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Washington, DC 20585

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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Deputy Director
Mail Stop T8-F5
Washington, DC 20555-0001

Subject: UMTRCA Disposal Cell Site Selection Process (Document No. S15077)

To Whom It May Concern:

The UMTRCA Disposal Cell Site Selection Process paper is submitted for your review and concurrence. This paper was developed by the Department of Energy, Office of Legacy Management to convey concepts and information related to stakeholder input about the perceived benefits and foreseeable risks of relocating disposal cells.

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Sincerely,

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UMTRCA Disposal Cell Site Selection Process

1.0 Introduction and Purpose

Under the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, 22 former uranium mill sites were remediated to reduce the risk of radon exposure from mill waste. A typical surface remediation consisted of consolidating contaminated material and covering it in a disposal cell. Cell covers are composed of compacted clay and rock layers and are designed to be effective for up to 1000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The selection of disposal cell locations followed a defined process as described in the *Technical Approach Document* (DOE 1989) with the objective of minimizing potential human health and environmental impacts.

At many of the mill sites, groundwater contamination resulted from the infiltration of contaminated water from unlined process ponds and tailings piles during mill operations as was the practice at the time, prior to surface remediation. The potential for ongoing groundwater contamination from the cells is of concern to the Navajo Nation, and it has been suggested that a disposal cell must be removed "to truly understand the effects of transient drainage from the disposal cell to the aquifer" (NNEPA 2015). Transient drainage can be defined as water released from the disposal cell after construction of the cell is complete. At locations where disposal cells were constructed directly on former mill sites, transient drainage will be combined with preexisting, and usually much more significant, levels of groundwater contamination originating from the milling process.

The UMTRCA disposal cells located on the Navajo Nation were all constructed at locations of former mills. Stakeholders on the Navajo Nation have requested that all legacy uranium milling wastes be moved off the Navajo Nation and that the disposal cell sites be returned to natural conditions.

Stakeholders have also suggested that the only way to understand the impacts from transient drainage from a disposal cell vs. the impacts to groundwater contamination associated with the original uranium milling is to relocate the disposal cell. To better understand the potential impacts of relocating a disposal cell, this paper describes the process for selection of disposal cell locations, either on or off the original mill sites. The examination of the disposal cell site selection process answers the following questions:

- Have uranium mill tailings ever been removed or relocated from a mill site?
- What are some of the environmental issues that have been considered, in cases where tailings piles have been moved?
- What regulations and guidance are relevant to disposal cell site selection?

With regard to the existing disposal cells:

- Has an UMTRCA disposal cell ever been moved?
- What are the issues that would factor in to the decision to relocate a disposal cell?
- Who has the decision-making authority to relocate a cell?
- What is the future plan for UMTRCA disposal cells?

2.0 Background on Uranium Milling Wastes and UMTRCA

Uranium mining and milling began in earnest in the 1950s to provide uranium in support of national defense projects. Mining and milling activity wound down in the 1970s after an adequate inventory of uranium had been developed. When the uranium mills were operating, many tailings piles accumulated at the mill sites, and after the mills shut down, tailings piles were left behind by the mill owner/operators. Additionally, groundwater at many mill sites was contaminated by the milling process. Mills were closed (sometimes abandoned) in a manner to minimize economic cost, without regard to potential for future environmental problems. Uranium production to support national defense projects was the overwhelming priority associated with mining and milling efforts. The possible future impacts resulting from mill tailings disposal were not fully considered, nor were laws in place to require cleanup.

