total dissolved solids
the act	Floyd D. Spence National Defense Authorization Act
UDEQ	Utah Department of Environmental Quality
UMTRCA	Uranium Mill Tailings Radiation Control Act
UMTRA	Uranium Mill Tailings Remedial Action (Project)
URC	Uranium Reduction Company
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service

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Executive Summary

The purpose of this document is to support a recommendation for determining the most appropriate long-term remediation approach for the Moab site as required by the Floyd D. Spence National Defense Authorization Act (the act). This document will be presented to the National Academy of Sciences (NAS) for review, and the Secretary of Energy will consider the NAS input before selecting an alternative.

The Moab site is a former uranium-ore processing facility located about 3 miles northwest of the city of Moab, in Grand County, Utah. The entire site encompasses approximately 400 acres, of which about 130 acres are covered by a mill tailings pile. Stakeholders have expressed concern about the effects of contaminants from the site on the Colorado River that borders the site. The act required the title of the property and responsibility for cleanup be transferred to the U.S. Department of Energy (DOE or department). The act further mandates remediation of the Moab site in accordance with Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA).

The "No Action" alternative was evaluated along with several on-site and off-site alternatives. The potential remedial alternatives evaluated in this plan consist of both mill tailings remediation and contaminated groundwater cleanup components:

<u>On-Site Alternatives</u>

- Cap-in-Place and Groundwater Treatment
- Solidification and Groundwater Treatment
- Soil Washing and Groundwater Treatment
- Vitrification and Groundwater Treatment

<u>Off-Site Alternatives</u>

- Off-Site Disposal
  - Relocated Site and On-Site Groundwater Treatment
  - East Carbon Development Corporation Site and On-Site Groundwater Treatment
  - Envirocare Site and On-Site Groundwater Treatment
- Off-Site Processing and On-Site Groundwater Treatment

An initial outline of the evaluation process for alternatives has been prepared. After an initial prescreening step, two alternatives were selected for more detailed evaluation. As part of DOE's refinement of the evaluation process, alternatives will be considered more specifically against the "No Action" baseline. The department will provide this next step in the preparation of the evaluation process to the NAS for their review as soon as possible.

Table ES–1. Evaluated Alternatives

Media	Alternative 1	Alternative 2
Mill tailings	Cap-in-place	Off-site disposal (relocated site)
Groundwater	Active treatment coupled with natural flushing	Active treatment coupled with natural flushing

The evaluation criteria for these alternatives were also organized according to risk/benefits and costs. Within these categories, the evaluation criteria are presented in a series of questions. The evaluation criteria are presented below:

Risk and Benefit Analysis

- Is the Alternative Protective of Human Health?
- Is the Alternative Protective of the Environment?
- What Are the Regulatory Consequences of This Alternative?
- Will This Alternative Be Effective in the Long Term?
- What Are the Short-Term and Technical Implementability Issues Associated With This Alternative?
- Will the Alternative Likely Be Acceptable to Stakeholders?

Cost Analysis

- What Is the Cost of the Alternative?

The selection of the remedial action alternative involves balancing risks, benefits, and costs along with being responsive to input from stakeholders affected by the decision. In the near term, both the cap-in-place and relocated site alternatives can be expected to perform equally well. A groundwater interim action will be performed for both options and it is assumed that this interim action will be successful in mitigating contaminants reaching the river. The most significant difference between the two alternatives in the near term is the lower estimated cost for the cap-in-place option as listed below:

Alternative	Estimated Capital Cost[a]	Net Present Value of the Estimated Annual Costs[a]
Cap-in-Place and Groundwater Cleanup	$113,700,000	$23,300,000
Off-Site Disposal and Groundwater Cleanup	$363,600,000	$23,200,000

[a]These costs do not include contingencies.

For the Moab site, considerable uncertainty regarding long-term performance of the stabilized pile and the long-term effect of the pile on groundwater quality is associated with the cap-in-place option. By removing the pile and disposing of the tailings off site, a stable disposal site can be selected to better guarantee cell performance; tailings can be placed in the cell in a manner that minimizes potential long-term hazards and maintenance requirements; and remediation of groundwater at the Moab site is simplified and has a greater likelihood of being successful.

At this point, DOE wants to ensure

1) There is a clear understanding of the risks the mill tailings pile places on the environment and human health.

2) The criteria used to evaluate the remediation alternatives compared to no action has a science base.

3) Any necessary data or analysis needed to make a sound evaluation of the current conditions, no action, and remediation alternatives are identified.

4) The evaluation of the current conditions, no action, and remediation alternatives has a scientific foundation.

DOE will not formally select a preferred alternative until after the NAS has completed their review. Thus, DOE is looking forward to working with the Academy as they conduct their review. It is expected that this will be an iterative process with DOE filling information gaps prior to the final report by the Academy.

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1.0 Background

The purpose of this document is to support a recommendation for determining the most appropriate long-term remediation approach for the Moab, Utah, site as required by the Floyd D. Spence National Defense Authorization Act (the act). This act requires that a remediation plan be prepared to evaluate "the costs, benefits, and risks associated with various remediation alternatives, including removal or treatment of radioactive or other hazardous materials at the site, groundwater restoration, and long-term management of residual contaminants." Upon completion, this draft plan will be presented to the National Academy of Sciences (NAS) for review in accordance with requirements of the act. NAS will then be responsible for providing "technical advice, assistance, and recommendations" for remediation of the Moab site. The Secretary of Energy will consider comments to this draft provided by NAS before selecting an alternative. If the Secretary does not concur with the recommendations of NAS, the Secretary must submit a report to Congress explaining the reasons for deviation from NAS recommendations.

In preparing this document, the U.S. Department of Energy (DOE) did not perform any characterization or modeling activities. The information in this document was extracted from existing documentation, particularly the U.S. Nuclear Regulatory Commission's (NRC's) 1999 Final Environmental Impact Statement (FEIS) (NRC 1999a) and the Moab Trustee Report of the hydrogeologic and geochemical characteristics of the site (Shepherd Miller, Inc. 2001). In reviewing existing documentation in preparation of this report, DOE noted technical inconsistencies and data gaps among the references used. Future work on this project will need to clarify significant discrepancies and be supported by additional characterization and monitoring studies.

1.1 Site History

The Moab site is a former uranium-ore-processing facility located about 3 miles northwest of the city of Moab in Grand County, Utah (Figures 1–1 and 1–2), and lies on the west bank of the Colorado River at the confluence with Moab Wash.

The Moab site is irregularly shaped and encompasses approximately 400 acres; a 130-acre uranium mill tailings pile occupies much of the western portion of the site. The Moab site is bordered on the north and southwest by steep sandstone cliffs. The Colorado River forms the southeastern boundary of the site. U.S. Highway 191 parallels the northern site boundary, and State Highway 279 parallels the southwestern boundary. The entrance to Arches National Park is located less than 1 mile northwest of the site across U.S. Highway 191; Canyonlands National Park is about 12 miles to the southwest. The Union Pacific Railroad traverses a small section of the site just west of State Highway 279, then enters a tunnel and emerges several miles to the southwest. Moab Wash runs northwest to southeast through the center of the site and joins with the Colorado River. The wash is an ephemeral stream that flows only after precipitation or during snowmelt. Figure 1–2 shows major site features. The map in Figure 1–2 was completed in 1983; the majority of on-site buildings have since been demolished and the on-site tailings were consolidated. However, contamination is still present in many areas of the site.

Originally, the property and facility were owned by the Uranium Reduction Company (URC) and were regulated by the U.S. Atomic Energy Commission, predecessor agency to DOE. In

1956, URC began operation of the Moab mill. In 1962, the Atlas Minerals Corporation (Atlas) acquired URC and operated the mill until operations ceased in 1984. Between 1956 and 1984, uranium mill tailings were disposed of on site in an unlined impoundment. Decommissioning of the mill began in 1988, and an interim cover was placed on the tailings impoundment between 1989 and 1995. In 1996, Atlas proposed to reclaim the tailings pile for permanent disposal in its current location. Atlas declared bankruptcy in 1998 and subsequently the NRC appointed PricewaterhouseCoopers as the Trustee of the Moab Mill Reclamation Trust and licensee for the site. Appendix A, "Moab Site History, Background, and Chronology," provides a more detailed description of the site history.

Stakeholders have expressed concern about the effects of contaminants from the site on the Colorado River. These stakeholders include environmental groups and agencies, as well as downstream users of Colorado River water. The FEIS completed for the site received numerous comments both in favor of and opposed to the proposed action of cap-in-place (NRC 1999a).

1.2 Requirements of the Floyd D. Spence National Defense Authorization Act

Remediation of the Moab site is mandated by the act for Fiscal Year 2001 (House of Representatives 2000). The act specifies that the license issued by NRC for the materials at the Moab site be terminated and that the title and responsibility for cleanup be transferred to DOE. The act further designates that the Moab site undergo remediation in accordance with Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 *United States Code* [U.S.C.] 7912), with certain exemptions. Under Title II of UMTRCA, the licensee proposed cap-in-place as the preferred means for reclamation of the mill tailings and tailings-contaminated material. NRC was required only to review the licensee's proposed alternative. Because of the requirements of the act, DOE must consider a wider range of alternatives for site remediation, including treatment and off-site disposal. Therefore, the act has widened the scope of alternatives that require evaluation.

UMTRCA regulations consist of Subparts A, B, and C, as promulgated by the U.S. Environmental Protection Agency (EPA), and set standards for both disposal and cleanup of residual radioactive materials and cleanup of associated contaminated groundwater. Remediation of the Moab site must conform to these requirements. The development of a plan for remediation was also a requirement of the act. This document fulfills that purpose.

Although required by the act, discussions on how to transfer all responsibilities and title efficiently and legally to the Moab site from the Trustee of the Moab Mill Reclamation Trust to DOE will not be addressed in this document.

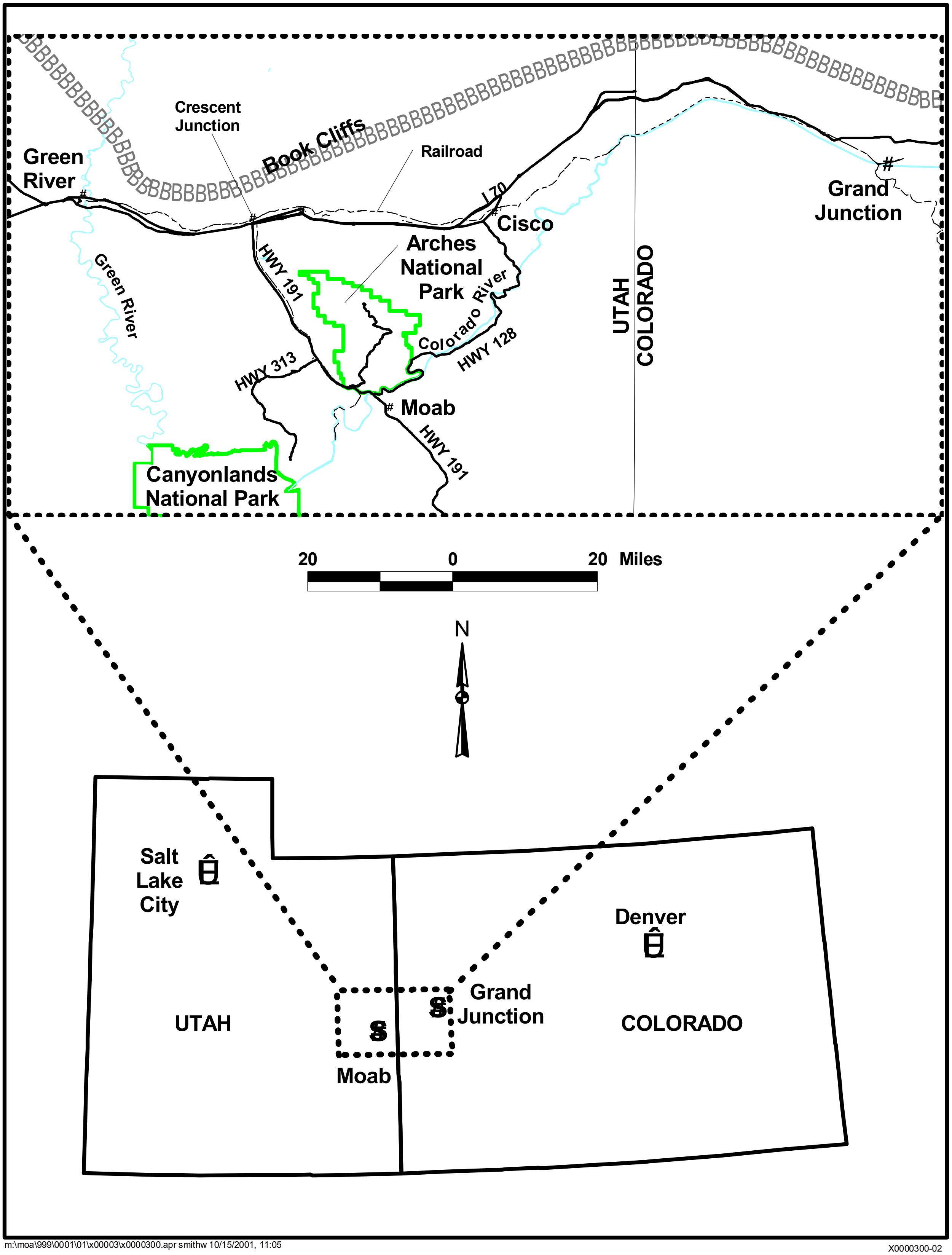

Figure 1–1. Regional Location Map

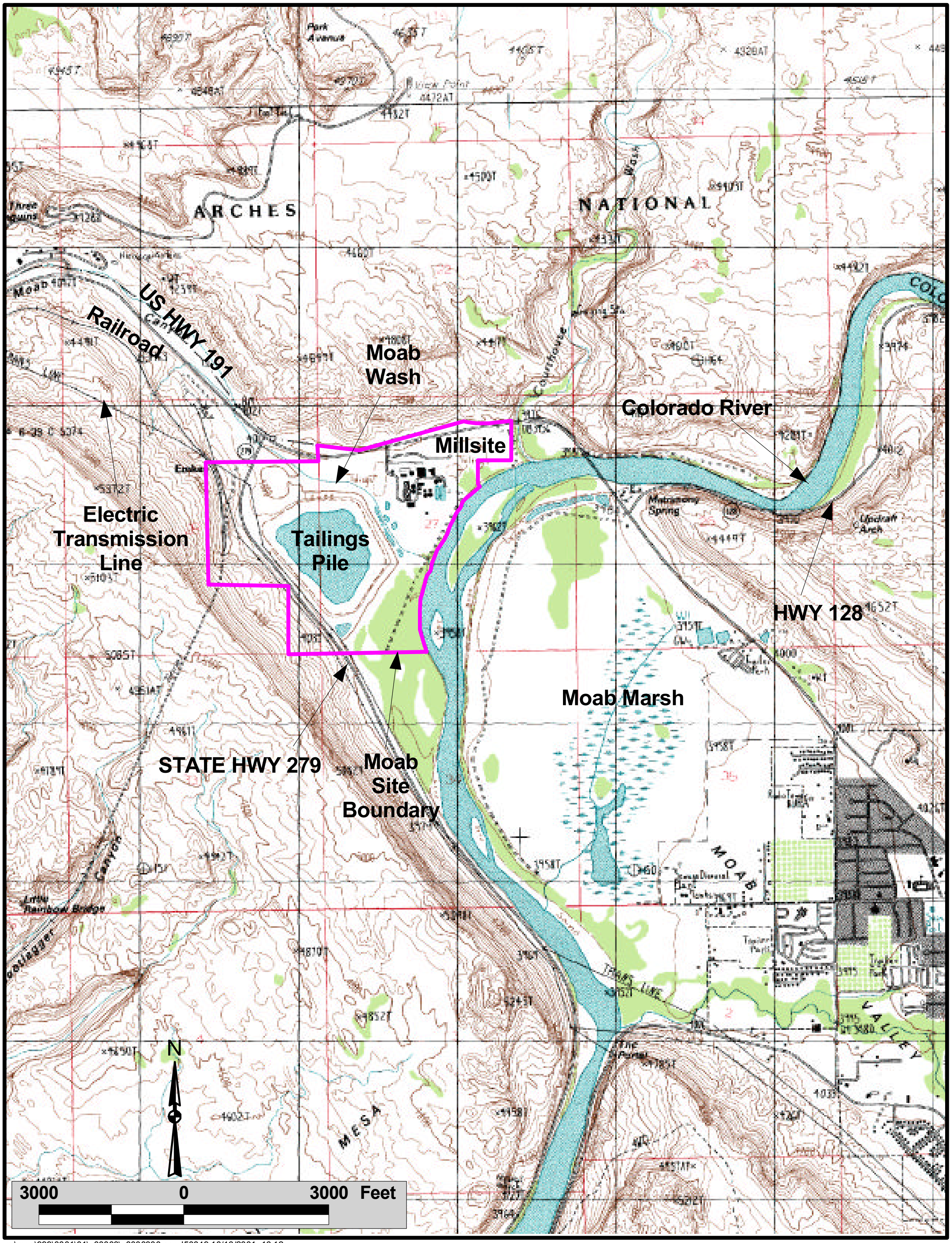

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Figure 1–2. Moab Site and Surrounding Area

1.3 Remediation Alternative Framework

This section provides descriptions of the major regulatory drivers that are applicable to the remedy selection process for the Moab site. Section 3.0, "Evaluation Criteria," includes regulations that are alternative specific. All on-site and off-site remedial activities must comply with applicable federal, state, and local environmental requirements. Appendix B, "Moab Remedial Action Selection Process," contains a draft flow chart that presents the Moab remedial action selection process.

The U.S. Congress passed UMTRCA in 1978 in response to public concerns about potential health hazards from long-term exposure to uranium mill tailings. UMTRCA authorized DOE to stabilize, dispose of, and control uranium mill tailings and other contaminated materials at inactive uranium-ore-processing sites in a safe and environmentally sound manner. Title I of UMTRCA designates inactive processing sites for remediation and stipulates that remedial action be selected and performed with the concurrence of NRC and in consultation with the states and Indian tribes; directs NRC to license the disposal sites for long-term care; and directs DOE to enter into cooperative agreements with the affected states and Indian tribes. Under Title I, affected states are required to provide a 10 percent cost share for remedial actions. However, the act exempts the cooperative agreement participation of the state and its cost-share requirements for the Moab site. As directed by UMTRCA, EPA published Title 40 *Code of Federal Regulations* (CFR) Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings." The standards in 40 CFR 192, Subparts A, B, and C, apply to the remediation and final disposition of contaminated materials at the Moab site and are included in Appendix C, "40 CFR 192."

The Subpart A disposal standards for control of residual radioactive material are design based with specific performance requirements; disposal of residual radioactive material must be reasonably effective for up to 1,000 years (and a minimum of 200 years), limit release of radon-222 to the atmosphere, and provide groundwater protection. Numerical standards are provided for radon-222 releases to the atmosphere and for groundwater protection. Corrective actions are required within an 18-month period if contaminant concentrations in groundwater at disposal sites exceed the groundwater protection standards. Provisions in 40 CFR 192 also allow for the application of supplemental standards and alternate concentration limits for groundwater contaminants based on site-specific circumstances.

The Subpart B standards for cleanup provide numerical standards for cleanup of residual radioactive material based on concentrations of radium-226 in surface materials (e.g., soils) and for exposure to radiation in buildings. Groundwater cleanup standards are the same as the protection standards specified in Subpart A. In addition to active remediation, natural flushing is an acceptable means of meeting the standards if they can be met within 100 years and if enforceable institutional controls can be put in place during this time.

Subpart C of 40 CFR 192 provides guidance for implementing Subparts A and B. Subpart C requires that standards are met on a site-specific basis using information gathered during site characterization and monitoring. A remedial action plan is required to demonstrate how requirements of Subparts A and B are to be met. Criteria are also presented for determining the applicability of supplemental standards.

During the Uranium Mill Tailings Remedial Action (UMTRA) Project, DOE prepared site-specific National Environmental Policy Act (NEPA) documentation (either an environmental assessment or an Environmental Impact Statement) for each Title I uranium-processing site to address surface remediation at the site (i.e., cleanup of tailings, residual processing materials, soil, and buildings).

NEPA requirements for surface remediation of the Moab site must also be met. These requirements have been met, in part, by the FEIS (NRC 1999a). The alternatives evaluated in the FEIS included cap-in-place (the Atlas proposal and preferred alternative), disposal at an alternate site (specifically the Plateau site) and No Action. Alternatives were evaluated based on potential impacts to air quality, land use, soils, groundwater, surface water, aquatic ecology (including threatened or endangered (T&E) species), terrestrial ecology (including T&E species), wetlands, human populations, economic resources, aesthetics and recreation, public services and infrastructure, historic and cultural resources, radiological impacts, environmental justice, and costs.

Additional alternatives for surface remediation are discussed in this plan for remediation using criteria similar to those required for a NEPA alternatives evaluation. Additional evaluations needed to satisfy NEPA requirements will be prepared at a later date (see Appendix B, "Moab Remedial Action Selection Process").

In 1994, DOE drafted the *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS), which was made final in 1996 (DOE 1996). The purpose of the PEIS was to present an analysis of the potential negative and positive effects of implementing four programmatic alternatives for groundwater compliance at the designated processing sites. The preferred alternative for the UMTRA Ground Water Project was published in a Record of Decision in 1997. All subsequent actions on the UMTRA Ground Water Project comply with the Record of Decision.

The PEIS framework used to determine the appropriate groundwater compliance strategies for groundwater cleanup at Title I sites is presented in greater detail in Section 2.0, "Remediation Alternatives," and Appendix D. "Groundwater Compliance Strategy," in this document. The framework takes into consideration risks (human health and environmental), costs, and stakeholder input. The decision framework is designed to maximize benefits of conducting groundwater cleanup. Therefore, this framework satisfies the requirements of UMTRCA in the selection of a groundwater compliance strategy for the Moab site. This framework is applicable regardless of the remedy selected for surficial materials. Three major options are provided for achieving compliance with groundwater standards: no remediation, natural flushing, or active remediation or some combination of the three. The standards that may be met include background, maximum concentration limits (MCLs), as stipulated in 40 CFR 192, Subpart A; alternate concentration limits (ACLs), or supplemental standards. The applicable standards are determined on a site-specific basis.

Though not directly providing guidelines for remediation alternative selection, the Endangered Species Act is an important regulatory driver for the remediation of the Moab site. Section 7 of the Environmental Species Act requires that every federal agency, in consultation with the Secretary of Interior, represented by the U.S. Fish and Wildlife Service [USFWS], ensures that any action authorized by that agency is not likely to jeopardize the continued existence of any listed, threatened, or endangered species or its habitat. The USFWS has determined that consultation is required because of the presence of Environmental Species Act-listed species and -designated critical habitat.

DOE recognizes that the regulatory drivers described above are not comprehensive, but they are the regulations most significant to remediation alternative selection within the context of this plan. Other federal and state requirements, such as regulations, executive orders, guidance, and DOE orders, will require evaluation for applicability depending upon the scope of interim or final remedial actions.

1.4 Current Site Conditions

During its 28 years of operation, the mill accumulated an estimated 10.5 million tons of uranium mill tailings in an unlined impoundment in the floodplain of the Colorado River. The tailings pile covers approximately 130 acres, is about 0.5 mile in diameter, averages about 94 feet (ft) in height above the surface of the Colorado River terrace, and is located about 750 ft west of the Colorado River. Contaminated surface material at the site includes mill tailings in the tailings pile as well as soils contaminated from windblown tailings or past disposal practices. The tailings in this pile are the major focus of remediation activities.

The pile consists of an outer compact embankment of coarse tailings, an inner impoundment of both coarse and fine tailings, and an interim cover of soils taken from the site outside the pile area. The pile has five embankments, or terraces, that were raised to their present elevation of 4,076 ft above mean sea level after a 1979 license renewal. Debris from dismantling the mill buildings and associated structures has been placed in an area at the southern toe of the pile and covered with contaminated soils and fill (NRC 1999a).

A geotechnical, geochemical, and hydrologic investigation of the tailings impoundment was conducted by Steffen Robertson and Kristen (SRK 2000) on behalf of the site Trustee. The results of the investigation indicated that the center of the tailings pile remains saturated. In order to dewater and consolidate the pile, vertical band drains, also called wicks, were installed to within approximately 10 feet of the bottom of the tailings on roughly 3 meter centers over most of the impoundment surface. The surface of the tailings was surcharged with impacted surface soils excavated from the mill site and materials from the regrading of the impoundment side slopes. This surcharging caused increased pore water pressure in the tailings that allows tailings water to flow up the band drains to the surface of the tailings for subsequent evaporation (SMI 2001).

Less surcharge was placed on the tailings than originally planned, resulting in slower consolidation rates and less water being brought to the surface of the impoundment than anticipated. To date, no as-built survey of the existing tailings surface configuration is available. Therefore, it is not known how much surcharging was placed on the tailings or how much water has been brought to the surface (SMI 2001). No accurate estimate of the amount of water brought to the surface by the band drains has been made. The tailings water is ponded on the surface of the impoundment and is in communication with the band drains, decreasing the effectiveness of the band drains for dewatering (SMI 2001). Dewatering continues today, though at a slower rate than previously.

A radiological survey of site soils outside the tailings area was completed by Harding Lawson Associates (HLA) during the summer of 2000 (HLA 2000). The objective of the survey was to identify the extent of soil contamination exceeding applicable radiological cleanup criteria. Results of the survey indicated that radium-226 concentrations over a large portion of the site exceeded the cleanup criterion for surface soils of 7.5 picocuries per gram (pCi/g) (5.0 pCi/g plus background). The final environmental impact statement for the site (NRC 1999a) estimated that an additional 0.8 million tons of surface soils and subpile soils will also require removal to meet radiologic cleanup standards.

If the selected remedial option requires excavation of the tailings pile, another 0.6 million tons of clean fill material placed on top of the pile will also be included as part of the remediation effort. On the basis of experience in cleanup of other mill tailings sites, estimated amounts of materials requiring remediation probably represent a minimum.

Besides radiologically contaminated tailings and soils, surface contamination includes a variety of disposal ponds used during processing activities, trash disposal trenches, and other features used for waste management during mill operation. Chemicals present in these areas may include barium chloride, lithium fluoride, sodium fluoride, and organic solvents based on knowledge of past practices (SMI 2001). Some of these former ponds have been cleaned up to some degree or another; others have simply been backfilled (SMI 2001). Leftover chemicals from ore processing are still stored on-site, evidence of PCB spills from transformers exists, and, based on the time of their construction, on-site building materials very likely contain asbestos.

Groundwater in the shallow alluvium at the site has also been contaminated by uranium milling operations. Constituents of potential concern (COPCs) based on analytical information from several reports are ammonia, manganese, molybdenum, nitrate, selenium, sulfate, uranium, and vanadium (Shepherd Miller, Inc. 2001). Some uncertainties associated with the list exist because historical sampling has not been consistent with regard to location of sampling points, selection of analytes, and sampling depths in the aquifer. This list may be modified after DOE completes a baseline risk assessment. The estimated distribution of COPCs in the vicinity of the Moab site is based on existing characterization data and is reported in several documents (Shepherd Miller, Inc. 2001; NRC 1999a, 1999b; ORNL 1998). Site-related contamination is generally confined to areas east and southeast of the site, though on-site data are minimal. NRC concluded that tailings contamination has affected only a limited area of off-site adjacent property between the millsite and the Colorado River. Off-site contaminant migration at the southwest hydraulically downgradient corner of the site is unlikely (although not yet confirmed) because of the naturally occurring brine in the shallow alluvial aquifer that acts as a density barrier to groundwater flow from the Moab site (NRC 1997).

Most of the groundwater characterization to date has focused on discharge of ammonia to the Colorado River. Shepherd Miller, Inc. estimated that approximately 800,000,000 gallons of groundwater would require remediation to reduce ammonia concentrations to acceptable levels (Shepherd Miller, Inc. 2001). Remediation of additional COPCs has not been addressed. Table 1–1 presents a summary of site-related groundwater quality and provides the UMTRCA MCLs for comparison.

Surface water in the adjacent Colorado River has been extensively sampled by Atlas, the State of Utah, and Shepherd Miller, Inc. (Shepherd Miller, Inc. 2001). The primary site-related COPC in surface water is ammonia, which potentially affects endangered species in the river. Additional constituents, particularly uranium and manganese, are also elevated in surface water samples. Alternatives for remedial actions to decrease contaminant levels in the river were discussed in the Shepherd Miller, Inc., report and will be evaluated for implementation in fiscal year 2002 (Shepherd Miller, Inc. 2001).

Table 1–1. UMTRCA Groundwater Standards and Water Quality Summary for Inorganic Constituents in Groundwater Samples at and Downgradient of the Moab Site (mg/L)

Constituent	MCL[a]	Background (average)	Tailings Pore Fluids	Millsite Groundwater	Downgradient Groundwater
Arsenic	0.05	--	--	--	--
Barium	1.0	--	--	--	--
Cadmium	0.01	--	--	0.003	0.007
Chromium	0.05	--	--	--	--
Lead	0.05	--	--	--	--
Mercury	0.002	--	--	0.001	0.003
Molybdenum	0.10	0.025	10.8	1.73	10.11
Nitrate (as N)	10	10.3	181	152	744
Selenium	0.01	0.011	--	0.024	0.11
Silver	0.05	--	--	--	--
Radium-226+228	5[b]	--	--	--	--
Uranium-234+238	0.044	0.026	3.97	23.3	6.11
Gross alpha	15[b]	--	--	--	1,570
Ammonia		0.145	297	511	4,220
Chloride		3,380	2,150	7,460	67,800
Manganese		0.019	8.06	5.27	12.33
Nickel		0.015	--	0.03	0.06
Sodium		2,030	3,020	6,850	34,600
Sulfate		992	4,910	15,300	29,000
Total dissolved solids		7,090	--	13,700	107,000
Vanadium		0.011	0.015	0.40	0.217

[a]UMTRCA MCL; MCL for uranium of 30 picocuries per liter (pCi/L) is equal to 0.044 milligram per liter (mg/L) if U-234 and U-238 are in equilibrium.
[b]pCi/L (picocuries per liter).
NOTE: Site-related water quality concentrations are based on the maximum result of a sample from any monitor well from any date from any depth.

References to ammonia concentrations actually refer to concentrations of ammonia (NH_3, un-ionized) plus ammonium (NH_4^+, ionized). Though ammonium is the dominant species present, these compounds are generally referred to as ammonia or total ammonia. The EPA ambient water quality criteria for ammonia (EPA 1999) are based on total ammonia expressed as N and are referred to as "total ammonia nitrogen." Past documentation for the Moab site did not consistently note how ammonia/ammonium was being reported. Any future analyses performed for the site in support of cleanup will specify exactly what is being reported.

Additional description of the Moab site can be found in Section 4.0.

1.5 Plan Organization

Section 2.0, "Remediation Alternatives," of this plan presents descriptions of the remedial approaches to be evaluated. Alternatives will be developed to address mill tailings and associated materials (e.g., contaminated soils) and to address groundwater restoration. It also prescreens alternatives to eliminate those not considered viable. Section 3.0, "Evaluation Criteria," presents the criteria that will be used in evaluating the identified alternatives. Section 4.0, "General

Descriptions," presents background information on the alternatives that passed the prescreening. Section 5.0, "Evaluation of Alternatives," contains a comparison of alternatives. A summary is presented in Section 6.0. This plan is intended to be a summary-level document. References to more detailed reports are provided and some supporting documentation is included in the appendices.

Data provided in this document for evaluation of alternatives (such as costs) are intended for use in a relative comparison only. Additional details and updated cost estimates will be developed at a later time when a specific alternative is selected.

2.0 Remediation Alternatives

This section presents descriptions of the remediation alternatives for the tailings pile and contaminated groundwater at the Moab site. It also screens from further consideration the least viable options or alternatives using prescreening criteria based on risks, benefits, and costs.

2.1 Mill Tailings Remediation Alternatives

The mill tailings remediation alternatives were organized into two categories: on site (Section 2.1.1) and off site (Section 2.1.2); the no action alternative was also evaluated. The following four on-site alternatives were evaluated: 1) cap-in-place, 2) solidification, 3) soil washing, and 4) vitrification. The four off-site alternatives include: 1) transport and disposal at a relocated site in a new disposal cell, 2) transport of the tailings to the Envirocare of Utah, Inc., facility near Salt Lake City, Utah, for disposal, 3) transport of the tailings to the East Carbon Development Corporation (ECDC) in Carbon County, Utah, for disposal, and 4) off-site processing of the tailings at the White Mesa Mill near Blanding, Utah. Appendix E, "Disposal Cell Components," presents UMTRA Project disposal cell design criteria that would apply to the construction of the cap-in-place, the on-site treatment options, and the off-site disposal alternatives.

2.1.1 No Action

The no-action alternative assumes all further work at the site would cease and the site would remain uncontrolled in its current condition. No further characterization of the site would take place. Dewatering and consolidation of the tailings pile through the currently existing system of vertical band drains would continue, but no maintenance or monitoring would occur. Contaminated soils on the pile and elsewhere on site would remain exposed at the surface. No dust control measures would be taken to prevent airborne releases of contaminated tailings or soil. No cleanup of other chemical contamination or building decommissioning would occur. No actions would be taken to remediate groundwater or prevent discharge of contaminated groundwater to the Colorado River. Elevated levels of ammonia and other chemicals would continue to be present in the river. No controls would be put in place to prevent erosion of the tailings pile by high stages of the Colorado River or by flooding of Moab Wash. No institutional controls would be placed on the site and unrestricted access by the general public could occur; no restrictions would be placed on groundwater useage.

2.1.2 On-Site Alternatives

The on-site alternatives evaluated in this section are cap-in-place, solidification, soil washing, and vitrification.

Cap-in-Place

For purposes of this document, the cap-in-place remedy alternative for permanent disposal is similar to the proposed action identified in the FEIS (NRC 1999a). For cost estimating purposes, DOE has slightly modified the FEIS design by increasing the moisture storage layer and adding a radon barrier to the side slopes. The cap-in-place alternative involves consolidating all contaminated soils and stabilizing the 130-acre tailings pile in place in an above-grade disposal cell at its current location on the Moab site (see Figure 1–2). The edge of the existing tailings pile is approximately 750 ft west of the Colorado River. Disposal cell grading would follow the configuration specified in the FEIS.

A detailed description of the geology of the Moab site is available in the FEIS and in the Final Technical Evaluation Report (FTER) (NRC 1997) and a summary is provided in Section 4.0, "General Site Descriptions." The additional geological information presented in this section is directly relevant to design and performance of an on-site disposal cell.

The Moab site is underlain by Quaternary alluvium and colluvium and is located near the northwest end of a collapsed salt-anticline in the Moab–Spanish Valley of the Paradox Basin. Located approximately 1,100 ft west of the site is the Poison Spider Mesa that creates a high escarpment. No Quaternary sinkholes or other Quaternary subsidence features are evident in the Moab–Spanish Valley near Moab.

The Moab Fault trace, which likely runs beneath the pile on the Moab site, is believed to be the surface expression of the salt-anticline in the Moab–Spanish Valley. The probability of experiencing a strong seismic earthquake cannot be predicted with any degree of confidence. However, a probabilistic seismic hazard analysis produces a return interval of 10,000 years for a strong earthquake. This figure is somewhat plausible because of the numerous balanced rocks in the region, which imply that earthquake occurrences are rare.

Displacement along the Moab Fault has been a combination of salt collapse and crustal rifting that has resulted from salt upwelling (salt diapirism). Faults of the Moab fault system are not capable faults as defined in 10 CFR 100, "Reactor Site Criteria," Appendix A. No surface evidence exists of movement within the last 35,000 years or evidence that movement has occurred at least twice in the last 500,000 years (NRC 1997).

In addition, no seismic record exists of movement associated with the Moab Fault or evidence that the Moab Fault is structurally connected to a significant seismological source that would render the Moab Fault significantly seismological (Wong and Humphrey 1989; Wong et al., 1996; Woodward–Clyde, 1996). Nevertheless, faults of the Moab system are considered potential hazards because they are in positions that may affect the pile should they slip in response to differential subsidence (NRC 1997).

Surface soils surrounding the site are predominately sands mixed with clays, silts, and gravels. Soil erosion gullies and soil pipes have not been observed. Depth to groundwater varies from 15 to 50 ft below ground surface. Soils in the saturated zone are subject to liquefaction when shaken. Soil liquefaction requires a shaking motion, and since seismic events are not expected at the site, soil liquefaction is not likely.

A probable maximum flood (PMF) of 300,000 cubic feet per second (cfs) for the Colorado River is reported in the FEIS. A hydrologic analysis performed on the river indicates that the river level during the PMF would rise to a height of 29 ft on the side slope of the tailings pile. However, the greatest recorded flood is reported to be approximately 70,000 cfs. Floodplain boundaries (100- year, 200-year, 500-year, and PMF) have not been determined.

Construction support facilities would be required at the Moab site and would partially consist of field office trailers, decontamination facilities, access control fencing, material laydown yard, construction water supply, and an equipment maintenance yard. Storm water runoff control features would be constructed before any excavation and would be maintained for the duration of construction. Tailings adjacent to the pile would be excavated and consolidated on the pile. Soil that was placed on top of the pile to aid in the pile-dewatering project would be left in place and covered as part of the pile.

The cover proposed in the FEIS is slightly modified in this document to address NRC concerns published in the FTER (NRC 1997). Concerns were raised about the suitability of the proposed cover design to limit infiltration to levels that are protective of groundwater. To address this issue, a 5-ft-thick soil protective layer has been added to the conceptual design. This layer would cover both the top slope and side slopes, would act as a “sponge” and store excess infiltrated moisture, would provide a rooting medium for volunteer plant establishment, and would protect the barrier layer from desiccation by evaporation and root intrusion. The radon barrier thickness was also changed to a uniform compacted 1 ft for construction ease. These assumptions are for the purposes of this report only; this modification is consistent with DOE (1989), which allows some design modifications based on site-specific considerations. The final design will meet the requirements of disposal cells under UMTRCA/EPA Project standards.

Under the cap-in-place alternative, an above-grade disposal cell would be constructed as shown on Figure 2–1. Side slopes of the existing pile would be recontoured to 33 percent grade, that is, 3 horizontal to 1 vertical (3H:1V). The top slope would slope slightly down and inward toward the middle and the northwest, promoting collection of surface runoff and drainage to Moab Wash. Surface runoff from the top of the pile would be routed into several collection ditches leading to a drainage channel terminating at Moab Wash. The cover system would be constructed on the regraded tailings as shown on Figure 2–1. The cover system would use a 1-ft-thick basal clay radon/infiltration barrier overlain by a 5-ft soil-protective layer, covered with a rock erosion-protection layer. Gravel and cobbles would make up the surface on the top slope, and large angular riprap would protect the side slopes.

Moab Wash would be rechanneled to run through the former millsite area. The reconfigured channel would discharge into the river upstream at the current discharge point. An inner channel would be designed to carry runoff for an approximate 200-year flood. Flood protection along the base of the pile would protect it from more significant floods. Material excavated during construction of the reconfigured channel would be used as cover material for the pile, and any material identified as contaminated would be placed on the tailings pile before the cover was installed.

Construction water needed for compaction and dust control would be taken from the river using existing Colorado River water rights. Water would be pumped out and stored in tanks until needed; however, limitations may be placed on quantities withdrawn because of potential negative effects to endangered species.

When the disposal cell is completed, the area outside of the cell would be reclaimed by recontouring and revegetating where needed to limit erosion, and eventually these areas would be released for use with minimal surface restrictions. A minimum of 6 inches (in.) of soil covering would be placed over the entire site to meet the 40 CFR 192 subsurface soil standards of 15 pCi/g radium-226 (the standards apply regardless of future land use). The cell would be protected by a security chain-link fence around its perimeter. All construction support facilities and temporary storm drainage facilities would be removed. Table 2–1 presents proposed sources and estimated quantities of construction materials.

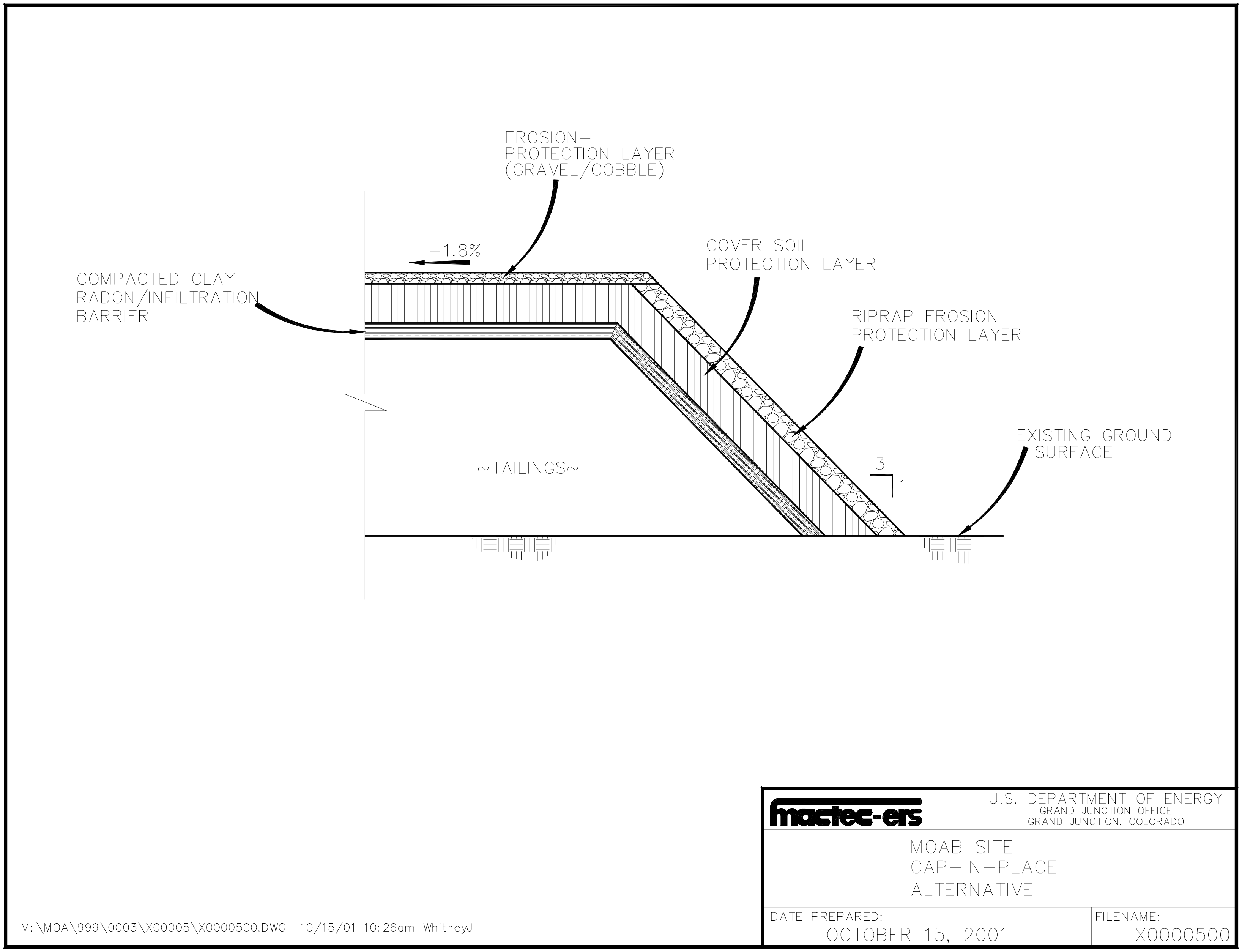

Figure 2–1. Moab Site Cap-in-Place Alternative

Table 2–1. Cap-in-Place Materials List

Material	Estimated Quantity	Proposed Source	Approximate Distance (one way)	Transportation Method
Clay barrier layer	240,000 yd^3	Klondike Flats	21 miles	Truck
Soil-protection layer	1,100,000 yd^3	On-site and Klondike Flats	0 mile and 21 miles	Truck
Rock – Erosion protection; top slope	42,000 yd^3	Spanish Valley commercial pit	10 miles	Truck
Rock – Erosion protection; side slope	47,000 yd^3	Kane Creek site (potash)	18 miles	Rail

<u>Schedule</u>

Complete construction for cap-in-place is anticipated to take a total of 4 years. The construction activities that would be completed each year at the Moab site are listed below:

Year 1
- Construct storm water controls
- Provide temporary construction facilities
- Excavate adjacent pile soils
- Dewater pile

Year 2–3
- Place cover on pile

Year 3
- Backfill adjacent excavated areas

Year 4
- Revegetate site
- Remove temporary construction facilities
- Construct fences

Solidification

This alternative involves adding a stabilizing reagent to a soil or sediment. The reagent fills the interstitial spaces, blocking the flow of water and other fluids into these spaces and reducing contact and leaching of contaminants.

A study of polyethylene macroencapsulation conducted by DOE and Envirocare at the Envirocare site near Salt Lake City, Utah, site showed that this technology could be applied to reduce leachate from radioactively contaminated lead bricks. The extruder used at Envirocare had a capacity of 2,000 pounds per hour (Federal Remediation Technologies Roundtable [FRTR] 2001).

A study of seven solidification/stabilization reagents for treatment of contaminated sediments at the New Bedford Harbor Superfund site in Massachusetts did not give encouraging results. Concentrations of Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic Leaching Procedure metals, particularly barium, copper, and zinc, actually increased in leachate generated from a number of post-treatment samples (EPA 2001).

Soil Washing

Notwithstanding the name, most soil-washing processes do not actually wash soils. Rather, they use water, sometimes combined with chemical additives, to separate contaminated soils into contaminated and clean constituents. Contaminants tend to bind to silt and clay. Soil-washing processes separate silt and clay from sand and gravel particles that constitute the bulk of most contaminated soils. The silts and clays, which contain the contaminants, must then be treated by other means before disposal. The sand and gravel can be disposed of as nonhazardous material. Soil washing, then, is a waste volume-reduction technology. It can be effective, resulting in volume reductions of as much as 90 percent.

Soil washing has been used at a number of Superfund sites, notably at the King of Prussia Technical Corporation site in 1993, where 19,200 tons of metal-contaminated soil and sludge was treated. The treated soil (sand and gravel) from the King of Prussia site met or exceeded all the treatment standards (EPA 1995).

A DOE site where soil washing has been used was at Ashtabula, Ohio, to treat 40,000 tons of soils commingled with depleted uranium. This application more nearly approximated true "soil washing" because it used a chemical extraction to leach the uranium from the soil. The results of this deployment appear to be mixed, although the volume reduction was nearly 98 percent (DOE 2001a).

Technical feasibility may be even a more serious obstacle to the use of soil washing at the Moab site. The uranium at the Moab site is chemically bound to the tailings because it occurs naturally in the ore and the tailings are the by-product of the milling process. The uranium remaining in the tailings is that which remained bound to the substrate after the leaching process was used at the mill. It would likely be difficult to remove the uranium in a second stage of processing. Furthermore, a significant portion of the Moab tailings consists of "slimes," which are difficult to handle in physical processes and do not disperse readily. The soil-washing systems used to date have relatively low capacities. The King of Prussia system operated at 25 tons per hour, so it would require 54 years to treat the Moab pile at 100 percent on-stream. The Ashtabula system operated at 10 tons per hour, a rate that would require 136 years to treat the Moab pile. Pulse Technology, a private firm marketing a soil-washing technology developed with Russian aid, offers a stationary system that can process up to 90 tons per hour. This would treat the Moab pile in 15 years with no allowance for downtime. Because residual contamination will remain after soil washing, the resulting waste will still have to be managed and disposed of as radiological waste.

Vitrification

This treatment alternative uses electricity to heat contaminated soils to their melting points in place, then allows the melted soils to cool as glass. The high temperatures required for vitrification (quartz melts at 1,610 °C) destroys many contaminants, and contaminants that are not destroyed are encapsulated in the glass.

Vitrification has been used at a number of DOE and other sites to treat small quantities of high-level radioactive waste. It is particularly useful for treatment of high-level liquid wastes. The Savannah River (Pickett et al. 2000) and Hanford Sites (DOE 1999) are using vitrification for this purpose. An in situ vitrification treatment system was successfully used for treatment of contaminated soils and sediment at the Parsons Chemical/ETM Enterprises Superfund site

(EPA 1997). Oak Ridge National Laboratory (ORNL) has successfully demonstrated a Transportable Vitrification System for ex situ treatment of contaminated soils (DOE 1998). An in situ pilot test at Brookhaven National Laboratory in 1996 was less successful, and, in the words of the report on that test, “raised concerns about the effectiveness of ISV [in situ vitrification]” (DOE 2001b).

The quantities of wastes treated by vitrification have been small compared with the volume of contaminated tailings and soils at Moab. The ORNL ex situ demonstration (DOE 1998) treated about 8 tons of mixed waste, and the Parsons/ETM project (EPA 1997) treated approximately 3,000 cubic yards of soils and sediment. The estimated volume of solid material at the Moab site is 8.8 million cubic yards of material.

2.1.3 Off-Site Disposal and Processing Alternatives

Three off-site disposal sites were considered for evaluation. A relocated site would consist of constructing a new disposal cell on public land. Several potential locations are available for off-site disposal. Only one site, considered to be representative, is evaluated in this document, and it is referred to as the relocated site. For the purposes of this report, the relocated site is about 17 miles northwest of Moab and is also referred to as the Klondike site. The other two off-site locations considered here, the Envirocare and ECDC sites, are two currently operating private disposal sites that could potentially receive the mill tailings. In addition to these off-site disposal options, off-site processing at the White Mesa mill near Blanding, Utah, was also considered. Figure 2–2 presents the locations of all three disposal sites, the processing location, and the Moab site.

Off-Site Disposal

Excavation activities and support facilities required for transporting the tailings from the Moab site were assumed to be the same for all off-site disposal alternatives. For all alternatives, rail cars would be the initial method used to transport the tailings. A 1,500-ft railroad spur for loading rail cars would be constructed parallel with the main rail line. A covered conveyor system approximately 1,000 ft long would be constructed from the tailings pile north across State Highway 279 to a train loadout station that would be constructed on the rail siding. Construction support facilities would be required at the Moab site and would partially consist of field office trailers, decontamination facilities, access control fencing, material laydown yard, construction water supply, and equipment maintenance yard. Storm water runoff control features would be constructed before any excavation and would be maintained for the duration of construction.