2.1 Regulatory Background

As collective awareness and concern for the environment and human health issues increased throughout the late 1960s and 1970s, laws were passed to address a variety of issues, including the Clean Air and Clean Water Acts, the National Environmental Policy Act, and the Safe Drinking Water Act. UMTRCA was passed into law in 1978. UMTRCA's stated purposes included:

> To provide for stabilization, disposal, and control in a safe and environmentally sound manner ...tailings in order to prevent or minimize radon diffusion into the environment and to prevent or minimize other environmental hazards from such tailings...To provide in cooperation with the interested States, Indian tribes, and the persons who own or control inactive mill tailings sites, a program of assessment and remedial action at such sites, including, where appropriate, the reprocessing of tailings to extract residual uranium and other mineral values where practicable, in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public, and (to provide) a program to regulate mill tailings during uranium or thorium ore processing at active mill operations and after termination of such operations in order to stabilize and control such tailings in a safe and environmentally sound manner and to minimize or eliminate radiation health hazards to the public. (Section 7901)
>
> *Uranium Mill Tailings Remediation Performed by the US DOE: An Overview* (Robinson 2004)

Title I of UMTRCA addresses tailings produced from uranium milling for the production of nuclear weapons. Title I sites are those that operated primarily from the mid-1940s through the 1970s (although one site was in operation as early as the 1920s, and others extended operations into the 1980s) and produced uranium solely for the Atomic Energy Commission for legal ownership by the U.S. government (Robinson 2004).

The U.S. Environmental Protection Agency (EPA) and the U.S. Nuclear Regulatory Commission (NRC) adopted regulations to implement the authorities provided in UMTRCA. EPA adopted a set of performance standards applicable to uranium mill tailings. NRC adopted a set of design and review criteria for review and approval of uranium mill tailings remediation plans. EPA's regulations are codified as Title 40 *Code of Federal Regulations* Part 192 (40 CFR 192). NRC's regulations are found in 10 CFR 40, Appendix A. Additionally, "UMTRCA regulations, standards and criteria…have also served as a model for uranium mill tailings management requirements in other uranium producing countries and the International Atomic Energy Agency" (Robinson 2004).

The U.S. Department of Energy (DOE) Office of Legacy Management "has control and custody for legacy land, structures and facilities and is responsible for maintaining them at levels consistent with long-term plans" and regulatory requirements (https://www.energy.gov/lm/mission).

2.2 Guidance Used for UMTRCA Title I Disposal Cell Site Selection

The 1978 UMTRCA legislation mandated, in part, that DOE clean up and provide perpetual care for 22 inactive (Title I) uranium mill sites. Field investigations ensued, and in 1989 DOE published the *Technical Approach Document* (TAD, DOE 1989). The TAD describes "general technical approaches and design criteria adopted by the U.S. Department of Energy in order to implement remedial action plans (RAPs) and final designs that comply with EPA standards." The RAPs are intended to "address groundwater contamination at processing sites and compliance with groundwater standards" and "must come as close to meeting the otherwise applicable standard as is reasonably achievable and must protect human health and the environment."

The TAD describes the primary design criteria for disposal cells: "to withstand maximum credible earthquakes, Probable Maximum Precipitation events, and Probable Maximum Flood events" and to satisfy a design lifespan of 1000 years whenever reasonably achievable, but in any case, a minimum performance period of 200 years.

The TAD provided an outline of the essential steps for evaluating and selecting disposal cell locations as follows:

[1] Identify hazards associated for stabilization in place (SIP) and remedial action necessary for technical acceptability.

[2] Assess the design features necessary for technically acceptable stabilization on site (SOS) if technical acceptability of SIP is not possible or is in question.

[3] Assess potential alternate sites if neither SIP nor SOS is technically feasible. (The assessment of the relocation option is always necessary for comparative purposes.) Remedial measures required to assure technical feasibility of SIP or SOS may result in more costly solutions than relocation.

[4] Identify the hazards and potential design options at one or more potential alternate sites.

[5] Perform cost estimates for each potential SIP, SOS, and relocation option.

[6] Select the preferred alternative for stabilization and final configuration based on the amount of risk associated with any factors that cannot be fully evaluated, as well as the cost.

Note that assessment of the relocation option (step 3) is always necessary for comparison, and that the selection of a preferred alternative (step 6) is based first on protection from risk factors that cannot be fully evaluated, and second on cost. Thus, for all UMTRCA Title I sites for which surface remediation occurred after issuance of the TAD, all options (SIP, SOS, relocation) were evaluated before RAPs were finalized. Prior to issuance of the TAD, disposal cell site selection was guided by *Criteria for Evaluating Disposal Sites* (UMTRA-DOE/ALO-7 1982).