An estimated 11.9 million tons (8.8 million cubic yards) of contaminated tailings would be removed from the Moab site. This total consists of the pile, which is estimated to contain 10.5 million tons; the subpile soil (assumed to be 2 ft thick) and areas adjacent to the pile that are estimated to contain 800,000 tons; and an estimated 600,000 tons of soil that was placed on top of the pile to assist in the pile dewatering project. The pile would then be excavated and moved to the existing rail line via a covered conveyor. The tailings would be loaded into open-topped gondola railroad cars and covered with automatic tarping devices or sprayed with a surfactant to prevent tailings from blowing out of the rail cars. The gondola cars would be transported on mostly existing Union Pacific tracks to the disposal site. Contaminated mill debris too large for the conveyor system would be transported by truck to the disposal site on state and interstate highways.

Once the tailings are removed, the Moab site would be reclaimed by recontouring and revegetating where needed to limit erosion, and the entire site would eventually be released with minimal restrictions. Moab Wash would not require rerouting, but it would be recontoured and reinforced to accommodate a 100-year storm event. With the tailings removed from the site, protection from a 200-year storm event or greater would not be necessary. A minimum of 6 in. of soil covering would be placed over the entire site to meet the EPA subsurface soil standards of 15 pCi/g radium-226. All construction support facilities and temporary storm drainage facilities would be removed.

Relocated Site

The relocated site is located on Klondike Flats, a low-lying plateau (Figure 2–3). The Klondike site consists of approximately 14,500 acres of contiguous undeveloped land. The southern most area boundary is approximately 17 miles northwest of Moab (Figure 2–3). The eastern Klondike site boundary is adjacent to U.S. Highway 191 both south of and north of the privately owned Canyonlands Field Airport property. Klondike site is located within Bureau of Land Management (BLM)-administrated land in portions of Townships 23 and 24S, and Ranges 19 and 20E. The Klondike site is located in Grand County and is open for public use. The Klondike site includes the principal off-site disposal location NRC identified in its FEIS. In the FEIS, NRC compared this alternative with the cap-in-place proposal and identified the Klondike area as one of the best alternate sites.

If this site is selected, administration of the necessary land area would be transferred from the U.S. Department of Interior to DOE. The plateau is approximately 50 ft higher than the adjacent terrain to the south and east and is relatively level with sparse, salt-desert vegetation. No permanent streams are on the site, but some ephemeral washes are present. Groundwater is not present in significant quantities at the relocated site (NRC 1999a); however, additional investigation will be needed for a more thorough characterization of groundwater conditions.

Evaporite deposits, including potash, underlie the area, and the Moab Fault extends south and southwest of the site roughly 3 miles away. A lens of the Mancos Shale Formation is estimated to be several hundred feet thick in this region.

This alternative proposes construction of a new disposal cell within the Klondike site and transport of the tailings from the Moab site by rail. At the relocated site, a new rail spur from the existing rail line would be constructed south of the airport and run west on the south side of Blue Hills Road, cross the road west of the airport, and continue west parallel to the road. The new rail spur would be approximately 3 miles long and would end at a rail-to-truck transfer station. A haul road, approximately 3 miles long, would be constructed from the transfer station north to the top of the plateau and into the disposal cell. The exact configuration of the rail and haul road would depend on where the disposal cell is located within the Klondike site. Construction support facilities would be required at the relocated site and would partially consist of field office trailers, decontamination facilities, access control fencing, material laydown yard, construction water supply, and an equipment maintenance yard. Storm water runoff-control features would be constructed at the relocated site before any cell construction work and would be maintained for the duration of cell construction activities.

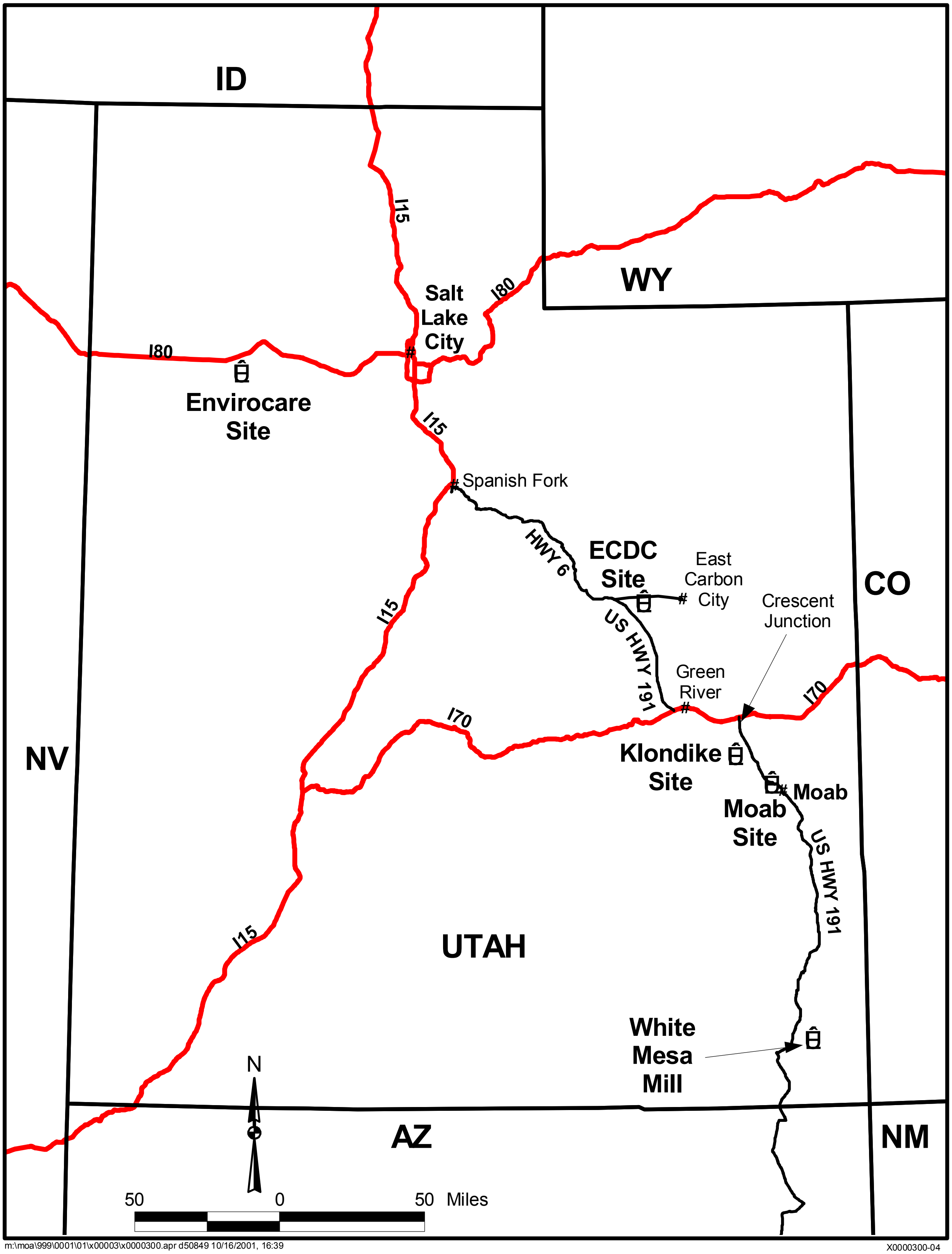

Figure 2–2. Potential Off-Site Disposal and Processing Locations for Tailings From Moab Site

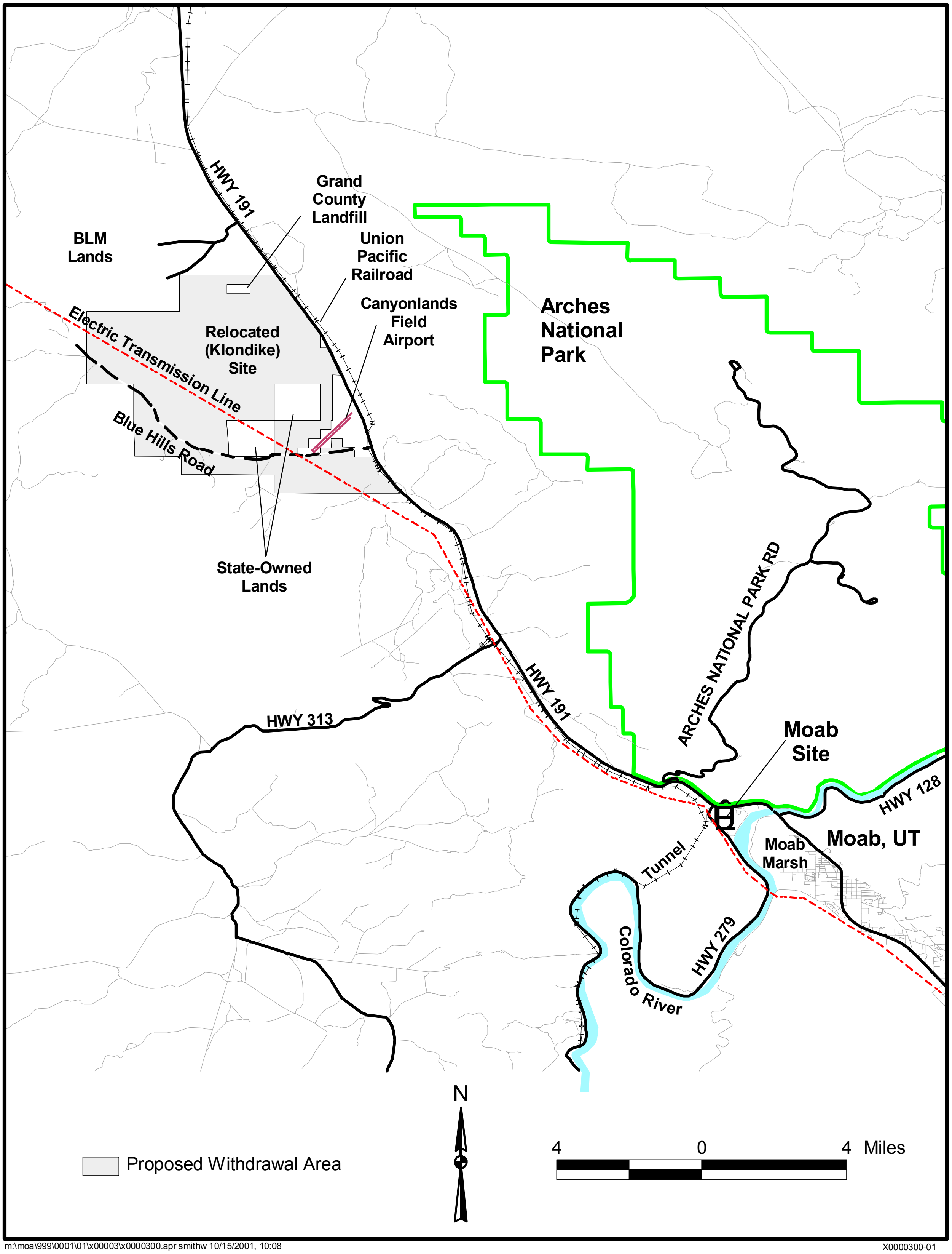

Figure 2–3. Location of the Relocated or Klondike Site

At the transfer station, tailings contained in gondola cars would be dumped by a "rail car roller" into a concrete-walled stockpile pit. Tailings would then be loaded with front-end loaders onto off-road, large-capacity haul trucks and transported to the disposal cell where they would be spread out evenly in lifts and compacted. The transfer station and haul road would be a radiological controlled area for the duration of the project.

As shown on Figure 2–4, the relocated off-site disposal option consists of a partial below-grade, balanced earthwork, cut-and-fill embankment disposal cell. The cut-and-fill balance is obtained by excavating, from an assumed flat surface grade, a pit approximately 13 ft deep with base dimensions of approximately 1,570 ft by 2,870 ft. Side slopes would be cut to 2 horizontal to 1 vertical (2H:1V). A 1-ft-thick clay liner would then be compacted in the base and up the side slopes of the excavation. It is assumed that clay would be derived from the excavation. Spoil material would be used to construct buttress berms around the pit perimeter approximately 40 ft high with 2H:1V interior side slopes and 3H:1V exterior slopes. Tailings placement would commence from the base of the disposal cell upward until level with the top of the clean-fill berms. At the center of the cell, tailings would extend above the berms approximately 21 ft and follow a descending grade outward at a 2 to 3 percent slope.

The cover system would consist of a 1-ft clay radon/infiltration barrier layer compacted directly on the tailings. It is assumed that clay would be derived from the excavation. The barrier would be overlain by a 5-ft-thick soil-protection layer to protect the barrier layer from cracking from freeze-thaw cycles, desiccation, and plant root intrusion. This soil would also be obtained from the excavation. Top-slope erosion protection would be provided by a 6-in.-thick layer of gravel and cobbles trucked to the site from a commercial pit south of Moab in the Spanish Valley. Exterior buttress slopes would be protected from erosion with riprap rock armoring. A riprap source has been identified 17 miles south of the Moab site on private property referred to as the Kane Creek site. A quarry site in this area has not been evaluated. Once located, it would be developed, and the riprap would be extracted, sized, and transported to the relocated site by rail. Additional borrow materials would be transported by truck or train to the relocated site as needed. Construction water needed for compaction and dust control would be from wells drilled in the area and transported to the site by water trucks or temporary piping. If water is not available in the area, alternate sources would be identified and could be transported by trucks or rail. Table 2–2 presents proposed sources and estimated quantities of construction materials.

Table 2–2. Relocated Site Disposal Materials List

Material	Estimated Quantity	Proposed Source	Approximate Distance (one way)	Transportation Method
Clay barrier layer	238,600 yd^3	On site	0 mile	Truck
Soil-protection layer	1,100,000 yd^3	On site	0 mile	Truck
Clean-fill berms	644,000 yd^3	On site	0 mile	Truck
Rock – Erosion protection; top slope	64,800 yd^3	Spanish Valley commercial pit	23 miles	Truck
Rock – Erosion protection; side slope	20,200 yd^3	Kane Creek site	17 miles	Rail

At the end of construction, all temporary facilities such as the railroad spur, transfer stations, and construction support facilities would be removed and the disturbed areas would be reclaimed. The disposal cell would be protected by constructing a security chain link fence around its perimeter. The haul road would remain in place to allow access for future long-term surveillance and maintenance activities.

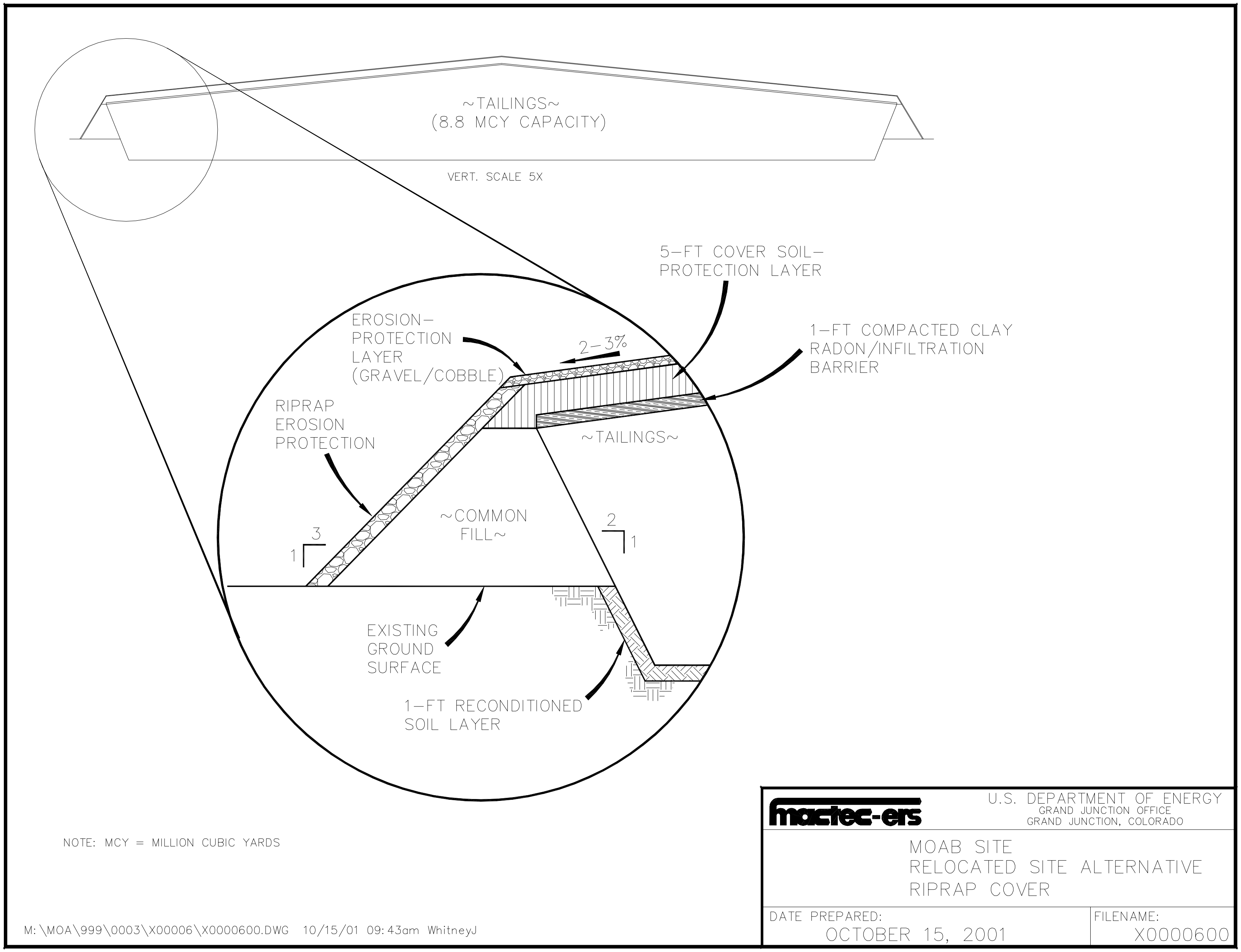

Figure 2–4. Moab Site Relocated Site Alternative Riprap Cover

Schedule

Complete construction for a relocated site alternative is anticipated to take a total of 8 years. Listed below are the construction activities that would be completed each year at the relocated site and at the Moab site.

	Relocated Site	Moab Site
Year 1	• Construct storm water controls • Provide temporary construction support facilities • Railroad spur • Rail-to-truck transfer station • Haul road • Cell excavation	• Construct storm water controls • Provide temporary construction support facilities • Conveyor system • Railroad spur • Train loadout station
Year 2–5	• Place tailings in cell	• Excavate tailings pile and load onto trains
Year 5	• Initiate cover placement	
Year 6 Through Year 7	• Complete cover placement • Remove railroad spur • Remove rail-to-truck transfer station	• Backfill and re-grade site • Remove conveyor system • Remove railroad spur • Remove train loadout station
Year 8	• Remove temporary construction support facilities • Construct fences • Revegetate disturbed areas	• Remove temporary construction support facilities • Revegetate millsite

Envirocare of Utah, Inc.

The Envirocare site is approximately 80 miles west of Salt Lake City and 230 miles northwest of Moab (see Figure 2–2). This site occupies 540 acres with a DOE-managed, 100-acre uranium mill tailings disposal cell adjacent to it on State of Utah land. This DOE disposal cell holds material relocated from the UMTRA Project Vitro processing site in Salt Lake City, Utah; additional land next to the site is available to accommodate expansion.

Envirocare of Utah, Inc., is a private company licensed by NRC to receive and dispose of up to 5.5 million cubic yards of uranium and thorium mill tailings and related wastes. Thus, the tailings from the Moab site would likely meet the waste acceptance criteria at the Envirocare site. In addition to the Vitro material, radioactive contaminated soils from the EPA Denver (Colorado) Radium Superfund site and several DOE sites were disposed of at the Envirocare facility. The volume of tailings and related material at the Moab site is twice the amount of licensed capacity of the Envirocare site; therefore, additional capacity for this site would require an amendment to the existing NRC license and an environmental evaluation.

This alternative consists of excavating the contaminated tailings from the Moab site and transporting them by rail to the Envirocare site, where the gondola cars would be unloaded with Envirocare’s railcar rollover facility. Tailings would then be transported to the cell with large-capacity haul trucks. No additional facilities, except an expansion of the repository, would need to be constructed at the Envirocare site.

It is assumed that construction of the cell at the Envirocare facility would be done with the same design criteria established for the relocated site alternative. DOE would maintain all responsibility for the tailings and the cell, and long-term stewardship would become DOE's responsibility after the cell is licensed.

Sources and quantities of material for this alternative are not presented because the disposal cell operator would be responsible for processing the material.

<u>Schedule</u>

It would take 2 years for the disposal cell to be ready to accept the tailings. Complete construction for the Envirocare site is anticipated to take 9 years. The construction activities that would be completed each year at the Envirocare site and at the Moab site are listed below:

	Envirocare Site	Moab Site
Year 1	• Construct storm water controls • Cell excavation	• Construct storm water controls • Provide temporary construction facilities • Conveyor system • Railroad spur • Train loadout station
Year 2–7	• Fill cell	• Excavate tailings pile and load onto trains.
Year 7	• Commence cover placement	
Year 7–8	• Complete cover placement	• Backfill and re-grade site • Remove conveyor system
Year 8		• Remove railroad spur • Remove train loadout station • Construct fences
Year 9	• Construct fences • Revegetate disturbed areas	• Remove temporary construction facilities • Revegetate disturbed areas

East Carbon Development Corporation

The ECDC facility is located in East Carbon City, Carbon County, Utah, and is approximately 100 miles by rail northwest of the Moab site (see Figure 2–2). The site encompasses 2,271 acres, of which 640 acres are leased by ECDC from East Carbon City. The estimated total lifetime disposal capacity of the facility is 300 million cubic yards. The facility is operating under a May 1990 Solid Waste Plan (permit) issued by the Utah Bureau of Solid and Hazardous Waste, which subsequently became the Utah Department of Environmental Quality (UDEQ). Wastes accepted under the permit include household waste, ash from RCRA facilities, mining wastes, and petroleum-contaminated media. Under the permit, the facility is not allowed to receive regulated radioactive waste. Within the facility, 29 discreet cells are planned for construction or are in operation. Each cell is constructed with a double-lined, 60-mil (0.060-in.), high-density, polyethylene system containing leachate-collection and leak-detection systems.

Under this alternative, tailings would be transported by Union Pacific rail along the same rail line as the other off-site disposal alternatives. A dedicated 4-mile rail spur from the Union Pacific main line into the ECDC facility is already in place. The gondola cars would be unloaded with ECDC's rollover facility dedicated to this project, and tailings could be transported to the cell with large capacity haul trucks. Construction of the cell would be done with the same design criteria as those established for the relocated site alternative.

The FEIS states that the site would require a license from NRC for disposal of the tailings. Another alternative that might be feasible would be for ECDC to transfer ownership of the dedicated disposal cell land to DOE. DOE would contract with ECDC for hauling, disposal cell construction, and tailings placement in the cell. DOE would maintain all responsibility for the tailings and the cell and would maintain long-term stewardship after the site is licensed. Therefore, a license for disposal at ECDC would not be required, but the site would be reviewed by NRC as part of DOE's Remedial Action Plan for off-site disposal.

Because it would be the responsibility of the ECDC to obtain the material needed to construct the cell, sources and quantities of material for this alternative are not presented.

Schedule

It would take 2 years for the disposal cell to be ready to accept the tailings, and complete construction for the ECDC site is anticipated to take 9 years. The following lists present the construction activities that would be completed each year at the ECDC site and at the Moab site:

	ECDC Site	**Moab Site**
Year 1	• Construct storm water controls • Rail-to-truck transfer station • Haul road • Cell excavation	• Construct storm water controls • Provide temporary construction facilities • Conveyor system • Railroad spur • Train loadout station
Year 2–7	• Fill cell	• Excavate tailings pile and load onto trains
Year 7	• Commence cover placement	
Year 8	• Construct fences • Revegetate disturbed areas	• Remove temporary construction facilities • Revegetate disturbed areas
Year 8 Through Year 9	• Complete cover placement	• Backfill and re-grade site • Remove conveyor system • Remove railroad spur • Remove train loadout station • Construct fences

Off-Site Processing (White Mesa Mill)

TSE of Vancouver, British Columbia, operates the NRC-licensed White Mesa mill outside Blanding, Utah, through its U.S. subsidiary, the International Uranium Corporation (USA). The White Mesa mill processes ores and tailings in a multilevel process to recover uranium, vanadium, and other materials. Since coming on line in 1980, the White Mesa mill has processed more than 3.8 million tons of ore to recover 28.3 million pounds of uranium oxide (U_3O_8) and 43 million pounds of vanadium oxide (V_2O_5) (International Uranium [USA] Corporation Internet Homepage [no date]). NRC-licensed on-site disposal exists for the tailings material. As an UMTRCA Title II site, DOE will ultimately be responsible for long-term stewardship.

Typical feeds to the mill have uranium concentrations of 0.15 percent (Molycorp), 0.74 percent (W.R. Grace), and 0.07 percent (Linde) (WISE [no date]). The Moab tailings and slimes have an average uranium concentration of 176 milligrams per kilogram (mg/kg) or 0.0176 percent (NRC 1999a). On April 9, 1999, the Utah Radiation Control Board established a minimum uranium concentration of 0.05 percent for materials to be accepted as alternate feed material for processing in a uranium mill (WISE [no date]). DOE would have to obtain a variance for the Moab tailings before White Mesa could accept them. The vanadium concentration in the Moab tailings has not been evaluated with respect to reprocessing feasibility.

No rail access line exists from Moab to the mill. The only means of transportation between the two sites is U.S. Highway 191. Transportation to White Mesa would require trucks filled with tailings to pass through the communities of Moab, Monticello, and Blanding, Utah, 6 or 7 days a week for many years. Given the controversy surrounding the operation of the White Mesa mill (in May, 2001 more than 40 individuals walked from Blanding to Moab as a “Walk Against Nuclear Waste”), local citizens would not likely support transportation of more than 11 million tons of tailings through this area without challenge. Monticello, Utah, area residents also previously opposed a truck haul to the mill for tailings located in that community.

2.2 Groundwater Compliance

Under the no action alternative, no groundwater remediation would occur and compliance would not be achieved. For active remediation scenarios, selection of the groundwater compliance strategy is based on the Title I UMTRCA Ground Water Project PEIS decision framework (DOE 1996). A detailed explanation of how the groundwater compliance selection process is applied to the Moab site is provided in Appendix D, “Groundwater Compliance Strategy.” The proposed groundwater compliance strategy for the Moab site is to meet MCLs, background, or ACLs for COPCs by implementing active remediation in conjunction with natural flushing. This strategy will include active remediation for the ammonia currently discharging to the Colorado River adjacent to the tailings site and the uranium plume adjacent to the millsite area northeast of the tailings pile. Ammonia is currently discharging to the river at unacceptable levels and is adversely affecting endangered aquatic species and designated critical habitat (USFWS 2000).

The active remediation scenario and configuration would include some form of an active system, such as a permeable reactive barrier, extraction wells, a distillation treatment system, and an evaporation pond. Groundwater treatment would likely take at least 35 years (Shepherd Miller, Inc. 2001). It is anticipated that after contaminant concentrations are significantly decreased by the active remediation, natural flushing processes will reduce concentrations to acceptable standards within the 100-year regulatory time frame, although additional groundwater evaluations are needed to provide a more accurate estimate of this time frame. Treated water may be reinjected upgradient of the contaminated area of the site to enhance the natural flushing rate or used to assist in reclamation.

Only a conceptual description of the groundwater remediation system is possible at this time. Most of the groundwater characterization has been focused on the groundwater adjacent to the river; few data are available for the rest of the site. How much of the tailings pile is a continuing source of groundwater contamination is also not well understood. The selection of a remedial alternative for the tailings pile is likely to have an effect on groundwater remedial design in terms of optimization, logistics, and duration. System design would take full advantage of surface remediation activities (e.g., relocation of Moab Wash, removal or stabilization of the pile).

At this time, based on current site knowledge, it is assumed that the groundwater remediation and compliance strategy will be essentially the same for the cap-in-place, treatment, or off-site disposal alternatives, with minor variations as described below:

- ACLs are applicable to groundwater directly beneath the disposal cell. DOE will retain perpetual ownership and control of the actual disposal cell; however, contaminated groundwater adjacent to the disposal cell would need to be remediated to applicable standards within the 100-year active remediation and natural flushing period.
- Minor variation in the configuration of the active remediation methods and remediation time frame may occur, depending on the disposal alternative selected. If the tailings pile remains on site, much of the contaminant plume in groundwater would remain covered by the disposal cell and would not be available for remediation. Thus, only the areas adjacent to the cell extending to the Colorado River would be subject to remediation. The active remediation time frame may be longer because all the source material would remain on the site and could provide a continuing source for groundwater contamination. However, without more data, this time frame is difficult to quantify.
- If the tailings pile is removed from the site, the entire area would be subject to remediation. The source would be removed, including some material (assumed to be 2 ft in thickness) in the unsaturated zone beneath the tailings. Because the source material would be removed, the groundwater remediation time frame potentially would be shorter, and the configuration of the selected cleanup system would not be constrained by the presence of the tailings.

2.3 Costs

For active remediation alternatives, a complete alternative will always be a combination of a mill tailings remediation component and a groundwater remediation component. A discussion of each of these cost components is presented in the following sections. Under the no action alternative it is assumed that no activities would occur and no costs would be incurred. Costs of the individual components for active remediation are combined into alternatives and summarized in Table 2–3.

2.3.1 No Action

No activities would take place and no costs would be incurred.

2.3.2 Mill Tailings Alternatives

On Site

Cap-in-Place

Detailed cost estimates and an explanation of costs are presented in Appendix F–1, "Cap-in-Place." Cap-in-place disposal costs are estimated as follows:

Technical Assistance Contract		$ 31,700,000
Construction Contract		76,500,000
	Total Cost	**$108,200,000**

A conceptual estimate can be expected to be up to 25 percent above the final estimated cost. Therefore, the cost range for this alternative is up to $132,300,000.

Annual costs for long-term surveillance and maintenance (LTSM) for the cap-in-place alternative are $21,100. Detailed LTSM costs are included in Appendix F–1, "Cap-in-Place."

Solidification

The current cost of the treatment system used at Envirocare (excluding the costs of the initial treatability studies that resulted in a viable technology) was estimated at $90 to $100 per cubic foot based on a demonstration performed on waste streams from 23 DOE sites (FRTR 2001). The estimated total volume of contaminated tailings and soils at the Moab site is 8.8 million cubic yards, or 238 million cubic feet (ft^3). Thus, the cost of remediating the Moab site using Envirocare macroencapsulation would be $21 to $24 billion. Macroencapsulation is inherently an ex situ process; therefore, this cost would be in addition to the cost of excavating the entire volume of contaminated tailings and soil. Because the solidified material remains classified as residual radioactive material, it will still have to be disposed of as a radioactive waste. However, additional disposal costs were not estimated because of the excessive costs associated with the treatment.

Soil Washing

Soil washing is an expensive technology. The project cost at the King of Prussia site was $7.7 million, or $401 per ton of soil (EPA 1995). The unit treatment cost at Ashtabula was estimated at $370 per ton (DOE 2001a). Either of these figures, if extrapolated to the total volume of more than 11 million tons of contaminated tailings and soils at the Moab site, results in a total treatment cost of more than $4 billion. The lowest cost suggested by EPA for soil washing is $90 per ton (DOE 2001a), equivalent to $1 billion for the Moab site. To make soil washing economically feasible at the site, the unit costs would have to be an order of magnitude lower than those reported at the other sites where that technology has been used. There is no indication that such a reduction could be achieved.

Table 2–3. Cost Summary[a]

Mill Tailings Alternatives	Estimated Capital Cost	Estimated NPV of Total Annual LTSM Costs	Groundwater Alternative	Estimated Capital Cost	Estimated NPV of Total Annual Groundwater Treatment Costs	Estimated Total Capital Cost	Estimated NPV of Total Annual Costs	Estimated Total Costs
Cap-in-place	$108,200,000	$308,000	On site	$5,500,000	$23,024,000	$113,700,000	$23,300,000	$137,000,000
Solidification	>$20 billion	$308,000	On site	$5,500,000	$23,024,000	>$20 billion	$23,300,000	>$20 billion
Soil washing	>$4 billion	$308,000	On site	$5,500,000	$23,024,000	>$4 billion	$23,300,000	>$4 billion
Vitrification	>$4 billion	$308,000	On site	$5,500,000	$23,024,000	>$4 billion	$23,300,000	>$4 billion
Relocated site	$358,100,000	$222,000	Off site	$5,500,000	$22,949,000	$363,600,000	$23,200,000	$386,800,000
Envirocare	[b]	$222,000	Off site	$5,500,000	$22,949,000	[b]	$23,200,000	[b]
ECDC	[b]	$222,000	Off site	$5,500,000	$22,949,000	[b]	$23,200,000	[b]
White Mesa Mill	NA	$222,000	Off site	$5,500,000	$22,949,000	NA	$23,200,000	NA

NPV = net present value; LTSM = long-term surveillance and maintenance; NA = not applicable

[a]Estimated costs do not include contingencies.

[b]The estimated capital costs for this alternative will be greater than the relocated site because of increased transportation costs.

Net present value of the annual costs were estimated as follows:

Groundwater Treatment Costs (years 0–35):	Average Annual Cost	= $	1,445,700
	NPV	= $	22,802,200
Groundwater Treatment Costs/On site (years 36-100):	Average Annual Cost	= $	73,900
	NPV	= $	220,800
Groundwater Treatment Costs/Off site (years 36–100):	Average Annual Cost	= $	49,200
	NPV	= $	147,000
LTSM Costs/On site (years 5 –200):	Average Annual Cost	= $	21,100
	NPV	= $	307,600
LTSM Costs/Off site (years 5–200):	Average Annual Cost	= $	18,700
	NPV	= $	221,800

All costs were discounted using an annual rate of 5.30 percent (nominal interest rate based on Treasury notes and bonds for 2001; OMB 1992).

Vitrification

Partly because of the relatively small volumes treated, the reported unit costs of in situ vitrification projects have been high.

- The in situ vitrification project at the Parsons Chemical/ETM Enterprises Superfund site in Grand Ledge, Michigan, that treated approximately 3,000 cubic yards of contaminated soils and sediments in 1993 and 1994, reported a cost of $270 per cubic meter.
- DOE's report on in situ vitrification reported average costs of $375–$425 per ton for projects at Parsons, ORNL, Wasatch, and a private Superfund site.
- *Vitrification of Geomaterials* (Mayne and Beaver 1996) reported a range of operating costs of $308 to $695 per cubic meter.

The total treatment cost of the ORNL ex situ transportable vitrification system was calculated at $8 to $15 per kilogram.

Applying the average of the costs of the in situ processes (excluding the ORNL ex situ transportable vitrification system) to the total volume of the tailings and contaminated soils at the Moab site yields an estimated total cost of more than $4 billion for remediation of the site using in situ vitrification. Some economy of scale would certainly be realized in a project the size of Moab. However, the most significant cost element in a vitrification process is electricity. DOE used an estimated unit cost of $0.05 per kilowatt hour to derive the cost range for vitrification projects, and it is highly unlikely that the cost of electricity for the Moab project would be significantly lower than this value. To make vitrification economically feasible at Moab, the unit costs would have to be more than an order of magnitude lower than those reported at the other sites where that technology has been used. The consistency between the reported unit costs for the various in situ vitrification projects suggests that an order of magnitude reduction is unlikely. In addition, like other treatment alternatives, this waste will still need to be managed and disposed of as a radioactive waste.

Off Site

Relocated Site

Detailed cost estimates and an explanation of costs are presented in Appendix F–2, "Off-Site Disposal." Relocated-site disposal costs were estimated as follows:

Technical Assistance Contract	$ 54,800,000
Architectural/Engineering Contract	32,100,000
Construction Contract	271,200,000
Total Cost	**$358,100,000**

A conceptual estimate is expected to be up to 25 percent above the final estimated cost. Therefore, the cost range for this alternative is up to $447,600,000.

Annual LTSM costs for the relocated site are $18,700. Detailed LTSM costs are included in Appendix F–2.

Envirocare

Specific costs to move the tailings pile were not estimated. However, for the purposes of this report, the costs for constructing a disposal cell were assumed to be similar to the relocated site because the same cell design was assumed for both alternatives. Cost for this disposal option will be higher than the relocated site because of increased transportation costs (longer haul distance) and tipping fees. The advantage of this alternative is the site has already proven to be viable for mill tailings disposal and it would negate contaminating a new site. A cost estimate will be prepared for the refined version of this report.

East Carbon Development Corporation

Specific costs to move the tailings pile were not estimated. However, for the purposes of this report, the costs to construct a disposal cell were assumed to be similar to the relocated site because the same cell design was assumed for both alternatives. Cost for this disposal option will be higher than the relocated site because of increased transportation costs (longer haul distance) and tipping fees. However, as with the Envirocare alternative, this alternative would negate contaminating a new site. A cost estimate will be prepared for the refined version of this report

2.3.3 Groundwater Remediation

Active remediation in combination with natural flushing is the proposed groundwater compliance strategy selected for both the on-site alternatives (cap-in-place, solidification, soil washing, and vitrification) and the off-site alternatives (off-site disposal or processing) (Appendix D). Results of conceptual computer modeling (Shepherd Miller, Inc. 2001) suggest that an extraction field pumping at 45 gallons per minute for 35 years will remove the ammonia plume to acceptable levels. At the end of the 35-year period, it is assumed that natural flushing will reduce any residual contamination to acceptable levels within 65 years. Table 2–4 presents a summary of costs and basis of estimates for the on-site alternatives. Costs and basis of estimates for the off-site alternatives are summarized in Table 2–5. Note these are conceptual costs based on existing information and may undergo considerable modification after additional site characterization data are gathered or if different technologies, including innovative technologies, are used to remediate the site.

2.4 Prescreening of the Alternatives

To focus this plan for remediation on the most viable remedial alternatives, a prescreening step was included to avoid a detailed analysis of alternatives with significant flaws. Prescreening criteria are organized into general categories of risks/benefits and costs. The act prescribes that the remediation alternatives be evaluated according to these categories. The following prescreening questions were developed to quickly identify the most feasible alternatives:

Risks/Benefits

- Is the alternative protective of human health (including the health of workers) and the environment?
- Does the alternative offer an effective long-term solution?
- Is it technically feasible to implement the alternative?
- Are regulators and the public likely to accept the alternative?

Table 2–4. Estimated Groundwater Remediation Costs for the On-Site Alternatives

Groundwater Constituent and Treatment Volumes	Description	Estimated Cost ($)	Basis of Estimate
Ammonia plume (827,820,000 gallons or 45 gallons per minute [gal/min] over 35 years)	Distillation system Slurry wall and extraction field Operations and maintenance ($0.05/gal)	3,900,000 1,400,000 41,400,000[a]	Assumes some form of ammonia stripper in combination with a distillation system similar to the one from the Monument Valley, Arizona, alternatives evaluation (DOE 2000). Wall and extraction field based on Shepherd Miller, Inc. (2001). Operation and maintenance based on DOE costs for distillation system at Tuba City, Arizona. Assumes remaining ammonia will flush naturally after 35 years of active treatment.
Uranium and other COPCs (184,000,000 gallons or 10 gal/min over 35 years)	Distillation system Extraction field Operations and maintenance ($0.05/gal)	No additional cost 200,000 9,200,000[a]	Assumes capacity of the treatment system is adequate for additional 10 gal/min to treat other COPCs. Assumes transient flux from tailings will be captured within first 35 years of active pumping. Assumes subpile soils will act as a continuing source and will require periodic pumping every 10 years for 65 additional years. Assumes at the end of the 65-year period, in combination will natural flushing, the system will be at acceptable levels.
All COPCs (31,500,000 gallons or 10 gal/min over 6 years of pumping)	Natural flushing Periodic pumping ($0.05/gal)	3,200,000[b] 1,600,000[b]	Operations and maintenance for natural flushing estimated for 65 years after 35 years of active treatment is completed. Assumes operations and maintenance for six periodic pumping events estimated once every 10 years for 65 years to remediate subpile soils to levels that will naturally flush.
Total		**60,900,000**	

[a]Annual costs over the 35-year period are $50,600,000; average annual costs per year are $1,446,700.
[b]Total annual costs over the 65-year period are $4,800,000; average annual costs are $73,900.

Table 2–5. Estimated Groundwater Remediation Costs for the Off-Site Alternatives

Groundwater Constituent and Treatment Volumes	Description	Estimated Cost ($)	Basis of Estimate
Ammonia plume (827,820,000 gallons or 45 gal/min over 35 years)	Distillation system Slurry wall and extraction field Operations and maintenance ($0.05/gal)	3,900,000 1,400,000 41,400,000[a]	Assumes some form of ammonia stripper in combination with a distillation system similar to the one from the Monument Valley, Arizona, alternatives evaluation (DOE 2000). Wall and extraction field based on Shepherd Miller, Inc. (2001). Operation and maintenance based on DOE costs for distillation system at Tuba City, Arizona. Assumes remaining ammonia will flush naturally after 35 years of active treatment.
Uranium and other COPCs (184,000,000 gallons or 10 gal/min over 35 years)	Distillation system Slurry wall and extraction field Operations and maintenance ($0.05/gal)	No additional cost 200,000 9,200,000[a]	Assumes capacity of the treatment system is adequate for additional 10 gal/min. Assumes subpile soils are excavated to a depth that residuals will not act as a continuing source of groundwater contamination. Assumes remaining uranium and COPCs will naturally flush to acceptable levels after 35 years of active treatment.
All COPCs	Natural flushing	3,200,000[b]	Operations and maintenance estimated at $50,000 per year for 65 years. This includes monitoring activities after the 35-year treatment period is complete.
Total		**59,300,000**	

[a]Annual costs over the 35-year period are $50,600,000; average annual costs per year are $1,446,700.
[b]Total annual costs over the 65-year period are $3,200,000; average annual costs are $49,200.

Costs

- Is the cost of the technology low, medium, or high compared with the costs of other technologies being evaluated?

2.4.1 Mill Tailings Alternatives

For the on-site alternatives, the estimated costs for solidification, soil washing, and vitrification are over 30 times the cost of cap-in-place and over 10 times the cost of a relocated site, without commensurate risk reduction advantages. This, coupled with the use of these technologies on wastes that are only a fraction of the Moab mill tailings pile, eliminates these alternatives from further consideration. As for off-site alternatives, the disposal at a relocated site is the only one that has had some depth of analysis. Additional analysis of the other alternatives will be performed in the refined version of this report.

2.4.2 Alternatives Considered for Further Evaluation

For the initial evaluation of alternatives, Table 2–6 presents the alternatives that have been retained for evaluation in Section 5.0, "Evaluation of Alternatives."

Table 2–6. Retained Alternatives

Media	Alternative 1	Alternative 2
Mill tailings	Cap-in-place	Off-site disposal (relocated site)
Groundwater	Active treatment coupled with natural flushing	Active treatment coupled with natural flushing

The cap-in-place alternative has been retained because it is technically feasible to engineer the cap to be protective and meet the minimum technical standards; this alternative has the lowest costs. The off-site disposal has been retained because it is consistent with alternatives implemented at other Title I UMTRCA sites. The relocated site was retained for further evaluation as the example of off-site disposal because it has lower costs than the other disposal locations.

End of current text

3.0 Evaluation Criteria

The evaluation criteria are designed to evaluate three general characteristics of the remediation alternatives: risks, benefits, and costs. The issues of risks and benefits are intertwined and have been combined into one category. A separate category considers analysis of costs. Within these categories, the evaluation criteria are organized into a series of questions. Each question has subtiered issues that should be considered to answer the question and thus evaluate the various alternatives. This section presents the evaluation questions and the relevant issues required to address these questions; the actual evaluation of each remediation alternative against these questions is in Section 5.0, "Evaluation of Alternatives."

The general categories for the evaluation criteria were selected on the basis of criteria in the act, which prescribes that the various remediation alternatives be evaluated for costs, benefits, and risks. The *National Environmental Policy Act Environmental Impact Statement Checklist* (DOE 1997) served as guidance to develop the evaluation questions and the relevant issues to be considered when answering the questions. Stakeholder concerns documented in the FEIS and comments and responses in the Final Technical Evaluation Report (NRC 1997) were also considered in developing this evaluation approach.

3.1 Risk and Benefit Analysis

3.1.1 Is the Alternative Protective of Human Health?

The most comprehensive evaluation of risks to human health is presented in the FEIS (NRC 1999a). The analysis in the FEIS focuses primarily on radiological doses to the surrounding population and occupational workers associated with the cap-in-place and off-site disposal alternatives. That analysis provides quantitative dose calculations and describes the assumptions on which the calculations are based.

For the purposes of this document, risks to human health associated with each alternative are considered qualitatively. It is assumed that a quantitative baseline risk assessment will be performed in the future to support a final remediation decision. For this qualitative assessment, both short-term risks associated with implementation of the alternative and long-term risks associated with system performance are evaluated. Some specific considerations for short-term and long-term risks are given below.

Short-Term Risks

- Will implementation of the alternative result in any additional or continual contaminant releases (beyond those that currently exist)? If so, to what media will those releases be made?
- Will there be any complete exposure pathways to the general public for contaminant releases in air, surface water, groundwater, or soil?
- Will there be any complete exposure pathways to site workers for contaminant releases in air, surface water, groundwater, or soil?
- How large a population is potentially affected by any contaminant releases and what is the proximity of the population?
- How many workers will be needed to conduct remediation activities?

- Given the operational nature of the remedial alternative, what is the expected probability and nature of worker injuries?
- Given the transportation miles, transportation corridors, and nature of materials to be transported to or from the site, what risks are likely to be associated with transportation accidents?

Long-Term Risks

- Will the alternative reduce exposures to contaminants? If so, in what media?
- Will the alternative reduce the concentrations or mobility of contaminants?
- Will restrictions on land use be required to prevent potential exposures to contaminated media?
- How long will use/access restrictions be required to prevent potentially unacceptable exposures to contaminated media (i.e., how soon will unrestricted access be restored)?
- How accessible are locations where contaminated media will remain?
- How large a population is likely to be affected by long-term performance of the alternative?

Other issues related to long-term risks are discussed in Section 3.1.4 with regard to long-term stewardship. Long-term risks are directly related to issues of long-term effectiveness of the alternative.

3.1.2 Is the Alternative Protective of the Environment?

Environmental risks include impacts on natural resources, cultural resources, ecological receptors, and environmental media (air, soils, sediments, surface water, and groundwater). They consist of short-term, long-term, and cumulative effects, depending on the nature, degree, and duration of each proposed action. Impacts considered in this section are physical and chemical impacts; regulatory impacts are considered in Section 3.1.3. In discussing environmental risks and consequences, both positive and negative impacts must be addressed. Many of the potential impacts can be reduced or eliminated through planning, and engineering design. Specific issues that are considered are listed below:

Ecological Risks—This issue considers impacts of the alternative to all flora and fauna (aquatic and terrestrial).

Wildlife/Threatened or Endangered (T&E) Species—This issue considers impacts of the alternative to T&E aquatic, avian, and terrestrial species and their habitats.

Floodplains/Wetlands—This issue considers the effects that the alternative would have on floodplains and wetlands.

Surface Water Quality—This issue considers the likelihood and time frame of the alternatives to affect surface water quality.

Groundwater—Alternatives are evaluated to determine what effects implementation will have on groundwater quality.

Spills and Releases of Residual Radioactive Material and Pollutants—Each alternative is evaluated on the basis of the potential for spills and releases that may adversely affect the environment (e.g., spills or releases to streams or tributaries).

Air Quality—Each alternative is evaluated on the basis of the degree of impact from fugitive dust and equipment used to complete remedial actions.

Cultural Resources—This issue considers the potential of an alternative to affect archaeological, anthropological, paleontological, historical, and cultural resources.

Scenic and Visual Qualities—Although aesthetic considerations are somewhat subjective, this issue considers potential impacts to scenic and visual qualities as a result of implementing each alternative. Specific issues address the proximity of construction activities to roadways, the amount of area to be disturbed by construction activities, the duration of the construction activity, the post-construction condition of the site, and impacts to air quality from dust generated as a result of construction activities.

3.1.3 What Are the Regulatory Consequences of This Alternative?

Depending on the activities required for implementing a remedial alternative, certain regulatory requirements may apply. This section addresses regulations that may affect the selection of a remedial alternative.

Section 1.3 discusses regulations governing disposal and cleanup standards for uranium and thorium mill tailings. Other activities associated with remediation that may be addressed by one or more regulations include

- Land disturbance, particularly in floodplain or wetland areas
- Use of surface water or groundwater for consumptive purposes
- Discharge of water to a surface water body (e.g., point source discharge from a water treatment system)
- Dredging or filling of a surface water body
- Creation of air emissions (e.g., fugitive dust, release of volatile contaminants, radioactive emissions)
- Transportation of radioactive or hazardous materials
- Injection or infiltration of water to the subsurface (e.g., effluent from a water treatment system)
- Disturbance of archeological or cultural resources
- Placement of restrictions on access to or use of land and water

Descriptions of the key regulatory drivers that may govern these activities follow.

Uranium Mill Tailings Radiation Control Act—Identifies EPA remediation disposal and cleanup standards for soils and groundwater and requires characterization and monitoring (see Appendix C, “40 CFR 192”). UMTRCA also requires the use of institutional controls under certain conditions. Different standards or requirements may apply to different remedial alternatives or to different locations.

National Environmental Policy Act—NEPA requires that a federal agency evaluate potential environmental effects of implementing a proposed action. NEPA also has requirements for public involvement, depending on the nature and scope of the proposed action.

Endangered Species Act—Section 7 of this act requires that every federal agency, in consultation with the Secretary of Interior (USFWS), ensures that any action it authorizes is not likely to jeopardize the continued existence of any listed, threatened, or endangered species or its habitat. Title 50 Part 402 of the *Code of Federal Regulations* sets forth the regulations that implement the act.

Floodplain Management and Protection of Wetlands—DOE regulation 10 CFR 1022 implements the requirements of Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) for actions that may affect these areas. Specifically, they require federal agencies to evaluate actions they may take to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain or a wetland. The FEIS (NRC 1999a) states that a portion of the Moab site falls within the 100-year floodplain of the Colorado River. The FEIS addresses wetlands that may potentially exist within and adjacent to the site; however, a formal wetlands delineation has not been conducted to date. A comprehensive Floodplain/Wetland Assessment will be required before the implementation of interim or remedial actions.

Clean Water Act—This act and its implementing regulations (40 CFR 122–125, 230–231, and 404; 33 CFR 323, and Utah Administrative Code) address discharges to U.S. surface waters, the use of reinjection wells, discharges of dredged or fill material into navigable waters, and wetlands management. Existing discharges to the Colorado River are outside the scope of the Clean Water Act. Point source discharges from wastewater treatment facilities associated with the Moab site remediation would be regulated and would require a Utah Pollutant Discharge Elimination System permit. Construction activities that disturb more than 1 acre of land require compliance with storm water management and erosion control regulations and require storm water discharge permits. Dredging or filling activities of the Colorado River would also require a 404 permit. Any wetland area disturbance during remediation and restoration must comply with the appropriate requirements. Wetland areas must be identified and delineated for the Moab site and any off-site project locations.

State Water Appropriations—Uses of surface water and groundwater require compliance with water rights appropriations requirements that are administered by the Utah State Engineer's Office, Department of Natural Resources, Division of Water Rights. Ponding of groundwater, construction dewatering of groundwater, and use of surface water (i.e., Colorado River) for dust suppression and tailings compaction may be considered consumptive use.

Clean Air Act—This act and its implementing regulations at 40 CFR 50 and the Utah Administrative Code regulate air emissions from treatment processes and construction equipment, fugitive dust, and radon emissions from the tailings pile. The National Emissions Standards for Hazardous Air Pollutants (NESHAP) Subpart Q requirements are applicable to control radiological contamination on DOE facilities and would apply to the tailings final disposal location. However, the NESHAP requirements do not apply during periods of active remediation. Utah Air Conservation Rules require that fugitive dust be minimized or that measures be taken to prevent its occurrence. Air emissions from a groundwater treatment system could also potentially be regulated by these requirements and would require a permit. The Utah Administrative Code requires that construction activities monitor ambient air. The National and Secondary Ambient Air Quality Standards at 40 CFR 50 and 53 address standards and monitoring requirements for PM_{10} (particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers) and lead in ambient air.

Archaeological and Historic Preservation Act and National Historic Preservation Act—Cultural resources are protected by these acts and by their implementing regulations. The regulations at 36 CFR 800 require federal agencies to take into account the effect of their proposed action on a structure or object that is included on or eligible for the National Register of Historic Places and establishes procedures to identify and provide for preservation of historic and archeological data that might be destroyed through alteration of terrain as a result of a federal action.

Transportation Requirements—Transportation of hazardous and radioactive materials in commerce shall be conducted in compliance with all applicable state and federal regulations as codified at 49 CFR 130–180. The Department of Transportation exemption at 49 CFR 761 may be applied to the bulk transportation of regulated radioactive mill tailings. This exemption provides relief from labeling, placarding, and manifesting requirements that are normally applicable to individual bulk shipments. Bulk transportation packaging requirements for haul trucks and rail cars (e.g., diapering tailgates on haul trucks, covering loads, reducing moisture content) would still apply.

3.1.4 Will This Alternative Be Effective in the Long Term?

Long-term effectiveness refers to the effectiveness of an alternative after completion of active remediation. The location of a disposal site must meet certain geotechnical suitability, seismic activity, and soil stability standards to be considered effective in the long term. UMTRCA defines the long-term design life of a disposal cell to be 1,000 years without active maintenance but in no case less than 200 years. At a minimum, the remediation alternative must consider the geotechnical, hydrological, and geological specifications identified in the UMTRA Technical Approach Document (DOE 1989) to evaluate its long-term effectiveness. The numerical specifications in the Technical Approach Document apply only to the selection of an alternate site for relocation of tailings. However, they are useful for evaluating the suitability of the stabilization-in-place option.

Seismic—The final disposal site should be located in an area greater than 1 kilometer (3,281 ft) from a capable fault as defined by 10 CFR 100, "Reactor Site Criteria," Appendix A.

Liquefaction—The final disposal site should be located in an area that is at least 250 meters (820 ft) from saturated loose sands or visible surface indications of disrupted drainage or broken ground.

Erosive Soils—A final disposal site should be located away from areas of known highly erosive soils, including fluvial environments subject to flash flooding.

Slopes and Escarpments—Final disposal should only occur in areas with slopes less than 33 percent.

Wetlands—Location of a disposal site within a wetland as defined by the U.S. Army Corps of Engineers should be avoided or mitigated.

Floodplains—Locating a disposal cell in a 100-year floodplain should be avoided or mitigated.

Aquifers—A final disposal site should not be sited over a Class I aquifer. Potential for groundwater contamination should be evaluated.

Subsidence Areas—A final disposal site should be located farther than 400 meters (1,312 ft) from areas susceptible to subsidence by natural or human causes.

In addition, an alternative must address long-term stewardship issues for it to be considered beneficial. Long-term stewardship describes the care and attention that contaminated areas will receive after remediation has been completed. The objective of these measures is to ensure that the implemented remedy continues to be protective of human health and the environment. Stewardship activities can include monitoring, inspections, maintenance, institutional controls, reporting, and remedial action reevaluation requirements. Many of the potential stewardship requirements are related to risks associated with the completed remediation, stability of the remedy through time, requirements for information dissemination, persistence of contamination, and technological advancements through time.

Some specific issues that are considered to determine how well an alternative can meet long-term stewardship objectives include the following:

Institutional controls—To prevent unwanted intrusion at a remediated site where contamination is left in place, either temporarily or permanently, institutional controls are generally put in place to prevent or control access. Appropriate institutional controls should be identified for each remedial alternative. An evaluation should be made as to the likely effectiveness of these controls over the period required. A consideration should also be made as to the possible consequences of a plausible breach in these controls.

Monitoring parameters (e.g., chemical sampling and analysis, precipitation rates, stream discharge rates), frequencies, and durations—These requirements are usually based on chemical, physical, and meteorological characteristics of the site. A consideration of media interactions, impacts to off-site locations, and variability of the parameters should be considered. Requirements will probably change through time, particularly depending on the persistence of contaminants.

Nature and frequency of inspection and maintenance requirements—These requirements could include visual inspections and as-needed repairs. They would most likely be based on the stability of the remediated site and site characteristics. Site accessibility would be a consideration. Inspections could include an assessment of the effectiveness of institutional controls.

Reporting requirements—Results of monitoring, inspections, and associated activities would need to be reported to various entities, depending on legal requirements and stakeholder interest. These reporting requirements could change through time.

Reevaluation of the remedial action—With technological advances, more effective remediation approaches could be developed. In evaluating alternatives, one consideration should be how adaptable the alternatives are to take advantages of advances in technology. It may be necessary to readjust remediation goals through time as priorities change or new information becomes available. Alternatives should be evaluated for this adaptability as well.

Future land use—Depending on the nature of the alternatives, certain future uses may be precluded or land could be remediated to allow for beneficial use not currently allowed. Effects of each alternative or use of affected land should be evaluated.

This list is not comprehensive; other site characteristics relevant to long-term control are also considered.

3.1.5 What Are the Short-Term and Technical Implementability Issues Associated With This Alternative?

For the purpose of this evaluation, implementability is defined as the ease of performing site remediation. These issues focus on short-term aspects of alternative implementation and operation. Although proper project planning can greatly facilitate implementability, some issues are unique to or magnified by a specific remediation alternative. Specific issues that should be considered are listed below:

Multiple Handling of Waste—Whether or to what extent a remediation alternative would rely on multiple handling of waste. Reliance of an alternative on extensive multiple waste handling is inefficient because it increases the potential for worker exposure and increases project cost and time.

Secondary Waste Streams—Whether or to what extent a remediation alternative generates secondary waste streams (treatment wastes) that would require subsequent management. The type of waste that would be generated (including waste classification, volumes, and physical states) also affects the implementability of an alternative because subsequent management options are waste-type dependent.

Operational Requirements—The operational complexity of implementing a remediation alternative. Potential maintenance requirements should also be addressed.

Duration of Treatment and Cleanup—The amount of time required to achieve the site standards for surface material and groundwater. Project management decisions affect the amount of time required to complete a task (e.g., number of hours in a workday, number of workdays per week, number of trackhoes used, and number of laborers) and the amount of available funding.

Although this issue is somewhat subjective because of its interdependency with other issues, experience has shown that shorter project durations have lower overall project costs and less negative impact on the surrounding environment and community.

Transportation—Potential transportation issues associated with each alternative. Items to be considered in the evaluation of each alternative include effects on local traffic flow from additional vehicles (haul and worker vehicles), affects on road conditions as a result of increased traffic, the potential for haul vehicle accidents, and required modification or additions to existing haul routes.

Mineral Resources—The loss of access to mineral resources because of land-use restrictions or other factors. This issue also includes the consumption of mineral resources that would be needed to support each remedial alternative. These resources may be lost through the use of earth, gravel, and rock to isolate the mill tailings or through the loss of soil during construction.

Noise Levels—Short-term effects on the surrounding community caused by noise from construction and transportation activities associated with each remediation alternative.

Land Use—Near-term land-use restrictions associated with the Moab site and any other site affected by each alternative. Near-term land-use requirements are those associated with active remediation (e.g., surface cleanup, active groundwater remediation) and may be different from post-remediation requirements.

Recreational Impacts—Each alternative's potential short-term impacts to the area's recreational and tourist industry.

Impacts on Population and Workforce—Each alternative's potential socioeconomic effects on the Moab community while near-term construction and remediation activities are being completed.

Socioeconomic Impacts—Potential economic effects on the Moab community from each alternative. Issues that should be included in this discussion are short-term increases in employment and population in the Moab area, transportation of materials on public roads in and near Moab, and impacts to public services and infrastructure.

3.1.6 Will the Alternative Likely Be Acceptable to Stakeholders?

As part of the NEPA process, public comments were received on the FEIS (NRC 1999a). Appendix G, "Summary of Stakeholder Concerns/Comments," presents a summary of the public comments from the FEIS and from major activities that have taken place since then. Information on this issue will be updated after this plan is presented to NAS and other stakeholders.

3.2 Cost Analysis

3.2.1 What Is the Cost of the Alternative?

Three types of costs are generally evaluated for remedial alternatives: capital costs, annual costs, and net present value costs. An explanation of these costs is given below. Costs include those required for surface and groundwater remediation and for LTSM activities for each alternative.

Capital Costs—Includes the costs for purchasing and operating equipment and materials needed to implement a remedial alternative. Examples include costs for road building, heavy equipment purchase, construction equipment rentals, buildings, construction materials and rock, design, construction supplies, relocating contaminated materials, and construction oversight.

Annual Costs—Costs expressed on an annual basis that are needed to operate and maintain a remedial alternative. These are repetitive costs that occur while the remedial alternative is in operation. Examples include costs for electricity, groundwater sampling, long-term facility maintenance and surveillance, treatment chemicals or resins, and equipment repairs.

Net Present Value Costs—Provides a current value of future cash flows obtained by discounting. Net present value costs are calculated by using unescalated annual costs and a discount rate. Net present value costs are typically used to compare costs occurring at different times on a common basis.

In this plan, estimated capital construction costs and the net present value of total annual costs were used to compare the costs of the various alternatives. The estimated capital construction costs were based on the expected contractor construction costs to implement the alternatives. They also include design and DOE contractor oversight costs. The estimated net present value of the total estimated annual costs include costs associated with LTSM activities and contaminated groundwater remediation. The estimated net present value of total annual costs was estimated to account for these long-term costs in current dollars using a discount rate of 5.3 percent (nominal interest rate based on Treasury notes and bonds for 2001) (OMB 1992). The significant uncertainties and assumptions used to develop the costs presented in this plan should be strongly considered when comparing the relative costs among the alternatives. Furthermore, the estimated costs presented in this document are not intended for use in developing future project budgets or funding requests.

End of current text

4.0 General Site Descriptions

This section provides general site descriptions of the cap-in-place and Klondike site alternatives. The purpose of this section is to provide factual information for the evaluation of the two alternatives (see Section 5.0). General environmental components described in this section include

- Sociological
- Air
- Geotechnical
- Groundwater
- Surface water
- Ecological

Because only previously existing information could be used to prepare this document, the environmental information provided in this section is not considered to be complete. DOE will need to perform additional field studies and research to obtain the information needed to fill in existing technical data gaps.

4.1 Sociological

This subsection provides land use, socioeconomic, archaeological/cultural resources, and aesthetic information for each alternative.

4.1.1 Cap-in-Place

Land Use

Public access to the Moab site is presently restricted. About 130 acres of the approximately 400-acre Moab site is currently used for uranium mill tailings storage; contamination remains in several other areas of the site (NRC 1999a).

The Moab site lies about 3 miles northwest of Moab, Grand County, Utah, adjacent to the main highway (U.S. Highway 191), which accesses Moab from the north. A few residences, recreation-vehicle parks, motels, a restaurant, and other light commercial businesses exist along the highway between the Moab site and the city of Moab. Moab is the county seat for Grand County, which predominantly consists of BLM-administrated lands (NRC 1999a).

In 1998, the population of Moab was approximately 5,200. The majority of businesses in Moab are tourism and recreational industry related. Popular activities include mountain biking, four-wheeling, white-water rafting and kayaking, camping, and hiking (NRC 1999a).

The Moab site lies close to areas set aside as national parks or state preserves. The Moab site is approximately 1 mile southeast of the Arches National Park headquarters complex, which serves as the main park entrance and houses or employs about 20 people in the summer. Arches National Park is a popular tourist attraction with more than 2,000 natural sandstone arches. The

FEIS shows that visitation has increased roughly 13 percent each year in recent times. The number of visitors in 1997 was 858,525 (NRC 1999a).

The closest Canyonlands National Park and Dead Horse Point State Park boundaries are approximately 12 miles and 8 miles, respectively, southwest of the Moab site. However, the primary access to these parks requires the use of State Highway 313, which intersects with U.S. Highway 191 about 12 miles northwest of the Moab site.

The La Sal Mountains and Manti-La Sal National Forest are also recreationalist draws, and include hunting, fishing, and backcountry skiing (NRC 1999a). They are located approximately 10 miles east of Moab.

The Moab site lies directly across the Colorado River from the Scott M. Matheson Wetlands Preserve, also known as the Moab Marsh. This area consists of marsh and riparian habitat, including dense growth of tamarisk. The Preserve is jointly owned and managed by the Nature Conservancy and the Utah Division of Wildlife Resources. The area has improvements for walking, wildlife viewing, and educational kiosks. NRC stated that water in the marsh was not affected by the contaminated groundwater beneath the Moab site (NRC 1999a).

Mesa tops located north and west of the Moab site are federally owned land that is used primarily for cattle grazing and recreation.

Socioeconomic

Moab is the major population center in southeastern Utah. The nearest large city is Grand Junction, Colorado, which is located approximately 120 miles northeast of Moab. The Moab area was originally settled by American pioneers in support of agricultural and mining activities. As discussed in the FEIS, the city of Moab and Grand County are undergoing substantial population and economic growth fueled chiefly by the tourist and recreation industries. A large percentage of the tourists are from foreign countries. The tourist and recreation industries tend to thrive more during the summer season. The area is also gaining interest as a retirement community. Only 5 percent of Grand County is in private ownership and property values have appreciated in recent years in response to the increased demand (NRC 1999a).

Archaeological/Cultural Resources

The area surrounding Moab, has a history that includes Native American occupancy as early as 10,000 B.C. The Paiute and Ute tribes occupied the area in recent times. Permanent settlers arrived in the area in the 1870s, although there is evidence that the Old Spanish Trail in the area was traveled in the mid-1700s and was used extensively in the early 1800s. The Utah State Historic Preservation Office indicated that no historic or cultural sites are known to be located within the Moab site (NRC 1999a). An archeological survey must be conducted in any previously undisturbed areas within the Moab site to obtain more conclusive data.

Aesthetic

The Moab site tailings pile is observable from the U.S. Highway 191 that leads from Interstate 70 into Moab and also from the main Arches National Park access road. In its present state, the Moab site detracts from the overall aesthetically pleasing natural setting of the Moab area.

4.1.2 Klondike Site

Land Use

The Klondike site consists of approximately 14,500 acres of contiguous undeveloped land generally located on a low-lying plateau named Klondike Flats. The southern most area boundary is approximately 17 miles northwest of Moab (Figure 2–3). The eastern Klondike site boundary is adjacent to U.S. Highway 191 both south of and north of the privately owned Canyonlands Field Airport property. Klondike site is located within BLM-administrated land in portions of Townships 23 and 24S, and Ranges 19 and 20E. The entire site is located in Grand County and is open for public use. The Klondike site includes the principal off-site disposal location that NRC identified in the FEIS as the "Plateau site."

The closest boundary to Arches National Park is approximately 3.5 miles due east of the Klondike site across U.S. Highway 191. No residences are in the vicinity of the site.
The nearest commercial property is Canyonlands Field Airport, which is bounded to the north, west, and south by the Klondike site. The next closest commercial property exists several miles to the south at the intersection of U.S. Highway 191 and State Highway 131.

The Klondike site area can be accessed by several public dirt roads. The area is used for recreational activities, such as informal camping, all-terrain vehicles, and dirt biking, and for livestock grazing. Recreation use near the Klondike site is heaviest in the Blue Hills area, which is located 2 or 3 miles west of the Klondike site. The area is not as popular as the more attractive areas located closer to the national parks and Moab.

If an area within the Klondike site is selected as the location for the off-site disposal cell, administration of the area would be transferred from the U.S. Department of the Interior to DOE. On the basis of the preliminary disposal cell design, it is estimated that less than 200 acres would be needed to locate the cell; this area would be restricted from public access in perpetuity.

The northern 2,500 acres of public land at the Klondike site has been identified by BLM in its long-term planning documents as an area to be set aside for potential disposal of the Moab mill tailings. Approximately 80 acres of this area are currently leased to Grand County for use as a commercial landfill.

Socioeconomic

As a remotely located, unpopulated, undeveloped parcel of land, the Klondike site has no specific socioeconomic issues. It is administrated by BLM; fees are collected from ranchers for livestock grazing on the site. The area has a low potential for locatable minerals resources (NRC 1999a). Several oil and gas, and potassium leases exist within the Klondike site; however, a disposal cell site would be located within the Klondike site to avoid these locations and therefore would not have a socioeconomic impact.

Archaeological/Cultural Resources

The archaeological/cultural history previously described for the cap-in-place alternative also applies to the Klondike site alternative. The Utah State Historic Preservation Office indicated that no historic or cultural sites are known to be located within certain portions of the regional Klondike Flats area (NRC 1999a). It is reasonable to assume that this information is also true for other portions of the regional Klondike Flats area. However, the Old Spanish Trail may have passed near or through the site. An archeological investigation needs to be conducted to obtain more conclusive data.

Aesthetic

The Klondike site consists of exposed sandy soil and sparse vegetation and, for the most part, is aesthetically unremarkable. Possibly its strongest attribute is its relatively quiet remoteness.

4.2 Air

This subsection provides meteorology, climate, air quality, and visibility information for each alternative.

4.2.1 Cap-in-Place

Meteorology and Climate

The climate of the Moab region is semiarid. Semiarid climates are characterized by small amounts of annual precipitation with low relative humidity. The average annual temperature in the Moab area is about 57 ºF, with the coldest temperatures occurring in January (average temperature is 30 ºF). The warmest temperatures occur in July (average temperature is 82 ºF). Temperatures of 90 ºF or higher occur about 100 days per year, mostly during June, July, and August. Temperatures below 32 ºF (freezing) occur about 123 days per year, mostly during November through February. Average annual precipitation at Moab is 8 in. and occurs in all seasons with slight peaks during spring and fall. Snowfall averages about 11 in. per year. Prevailing winds in the Moab region are southeasterly (NRC 1999a).

Potential evapotranspiration (about 50 in. per year) greatly exceeds annual precipitation, as does the mean pan evaporation (about 55 in. per year) and the lake evaporation rates (about 38 in. per year) (NRC 1999a).

Air Quality

Utah adopted the National Ambient Air Quality Standards (NAAQS) as the air quality standards for the state. NAAQS are identified in 40 CFR 50 and are expressed as concentrations of specific pollutants that are not to be exceeded in the ambient air to which the general public has access. NAAQS exist for sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), lead (Pb), and PM–10, particulate matter such as dirt and dust with an aerodynamic diameter less than 10 microns (small enough to easily enter the lower respiratory tract). The air quality around Moab is good, and Grand County is designated as being in compliance with the NAAQS for SO_2, NO_2, CO, and O_3 (NRC 1999a). Because not enough Grand County data are available to support a classification for PM-10, this type of particulate matter is designated as "unclassifiable" for Grand County. Utah does not designate a standard for lead (NRC 1999a).

Standards for the prevention of significant deterioration (PSD) of air quality also exist. PSD requirements establish allowable increases in concentrations of pollutants within NAAQS attainment areas. As specified in the FEIS, allowable PSD increments (in the atmospheric concentrations of specific pollutants) currently exist for only SO_2, NO_2, and PM-10. PSD is divided into two classes, depending on the area to be protected. Class I areas, which include certain national parks and monuments, wilderness areas, and other areas as described at 40 CFR 51 and 81, have more stringent requirements than do Class II areas, which cover most of the United States. The closest PSD Class I area to the Moab site is Arches National Park, where visibility and integral vistas are considered an important value (NRC 1999a).

Visibility

The FEIS (NRC 1999a) identifies the current median visual range for the Moab region as about 81 miles and explains that the curvature of the Earth limits visual range (where elevation differences between the viewer and the object viewed are less than about 0.9 mile) at such distances. At the Moab site, surrounding natural obstacles (i.e., cliffs) limit the range of visibility.

4.2.2 Klondike Site

Meteorology and Climate

Meteorology and climate data are unavailable for the Klondike site, but it is expected to be similar to that described for the Moab site. Possible differences could include the prevailing wind direction and wind speeds because the Klondike site is located in a more exposed environment on a broad plateau. Slight variations in temperature could also be expected because of the higher elevation at the Klondike site. The Klondike site area possibly has a lower relative humidity because it is not located near the Colorado River or near irrigated land.

Air Quality

Air quality information is unavailable for the Klondike site but it is expected to be similar or better than that described for the Moab site because the Klondike site is more remotely located in an undeveloped area and is not directly affected by industry or high vehicle use.

Visibility

Visibility information is unavailable for the Klondike site but it is expected to be similar to that described for the Moab region. Because the Klondike site is on a plateau, the range of visibility is expected to be greater in most locations than at the Moab site where it is impeded by natural obstacles. However, low areas and hills do exist within the Klondike site and could also act to impede visibility.

4.3 Geotechnical

This subsection provides geologic, soils, seismicity, and mineral resource information for each alternative.

4.3.1 Cap-in-Place

Geology

The Moab site is physiographically located in the Colorado Plateau Province, and geologically located in the fold-and-fault belt of the Pennsylvanian Paradox basin. The Colorado River flows along the southeast side of the Moab site. Geologic features of the area were influenced by Middle Pennsylvanian to Late Triassic salt tectonics, Middle Pennsylvanian to Late Cretaceous sedimentation, Tertiary folding and faulting, and Quaternary erosion and salt dissolution. With the uplift of the Colorado Plateau, the Colorado River eroded the sedimentary formations and formed deep canyons, slopes, and cliffs. The formations formed either cliffs or slopes according to their erosional resistance. After erosion cut down deep enough, ground water reached the upper parts of the underlying evaporite deposits and dissolved salt. The ensuing collapse created graben-valleys, such as the Moab Valley, that overlie the salt deposits. The Moab site is at the northwest end of the Moab Valley. Consolidated sedimentary rocks exposed in the area range in age from Middle Pennsylvanian to Late Cretaceous. Unconsolidated deposits of sand, silt, gravel, and clay, which are products of the current erosional regime, overlie the bedrock formations in places. Thickness and distribution of the geologic units vary considerably in the area.

The Moab site is bordered on the north and west sides by bedrock units, and by the Colorado River on the southeast side. The ephemeral Moab Wash enters the site at the northwest corner and drains through the site into the Colorado River. The site is directly underlain by Quaternary alluvial deposits, which in turn overlie various bedrock units at depth depending on the structural configuration beneath the site. Two large faults are likely present beneath the site, including the northeast-dipping normal Moab fault and the southeast-dipping "arcuate" fault. The arcuate fault defines the northwest extent of the Moab salt valley (Shepherd Miller, Inc. 2001).

Geomorphic processes at the Moab site have been assessed by NRC (NRC 1997) resulting in the following observations. The following features and conditions represent potentially significant sources of surface instability: 1) windblown sand, 2) rock and debris falls, 3) migration of the Colorado River, and 4) flooding of Moab Wash. NRC has evaluated these conditions in the FTER and they were all acceptably addressed in the proposed design to meet the requirements in Appendix A of 10 CFR 40 (NRC 1997). The following potential hazards were reviewed and found too improbable to be considered in the design: 1) landslides, 2) volcanic ash fall, and 3) mineral resource exploration and extraction.

Soils

Soils at the existing site are initially described in Section 2.1.2 of this document. Additional information is available in the *Soil Survey of Grand County, Utah, Central Part* (U.S. Department of Agriculture 1989). Soils at the site, exclusive of the tailings pile, are classified as Nakai fine sandy loams. Soils include sandy loams to loamy fine sands. Soils are generally deep (depths greater than 36 in.), well drained, having a minimal water-erosion potential, a moderate hazard of blowing potential, and an estimated erosion rate of 3 tons per acre per year.

Seismicity

The Moab site is located in the Paradox Basin in the interior of the Colorado Plateau. The plateau is generally considered to be relatively stable. The historic record of seismicity in the plateau is short; adequate seismic coverage of the area did not occur until 1970. After 1979, a regional seismic network was installed that improved the detection of earthquakes to those above magnitude 2.0. The Moab site location is characterized by infrequent, low-level, small-magnitude earthquakes. From July 1979 to June 1987, about 1,100 earthquakes up to magnitude 3.3 were recorded within a 125-mile radius of Moab (Wong and Humphrey 1989).

Information suggests that the trace of the Moab Fault runs through the site and lies beneath the tailings pile. Available evidence suggests that most, if not all, of the slip on the Moab Fault is pre-Quaternary (greater than 2 million years ago). Displacement patterns, crosscutting relations, and differences in structural style between salt dissolution-subsidence deformation and deformation observed along the Moab Fault strongly suggest that the primary displacement on the Moab Fault occurred before, and is unrelated to, Quaternary dissolution subsidence in the Moab-Spanish Valley (Woodward-Clyde 1996).

The *Evaluation of Potential Seismic and Salt Dissolution Hazards at the Atlas Uranium Mill Tailings Site, Moab, Utah* (Woodward-Clyde 1996), states that

> "Based on all the geologic and geophysical data, we believe there is strong evidence . . . the Moab Fault is not a capable structure and does not pose a significant earthquake threat to the pile. However, the subject of capable fault and maximum credible earthquake as related to the Moab site continues to be debated."

The arcuate fault, which also likely runs through the Moab site, does not extend under the tailings pile and is not considered to be a capable fault (NRC 1997).

See also the discussion on seismicity in Section 2.1.1.

Mineral Resource

Geology and Grand County (UDNR 1987) discusses the mineral resources of Grand County. Potentially commercial deposits of potash, rock salt, magnesium salts, and gypsum may be present at the Moab site (NRC 1999a). Oil and gas production occurs in the Paradox Formation of Grand County, which also contains hydrocarbon source beds. Most oil and gas production occurs in the northeast quarter of Grand County. No significant oil and gas reserves have been identified at the Moab site. The nearest significant oil production is 10 miles west of Moab (NRC 1999a). Other mineral resources include tar sands, oil shale, and coal, none occurring in the near vicinity of the Moab site. Abandoned uranium mines are located 5 to 10 miles northwest of the Moab site (NRC 1999a).

4.3.2 Klondike Site

Geology

The Klondike site is in the same general setting as the Moab site, but is situated over a younger sequence of bedrock units and is not adjacent to a major stream. The Klondike site is principally underlain by Cretaceous Mancos Shale, which is mostly medium-gray fissile shale that forms a soft slope. The lower part of the Mancos Shale corresponds to the Tununk Shale Member, which grades upward into the Ferron Sandstone Member. This is overlain by the upper member of the Mancos Shale. The Mancos Shale is underlain by Cretaceous sandstones, which in turn overlie various Jurassic formations. The Klondike site lies in a folded area that is traversed by several northwest trending faults, including the Moab fault. The area is relatively stable and the nature and extent of geomorphic processes could be identified and potential geomorphic hazards would be incorporated into the design of an alternative disposal site.

Soils

Three main soil types are identified at the Klondike site. Descriptions are taken from the *Soil Survey of Grand County, Utah, Central Part* (U.S. Department of Agriculture 1989). The dominant soil type depends on the location within the Klondike site, so all three types are discussed in this plan. Soil types are delineated on maps made from aerial photographs included with the soil survey.

The Chipeta complex occurs on broad plains possessing slopes of 1 to 10 percent. The majority of this soil series is silty clay loams, generally shallow (less than 12 in. thick), derived from marine shale parent materials, with low permeability and low erosive potential (estimated to be 1 ton per acre per year), and is saline.

Sagers silt loam occurs on valley floors formed in alluvium derived from marine shale. This soil consists of silt loams, sandy clay loams and silty clay loams, occurs on relatively flat slope of 1 to 3 percent, is deep (greater than 60 in.) well drained soil, has a moderate shrink-swell potential, and is highly erosive (estimated to be greater than 5 tons per acre per year).

Toddler-Ravola-Glenton families association makes up the third series. This soil unit occurs on floodplains, along drainageways, and on valley flats in the area. Soils are fine sandy loams, silty clay loams, and silt loams. Approximately 25 percent Toddler and Ravola family soils exist each, 20 percent Glenton family, 10 percent very fine shallow clayey soil, 10 percent deep silty soils, and 5 percent each salt-affected soil and sandy eolian deposited soils. Permeability of these soils is slow to moderate, depth of the three major families is greater than 60 in., generally with low organic content and high erosive characteristics (5 tons per acre per year).

Seismicity

The general seismicity information provided for the cap-in-place discussion also applies for the Klondike site. However, the Moab Fault extends roughly 3 miles to the south and southwest of Klondike site boundary. A disposal cell site would be selected within the Klondike site to avoid locations near faults or fault traces.

Mineral Resources

Potentially commercial deposits of potash, rock salt, magnesium salts, and gypsum may be present at the Klondike site but may be too deep to be exploited (NRC 1999a). Oil and gas production occurs in the Paradox Formation of Grand County, which also contains hydrocarbon source beds. No significant oil and gas reserves have been identified at the Klondike site (NRC 1999a). However, several oil and gas, and potassium leases exist within the Klondike site. Other mineral resources include tar sands and oil shale, which are located approximately 5 miles northwest of the Klondike site. Coal resources are present in the Book Cliffs region, located about 15 miles north of the Klondike site (NRC 1999a).

4.4 Groundwater

This subsection provides hydrogeologic, groundwater quality, groundwater resources, and groundwater use information for each alternative.

4.4.1 Cap-in-Place

Hydrogeology

The hydrogeology in the vicinity at the Moab site has been characterized by several investigators. The following summary is based primarily on information from the Shepherd Miller, Inc. report (Shephard Miller, Inc. 2000).

The Moab site is located adjacent to an outside meander of the Colorado River at the northwest end of Moab Valley. The ephemeral Moab Wash crosses the property just northeast of the tailings pile. The Moab site overlies Quaternary deposits derived mainly from the Colorado River and Moab and Courthouse Washes and from cliffs located west of the site. The deposits include alluvium, talus, and eolian sediments. The “shallow alluvium” consists of sandy sediments (lenticular deposits of fine-grained, well-graded sands and silts with some gravels and clays) ranging in thickness from 8 to 30 ft. The “deeper alluvium” consists of gravelly sediments (interbedded sandy gravel and gravelly sands with occasional clay and silt rich intervals) ranging in thickness from 28 to greater than 406 ft. The unconsolidated sediments are underlain by various bedrock units of the Triassic Glen Canyon Group and older units, at different depths.

Two large faults are likely present beneath the site, including the northeast-dipping normal Moab Fault and the southeast-dipping "arcuate" fault. The general location and configuration of the faults have been tentatively identified by geologic mapping and geophysical methods. The arcuate fault defines the northwest extent of the Moab salt valley, which is the elongate depression formed by removal of subterranean salt masses. Groundwater dissolves the salt (halite) and leaves the less soluble gypsum. This causes collapse and contributes to the briny nature of the groundwater at depth. The site is bounded by bedrock to the west and north.

Groundwater occurs under unconfined conditions in the alluvium beneath the site with depth to the water table ranging from 15 to 50 ft below ground surface. Groundwater generally flows to the southeast toward the Colorado River. The alluvial system is recharged by groundwater underflow, infiltration of precipitation, Moab Wash, and the Colorado River during periods of high flow. The alluvial system discharges to the Colorado River during low flow conditions. The alluvial aquifer is chemically stratified by fresh and brine groundwater regimes, which is a result of two distinct sources of water with a large disparity in dissolved solids. Fresh water flow originates from the Glen Canyon aquifer that subcrops along the elevated block, west of the arcuate fault and northeast of the Moab Fault. The fresh water regime is of primary interest because it occupies the upper portion of the alluvial sediments and is the system in which the site-derived constituents are transported. Brine groundwater originates from the dissolution of evaporitic deposits in the Pennsylvanian Paradox Formation of the lowered block, east of the arcuate fault. As fresh water flows over the subsurface expression of the arcuate fault toward the Colorado River, it depresses the underlying brine and forms a lens that is thickest in the middle of the basin and pinches out toward the basin margins and the Colorado River. The two flow systems are separated by a transition zone of approximately 20 to 25 ft, with the top of the transition zone ranging from 30 to 55 ft below ground surface.

Groundwater Quality

The list of constituents in groundwater beneath the site is based on analytical information from several reports, with emphasis on water quality data summary in the Shepherd Miller, Inc., report (Shepherd Miller, Inc. 2001; NRC 1999a, 1999b; and ORNL 1998) (see Table 1–1). Background groundwater quality has been determined from analyses of samples from several monitor wells upgradient from the site (see Table 1–1). It is characterized by elevated concentrations of sodium, chloride, and total dissolved solids (Shepherd Miller, Inc. 2001).

Groundwater in the alluvium consists of a shallow fresh water zone overlying the brine groundwater in the thicker alluvium southeast of the arcuate fault. There is a transition zone from approximately 30 to 55 ft below ground surface. Very high chloride levels (greater than 10,000 mg/L) south of the Moab site indicate that the brine layer is within approximately 20 to 30 ft of surface in this area (ORNL 1998).

Groundwater in the shallow alluvium has been contaminated by uranium milling operations over the years. COPCs consist of molybdenum, nitrate, selenium, uranium, ammonium, manganese, sulfate, and vanadium (see Table 1–1). The distribution of COPCs in groundwater has been discussed in the various documents cited above. Site-related contamination is generally east and southeast of site. NRC concluded that tailings contamination has had an impact on only a limited area of adjacent property to the south, near the property boundary with the site (NRC 1997, 1999b). Additional contamination of adjacent property is unlikely because of the presence of naturally occurring brine in the shallow alluvial aquifer, which acts as a density barrier to groundwater flow from the Moab site property (NRC 1997).

There is some uncertainty associated with the COPC list because historical sampling has not been consistent with regard to location of sampling points, selection of analytes, and sampling depths in the aquifer. The list of COPCs will be confirmed when the baseline risk assessment process is completed for the Moab site.

NRC required detection monitoring under the Atlas licensing agreement that consisted of collecting groundwater samples from four on-site monitor wells on a quarterly/semiannual basis (NRC 1999b). Constituents to be analyzed included chromium, molybdenum, selenium, radium, uranium, gross alpha, nickel, and vanadium.

Groundwater Resources and Use

A relatively thin zone of fresh groundwater overlies the brine groundwater zone beneath the Moab site. There is no current or historic use of groundwater as a drinking water source in the vicinity of the Moab site. The nearest domestic well is located 900 ft east of the background well in the northeast corner of the site. It has been noted that alluvial groundwater from the fresh water system in the vicinity of the site is unsuitable for use as a domestic drinking water supply and has never been used for human consumption (Shepherd Miller, Inc. 2001). A groundwater supply well, installed for the National Park Service at the Arches National Park entrance north of the site, was completed in the Entrada Formation of the San Rafael Group (bedrock).

4.4.2 Klondike Site

Hydrogeology

The area of the proposed Klondike site is principally underlain by Cretaceous Mancos Shale. The Mancos Shale is mostly medium-gray fissile shale that forms a soft slope. Most of the shale is slightly calcareous. The lower part of the Mancos Shale corresponds to the Tununk Shale Member, which grades upward into the Ferron Sandstone Member. This is overlain by the upper member of the Mancos Shale. The thickness of the Mancos Shale varies throughout the proposed site area, from several hundred feet in the southern part of the area, to approximately 1,000 ft in the northern part of the area. The Mancos Shale is underlain by Cretaceous sandstones, which in turn overlie various Jurassic formations.

Although there may be intermittent perched groundwater in the sandier or fractured portions of the Mancos Shale and in underlying sandstones, the first significant water-bearing aquifer zone in this area would most likely be the Moab Member of the Jurassic Curtis/Entrada Formation. Depth to this aquifer beneath the surface would vary throughout the area and would depend on the presence and thickness of intervening formations.

Groundwater Quality

On the basis of information provided in regional literature, groundwater quality in the first significant water-bearing aquifer zone beneath the proposed site area would be good. The quality of groundwater encountered in intermittent zones above this aquifer would most likely be marginal and not amenable for any useful purpose.

Groundwater Resources and Use

There may be a groundwater resource at depth beneath the proposed Klondike site area. There is no current or potential use of groundwater in the area.

4.5 Surface Water

This subsection provides surface water body, hydrology, floodplain, surface water quality, and use information for each alternative.

4.5.1 Cap-in-Place

Surface Water Bodies and Hydrology

The Colorado River is one of the few major rivers flowing through the semiarid to arid southwest. The Colorado River Basin encompasses seven states and two countries. It headwaters in the Rocky Mountains in the state of Colorado, flows through five states, crosses into Mexico, and terminates at the Gulf of California. Water flow is controlled along the river by several major and minor dams. Upstream dams provide minimal control of the flow of the Colorado River near Moab. Glen Canyon Dam, which forms Lake Powell, is located 150 miles downstream from Moab. The confluence of the Colorado and Dolores Rivers occurs approximately 20 miles upstream of the Moab site. The Green River flows into the Colorado River approximately 35 miles downstream of the Moab site.

The Moab site is located on the west-bank of the Colorado River at the confluence with Moab Wash. Approximately 0.75 mile of eastern boundary of the Moab site is adjacent to the Colorado River. The Moab site is located along the outside of a meander bend of the Colorado River. A cutoff chute flows along the inside of the meander through the Scott M. Matheson Wetlands Preserve (Moab Marsh), a shallow wetland that covers approximately 875 acres. Several small islands separate the main channel of the Colorado River from the chute.

The Moab Wash channel is located along the north and northeast sides of the tailings pile. It is an ephemeral stream that only flows when there is a precipitation event or during snowmelt; it drains an area of only 5 square miles. The course of the Moab Wash channel was rerouted east of the mill during operations to mitigate flooding potential during peak flows. Other tributaries near the Moab site include Courthouse Wash and Mill Creek. Courthouse Wash empties into the north side of the Colorado River 0.1 mile upstream from the Moab site. Courthouse Wash is also ephemeral and is dry much of the year. It drains 102 square miles, has an average discharge rate of 2.12 cfs, and produces peak flows reaching 12,300 cfs. It also sustains flows for a longer duration than Moab Wash (NRC 1999a).

The Moab Marsh and Mill Creek are located on the opposite side of the river from the tailings pile. The Colorado River in the vicinity of Moab receives large quantities of sediment that have contributed to the formation of the Moab Marsh. The presence of the Moab Marsh may be evidence of regional subsidence (Harden et al. 1985).

The nearest gaging station is located about 31 miles upstream from the Moab site and is known as the Cisco Gaging Station. The average discharge rate between 1911 and 1970 was 7,711 cfs, while maximum and minimum flows measured 76,000 cfs and 558 cfs, respectively (NRC 1999a).

Along its course, the Colorado River is bounded by steep sandstone walls, which are interrupted by the open geomorphology of the Moab-Spanish Valley in which the Moab site is located. Resumption of the sandstone wall occurs 2 miles downstream from the Moab site at a location known as the Portal, where the river makes an acute bend. High Colorado River flows are naturally constricted at the Portal, causing the formation of backwater in the area of the Moab site during floods (Mussetter and Harvey 1994). This hydraulic influence is diminished for Colorado River flows below approximately 70,000 cfs (NRC 1999a).

The eastern extent of the Moab site tailings pile lies approximately 750 ft from the Colorado River (NRC 1999a).

Two small (approximately 1-acre) ponds have been identified on the Moab site. One pond was apparently used for storing water obtained from the Colorado River for dust suppression purposes; the other pond located in the middle of the tailings pile apparently functioned as a decontamination pond. The pond used for dust control currently contains water and moss and sediments. It is not known if these ponds are lined.

No other bodies of surface water exist on the Moab site.

Floodplain

The upper floodplain materials were deposited during Holocene time (8,000 years to present) (NRC 1997). The potential exists for bank erosion; if extensive erosion occurs, the Colorado River channel could migrate toward the tailings pile because the Moab site is located on the outer side of a bend in the river. As discussed in the FEIS, no evidence of channel migration has been documented since the mill was constructed on the site. However, NRC staff observed small amounts of bank erosion occurring at the Moab site. The FEIS and Technical Evaluation Report present reasons why migration of the Colorado River channel may have occurred in the past and why it could occur in the future. Conversely, discussions are included as to why the potential for lateral river migration may be low. The Utah Geologic Survey considers it possible that the tailings pile may be affected by channel migration of the Colorado River and erosion within the next 1,000 years. The Utah Geologic Survey also considers the current riverbank deposits from Moab and Courthouse Washes to be sufficiently heterogeneous in grain size and laterally discontinuous to not be a reliable deterrent to riverbank erosion.

A flood hazard map (Federal Emergency Management Agency 1981) that uses the original configuration of Moab Wash indicates that small portions of the base of the tailings pile are located on the 100-year floodplain of the Colorado River (NRC 1999a). Recent information provided by NRC indicates that the base of the tailings pile is immediately adjacent to the upper boundary of the floodplain, but the pile itself is not on the floodplain (HLA 1998). On several occasions, flood waters have risen from 3 to 4 ft above the base of the pile, which has an elevation of 3,968 ft. Although the floodplain of Moab Wash has not been mapped, the 100-year floodplain extends up the wash at least several hundred yards (HLA 1998).

The U.S. Geological Survey estimated a 500-year flood discharge rate of 123,500 cfs at the upstream Cisco Gaging Station (Jacoby and Gonzales 1993). On the basis of this discharge rate, a 500-year flood level (3,976 ft) was calculated to be 8 ft above the base of the tailings pile. This estimate of flood level did not account for surface water entering the Colorado River between Cisco and Moab. Therefore, the flood level at Moab would be slightly higher than the previous calculation.

NRC calculated that a 300,000-cfs discharge rate is applicable to the Moab site during the probable maximum flood (PMF) (Jacoby and Gonzales 1993). The calculated PMF elevation was 3,997 ft, which corresponds to a water depth above the toe of the pile of 29 ft (Mussetter and Harvey 1994). The PMF discharge rate developed for Moab Wash ranged from 16,069 to

36,000 cfs. Floodplain boundaries (100-year, 200-year, 500-year, and PMF) have not been determined.

Apparently the largest flood of record along the upper Colorado River in Utah occurred in 1984 and probably flooded part of the Moab site (Christensen et al. 1991). This flood had an estimated recurrence interval exceeding 100 years and was caused by snowmelt combined with rainfall. The five major Utah floods (considering all rivers in the state) of record (1952, 1965, 1966, 1983, and 1984) having recurrence intervals ranging from 25 to more than 50 years did not inundate the Moab site. Anecdotal evidence indicates that the 1984 flood rose approximately 4 ft above the toe of tailings pile.

NRC suggests there is no conclusive data available that would indicate that subsidence caused by dissolution of salt affected the migration of the Colorado River in the Moab-Spanish Valley.

Surface Water Quality

Surface water in the Colorado River adjacent to the Moab site has been extensively sampled by Atlas Minerals Corporation (former operator of the mill at Moab), the State of Utah, and Shepherd Miller, Inc. (Shepherd Miller, Inc. 2001). Water quality is described in the FEIS as turbid, of considerable hardness, with high suspended solids loading, of fairly high salinity for a freshwater river, and as often having wide fluctuations in the concentrations of all of these constituents (NRC 1999a).

The primary site-related COPC in surface water is ammonia, which may affect endangered species (i.e., fish) in the river. Other constituents such as uranium and manganese are elevated as well. Monitoring efforts conducted between April and November 2000 indicate that ammonia concentrations in the Colorado River adjacent to the Moab site exceeded background levels (Shepherd Miller, Inc. 2001). River sampling results indicate that the distribution and magnitude of ammonia concentrations in the river water samples varied dramatically between sampling events because of the fluctuating flow of the river and distance the sample was taken from the bank. Low river flows expose greater portions of the Moab Wash sandbar, creating increased backwater areas that allow for the higher concentrations of ammonia in the surface water. However, this study determined that during high flows, backwater areas are eliminated near the site and ammonia concentrations near the shore are diluted to protective levels (within the EPA's recommended total ammonia protection criteria), or loading is temporarily stopped by river water flowing into the aquifer because of the seasonally high river stage. This finding suggests that snowmelt runoff periods (May and June) may effectively reduce the ammonia concentration in the Colorado River. Studies conducted by other entities show a larger areal extent of contamination. Alternative interim actions to mitigate the levels of ammonia in the river were discussed in the Shepherd Miller, Inc., report (Shepherd Miller, Inc. 2001) and will be evaluated for implementation by DOE.

Utah Water Quality Standards (Utah 2001a; Utah 2001b) classify the Colorado River and its tributaries as

1C Protected for domestic purposes with prior treatment processes as required by the Utah Division of Drinking Water;
2B Protected for secondary contact recreation such as boating, wading, or similar uses;
3B Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain; and
4 Protected for agricultural uses including irrigation of crops and stock watering.

As discussed in the FEIS, dams and water-diversion projects have greatly accelerated water loss through evaporation and consumption, resulting in higher salinities (i.e., total dissolved solids [TDS]), altered temperature and flow regimes, and altered nutrient and suspended solids transport (Carlson and Muth 1989). Industrial development and rapid urbanization have introduced wastewaters containing a variety of contaminants into the river.

The large amount of sediment loading into the Colorado River near Moab has also contributed to a medium-to-high salinity hazard and a low-sodium hazard for agricultural irrigation (Sumsion 1971).

Treated sewage is discharged to the Colorado River by the city of Moab (Sumsion 1971). Exact discharge points need to be identified to better evaluate potential surface water quality impacts adjacent to the site.

Surface Water Use

Surface water consumption from the Colorado River watershed is less than 25 million gallons per day in Grand County, Utah. This water is used almost exclusively for landscaping and agricultural irrigation. Less than 10 percent of this consumption is attributable to industry, mining, and thermoelectric power plant cooling use. Water from the Colorado River is not presently used for domestic and public drinking water supplies for the city of Moab; groundwater, local springs, and streams are used for those purposes. The river in the vicinity of Moab is used for recreational purposes, including rafting, boating, and fishing and is a recognized scenic waterway (NRC 1999a).

The FEIS describes the Colorado River Compact of 1922 and the 1944 Treaty with Mexico. It reports numerous diversions occur downstream of Moab for irrigation and that the U.S. cities of Phoenix and Tucson, Arizona, as well as the Mexican border towns of Mexicali and Tijuana, Mexico, use the Colorado River for drinking water. Discharge of surface water into the Gulf of California no longer occurs because of the high demand for water (NRC 1999a).

4.5.2 Klondike Site

Surface Water Body and Hydrology

The Klondike site is located near a surface water divide that diverts runoff toward either the Colorado River or the Green River. Tenmile Wash flows southward from the Klondike site to the Green River. Bartlett Wash, which enters Klondike Wash, discharges into Courthouse Wash, a direct Colorado River tributary (Unitah Engineering, Inc. 1994). Headwaters emanating from Klondike site drain small areas. All of these washes are ephemeral and are dry much of the year.

Ephemeral washes located on the Klondike site ungaged. Calculations are not available to quantify extreme floodwater surface elevations or evaluate the effects of extreme storms.

Floodplain

Floodplains do not exist on the Klondike site.

Surface Water Quality

Washes located in the Klondike site area are dry most of the year; no water quality data are available (NRC 1999a).

Surface Water Use

Surface water use at the Klondike site is limited to a few small stock-watering dams.

4.6 Ecological

This subsection provides aquatic ecology, terrestrial ecology (including vegetation and wildlife), wetlands, and threatened and endangered species information for each alternative.

4.6.1 Cap-in-Place

Aquatic Ecology

Aquatic species of the Colorado River must continuously adapt to fluctuating physical and chemical conditions, including river flow rates, bottom scouring by sand and silt, temperature, sediment loading, chemical composition, salinity, and the introduction of nonnative species into the existing system (NRC 1999a). Algal, invertebrate, and fish diversity in the main channel are continuously challenged by heavy sediment loading, swift currents, and scouring of the sand and silt bottom. These environmental challenges have led to compromised growth and reproduction of several native species (NRC 1999a).