An assessment of the SIP option includes an evaluation of the stability and configuration of the tailings pile and cover, optimal radon barrier design, and potential surface water and groundwater impacts. Specifically, with regard to surface water and groundwater, SIP assessment includes the following steps.

- Identify the modifications that exist (if any) to avoid impact of upland drainage areas or nearby large streams.
- Identify the risks associated with location in a floodplain (not automatically a reason for relocation).
- Ensure that contaminated materials are well above the groundwater table.

Guidance for assessment of SOS echoes the requirements for SIP assessment with regard to potential for surface water and groundwater impacts, as follows.

- Assess the modifications available to avoid any existing hydrologic impacts. Greater control of hydraulic conditions is possible with SOS than SIP, thereby reducing erosion protection requirements.
- Evaluate the necessity for substantial erosion protection requirements due to flooding, runoff from upland drainage basins, and flow in stream channels.

Finally, with regard to relocation of tailings to an alternative site, the TAD again provides guidance for protection of surface water and groundwater.

- Exercise maximum flexibility in selecting a site and choosing a configuration that minimizes hydrologic impacts.
- Avoid sites with shallow groundwater. Shallow groundwater will affect the pile configuration by limiting the degree of below-grade disposal.

In addition to the general guidance through the assessment of tailings SIP, SOS, and relocation, the TAD provides guidance on the selection of alternative sites, which includes "…processes to be used by the DOE with input from the affected states and tribes." The Alternate Site Selection Process involves the following three phases.

- Designation of a Search Region. The search region is selected in consultation with the affected tribe or state and includes consideration of local/state/tribal preferences, political boundaries, and the likelihood of finding a suitable site—typically within a 5-mile radius of the UMTRCA mill site.
- Preliminary Screening. Screening the search region is based on geotechnical, hydrologic, and environmental factors. Screening will result in identification of suitable and unsuitable areas within the search region.

- Identification and Evaluation of Sites. No more than three suitable areas, ranging in area from 40 to 600 acres, are identified for evaluation.
  - Surface characteristics to consider include: "accessibility and terrain, nearby structures, potential borrow sites for cover material and constructability."
  - Hydrologic considerations include: "presence of complex watersheds, flooding potential, geomorphic stability, aquifer parameters, depth to groundwater, direction of groundwater flow, volume flux beneath the disposal site, aquifer and subsoil geochemical properties, background water quality and classification of groundwater and potential impacts of tailings seepage on groundwater including compliance with EPA groundwater standards."
  - Geotechnical considerations include: "nearby faults and fault zones, latest seismic activity and extent, erosion potential, liquefaction potential, slope stability and other considerations."
  - Environmental considerations include: "distances to parks, monuments, critical habitats, prime farmlands, cultural resources and the like."

It is noteworthy that hydrologic considerations comprise the longest list of criteria for site evaluation.

2.3 Site Selection Assessment and Decision-Making

The evaluation of disposal cell site selection (guided by the TAD) was then documented through the National Environmental Policy Act (NEPA) process, which requires development of an Environmental Impact Statement (EIS) or an Environmental Assessment (EA) for "major Federal actions significantly affecting the quality of the human environment." For surface remediation activities at UMTRCA sites, EAs were prepared. EAs for UMTRCA surface remediation activities generally involved a statement of Need for Remedial Action, evaluation of alternatives (no action, stabilizing tailings in place, or relocating tailings) and a description of the affected environment and environmental impacts. The EA for the Tuba City, Arizona, Disposal Site is used as an example of the environmental considerations in disposal cell site selection.

2.3.1 Overview of the Tuba City EA

The typical alternatives for UMTRCA site surface remediation, as noted above, were evaluated for the Tuba City site. Consideration was also given to reprocessing the tailings for metals recovery or returning the tailings to the mines from which the ore was originally obtained. Assessment of the alternatives as presented in the Tuba City EA (DOE 1986) is discussed in the following subsections.