Macroinvertebrates, such as chironomids and oligochaetes, probably dominate the benthic community of the main channel (NRC 1999a). Backwater areas, such as the wetlands formed by periodic inundation of the floodplain just downstream and across the river from the Moab site, probably support a much more diverse and more productive benthos. Similarly, rooted macrophytes, along with algae and zooplankton, flourish in the backwaters, but are almost non-existent in the main channel (NRC 1999a). The backwaters and inundated floodplains often serve as important nurseries and forage suppliers for fish, including the endangered Colorado pikeminnow (Valdez and Wick 1983). Fish species known or believed to be present near the Moab site are identified in the FEIS.

Several fish species have been classified as endangered under the Endangered Species Act by USFWS and are discussed in the "Threatened and Endangered Species" subsection.

Terrestrial Ecology—Vegetation

Vegetation types at the Moab site include marsh, riparian woodland, grassland, and shadscale (saltbush). Riparian woodland at the site consists of dense growths of tamarisk, an introduced species that has taken over land adjacent to the river. Woodland dominated by native tree species such as black willow and Fremont cottonwood is present across the river in the Moab Marsh. Other plants in the marsh include tamarisk, sedges, bulrush, and cattail. Although blackbrush has been recognized as the potential natural vegetation of valley bottoms in the region, it appears to be absent at the Moab site (NRC 1999a). Grassland and the shadscale community are the most extensive upland vegetation types at the site (Eyre 1980; West 1988)

Terrestrial Ecology—Wildlife

The Moab tailings pile supports little vegetation and provides limited wildlife habitat. Some habitat for birds and small mammals are provided by the dense growths of tamarisk along the base of the pile on the Colorado River floodplain. Big game animals are not likely to frequent the site. The only big game animal frequently reported near the Moab site is the mule deer. The site vicinity provides habitat for many species of smaller mammals, such as striped skunk, desert cottontail, jackrabbit, and rock squirrel. Muskrat, beaver, and river otter (a state-listed sensitive species) occur in Moab Marsh. The northern leopard frog, a state-listed sensitive species also occurs in the marsh. Many species of birds occur in Moab Valley, although relatively few species would nest on the Moab site. More than 175 species of birds have been observed at Moab Marsh. A great blue heron rookery is present in the lower end of the marsh (Nature Conservancy undated). Several raptor species occur in the area, including the turkey vulture, ferruginous hawk, red-tailed hawk, golden eagle, and the peregrine falcon (NRC 1999a).

Wetlands

Wetlands in the vicinity of the Moab site include Moab Marsh and portions of the river banks and floodplain adjacent to the Colorado River. Moab Marsh covers approximately 875 acres and is the major wetland along this area of the river (NRC 1999a). This palustrine wetland includes persistent emergent wetland (e.g., wet meadow), scrub-shrub wetland, and forested wetland (Cowardin et al. 1979). Palustrine wetland also occupies part of the Colorado River floodplain at the Moab site where dense stands of tamarisk form a scrub-shrub wetland. The Colorado River and its banks are riverine wetland and include nonpersistent emergent wetland, aquatic bed, unconsolidated shore, and unconsolidated bottom (Cowardin et al. 1997). Biota found in the wetlands was previously discussed in "Aquatic Ecology." No National Wetland Inventory maps are available for the Moab area, and no survey of wetlands has been conducted on the Moab site.

Threatened and Endangered Species

Information regarding T&E species in the area of the Moab site was obtained from agency consultations available in the FEIS. These data were obtained in 1994 and 1995. Before selecting the final disposal option, this information must be updated. In 1994, USFWS identified that four T&E aquatic species existed in the area of the Moab site and that the site provides potential habitat for a fifth terrestrial species. The four aquatic species, Humpback chub (*Gila cypha*), Bonytail chub (*Gila elegans*), Colorado pikeminnow (*Ptychocheilus lucius*), and the Razorback sucker (*Xyrauchen texanus*), are known to exist in the Colorado River system. According to the

USFWS, the Colorado River near Moab has been designated as critical habitat for the Colorado pikeminnow and the Razorback sucker.

Several studies have been conducted to determine the effect of the constituents in the groundwater from the Moab site on aquatic T&E species, and, although the degree and extent of impact differs among studies, they are consistent in their conclusions that at certain times of the year, for specific areas in the river, the ammonia released from the Moab site groundwater to the Colorado River is negatively impacting T&E fish species.

In 1995, USFWS identified one terrestrial endangered species as potentially occurring in the vicinity of the Moab site. The Southwestern willow flycatcher (*Empidonax traillii extimus*) utilizes willow and cottonwood riparian habitat but also has been observed in tamarisk areas. The Moab site has dense tamarisk covering approximately 50 acres below the tailings pile and next to the Colorado River. The species has since been observed during several surveys, specifically in the Moab Marsh and also several miles downstream of the Moab site. No nesting activity was observed in these areas (NRC 1999a). The species has not been observed on the Moab site (NRC 1999a). However, USFWS was concerned enough about the Moab site's tamarisk being potential habitat for the species that the agency placed restrictions on the NRC Trustee to minimize loss of tamarisk at the site (NRC 1999a).

4.6.2 Klondike Site

Aquatic Ecology

Surface water does not exist at the Klondike site; therefore, no aquatic ecology exists.

Terrestrial Ecology—Vegetation

The Klondike site area is dominated by a shadscale community, which is extensive in this region of the Colorado Plateau. Vegetative cover is somewhat sparse (e.g., 50 percent cover) with substantial bare soil areas, reflecting the low rainfall in this region and overgrazing by cattle (NRC 1999a).

Terrestrial Ecology—Wildlife

The Klondike site is likely to support fewer wildlife species than the Moab site because of the lack of water. Also, population densities are relatively low because of the low productivity of the vegetation and a history of grazing. Pronghorn may occasionally occur at the site. Small animals include the prairie dog, short-horned lizard, raven, and horned lark.

The raptors species discussed for the Moab site may also be present at the Klondike site. However, because of the lack of surface water in the area of the Klondike site, it is unlikely that this site would be aerie habitat.

Wetlands

Wetland areas are not known to be present at the Klondike site.

Threatened and Endangered Species

Information regarding T&E species in some areas of the Klondike site was obtained from agency consultations available in the FEIS. These data were obtained in 1994 and 1995. Before selecting the final disposal option, this information must be updated.

The State of Utah, in a 1994 consultation letter for the FEIS, identified two “Category 2” candidate plant species for listing as T&E species. The species, Cisco milkvetch (*Astragalus sabulosus*) and Oreoxis (*Oreoxis trotteri*), were later considered to be “species of concern” by USFWS and were not under the legal protection of Section 7 of the Endangered Species Act. However, USFWS encourages protection of such species. The current status of these two species needs to be determined. Both are know to be endemic to Grand County, Utah (NRC 1999a).

End of current text

5.0 Evaluation of Alternatives

This section evaluates the two alternatives remaining after the prescreening process: (1) cap-in place at the Moab site coupled with active groundwater treatment and natural flushing and (2) off-site disposal at a relocated site coupled with active groundwater treatment and natural flushing at the Moab site. In this report, the two alternatives are simply compared to one another. In the refined version of this report, the alternatives will be more specifically compared to the no action baseline alternative.

As noted previously, the relocated (Klondike) site is used as the representative off-site disposal location. Some of the characteristics evaluated here for the relocated site may or may not apply to a different relocated site (e.g., geotechnical criteria, distance); however, the differences in site-specific characteristics should not fundamentally alter the evaluation of the two alternatives. The evaluation uses the criteria described in Section 3.0, “Evaluation Criteria.” Where descriptors such “greater,” “lesser,” or “same” are used, the evaluation is comparing the two alternatives. The term “interim action” is used to refer to actions that DOE is planning to take in the near term to prevent further discharge of contaminants to the Colorado River and/or eliminate potential threats to T&E aquatic species. These interim actions are outside the scope of the longer term groundwater compliance strategy described in Section 2.0 but should alleviate potential ecological risks until the long-term strategy can be implemented.

5.1 Is the Alternative Protective of Human Health?

Cap-in-Place	Relocated Site
Short-Term Risks	
• No complete exposure pathways to groundwater. • Surface water contamination related to groundwater discharge is not a human health concern because of the limited amount of potential exposure. • Requires handling of an estimated 0.8 million tons of material for surface remediation. • Minimal increased risk to general public because tailings remain on site and access to the site is restricted.	• No complete exposure pathways to groundwater. • Higher worker risk because more material (soils, tailings) requires handling for surface remediation – approximately 11.9 million tons. • Could cause increased exposure to public through remedial activities (e.g., transportation spills). • Greater potential for exposure of public to radon with the pile open during excavation of tailings.
Long-Term Risks	
• Groundwater could remain a problem for a longer period of time because of a continued source if pumping is not effective at extracting constituents. • Greater possibility that natural processes could breach cell and cause releases because of the complexity of the site (e.g., change in drainage on site, change in course of Colorado River). • If cap fails or cell is breached, a larger population center is affected because of site location.	• Minimizes the chance that natural geologic processes could result in significant releases. • If releases do occur, remote location ensures that few, if any, people are affected. • Source control may mean that potential on-site risks to groundwater can be lessened in a more timely fashion.

5.2 Is the Alternative Protective of the Environment?

Cap-in-Place	Relocated Site
Ecological Risks	
• Geologic complexity of the site results in greater likelihood that releases could occur (e.g., from flooding, faulting) and result in exposure to ecological receptors. • The attractive habitat in this area invites a greater diversity, distribution, and abundance of wildlife species. Greater numbers of ecological receptors could be exposed to contamination if releases occur. • Interim actions that would reduce or eliminate contaminant effects (e.g., ammonia) in the Colorado River would be implemented to protect aquatic species.	• Removal of potential subpile source to groundwater may provide increased long-term protection to aquatic receptors at the Moab site. • Relocated site would be selected to reduce the number of species and populations that would be affected by the contaminants. • Longer-term contaminant risks to aquatic receptors (e.g., fish, migratory birds) should be nonexistent at the relocated site because of the lack of suitable habitat. • Potential effects of contaminants upon key receptors in the event of a catastrophic event (e.g., flood) would be marginal to nonexistent at the relocated site because of its geologic stability.
Wildlife/Threatened or Endangered Species	
• Presence of habitat for threatened and endangered species presents greater likelihood that they may be affected by long-term disposal of tailings if releases of contamination occur. • Some disturbances would be associated with LTSM activities and ongoing maintenance of the pile. • Short-term localized disturbances (e.g., noise, habitat loss) would displace wildlife during surface and groundwater remedial actions. The duration of surface disturbance is less for this alternative though active groundwater remediation may be prolonged or affect a larger area. T&E species (e.g., southwest willow flycatcher) could be affected.	• Longer duration of short-term site disturbances at the Moab site because of surface remediation. • Long-term increase of floodplain and wetland and riparian habitats at the Moab site. Sensitive habitat would not likely be present at the off-site disposal location. • T&E species would not be affected by off-site LTSM activities. • Groundwater cleanup at Moab site may be of shorter duration.
Floodplains/Wetlands	
• Potential long-term negative impacts to the Colorado River floodplain, wetlands, and adjacent riparian area ecosystems. Impacts include potential release of contaminants and disturbances associated with maintenance and repairs because of unanticipated events (e.g., river encroachment, landslides, floods) that could affect pile stability. • Surface remediation would be of shorter duration.	• Short-term effects of surface remediation have longer duration. More lands would be available for reconstructing wetlands at Moab site after remediation. • No potential adverse long-term impacts to floodplains, wetlands, or riparian areas.
Surface Water Quality	
• Interim action for groundwater will reduce risks to surface water and the environment and active remediation combined with natural flushing of groundwater will be protective. • The potential for future negative contaminant impacts to Colorado River quality exists if the disposal cell is disturbed by unanticipated events (e.g., major flood).	• No negative impact to surface water at relocated disposal site because of lack of surface water bodies. • Active remediation combined with natural flushing of groundwater at the Moab site will be protective. • Potential mobilization of contaminants through pile removal could cause temporary near-term increases of some contaminants in groundwater. Interim action should control short-term releases to surface water.

Cap-in-Place	Relocated Site
Groundwater Quality	
• Remedial action would improve groundwater quality. Presence of pile could prolong remedial action period.	• Groundwater remedial actions at the Moab site would be easier to optimize if the tailings were removed; this could shorten the cleanup duration. • No negative groundwater impacts are anticipated at the off-site location. • Tailings removal may cause short-term increases in contaminant concentrations in groundwater. Active groundwater remediation would need to address these elevated concentrations.
Spills and Releases of Residual Radioactive Material and Pollutants	
• In the short term during remediation activities, potential spills and releases of contaminated material would be confined to the Moab site and are anticipated to be of a lesser risk to environmental media (e.g., Colorado River). • In the long term, the potential for releases to environmental media (e.g., groundwater) is greater because of the geologic complexity of the location.	• In the short-term, the potential of spills and releases would be greater than cap-in-place because of transporting contaminated material by rail and on public and/or BLM roads. • In the long-term, the potential for releases from the relocated disposal cell would be considered marginal.
Air Quality	
• In the short term, unmitigated emissions could adversely affect air quality. • In the long term, air quality would not be affected.	• In the short term, unmitigated emissions could adversely affect air quality and this alternative would also result in a longer duration of impact. • In the long term, air quality would not be affected.
Cultural Resources	
• The potential for short-term or long-term effects on cultural resources is low. The site is a disturbed area with little potential for findings of archaeological significance.	• The potential for effects on cultural resources at the disposal site is greater because the site has not been characterized. Cultural resource surveys would be required for the relocated site; if cultural resources are identified, mitigation may be required.
Scenic and Visual Quality	
• Because of proximity to national parks, the city of Moab, and recreational activities (e.g., river rafting, rock climbing, camping), this alternative has an adverse impact on scenic and visual qualities of the area.	• The off-site location has minimal visibility in a remote location that does not receive much use.

5.3 What Are the Regulatory Consequences of This Alternative?

Cap-in-Place	Off-Site Disposal
UMTRCA	
• Need to meet disposal standards of Subpart A and cleanup standards of Subpart B at the Moab site. • Of the more than 20 Title I UMTRCA sites, no precedent exists for capping a large tailings pile in place (stabilization in place) in a floodplain.	• Off-site location would need to meet Subpart A disposal standards; groundwater at Moab site would need to meet Subpart B cleanup standards. • Stabilization in an off-site repository (constructed cell) regularly approved for UMTRCA Title I sites.
NEPA	
• Most of the evaluation for the on-site alternative is completed; stakeholder input required.	• More rigorous evaluation of relocated site required; stakeholder input required.

Cap-in-Place	Off-Site Disposal
Endangered Species Act	
• Location within T&E species habitat requires more consultation to demonstrate protectiveness.	• Less consultation required for relocated site because it will not be within a T&E species habitat.
Floodplain Management and Protection of Wetlands	
• Would require assessment of floodplains and wetlands to ensure that on-site disposal of tailings can be protective long term. May require mitigative measures.	• Floodplains and wetlands are not located at off-site disposal sites. Need assessment for short-term effects of pile removal.
Clean Water Act	
• Interim action requirements same; relocation of Moab Wash may involve more extensive requirements.	• Applies for interim action; may need some permitting for modification of Moab Wash, if necessary.
State Water Appropriations	
• Have water rights for use of Colorado River.	• Have water rights for use of Colorado River. Additional water rights may need to be obtained for water used in construction at relocated site.
Clean Air Act	
• Would design remediation to meet these requirements.	• Would design to meet requirements. Would require more extensive control than on-site alternative because of more extensive material handling.
Archaeological and Historic Preservation Act and National Historic Preservation Act	
• No negative impacts are anticipated.	• Would require survey of relocated site and possible mitigation.
Transportation Requirements	
• Tailings remain on site. Only transportation would be within site boundaries for consolidation and transport of construction materials to the site from off-site locations. • May require local conditional use permit.	• More rigorous requirements because of transport of radioactive material on rail and public highways; special marking of vehicles; additional worker training required. • DOT exemption would be required for transport of radioactive materials. Can be difficult to obtain.

5.4 How Likely Will This Alternative Be Effective in the Long Term?

Cap-in-Place	Off-Site Disposal
Seismic	
• Moab Fault trace runs beneath pile. • Earthquake probability small.	• No faults will be present at relocated site. • Possible fault within 3 miles of one of the relocated site boundaries, though fault is noncapable. • Earthquake probability small.
Liquefaction	
• Not an issue; low probability.	• Not an issue; low probability.
Erosive Soils	
• The potential for erosion is low. • Major washes on and near site are subject to flash flooding.	• Native soils are eolian and are subject to erosion. • Site soils exhibit low to moderate shrink-swell; need to be evaluated and engineered accordingly. • Site will be chosen that is not subject to flooding.

Cap-in-Place	Off-Site Disposal
Slopes and Escarpments	
• Escarpment exists in area; over the long term, potential for rock falls and erosion exists. • Within approximately 1,080 ft of an escarpment. • Sited on level surface. • Surface water diversion channel to be constructed along cell boundary will protect cell from damage due to potential rock fall.	• Site will be located so that no escarpments exist in area. • Will be sited on nearly level surface.
Wetlands	
• Wetlands assessment needed. • This alternative would be less effective in the protection of wetlands and riparian areas. The threat of contaminant releases and physical disturbances associated with LTSM activities would diminish the ecological value of existing wetlands. There would be no potential for newly created wetlands and associated riparian areas for the area covered by the pile.	• No wetlands would exist at the relocated site. After removal of tailings from the Moab site, additional wetlands could be established in that area.
Floodplains	
• Extent of the 100-year floodplain is unclear. • Flooding will occur. Probable maximum flood rises one-third of the proposed disposal cell height on side slope. However, flow velocities in Colorado River are low and should not significantly damage the pile cover.	• Site will not be near a floodplain.
Aquifers	
• Not a Class I aquifer; subpile soils and tailings leachate may affect aquifer; groundwater levels could rise and intersect pile during flood events. • Vadose zone rewetting may extend active remediation period for groundwater. • Based on existing modeling for the site, it is assumed that continued groundwater contamination can be removed by periodic pumping and treatment. • Restricts groundwater use below the cell for perpetuity.	• No anticipated negative impacts to groundwater at the off-site location; clay liner at cell base would protect aquifer. • Restricts groundwater use beneath the cell at the relocated site for perpetuity. • Moab site groundwater cleanup may be quicker because of removal of source material.
Subsidence Areas	
• No sinkholes or surface expressions of subsidence observed.	• No sinkholes observed in area. • Hydrocollapse of eolian site soils unknown, assumed to be minimal.

5.4.1 Long-Term Stewardship

Cap-in-Place	Off-Site Disposal
Institutional Controls	
• Institutional controls needed for pile and for on-site groundwater until flushing is complete. • Institutional controls for groundwater in perpetuity under cell. • 100-year institutional controls for groundwater plume outside cell.	• Institutional controls needed for relocated cell and for Moab site groundwater until flushing is complete. • Institutional controls for land withdrawn for cell will remain in perpetuity. • Institutional controls needed at the Moab site for all contaminated groundwater for 100 years or until groundwater standard is achieved.

Cap-in-Place	Off-Site Disposal
Monitoring Parameters (e.g., chemical sampling and analysis, precipitation rates, stream discharge rates), Frequencies, and Durations	
• May monitor river encroachment and other river parameters that could affect cell performance; may monitor erosion of escarpments; location of Moab Wash; changes in physical surroundings. • Monitoring required until groundwater standards met outside cell. • Groundwater monitoring in perpetuity beneath cell (point of compliance wells). • Monitoring performance of stabilized pile and potential effects on groundwater could be required.	• Few requirements for relocated site; some type of performance monitoring for relocated cell will be needed depending on specific site characteristics. • Requirements for groundwater at the Moab site may be simpler because of absence of pile (less monitoring to determine long-term effects of pile on groundwater).
Nature and Frequency of Inspection and Maintenance Requirements	
• Will probably require frequent inspections and more maintenance; location near river and near relatively high population will require more frequent monitoring to verify institutional controls. • As pile consolidates, maintenance will be required.	• Will be routinely required for relocated site; not anticipated as high maintenance based on location of cell; accessibility is low. • Requirements for Moab site would be minimal.
Reporting Requirements	
• May be more visible and generate more interest. • More frequent reporting to larger audience may be required.	• May be less frequent and to fewer stakeholders for relocated site. • Reporting results of groundwater monitoring for Moab site would be required.
Reevaluation of the Remedial Action	
• Not typically done for UMTRA Project surface cleanup. • Groundwater cleanup may require reevaluation if cleanup not proceeding as expected. Greater likelihood for reevaluation if impacts to groundwater from the pile are greater than assumed.	• Not typically done for UMTRA Project surface cleanup. • May reexamine groundwater cleanup if not proceeding as expected. Less likelihood for this because groundwater cleanup should be more straightforward with absence of pile.
Land Use	
• Precludes use of land in high use area for beneficial purposes.	• Relocated site precluded from use. Allows use of Moab site, located in high use areas, for beneficial purposes such as recreation, tourism, development, etc. • Some oil and gas leases and grazing permits for portions of the relocated site. Would need to work around these or withdraw land from these uses.

5.5 What Are the Short-Term and Technical Implementability Issues for This Alternative?

Cap-in-Place	Relocated Site
Multiple Handling of Waste	
• Less handling.	• Requires more handling.
Secondary Waste Streams	
• Less personal protection equipment.	• More personal protection equipment; more decontamination required. • Greater possibility that dewatering and water management will be required because of wetness of tailings and depth of excavation.

Cap-in-Place / Relocated Site

Operational Requirements

Cap-in-Place

- Less complex.

Relocated Site

- More complex because tailings must be excavated and transported.
- Water source must be determined for relocated site construction.
- Two sites are involved instead of one.

Treatment/Cleanup

Cap-in-Place

- Groundwater treatment duration may be extended because of continuing contaminant source; surface remediation shorter.
- Excessive or aggressive pumping of groundwater could pull brine up and into treatment system, which would impact treatability.
- Periodic flooding could inundate system.
- Groundwater beneath cell would not require direct cleanup.

Relocated Site

- Removal of pile could mobilize contaminants in groundwater; could require additional active remediation of groundwater to address higher concentrations and potentially higher flow rates.
- Potential to contaminate aquifer at new site.
- Duration of surface remediation is longer.

Transportation

Cap-in-Place

- Transport within site boundaries to consolidate; transport required to bring clean construction materials to site.
- Pond sludge from groundwater treatment would require periodic transport and disposal.

Relocated Site

- Requires construction of a rail spur.
- Transport of clean materials to relocated site required; similar or lesser impact than cap-in-place depending on borrow material source.
- Transport of residual radioactive material from Moab site to relocated site requires special handling.
- Pond sludge from groundwater treatment from Moab site will require periodic transport and disposal.

Mineral Resources

Cap-in-Place

- No loss of access to mineral resources is expected.
- Consumptive use of earth/gravel/rock will be similar; materials from an off-site location would be required.

Relocated Site

- No known commercially viable deposits exist at the relocated site, although oil and gas leases do exist.
- Consumptive use of earth/gravel/rock will be similar; some materials from the relocated site may be used.

Noise Levels

Cap-in-Place

- Shorter duration.

Relocated Site

- Longer duration.

Land Use

Cap-in-Place

- Requires institutional controls for cell and land restriction in perpetuity.
- Land cannot be used for beneficial purposes. May need additional restrictions during construction.

Relocated Site

- Restrictions in place during construction at the Moab and relocated sites. Some postconstruction restrictions at the relocated site. However, surface land use at the Moab site could be restored once material is removed. At similar sites, reclaimed land used for parks, golf courses, etc.
- Some grazing occurs on relocated site land. Area required for construction would restrict this practice.

Recreation/Tourism Impacts

Cap-in-Place

- Limits recreational use on land.
- Because of proximity to the Colorado River and national parks and the area experiencing high recreational and tourist activities, on-site remediation and disposal activities could be considered aesthetically unappealing.
- Short duration of remediation activities, but cell would remain at site in near- and long-term and could be less attractive and more restrictive for recreational activities.

Relocated Site

- No high-use recreational area at the relocated site; Moab site restrictions during construction.
- The duration of remediation activities would be longer.
- Removal of the tailings pile at the Moab site may provide more recreation/tourism opportunities in this high-use area.
- Possible access road for relocated site is heavily used for recreational access to the Blue Hills area. Accommodations would need to be made for this use.

Cap-in-Place	Off-Site Disposal
Socioeconomic Impacts	
• Shorter durations for construction employment and population increases.	• More construction workforce employment; greater positive economic impact to the community.
• May have loss of tourism income during construction because area may be less attractive.	• Longer potential negative impact to tourism during construction because remediation will take longer.

5.6 Will the Alternative Likely be Acceptable to Stakeholders?

Overall, stakeholder preference appears to be polarized between a desire to minimize taxpayer expenses and a concern over long-term protection of the environment. There is a high level of stakeholder interest in the Moab site, and stakeholder input was the primary factor leading to the passage of the act and to the development of this plan. A summary of stakeholder concerns/comments is included as Appendix G. Additional stakeholder opinion must be obtained prior to making a final remediation alternative selection.

5.7 What Are Costs of the Alternatives?

	Cap-in-Place	Notes	Off-Site Disposal	Notes
Capital Costs	$113,700,000	(–25/+25 percent)	$363,600,000	(–25/+25 percent)
Net Present Value of Total Annual Costs	$ 23,300,000	Considerable Uncertainties	$ 23,200,000	Considerable Uncertainties
Totals	**$137,000,000**		**$386,800,000**	

5.8 Major Uncertainties and Assumptions

Summaries of the major uncertainties and assumptions associated with implementing each alternative are presented below. Some of the basic assumptions are similar for both alternatives (e.g., the need to clean up groundwater at the Moab site), although the issues associated with implementation may be different. Some of the uncertainties can be removed by performing additional studies or analyses. Others, particularly those associated with long-term performance, may never be known but may be accommodated in remediation system design and monitoring.

Cap-in-Place	Relocated Site
• It is assumed that an interim action will be conducted to prevent discharge of contaminated groundwater to the Colorado River and that this action will effectively eliminate potential risks to T&E species.	• It is assumed that an interim action will be conducted to prevent discharge of contaminated groundwater to the Colorado River and that this action will effectively eliminate potential risks to T&E species.
• It is assumed that cleanup of groundwater to EPA groundwater standards in 40 CFR 192 is warranted. The feasibility of groundwater cleanup is unknown, particularly with regard to the brine layer.	• It is assumed that cleanup of groundwater to EPA groundwater standards in 40 CFR 192 is warranted. The feasibility of groundwater cleanup is unknown, particularly with regard to the brine layer.
• It is assumed that surface soils will be removed to meet UMTRCA radiologic standards. It is not clear what effect this removal effort would have on groundwater and surface water, particularly the removal of soils and vegetation that are adjacent to the Colorado River (the vegetation may actual help attenuate groundwater contaminants).	• It is assumed that surface soils will be removed to meet UMTRCA radiologic standards. It is not clear what effect this removal effort would have on groundwater and surface water, particularly the removal of soils and vegetation that are adjacent to the Colorado River (the vegetation may actually help attenuate groundwater contaminants).

Cap-in-Place

- Stakeholder preferences are not well understood, though based on continuing interest of the community and congressional representatives (leading to passage of the act), it is assumed that many stakeholders are opposed to the cap-in-place alternative.
- Uncertainty exists regarding the effects of the pile on groundwater quality. More characterization would be required to better demonstrate that leaving the pile in place would be protective of groundwater (and groundwater discharge to surface water). Optimization of the groundwater flow-and-transport model would be required to have greater confidence that groundwater cleanup can be achieved with the pile stabilized in place.
- Because of the complexity of the geologic setting of the Moab site, it is inevitable that natural forces (e.g., flooding) will have some effect on the tailings pile in the long term. However, it is not certain what the magnitude and severity of these effects might be. The potential exists for the pile to be breached and direct releases of tailings to occur. A rise in groundwater levels may result in leaching of contaminants from tailings to groundwater with subsequent migration to surface water. Additional characterization may increase the understanding of these potential effects.
- Uncertainty exists regarding the effectiveness of dewatering a large volume of slimes and consolidation of the pile. Differential settling of disposed materials can affect the integrity of the cap and could result in contaminant releases.
- Major uncertainties associated with cost include assumptions regarding the duration and success of groundwater cleanup, the source of borrow materials, the extent of engineering controls needed to improve longevity, the volume of site contamination that would need to be consolidated, and the measures needed to protect endangered species.
- Uncertainties exist regarding the feasibility of maintaining surface cleanup levels for soil (5 pCi/g) if periodic flooding of the Colorado River and Moab Wash remove the 6-in. clean fill layer and expose deeper soils (15 pCi/g is permitted in soils greater than 6 in. in depth).
- COPCs in groundwater have not been identified. A baseline risk assessment would assist in this identification.

Relocated Site

- Although short-term risks associated with this alternative are higher than the cap-in-place alternative, it is assumed that these can be minimized with standard engineering controls.
- It is assumed that a relocated site can be selected that minimizes negative impacts to the environment and maximizes integrity of the cell. Additional characterization of the potential relocated site is required before selection.
- It is assumed that groundwater cleanup would be more straightforward and less complex if the pile were removed.
- It is assumed that tailings can be transported to the relocated site by rail so that highway transport is minimized.
- Although many people want the pile moved, it is not clear if they have a good understanding of the short-term impact associated with pile relocation, such as the increased use of trains and the longer project duration. Additional stakeholder input is required.
- The accuracy of estimated volumes of tailings to be removed is uncertain. It is assumed that removal of 2 ft of soil beneath the tailings pile would be adequate. It is most likely that volume estimates represent a minimum. If significant increases occur, this would have impacts on cost, schedule, and design. For other UMTRA Project sites, volume estimates were typically lower than the actual relocated volume.
- Uncertainty exists regarding short-term effects of tailings removal on groundwater. At other UMTRA Project sites, surface disturbance has often resulted in short-term increases in contaminant concentrations in groundwater. Active groundwater remediation will minimize this issue.
- Major uncertainties associated with cost include volume of tailings to be disposed, source of construction materials for the relocated site, the requirement and size of tipping fees, exact costs to use the existing railroad, the extent of off-site characterization required, and the need for road improvements.
- Uncertainties exist regarding the feasibility of maintaining surface cleanup levels for soil (5 pCi/g) if periodic flooding of the Colorado River and Moab Wash remove the 6-in. clean fill layer and expose deeper soils (15 pCi/g is permitted in soils greater then 6 in. in depth).
- COPCs in groundwater have not been identified. A baseline risk assessment would assist in this identification.

5.9 Critical Alternative Evaluation Criteria

Upon completion of the more rigorous alternatives evaluation, a summary of the major factors likely to influence alternative selection will be prepared. The department would consider NAS review of the evaluation criteria and the advisability of assigning weights. The uncertainties and assumptions described in Section 5.8 may affect the degree to which an individual criterion affects the decision-making process. After preparation of this section, the department will provide it to the NAS for their review.

6.0 Summary

Several alternatives were evaluated for remediation of the Moab site. These included the no action alternative as well as several on-site and off-site options. The no action alternative was eliminated in the prescreening step because it is not protective of human health and the environment and it would not be in compliance with applicable regulations. Treatment options were eliminated because of high costs and lack of tangible benefits. Two surface remediation options were retained for further evaluation: cap-in-place and off-site disposal of tailings at a relocated site. Other off-site locations were not completely eliminated; if off-site disposal is chosen, all options will be reconsidered. Both the on-site and off-site alternative include active groundwater remediation.

The selection of a remedial action alternative for any site involves balancing long- and short-term risks, benefits, and costs along with being responsive to input from stakeholders affected by the decision. The following is an outline of the summary of the evaluation of alternatives. However, at this point, it is very preliminary and will be further refined and provided to the NAS for their review.

In the near term, both the cap-in-place and relocated site alternatives can be expected to perform equally well. A groundwater interim action will be performed for both options, and it is assumed that this interim action will be successful in mitigating contaminants reaching the Colorado River. Construction activities associated with both alternatives can be performed through the use of standard engineering practices to minimize risks to both the general public and to workers. The duration of construction activities for cap-in-place is expected to be 4 years, while relocated site construction would take approximately 8 years. Construction and transportation issues associated with relocating the tailings are more complex than for cap-in-place but are similar to activities that have been conducted at numerous UMTRCA Title I sites in the past. The most significant difference between the two alternatives in the near term is the lower estimated cost for the cap-in-place option, which is expected to cost approximately $250 million less than relocating the tailings off site.

While the major benefit for cap-in-place is a cost savings in the near term, there is a greater likelihood that costs could increase in the long term. Because of the geologic complexity of the Moab site, there are many uncertainties associated with the long-term integrity of that alternative. Minimum technical requirements for disposal would be met by the cap-in-place alternative; however, the characteristics of the Moab site need to be evaluated against the siting criteria for an alternate disposal location as listed in the Technical Approach Document (NRC 1989). Groundwater cleanup may be complicated by the pile. However, groundwater modeling performed for the site indicates that the presence of the stabilized pile should have little effect on groundwater quality (as evidenced by similarity in cost estimates for groundwater cleanup for both alternatives). The modeling includes numerous assumptions that require validation and additional data collection.

An UMTRCA Title I precedent exists for moving a tailings pile located in a floodplain. Tailings piles at seven other UMTRCA Title I processing sites located in the Colorado River drainage basin upstream from the Moab site were relocated to engineered cells constructed in areas outside the influence of the river. Several of these sites, including the ones on the Colorado River at Rifle and Grand Junction, Colorado, are somewhat similar to the Moab site in that they are located in fairly populous areas that are undergoing growth, and the Colorado River in those areas receives significant recreational use.

The evaluation of alternatives should also consider the NAS recommendations for long-term management of DOE legacy waste sites (National Research Council 2000). Two of the major recommendations of the NAS study are that DOE should "plan for uncertainty" and "plan for fallibility." As stated in the report, "…a precautionary approach, that is, one that is self-consciously risk averse and therefore takes remedial actions even when harm is not clearly demonstrated, argues for erring on the side of contaminant reduction and removal to safer locations." Although moving the tailings to a relocated site is generally a "safer location," one disadvantage of this alternative is that it contaminates an area that is currently clean, unless it is collocated with another disposal cell.

Overall, selecting a remedial action alternative for the Moab site requires balancing initial cost savings with potential negative long-term impacts. The cap-in-place alternative offers lower initial costs coupled with the ability to isolate the tailings in the short term using engineering controls.

Path Forward

As stated in the Executive Summary, DOE is currently preparing a more detailed evaluation of alternatives while awaiting initial NAS review of the evaluation process.

During the review by NAS and the final decision process, DOE will be conducting activities to reduce potential risks to human health and the environment and to provide better characterization of the Moab site. First, DOE will be evaluating and implementing an interim action for groundwater contamination associated with the Moab site. The interim action will be focused on eliminating or reducing the discharge of ammonia to the Colorado River. Second, DOE will be conducting maintenance and radiological control activities. These will be designed to reduce contaminant releases and prevent exposures to the public. Third, further characterization and monitoring of both the soils and water will be performed. The purpose of these activities will be to obtain better delineation of areas of contamination and to support the selection of the interim action for contaminated groundwater. Finally, DOE will solicit stakeholder input on the remedial action alternatives for the Moab site.

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Appendix A

Moab Site History, Background, and Chronology

A.1 Site History and Background

The Atlas Moab uranium millsite is located about 3 miles northwest of Moab, Utah, on the west bank of the Colorado River at the confluence with Moab Wash. Moab Wash is an ephemeral stream that only flows when there is a precipitation event or during snowmelt. The entire site covers approximately 400 acres of land.

A Moab Site Chronology of Events (Attachment 1) is attached to this appendix. Originally, the property and facility were owned by the Uranium Reduction Company (URC) and were regulated by the U.S. Atomic Energy Commission (AEC, the U.S. Department of Energy's [DOE's] predecessor agency). In 1956, URC began operations at the Moab mill. In 1962, the Atlas Minerals Corporation, which operated the mill until operations ceased in 1984, acquired URC. Between October 1956 and 1984, uranium tailings were disposed of in an unlined impoundment. A tailings pond was constructed and completed in 1956, and, almost continuously, tailings were disposed of in the pond until the mill ceased operations in 1984.

The impoundment, also referred to as the tailings pile, covers approximately 130 acres and contains about 10.5 million tons of uranium tailings and contaminated soil. The tailings pile is approximately 0.5 mile in diameter. The height of the pile rises about 94 feet (ft) above the surface of the Colorado River terrace, which is approximately 3,970 ft above mean sea level at the side of the pile nearest the river. The pile consists of an outer compact embankment of coarse tailings, an inner impoundment of both coarse and fine tailings, and an interim cover of soils taken from the site outside of the pile area. The pile has five embankments or terraces that were raised to their present elevation of 4,076 ft above mean sea level after a 1979 license renewal (NRC 1999a).

During early operations, an acid leach process was used to process uranium, and lime was added to the mill tailings to help neutralize the tailings. In 1961, an alkaline leach process was initiated. Then, in 1967, a new acid circuit was installed, and, for a period of time, both the acid and alkaline circuits were used. From 1982 through 1984, only the acid leach process was used.

Two sump pits were excavated in the 1980s to collect water draining from tailings pile embankments. These pits are located on the northeast side of the pile and the south end of the pile. Pumps were also installed to collect the seepage water and pump it to an evaporation pond on top of the tailings pile. There was no collection of water in the pits for several years, so the pumps were subsequently removed. The U.S. Nuclear Regulatory Commission (NRC) amended the Atlas license to allow disposal of radioactively contaminated solid waste in the south sump pit.

In 1988, decommissioning of the mill began; between 1989 and 1995, an interim cover was placed on the impoundment.

In 1996, to allow for reclamation of the site, Atlas submitted an application to NRC for an amendment to its existing license (No. SUA–917). This amendment would allow Atlas to reclaim the tailings pile for permanent disposal and long-term custodial care by a government agency in its current location and to prepare the entire 400-acre Moab site for closure. Also required was the preparation of an Environmental Impact Statement (*Final Environmental Impact Statement Related to Reclamation of the Uranium Mill Tailings at the Atlas Site, Moab, Utah*, NUREG–1531, Vol. 1, March 1999) (FEIS) to assess potential impacts from the proposed reclamation plan. As required during preparation of the FEIS, stakeholder input on the Atlas proposal was obtained. Many comments were received from individuals, private groups, and government agencies. These comments are summarized in Appendix G.

Atlas filed for bankruptcy in September 1998, and a trust was created in March 1999 to fund future reclamation and site closure. Atlas has been released from all future liability with respect to the uranium mill facilities and tailings impoundment at the Moab site. In 1999, PricewaterhouseCoopers of Houston, Texas, became responsible for site closure as custodian of the Moab Mill Reclamation Trust.

The U.S. Fish and Wildlife Service (USFWS) has expressed concern regarding impacts to threatened and endangered fish species with the on-site stabilization alternative (e.g., dewatering of the tailings). Information regarding threatened and endangered species in the area of the Moab millsite and the potential off-site disposal sites was obtained from agency consultations documented in the FEIS. Both listed species and critical habitat require consideration within the context of this plan. Listed species potentially affected by millsite activities include four aquatic species and one avian species. One other avain species (peregrine falcon) that was originally considered in the FEIS has since been delisted. The Colorado River adjacent to the millsite is designated critical habitat for two endangered fish.

USFWS issued a final Biological Opinion in 1998. The opinion was based on the proposed action in the draft Environmental Impact Statement (on-site stabilization) and concluded that continued leaching of existing concentrations of ammonia (and other constituents) would jeopardize the razorback sucker (*Xyrauchen texamus*) and Colorado pikeminnow (*Ptychocheilus lucius*, formerly known as the Colorado squawfish). Depletion of water (associated with remedial actions) in the Colorado River would jeopardize the humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), the razorback sucker, and the Colorado pikeminnow. The action would also affect critical river habitat for the razorback sucker and Colorado pikeminnow. USFWS concluded that construction activities would not jeopardize the southwestern willow flycatcher. That agency also proposed mitigative measures consisting of five "parts" with specific time frames for protection of fish species. Because USFWS considered groundwater remediation an "interrelated action," an expedited groundwater compliance action plan was requested in the opinion. Plant species were not within the scope of the Biological Opinion. The opinion also included provisions for incidental taking of listed species, specified required reporting, and provided recommendations for conservation.

In April 2000 and in subsequent communications, USFWS requested that NRC reinitiate consultation based on new information related to remedial actions and concerns related to interim actions. By letter dated February 8, 2001, USFWS withdrew its Biological Opinion pending additional consultation. Withdrawal of the opinion also voided the incidental take provisions of the opinion. However, USFWS authorized four actions in the letter that were not likely to affect endangered species adversely. The four actions included erosion control measures, application of dust-control surfactants, development of a pumping system to manage drain water, and environmental characterization/cell maintenance.

Contaminants have leached into the alluvial aquifer and have migrated toward and discharged to the Colorado River. Tailings leachates entering the groundwater and the Colorado River could have an adverse impact on water quality and aquatic biota, including endangered and threatened species. Monitoring efforts, conducted between April-November 2000, have suggested that ammonia concentrations in the Colorado River adjacent to the Moab site exceeded background levels and the U.S. Environmental Protection Agency (EPA)-recommended total ammonia protection criterion for early freshwater aquatic life (Shepherd Miller, Inc., Interim Report: *Ammonia Concentrations in the Colorado River Adjacent to the Atlas Mill Tailings, Moab, Utah*, January 2001). River sampling results indicate that the distribution and magnitude of ammonia concentrations in the river varied dramatically between sampling events because of the flow of the river. Low river flows expose greater portions of the Moab Wash sandbar, creating increased backwater areas that allow for the accumulation of ammonia in the surface water. However, this study determined that backwater areas are eliminated near the site during high flows, and ammonia concentrations near the shore are diluted to protective levels (within the EPA's recommended total ammonia protection criterion) or loading is temporarily stopped by river water flowing into the aquifer because of the seasonally high river stage. This suggests that snowmelt runoff periods (May and June) may effectively reduce the adverse ammonia impact on the Colorado River. Studies conducted by other entities show a larger areal extent of contamination and greater impact on fish species.

Recent activities at the site have been conducted under NRC Materials License Number SUA–917, which is held by the Moab Mill Reclamation Trust. PricewaterhouseCoopers, the Trustee for the site, has been reclaiming the site under the authority of the NRC license and an NRC order, which transferred the license from the Atlas Company to the Moab Mill Reclamation Trust. The October 30, 2000, enactment of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, Public Law 106–398, required transfer of site ownership to DOE on or before October 30, 2001, and NRC consultation with DOE for activities related to the site but not directly specified in the legislation. Since the enactment of this legislation, DOE has been working with NRC, the State of Utah Department of Environmental Quality, and PricewaterhouseCoopers to agree on activities related to the Moab site and to prepare for and support a smooth transition to DOE site jurisdiction and ownership.

ATTACHMENT 1

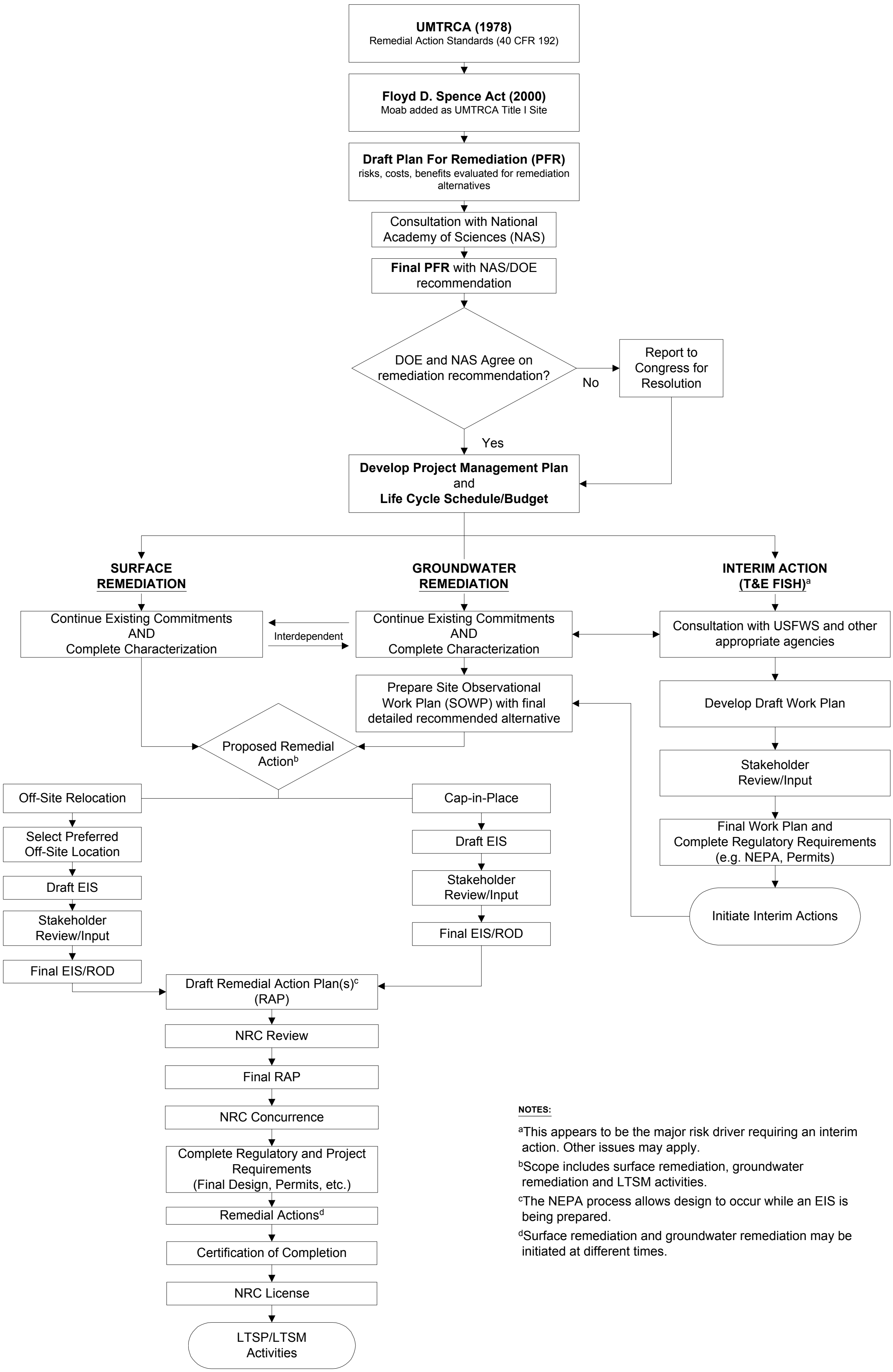
Moab Site Chronology of Events

1956 Moab Minerals Company Mill began operations under the Uranium Reduction Company
1961 Alkaline leach process initiated for uranium milling
1962 Atlas Minerals Company acquired the site
1967 Both the new acid leach circuit and alkaline leach circuit were operating
1974 Process circuits were modified to reduce water used for milling
1979 Atlas Corporation's license was renewed with U.S. Nuclear Regulatory Commission (NRC).
1982 Reclamation Plan approved by NRC
1982 An acid leach process only was used and continued through 1984
1984 Mill ceases operation under License SUA–917
1988 Decommissioning begins, significant plan revisions including a groundwater detection monitoring program and dewatering of the tailings
1989 Interim cover over tailings area begins
1992 Revised Reclamation Plan; mill decommissioning initiated to remove structures
1993 The Compliance Action Plan (CAP) was modified to discontinue enhanced evaporation
1993 Environmental Assessment published in *Federal Register* (FR) proposing selected revisions to the 1982 Reclamation Plan
Note: Extensive adverse public comment received; NRC decides to re-evaluate entire plan
1994 (Canonie) Atlas Ground Water Corrective Action Plan (CAP)
1994 NRC elects to prepare an Environmental Impact Statement to evaluate Reclamation Plan (FR Notice 3/30/94)
1995 Interim cover over tailings completed
1995 NRC consults U.S. Fish and Wildlife Service (USFWS) and initial Biological Assessment is submitted
Note: Concerns with contaminant effects on the fish in Colorado River
1996 Draft Technical Evaluation Report based on 10 CFR 40 and evaluation of applicable regulations; mill decommissioning of structures completed
1996 NRC notified Atlas that a revised CAP was needed to address groundwater
1997 NRC completes Final Technical Evaluation Report
1997 NRC submits supplement to initial Biological Assessment
1997 USFWS issues first Draft Biological Opinion; identified moving pile as "a reasonable and prudent alternative;" later determined NRC did not have authority to require this of Atlas
1998 Oak Ridge National Laboratory conducts limited groundwater investigation
1998 USFWS issues revised Draft and Final Biological Opinions stating that the groundwater CAP must be revisited and expedited.
1999 NRC completes Final Environmental Impact Statement (FEIS) to stabilize mill tailings in place
2000 Baseline Characterization Report is completed (Harding-Lawson)
2000 Moab site listed as Title I site under the Uranium Mill Tailings Radiation Control Act with the passage of the Floyd D. Spence National Defense Authorization Act.
2000 Site Management Plan (Harding-Lawson) to implement FEIS mitigative requirements is completed
2001 USFWS withdraws Final Biological Opinion
2001 Shepherd-Miller report on Moab site hydrogeology and geochemistry issued
2001 DOE Grand Junction Office develops Draft Plan for Remediation

Appendix B

Moab Remedial Action Selection Process

Moab Remedial Action Selection Process (Draft)



NOTES:

[a]This appears to be the major risk driver requiring an interim action. Other issues may apply.

[b]Scope includes surface remediation, groundwater remediation and LTSM activities.

[c]The NEPA process allows design to occur while an EIS is being prepared.

[d]Surface remediation and groundwater remediation may be initiated at different times.

Appendix C

40 CFR 192
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings

40 CFR
Protection of Environment
CHAPTER I
ENVIRONMENTAL PROTECTION AGENCY (CONTINUED)

SUBCHAPTER F -- RADIATION PROTECTION PROGRAMS

PART 192 -- HEALTH AND ENVIRONMENTAL PROTECTION STANDARDS FOR URANIUM AND THORIUM MILL TAILINGS

Subpart A -- Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites

Sec.

Subpart B -- Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

Subpart C -- Implementation

Subpart D -- Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

Subpart E -- Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

Authority: Sec. 275 of the Atomic Energy Act of 1954, 42 U.S.C. 2022, as added by the Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. 95-604, as amended.

Source: 48 FR 602, Jan. 5, 1983, unless otherwise noted.

Subpart A -- Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites

192.00 Applicability.

This subpart applies to the control of residual radioactive material at designated processing or depository sites under section 108 of the Uranium Mill Tailings Radiation Control Act of 1978 (henceforth designated "the Act"), and to restoration of such sites following any use of subsurface minerals under section 104(h) of the Act.

192.01 Definitions.

(a) *Residual radioactive material* means:

(1) Waste (which the Secretary determines to be radioactive) in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores; and

(2) Other wastes (which the Secretary determines to be radioactive) at a processing site which relate to such processing, including any residual stock of unprocessed ores or low-grade materials.

(b) *Remedial* action means any action performed under section 108 of the Act.

(c) *Control* means any remedial action intended to stabilize, inhibit future misuse of, or reduce emissions or effluents from residual radioactive materials.

(d) *Disposal site* means the region within the smallest perimeter of residual radioactive material (excluding cover materials) following completion of control activities.

(e) *Depository site* means a site (other than a processing site) selected under Section 104(b) or 105(b) of the Act.

(f) *Curie* (Ci) means the amount of radioactive material that produces 37 billion nuclear transformation per second. One picocurie (pCi) = 10^{-12} Ci.

(g) *Act* means the Uranium Mill Tailings Radiation Control Act of 1978, as amended.

(h) *Administrator* means the Administrator of the Environmental Protection Agency.

(i) *Secretary* means the Secretary of Energy.

(j) *Commission* means the Nuclear Regulatory Commission.

(k) *Indian tribe* means any tribe, band, clan, group, pueblo, or community of Indians recognized as eligible for services provided by the Secretary of the Interior to Indians.

(l) *Processing site* means:

(1) Any site, including the mill, designated by the Secretary under Section 102(a)(1) of the Act; and

(2) Any other real property or improvement thereon which is in the vicinity of such site, and is determined by the Secretary, in consultation with the Commission, to be contaminated with residual radioactive materials derived from such site.

(m) *Tailings* means the remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted.

(n) *Disposal period* means the period of time beginning March 7, 1983 and ending with the completion of all subpart A requirements specified under a plan for remedial action except those specified in §192.03 and §192.04.

(o) *Plan for remedial action* means a written plan (or plans) for disposal and cleanup of residual radioactive materials associated with a processing site that incorporates the results of site characterization studies, environmental assessments or impact statements, and engineering assessments so as to satisfy the requirements of subparts A and B of this part. The plan(s) shall be developed in accordance with the provisions of Section 108(a) of the Act with the concurrence of the Commission and in consultation, as appropriate, with the Indian Tribe and the Secretary of Interior.

(p) *Post-disposal period* means the period of time beginning immediately after the disposal period and ending at termination of the monitoring period established under §192.03.

(q) *Groundwater* means water below the ground surface in a zone of saturation.

(r) *Underground source of drinking water* means an aquifer or its portion:

(1)(i) Which supplies any public water system as defined in §141.2 of this chapter; or

(ii) Which contains a sufficient quantity of groundwater to supply a public water system; and

(A) Currently supplies drinking water for human consumption; or

(B) Contains fewer than 10,000 mg/l total dissolved solids; and

(2) Which is not an exempted aquifer as defined in §144.7 of this chapter.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2865, Jan. 11, 1995]

192.02 Standards.

Control of residual radioactive materials and their listed constituents shall be designed [1] to:

[1]Because the standard applies to design, monitoring after disposal is not required to demonstrate compliance with respect to §192.02(a) and (b).

(a) Be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(b) Provide reasonable assurance that releases of radon-222 from residual radioactive material to the atmosphere will not:

(1) Exceed an average [2] release rate of 20 picocuries per square meter per second, or

[2]This average shall apply over the entire surface of the disposal site and over at least a one-year period. Radon will come from both residual radioactive materials and from materials covering them. Radon emissions from the covering materials should be estimated as part of developing a remedial action plan for each site. The standard, however, applies only to emissions from residual radioactive materials to the atmosphere.

(2) Increase the annual average concentration of radon-222 in air at or above any location outside the disposal site by more than one-half picocurie per liter.

(c) Provide reasonable assurance of conformance with the following groundwater protection provisions:

(1) The Secretary shall, on a site-specific basis, determine which of the constituents listed in Appendix I to Part 192 are present in or reasonably derived from residual radioactive materials and shall establish a monitoring program adequate to determine background levels of each such constituent in groundwater at each disposal site.

(2) The Secretary shall comply with conditions specified in a plan for remedial action which includes engineering specifications for a system of disposal designed to ensure that constituents identified under paragraph (c)(1) of this section entering the groundwater from a depository site (or a processing site, if residual radioactive materials are retained on the site) will not exceed the concentration limits established under paragraph (c)(3) of this section (or the supplemental standards established under §192.22) in the uppermost aquifer underlying the site beyond the point of compliance established under paragraph (c)(4) of this section.

(3) Concentration limits:

(i) Concentration limits shall be determined in the groundwater for listed constituents identified under paragraph (c)(1) of this section. The concentration of a listed constituent in groundwater must not exceed:

(A) The background level of that constituent in the groundwater; or

(B) For any of the constituents listed in Table 1 to subpart A, the respective value given in that Table if the background level of the constituent is below the value given in the Table; or

(C) An alternate concentration limit established pursuant to paragraph (c)(3)(ii) of this section.

(ii)(A) The Secretary may apply an alternate concentration limit if, after considering remedial or corrective actions to achieve the levels specified in paragraphs (c)(3)(i)(A) and (B) of this section, he has determined that the constituent will not pose a substantial present or potential hazard to human health and the environment as long as the alternate concentration limit is not exceeded, and the Commission has concurred.

(B) In considering the present or potential hazard to human health and the environment of alternate concentration limits, the following factors shall be considered:

(*1*) Potential adverse effects on groundwater quality, considering:

(*i*) The physical and chemical characteristics of constituents in the residual radioactive material at the site, including their potential for migration;

(*ii*) The hydrogeological characteristics of the site and surrounding land;

(*iii*) The quantity of groundwater and the direction of groundwater flow;

(*iv*) The proximity and withdrawal rates of groundwater users;

(*v*) The current and future uses of groundwater in the region surrounding the site;

(*vi*) The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality;

(*vii*) The potential for health risks caused by human exposure to constituents;

(*viii*) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to constituents;

(*ix*) The persistence and permanence of the potential adverse effects;

(*x*) The presence of underground sources of drinking water and exempted aquifers identified under §144.7 of this chapter; and

(*2*) Potential adverse effects on hydraulically-connected surface-water quality, considering:

(*i*) The volume and physical and chemical characteristics of the residual radioactive material at the site;

(*ii*) The hydrogeological characteristics of the site and surrounding land;

(*iii*) The quantity and quality of groundwater, and the direction of groundwater flow;

(*iv*) The patterns of rainfall in the region;

(*v*) The proximity of the site to surface waters;

(*vi*) The current and future uses of surface waters in the region surrounding the site and any water quality standards established for those surface waters;

(*vii*) The existing quality of surface water, including other sources of contamination and their cumulative impact on surface water quality;

(*viii*) The potential for health risks caused by human exposure to constituents;

(*ix*) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to constituents; and (*x*) The persistence and permanence of the potential adverse effects.

(4) Point of compliance: The point of compliance is the location at which the groundwater concentration limits of paragraph (c)(3) of this section apply. The point of compliance is the intersection of a vertical plane with the uppermost aquifer underlying the site, located at the hydraulically downgradient limit of the disposal area plus the area taken up by any liner, dike, or other barrier designed to contain the residual radioactive material.

(d) Each site on which disposal occurs shall be designed and stabilized in a manner that minimizes the need for future maintenance.

[60 FR 2865, Jan. 11, 1995]

192.03 Monitoring.

A groundwater monitoring plan shall be implemented, to be carried out over a period of time commencing upon completion of remedial actions taken to comply with the standards in §192.02, and of a duration which is adequate to demonstrate that future performance of the system of disposal can reasonably be expected to be in accordance with the design requirements of §192.02(c). This plan and the length of the monitoring period shall be modified to incorporate any corrective actions required under §192.04 or §192.12(c).

[60 FR 2866, Jan. 11, 1995]

192.04 Corrective action.

If the groundwater concentration limits established for disposal sites under provisions of §192.02(c) are found or projected to be exceeded, a corrective action program shall be placed into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance. This corrective action program will restore the performance of the system of disposal to the original concentration limits established under §192.02(c)(3), to the extent reasonably achievable, and, in any case, as a minimum shall:

(a) Conform with the groundwater provisions of §192.02(c)(3), and

(b) Clean up groundwater in conformance with subpart B, modified as appropriate to apply to the disposal site.

[60 FR 2866, Jan. 11, 1995]

Table 1 to Subpart A -- Maximum Concentration of Constituents for Groundwater Protection

Constituent concentration\1\	Maximum
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Nitrate (as N)	10.
Molybdenum	0.1
Combined radium-226 and radium-228	5 pCi/liter
Combined uranium-234 and uranium-238\2\	30 pCi/liter
Gross alpha-particle activity (excluding radon and uranium).	15 pCi/liter
Endrin (1,2,3,4,10,10-hexachloro-6,7-exposy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma insomer).	0.004
Methoxychlor (1,1,1-trichloro-2,2'-bis(p-methoxyphenylethane)).	0.1
Toxaphene (C<INF>10</INF> H<INF>10</INF> Cl<INF>6</INF>, technical chlorinated camphene, 67-69 percent chlorine).	0.005
2,4-D (2,4-dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-trichlorophenoxypropionic acid).	0.01

\1\Milligrams per liter, unless stated otherwise.
\2\Where secular equilibrium obtains, this criterion will be satisfied by a concentration of 0.044 milligrams per liter (0.044 mg/l). For conditions of other than secular equilibrium, a corresponding value may be derived and applied, based on the measured site-specific ratio of the two isotopes of uranium.

[60 FR 2866, Jan. 11, 1995]

Subpart B -- Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

192.10 Applicability.

This subpart applies to land and buildings that are part of any processing site designated by the Secretary of Energy under section 102 of the Act. section 101 of the Act, states, in part, that "processing site" means --

(a) Any site, including the mill, containing residual radioactive materials at which all or substantially all of the uranium was produced for sale to any Federal agency prior to January 1, 1971, under a contract with any Federal agency, except in the case of a site at or near Slick Rock, Colorado, unless --

(1) Such site was owned or controlled as of Januray 1, 1978, or is thereafter owned or controlled, by any Federal agency, or

(2) A license (issued by the (Nuclear Regulatory) Commission or its predecessor agency under the Atomic Energy Act of 1954 or by a State as permitted under section 274 of such Act) for the production at site of any uranium or thorium product derived from ores is in effect on January 1, 1978, or is issued or renewed after such date; and

(b) Any other real property or improvement thereon which --

(1) Is in the vicinity of such site, and

(2) Is determined by the Secretary, in consultation with the Commission, to be contaminated with residual radioactive materials derived from such site.

192.11 Definitions.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in subpart A.

(b) *Land* means any surface or subsurface land that is not part of a disposal site and is not covered by an occupiable building.

(c) *Working Level* (WL) means any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130 billion electron volts.

(d) *Soil* means all unconsolidated materials normally found on or near the surface of the earth including, but not limited to, silts, clays, sands, gravel, and small rocks.

(e) *Limited use groundwater* means groundwater that is not a current or potential source of drinking water because (1) the concentration of total dissolved solids is in excess of 10,000 mg/l, or (2) widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up using treatment methods reasonably employed in public water systems, or (3) the quantity of water reasonably available for sustained continuous use is less than 150 gallons per day. The parameters for determining the quantity of water reasonably available shall be determined by the Secretary with the concurrence of the Commission.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2866, Jan. 11, 1995]

192.12 Standards.

Remedial actions shall be conducted so as to provide reasonable assurance that, *as a result of residual radioactive materials from any designated processing site:*

(a) The concentration of radium-226 in land averaged over any area of 100 square meters shall not exceed the background level by more than --

(1) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and

(2) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.

(b) In any occupied or habitable building --

(1) The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL, and

(2) The level of gamma radiation shall not exceed the background level by more than 20 microroentgens per hour.

(c) The Secretary shall comply with conditions specified in a plan for remedial action which provides that contamination of groundwater by listed constituents from residual radioactive material at any designated processing site (§192.01(1)) shall be brought into compliance as promptly as is reasonably achievable with the provisions of §192.02(c)(3) or any supplemental standards established under §192.22. For the purposes of this subpart:

(1) A monitoring program shall be carried out that is adequate to define backgroundwater quality and the areal extent and magnitude of groundwater contamination by listed constituents from residual radioactive materials (§192.02(c)(1)) and to monitor compliance with this subpart. The Secretary shall determine which of the constituents listed in Appendix I to part 192 are present in or could reasonably be derived from residual radioactive material at the site, and concentration limits shall be established in accordance with §192.02(c)(3).

(2) (i) If the Secretary determines that sole reliance on active remedial procedures is not appropriate and that cleanup of the groundwater can be more reasonably accomplished in

full or in part through natural flushing, then the period for remedial procedures may be extended. Such an extended period may extend to a term not to exceed 100 years if:

(A) The concentration limits established under this subpart are projected to be satisfied at the end of this extended period,

(B) Institutional control, having a high degree of permanence and which will effectively protect public health and the environment and satisfy beneficial uses of groundwater during the extended period and which is enforceable by the administrative or judicial branches of government entities, is instituted and maintained, as part of the remedial action, at the processing site and wherever contamination by listed constituents from residual radioactive materials is found in groundwater, or is projected to be found, and

(C) The groundwater is not currently and is not now projected to become a source for a public water system subject to provisions of the Safe Drinking Water Act during the extended period.

(ii) Remedial actions on groundwater conducted under this subpart may occur before or after actions under Section 104(f)(2) of the Act are initiated.

(3) Compliance with this subpart shall be demonstrated through the monitoring program established under paragraph (c)(1) of this section at those locations not beneath a disposal site and its cover where groundwater contains listed constituents from residual radioactive material.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2867, Jan. 11, 1995]

Subpart C -- Implementation

192.20 Guidance for implementation.

Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions with the concurrence of the Nuclear Regulatory Commission and the full participation of any State that pays part of the cost, and in consultation, as appropriate, with affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under section 108, are referred to hereafter as "the implementing agencies." The implementing agencies shall establish methods and procedures to provide "reasonable assurance" that the provisions of Subparts A and B are satisfied. This should be done as appropriate through use of analytic models and site-specific analyses, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and laboratory instruments in conjunction with reasonable survey and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites. In particular:

(a)(1) The purpose of Subpart A is to provide for long-term stabilization and isolation in order to inhibit misuse and spreading of residual radioactive materials, control releases of radon to air, and protect water. Subpart A may be implemented through analysis of the physical properties of the site and the control system and projection of the effects of natural processes over time. Events and processes that could significantly affect the average radon release rate from the entire disposal site should be considered. Phenomena that are localized or temporary, such as local cracking or burrowing of rodents, need to be taken into account only if their cumulative effect would be significant in determining compliance with the standard. Computational models, theories, and prevalent expert judgment may be used to decide that a control system design will satisfy the standard. The numerical range provided in the standard for the longevity of the effectiveness of the control of residual radioactive materials allows for consideration of the various factors affecting the longevity of control and stabilization methods and their costs. These factors have different levels of predictability and may vary for the different sites.

(2) Protection of water should be considered on a case-specific basis, drawing on hydrological and geochemical surveys and all other relevant data. The hydrologic and geologic assessment to be conducted at each site should include a monitoring program sufficient to establish background groundwater quality through one or more upgradient or other appropriately located wells. The groundwater monitoring list in Appendix IX of part 264 of this chapter (plus the additional constituents in Table A of this paragraph) may be used for screening purposes in place of Appendix I of part 192 in the monitoring program. New depository sites for tailings that contain water at greater than the level of "specific retention" should use aliner or equivalent. In considering design objectives for groundwater protection, the implementing agencies should give priority to concentration levels in the order listed under §192.02(c)(3)(i). When considering the potential for health risks caused by human exposure to known or suspected carcinogens, alternate concentration limits pursuant to paragraph 192.02(c)(3)(ii) should be established at concentration levels which represent an excess lifetime risk, at a point of exposure, to an average individual no greater than between 10^{-4} and 10^{-6}.

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      Table A to Sec. 192.20(a)(2)--Additional Listed Constituents
Nitrate (as N)
Molybdenum
Combined radium-226 and radium-228
Combined uranium-234 and uranium-238
Gross alpha-particle activity (excluding radon and uranium)
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(3) The plan for remedial action, concurred in by the Commission, will specify how applicable requirements of subpart A are to be satisfied. The plan should include the schedule and steps necessary to complete disposal operations at the site. It should include an estimate of the inventory of wastes to be disposed of in the pile and their listed constituents and address any need to eliminate free liquids; stabilization of the wastes to a bearing capacity sufficient to support the final cover; and the design and engineering specifications for a cover to manage the migration of liquids through the stabilized pile, function without maintenance, promote drainage and minimize erosion or abrasion of the cover, and accommodate settling and subsidence so that cover integrity is maintained. Evaluation of proposed designs to conform to subpart A should be based on realistic

technical judgments and include use of available empirical information. The consideration of possible failure modes and related corrective actions should be limited to reasonable failure assumptions, with a demonstration that the disposal design is generally amenable to a range of corrective actions.

(4) The groundwater monitoring list in Appendix IX of part 264 of this chapter (plus the additional constituents in Table A in paragraph (a)(2) of this section) may be used for screening purposes in place of Appendix I of part 192 in monitoring programs. The monitoring plan required under §192.03 should be designed to include verification of site-specific assumptions used to project the performance of the disposal system. Prevention of contamination of groundwater may be assessed by indirect methods, such as measuring the migration of moisture in the various components of the cover, the tailings, and the area between the tailings and the nearest aquifer, as well as by direct monitoring of groundwater. In the case of vicinity properties (§192.01(l)(2)), such assessments may not be necessary, as determined by the Secretary, with the concurrence of the Commission, considering such factors as local geology and the amount of contamination present. Temporary excursions from applicable limits of groundwater concentrations that are attributable to a disposal operation itself shall not constitute a basis for considering corrective action under §192.04 during the disposal period, unless the disposal operation is suspended prior to completion for other than seasonal reasons.

(b)(1) Compliance with §192.12(a) and (b) of subpart B, to the extent practical, should be demonstrated through radiation surveys. Such surveys may, if appropriate, be restricted to locations likely to contain residual radioactive materials. These surveys should be designed to provide for compliance averaged over limited areas rather than point-by-point compliance with the standards. In most cases, measurement of gamma radiation exposure rates above and below the land surface can be used to show compliance with §192.12(a). Protocols for making such measurements should be based on realistic radium distributions near the surface rather than extremes rarely encountered.

(2) In §192.12(a), "background level" refers to the native radium concentration in soil. Since this may not be determinable in the presence of contamination by residual radioactive materials, a surrogate "background level" may be established by simple direct or indirect (e.g., gamma radiation) measurements performed nearby but outside of the contaminated location.

(3) Compliance with §192.12(b) may be demonstrated by methods that the Department of Energy has approved for use under Pub. L. 92-314 (10 CFR part 712), or by other methods that the implementing agencies determine are adequate. Residual radioactive materials should be removed from buildings exceeding 0.03 WL so that future replacement buildings will not pose a hazard [unless removal is not practical -- see §192.21(c)]. However, sealants, filtration, and ventilation devices may provide reasonable assurance of reductions from 0.03 WL to below 0.02 WL. In unusual cases, indoor radiation may exceed the levels specified in §192.12(b) due to sources other than residual radioactive materials. Remedial actions are not required in order to comply with

the standard when there is reasonable assurance that residual radioactive materials are not the cause of such an excess.

(4) The plan(s) for remedial action will specify how applicable requirements of subpart B would be satisfied. The plan should include the schedule and steps necessary to complete the cleanup of groundwater at the site. It should document the extent of contamination due to releases prior to final disposal, including the identification and location of listed constituents and the rate and direction of movement of contaminated groundwater, based upon the monitoring carried out under §192.12(c)(1). In addition, the assessment should consider future plume movement, including an evaluation of such processes as attenuation and dilution and future contamination from beneath a disposal site. Monitoring for assessment and compliance purposes should be sufficient to establish the extent and magnitude of contamination, with reasonable assurance, through use of a carefully chosen minimal number of sampling locations. The location and number of monitoring wells, the frequency and duration of monitoring, and the selection of indicator analytes for long-term groundwater monitoring, and, more generally, the design and operation of the monitoring system, will depend on the potential for risk to receptors and upon other factors, including characteristics of the subsurface environment, such as velocity of groundwater flow, contaminant retardation, time of groundwater or contaminant transit to receptors, results of statistical evaluations of data trends, and modeling of the dynamics of the groundwater system. All of these factors should be incorporated into the design of a site-specific monitoring program that will achieve the purpose of the regulations in this subpart in the most cost-effective manner. In the case of vicinity properties (§192.01(l)(2)), such assessments will usually not be necessary. The Secretary, with the concurrence of the Commission, may consider such factors as local geology and amount of contamination present in determining criteria to decide when such assessments are needed. In cases where §192.12(c)(2) is invoked, the plan should include a monitoring program sufficient to verify projections of plume movement and attenuation periodically during the extended cleanup period. Finally, the plan should specify details of the method to be used for cleanup of groundwater.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2867, Jan. 11, 1995]

192.21 Criteria for applying supplemental standards.

Unless otherwise indicated in this subpart, all terms shall have the same meaning as defined in Title I of the Act or in subparts A and B. The implementing agencies may (and in the case of paragraph (h) of this section shall) apply standards under §192.22 in lieu of the standards of subparts A or B if they determine that any of the following circumstances exists:

(a) Remedial actions required to satisfy subpart A or B would pose a clear and present risk of injury to workers or to members of the public, notwithstanding reasonable measures to avoid or reduce risk.

(b) Remedial actions to satisfy the cleanup standards for land, §192.12(a), and groundwater, §192.12(c), or the acquisition of minimum materials required for control to satisfy §§192.02(b) and (c), would, notwithstanding reasonable measures to limit damage, directly produce health and environmental harm that is clearly excessive compared to the health and environmental benefits, now or in the future. A clear excess of health and environmental harm is harm that is long-term, manifest, and grossly disproportionate to health and environmental benefits that may reasonably be anticipated.

(c) The estimated cost of remedial action to satisfy §192.12(a) at a "vicinity" site (described under section 101(6)(B) of the Act) is unreasonably high relative to the long-term benefits, and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a vicinity site should be considered in evaluating this hazard. Remedial action will generally not be necessary where residual radioactive materials have been placed semi-permanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence post foundations. Supplemental standards should not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail under §192.12(a).

(d) The cost of a remedial action for cleanup of a building under §192.12(b) is clearly unreasonably high relative to the benefits. Factors that should be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by the remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

(e) There is no known remedial action.

(f) The restoration of groundwater quality at any designated processing site under §192.12(c) is technically impracticable from an engineering perspective.

(g) The groundwater meets the criteria of §192.11(e).

(h) Radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2868, Jan. 11, 1995]

192.22 Supplemental standards.

Federal agencies implementing subparts A and B may in lieu thereof proceed pursuant to this section with respect to generic or individual situations meeting the eligibility requirements of §192.21.

(a) When one or more of the criteria of §192.21(a) through (g) applies, the Secretary shall select and perform that alternative remedial action that comes as close to meeting the otherwise applicable standard under §192.02(c)(3) as is reasonably achievable.

(b) When §192.21(h) applies, remedial actions shall reduce other residual radioactivity to levels that are as low as is reasonably achievable and conform to the standards of subparts A and B to the maximum extent practicable.

(c) The implementing agencies may make general determinations concerning remedial actions under this section that will apply to all locations with specified characteristics, or they may make a determination for a specific location. When remedial actions are proposed under this section for a specific location, the Department of Energy shall inform any private owners and occupants of the affected location and solicit their comments. The Department of Energy shall provide any such comments to the other implementing agencies. The Department of Energy shall also periodically inform the Environmental Protection Agency of both general and individual determinations under the provisions of this section.

(d) When §192.21(b), (f), or (g) apply, implementing agencies shall apply any remedial actions for the restoration of contamination of groundwater by residual radioactive materials that is required to assure, at a minimum, protection of human health and the environment. In addition, when §192.21(g) applies, supplemental standards shall ensure that current and reasonably projected uses of the affected groundwater are preserved.

[48 FR 602, Jan. 5, 1983, as amended at 60 FR 2868, Jan. 11, 1995]

192.23 Effective date.

Subparts A, B, and C shall be effective March 7, 1983.

Subpart D -- Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

Source: 48 FR 45946, Oct. 7, 1983, unless otherwise noted.

192.30 Applicability.

This subpart applies to the management of uranium byproduct materials under section 84 of the Atomic Energy Act of 1954 (henceforth designated "the Act"), as amended, during and following processing of uranium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act.

192.31 Definitions and cross-references.

References in this subpart to other parts of the Code of Federal Regulations are to those parts as codified on January 1, 1983.

(a) Unless otherwise indicated in this subpart, all terms shall have the same meaning as in Title II of the Uranium Mill Tailings Rediation Control Act of 1978, subparts A and B of this part, or parts 190, 260, 261, and 264 of this chapter. For the purposes of this subpart, the terms "waste," "hazardous waste," and related terms, as used in parts 260, 261, and 264 of this chapter shall apply to byproduct material.

(b) *Uranium byproduct material* means the tailings or wastes produced by the extraction or concentration of uranium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material" for the purpose of this subpart.

(c) *Control* means any action to stabilize, inhibit future misuse of, or reduce emissions or effluents from uranium byproduct materials.

(d) *Licensed site* means the area contained within the boundary of a location under the control of persons generating or storing uranium byproduct materials under a license issued pursuant to section 84 of the Act. For purposes of this subpart, "licensed site" is equivalent to "regulated unit" in subpart F of part 264 of this chapter.

(e) *Disposal site* means a site selected pursuant to section 83 of the Act.

(f) *Disposal area* means the region within the perimeter of an impoundment or pile containing uranium by product materials to which the post-closure requirements of §192.32(b)(1) of this subpart apply.

(g) *Regulatory agency* means the U.S. Nuclear Regulatory Commission.

(h) *Closure period* means the period of time beginning with the cessation, with respect to a waste impoundment, of uranium ore processing operations and ending with completion of requirements specified under a closure plan.

(i) *Closure plan* means the plan required under §264.112 of this chapter.

(j) *Existing portion* means that land surface area of an existing surface impoundment on which significant quantities of uranium byproduct materials have been placed prior to promulgation of this standard.

(k) *As expeditiously as practicable considering technological feasibility* means as quickly as possible considering: the physical characteristics of the tailings and the site; the limits of available technology; the need for consistency with mandatory requirements of other regulatory programs; and factors beyond the control of the licensee. The phrase permits consideration of the cost of compliance only to the extent specifically provided for by use of the term "available technology."

(l) *Permanent Radon Barrier* means the final radon barrier constructed to achieve compliance with, including attainment of, the limit on releases of radon-222 in §192.32(b)(1)(ii).

(m) *Available technology* means technologies and methods for emplacing a permanent radon barrier on uranium mill tailings piles or impoundments. This term shall not be construed to include extraordinary measures or techniques that would impose costs that are grossly excessive as measured by practice within the industry or one that is reasonably analogous, (such as, by way of illustration only, unreasonable overtime, staffing or transportation requirements, etc., considering normal practice in the industry; laser fusion, of soils, etc.), provided there is reasonable progress toward emplacement of a permanent radon barrier. To determine grossly excessive costs, the relevant baseline against which cost increases shall be compared is the cost estimate for tailings impoundment closure contained in the licensee's tailings closure plan, but costs beyond such estimates shall not automatically be considered grossly excessive.

(n) *Tailings Closure Plan (Radon)* means the Nuclear Regulatory Commission or Agreement State approved plan detailing activities to accomplish timely emplacement of a permanent radon barrier. A tailings closure plan shall include a schedule for key radon closure milestone activities such as wind blown tailings retrieval and placement on the pile, interim stabilization (including dewatering or the removal of freestanding liquids and recontouring), and emplacement of a permanent radon barrier constructed to achieve compliance with the 20 pCi/m^2-s flux standard as expeditiously as practicable considering technological feasibility (including factors beyond the control of the licensee).

(o) *Factors beyond the control of the licensee* means factors proximately causing delay in meeting the schedule in the applicable license for timely emplacement of the permanent radon barrier notwithstanding the good faith efforts of the licensee to achieve compliance. These factors may include, but are not limited to, physical conditions at the site; inclement weather or climatic conditions; an act of God; an act of war; a judicial or administrative order or decision, or change to the statutory, regulatory, or other legal requirements applicable to the licensee's facility that would preclude or delay the performance of activities required for compliance; labor disturbances; any modifications, cessation or delay ordered by state, Federal or local agencies; delays beyond the time reasonably required in obtaining necessary governmental permits, licenses, approvals or consent for activities described in the tailings closure plan (radon) proposed by the licensee that result from agency failure to take final action after the licensee has made a good faith, timely effort to submit legally sufficient applications, responses to requests (including relevant data requested by the agencies), or other information, including approval of the tailings closure plan by NRC or the affected Agreement State; and an act or omission of any third party over whom the licensee has no control.

(p) *Operational* means that a uranium mill tailings pile or impoundment is being used for the continued placement of uranium byproduct material or is in standby status for such placement. A tailings pile or impoundment is operational from the day that uranium byproduct material is first placed in the pile or impoundment until the day final closure begins.

(q) *Milestone* means an enforceable date by which action, or the occurrence of an event, is required for purposes of achieving compliance with the 20 pCi/m ^{2}–s flux standard.

[48 FR 45946, Oct. 7, 1983, as amended at 58 FR 60355, Nov. 15, 1993]

192.32 Standards.

(a) *Standards for application during processing operations and prior to the end of the closure period.* (1) Surface impoundments (except for an existing portion) subject to this subpart must be designed, constructed, and installed in such manner as to conform to the requirements of §264.221 of this chapter, except that at sites where the annual precipitation falling on the impoundment and any drainage area contributing surface runoff to the impoundment is less than the annual evaporation from the impoundment, the requirements of §264.228(a)(2) (iii)(E) referenced in §264.221 do not apply.

(2) Uranium byproduct materials shall be managed so as to conform to the ground water protection standard in §264.92 of this chapter, except that for the purposes of this subpart:

(i) To the list of hazardous constituents referenced in §264.93 of this chapter are added the chemical elements molybdenum and uranium,

(ii) To the concentration limits provided in Table 1 of §264.94 of this chapter are added the radioactivity limits in Table A of this subpart,

(iii) Detection monitoring programs required under §264.98 to establish the standards required under §264.92 shall be completed within one (1) year of promulgation,

(iv) The regulatory agency may establish alternate concentration limits (to be satisfied at the point of compliance specified under §264.95) under the criteria of §264.94(b), provided that, after considering practicable corrective actions, these limits are as low as reasonably achievable, and that, in any case, the standards of §264.94(a) are satisfied at all points at a greater distance than 500 meters from the edge of the disposal area and/or outside the site boundary, and

(v) The functions and responsibilities designated in Part 264 of this chapter as those of the "Regional Administrator" with respect to "facility permits" shall be carried out by the regulatory agency, except that exemptions of hazardous constituents under §264.93 (b) and (c) of this chapter and alternate concentration limits established under §264.94 (b) and (c) of this chapter (except as otherwise provided in §192.32(a)(2)(iv)) shall not be effective until EPA has concurred therein.

(3)(i) Uranium mill tailings piles or impoundments that are nonoperational and subject to a license by the Nuclear Regulatory Commission or an Agreement State shall limit releases of radon-222 by emplacing a permanent radon barrier. This permanent radon barrier shall be constructed as expeditiously as practicable considering technological feasibility (including factors beyond the control of the licensee) after the pile or impoundment ceases to be operational. Such control shall be carried out in accordance with a written tailings closure plan (radon) to be incorporated by the Nuclear Regulatory Commission or Agreement State into individual site licenses.

(ii) The Nuclear Regulatory Commission or Agreement State may approve a licensee's request to extend the time for performance of milestones if, after providing an opportunity for public participation, the Nuclear Regulatory Commission or Agreement State finds that compliance with the 20 pCi/m^{2}–s flux standard has been demonstrated using a method approved by the NRC, in the manner required in 192.32(a)(4)(i). Only under these circumstances and during the period of the extension must compliance with the 20 pCi/m^{2}–s flux standard be demonstrated each year.

(iii) The Nuclear Regulatory Commission or Agreement State may extend the final compliance date for emplacement of the permanent radon barrier, or relevant milestone, based upon cost if the new date is established after a finding by the Nuclear Regulatory Commission or Agreement State, after providing an opportunity for public participation, that the licensee is making good faith efforts to emplace a permanent radon barrier; the delay is consistent with the definition of "available technology" in §192.31(m); and the delay will not result in radon releases that are determined to result in significant incremental risk to the public health.

(iv) The Nuclear Regulatory Commission or Agreement State may, in response to a request from a licensee, authorize by license or license amendment a portion of the site to remain accessible during the closure process to accept uranium byproduct material as defined in section 11(e)(2) of the Atomic Energy Act, 42 U.S.C. 2014(e)(2), or to accept materials similar to the physical, chemical and radiological characteristics of the in situ uranium mill tailings and associated wastes, from other sources. No such authorization may be used as a means for delaying or otherwise impeding emplacement of the permanent radon barrier over the remainder of the pile or impoundment in a manner that will achieve compliance with the 20 pCi/m^{2}–s flux standard, averaged over the entire pile or impoundment.

(v) The Nuclear Regulatory Commission or Agreement State may, in response to a request from a licensee, authorize by license or license amendment a portion of a pile or impoundment to remain accessible after emplacement of a permanent radon barrier to accept uranium byproduct material as defined in section 11(e)(2) of the Atomic Energy Act, 42 U.S.C. 2014(e)(2), if compliance with the 20 pCi/m^{2}−s flux standard of §192.32(b)(1)(ii) is demonstrated by the licensee's monitoring conducted in a manner consistent with §192.32(a)(4)(i). Such authorization may be provided only if the Nuclear Regulatory Commission or Agreement State makes a finding, constituting final agency action and after providing an opportunity for public participation, that the site will continue to achieve the 20 pCi/m2−s flux standard when averaged over the entire impoundment.

(4)(i) Upon emplacement of the permanent radon barrier pursuant to 40 CFR 192.32(a)(3), the licensee shall conduct appropriate monitoring and analysis of the radon-222 releases to demonstrate that the design of the permanent radon barrier is effective in limiting releases of radon-222 to a level not exceeding 20 pCi/m^{2}−s as required by 40 CFR 192.32(b)(1)(ii). This monitoring shall be conducted using the procedures described in 40 CFR part 61, Appendix B, Method 115, or any other measurement method proposed by a licensee that the Nuclear Regulatory Commission or Agreement State approves as being at least as effective as EPA Method 115 in demonstrating the effectiveness of the permanent radon barrier in achieving compliance with the 20 pCi/m^{2}−s flux standard.

(ii) When phased emplacement of the permanent radon barrier is included in the applicable tailings closure plan (radon), then radon flux monitoring required under §192.32(a)(4)(i) shall be conducted, however the licensee shall be allowed to conduct such monitoring for each portion of the pile or impoundment on which the radon barrier has been emplaced by conducting flux monitoring on the closed portion.

(5) Uranium byproduct materials shall be managed so as to conform to the provisions of:

(i) Part 190 of this chapter, "Environmental Radiation Protection Standards for Nuclear Power Operations" and

(ii) Part 440 of this chapter, "Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards, Subpart C, Uranium, Radium, and Vanadium Ores Subcategory."

(6) The regulatory agency, in conformity with Federal Radiation Protection Guidance (FR, May 18, 1960, pgs. 4402-4403), shall make every effort to maintain radiation doses from radon emissions from surface impoundments of uranium byproduct materials as far below the Federal Radiation Protection Guides as is practicable at each licensed site.

(b) *Standards for application after the closure period.* At the end of the closure period:

(1) Disposal areas shall each comply with the closure performance standard in §264.111 of this chapter with respect to nonradiological hazards and shall be designed[1] to provide reasonable assurance of control of radiological hazards to

[1]The standard applies to design with a monitoring requirement as specified in §192.32(a)(4).

(i) Be effective for one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years, and,

(ii) Limit releases of radon-222 from uranium byproduct materials to the atmosphere so as to not exceed an average [2] release rate of 20 picocuries per square meter per second (pCi/m2s).

[2]This average shall apply to the entire surface of each disposal area over periods of at least one year, but short compared to 100 years. Radon will come from both uranium byproduct materials and from covering materials. Radon emissions from covering materials should be estimated as part of developing a closure plan for each site. The standard, however, applies only to emissions from uranium byproduct materials to the atmosphere.

(2) The requirements of §192.32(b)(1) shall not apply to any portion of a licensed and/or disposal site which contains a concentration of radium-226 in land, averaged over areas of 100 square meters, which, as a result of uranium byproduct material, does not exceed the background level by more than:

(i) 5 picocuries per gram (pCi/g), averaged over the first 15 centimeters (cm) below the surface, and

(ii) 15 pCi/g, averaged over 15 cm thick layers more than 15 cm below the surface.

[48 FR 45946, Oct. 7, 1983, as amended at 58 FR 60355-60356, Nov. 15, 1993]

192.33 Corrective action programs.

If the ground water standards established under provisions of §192.32(a)(2) are exceeded at any licensed site, a corrective action program as specified in §264.100 of this chapter shall be put into operation as soon as is practicable, and in no event later than eighteen (18) months after a finding of exceedance.

192.34 Effective date.

Subpart D shall be effective December 6, 1983.

Table A to Subpart D

	pCi/liter
Combined radium-226 and radium-228	5

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Gross alpha-particle activity (excluding radon and uranium)..
15
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Subpart E -- Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended

Source: 48 FR 45947, Oct. 7, 1983, unless otherwise noted.

192.40 Applicability.

This subpart applies to the management of thorium byproduct materials under section 84 of the Atomic Energy Act of 1954, as amended, during and following processing of thorium ores, and to restoration of disposal sites following any use of such sites under section 83(b)(1)(B) of the Act.

192.41 Provisions.

Except as otherwise noted in §192.41(e), the provisions of subpart D of this part, including §§192.31, 192.32, and 192.33, shall apply to thorium byproduct material and:

(a) Provisions applicable to the element uranium shall also apply to the element thorium;

(b) Provisions applicable to radon-222 shall also apply to radon-220; and

(c) Provisions applicable to radium-226 shall also apply to radium-228.

(d) Operations covered under §192.32(a) shall be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as a result of exposures to the planned discharge of radioactive materials, radon-220 and its daughters excepted, to the general environment.

(e) The provisions of §192.32(a) (3) and (4) do not apply to the management of thorium byproduct material.

[48 FR 45946, Oct. 7, 1983, as amended at 58 FR 60356, Nov. 15, 1993]

192.42 Substitute provisions.

The regulatory agency may, with the concurrence of EPA, substitute for any provisions of §192.41 of this subpart alternative provisions it deems more practical that will provide at least an equivalent level of protection for human health and the environment.

192.43 Effective date.

Subpart E shall be effective December 6, 1983.

Appendix I to Part 192 -- Listed Constituents

Acetonitrile

Acetophenone (Ethanone, 1-phenyl)

2-Acetylaminofluorene (Acetamide, N-9H-fluoren-2-yl-)

Acetyl chloride

1-Acetyl-2-thiourea (Acetamide, N-(aminothioxymethyl)-)

Acrolein (2-Propenal)

Acrylamide (2-Propenamide)

Acrylonitrile (2-Propenenitrile)

Aflatoxins

Aldicarb (Propenal, 2-methyl-2-(methylthio)-,O-[(methylamino)carbonyl]oxime

Aldrin (1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro(1α,4α,4aβ,5α,8α,8αβ)-)

Allyl alcohol (2-Propen-1-ol)

Allyl chloride (1-Propane,3-chloro)

Aluminum phosphide

4-Aminobiphenyl ([1,1'-Biphenyl]-4-amine)

5-(Aminomethyl)-3-isoxazolol (3(2H)-Isoxazolone,5-(aminomethyl)-)

4-Aminopyridine (4-Pyridineamine)

Amitrole (lH-1,2,4-Triazol-3-amine)

Ammonium vanadate (Vanadic acid, ammonium salt)

Aniline (Benzenamine)

Antimony and compounds, N.O.S. [1]

[1]The abbreviation N.O.S. (not otherwise specified) signifies those members of the general class not specifically listed by name in this appendix.

Aramite (Sulfurous acid, 2-chloroethyl 2-[4-(1,1-dimethylethyl)phenoxy]-1-methylethyl ester)

Arsenic and compounds, N.O.S.

Arsenic acid (Arsenic acid H3 AsO4)

Arsenic pentoxide (Arsenic oxide As2 O5)

Auramine (Benzamine, 4,4'-carbonimidoylbis[N,N-dimethyl-])

Azaserine (L-Serine, diazoacetate (ester))

Barium and compounds, N.O.S.

Barium cyanide

Benz[c]acridine (3,4-Benzacridine)

Benz[a]anthracene (1,2-Benzanthracene)

Benzal chloride (Benzene, dichloromethyl-)

Benzene (Cyclohexatriene)

Benzenearsonic acid (Arsenic acid, phenyl-)

Benzidine ([1,1'-Biphenyl]-4,4'-diamine)

Benzo[b]fluoranthene (Benz[e]acephananthrylene)

Benzo[j]fluoranthene

Benzo[k]fluoranthene

Benzo[a]pyrene

p-Benzoquinone (2,5-Cyclohexadiene-1,4-dione)

Benzotrichloride (Benzene, (trichloro-

methyl)-)

Benzyl chloride (Benzene, (chloromethyl)-)

Beryllium and compounds, N.O.S.

Bromoacetone (2-Propanone, 1-bromo-)

Bromoform (Methane, tribromo-)

4-Bromophenyl phenyl ether (Benzene, l-bromo-4-phenoxy-)

Brucine (Strychnidin-10-one, 2,3-dimeth-

oxy-)

Butyl benzyl phthalate (1,2-Benzenedicarbozylic acid, butyl phenylmethyl ester)

Cacodylic acid (Arsinic acid, dimethyl)

Cadmium and compounds, N.O.S.

Calcium chromate (Chromic acid H2 CrO4, calcium salt)

Calcium cyanide (Ca(CN)2)

Carbon disulfide

Carbon oxyfluoride (Carbonic difluoride)

Carbon tetrachloride (Methane, tetrachloro-)

Chloral (Acetaldehyde, trichloro-)

Chlorambucil (Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]-)

Chlordane (4,7-Methano-1H-indene,1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-)

Chlorinated benzenes, N.O.S.

Chlorinated ethane, N.O.S.

Chlorinated fluorocarbons, N.O.S.

Chlorinated naphthalene, N.O.S.

Chlorinated phenol, N.O.S.

Chlornaphazin (Naphthalenamine, N,N’-bis(2-chlorethyl)-)

Chloroacetaldehyde (Acetaldehyde, chloro-)

Chloroalkyl ethers, N.O.S.

p-Chloroaniline (Benzenamine, 4-chloro-)

Chlorobenzene (Benzene, chloro-)

Chlorobenzilate (Benzeneacetic acid, 4-chloro-α-(4-chlorophenyl)-α-hydroxy-, ethyl ester) p-Chloro-m-cresol (Phenol, 4-chloro-3-methyl)

2-Chloroethyl vinyl ether (Ethene, (2-chloroethoxy)-)

Chloroform (Methane, trichloro-)

Chloromethyl methyl ether (Methane, chloromethoxy-)

β-Chloronapthalene (Naphthalene, 2-chloro-)

o-Chlorophenol (Phenol, 2-chloro-)

1-(o-Chlorophenyl)thiourea (Thiourea, (2-chlorophenyl-))

3-Chloropropionitrile (Propanenitrile, 3-chloro-)

Chromium and compounds, N.O.S.

Chrysene

Citrus red No. 2 (2-Naphthalenol, 1-[(2,5-dimethoxyphenyl)azo]-)

Coal tar creosote

Copper cyanide (CuCN)

Creosote

Cresol (Chresylic acid) (Phenol, methyl-)

Crotonaldehyde (2-Butenal)

Cyanides (soluble salts and complexes), N.O.S.

Cyanogen (Ethanedinitrile)

Cyanogen bromide ((CN)Br)

Cyanogen chloride ((CN)Cl)

Cycasin (beta-D-Glucopyranoside, (methyl-ONN-azoxy)methyl)

2-Cyclohexyl-4,6-dinitrophenol (Phenol, 2-cyclohexyl-4,6-dinitro-)

Cyclophosphamide (2H-1,3,2-Oxazaphosphorin-2-amine,N,N-bis(2-chloroethyl)

tetrahydro-,2-oxide)

2,4-D and salts and esters (Acetic acid, (2,4-dichlorophenoxy)-)

Daunomycin (5,12-Naphthacenedione,8-acetyl-10-[(3-amino-2,3,6-trideoxy-α-Llyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-,(8S-cis))

DDD (Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-)

DDE (Benzene, 1,1-(dichloroethylidene)bis[4-chloro-)

DDT (Benzene, 1,1'-(2,2,2-trichloroethlyidene)bis[4-chloro-)

Diallate (Carbomothioic acid, bis(1-methylethyl)-,S-(2,3-dichloro-2-propenyl) ester)

Dibenz[a,h]acridine

Dibenz[a,j]acridine

Dibenz[a,h]anthracene

7H-Dibenzo[c,g]carbazole

Dibenzo[a,e]pyrene (Naphtho[1,2,4,5-def)crysene)

Dibenzo[a,h]pyrene (Dibenzo[b,def]crysene)

Dibenzo[a,i]pyrene (Benzo[rst]pentaphene)

1,2-Dibromo-3-chloropropane (Propane, 1,2-dibromo-3-chloro-)

Dibutylphthalate (1,2-Benzenedicarboxylic acid, dibutyl ester)

o-Dichlorobenzene (Benzene, 1,2-dichloro-)

m-Dichlorobenzene (Benzene, 1,3-dichloro-)

p-Dichlorobenzene (Benzene, 1,4-dichloro-)

Dichlorobenzene, N.O.S. (Benzene; dichloro-, N.O.S.)

3,3'-Dichlorobenzidine ([1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-)

1,4-Dichloro-2-butene (2-Butene, 1,4-dichloro-)

Dichlorodifluoromethane (Methane, dichlorodifluoro-)

Dichloroethylene, N.O.S.

1,1-Dichloroethylene (Ethene, 1,1-dichloro-)

1,2-Dichloroethylene (Ethene, 1,2-dichloro-,(E)-)

Dichloroethyl ether (Ethane, 1,1'-oxybis[2-chloro-)

Dichloroisopropyl ether (Propane, 2,2'-oxybis[2-chloro-)

Dichloromethoxy ethane (Ethane, 1,1'-[methylenebis(oxy)bis[2-chloro-)

Dichloromethyl ether (Methane, oxybis[chloro-)

2,4-Dichlorophenol (Phenol, 2,4-dichloro-)

2,6-Dichlorophenol (Phenol, 2,6-dichloro-)

Dichlorophenylarsine (Arsinous dichloride, phenyl-)

Dichloropropane, N.O.S. (Propane,

dichloro-,)

Dichloropropanol, N.O.S. (Propanol, dichloro-,)

Dichloropropene; N.O.S. (1-Propane, dichloro-,)

1,3-Dichloropropene (1-Propene, 1,3-dichloro-)

Dieldrin (2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a,octahydro-,(1aα,2β,2aα,3β,6β,6aα,7β,7aα)-)

1,2:3,4-Diepoxybutane (2,2'-Bioxirane)

Diethylarsine (Arsine, diethyl-)

1,4 Diethylene oxide (1,4-Dioxane)

Diethylhexyl phthalate (1,2-Benzenedicarboxlyic acid, bis(2-ethylhexl) ester)

N,N-Diethylhydrazine (Hydrazine, 1,2-diethyl)

O,O-Diethyl S-methyl dithiophosphate (Phosphorodithioic acid, O,O-diethyl S-methyl ester)

Diethyl-p-nitrophenyl phosphate (Phosphoric acid, diethyl 4-nitrophenyl ester)

Diethyl phthalate (1,2-Benzenedicarboxylic acid, diethyl ester)

O,O-Diethyl O-pyrazinyl phosphorothioate (Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester)

Diethylstilbesterol (Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-,(E)-)

Dihydrosafrole (1,3-Benxodioxole, 5-propyl-)

Diisopropylfluorophosphate (DFP) (Phosphorofluoridic acid, bis(1-methyl ethyl) ester)

Dimethoate (Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino) 2-oxoethyl] ester)

3,3’-Dimethoxybenzidine ([1,1’-Biphenyl]-4,4’-diamine, 3,3’-dimethoxy-)

p-Dimethylaminoazobenzene (Benzenamine, N,N-dimethyl-4-(phenylazo)-)

7,12-Dimethylbenz[a]anthracene (Benz[a]anthracene, 7,12-dimethyl-)

3,3’-Dimethylbenzidine ([1,1’-Biphenyl]-4,4’-diamine, 3,3’-dimethyl-)

Dimethylcarbamoyl chloride (carbamic chloride, dimethyl-)

1,1-Dimethylhydrazine (Hydrazine, 1,1-dimethyl-)

1,2-Dimethylhydrazine (Hydrazine, 1,2-dimethyl-)

α,α-Dimethylphenethylamine (Benzeneethanamine, α,α-dimethyl-)

2,4-Dimethylphenol (Phenol, 2,4-dimethyl-)

Dimethylphthalate (1,2-Benzenedicarboxylic acid, dimethyl ester)

Dimethyl sulfate (Sulfuric acid, dimethyl ester)

Dinitrobenzene, N.O.S. (Benzene, dinitro-)

4,6-Dinitro-o-cresol and salts (Phenol, 2-methyl-4,6-dinitro-)

2,4-Dinitrophenol (Phenol, 2,4-dinitro-)

2,4-Dinitrotoluene (Benzene, 1-methyl-2,4-dinitro-)

2,6-Dinitrotoluene (Benzene, 2-methyl-1,3-dinitro-)

Dinoseb (Phenol, 2-(1-methylpropyl)-4,6-dinitro-)

Di-n-octyl phthalate (1,2-Benzenedicarboxylic acid, dioctyl ester)

1,4-Dioxane (1,4-Diethyleneoxide)

Diphenylamine (Benzenamine, N-phenyl-)

1,2-Diphenylhydrazine (Hydrazine, 1,2-diphenyl-)

Di-n-propylnitrosamine (1-Propanamine,N-nitroso-N-propyl-)

Disulfoton (Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl] ester)

Dithiobiuret (Thioimidodicarbonic diamide [(H2 N)C(S)]2 NH)

Endosulfan (6,9,Methano-2,4,3-benzodioxathiepin,6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9ahexahydro,3-oxide)

Endothall (7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid)

Endrin and metabolites (2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro1a,2,2a,3,6,6a,7,7a-octa-hydro,(1aα,2β,2aβ,3α,6α,6aβ,7β,7aα)-)

Epichlorohydrin (Oxirane, (chloromethyl)-)

Epinephrine (1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]-,(R)-,)

Ethyl carbamate (urethane) (Carbamic acid, ethyl ester)

Ethyl cyanide (propanenitrile)

Ethylenebisdithiocarbamic acid, salts and esters (Carbamodithioic acid, 1,2-Ethanediylbis-)

Ethylene dibromide (1,2-Dibromoethane)

Ethylene dichloride (1,2-Dichloroethane)

Ethylene glycol monoethyl ether (Ethanol, 2-ethoxy-)

Ethyleneimine (Aziridine)

Ethylene oxide (Oxirane)

Ethylenethiourea (2-Imidazolidinethione)

Ethylidene dichloride (Ethane, 1,1-

Dichloro-)

Ethyl methacrylate (2-Propenoic acid, 2-methyl-, ethyl ester)

Ethylmethane sulfonate (Methanesulfonic acid, ethyl ester)

Famphur (Phosphorothioic acid, O-[4-[(dimethylamino)sulphonyl]phenyl] O,O-dimethyl ester)

Fluoranthene

Fluorine

Fluoroacetamide (Acetamide, 2-fluoro-)

Fluoroacetic acid, sodium salt (Acetic acid, fluoro-, sodium salt)

Formaldehyde (Methylene oxide)

Formic acid (Methanoic acid)

Glycidylaldehyde (Oxiranecarboxyaldehyde)

Halomethane, N.O.S.