2.3.1.1 No Action Alternative

The no action alternative is included in the NEPA process to determine a baseline of environmental impacts that could occur if the proposed action is not executed. For the Tuba City site, the results of the no action alternative were described as continued dispersion of tailings by wind and water erosion, continued groundwater contamination, and potential for unauthorized removal of tailings material. Dispersion and unauthorized removal would result in radiological contamination of other areas and increased health risks. The no action alternative was dismissed because it would "not be consistent with the intent of Congress in UMTRCA (PL95-604) and would not result in the DOE's compliance with EPA standards" (DOE 1986).

2.3.1.2 Proposed Action: Stabilization of Tailings in Place

Stabilization in place involved consolidation of contaminated materials with the tailings and placement of an engineered cover with a compacted clay layer to inhibit radon emanation and water infiltration and a rock erosion barrier to prevent wind and water erosion and animal or human intrusion.

Preliminary disposal cell cover design features are described in the EA as well as in documents that describe the major construction activities. Construction using conventional practices and technologies was described and was expected to result in compliance with applicable regulations and would ensure "the safe and environmentally sound stabilization of the tailings and other contaminated materials." Construction activities were expected to include "site preparation, demolition of existing structures, construction of drainage control measures, consolidation of all contaminated materials onto the existing tailings pile, upgrading of haulage roads to the borrow sites, excavation of borrow materials, placement of cover materials onto the tailings pile and restoration of the area surrounding the tailings pile and borrow sites" (DOE 1986). Estimates of personnel requirements, energy and water consumption, volumes of materials, and costs for implementing the SIP alternative were also developed.

2.3.1.3 Alternate Disposal Site

A five-step process was used to locate and identify a suitable alternate disposal site: "(1) designation of a search region; (2) development of guidelines for eliminating unacceptable areas from the search region; (3) application of the guidelines; (4) evaluation and field reconnaissance of potential sites; and (5) selection of a single disposal site for comparison with the proposed action, stabilization in place" (DOE 1986).

A list of 22 screening guidelines was developed and was used to eliminate broad areas that might have required greater complexity in design or posed regulatory problems. Three candidate sites were identified in the screening step. These sites were then further evaluated on the basis of hydrologic, meteorologic, geologic, environmental, and economic data, as well as field reconnaissance. A preferred site was identified in Fivemile Wash, approximately 16 miles from the former processing site. The Fivemile Wash site was selected over the other two candidate sites primarily on the basis of groundwater conditions.

2.3.1.4 Tailings Reprocessing or Returning Tailings to Mine Sites

As noted in Section 2.3.1, reprocessing the tailings and returning tailings to the mines were also considered as alternatives. Both of these alternatives were rejected at the screening level.

Reprocessing tailings for the recovery of uranium, vanadium, and molybdenum was found to be technically feasible but at a cost that would exceed the value of the recovered metals. Further, reprocessing would not remove radium, and the tailings would still be a source of radon emissions, requiring construction of a disposal cell for the reprocessed tailings (DOE 1986).

Returning tailings to the mines from which the ore was originally obtained was found to be infeasible. The mine sites were scattered around Cameron, Arizona, and in the area of the Grand Canyon approximately 35 road miles and 85 road miles from the former processing site, respectively. At a screening level of evaluation "the excessive cost and many environmental concerns" (including increased worker and public exposure to radiation, potential for haul truck accidents and spilling radioactive material, increased air emissions from engine exhaust and windborne contaminants, larger area of disturbed land surface) "associated with stabilizing the tailings at the mines makes this option infeasible" (DOE 1986).

2.3.2 Assessment of Environmental Impacts

The assessment of environmental impacts of the alternatives (no action, stabilization in place, tailings relocation) covered the following areas.