Heptachlor (4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-)

Heptachlor epoxide (α, β, and γ isomers) (2,5-Methano-2H-indeno[1,2-b]-oxirene, 2,3,4,5,6,7,7-heptachloro-1a,1b,5,5a,6,6a-hexa-hydro-,(1aα,1bβ,2α,5α,5aβ,6β,6aα)-)

Hexachlorobenzene (Benzene, hexachloro-)

Hexachlorobutadiene (1,3-Butadiene, 1,1,2,3,4,4-hexachloro-)

Hexachlorocyclopentadiene (1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-)

Hexachlorodibenzofurans

Heptachlorodibenzo-p-dioxins

Hexachloroethane (Ethane, hexachloro-)

Hexachlorophene (phenol, 2,2'-Methylenebis[3,4,6-trichloro-)

Hexachloropropene (1-Propene, 1,1,2,3,3,3-hexachloro-)

Hexaethyl tetraphosphate (Tetraphosphoric acid, hexaethyl ester)

Hydrazine

Hydrocyanic acid

Hydrofluoric acid

Hydrogen sulfide (H2 S)

Indeno(1,2,3-cd)pyrene

Isobutyl alcohol (1-Propanol, 2-methyl-)

Isodrin (1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro, (1α,4α,4aβ,5β,8β,8aβ)-)

Isosafrole (1,3-Benzodioxole, 5-(1-propenyl)-)

Kepone (1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-)

Lasiocarpine (2-Butenoic acid, 2-methyl-,7-[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy]methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-l-yl ester)

Lead and compounds, N.O.S.

Lead acetate (Acetic acid, lead(2+) salt)

Lead phosphate (Phosphoric acid, lead(2+) salt(2:3))

Lead subacetate (Lead, bis(acetato-O)tetrahydroxytri-)

Lindane (Clohexane, 1,2,3,4,5,6-hexachloro-, (1α,2α,3β,4α,5α,6β)-)

Maleic anhydride (2,5-Furandione)

Maleic hydrazide (3,6-Pyridazinedione, 1,2-dihydro-)

Malononitrile (Propanedinitrile)

Melphalan (L-Phenylalanine, 4-[bis(2-chloroethyl)aminol]-)

Mercury and compounds, N.O.S.

Mercury fulminate (Fulminic acid, mercury(2+) salt)

Methacrylonitrile (2-Propenenitrile, 2-methyl-)

Methapyrilene (1,2-Ethanediamine, N,N-dimethyl-N’-2-pyridinyl-N’-(2-thienylmethyl)-)

Metholmyl (Ethamidothioic acid, N-[[(methylamino)carbonyl]oxy]thio-, methyl ester)

Methoxychlor (Benzene, 1,1’-(2,2,2-trichloroethylidene)bis[4-methoxy-)

Methyl bromide (Methane, bromo-)

Methyl chloride (Methane, chloro-)

Methyl chlorocarbonate (Carbonchloridic acid, methyl ester)

Methyl chloroform (Ethane, 1,1,1-trichloro-)

3-Methylcholanthrene (Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-)

4,4’-Methylenebis(2-chloroaniline) (Benzenamine, 4,4’-methylenebis(2- chloro-)

Methylene bromide (Methane, dibromo-)

Methylene chloride (Methane, dichloro-)

Methyl ethyl ketone (MEK) (2-Butanone)

Methyl ethyl ketone peroxide (2-Butanone, peroxide)

Methyl hydrazine (Hydrazine, methyl-)

Methyl iodide (Methane, iodo-)

Methyl isocyanate (Methane, isocyanato-)

2-Methyllactonitrile (Propanenitrile, 2-hydroxy-2-methyl-)

Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)

Methyl methanesulfonate (Methanesulfonic acid, methyl ester)

Methyl parathion (Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester)

Methylthiouracil (4(1H)Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-)

Mitomycin C (Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[(aminocarbonyl) oxy]methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methy-, [1aS-(1aα,8β,8aα,8bα)]-)

MNNG (Guanidine, N-methyl-N'-nitro-N-nitroso-)

Mustard gas (Ethane, 1,1'-thiobis[2-chloro-)

Naphthalene

1,4-Naphthoquinone (1,4-Naphthalenedione)

α-Naphthalenamine (1-Naphthylamine)

β-Naphthalenamine (2-Naphthylamine)

α-Naphthylthiourea (Thiourea, 1-naphthalenyl-)

Nickel and compounds, N.O.S.

Nickel carbonyl (Ni(CO)4 (T-4)-)

Nickel cyanide (Ni(CN)2)

Nicotine and salts (Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)-)

Nitric oxide (Nitrogen oxide NO)

p-Nitroaniline (Benzenamine, 4-nitro-)

Nitrobenzene (Benzene, nitro-)

Nitrogen dioxide (Nitrogen oxide NO2)

Nitrogen mustard, and hydrochloride salt (Ethanamine, 2-chloro-N-(2-chloroethyl)-N-methyl-)

Nitrogen mustard N-oxide and hydrochloride salt (Ethanamine, 2chloro-N-(2-chloroethyl)N-methyl-, N-oxide)

Nitroglycerin (1,2,3-Propanetriol, trinitrate) p-Nitrophenol (Phenol, 4-nitro-)

2-Nitropropane (Propane, 2-nitro-)

Nitrosamines, N.O.S.

N-Nitrosodi-n-butylamine (l-Butanamine, N-butyl-N-nitroso-)

N-Nitrosodiethanolamine (Ethanol, 2,2'-(nitrosoimino)bis-)

N-Nitrosodiethylamine (Ethanamine, N-ethyl-N-nitroso-1)

N-Nitrosodimethylamine (Methanamine, N-methyl-N-nitroso-)

N-Nitroso-N-ethylurea (Urea, N-ethyl-N-nitroso-)

N-Nitrosomethylethylamine (Ethanamine, N-methyl-N-nitroso-)

N-Nitroso-N-methylurea (Urea, N-methyl-N-nitroso-)

N-Nitroso-N-methylurethane (Carbamic acid, methylnitroso-, ethyl ester)

N-Nitrosomethylvinylamine (Vinylamine, N-methyl-N-nitroso-)

N-Nitrosomorpholine (Morpholine,

4-nitroso-)

N-Nitrosonornicotine (Pyridine, 3-(1-nitroso-2-pyrrolidinyl)-, (S)-)

N-Nitrosopiperidine (Piperidine, 1-nitroso-)

Nitrosopyrrolidine (Pyrrolidine, 1-nitroso-)

N-Nitrososarcosine (Glycine, N-methyl-N-nitroso-)

5-Nitro-o-toluidine (Benzenamine, 2-methyl-5-nitro-)

Octamethylpyrophosphoramide (Diphosphoramide, octamethyl-)

Osmium tetroxide (Osmium oxide OsO_4, (T-4)-)

Paraldehyde (1,3,5-Trioxane, 2,4,6-trimethyl-)

Parathion (Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester)

Pentachlorobenzene (Benzene, pentachloro-)

Pentachlorodibenzo-p-dioxins

Pentachlorodibenzofurans

Pentachloroethane (Ethane, pentachloro-)

Pentachloronitrobenzene (PCNB) (Benzene, pentachloronitro-)

Pentachlorophenol (Phenol, pentachloro-)

Phenacetin (Acetamide, N-(4-ethoxyphenyl)-)

Phenol

Phenylenediamine (Benzenediamine)

Phenylmercury acetate (Mercury, (acetato-O)phenyl-)

Phenylthiourea (Thiourea, phenyl-)

Phosgene (Carbonic dichloride)

Phosphine

Phorate (Phosphorodithioic acid, O,O-diethyl S-[(ethylthiomethyl] ester)

Phthalic acid esters, N.O.S.

Phthalic anhydride (1,3-isobenzofurandione)

2-Picoline (Pyridine, 2-methyl-)

Polychlorinated biphenyls, N.O.S.

Potassium cyanide (K(CN))

Potassium silver cyanide (Argentate(l-), bis(cyano-C)-, potassium)

Pronamide (Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)-)

1,3-Propane sultone (1,2-Oxathiolane, 2,2-dioxide)

n-Propylamine (1-Propanamine)

Propargyl alcohol (2-Propyn-1-ol)

Propylene dichloride (Propane, 1,2- dichloro-)

1,2-Propylenimine (Aziridine, 2-methyl-)

Propylthiouracil (4(1H)-Pyrimidinone, 2,3-dihydro-6-propyl-2-thioxo-)

Pyridine

Reserpinen (Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-smethyl ester, (3β,16 β,17α,18β,20α)-)

Resorcinol (1,3-Benzenediol)

Saccharin and salts (1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide)

Safrole (1,3-Benzodioxole, 5-(2-propenyl)-)

Selenium and compounds, N.O.S.

Selenium dioxide (Selenious acid)

Selenium sulfide (SeS2)

Selenourea

Silver and compounds, N.O.S.

Silver cyanide (Silver cyanide Ag(CN))

Silvex (Propanoic acid, 2-(2,4,5-trichlorophen oxy)-)

Sodium cyanide (Sodium cyanide Na(CN))

Streptozotocin (D-Glucose, 2-deoxy-2-[[methylnitrosoamino)carbonyl]amino]-)

Strychnine and salts (Strychnidin-10-one)

TCDD (Dibenzo[b,e][1,4]dioxin, 2,3,7,8-tetrachloro-)

1,2,4,5-Tetrachlorobenzene (Benzene, 1,2,4,5-tetrachloro-)

Tetrachlorodibenzo-p-dioxins

Tetrachlorodibenxofurans

Tetrachloroethane, N.O.S. (Ethane, tetrachloro-, N.O.S.)

1,1,1,2-Tetrachloroethane (Ethane, 1,1,1,2-tetrachloro-)

1,1,2,2-Tetrachloroethane (Ethane, 1,1,2,2-tetrachloro-)

Tetrachloroethylene (Ethene, tetrachloro-)

2,3,4,6-Tetrachlorophenol (Phenol, 2,3,4,6-tetrachloro-)

Tetraethyldithiopyrophosphate (Thiodiphosphoric acid, tetraethyl ester)

Tetraethyl lead (Plumbane, tetraethyl-)

Tetraethyl pyrophosphate (Diphosphoric acid, tetraethyl ester)

Tetranitromethane (Methane, tetranitro-)

Thallium and compounds, N.O.S.

Thallic oxide (Thallium oxide Tl2 O3)

Thallium (I) acetate (Acetic acid, thallium (1+) salt)

Thallium (I) carbonate (Carbonic acid, dithallium (1+) salt)

Thallium (I) chloride (Thallium chloride TlCl)

Thallium (I) nitrate (Nitric acid, thallium (1+) salt)

Thallium selenite (Selenius acid, dithallium (1+) salt)

Thallium (I) sulfate (Sulfuric acid, thallium (1+) salt)

Thioacetamide (Ethanethioamide)

3,Thiofanox (2-Butanone, 3,3-dimethyl-1-(methylthio)-, O-[(methylamino)carbonyl] oxime)

Thiomethanol (Methanethiol)

Thiophenol (Benzenethiol)

Thiosemicarbazide (Hydrazinecarbothioamide)

Thiourea

Thiram (Thioperoxydicarbonic diamide [(H2 N)C(S)]2S2, tetramethyl-)

Toluene (Benzene, methyl-)

Toluenediamine (Benzenediamine, ar-methyl-)

Toluene-2,4-diamine (1,3-Benzenediamine, 4-methyl-)

Toluene-2,6-diamine (1,3-Benzenediamine, 2-methyl-)

Toluene-3,4-diamine (1,2-Benzenediamine, 4-methyl-)

Toluene diisocyanate (Benzene, 1,3-diisocyanatomethyl-)

o-Toluidine (Benzenamine, 2-methyl-)

o-Toluidine hydrochloride (Benzenamine, 2-methyl-, hydrochloride)

p-Toluidine (Benzenamine, 4-methyl-)

Toxaphene

1,2,4-Trichlorobenzene (Benzene, 1,2,4-trichloro-)

1,1,2-Trichloroethane (Ethane, 1,1,2-trichloro-)

Trichloroethylene (Ethene,trichloro-)

Trichloromethanethiol (Methanethiol, trichloro-)

Trichloromonofluoromethane (Methane, trichlorofluoro-)

2,4,5-Trichlorophenol (Phenol, 2,4,5-trichlo-ro-)

2,4,6-Trichlorophenol (Phenol, 2,4,6-trichlo-ro-)

2,4,5-T (Acetic acid, 2,4,5- trichlorophenoxy-)

Trichloropropane, N.O.S.

1,2,3-Trichloropropane (Propane, 1,2,3-trichloro-)

O,O,O-Triethyl phosphorothioate (Phosphorothioic acid, O,O,O-triethyl ester)

Trinitrobenzene (Benzene, 1,3,5-trinitro-)

Tris(1-aziridinyl)phosphine sulfide (Aziridine, 1,1',1"phosphinothioylidyne-tris-))

Tris(2,3-dibromopropyl) phosphate (1-Propanol, 2,3-dibromo-, phosphate (3:1))

Trypan blue (2,7-Naphthalendisulfonic acid, 3,3'-[(3,3'-dimethyl[1,1'-biphenyl]-4,4'-diyl)bis(azo)]bis(5-amino-4-hydroxy-, tetrasodium salt)

Uracil mustard (2,4-(1H,3H)-Pyrimidinedione, 5-[bis(2-chloroethyl)amino]-)

Vanadium pentoxide (Vanadium oxide V2 O5)

Vinyl chloride (Ethene, chloro-)

Wayfarin (2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenlybutyl)-)

Zinc cyanide (Zn(CN)2)

Zinc phosphide (Zn3 P2)

[60 FR 2868, Jan. 11, 1995]

Appendix D

Groundwater Compliance Strategy

The United States Congress passed the Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 *United States Code* [U.S.C.] §7901 *et seq.*) in 1978 in response to public concerns about potential health hazards from long-term exposure to uranium mill tailings. UMTRCA directs the U.S. Environmental Protection Agency (EPA) to promulgate standards, mandates remedial action in accordance with these standards, stipulates that remedial action be selected and performed with the concurrence of the U.S. Nuclear Regulatory Commission (NRC) and in consultation with the states and Indian tribes, directs NRC to license the disposal sites for long-term care, and directs the U.S. Department of Energy (DOE) to enter into cooperative agreements with the affected states and Indian tribes. Three UMTRCA titles apply to uranium ore-processing sites. Title I designates 24 inactive processing sites for remediation. Title II applies to active uranium mills. Title III applies only to certain uranium mills in New Mexico.

DOE's Uranium Mill Tailings Remedial Action (UMTRA) Project is responsible for administering only Title I of UMTRCA. UMTRCA authorized DOE to stabilize, dispose of, and control uranium mill tailings and other contaminated materials at inactive uranium ore-processing sites. In 1988, Congress passed the Uranium Mill Tailings Remedial Action Amendments Act (42 U.S.C. §7922 *et seq.*), authorizing DOE to extend without limitation the time needed to complete groundwater remediation activities at the processing sites. Congress amended UMTRCA in 2000 to designate the Moab milling site as a processing site in accordance with Title I of UMTRCA (42 U.S.C. §7911 *et seq.*).

EPA Groundwater Protection Standards

UMTRCA requires EPA to promulgate standards for protecting public health, safety, and the environment from radiological and nonradiological hazards associated with uranium ore processing and the resulting residual radioactive materials. On January 5, 1983, EPA published standards (Title 40 *Code of Federal Regulations* [CFR] Part 192) for RRM disposal and cleanup. The standards were revised and a final rule was published January 11, 1995 (60 *Federal Register* [FR] 2854).

The standards (60 FR 2854) address two groundwater contamination scenarios: (1) future groundwater contamination that might occur from tailings material after disposal cell construction and (2) the cleanup of residual contamination from the milling process at the processing sites that occurred before disposal of the tailings material. The UMTRA Surface Project is designed to control and stabilize tailings and contaminated soil and is regulated by Subpart A of 40 CFR 192. The UMTRA Ground Water Project addresses groundwater contamination at the processing sites and is regulated by Subparts B and C of 40 CFR 192.

Subpart B: Standards for Cleanup of Land and Buildings

Subpart B, "Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites," requires documentation that action at the former ore-processing sites ensures that groundwater contamination meets any of the following three criteria:

- Background levels, which are concentrations of constituents in nearby groundwater not contaminated by ore-processing activities.

- UMTRA project maximum concentration limits (MCLs), which are limits set by EPA for certain hazardous constituents in groundwater and are specific to the UMTRA Project (Table D1). Note that numerical standards have also been established for some of these constituents by EPA under the Safe Drinking Water Act (SDWA) (also provided in Table D1). Most of the UMTRA MCLs are the same as the standards for corresponding contaminants but some differences do exist.

- Alternate concentrations limits (ACLs), which are selected concentration limits for hazardous constituents that do not pose a substantial hazard (present or potential) to human health or the environment as long as the limit is not exceeded.

Table D1. Standards for Inorganic Constituents in Groundwater at UMTRA Project Sites and Maximum Concentrations Measured at the Moab Site[a]

Constituent	UMTRA Standard[b]	SDWA Standard[c]	Maximum Groundwater Sampling Result (from Shepherd Miller, Inc., Table 2-20, April 2001)		
			Tailings Area	Mill Site Area	Downgradient of Tailings Area
Arsenic	0.05	0.05	not analyzed	not analyzed	not analyzed
Barium	1	2	not analyzed	not analyzed	not analyzed
Cadmium	0.01	0.005	not analyzed	0.003	0.0073
Chromium	0.05	0.1	not analyzed	not analyzed	not analyzed
Lead	0.05	N/A	not analyzed	not analyzed	not analyzed
Mercury	0.002	0.002	not analyzed	0.0011	0.003
Molybdenum	0.1	N/A	10.8	1.73	10.11
Nitrate (as N)	10.0[d]	10.0[d]	181[f]	152[f]	744[f]
Selenium	0.01	0.05	not analyzed	0.024	0.11
Silver	0.05	N/A	not analyzed	not analyzed	not analyzed
Combined radium-226 and radium-228	5 pCi/L	5 pCi/L	not analyzed	not analyzed	not analyzed
Combined uranium-234 and uranium-238	30 pCi/L[e]	N/A	3.97(mg/L)	23.3 (mg/L)	6.11 (mg/L)
Gross alpha-particle activity (excluding radon and uranium)	15 pCi/L	15 pCi/L	not analyzed	775[g]	1570[g]

[a]Concentrations reported in milligrams per liter (mg/L) unless otherwise noted.
[b]Maximum Concentration of Constituents for Groundwater Protection, UMTRA Standard (40 CFR 192, Table 1, Subpart A).
[c]Maximum Contaminant Levels, Safe Drinking Water Standard (40 CFR 141.23 and 141.62).
[d]Equivalent to 44 milligrams per liter (mg/L) nitrate as NO_3.
[e]Equivalent to 0.044 mg/L, assuming secular equilibrium of uranium-234 and uranium-238.
[f]Total NO_2+NO_3.
[g]Not adjusted for radon and uranium activity.
N/A = not applicable.
pCi/L = picocuries per liter.

Natural Flushing To Achieve Standards

Subpart B also allows natural flushing to meet EPA standards. Natural flushing allows natural groundwater processes to reduce the contamination in groundwater to acceptable standards (background levels, MCLs, or ACLs). Natural flushing must allow the standards to be met within

100 years. In addition, institutional controls and an adequate monitoring program must be established and maintained to protect human health and the environment during the period of natural flushing. Institutional controls would prohibit inappropriate uses of the contaminated groundwater. The groundwater also must not be a current or projected source for a public water system subject to provisions of the SDWA during the period of natural flushing.

Subpart C: Implementation

Subpart C provides guidance for implementing methods and procedures to reasonably ensure that standards of Subpart B are met. Subpart C requires that the standards of Subpart B are met on a site-specific basis using information gathered during site characterization and monitoring. The plan to meet the standards of Subpart B will be stated in a site-specific groundwater compliance action plan (GCAP). The plan must contain a compliance strategy and a monitoring program, if necessary.

Supplemental Standards

Under certain conditions, DOE may apply supplemental standards to contaminated groundwater in lieu of background levels, UMTRA MCLs, or ACLs (40 CFR Part 192.22). Supplemental standards may be applied if any of the following conditions are met:

- Remedial action necessary to implement Subpart A or B would pose a significant risk to workers or the public.
- Remedial action to meet the standards would directly produce environmental harm that is clearly excessive, compared to the health benefits of remediation, to persons living on or near the sites, now or in the future.
- The estimated cost of remedial action is unreasonably high relative to the long-term benefits, and the residual radioactive material does not pose a clear present or future hazard.
- There is no known remedial action.
- The restoration of groundwater quality at any processing site is technically impractical from an engineering standpoint.
- The groundwater is classified as limited-use groundwater. Subpart B of 40 CFR 192.11 (e) defines limited-use groundwater as groundwater that is not a current or potential source of drinking water because total dissolved solids (TDS) exceed 10,000 milligrams per liter (mg/L); there is widespread ambient contamination that cannot be cleaned up using treatment methods reasonably employed in public water supply systems; or the quantity of water available to a well is less than 150 gallons per day. When limited-use groundwater applies, supplemental standards ensure that current and reasonably projected uses of the groundwater are preserved (40 CFR 192).
- Radiation from radionuclides other than radium-226 and its decay products is present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive material.

National Environmental Policy Act

UMTRCA is a major federal action that is subject to the requirements of National Environmental Policy Act (NEPA) (42 U.S.C §4321 *et seq.*). Regulations of the Council on Environmental

Quality (to implement NEPA) are codified in 40 CFR 1500; these regulations require each federal agency to develop its own implementing procedures (40 CFR §1507.3). DOE-related NEPA regulations are contained in 10 CFR 1021, *National Environmental Policy Act Implementing Procedures*. DOE guidance is provided in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993a).

Pursuant to NEPA, DOE drafted a Programmatic Environmental Impact Statement (PEIS) in 1994 for the UMTRA Ground Water Project. The PEIS document was finalized October 1996 (DOE 1996). The purpose of the NEPA document was to analyze the potential impacts of implementing four programmatic alternatives for groundwater compliance at the designated processing sites. The preferred alternative for the UMTRA Ground Water Project and stakeholder review and acceptance of the final PEIS was published in a Record of Decision in 1997. All subsequent action on the UMTRA Ground Water Project must comply with the Record of Decision.

Compliance Strategy Selection Process

Selection of a strategy to achieve compliance with the EPA groundwater protection standards at the Moab site is governed by the framework defined in the final PEIS for the UMTRA Ground Water Project. The PEIS framework is summarized in the flow chart presented in Figure D1. The framework takes into consideration human health and environmental risk, stakeholder input, and cost. A systematic approach is followed until one, or a combination of one or more, of three general compliance strategies is selected for each alternative evaluated. The three possible compliance strategies allowable under the regulations are

- ***No remediation***—Compliance with the EPA groundwater protection standards would be met at the Moab site without altering the groundwater or cleaning it up in any way. This strategy could be applied for those contaminants that are already at or below MCLs or background levels or for those contaminants above maximum concentration limits or background levels that qualify for supplemental standards or ACLs as defined above.

- ***Natural flushing***— Compliance with the EPA groundwater protection standards would be met within a period of 100 years by allowing natural groundwater movement and geochemical processes to decrease contaminant concentrations to regulatory limits. The natural flushing strategy could be applied at the Moab site if groundwater compliance can be achieved within 100 years or less, where effective monitoring and institutional controls can be maintained, and where the groundwater is not, and is not projected to be, a source for a public water system.

- ***Active groundwater remediation***— Compliance with the EPA groundwater protection standards cannot be met by natural flushing. This option requires application of engineered groundwater remediation methods such as gradient manipulation, groundwater extraction, treatment, land application, phytoremediation, or in situ groundwater treatment to achieve compliance with the standards.

DOE is required by the PEIS to follow the groundwater compliance selection framework summarized in Figure D1 in selecting the appropriate compliance strategy(ies) to clean up the alluvial aquifer affected by former processing activities at the Moab site.

Groundwater Compliance Strategy

Based on the PEIS framework summarized in Figure D1, DOE has determined that a combination of active treatment for ammonia and retarded constituents of concern and natural flushing for the more mobile constituents of concern in the alluvial aquifer is the appropriate groundwater compliance strategy for the Moab site. This strategy is applicable for the cap-in-place, treatment in place, and the off-site disposal alternatives. A step-by-step explanation of how the targeted strategy was selected is presented in Table D2.

Data are not sufficient to evaluate which constituents of concern may naturally flush to acceptable levels within the 100-year period allowed under the regulations. On the basis of the relative geochemical mobility of the site-related constituents of concern, it is assumed that some of the more conservative species will naturally flush while the more retarded constituents will not. Therefore, the groundwater compliance strategy consists of natural flushing for all the mobile constituents of concern except ammonia (Table D2, Box 14). Active remediation is selected as the compliance strategy for the conservative constituent ammonia to eliminate the immediate flux to the river and for all the retarded constituents of concern that will remain after the tailings and associated contaminated soils have been disposed off-site, capped in place, or treated in place.

Natural flushing compliance strategy also requires application of an institutional control to prohibit the installation of wells into the alluvial aquifer for any purpose during the 100-year flushing period. During the natural flushing period after the active remediation is completed, it is assumed for this plan, that DOE may transfer title to the site property to another Federal agency, State, local government, or private ownership. One approach to implement institutional controls would be to apply a deed restriction to the property underlain by the contaminated groundwater when the title is transferred. The deed restriction would prevent inappropriate use of groundwater within the Moab site boundaries during the flushing period. Property underlain by contaminated groundwater outside the Moab site boundary must also have an effective institutional control. The Bureau of Land Management (BLM) currently administers the property downgradient of the millsite that extends to the Colorado River. This compliance strategy assumes BLM will restrict groundwater use through a property withdraw or special use permit during the natural flushing period.

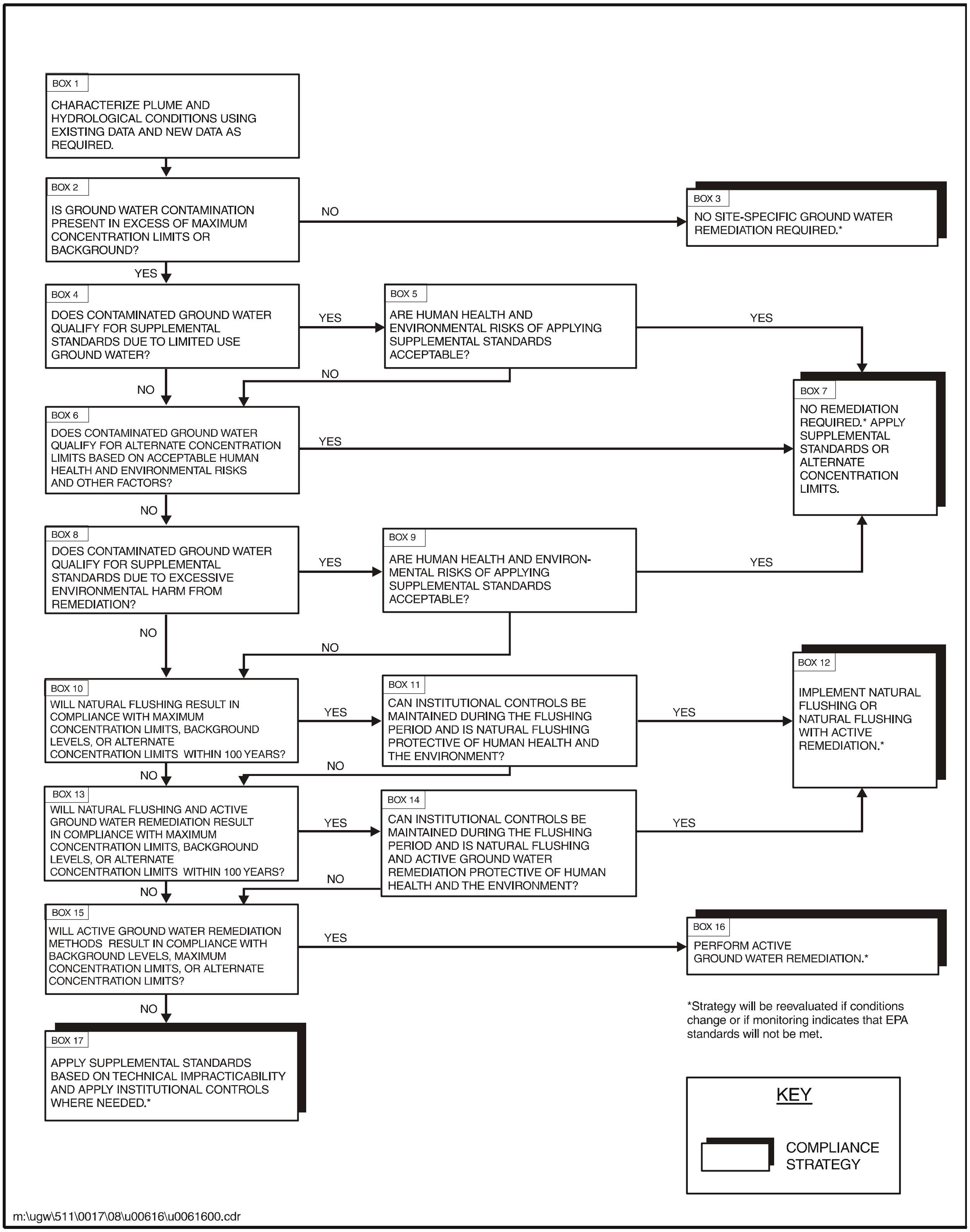

Figure D1. Summary of Groundwater Compliance Selection Framework

Table D2. Explanation of the Groundwater Compliance Strategy Selection Process for Moab Site

Box (Figure D1)	Action or Question	Result or Decision
1	Characterize plume and hydrological conditions.	Initial plume and hydrologic characterization is provided in ORNL 1998 (Limited Groundwater Investigation of The Moab Corporation Moab Mill) and Shepherd Miller, Inc., 2001 (Site Hydrogeologic and Geochemical Characterization and Alternatives Assessment for the Moab Uranium Mill Tailings Site). **Move to Box 2.**
2	Is groundwater contamination present in excess of UMTRA MCLs or background?	Maximum concentrations of cadmium, mercury, molybdenum, nitrate, selenium, uranium, and gross alpha exceed the UMTRA MCLs or SDWA standards at one or more monitoring points. Other constituents such as ammonia, manganese, sulfate, and strontium are elevated compared with background and exceed risk-based concentrations. **Move to Box 4.**
4	Does contaminated groundwater qualify for supplemental standards due to limited use groundwater?	Although the interface/contact between the lower brine zone and the upper fresh water has not been fully characterized, either in the horizontal or vertical direction, there appears to be some upgradient alluvial groundwater of high enough quality to be considered a potential source for drinking. Therefore, for purposes of this plan, the alluvial aquifer is not classified as limited use. **Move to Box 6.**
6	Does contaminated groundwater qualify for ACLs based on acceptable human health and environmental risk and other factors?	Contaminated groundwater will still remain beneath and downgradient from the former Moab millsite for either the cap-in-place, treatment in place, or the off-site disposal alternative at concentrations that are not protective of human health for cadmium, mercury, molybdenum, nitrate, selenium, uranium, gross alpha, ammonia, manganese, sulfate, and strontium. Existing impacts to threatened and endangered species and critical habitat due to elevated ammonia concentrations in groundwater discharging into the Colorado River will also still remain after the tailings are relocated off site. Therefore, the contaminated groundwater does not qualify for ACLs based on acceptable risk. **Move to Box 8**
8	Does contaminated groundwater qualify for supplemental standards due to excessive environmental harm from remediation?	Although the applicability has not been formally assessed, some potential exists that active pumping the shallow alluvial aquifer could induce upward flow of brine into the upper fresh groundwater system. However, for purposes of this plan, it is assumed that an extraction system can be designed and optimized to minimize the possibility that remedial action would cause excessive harm to the environment. **Move to Box 10.**
10	Will natural flushing result in compliance with UMTRA MCLs, background, or ACLs within 100 years?	Data are insufficient to evaluate the effectiveness of natural flushing. However, for purposes of this plan, it is assumed that conservative constituents such as nitrate and ammonia will naturally flush within 100-years while more retarded constituents such as selenium and arsenic will not. **Move to Box 11 for conservative constituents. Move to Box 13 for retarded constituents.**
11	Can institutional controls be maintained during the flushing period and is natural flushing protective of human health and the environment?	Institutional controls can be maintained during the flushing period that are protective of human health. However, institutional controls are not protective of the environment at the point of ammonia discharge to the river. **Move to Box 13.**

Box (Figure D1)	Action or Question	Result or Decision
13	Will natural flushing and active remediation result in compliance with UMTRA MCLs, background, or ACLs within 100 years?	Natural flushing will be protective for the more conservative constituents except ammonia. Active remediation will be protective by reducing the ammonia flux to the river. Data are insufficient to evaluate if active remediation will result in compliance with the more retarded constituents; however for purposes of this plan, it is assumed that an active treatment technology will be applied that is protective of human health for the more retarded constituents. **Move to Box 14.**
14	Can institutional controls be maintained during the flushing period and is natural flushing and active groundwater remediation compliance strategy protective of human health and the environment?	The final compliance strategy is protective of human health and the environment. Institutional controls can be maintained to prevent use of groundwater during the flushing period. Active remediation is protective of the environment by eliminating ammonia discharge to the river and is also protective for the more retarded constituents remaining after the tailings have been removed. Groundwater can be used without restriction after 100 years and will be protective of human health and the environment at that time. **Move to Box 12 – implement natural flushing with active remediation.**

Appendix E

Disposal Cell Components

This appendix presents a background discussion of disposal cell components that apply to all the on-site and off-site disposal alternatives. The disposal cell components described here are those specified in the Technical Approach Document (DOE 1989) for remediation under Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA).

For this discussion, a disposal cell may be thought of as two basic components—an embankment and a top cover. The disposal cell embankment consists of a perimeter dike or berm in conjunction with tailings and other contaminated material. A perimeter dike or berm is a soil mass enclosing the tailings and other contaminated material. Waste piles remediated in place result in an above-grade disposal cell. Relocated waste piles can be buried entirely beneath the ground surface in a below-grade disposal cell. Alternatively, the earthwork cut-and-fill quantities can be balanced to create an optimized disposal cell that is partially below grade.

A top cover overlies the embankment top slope and side slopes. The cover is composed of multiple functional components that create a system to isolate encapsulated waste permanently from the environment. Either top slope or side slope covers can be constructed from rock, a combination of soil and rock, or only soil. Plants included in the cover system provide erosion resistance and help remove water that could otherwise infiltrate through the cover.

Embankment

Geotechnical stability is demonstrated for the embankment by analyzing for slope stability, seismic conditions, liquefaction potential, and settlement. A slope stability analysis shows that all temporary construction and final configuration slopes are designed against slope failure. Construction slopes are designed to be stable under short-term loadings; final configuration slopes must be stable when subjected to long-term static and dynamic loadings. Dynamic loadings arise from seismic events. Regional seismicity is characterized by defining the design earthquake magnitude, the on-site peak horizontal ground acceleration, distance to and lengths of capable faults, and the types of capable faults and associated displacements. Liquefacation potential is assessed for tailings, other contaminated material, and foundation soils. Liquefacation will occur only if the soil materials are relatively loose, saturated or nearly saturated, and subject to shaking through a seismic event. Settlement of the embankment is assessed to ensure that proper construction measures have been taken to prevent differential movements. Differential settlement can lead to the development of depressions that could cause excessive erosion and cover cracking that would allow exposure pathways to open.

Top Cover

Top covers are divided into top slope cover and side slope cover systems. Both systems must be designed to resist erosion and to limit infiltration of water. Success in long-term disposal of uranium mill tailings relies on understanding and controlling the cover water balance to protect groundwater resources, limiting radon emission from the surface of the embankment, and preventing erosion. The water-balance term is defined as the balance between inflow of rainfall and snowmelt and outflow of water by surface runoff, evapotranspiration, and drainage. Cover longevity is obtained through use of natural materials.

Top Slope Cover

Top slope cover systems typically consist of the following layers from the base of the cover at the tailings/contaminated material interface upward to the surface (shown in Figure E1).

- A low hydraulic-conductivity, compacted soil-barrier layer consisting of clay to prevent release of radon and limit infiltration.

- A loose soil layer to protect the barrier layer from freeze-thaw cycling and desiccation and to provide a water storage layer in evapotranspiration covers. Often a rock layer is constructed in this layer to mitigate intrusion of small mammals.

- An erosion-protection layer consisting of rock, a soil-rock matrix, or a vegetated soil.

A compacted clay soil is designed as the radon/infiltration barrier layer using the U.S. Nuclear Regulatory Commission (NRC)-specified RADON computer program. Flux of water through this layer is limited by highly compacting the clay to create a tight, low-permeability soil layer. Construction quality is controlled to ensure that the layer does not desiccate before overlying layers are placed.

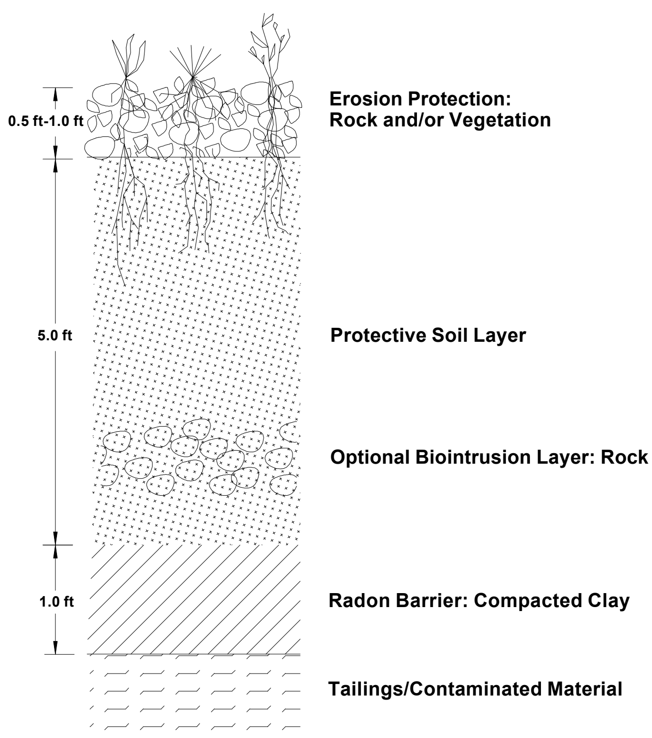

Figure E1. Top Flow Cover System Schematic

The barrier layer must be protected after construction from cracking that arises from freeze-thaw cycling, desiccation, and biointrusion, that is, intrusion from burrowing rodents and plant roots. Radon barrier protection is provided by constructing a loose soil layer over the barrier layer. Functional storage capacity of the protective soil layer can be used when the layer is planted and used as growth medium for evapotranspiration caps. Evapotranspiration covers provide infiltration control by maximizing plant use throughout the entire growing season by storing moisture in the soil matrix. Design of the soil-protection layer requires balancing the minimum depth required for frost protection with the minimum thickness necessary for water storage. Plant stems also increase surface erosion resistance, the leaf canopy reduces soil erosion by intercepting rainfall impact, and enhanced infiltration reduces runoff.

The erosion-protection layer must prevent soil loss through wind and water sheet wash and rill erosion. Erosion resistance is provided through a rock layer or a vegetated-rock layer. Rocks are dimensioned according to the design storm event hydrology. Durability of available rock material is verified using NRC procedures (NRC 1999c). When vegetation is used in conjunction with rock, the erosion resistance provided through the plant stems is used to reduce the required size of rock. Also, plants increase public acceptance of a disposal cell by creating an aesthetically pleasing site.

Side Slope Cover

The side slope cover system depends on the embankment type. When the disposal cell embankment is a cap-in-place (stabilize-in-place) design and tailings are placed beneath the slope, the side slope requires a radon barrier, protective soil layer, and erosion protection layer, similar to the top slope cover system. A functional trade-off is made in side-slope cover designs that have steep slope gradients. A steep slope reduces infiltration by increasing runoff but increases the potential erosion through increased surface flow velocities. Thus, a functioning side slope must minimize infiltration and resist greater erosive forces than a top slope.

When an off-site relocate design is used and a fully or partially below-grade disposal option is selected, clean-fill berms or dikes often are used to buttress the tailings. Increased excavation and construction costs are incurred in berm construction.

Appendix F

Cost Estimates

Construction Costs for Disposal Alternatives

These estimates are the estimated costs to DOE by the construction contractor who will do the work of disposing of contaminated material by either cap-in-place or relocating to an off-site location with any transportation costs if applicable.

Duration of construction activities and material quantities for each alternative are those presented in Section 2.0. *R.S. Means Heavy construction Cost Data, 15th Annual Edition, 2001*, was used for unit cost data.

Design/Build Costs

Design and build cost estimates have been developed for the off-site disposal alternative only. The cost estimates are costs to DOE by the Architectural/Engineering contractor who will perform detailed design and construction oversight for each of the alternatives.

Duration of design activities and construction oversight are those presented in Section 2.0. An actual average labor rate for each discipline was used for unit cost data.

Technical Assistance Contractor Costs

Technical Assistance Contractor (TAC) cost estimates have been developed for each disposal alternative. The cost estimates are costs to DOE by the TAC who will perform the conceptual design and detailed design and construction oversight for the off-site disposal alternative. In the case where the disposal alternative chosen is to cap-in-place, the cost estimates are costs to DOE by the TAC to provide design modification and construction oversight.

Duration of design activities and construction oversight are those presented in Section 2.0. An actual average labor rate for each discipline was used for unit cost data.

Net Present Value for the Total Annual Costs

Annual costs are associated with long-term surveillance and maintenance (LTSM) and the remediation of contaminated groundwater. This appendix presents the annual LTSM costs and additional detail on the Net Present Value (NPV) estimates; estimated annual groundwater remediation costs were presented in Section 2.0.

The following sections present the detailed cost estimates and descriptions of what is included in the cost estimate.

Cap-in-Place Alternative

Construction Costs

The cap-in-place disposal alternative construction cost estimate consists of two cost elements and are described below.

Administration

These costs include the construction contractor's main office costs for administering the contract as well as the field personnel to manage the work being performed. The field personnel will consist of a project manager, a construction superintendent for the Moab site, field engineers, field office clerks and health and safety, quality assurance, and radiological technicians. The project duration of 4 years is applied to a weekly rate for each position. Also included in Administrative costs is permitting and mobilization/demobilization.

Cap-in-Place Construction

These costs include excavating contaminated material adjacent to the pile, consolidation on the pile and placing the pile cover. Also included is the reclamation of the millsite after remediation is complete.

Technical Assistance Contractor (TAC) Costs

The cost estimate for the Technical Assistance Contractor (TAC) overseeing the cap-in-place disposal alternative consists of four cost elements and are described below.

Characterization

These costs include the estimated TAC personnel required to perform characterization of the millsite area. Support personnel includes engineers and designers, Graphics Information Support (GIS) management, scientists, geo/hydrologists, health and safety personnel, radiological assessment support, records personnel, surveyors, and contract administration. Also included are costs associated with expenses and equipment subcontracts required for characterization. The duration of one year is applied to the average hourly rate for each field of specialty.

Design Modifications

These costs include the estimated TAC costs for review and modification of the proposed, existing design for the cap-in-place disposal alternative. TAC support personnel include engineers and designers, surveyors, GIS management, technical coordinators, environmental specialists, geo/hydrologists, quality assurance personnel, contract administration and records management. The duration of 1.5 years is applied to the average hourly rate for each field of specialty.

Construction Oversight

These costs include the estimated TAC costs to administer the construction subcontract for the cap-in-place disposal alternative. Support personnel includes field and off-site support during the performance period and include engineers and designers, surveyors, GIS management, technical coordinators, environmental specialists, geo/hydrologists, contract administrators, records personnel, health and safety personnel, construction inspectors and field engineers, quality assurance personnel, radiological assessment specialists, and financial management personnel. Also included are costs associated with quality assurance equipment required. The project duration of 4 years is applied to the average hourly rate for each field of specialty.

Completion Reports/Project Closeout

These costs include the estimated TAC personnel required to perform the functions involved in closing the project. Support personnel includes engineers, designers, technical writers/editors, GIS management, field engineers, radiological and records personnel, and contract administrators. Tasks associated with the project closeout assume development of various phases of project completion report, records management and archiving, and contract/claim negotiating. The duration of 1.5 years is applied to the average hourly rates for each field of specialty.

Costs associated with the project management personnel for each disposal alternative are applied for the project life of the alternative using average hourly rates for each discipline.

Off-Site Disposal, Klondike Site

Construction Costs

The off-site disposal, Klondike site alternative construction cost estimate consists of four cost elements and are described below.

<u>Administration</u>

These costs include the construction contractor's main office costs for administering the contract as well as the field personnel to manage the work being performed. The field personnel will consist of a project manager, a construction superintendent for the Moab site and one for the disposal site, field engineers for both sites, field office clerks and health and safety, quality assurance, and radiological technicians for both sites. The project duration of 8 years is applied to a weekly rate for each position. Also included in administrative costs is permitting and mobilization/demobilization for both sites.

<u>Disposal Site/Tailings Haul</u>

These costs include constructing the new cell, placing the contaminated material into the cell, and placing the cell cover. Also included is hauling the material from the Moab site to the Klondike site and all transportation infrastructures required.

<u>Tailings Pile Removal</u>

These costs include excavation of the pile and material adjacent to it, transporting it to the railroad spur and loading railroad cars. Also included is the construction of the conveyor belt system.

<u>Moab Site Reclamation</u>

These costs include backfilling and grading excavated areas, revegetating and fencing at the Moab site after remediation is complete.

Architectural/Engineering costs

This consists of the following two costs elements:

<u>Detailed Design</u>

These costs include the architectural/engineering (AE) contractor personnel costs for management, engineering, design, surveying, Graphics Information System (GIS) support, technical coordination, environmental support, geo/hydrologist, contract administration, as well as a lump sum estimate of addition subcontract support. The duration of the detailed design of 2 years is applied to the average hourly rates for each field of specialty.

Construction Oversight

These costs include the AE contractor personnel cost for the same items listed above with the additional support in the areas of records management, health and safety, construction/field inspectors, quality control personnel, and financial specialists. Also included with these costs are capital costs associated with a field laboratory to conduct quality control testing for the project. The project duration of 8 years is applied to the average hourly rates for each field of specialty.

Technical Assistance Contractor Costs

The Technical Assistance Contractor (TAC) cost estimate consists of five cost elements as described below.

Characterization

These costs include the estimated TAC support personnel required to perform site characterization at the millsite and the disposal area. Support personnel includes engineers and surveyors, scientists, geo/hydrologists, health and safety, radiological personnel, records management, contract administration, and miscellaneous expenses and subcontracts as needed to complete the characterization. The duration of 1 year is applied to the average hourly rate for each field of specialty.

Conceptual Design

These costs include the estimated TAC personnel required to perform the conceptual design for off-site disposal. Support personnel includes engineers, designers, surveyors, GIS management, environmental specialists, technical coordinators, records personnel, and contract administrators. Also included is an estimated amount for additional engineering design consultants to assist in specialized areas. The duration of 1.5 years is applied to the average hourly rate for each field of specialty.

Design Oversight

These costs include the estimated TAC personnel required for oversight of the AE contractor. Support personnel include engineers, designers, surveyors, GIS support, environmental specialists, geo/hydrology support, technical coordinators, records, and contract administration. Personnel will provide technical direction where needed for the AE contractor and provide support for DOE in the design review process. The duration of 2 years is applied to the average hourly rate for each field as specialty.

Construction Oversight

These costs include the estimated TAC personnel required to provide oversight to the AE contractor during construction operations. Support personnel is the same as that of design oversight with additional support in the form of Health and Safety, field engineers, Quality Assurance, radiological, and financial personnel. Again, the duration of 8 years is applied to the average hourly rates for each field of specialty.

Completion Report/Project Closeout

These costs include the estimated TAC personnel required to perform the functions involved in closing the project. Support personnel includes engineers, designers, technical writers/editors, GIS management, field engineers, radiological and records personnel, and contract administrators. Tasks associated with the project closeout assume development of various phases of project completion report, records management and archiving, and contract/claim negotiating. The duration of 1.5 years is applied to the average hourly rates for each field of specialty.

Appendix F–1

Cap-in-Place

Summary Costs for MOAB Cap-In-Place Alternative

Technical Assistance Contractor (TAC) Contract

Item	Description	Total
Line 001	Project Management	$12,693,000
Line 002	Characterization	$2,029,000
Line 003	Design Modifications	$1,966,000
Line 004	Construction Oversight	$14,119,000
Line 005	Completion Reports	$935,000
	Subtotal	$31,742,000

Construction Contract

Item	Description	Subtotal
Line 006	Construction Contract	$76,456,000
	Subtotal	$76,456,000
	Total	$108,198,000

Note: Total project costs do not reflect contingency or escalation over project life.

Moab Cap-In-Place Alternative

Line 001: TAC Project Management

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Moab Program Manager	1.00	1,890.00	7.50	14,175	Hr	$81.00	$1,148,175.00	$114,818.00	$1,262,993.00	1. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
Moab Project (site) Manager	1.00	1,890.00	7.50	14,175	Hr	$81.00	$1,148,175.00	$114,818.00	$1,262,993.00	
Moab Senior Field Engineer	1.00	1,890.00	7.50	14,175	Hr	$39.00	$552,825.00	$55,283.00	$608,108.00	
Health and Safety Manager	0.25	473.00	7.50	3,548	Hr	$81.00	$287,348.00	$28,735.00	$316,083.00	
Environmental Services Manager	0.25	473.00	7.50	3,548	Hr	$81.00	$287,348.00	$28,735.00	$316,083.00	2. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Project/Technical Manager (QA)	0.50	945.00	7.50	7,088	Hr	$67.00	$474,863.00	$47,487.00	$522,350.00	
Program Planning Services Manager	0.25	473.00	7.50	3,548	Hr	$81.00	$287,348.00	$28,735.00	$316,083.00	
Program Planning Services Technician (Estimator)	1.00	1,890.00	7.50	14,175	Hr	$65.00	$921,375.00	$92,138.00	$1,013,513.00	
Program Planning Services Technician (Scheduler)	0.50	945.00	7.50	7,088	Hr	$65.00	$460,688.00	$46,069.00	$506,757.00	3. Labor rates used are average rates of individual fields of specialty.
Program Planning Services Technician (Cost Accountant)	1.00	1,890.00	7.50	14,175	Hr	$65.00	$921,375.00	$92,138.00	$1,013,513.00	
Engineering Manager	0.20	378.00	7.50	2,835	Hr	$81.00	$229,635.00	$22,964.00	$252,599.00	
Administrative Assistants	4.00	7,560.00	7.50	56,700	Hr	$46.00	$2,608,200.00	$260,820.00	$2,869,020.00	4. Assumes 1890 hours per year are available from each FTE
Records Management	3.00	5,670.00	7.50	42,525	Hr	$30.00	$1,275,750.00	$127,575.00	$1,403,325.00	
Procurement Manager	0.50	945.00	7.50	7,088	Hr	$66.00	$467,775.00	$46,778.00	$514,553.00	
Database Manager	0.50	945.00	7.50	7,088	Hr	$66.00	$467,775.00	$46,778.00	$514,553.00	
Total	**14.95**	**28,257.00**		**211,928**		**995.00**	**11,538,655.00**	**$1,153,871.00**	**$12,693,000.00**	

Moab Cap-In-Place Alternative

Line 002: TAC Characterization of Sites

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	0.75	1,417.50	1.00	1,418.00	Hr	$81.00	$114,858.00	$11,486.00	$126,344.00	Geotechnical Characterization of the pile. Includes drilling and lab subcontracts and off-site borrow sources.
Designer	0.50	945.00	1.00	945.00	Hr	$47.00	$44,415.00	$4,442.00	$48,857.00	
GIS Specialists	0.50	945.00	1.00	945.00	Hr	$53.00	$50,085.00	$5,009.00	$55,094.00	
Scientist	0.50	945.00	1.00	945.00	Hr	$62.00	$58,590.00	$5,859.00	$64,449.00	
Geo/Hydrologist	0.50	945.00	1.00	945.00	Hr	$65.00	$61,425.00	$6,143.00	$67,568.00	
Health & Safety Technician	0.33	630.00	1.00	630.00	Hr	$52.00	$32,760.00	$3,276.00	$36,036.00	
Survey	1.00	1,890.00	1.00	1,890.00	Hr	$81.00	$153,090.00	$15,309.00	$168,399.00	
Contract Administrator	0.33	630.00	1.00	630.00	Hr	$66.00	$41,580.00	$4,158.00	$45,738.00	
Radiological Assessment	0.33	630.00	1.00	630.00	Hr	$53.00	$33,390.00	$3,339.00	$36,729.00	
Records Assistant	0.25	472.50	1.00	473.00	Hr	$30.00	$14,190.00	$1,419.00	$15,609.00	
Drilling/Trackhoe Subcontract				1.00	LS				$250,000.00	
Radiological Assessment Lead	1.00	1,890.00	1.50	2,835.00	Hr	$53.00	$150,255.00	$15,026.00	$165,281.00	Radiological Characterization
Radiological Assessment	3.00	5,670.00	1.50	8,505.00	Hr	$53.00	$450,765.00	$45,077.00	$495,842.00	
Survey	1.00	1,890.00	1.50	2,835.00	Hr	$81.00	$229,635.00	$22,964.00	$252,599.00	
Expenses				1.00	LS				$200,000.00	
Total	**10.00**	**18,900.00**		**23,628.000**		**777.00**	**1,435,038.00**	**$143,507.00**	**$2,029,000.00**	

Moab Cap-In-Place Alternative

Line 003: TAC Design Modifications

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	3.00	5,670.00	1.50	8,505.00	Hr	$81.00	$688,905.00	$68,891.00	$757,796.00	1. Assumes an 18 month design duration.
Designer	2.00	3,780.00	1.50	5,670.00	Hr	$47.00	$266,490.00	$26,649.00	$293,139.00	2. 1890 hours per year are available from each FTE.
Surveyor	1.00	1,890.00	1.00	1,890.00	Hr	$81.00	$153,090.00	$15,309.00	$168,399.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	1.00	1,890.00	1.50	2,835.00	Hr	$53.00	$150,255.00	$15,026.00	$165,281.00	
Technical Coordinator	1.00	1,890.00	1.50	2,835.00	Hr	$40.00	$113,400.00	$11,340.00	$124,740.00	
Environmental Specialist	1.00	1,890.00	1.50	2,835.00	Hr	$42.00	$119,070.00	$11,907.00	$130,977.00	4. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Geo/Hydrologist	1.00	1,890.00	1.00	1,890.00	Hr	$65.00	$122,850.00	$12,285.00	$135,135.00	
Technical Specialist (QA)	0.25	473.00	1.00	473.00	Hr	$53.00	$25,069.00	$2,507.00	$27,576.00	
Contract Administrator	0.50	945.00	1.00	945.00	Hr	$66.00	$62,370.00	$6,237.00	$68,607.00	
Records Assistant	1.00	1,890.00	1.50	2,835.00	Hr	$30.00	$85,050.00	$8,505.00	$93,555.00	
Total	**11.75**	**22,208.00**		**30,713.000**		**558.00**	**1,786,549.00**	**$178,656.00**	**$1,966,000.00**	

Moab Cap-In-Place Alternative

Line 004: TAC Construction Oversite

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	3.00	5,670.00	4.00	22,680.00	Hr	$81.00	$1,837,080.00	$183,708.00	$2,020,788.00	1. Assumes an 8 year Construction duration.
Designer	1.00	1,890.00	4.00	7,560.00	Hr	$47.00	$355,320.00	$35,532.00	$390,852.00	2. 1890 hours per year are available from each FTE.
Surveyor	3.00	5,670.00	4.00	22,680.00	Hr	$81.00	$1,837,080.00	$183,708.00	$2,020,788.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	1.00	1,890.00	4.00	7,560.00	Hr	$53.00	$400,680.00	$40,068.00	$440,748.00	
Technical Coordinator	2.00	3,780.00	4.00	15,120.00	Hr	$40.00	$604,800.00	$60,480.00	$665,280.00	
Environmental Specialist	1.00	1,890.00	4.00	7,560.00	Hr	$42.00	$317,520.00	$31,752.00	$349,272.00	4. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Geo/Hydrologist	1.00	1,890.00	4.00	7,560.00	Hr	$65.00	$491,400.00	$49,140.00	$540,540.00	
Contract Administrator	1.00	1,890.00	4.00	7,560.00	Hr	$66.00	$498,960.00	$49,896.00	$548,856.00	
Contract Administrator Assistant	1.00	1,890.00	4.00	7,560.00	Hr	$66.00	$498,960.00	$49,896.00	$548,856.00	
Records Assistant	1.00	1,890.00	4.00	7,560.00	Hr	$30.00	$226,800.00	$22,680.00	$249,480.00	5. Where 4 FTE's are used it is assumed at least one will be needed at each location of the overall site.
Health Physicist	1.00	1,890.00	4.00	7,560.00	Hr	$64.00	$483,840.00	$48,384.00	$532,224.00	
Health & Safety Technician	4.00	7,560.00	4.00	30,240.00	Hr	$52.00	$1,572,480.00	$157,248.00	$1,729,728.00	6. QA FTE's assumes 1-lead, 2-field, and one office/lab required.
Construction Inspector/Field Engr.	4.00	7,560.00	4.00	30,240.00	Hr	$39.00	$1,179,360.00	$117,936.00	$1,297,296.00	
Technical Specialist (QA)	1.00	1,890.00	4.00	7,560.00	Hr	$53.00	$400,680.00	$40,068.00	$440,748.00	
Technical Specialist (QA Technician)	2.00	3,780.00	4.00	15,120.00	Hr	$33.00	$498,960.00	$49,896.00	$548,856.00	
Radiological Assessment Lead	1.00	1,890.00	2.00	3,780.00	Hr	$53.00	$200,340.00	$20,034.00	$220,374.00	
Radiological Assessment	4.00	7,560.00	2.00	15,120.00	Hr	$53.00	$801,360.00	$80,136.00	$881,496.00	
Financial Specialist	1.00	1,890.00	4.00	7,560.00	Hr	$52.00	$393,120.00	$39,312.00	$432,432.00	
QA Lab Trailer				1.00	LS				$10,000.00	7. Assumes a one time capitol cost for QA Lab.
QC Construction Contract				1.00	LS				$250,000.00	8. Assumes Third Party QC group plus OH&P.
Total	**33.00**	**62,370.00**		**230,580.000**		**970.00**	**12,598,740.00**	**$1,259,874.00**	**$14,119,000.00**	

Moab Cap-In-Place Alternative

Line 005: Completion Reports/Project Closeout

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Technical Writer/Editor	2.00	3,780.00	1.00	3,780.00	Hr	$40.00	$151,200.00	$15,120.00	$166,320.00	1. Assumes a 12 month duration.
Designer	1.00	1,890.00	1.00	1,890.00	Hr	$47.00	$88,830.00	$8,883.00	$97,713.00	2. 1890 hours per year are available from each FTE.
Engineer	1.00	1,890.00	1.00	1,890.00	Hr	$81.00	$153,090.00	$15,309.00	$168,399.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	0.50	945.00	1.00	945.00	Hr	$53.00	$50,085.00	$5,008.50	$55,093.50	
Technical Coordinator	0.50	945.00	1.00	945.00	Hr	$40.00	$37,800.00	$3,780.00	$41,580.00	
Radiological Assessment Lead	1.00	1,890.00	1.00	1,890.00	Hr	$53.00	$100,170.00	$10,017.00	$110,187.00	
Radiological Assessment	0.50	945.00	1.00	945.00	Hr	$53.00	$50,085.00	$5,009.00	$55,094.00	
Records Lead	1.00	1,890.00	1.00	1,890.00	Hr	$66.00	$124,740.00	$12,474.00	$137,214.00	
Records Assistant	1.00	1,890.00	1.00	1,890.00	Hr	$30.00	$56,700.00	$5,670.00	$62,370.00	
Construction Inspector	0.50	945.00	1.00	945.00	Hr	$39.00	$36,855.00	$3,685.50	$40,540.50	
Total	**9.00**	**17,010.00**		**17,010.000**		**502.00**	**849,555.00**	**$84,956.00**	**$935,000.00**	

CAP-IN-PLACE

Atlas Site Capping

Item	Description	Total Line Item Cost
Line 001	Excavate Off-Pile Material	$720,000
Line 002	Consolidate Off-Pile Material Onto Main Pile	$100,000
Line 003	Groom Main Pile Slopes	$518,000
Line 004	Place Soil Cover Material	$39,018,000
Line 005	Place Rip Rap Erosion Protection Material	$16,284,000
Line 006	Backfill Off-Pile Areas	$2,649,000
Line 007	Revegatate Project Area	$2,293,000
Line 008	Construct fences, gates	$365,000
Line 009	Temporary Construction Facilities and Controls	$803,000
Line 010	Rail Spur	$304,000
Line 011	Relocate Moab Wash and Protect	$1,190,000
		$64,244,000

Administration

Item	Description	Total Line Item Cost
Line 012	Permits (2% of Total Including OH&P)	$1,607,000
Line 013	Main office expense (3.9% of Bare Costs)	$2,506,000
Line 014	Field personnel clerk average	$344,000
Line 015	Field personnel, field engineer, maximum	$1,229,000
Line 016	Field personnel, project manager, maximum	$657,000
Line 017	Field personnel, superintendent, maximum	$2,470,000
Line 018	Field personnel, general purpose laborer, average	$3,016,000
Line 019	Mobilization/Demobilization @ 0.5% Total Project Cost	$383,000
		$12,212,000
	Total	**$76,456,000**

Note: Total project costs do not reflect contingency or escalation over project life.

Moab UMTRA Project
Line 001: Moab Tailings Pile (Excavate Off-Pile Areas)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Excavation, self prop scraper, 21 CY 1/4 push dozer, sand&gvl, 3000' haul.	B33E	805	0.017	96,000.00	C.Y.	$0.00	$47,040.00	$220,800.00	$2.79	$267,840.00	Assumes excavation and 3000 ft. R/T haul to main pile.
Excavating, bulk, dozer, open site, 300 HP, 50' haul, sand & gravel	B10M	1,900	0.006	96,000.00	C.Y.	$0.00	$53,760.00	$254,400.00	$3.21	$308,160.00	Dozer maintains distribution across main tailings pile.
Subtotal						**$0.00**	**$100,800.00**	**$475,200.00**	**$6.00**	**$576,000.00**	
25% OH&P										**$ 144,000.00**	
Total										**$ 720,000.00**	

Moab UMTRA Project

Line 002: Moab Tailings Pile (Consolidate Off-Pile Materials)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	96,000.00	C.Y.	$0.00	$9,600.00	$17,280.00	$0.28	$26,880.00	Compact Off-Pile material
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	96,000.00	C.Y.	$19,200.00	$9,600.00	$24,000.00	$0.55	$52,800.00	Dust control and compaction
Subtotal						**$19,200.00**	**$19,200.00**	**$41,280.00**	**$0.83**	**$80,000.00**	
25% OH&P										**$ 20,000.00**	
Total										**$ 100,000.00**	

Moab UMTRA Project

Line 003: Moab Tailings Pile (Main Pile Grooming)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Excavating, bulk, dozer, 200 HP, 300' haul, sand & gravel	B10B	310	0.039	120,000.00	C.Y.	$0.00	$129,600.00	$284,400.00	$3.45	$414,000.00	Assumes dozer will groom slopes and top a minimum of 6" deep.
Subtotal						**$0.00**	**$129,600.00**	**$284,400.00**	**$3.45**	**$414,000.00**	
25% OH&P										**$ 103,500.00**	
Total										**$ 517,500.00**	

Moab UMTRA Project
Line 004: Moab Tailings Pile (Place Cover Materials)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Stripping, topsoil & stockpiling, sandy loam, 200 HP dozer, ideal condtn	B10B	2,300	0.005	60,000.00	C.Y.	$0.00	$9,000.00	$19,200.00	$0.47	$28,200.00	Assumes 6" topsoil removed and stockpiled adjacent to radon barrier borrow area (37 acres).
Excavation, self prop scraper, 21 CY 1/4 push dozer, com earth, 1500' haul	B33E	1,025	0.014	60,000.00	C.Y.	$0.00	$22,800.00	$127,200.00	$2.50	$150,000.00	Move stripped topsoil material to stockpiles.
Borrow, bank measure, clay/till/blasted rock, FE loader, trk mtd, 5 CY bkt	B10Q	1,825	0.007	240,000.00	C.Y.	$1,200,000.00	$43,200.00	$129,600.00	$5.72	$1,372,800.00	Assumes radon barrier material taken from a four foot zone at Klondyke Flats area.
Hauling, LCY, no loading, 20 c.y dump trailer, 20 MI RT, .5 lds/hr	B34D	78	0.103	240,000.00	C.Y.	$0.00	$829,440.00	$2,413,440.00	$13.51	$3,242,880.00	Haul radon barrier material from Klondyke flats 21 miles one-way. Actual round trip miles are 42. Assume additional 2$ per loaded mile (incl OH&P) equates to additional $0.42/CY labor and $1.23/CY equipment before OH&P is applied. Total also adjusted by 20% for medium traffic.
Hauling, grading at dump, or embankment IF required, by dozer	B10B	1,000	0.012	240,000.00	C.Y.	$0.00	$79,200.00	$177,600.00	$1.07	$256,800.00	Assumes grading radon barrier material at main pile dump area required.
Compaction, riding, sheepsfoot or wobbly whl rlr, 6" lifts, 3 passes	B10G	1,725	0.007	240,000.00	C.Y.	$0.00	$45,600.00	$86,400.00	$0.55	$132,000.00	Compact imported radon barrier material
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	480,000.00	C.Y.	$96,000.00	$48,000.00	$120,000.00	$0.55	$264,000.00	Dust control and compaction during radon barrier placement and reclamation (shown as double quantity).
Excavation, self prop scraper, 21 CY 1/4 push dozer, com earth, 1500' haul	B33E	1,025	0.014	60,000.00	C.Y.	$0.00	$22,800.00	$127,200.00	$2.50	$150,000.00	Backfill borrow area from topsoil stockpile.
Fine grade, finishing grading slopes, gentle	B11L	8,900	0.002	180,000.00	S.Y.	$0.00	$9,000.00	$9,000.00	$0.10	$18,000.00	Finish grade for seeding.
Upland (Flat) Reclamation				37.25	Acre				$4,500.00	$167,625.00	Revegatate radon barrier material borrow area. Unit prices are historical and include labor, materials, and equipment.
Stripping, topsoil & stockpiling, sandy loam, 200 HP dozer, ideal condtn	B10B	2,300	0.005	110,000.00	C.Y.	$0.00	$16,500.00	$35,200.00	$0.47	$51,700.00	Assumes 6" topsoil removed and stockpiled adjacent to soil protection material borrow area (137 acres).
Excavation, self prop scraper, 21 CY 1/4 push dozer, com earth, 1500' haul	B33E	1,025	0.014	110,000.00	C.Y.	$0.00	$41,800.00	$233,200.00	$2.50	$275,000.00	Move stripped topsoil material to stockpiles.
Borrow, bank measure, clay/till/blasted rock, FE loader, trk mtd, 5 CY bkt	B10Q	1,825	0.007	1,100,000.00	C.Y.	$5,500,000.00	$198,000.00	$594,000.00	$5.72	$6,292,000.00	Assumes soil protection material taken from a five foot zone at Klondyke Flats area.
Hauling, LCY, no loading, 20 c.y dump trailer, 20 MI RT, .5 lds/hr	B34D	78	0.103	1,100,000.00	C.Y.	$0.00	$3,801,600.00	$11,061,600.00	$13.51	$14,863,200.00	Haul soil protection material from Klondyke flats 21 miles one-way. Actual round trip miles are 42. Assume additional 2$ per loaded mile (incl OH&P) equates to additional $0.42/CY labor and $1.23/CY equipment before OH&P is applied. Total also adjusted by 20% for medium traffic.
Hauling, grading at dump, or embankment IF required, by dozer	B10B	1,000	0.012	1,100,000.00	C.Y.	$0.00	$363,000.00	$814,000.00	$1.07	$1,177,000.00	Assumes grading soil protection material at main pile dump area required.
Compaction, riding, sheepsfoot or wobbly whl rlr, 6" lifts, 3 passes	B10G	1,725	0.007	1,100,000.00	C.Y.	$0.00	$209,000.00	$396,000.00	$0.55	$605,000.00	Compact imported soil protection material
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	2,200,000.00	C.Y.	$440,000.00	$220,000.00	$550,000.00	$0.55	$1,210,000.00	Dust control and compaction during soil protection placement and reclamation (shown as double quantity).
Excavation, self prop scraper, 21 CY 1/4 push dozer, com earth, 1500' haul	B33E	1,025	0.014	110,000.00	C.Y.	$0.00	$41,800.00	$233,200.00	$2.50	$275,000.00	Backfill borrow area from topsoil stockpile.
Fine grade, finishing grading slopes, gentle	B11L	8,900	0.002	660,000.00	S.Y.	$0.00	$33,000.00	$33,000.00	$0.10	$66,000.00	Finish grade for seeding.
Upland (Flat) Reclamation				137.00	Acre				$4,500.00	$616,500.00	Revegatate soil protection material borrow area. Unit prices are historical and include labor, materials, and equipment.
Subtotal						**$7,236,000.00**	**$6,033,740.00**	**$17,159,840.00**	**$9,053.94**	**$31,214,000.00**	
25% OH&P										**$ 7,803,500.00**	
Total										**$ 39,017,500.00**	

Moab UMTRA Project
Line 005: Moab Tailings Pile (Place Rip Rap Erosion Protection Materials)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Aggregate, loaded at pit, crushed bank gravel				42,000.00	C.Y.	$676,200.00	$0.00	$0.00	$16.10	$676,200.00	Tops slope rock. Price includes loading at pit.
Aggregate, sand & stone, for trucking 10 miles, add to the above				42,000.00	C.Y.	$235,200.00	$0.00	$0.00	$5.60	$235,200.00	Top slope rock. Price includes hauling 10 miles from pit to site.
Fill, spread dumped material, by dozer, no compaction	B10B	1,000	0.012	42,000.00	C.Y.	$0.00	$13,860.00	$31,080.00	$1.07	$44,940.00	Top slope rock, spreading at site.
Compaction, riding, vibrating roller, 6" lifts, 3 passes	B10Y	2,300	0.005	42,000.00	C.Y.	$0.00	$44,940.00	$6,720.00	$0.31	$13,020.00	Top slope rock, compacting with smooth drum vibratory roller.
Drilling & blasting, deep hole method, over 1500 CY	B47	66	0.364	21,000.00	C.Y.	$37,800.00	$194,250.00	$236,250.00	$22.30	$468,300.00	Sideslope rock, pit quarry operations.
Drilling & blasting only, rock, open face, over 1500 CY	B47	300	0.08	21,000.00	C.Y.	$37,800.00	$42,840.00	$51,870.00	$6.31	$132,510.00	Sideslope rock, open face quarry operations.
Drilling&blasting only,boulder	B47	100	0.24	23,500.00	C.Y.	$42,300.00	$143,350.00	$173,900.00	$15.30	$359,550.00	Sideslope rock, assumes half of the total rock quarried will require drilling/blasting to reach desired size.
Drilling & blasting, jackhammer opers with foreman compr, air tools	B9	1	40	444.00	Day	$0.00	$412,920.00	$78,144.00	$1,106.00	$491,064.00	Sideslope rock, assumes a two year operation @ 222 days per year.
Screening plant 110 HP w /5' x 16'screen				48.00	Month+	$0.00	$0.00	$323,424.00	$6,738.00	$323,424.00	Sideslope rock, assumes 2-screen plants operating 222 days per year. Also includes hourly operating costs for each.
Drilling & blasting, excavate and load boulders, less than 0.5 CY	B10T	80	0.15	47,000.00	C.Y.	$0.00	$196,460.00	$230,300.00	$9.08	$426,760.00	Sideslope rock, loading only, onto rail cars.
Rail Rip Rap Haul				1,890,000.00	TNMI				$0.10	$189,000.00	Sideslope rock, Rip Rap transfer from quarry to millsite loadout station.
Rail car belly dump station at Millsite				1.00	L.S.				$100,000.00	$100,000.00	Assumes improvements to rail dump station.
Excavating, bulk bank measure, backhoe, hyd, 3 CY cap = 160 CY/hr	B12D	1,275	0.013	47,000.00	C.Y.	$0.00	$16,920.00	$72,380.00	$1.90	$89,300.00	Siseslope rock, loading trucks at dump station.
Hauling, off hwy haulers, 34 CY rear/bot dump, 1 MI RT, 3.5 lds/hr	B34G	775	0.01	47,000.00	C.Y.	$0.00	$11,750.00	$88,830.00	$2.14	$100,580.00	Sideslope rock, haul from rail dump station to pile.
Rip-rap, dumped, 50 LB average	B11A	800	0.02	105,000.00	Ton	$1,102,500.00	$55,650.00	$96,600.00	$11.95	$1,254,750.00	Sideslope rock, dumping at pile.
Rip-rap, mach placed for slp protec, 18" min thick. not grouted	B13	53	1.057	141,000.00	S.Y.	$2,777,700.00	$3,666,000.00	$1,677,900.00	$57.60	$8,121,600.00	Sideslope rock, placing on sideslopes.
Subtotal						**$4,909,500.00**	**$4,798,940.00**	**$3,067,398.00**	**$107,993.76**	**$13,027,000.00**	
25% OH&P										**$ 3,256,750.00**	
Total										**$ 16,283,750.00**	

Moab UMTRA Project
Line 006: Millsite (Backfill Off-Pile Areas with Clean Material)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Stripping, topsoil & stockpiling, sandy loam, 200 HP dozer, ideal condtn	B10B	2,300	0.005	24,000.00	C.Y.	$0.00	$3,600.00	$7,680.00	$0.47	$11,280.00	Assumes 6" topsoil removed and stockpiled For finish of millsite.
Borrow, bank measure, clay/till/blasted rock, FE loader, trk mtd, 5 CY bkt	B10Q	1,825	0.007	96,000.00	C.Y.	$480,000.00	$17,280.00	$51,840.00	$5.72	$549,120.00	Assumes backfill borrow material taken from a 1.5' zone at Klondyke Flats area.
Hauling, LCY, no loading, 20 c.y dump trailer, 20 MI RT, .5 lds/hr	B34D	78	0.103	96,000.00	C.Y.	$0.00	$331,776.00	$965,376.00	$13.51	$1,297,152.00	Haul borrow material from Klondyke flats 21 miles one-way. Actual round trip miles are 42. Assume additional 2$ per loaded mile (incl OH&P) equates to additional $0.42/CY labor and $1.23/CY equipment before OH&P is applied. Total also adjusted by 20% for medium traffic.
Hauling, grading at dump, or embankment IF required, by dozer	B10B	1,000	0.012	96,000.00	C.Y.	$0.00	$31,680.00	$71,040.00	$1.07	$102,720.00	Assumes grading borrow material at Off-pile dump area required.
Compaction, riding, sheepsfoot or wobbly whl rlr, 6" lifts, 3 passes	B10G	1,725	0.007	96,000.00	C.Y.	$0.00	$18,240.00	$34,560.00	$0.55	$52,800.00	Compact imported borrow material
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	192,000.00	C.Y.	$38,400.00	$19,200.00	$48,000.00	$0.55	$105,600.00	Dust control and compaction during borrow removal and placement (shown as double quantity).
Subtotal						**518,400.00**	**421,776.00**	**$1,178,496.00**	**$15.68**	**$2,119,000.00**	
25% OH&P										**$529,750.00**	
Total										**$2,648,750.00**	

Moab UMTRA Project

Line 007: Millsite (Revegatate Off-Pile wetlands, riparian, and upland areas)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Wetland Reclamation				100.00	Acre				$10,000.00	$1,000,000.00	Assumes 400 acre disturbance at the millsite. Unit prices are
Upland (Flat) Reclamation				170.00	Acre				$4,500.00	$765,000.00	historical and include labor materials and equipment.
Fence, misc metal, snow fence on steel posts 10' OC, 4' high	B1	500	0.048	17,000.00	L.F.	$26,690.00	$19,210.00	$0.00	$2.70	$45,900.00	Assumes Plastic fabric (safety) fencing used for protection of reclaimed areas.
Fence, double swing gates, 8' high, 20' opening	B80	1	22.069	2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes two-way traffic gates.
Fence, 5'-0" high fn, gate, 4' wide, 5' high, 2" frame, galv steel	B80	10	3.2	2.00	Ea.	$208.00	$160.00	$109.00	$238.50	$477.00	Assumes two man-gates required.
Site dml, fencing, barbed wire, 3 strand	2 Clab	430	0.037	17,000.00	L.F.	$0.00	$14,450.00	$0.00	$0.85	$14,450.00	Assumes reclamation fence demolition.
Salvage Fence	B-34B	1,550	0.005	8,000.00	C.Y.	$0.00	$960.00	$2,480.00	$0.43	$3,440.00	Haul fence to storage location or salvager.
Subtotal						**0.00**	**0.00**	**$0.00**	**$14,500.00**	**$1,834,000.00**	
25% OH&P										**$458,500.00**	
Total										**$2,292,500.00**	

Moab UMTRA Project

Line 008: Millsite (Construct fences, gates and remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Fence, CL, indl, 3 strd barb wire, 2-1/2" post @10' OC., set in concrete, 8' H, 6 ga. wire, galv st	B80	180	0.178	10,000.00	L.F.	$192,000.00	$44,400.00	$30,400.00	$26.68	$266,800.00	Assumes millsite is 130 acres at pile and adjacent areas (9518' x 9518'). Also includes approximately 400 LF of fencing to be used around access control points.
Fence, double swing gates, 8' high, 20' opening	B80	1	22.069	2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes two-way traffic gates.
Fence, 5'-0" high fn, gate, 4' wide, 5' high, 2" frame, galv steel	B80	10	3.2	2.00	Ea.	$208.00	$160.00	$109.00	$238.50	$477.00	Assumes at least two man-gates required.
Site dml, chain link, posts & fabric, 8' to 10' high	B6	445	0.054	10,000.00	L.F.	$0.00	$13,400.00	$4,100.00	$1.75	$17,500.00	Chainlink Fence Demolition
Salvage Fence	B-34B	1,550	0.005	8,000.00	C.Y.	$0.00	$960.00	$2,480.00	$0.43	$3,440.00	Haul fence to storage location or salvager.
Subtotal						**$194,098.00**	**$45,660.00**	**$31,259.00**		**$292,000.00**	
25% OH&P										**$73,000.00**	
Total										**$365,000.00**	

Moab UMTRA Project

Line 009: Mill (Construct and install temporary facilities to sites, Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Temporary Construction Facilities				1.00	L.S.	$0.00	$0.00	$0.00	$468,520.00	$234,260.00	See Henshall Estimate. (For Cap-in place this number is half)
Power to Millsite				1.00	Mi.	$0.00	$0.00	$0.00	$40,000.00	$40,000.00	Pricing taken from Monument Valley cost estimate for UGW final action.
Stormwater Drainage Controls/ponds				1.00	L.S.	$0.00	$0.00	$0.00	$500,000.00	$250,000.00	Includes ditches, Culverts, Sediment ponds, etc.
Remove construction facilities				1.00	L.S.	$0.00	$0.00	$0.00	$234,260.00	$117,130.00	Assumes length of project will esalate costs of removal to approximately 50% of original estimate for installation.
Subtotal						**$0.00**	**$0.00**	**$0.00**	**$234,260.00**	**$642,000.00**	
25% OH&P										**$160,500.00**	
Total										**$802,500.00**	

Moab UMTRA Project

Line 010: Millsite (Install new rail spur at millsite and remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Railroad,sdg,yd spur,lvl gr,wd ties & ballast,100lb rail,ARA-A & AREA	B10B	57	0.842	1,800.00	L.F.	$106,200.00	$36,900.00	$5,706.00	$82.67	$148,806.00	Includes Track, Treated Ties, Apputenances, Ballast, and Construction Crew.
Railroad, resurface & realign exst track, for crushed stone blst, add	B33D	500	0.096	1,800.00	L.F.	$16,290.00	$4,176.00	$648.00	$11.73	$21,114.00	Assumes 6" additional ballast required under bottom of ties.
Railroad, switch timber, compl set of timbers, 3.7 M.B.F for #8 sw	B10G	1	48.000	2.00	Total	$5,350.00	$2,300.00	$362.00	$4,006.00	$8,012.00	Switching Appurtenances.
Railroad, turnouts, timbers & ballast 6" deep	B59	1	96.000	2.00	Ea.	$37,600.00	$4,650.00	$720.00	$21,485.00	$42,970.00	Turnout Timbers, Ballast, and Apputenances.
Compaction, riding, vibrating roller, 6" lifts, 3 passes	B10G	2300	0.005	6,013.00	C.Y.	$0.00	$901.95	$962.08	$0.31	$1,864.03	Compact 6" layer of scarified subgrade.
Compaction, water, truck, 3000 gal, 3 mile haul	A1	1900	0.008	6,013.00	C.Y.	$1,202.60	$1,382.99	$2,284.94	$0.81	$4,870.53	Water required for compaction of subgrade and dust control.
Site dml, RR removal, ties & track	B10G	330	0.170	1,800.00	L.F.	$0.00	$7,560.00	$3,438.00	$6.11	$10,998.00	Assumes additional 20 quantity to cover cost for removing switches, signs and other apputenances.
Site dml, RR removal, ties & track, ballast	B59	500	0.096	1,300.00	C.Y.	$0.00	$3,016.00	$468.00	$2.68	$3,484.00	Remove railroad bed ballast.
Subtotal						**$166,642.60**	**$60,886.94**	**$14,589.02**		**$243,000.00**	
25% OH&P										**$60,750.00**	
Total										**$303,750.00**	

Moab UMTRA Project
Line 011: Millsite (Relocate Moab Wash)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Loam or topsoil, remove and stkpile on site, 200 h.p dozer, 500' haul	B10B	225	0.053	6,020.00	C.Y.	$0.00	$8,969.80	$19,685.40	$9,270.80	$28,655.20	Strip topsoil for channel excavation.
Fill, spread dumped material, by dozer, no compaction	B10B	1,000	0.012	6,020.00	C.Y.	$0.00	$1,986.60	$4,454.80	$9,270.80	$6,441.40	Waste topsoil across millsite off-pile areas.
Excavating, bulk bank measure, backhoe, hyd, 3 CY cap = 160 CY/hr	B12D	1,275	0.013	47,220.00	C.Y.	$0.00	$16,999.20	$72,718.80	$72,718.80	$89,718.00	Excavate channel 4.5' deep, 100' wide bottom, trapezoidal shape.
Borrow, bank measure, clay, till, or blasted rock, shovel, 1-1/2 CY bucket	B12O	965	0.017	27,963.00	C.Y.	$139,815.00	$13,142.61	$24,607.44	$43,063.02	$177,565.05	Purchase and load rip rap for channel at local quarry.
Hauling, LCY, no loading, 20 c.y dump trailer, 20 MI RT, .5 lds/hr	B34D	78	0.103	27,963.00	C.Y.	$0.00	$68,788.98	$199,935.45	$43,063.02	$268,724.43	Haul rip rap to site, 20 mile round-trip.
Rip-rap, random, machine placed for slope protection	B12G	62	0.258	27,963.00	C.Y.	$0.00	$205,528.05	$174,768.75	$43,063.02	$380,296.80	Machine place riprap.
Subtotal						**$139,815.00**	**$315,415.24**	**$496,170.64**		**$952,000.00**	
25% OH&P										**$238,000.00**	
Total										**$1,190,000.00**	

Moab UMTRA Project
Line 12 to 19: Administration

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total
Permits (2% of Total Including OH&P)				1.00	Job	$0.00	$0.00	$0.00	$1.00	$1,284,880.00
Main office expense (3.9% of Bare Costs)				1.00	% Vol	$0.00	$0.00	$0.00	$2,004,327.00	$2,004,327
Field personnel clerk average				624.000	Week	$0.00	$174,720.00	$0.00	$174,720.00	$274,560.00
Field personnel, field engineer, maximum				624.000	Week	$0.00	$624,000.00	$0.00	$624,000.00	$982,800.00
Field personnel, project manager, maximum				208.000	Week	$0.00	$332,800.00	$0.00	$332,800.00	$525,200.00
Field personnel, superintendent, maximum				832.000	Week	$0.00	$1,248,000.00	$0.00	$1,248,000.00	$1,976,000.00
Field personnel, general purpose laborer, average				1,664.000	Week	$0.00	$1,539,200.00	$0.00	$1,539,200.00	$2,412,800.00
Mobilization/Demobilization @ 0.5% Total Project Cost				1.00	LS	$0.00	$0.00	$0.00	$305,796.82	$305,796.82
Subtotal						**$0.00**	**$3,918,720.00**	**$0.00**		**$9,767,000.00**
25% OH&P										**$2,441,750.00**
Total										**$12,208,750.00**

Estimate of Net Present Value For Total Annual Costs for Cap-in-Place and Off Site Disposal

Alternative	Annual Cost	Start Year	End Year	Discount rate	NPV in Start Yr	NPV Today $
LTSM Cap-in-place	$21,100	5	200	5.30%	$398,096	$307,501
LTSM Off-Site Disposal	$18,700	9	200	5.30%	$352,812	$221,660
Active GW Treatment(on and off site)	$1,445,700	1	35	5.30%	$22,802,191	$22,802,191
Out Year GW Treatment On site	$73,900	35	100	5.30%	$1,345,752	$220,786
Out year GW Treatment Off site	$49,200	35	100	5.30%	$895,954	$146,992

Total On Site NPV = $23,330,478
Total Off site NPV= $23,170,843

NPV is net present value

Estimated Annual LTSM Costs for the Cap-in-Place Alternative

Activity	Cap-in-Place	Notes
Inspections	$2,100	Includes reporting
Maintenance	$10,600	Additional maintenance for cap-in-place
Environmental Monitoring	$5,800	Groundwater monitoring
Site Management	$2,600	Miscellaneous activities
Total	**$21,100**	

Appendix F–2

Off-Site Disposal

Summary Costs for MOAB Relocated Site - Klondike Site

Technical Assistance Contractor (TAC) Contract

Item	Description	Total
Line 001	Project Management	$23,693,000
Line 002	Characterization	$1,945,000
Line 003	Conceptual Design	$3,074,000
Line 004	Design Oversight	$876,000
Line 005	Construction Oversight	$23,616,000
Line 006	Completion Reports	$1,608,000
	Subtotal	$54,812,000

A/E Contract

Item	Description	Subtotal
Line 007	Detailed Design	$6,583,000
Line 008	Construction Oversight	$25,541,000
	Subtotal	$32,124,000

Construction Contract

Item	Description	Subtotal
Line 009	Construction Contract	$271,140,000
	Subtotal	$271,140,000
	Total	$358,076,000

Note: Total project costs do not reflect contingency or escalation over project life.

Moab Site Relocation Alternative

Line 001: TAC Project Management

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Moab Program Manager	1.00	1,890.00	14.00	26,460	Hr	$81.00	$2,143,260.00	$214,326.00	$2,357,586.00	1. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
Moab Project (site) Manager	1.00	1,890.00	14.00	26,460	Hr	$81.00	$2,143,260.00	$214,326.00	$2,357,586.00	
Moab Senior Field Engineer	1.00	1,890.00	14.00	26,460	Hr	$39.00	$1,031,940.00	$103,194.00	$1,135,134.00	
Health and Safety Manager	0.25	473.00	14.00	6,622	Hr	$81.00	$536,382.00	$53,639.00	$590,021.00	
Environmental Services Manager	0.25	473.00	14.00	6,622	Hr	$81.00	$536,382.00	$53,639.00	$590,021.00	2. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Project/Technical Manager (QA)	0.50	945.00	14.00	13,230	Hr	$67.00	$886,410.00	$88,641.00	$975,051.00	
Program Planning Services Manager	0.25	473.00	14.00	6,622	Hr	$81.00	$536,382.00	$53,639.00	$590,021.00	
Program Planning Services Technician (Estimator)	1.00	1,890.00	14.00	26,460	Hr	$65.00	$1,719,900.00	$171,990.00	$1,891,890.00	
Program Planning Services Technician (Scheduler)	0.50	945.00	14.00	13,230	Hr	$65.00	$859,950.00	$85,995.00	$945,945.00	3. Labor rates used are average rates of individual fields of specialty.
Program Planning Services Technician (Cost Accountant)	1.00	1,890.00	14.00	26,460	Hr	$65.00	$1,719,900.00	$171,990.00	$1,891,890.00	
Engineering Manager	0.20	378.00	14.00	5,292	Hr	$81.00	$428,652.00	$42,866.00	$471,518.00	
Administrative Assistants	4.00	7,560.00	14.00	105,840	Hr	$46.00	$4,868,640.00	$486,864.00	$5,355,504.00	4. Assumes 1890 hours per year are available from each FTE
Records Management	3.00	5,670.00	14.00	79,380	Hr	$30.00	$2,381,400.00	$238,140.00	$2,619,540.00	
Procurement Manager	0.50	945.00	14.00	13,230	Hr	$66.00	$873,180.00	$87,318.00	$960,498.00	
Database Manager	0.50	945.00	14.00	13,230	Hr	$66.00	$873,180.00	$87,318.00	$960,498.00	
Total	**14.95**	**28,257.00**		**395,598**		**995.00**	**21,538,818.00**	**$2,153,885.00**	**$23,692,703.00**	

Moab Site Relocation Alternative

Line 002: TAC Characterization of Sites

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	0.75	1,418.00	1.00	1,418.00	Hr	$81.00	$114,858.00	$11,486.00	$126,344.00	Geotechnical Characterization of the pile and relocation site. Includes drilling and lab subcontracts.
Designer	0.50	945.00	1.00	945.00	Hr	$47.00	$44,415.00	$4,442.00	$48,857.00	
GIS Specialists	0.50	945.00	1.00	945.00	Hr	$53.00	$50,085.00	$5,009.00	$55,094.00	
Scientist	0.50	945.00	1.00	945.00	Hr	$62.00	$58,590.00	$5,859.00	$64,449.00	
Geo/Hydrologist	0.50	945.00	1.00	945.00	Hr	$65.00	$61,425.00	$6,143.00	$67,568.00	
Health & Safety Technician	0.33	630.00	1.00	630.00	Hr	$52.00	$32,760.00	$3,276.00	$36,036.00	
Survey	1.00	1,890.00	1.00	1,890.00	Hr	$81.00	$153,090.00	$15,309.00	$168,399.00	
Contract Administrator	0.33	630.00	1.00	630.00	Hr	$66.00	$41,580.00	$4,158.00	$45,738.00	
Radiological Assessment	0.33	630.00	1.00	630.00	Hr	$53.00	$33,390.00	$3,339.00	$36,729.00	
Records Assistant	0.25	473.00	1.00	473.00	Hr	$30.00	$14,190.00	$1,419.00	$15,609.00	
Drilling/Trackhoe Subcontract				1.00	LS				$250,000.00	
Radiological Assessment Lead	1.00	1,890.00	1.50	2,835.00	Hr	$53.00	$150,255.00	$15,026.00	$165,281.00	Radiological Characterization
Radiological Assessment	3.00	5,670.00	1.50	8,505.00	Hr	$53.00	$450,765.00	$45,077.00	$495,842.00	
Survey	1.00	1,890.00	1.00	1,890.00	Hr	$81.00	$153,090.00	$15,309.00	$168,399.00	
Expenses				1.00	LS				$200,000.00	
Total	**10.00**	**18,901.00**		**22,683.000**		**777.00**	**1,358,493.00**	**$135,852.00**	**$1,944,345.00**	

Moab Site Relocation Alternative

Line 003: TAC Conceptual Design

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	6.00	11,340.00	1.50	17,010.00	Hr	$81.00	$1,377,810.00	$137,781.00	$1,515,591.00	1. Assumes an 18 month design duration.
Designer	3.00	5,670.00	1.50	8,505.00	Hr	$47.00	$399,735.00	$39,974.00	$439,709.00	2. 1890 hours per year are available from each FTE.
Surveyor	1.00	1,890.00	1.50	2,835.00	Hr	$81.00	$229,635.00	$22,964.00	$252,599.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	1.00	1,890.00	1.50	2,835.00	Hr	$53.00	$150,255.00	$15,026.00	$165,281.00	
Technical Coordinator	1.00	1,890.00	1.50	2,835.00	Hr	$40.00	$113,400.00	$11,340.00	$124,740.00	
Environmental Specialist	1.00	1,890.00	1.50	2,835.00	Hr	$42.00	$119,070.00	$11,907.00	$130,977.00	4. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Contract Administrator	0.25	473.00	1.50	710.00	Hr	$66.00	$46,860.00	$4,686.00	$51,546.00	
Records Assistant	1.00	1,890.00	1.50	2,835.00	Hr	$30.00	$85,050.00	$8,505.00	$93,555.00	
Engineering/Design Subcontracts				1.00	LS				$300,000.00	5. Outside subcontracts will handle additional design consultants when undertaking portions of the conceptual design that are outside of our immediate area of expertise. Assumes 6% of total.
Total	**14.25**	**26,933.00**		**40,401.000**		**440.00**	**2,521,815.00**	**$252,183.00**	**$3,073,998.00**	

Moab Site Relocation Alternative

Line 004: TAC Design Oversite

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (7.5%)	Total	Notes and Assumptions
Engineer	1.00	1,890.00	2.00	3,780.00	Hr	$81.00	$306,180.00	$22,964.00	$329,144.00	1. Assumes a 24 month design duration.
Designer	0.50	945.00	2.00	1,890.00	Hr	$47.00	$88,830.00	$6,663.00	$95,493.00	2. 1890 hours per year are available from each FTE.
Surveyor	0.25	473.00	2.00	946.00	Hr	$81.00	$76,626.00	$5,747.00	$82,373.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	0.25	473.00	2.00	946.00	Hr	$53.00	$50,138.00	$3,761.00	$53,899.00	
Technical Coordinator	0.25	473.00	2.00	946.00	Hr	$40.00	$37,840.00	$2,838.00	$40,678.00	
Environmental Specialist	0.25	473.00	2.00	946.00	Hr	$42.00	$39,732.00	$2,980.00	$42,712.00	4. Other direct costs assume dollars for office support equipment, etc.
Geo/Hydrologist	0.25	473.00	2.00	946.00	Hr	$65.00	$61,490.00	$4,612.00	$66,102.00	
Contract Administrator	0.50	945.00	2.00	1,890.00	Hr	$66.00	$124,740.00	$9,356.00	$134,096.00	
Records Assistant	0.25	473.00	2.00	946.00	Hr	$30.00	$28,380.00	$2,129.00	$30,509.00	
Total	**3.50**	**6,618.00**		**13,236.000**		**505.00**	**813,956.00**	**$61,050.00**	**$875,006.00**	

Moab Site Relocation Alternative

Line 005: TAC Construction Oversite

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Engineer	2.00	3,780.00	8.00	30,240.00	Hr	$81.00	$2,449,440.00	$244,944.00	$2,694,384.00	1. Assumes an 8 year Construction duration.
Designer	1.00	1,890.00	8.00	15,120.00	Hr	$47.00	$710,640.00	$71,064.00	$781,704.00	2. 1890 hours per year are available from each FTE.
Surveyor	1.00	1,890.00	8.00	15,120.00	Hr	$81.00	$1,224,720.00	$122,472.00	$1,347,192.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	0.50	945.00	8.00	7,560.00	Hr	$53.00	$400,680.00	$40,068.00	$440,748.00	
Technical Coordinator	1.00	1,890.00	8.00	15,120.00	Hr	$40.00	$604,800.00	$60,480.00	$665,280.00	
Environmental Specialist	1.00	1,890.00	8.00	15,120.00	Hr	$42.00	$635,040.00	$63,504.00	$698,544.00	4. Other direct costs assume dollars for office support equipment, travel, per diem, GSA vehicles, incidental rentals, subcontracts, etc.
Geo/Hydrologist	0.25	473.00	8.00	3,784.00	Hr	$65.00	$245,960.00	$24,596.00	$270,556.00	
Contract Administrator	1.00	1,890.00	8.00	15,120.00	Hr	$66.00	$997,920.00	$99,792.00	$1,097,712.00	
Contract Administrator Assistant	1.00	1,890.00	8.00	15,120.00	Hr	$66.00	$997,920.00	$99,792.00	$1,097,712.00	
Records Assistant	1.00	1,890.00	8.00	15,120.00	Hr	$30.00	$453,600.00	$45,360.00	$498,960.00	5. Where 4 FTE's are used it is assumed at least one will be needed at each location of the overall site.
Health Physicist	1.00	1,890.00	8.00	15,120.00	Hr	$64.00	$967,680.00	$96,768.00	$1,064,448.00	
Health & Safety Technician	6.00	11,340.00	8.00	90,720.00	Hr	$52.00	$4,717,440.00	$471,744.00	$5,189,184.00	6. QA FTE's assumes 1-lead, 2-field, and one office/lab required.
Field Engineer	2.00	3,780.00	8.00	30,240.00	Hr	$39.00	$1,179,360.00	$117,936.00	$1,297,296.00	
Technical Specialist (QA)	1.00	1,890.00	8.00	15,120.00	Hr	$53.00	$801,360.00	$80,136.00	$881,496.00	7. Assumes Surveyor is used half-time for QA and half-time for field assessments.
Technical Specialist (QA Technician)	3.00	5,670.00	8.00	45,360.00	Hr	$33.00	$1,496,880.00	$149,688.00	$1,646,568.00	
Radiological Assessment Lead	1.00	1,890.00	4.00	7,560.00	Hr	$53.00	$400,680.00	$40,068.00	$440,748.00	
Radiological Assessment	4.00	7,560.00	4.00	30,240.00	Hr	$53.00	$1,602,720.00	$160,272.00	$1,762,992.00	
Financial Specialist	2.00	3,780.00	8.00	30,240.00	Hr	$52.00	$1,572,480.00	$157,248.00	$1,729,728.00	
QA Lab Trailer			8.00	1.00	LS				$10,000.00	8. Assumes a one time capitol cost for QA Lab.
Total	**29.75**	**56,228.00**		**412,024.000**		**970.00**	**21,459,320.00**	**$2,145,932.00**	**$23,615,252.00**	

Moab Site Relocation Alternative

Line 006: Completion Reports/Project Closeout

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Technical Writer/Editor	2.00	3,780.00	1.50	5,670.00	Hr	$40.00	$226,800.00	$22,680.00	$249,480.00	1. Assumes an 18 month duration.
Designer	1.00	1,890.00	1.50	2,835.00	Hr	$47.00	$133,245.00	$13,325.00	$146,570.00	2. 1890 hours per year are available from each FTE.
Engineer	1.00	1,890.00	1.50	2,835.00	Hr	$81.00	$229,635.00	$22,964.00	$252,599.00	3. Burdened rates include fringe benefits, and all general and administrative costs, site overhead, and award fee dollars.
GIS Specialists	0.50	945.00	1.50	1,418.00	Hr	$53.00	$75,154.00	$7,516.00	$82,670.00	
Technical Coordinator	0.50	945.00	1.50	1,418.00	Hr	$40.00	$56,720.00	$5,672.00	$62,392.00	
Radiological Assessment Lead	1.00	1,890.00	1.50	2,835.00	Hr	$53.00	$150,255.00	$15,026.00	$165,281.00	
Radiological Assessment	0.50	945.00	1.50	1,418.00	Hr	$53.00	$75,154.00	$7,516.00	$82,670.00	
Records Lead	1.00	1,890.00	1.50	2,835.00	Hr	$66.00	$187,110.00	$18,711.00	$205,821.00	
Records Assistant	1.00	1,890.00	1.50	2,835.00	Hr	$30.00	$85,050.00	$8,505.00	$93,555.00	
Contract Administrator	1.00	1,890.00	1.50	2,835.00	Hr	$66.00	$187,110.00	$18,711.00	$205,821.00	
Field Engineer	0.50	945.00	1.50	1,418.00	Hr	$39.00	$55,302.00	$5,531.00	$60,833.00	
Total	**10.00**	**18,900.00**		**28,352.000**		**568.00**	**1,461,535.00**	**$146,157.00**	**$1,607,692.00**	

Moab Site Relocation Alternative

Line 007: A/E Detailed Design

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Project Management	2.00	3,780.00	2.00	7,560.00	Hr	$100.00	$756,000.00	$75,600.00	$831,600.00	1. Assumes an 24 month design duration.
Engineer	6.00	11,340.00	2.00	22,680.00	Hr	$85.00	$1,927,800.00	$192,780.00	$2,120,580.00	2. 1890 hours per year are available from each FTE.
Designer	3.00	5,670.00	2.00	11,340.00	Hr	$55.00	$623,700.00	$192,780.00	$816,480.00	3. Burdened rates include A/E Overhead and Profit.
Surveyor	2.00	3,780.00	2.00	7,560.00	Hr	$55.00	$415,800.00	$62,370.00	$478,170.00	4. Other direct costs assume dollars for office support equipment, travel, per diem, incidental rentals, etc.
GIS Specialists	1.00	1,890.00	2.00	3,780.00	Hr	$55.00	$207,900.00	$41,580.00	$249,480.00	
Technical Coordinator	2.00	3,780.00	2.00	7,560.00	Hr	$30.00	$226,800.00	$20,790.00	$247,590.00	
Environmental Specialist	1.00	1,890.00	2.00	3,780.00	Hr	$60.00	$226,800.00	$22,680.00	$249,480.00	5. Outside subcontracts will handle additional design consultants when undertaking portions of the conceptual design that are outside of their immediate area of expertise.
Geo/Hydrologist	2.00	3,780.00	2.00	7,560.00	Hr	$65.00	$491,400.00	$36,855.00	$528,255.00	
Contract Administrator	1.00	1,890.00	2.00	3,780.00	Hr	$75.00	$283,500.00	$22,680.00	$306,180.00	
Administrative Assistant	2.00	3,780.00	2.00	7,560.00	Hr	$30.00	$226,800.00	$28,350.00	$255,150.00	
Engineering/Design Subcontracts				1.00	LS				$500,000.00	
Total	**22.00**	**41,580.00**		**83,161.000**		**610.00**	**5,386,500.00**	**$696,465.00**	**$6,582,965.00**	

Moab Site Relocation Alternative

Line 008: A/E Construction Oversite

Description	FTE	Annual Output (Hrs/FTE)	Project Duration (yrs)	Qty	Unit	Burdened Labor Rate	Burdened Labor Cost	Other Direct Costs (10%)	Total	Notes and Assumptions
Project Management	2.00	3,780.00	8.00	30,240.00	Hr	$100.00	$3,024,000.00	$302,400.00	$3,326,400.00	1. Assumes an 8 year Construction duration.
Engineer	4.00	7,560.00	8.00	60,480.00	Hr	$85.00	$5,140,800.00	$514,080.00	$5,654,880.00	2. 1890 hours per year are available from each FTE.
Designer	1.00	1,890.00	8.00	15,120.00	Hr	$55.00	$831,600.00	$83,160.00	$914,760.00	3. Burdened rates include fringe overhead and profit.
Surveyor	2.00	3,780.00	8.00	30,240.00	Hr	$55.00	$1,663,200.00	$166,320.00	$1,829,520.00	4. Other direct costs assume dollars for office support
Technical Coordinator	1.00	1,890.00	8.00	15,120.00	Hr	$40.00	$604,800.00	$60,480.00	$665,280.00	equipment, travel, per diem, GSA vehicles, incidental
Geo/Hydrologist	1.00	1,890.00	8.00	15,120.00	Hr	$65.00	$982,800.00	$98,280.00	$1,081,080.00	rentals, subcontracts, etc.
Contract Administrator	1.00	1,890.00	8.00	15,120.00	Hr	$75.00	$1,134,000.00	$113,400.00	$1,247,400.00	
Records Assistant	1.00	1,890.00	8.00	15,120.00	Hr	$30.00	$453,600.00	$45,360.00	$498,960.00	5. Where 4 or more FTE's are used it is assumed at least one
Health Physicist	1.00	1,890.00	8.00	15,120.00	Hr	$70.00	$1,058,400.00	$105,840.00	$1,164,240.00	will be needed at each location of the overall site as well as
Construction Inspector	4.00	7,560.00	8.00	60,480.00	Hr	$40.00	$2,419,200.00	$241,920.00	$2,661,120.00	office support in labs and lab testing, etc.
Technical Specialist (QC)	1.00	1,890.00	8.00	15,120.00	Hr	$55.00	$831,600.00	$83,160.00	$914,760.00	6. QA FTE's assumes 1-lead, 4-field, and 2 office/lab
Technical Specialist (QC Technician)	6.00	11,340.00	8.00	90,720.00	Hr	$45.00	$4,082,400.00	$408,240.00	$4,490,640.00	personnel required.
Financial Specialist	1.00	1,890.00	8.00	15,120.00	Hr	$65.00	$982,800.00	$98,280.00	$1,081,080.00	7. Two engineers for field, two for submittal support.
QC Lab Trailer			8.00	1.00	LS				$10,000.00	8. Assumes a one time capitol cost for QA Lab.
Total	**26.00**	**49,140.00**		**393,120.000**		**780.00**	**23,209,200.00**	**$2,320,920.00**	**$25,540,120.00**	

Relocated Site - Klondike Site

Disposal Site/Tailings Haul

Item	Description	Total Line Item Cost
Line 001	Construct Cell, Place Tailings, and Construct Cover	$42,250,000
Line 002	Construct Rail Siding and Remove	$2,529,000
Line 003	Construct Gravel Haul Road and Remove	$2,616,000
Line 004	Rail Tailings Haul	$22,275,000
Line 005	Construct fences, gates and remove	$369,000
Line 006	Construct Rail Truck Transfer Station and Truck to Cell, Remove Rail	$49,964,000
Line 007	Temporary Construction Facilities and Controls	$1,846,000
Line 008	Site Security Fence	$305,000
		$122,154,000

Moab Tailings Pile Removal

Item	Description	Total Line Item Cost
Line 009	Excavate main tailings pile	$49,611,000
Line 010	Excavate Subpile and Windblown Areas	$4,500,000
Line 011	Conveyor Material Handling and System	$45,213,000
Line 012	Temporary Construction Facilities and Controls	$1,604,000
Line 013	Construct fences, gates and remove	$398,000
		$101,326,000

Millsite Reclamation

Item	Description	Total Line Item Cost
Line 014	Clean Material Backfill	$11,213,000
Line 015	Revegatate wetlands, riparian, and upland areas	$3,039,000
Line 016	Reclamation Fencing	$86,000
		$14,338,000

Administration

Item	Description	Total Line Item Cost
Line 017	Permits (2% of Above Totals Including OH&P)	$5,946,000
Line 018	Main office expense (3.9% of Bare Costs)	$9,263,000
Line 019	Field personnel clerk average	$437,000
Line 020	Field personnel, field engineer, maximum	$1,560,000
Line 021	Field personnel, project manager, maximum	$832,000
Line 022	Field personnel, superintendent, maximum	$6,240,000
Line 023	Field personnel, general purpose laborer, average	$7,696,000
Line 024	Mobilization/Demobilization @ 0.5% Total Project Cost	$1,348,000
		$33,322,000
	Total	**$271,140,000**

Note: Total project costs do not reflect contingency or escalation over project life.

Moab UMTRA Project

Line 001: Klondike Site Cell (Construct Cell, Place Tailings, and Construct Cover)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Loam or topsoil, remove and stkpile on site, 200 h.p dozer, 500' haul	B10B	225	0.053	121,178.00	C.Y.	$0.00	$180,555.22	$396,252.06	$4.76	$576,807.28	Assumes topsoil stripping depth of 6" over cell, stockpiles, and haul roads.
Excavation, self prop scraper, 14 CY 1/4 push dozer, com earth, 3000' haul	B33D	700	0.02	1,880,118.00	C.Y.	$0.00	$1,052,866.08	$4,982,312.70	$3.21	$6,035,178.78	Cell Excavation and Stockpiling all 2 MCY except topsoil in footprint of cell.
Fill, spread dumped material, by dozer, no compaction	B10B	1,000	0.012	644,000.00	C.Y.	$0.00	$212,520.00	$476,560.00	$1.07	$689,080.00	Buttress Construction.
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	644,000.00	C.Y.	$0.00	$64,400.00	$115,920.00	$0.28	$180,320.00	Buttress Construction.
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	644,000.00	C.Y.	$128,800.00	$64,400.00	$161,000.00	$0.55	$354,200.00	Buttress Construction.
Ripping, shale, medium hard, 300 HP dozer, ideal conditons	B10M	720	0.017	199,653.00	C.Y.	$0.00	$91,840.38	$285,503.79	$1.89	$377,344.17	Re-condition cell sideslopes and floor 1 ft. deep.
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	199,653.00	C.Y.	$39,930.60	$19,965.30	$49,913.25	$0.55	$109,809.15	Re-condition cell sideslopes and floor 1 ft. deep.
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	199,653.00	C.Y.	$0.00	$19,965.30	$35,937.54	$0.28	$55,902.84	Re-condition cell sideslopes and floor 1 ft. deep.
Tilling topsoil, tilling topsoil, 26" rototiller, 2" deep, 6" deep	A1	750	0.011	598,958.00	S.Y.	$0.00	$143,749.92	$53,906.22	$0.33	$197,656.14	Re-condition cell sideslopes and floor in top 6".
Fill, spread dumped material, by dozer, no compaction	B10B	1,000	0.012	8,800,000.00	C.Y.	$0.00	$2,904,000.00	$6,512,000.00	$1.07	$9,416,000.00	Spread dumped Tailings in cell for compaction.
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	8,800,000.00	C.Y.	$1,760,000.00	$880,000.00	$2,200,000.00	$0.55	$4,840,000.00	Apply water to tailings in cell for both dust and compaction control.
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	8,800,000.00	C.Y.	$0.00	$880,000.00	$1,584,000.00	$0.28	$2,464,000.00	Compaction of tailings.
Tilling topsoil, tilling topsoil, 26" rototiller, 2" deep, 6" deep	A1	750	0.011	627,137.00	S.Y.	$0.00	$150,512.88	$56,442.33	$0.33	$206,955.21	Condition Radon barrier material @ 6" increments.
Excavation, self prop scraper, 14 CY 1/4 push dozer, com earth, 3000' haul	B33D	700	0.02	1,356,000.00	C.Y.	$0.00	$759,360.00	$3,593,400.00	$3.21	$4,352,760.00	Excavate and haul stockpiled cover material to cell.
Compaction, riding, sheepsfoot or wobbly whl rlr, 6" lifts, 3 passes	B10G	1,725	0.007	238,600.00	C.Y.	$0.00	$45,334.00	$85,896.00	$0.55	$131,230.00	Compact Radon Barrier Material.
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	1,117,400.00	C.Y.	$0.00	$111,740.00	$201,132.00	$0.28	$312,872.00	Compact remaining cover soils.
Compaction, water, wagon, 6000 gal, 3 mile haul	B59	2,000	0.004	1,356,000.00	C.Y.	$271,200.00	$135,600.00	$339,000.00	$0.55	$745,800.00	Water for cover material compaction and dust control.
Rip-rap, random, machine placed for slope protection	B12G	62	0.258	85,000.00	C.Y.	$0.00	$624,750.00	$531,250.00	$32.40	$2,754,000.00	Does not include haul to cell or quarry costs. Adjust unit cost to reflect no material costs.
Subtotal						**2,199,930.60**	**8,341,559.08**	**21,660,425.89**	**52.14**	**$33,799,915.57**	
25% OH&P										**$ 8,449,978.89**	
Total										**$ 42,249,894.46**	

Moab UMTRA Project
Line 002: Klondike Site (Construct Rail Siding and Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Railroad,sdg,yd spur,lvl gr,wd ties & ballast,100lb rail,ARA-A & AREA	B10B	57	0.842	15,840.00	L.F.	$934,560.00	$324,720.00	$50,212.80	$82.67	$1,309,492.80	Includes Track, Treated Ties, Apputenances, Ballast, and Construction Crew.
Railroad, resurface & realign exst track, for crushed stone blst, add	B33D	500	0.096	15,840.00	L.F.	$143,352.00	$36,748.80	$5,702.40	$11.73	$185,803.20	Assumes 6" additional ballast required under bottom of ties.
Railroad, car bumpers, heavy duty	B10B	2	24.000	1.00	Ea.	$3,900.00	$580.00	$90.50	$4,570.50	$4,570.50	Assumes one Rail Stop at the End-Of-Line.
Railroad, switch timber, compl set of timbers, 3.7 M.B.F for #8 sw	B10G	1	48.000	1.00	Total	$2,675.00	$1,150.00	$181.00	$4,006.00	$4,006.00	Switching Appurtenances.
Railroad, turnouts, timbers & ballast 6" deep	B59	1	96.000	1.00	Ea.	$18,800.00	$2,325.00	$360.00	$21,485.00	$21,485.00	Turnout Timbers, Ballast, and Apputenances.
Clearing, brush with saw, with dozer, ball and chain, med clearing	B10M	2	10.667	5.00	Acre	$0.00	$1,420.00	$2,450.00	$774.00	$3,870.00	Assumes 2 of the three miles require clearing medium density brush.
Tilling topsoil, tilling topsoil, 26" rototiller, 2" deep, 6" deep	B59	750	0.011	36,081.00	S.Y.	$0.00	$8,659.44	$3,247.29	$0.33	$11,906.73	Scarify Bottom 6" prior to placing fill for railroad bed.
Compaction, riding, vibrating roller, 6" lifts, 3 passes	B10G	2300	0.005	6,013.00	C.Y.	$0.00	$901.95	$962.08	$0.31	$1,864.03	Compact 6" layer of scarified subgrade.
Compaction, water, truck, 3000 gal, 3 mile haul	A1	1900	0.008	6,013.00	C.Y.	$1,202.60	$1,382.99	$2,284.94	$0.81	$4,870.53	Water required for compaction of subgrade and dust control.
Hauling, off hwy haulers, 34 CY rear/bot dump, 2 MI RT, 3.0 lds/hr	B10B	665	0.012	116,160.00	C.Y.	$0.00	$33,686.40	$255,552.00	$2.49	$289,238.40	Temporary Borrow from Cell Excavation 3 miles away. Quantity reported is 3-times the actual required in order to adjust for a 6-mile round trip. Quantity doubled for return of material to repository.
Fill, spread dumped material, by dozer, no compaction	B59	1000	0.012	19,360.00	C.Y.	$0.00	$6,388.80	$14,326.40	$1.07	$20,715.20	Assumes spreading dumped material foir railroad bed fill.
Compaction, water, wagon, 6000 gal, 3 mile haul	B10G	2000	0.004	19,360.00	C.Y.	$3,872.00	$1,936.00	$4,840.00	$0.55	$10,648.00	Assumes water usage for compaction and dust control for railroad bed construction.
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	A1	3500	0.003	19,360.00	C.Y.	$0.00	$1,936.00	$3,484.80	$0.28	$5,420.80	Compact Railroad bed fill prior to placing ballast.
Piping, storm drain, CMP, bitum ctd w/paved invert,20'L,48" dia,12ga	B33D	100	0.560	225.00	L.F.	$10,575.00	$3,116.25	$1,417.50	$67.15	$15,108.75	Assumes 5 general dimesioned areas will require construction of 48" culverts in ravines and low areas.
Hauling, off hwy haulers, 34 CY rear/bot dump, 2 MI RT, 3.0 lds/hr	B10G	665	0.012	780.00	C.Y.	$0.00	$226.20	$1,716.00	$2.49	$1,942.20	Fill required over culverts. Assumes 3 times the quantity to adjust a 2-mile round trip to 6 miles.
Site dml, RR removal, ties & track	B10G	330	0.170	20,000.00	L.F.	$0.00	$84,000.00	$38,200.00	$6.11	$122,200.00	Assumes additional 20 quantity to cover cost for removing switches, signs and other apputenances.
Site dml, RR removal, ties & track, ballast	B59	500	0.096	3,500.00	C.Y.	$0.00	$8,120.00	$1,260.00	$2.68	$9,380.00	Remove railroad bed ballast.
Subtotal						**$1,118,936.60**	**$517,297.83**	**$386,287.71**		**$2,022,522.14**	
25% OH&P										**$505,630.54**	
Total										**$2,528,152.68**	

Moab UMTRA Project
Line 003: Klondike Site (Construct Gravel Haul Road and Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Temporary Construction Facilities				1.00	L.S.	$0.00	$0.00	$0.00	$2,092,535.11	$2,092,535.11	See Henshall Estimate for detail.
Subtotal						**$0.00**	**$0.00**	**$0.00**	**$2,092,535.11**	**$2,092,535.11**	
25% OH&P										**$523,133.78**	
Total										**$2,615,668.89**	

Moab UMTRA Project
Line 004: Klondike Site (Rail Tailings Haul)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Rail Tailing Haul				178,200,000.00	TNMI				$0.10	$17,820,000.00	Assumes 7.8 MCY and 0.6 MCY from EIS report along with an estimated 0.4 MCY additionqal material placed on current cover. The conversion factor between Tons and Cubic Yards Used in this estimate is 1.35 Ton/CY.
Subtotal						**$0.00**	**$0.00**	**$0.00**		**$17,820,000.00**	
25% OH&P										**$4,455,000.00**	
Total										**$22,275,000.00**	

Moab UMTRA Project
Line 005: Klondike Site (Construct fences, gates and remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Fence, CL, indl, 3 strd barb wire, 2-1/2" post @10' OC., set in concrete, 8' H, 6 ga. wire, galv st	B80	180	0.178	6,000.00	L.F.	$115,200.00	$26,640.00	$18,240.00	$26.68	$160,080.00	Assumes 100' Buffer Zone around cell and stockpiles (3500' x 2300') & fence/gates at transfer station (1000 x 500). Also includes approximately 400 LF of fencing to be used around access control points, etc.
Fence, misc metal, snow fence on steel posts 10' OC, 4' high	B1	500	0.048	31,680.00	L.F.	$49,737.60	$35,798.40	$0.00	$2.70	$85,536.00	Assumes Plastic fabric (safety) fencing used for haul road.
Fence, double swing gates, 8' high, 20' opening	B80	1	22.069	2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes one-way traffic gates.
Fence, 5'-0" high fn, gate, 4' wide, 5' high, 2" frame, galv steel	B80	10	3.2	4.00	Ea.	$416.00	$320.00	$218.00	$238.50	$954.00	Assumes two man-gates required.
Site dml, chain link, posts & fabric, 8' to 10' high	B6	445	0.054	6,000.00	L.F.	$0.00	$8,040.00	$2,460.00	$1.75	$10,500.00	Chainlink Fence Demolition
Site dml, fencing, barbed wire, 3 strand	2 Clab	430	0.037	31,680.00	L.F.	$0.00	$26,928.00	$0.00	$0.85	$26,928.00	Haul Road Fence Demolition
Salvage Fence	B-34B	1,550	0.005	16,000.00	C.Y.	$0.00	$1,920.00	$4,960.00	$0.43	$6,880.00	Haul fence to storage location or salvager.
Subtotal						**$167,243.60**	**$63,858.40**	**$19,208.00**		**$294,618.00**	
25% OH&P										**$73,654.50**	
Total										**$368,272.50**	

Moab UMTRA Project

Line 006: Klondike Site (Construct Rail Truck Transfer Station and Truck to Cell, Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Rotary Dump Station @ transfer point. Build.				1.00	L.S.	$0.00	$0.00	$0.00	$1,400,000.00	$1,400,000.00	Pricing taken from ECDC cost estimate for rotary dump facility construction.
Stripping, topsoil & stockpiling, sandy loam, 200 HP dozer, ideal condtn	B10B	2300	0.005	279.00	C.Y.	$0.00	$41.85	$89.28	$0.47	$131.13	Strip and stockpile topsoil for transfer station operations.
Compaction, riding, vibrating roller, 12" lifts, 3 passes	B10Y	3500	0.003	279.00	C.Y.	$0.00	$27.90	$27.90	$0.20	$55.80	Compact subgrade to prepare for gravel base.
Borrow, bank measure, select granular fill, shovel, 3 CY bucket	B12T	1975	0.008	9,260.00	C.Y.	$71,302.00	$2,129.80	$5,556.00	$8.43	$78,061.80	Purchase and load roadbase.
Hauling, LCY, no loading, 20 c.y dump trailer, 20 MI RT, .5 lds/hr	B34D	78	0.103	23,150.00	C.Y.	$0.00	$56,949.00	$165,522.50	$9.61	$222,471.50	Haul gravel to site. Roundtrip actually 50 miles.Total required quantity is 2.5 times greater to accomodate additional miles.
Compaction, riding, vibrating roller, 6" lifts, 3 passes	B10Y	2300	0.005	9,260.00	C.Y.	$0.00	$1,389.00	$1,481.60	$0.31	$2,870.60	Compact gravel base on site.
Conc in place, SOG, w/trowel fin, no forms/reinf, 8" thk, >10,000 SF	C14F	3175	0.023	8,500.00	S.F.	$14,620.00	$5,100.00	$85.00	$2.33	$19,805.00	Estimated quantity of concrete for off-loading tailings at transfer point.
Concrete in place, footings, strip, 36" x 12", reinforced	C14C	61.5	1.82	40.00	C.Y.	$3,520.00	$2,040.00	$24.80	$139.62	$5,584.80	Estimated quantity of concrete footing required for retaining walls that will contain contaminated material after dumping from rail cars. Also include is an estmated quantity of concrete footings to support walls that house the rail car rotary device.
Concrete in place, retaining walls, gravity, 4' high see div 02370-700	C14D	66	3.021	60.00	C.Y.	$5,280.00	$5,250.00	$561.00	$184.85	$11,091.00	See note for footings above.
Forms in place, SOG, bulkhead forms w/keyway, wood, 1 use, 3 piece	C1	400	0.08	700.00	L.F.	$595.00	$1,547.00	$0.00	$3.06	$2,142.00	Forms for Slab-on-grade
Finishing floors, monolithic, screed, float & broom finish	1 Cefi	630	0.013	8,500.00	S.F.	$0.00	$3,060.00	$0.00	$0.36	$3,060.00	Finish work for slab-on-grade
Remove, bank measure, select granular fill, shovel, 3 CY bucket	B12T	1975	0.008	9,260.00	C.Y.	$0.00	$2,129.80	$5,556.00	$8.43	$78,061.80	Load gravel base for transport to cell.
Hauling, off hwy haulers, 34 CY rear/bot dump, 2 MI RT, 3.0 lds/hr	B34G	665	0.012	9,260.00	C.Y.	$0.00	$4,167.00	$31,854.40	$3.89	$36,021.40	Unit rate adjusted to accommodate additional 4 round trip miles.
Borrow, bank measure, topsoil/loam from stkpile, FE lder, whl mtd, 3 CY bkt	B10T	1,575	0.008	279.00	C.Y.	$0.00	$58.59	$69.75	$0.46	$128.34	Load stockpiled topsoil for replacement.
Hauling, LCY, no loading, 12 c.y dump truck, 1/2 MI RT, 3.2 lds/hr	B34B	250	0.032	279.00	C.Y.	$0.00	$214.83	$538.47	$2.70	$753.30	Haul topsoil from stockpile area and dump.
Fill, spread dumped material, by dozer, no compaction	B10B	1,000	0.012	279.00	C.Y.	$0.00	$92.07	$206.46	$1.07	$298.53	Spread topsoil material to prepare for compaction.
Compaction, riding, vibrating roller, 6" lifts, 2 passes	B10Y	3,000	0.004	279.00	C.Y.	$0.00	$30.69	$33.48	$0.23	$64.17	Compact topsoil.
Compaction, water, wagon, 6000 gal, 6 mile haul	B59	1,600	0.005	9,539.00	C.Y.	$1,907.80	$1,144.68	$3,052.48	$0.64	$6,104.96	Apply water for dust and compaction control.
Borrow, bank measure, com earth, front end loader, wheel mtd, 5 CY bucket	B10U	2,600	0.005	8,800,000.00	C.Y.	$0.00	$1,144,000.00	$2,728,000.00	$0.44	$3,872,000.00	Load tailings onto off-road haulers from transfer point. Cost adjusted to remove bare material charges.
Hauling, off hwy haulers, 34 CY rear/bot dump, 2 MI RT, 3.0 lds/hr	B34G	665	0.012	8,800,000.00	C.Y.	$0.00	$3,960,000.00	$30,272,000.00	$3.89	$34,232,000.00	Unit rate adjusted to accommodate additional 4 round trip miles.
Subtotal						**$97,224.80**	**$5,189,372.21**	**$33,214,659.12**		**$39,970,706.13**	
25% OH&P										**$9,992,676.53**	
Total										**$49,963,382.66**	

Moab UMTRA Project

Line 007: Klondike Site (Construct and install temporary facilities to sites, Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Temporary Construction Facilities				1.00	L.S.	$0.00	$0.00	$0.00	$597,540.00	$597,540.00	See Henshall Estimate. Added one building at repository end for rest facility @ 125,000.
Power to Truck Rail Transfer & Repository				2.00	Mi.	$0.00	$0.00	$0.00	$40,000.00	$80,000.00	Pricing taken from Monument Valley cost estimate for UGW final action.
Stormwater Drainage Controls/ponds				1.00	L.S.	$0.00	$0.00	$0.00	$500,000.00	$500,000.00	Includes ditches, Culverts, Sediment ponds, etc.
Remove construction facilities				1.00	L.S.	$0.00	$0.00	$0.00	$298,770.00	$298,770.00	Assumes length of project will esalate costs of removal to approximately 50% of original estimate for installation.
Subtotal						**$0.00**	**$0.00**	**$0.00**	**$298,770.00**	**$1,476,310.00**	
25% OH&P										**$369,077.50**	
Total										**$1,845,387.50**	

Moab UMTRA Project

Line 008: Klondike Site (Construct and install temporary facilities to sites, Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Fence, 8' H, 6 ga. wire, 2-1/2" line post, galv st				9,000.000	L.F.	$172,800.00	$39,960.00	$27,360.00	$26.68	$240,120.00	Assumes a 100' Buffer Zone around cell and stockpiles(3500' x 2300') and fence/gates at transfer station (1000' x 500'). Also includes approximately 400 LF of fencing to be used around access control points.
Fence, double swing gates, 8' high, 20' opening				2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes one-way traffic gates.
Subtotal						**$174,690.00**	**$41,060.00**	**$28,110.00**		**$243,860.00**	
25% OH&P										**$60,965.00**	
Total										**$304,825.00**	

Moab UMTRA Project

Line 009: Moab Tailings Pile (Excavate main tailings pile)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Excavation, self prop scraper, 21 CY 1/4 push dozer, sand&gvl, 3000' haul.	B33E	805	0.017	8,200,000.00	C.Y.	$0.00	$3,526,000.00	$19,680,000.00	$2.83	$23,206,000.00	Assumes excavation and 1500 ft. haule to stockpile at loading area
Excavating, bulk, dozer, open site, 300 HP, 50' haul, sand & gravel	B10M	1,900	0.006	8,200,000.00	C.Y.	$0.00	$1,476,000.00	$4,428,000.00	$0.72	$5,904,000.00	Dozer maintains stockpile conditions at the converyor loadout area.
Excavating, bulk, dozer, open site, 700 HP, 300' haul, Common	B10M	1,900	0.006	21,420.00	Hrs.	$0.00	$0.00	$0.00	$246.93	$5,289,311.99	Assumes two mixing dozers are required to maintains consistency of soil being taken to the conveyor loading facility for 3.5 years.
Excavating, bulk, dozer, open site, 700 HP, 300' haul, Common	B10M	1,900	0.006	21,420.00	Hrs.	$0.00	$0.00	$0.00	$246.93	$5,289,311.99	
Subtotal						**$0.00**	**$5,002,000.00**	**$24,108,000.00**		**$39,688,623.99**	
25% OH&P										**$ 9,922,156.00**	
Total										**$ 49,610,779.98**	

Moab UMTRA Project

Line 010: Moab Tailings Pile (Excavate Subpile and Windblown Areas)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Excavation, self prop scraper, 21 CY 1/4 push dozer, sand&gvl, 3000' haul.	B33E	805	0.017	600,000.00	C.Y.	$0.00	$294,000.00	$1,380,000.00	$2.79	$1,674,000.00	Assumes excavation and 3000 ft. R/T haul to stockpile at loading area and back
Excavating, bulk, dozer, open site, 300 HP, 50' haul, sand & gravel	B10M	1,900	0.006	600,000.00	C.Y.	$0.00	$336,000.00	$1,590,000.00	$3.21	$1,926,000.00	Dozer maintains stockpile conditions at the converyor loadout area.
Subtotal						**$0.00**	**$ 630,000.00**	**$ 2,970,000.00**		**$3,600,000.00**	
25% OH&P										**$ 900,000.00**	
Total										**$ 4,500,000.00**	

Moab UMTRA Project

Line 011: Moab Tailings Pile (Conveyor Material Handling and System)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Conveyor System and Installation				1.00	L.S.				$3,500,000.00	$3,500,000.00	Assumes ECDC Costs for conveyor system and installation is appropriate.
Conveyor Loading Costs				8,800,000.00	C.Y.	$0.00	$0.00	$17,952,000.00	$3.71	$32,670,000.00	Assumes ECDC Costs for loading tailings onto conveyor system is appropriate.
Subtotal						**$0.00**	**$0.00**	**$ 17,952,000.00**		**$36,170,000.00**	
25% OH&P										**$ 9,042,500.00**	
Total										**$ 45,212,500.00**	

Moab UMTRA Project

Line 012: Mill (Construct and install temporary facilities to sites, Remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Temporary Construction Facilities				1.00	L.S.	$0.00	$0.00	$0.00	$468,520.00	$468,520.00	See Henshall Estimate.
Power to Millsite & Rail loadout station				2.00	Mi.	$0.00	$0.00	$0.00	$40,000.00	$80,000.00	Pricing taken from Monument Valley cost estimate for UGW final action.
Stormwater Drainage Controls/ponds				1.00	L.S.	$0.00	$0.00	$0.00	$500,000.00	$500,000.00	Includes ditches, Culverts, Sediment ponds, etc.
Remove construction facilities				1.00	L.S.	$0.00	$0.00	$0.00	$234,260.00	$234,260.00	Assumes length of project will esalate costs of removal to approximately 50% of original estimate for installation.
Subtotal						**$0.00**	**$0.00**	**$0.00**	**$234,260.00**	**$1,282,780.00**	
25% OH&P										**$320,695.00**	
Total										**$1,603,475.00**	

Moab UMTRA Project
Line 013: Millsite (Construct fences, gates and remove)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Fence, CL, indl, 3 strd barb wire, 2-1/2" post @10' OC., set in concrete, 8' H, 6 ga. wire, galv st	B80	180	0.178	10,500.00	L.F.	$201,600.00	$46,620.00	$31,920.00	$26.68	$280,140.00	Assumes millsite is 130 acres at pile and adjacent areas (9518' x 9518'). Also includes approximately 400 LF of fencing to be used around access control points and 500 LF around train and conveyor loadout points.
Fence, double swing gates, 8' high, 20' opening	B80	1	22.069	2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes two-way traffic gates.
Fence, 5'-0" high fn, gate, 4' wide, 5' high, 2" frame, galv steel	B80	10	3.2	4.00	Ea.	$416.00	$320.00	$218.00	$238.50	$954.00	Assumes at least four man-gates required.
Site dml, chain link, posts & fabric, 8' to 10' high	B6	445	0.054	15,000.00	L.F.	$0.00	$20,100.00	$6,150.00	$1.75	$26,250.00	Chainlink Fence Demolition
Salvage Fence	B-34B	1,550	0.005	16,000.00	C.Y.	$0.00	$1,920.00	$4,960.00	$0.43	$6,880.00	Haul fence to storage location or salvager.
Subtotal						**$203,906.00**	**$48,040.00**	**$32,888.00**		**$317,964.00**	
25% OH&P										**$79,491.00**	
Total										**$397,455.00**	

Moab UMTRA Project
Line 014: Millsite Clean Material Backfill

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Borrow, bank measure, com earth, front end loader, wheel mtd, 5 CY bucket	B10U	2,600	0.005	600,000.00	C.Y.	$4,050,000.00	$78,000.00	$186,000.00	$7.19	$4,314,000.00	Assumes total replacement of subpile and windblown areas on millsite.
Hauling, LCY, no loading, 20 c.y dump trailer, 10 MI RT, .75 lds/hr	B34D	110	0.073	600,000.00	C.Y.	$0.00	$1,044,000.00	$3,060,000.00	$6.84	$4,104,000.00	
Compaction, riding, sheepsfoot or wobbly whl rlr, 12" lifts, 3 passes	B10G	3,500	0.003	600,000.00	C.Y.	$0.00	$60,000.00	$108,000.00	$0.28	$168,000.00	
Compaction, water, wagon, 6000 gal, 6 mile haul	B59	1,600	0.005	600,000.00	C.Y.	$120,000.00	$72,000.00	$192,000.00	$0.64	$384,000.00	
Subtotal						**4,170,000.00**	**1,254,000.00**	**$3,546,000.00**	**$14.95**	**$8,970,000.00**	
25% OH&P										**$2,242,500.00**	
Total										**$11,212,500.00**	

Moab UMTRA Project

Line 015: Millsite Revegatate wetlands, riparian, and upland areas

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Wetland Reclamation				100.00	Acre				$10,000.00	$1,000,000.00	Assumes 400 acre disturbance at the millsite. Unit prices are historical and include labor materials and equipment.
Upland (sloped > 4:1) Reclamation				30.00	Acre				$7,200.00	$216,000.00	
Upland (Flat) Reclamation				270.00	Acre				$4,500.00	$1,215,000.00	
Subtotal						**0.00**	**0.00**	**$0.00**	**$21,700.00**	**$2,431,000.00**	
25% OH&P										**$607,750.00**	
Total										**$3,038,750.00**	

Moab UMTRA Project
Line 016: Millsite (Reclamation Fencing)

Description	Crew	Daily Output	Labor Hours	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Fence, misc metal, snow fence on steel posts 10' OC, 4' high	B1	500	0.048	17,000.00	L.F.	$26,690.00	$19,210.00	$0.00	$2.70	$45,900.00	Assumes Plastic fabric (safety) fencing used for protection of reclaimed areas.
Fence, double swing gates, 8' high, 20' opening	B80	1	22.069	2.00	Opng.	$1,890.00	$1,100.00	$750.00	$1,870.00	$3,740.00	Assumes two-way traffic gates.
Fence, 5'-0" high fn, gate, 4' wide, 5' high, 2" frame, galv steel	B80	10	3.2	2.00	Ea.	$208.00	$160.00	$109.00	$238.50	$477.00	Assumes two man-gates required.
Site dml, fencing, barbed wire, 3 strand	2 Clab	430	0.037	17,000.00	L.F.	$0.00	$14,450.00	$0.00	$0.85	$14,450.00	Assumes reclamation fence demolition.
Salvage Fence	B-34B	1,550	0.005	8,000.00	C.Y.	$0.00	$960.00	$2,480.00	$0.43	$3,440.00	Haul fence to storage location or salvager.
Subtotal						**$28,788.00**	**$20,470.00**	**$859.00**		**$68,007.00**	
25% OH&P										**$17,001.75**	
Total										**$85,008.75**	

Moab UMTRA Project

Lines 017 - 024: Administration

Description	Qty	Unit	Bare Mat.	Bare Labor	Bare Equip.	Unit Cost	Total	Note
Permits (2% of Total Including OH&P)	1.00	Job	$0.00	$0.00	$0.00	$4,756,360.00	$4,756,360.00	
Main office expense (3.9% of Bare Costs)	1.00	% Vol.	$0.00	$0.00	$0.00	$7,410,194.30	$7,410,194.30	
Field personnel clerk average	1,248.00	Week	$0.00	$280.00	$0.00	$280.00	$349,440.00	
Field personnel, field engineer, maximum	1,248.00	Week	$0.00	$1,000.00	$0.00	$1,000.00	$1,248,000.00	
Field personnel, project manager, maximum	416.00	Week	$0.00	$1,600.00	$0.00	$1,600.00	$665,600.00	
Field personnel, superintendent, maximum	3,328.00	Week	$0.00	$1,500.00	$0.00	$1,500.00	$4,992,000.00	
Field personnel, general purpose laborer, average	6,656.00	Week	$0.00	$925.00	$0.00	$925.00	$6,156,800.00	
Subtotal			**0.00**	**5,305.00**	**0.00**	**12,171,859.30**	**$25,578,394.30**	
25% OH&P							**$ 6,394,598.57**	
Total							**$ 31,972,992.87**	

Estimate of Net Present Value For Total Annual Costs for Cap-in-Place and Off Site Disposal

Alternative	Annual Cost	Start Year	End Year	Discount rate	NPV in Start Yr	NPV Today $
LTSM Cap-in-place	$21,100	5	200	5.30%	$398,096	$307,501
LTSM Off-Site Disposal	$18,700	9	200	5.30%	$352,812	$221,660
Active GW Treatment(on and off site)	$1,445,700	1	35	5.30%	$22,802,191	$22,802,191
Out Year GW Treatment On site	$73,900	35	100	5.30%	$1,345,752	$220,786
Out year GW Treatment Off site	$49,200	35	100	5.30%	$895,954	$146,992

Total On Site NPV = $23,330,478
Total Off site NPV= $23,170,843

NPV is net present value

Estimated Annual LTSM Costs for Disposal Off Site
(Relocated Site)

Activity	Disposal Off Site	Notes
Inspections	$2,100	Includes reporting
Maintenance	$5,300	One-half the maintenance compared to cap-in-place because of fewer intrusions.
Environmental Monitoring	$8,700	Moab site cost plus 50 percent for less rigorous monitoring off site.
Site Management	$2,600	Miscellaneous activities
Total	**$18,700**	

Appendix G

Summary of Stakeholder Concerns/Comments

Summary of Stakeholder Concerns/Comments

In preparing the Draft Plan for Remediation, the U.S. Department of Energy (DOE) attempted to objectively determine stakeholder interests related to the location of the tailings pile (on-site vs. off-site disposal) based on information previously collected during preparation of the *Final Environmental Impact Statement Related to Reclamation of the Uranium Mill Tailings at the Atlas Site, Moab, Utah* (FEIS) (NRC 1999a) and the Final Technical Evaluation Report (FTER) (NRC 1997). These data represent the most complete and formalized public input available. All the 245 comments and responses in Appendix J of the FEIS and the majority of the comments in the FTER were reviewed to qualify and determine which concerns required further evaluation and resolution. Federal, state, county and local agencies, private industry, interest groups, and individual comments were included in the review. A list of the key concerns and the scope of the concerns is outlined in Table G1 (located at the end of this Appendix). Note that many of the concerns included in the 1996 comments in the FEIS have been resolved or are in the process of being resolved (e.g., additional characterization, further evaluation of an off-site alternative). In addition, some of the comments received in 1996 are no longer applicable because of changes in the regulatory status of the Moab site.

In reviewing the FEIS and FTER comments, DOE also attempted to determine if a preference and rationale for a preference was expressed regarding disposition of the Moab site tailings. Table G2 shows the breakdown for preference expressed in the FEIS. A range is shown vs. actual numbers because preferences expressed in 1996 may not reflect current sentiment (for reasons included above).

Table G2. General Overview of Stakeholder Preference for Location

Stakeholder Group	On-Site Preferred	Relocation Preferred	On-Site Not Defensible[a]	No Preference Expressed[b]
Federal Agencies	None	0 - 5	0 – 5	None
State Agencies	None	None	None	0 - 5
County/Local Agencies	0 – 5	0 - 5	0 – 5	0 - 5
Industry/Private Orgs.	5 - 10	5 - 10	None	0 - 5
Individuals	150 - 200	0 - 50	0 – 50	0 - 50

[a]Commentors did not disagree with on-site cap-in-place but felt that NRC had not adequately addressed key issues to this alternative
[b]Commentors expressed concerns with both on-site and off-site alternatives or were concerned with ancillary issues and did not express a preference for location.

Summary of Key Concerns

Of the commentors who supported on-site cap-in-place, the overwhelming concern was related to the cost of relocation. Of the commentors who did not explicitly support on-site cap-in-place, most favored relocation primarily for environmental reasons. Some believed more work needed to be done prior to making a decision, and a few commentors expressed no preference (majority of this group expressed concerns with both alternatives or concerns with borrow pit locations and impacts). The following key concerns were expressed by these three categories of commentors:

- On-site costs are biased, life-cycle estimates were not included or were not comprehensive, and were artificially low in support of on-site stabilization. A cost/benefit analysis is lacking.
- Surface water quality standards and environmental risks to receptors (including threatened and endangered species) were not adequately addressed.
- Characterization of all media was not adequate; data quality objectives were lacking.
- Twenty unresolved issues in the FTER have not been adequately addressed.
- River migration over time would negatively affect the disposal cell in its current location.
- Adverse effects to humans and the environment because of location in a floodplain/wetland area, including effects during catastrophic events (100- to 500- year floods).
- No agreement on standards, detection limits for contaminants, monitoring needs, etc.
- Incomplete and biased National Environmental Policy Act (NEPA) analysis.
- Inadequate consideration of future use of the area.
- Negative impact on tourism if left in place (aesthetics, visual quality, proximity to national parks).
- Seismic activity status is not well defined.
- Transportation/accident analysis is inadequate.

Summary of Stakeholder Preference for Location

Of the federal, state, and local agencies commenting on the FEIS and FTER, most were not in agreement with on-site cap-in-place (based on the FEIS and FTER) on the basis of actual or potential adverse environmental effects in the long-term and the lack of a cost/benefit analysis that would include long-term surveillance and maintenance activities.

Most of the individual commentors in favor of on-site cap-in-place believed costs to relocate could not be justified, and risk to human health is minimal. Concerns related to environmental impacts associated with on-site cap-in-place were not expressed. Conversely, actual or potential short- and long-term environmental impacts associated with on-site cap-in-place were the primary concern for those not favoring this alternative. It appears that many of the commentors in favor of on-site cap-in-place used a form letter.

More Recent Stakeholder Input

Newspaper articles and congressional legislative information have been reviewed since the formal draft Environmental Impact Statement comment period in an attempt to get a better understanding of current stakeholder opinion regarding a preference for the cap-in-place or the relocated site alternatives. DOE understands that these sources are not direct reflections of stakeholder opinion.

Early drafts of proposed legislation for the Moab site remediation and funding were initiated by downstream water user states that expressed a strong preference that the uranium tailings be removed from the Moab site, largely because of the perceived negative affect on surface water quality. As proposed legislation evolved, the purpose shifted from removal of the tailings from the site to an evaluation of a wide range of alternatives for site remediation, as is defined in the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (House of Representatives 2000).

Articles appearing in local and select national newspapers about the Moab site were surveyed for the time period from January 1, 1997, through September 23, 2001, from the following newspapers:

- The Salt Lake Tribune (Salt Lake City, Utah)
- The Deseret News (Salt Lake City, Utah)
- The Times-Independent (Moab, Utah)
- The San Juan Record (Monticello, Utah)
- The Daily Sentinel (Grand Junction, Colorado)
- The Arizona Republic (Phoenix, Arizona)
- Las Vegas Review-Journal (Las Vegas, Nevada)
- Los Angeles Times (Los Angeles, California)
- The San Diego Union-Tribune (San Diego, California)
- The New York Times (New York City, New York)
- The Washington Post (Washington, DC)
- USA Today (Washington, DC)

The articles covered a variety of site topics, including the Atlas bankruptcy, discussions about dust emissions, discussions on surface-water quality adjacent to the site and impacts to aquatic life in the river, concerns of downstream water users, discussions about interim actions being performed by PricewaterhouseCoopers, etc. Articles that did address site remediation often did not identify which alternative (cap-in-place or the relocated site alternative) was preferred. Terminology used in the articles tended to be ambiguous when reviewed from a frame of reference of which specific alternative was preferred. Overall, it appears that there was a tendency for public opinion to favor the removal of the tailings from the Moab site. Although the articles themselves do not define a stakeholder preference between the two alternatives, it can be concluded, based on the large number of published articles, that stakeholder interest on this topic has consistently remained high.

Additional stakeholder opinion must be obtained before making a final remediation alternative decision.

Table G1. General Summary of Key Stakeholder Concerns
(Only issues that are relevant to alternative analysis are included)

KEY ISSUES	FEIS	FTER
	Scope of Concern	**Scope of Concern**
Regulatory compliance	Compliance with the National Environmental Policy Act (NEPA) requirements, NEPA process, cumulative impacts. Environmental consequences not adequately addressed.	Too many open issues, 20 identified in the FTER and FEIS.
Alternatives analysis	More detailed analysis, particularly off-site alternatives. Costs may be greater for groundwater remediation if tailings left on-site.	On-site stabilization does not meet Criterion "1" for several reasons (e.g., remoteness from populated areas).
Integration/review documents	Information and documents need to complement each other. Concerns that standards would not be met.	Coordination with State of Utah and the public.
Costs/benefits	Cost should be included for potential catastrophic event. Cost weighted more heavily than environmental considerations. Costs used for on-site stabilization out dated and not well supported.	
Environmental risk (containments) (primary to aquatic receptors)	Pile should be moved from the floodplain. Commentors wanted more analysis of long-term risk included; better analysis of risk to aquatic receptors.	
Characterization/monitoring (soil and groundwater)	Characterization inadequate to evaluate alternatives, specifically chemical and physical characteristics of the "pile."	Contaminants were excluded from monitoring that should be included/may be health effects from excluded contaminants/monitoring not documented/characterization methods for tailings/radon attenuations/biointrusion.
Design of disposal cell	More detailed design included in FEIS.	Ability to withstand 100/500-year flood/adequacy of controls for 1,000 years/liquefaction of soils/moisture retention/lift thickness affect on groundwater/ permeability/groundwater fluctuations.
Borrow pit location/materials	Borrow pit locations in the FEIS were unsatisfactory and needed more environmental assessment.	Will materials meet design requirements? Locations?
Surface water quality	More consideration needed to be given to regulatory requirements (e.g., wetlands); mass loading of the river and data for selecting contaminants of concern; plus comments at meetings.	Effects of groundwater on Colorado River.
Air quality/noise	Moving the pile would re-contaminate areas, and borrow pit areas not adequately assessed.	

Table G1 (continued). General Summary of Key Stakeholder Concerns
(Only issues that are relevant to alternative analysis are included)

KEY ISSUES	FEIS	TER
	Scope of Concern	**Scope of Concern**
Geologic concerns (seismic activity, landslides)	On-site stabilization due to the Moab Fault and landslides not yet resolved.	Not enough information or defensible proof that the fault is not a capable fault, and related landslide, subsidence concerns.
Groundwater compliance/standards	The tailings pile (if left in place) will serve as a continuing source and could continue leaching to groundwater and surface water.	There are nonradioactive constituents above state standards/alternate concentration limits require consultation with State/Groundwater Compliance Action Plan needs more work.
Groundwater hydrology/modeling	More information needed and interpretation of data is weak.	Hydraulic properties/conductivity/flow direction/ leachate analysis/ background water quality/ seeps/effects on surface water.
Groundwater use	Future uses, downstream uses.	Local water users/potability.
Floodplains and wetlands (including Moab & courthouse washes)	Adequacy of flood analysis, and the relocation of Moab Wash and design of cell to withstand flooding, and river encroachment.	Migration of the river and its affect on the pile over time/Moab Wash protection.
Surface water uses	Downstream uses of Colorado River not considered including impacts to Lake Powell and recreational users.	
Land use (including future land use and adjacent properties)	Use of lands downstream and if tailings left in place; would property be available for unrestricted use.	
Cultural, socioeconomic aesthetic/recreation	Concerns ranged from land ownership to the color of the cap, and included future development of the area. Disruption of recreation and tourism industry and impacts to national parks also discussed.	
Transportation	Safety and road repair needs were the focus of this concern. Accident analysis was suggested.	
Human risk	Radiological and nonradiological concerns (floods, earthquakes, etc.) to local public and tourists.	