- **Radiation:** health effects during remediation, hypothetical accidents, and health effects after remediation
- **Air quality:** wind erosion and emissions during remediation from heavy equipment exhaust
- **Soils:** disturbance and permanent loss of soils due to excavation of contaminated materials and borrow materials, roadwork, and construction of staging areas
- **Mineral resources:** use of soil and rock as borrow materials for cover construction, and potential impact on economic mineral reserves in the borrow areas
- **Surface water and groundwater:** water use during construction and impacts to water resources
- **Flora and fauna:** temporary and permanent losses of vegetation, wildlife habitat, and livestock grazing acreage
- **Land use:** final area of stabilized tailings in disposal cell, restoration of surrounding land area, reclamation of borrow areas, impacts on grazing, and occasional occupancy of nearby housing units
- **Noise:** operation of heavy equipment during remediation
- **Scenic, historic, and cultural resources:** viewshed, presence of cultural resources based on archaeological survey
- **Population and employment:** workforce for the duration of remediation, induced employment in the community, change in local population
- **Housing, social structure, and community services:** impact on local social structure, school system, and municipal utilities (water and sewer) resulting from non-local workers moving to Tuba City
- **Economic structure:** local wages and salaries to direct and indirect employees; local spending on materials, equipment, and supplies
- **Transportation networks:** affected roadways, incremental traffic increase due to workers commuting to the site, bringing in heavy equipment for site preparation, and hauling borrow material for cover construction.

- **Energy and water consumption:** vehicle fuel, water for human consumption and construction uses (cover compaction, equipment washdown, dust control)
- **Accidents not involving radiation:** construction-related accidents and highway traffic/commuting accidents
- **Mitigation measures:** site security, conducting operations only during normal work hours, maintaining close communication with the local population.

The proposed action (stabilization of tailings in place) was qualitatively compared with the alternate disposal site option and with the no action alternative using all of the criteria listed above. For virtually all criteria, the proposed action presented the least impact on human health and environment. Some of the findings supporting the proposed action include:

- A lower occurrence of excess health effects related to radiation exposure and air pollutants.
- Smaller area of surface disturbance.
- Mitigated effects of erosion through design of surface flow drainage/diversion channels and cell cover features.
- Reduced potential for infiltration of rainfall through tailings and into the subsurface, reaching groundwater, through cell cover design.
- No health risks related to groundwater contamination, because there were no withdrawals of groundwater downgradient from the tailings pile.
- Mitigated effects for future use of groundwater through institutional controls.
- A lower occurrence of construction and highway accidents.

Based on evaluation of all environmental criteria, the impacts of the proposed action (stabilization in place) were judged to be less significant in comparison with the impacts of no action or the alternate disposal site. A Finding of No Significant Impact was issued and the proposed action was implemented.

The assessment and decision-making process for disposal cell site selection described above is typical for all UMTRCA sites. The locations of disposal cells for the original 22 UMTRCA sites are described in the following section.

2.4 Disposal Location Selections for Title 1 Sites

At 10 of the original 22 inactive mill sites, risk evaluations led to decisions to perform onsite cleanup, with no need to relocate the tailings piles and other contaminated debris.

In cases where field investigations, modeling, and risk assessment indicated that tailings should not be relocated, the surface cleanup effort undertaken by DOE included the collection of tailings and contaminated debris to be covered in place, using disposal cells that were specifically designed and constructed to be effective for up to 1000 years, to the extent achievable, and in any case, for at least 200 years for containment of tailings and other mill-related materials, effectively isolating the waste from the natural environment (DOE 1989). In order for this requirement to be achieved, UMTRCA disposal cell covers are composed of multiple design components, each of which is intended to enhance key aspects of long-term performance. Cover components typically include a low-permeability radon barrier, frost protection barrier, bedding layer, and surface riprap to minimize potential for erosion. The specific combination and configuration of cover components is dependent on site-specific characteristics and performance requirements. Uncontrolled emission of radon gas is the component of tailings and other mill-related wastes that presents the most serious potential health hazard. Accordingly, each disposal cell contains a low-permeability radon barrier that is specially designed to maintain radon flux to less than 20 picoCuries per square meter per second (40 CFR 192). A typical disposal cell and cover cross section is shown in Figure 1 (DOE 2017b).

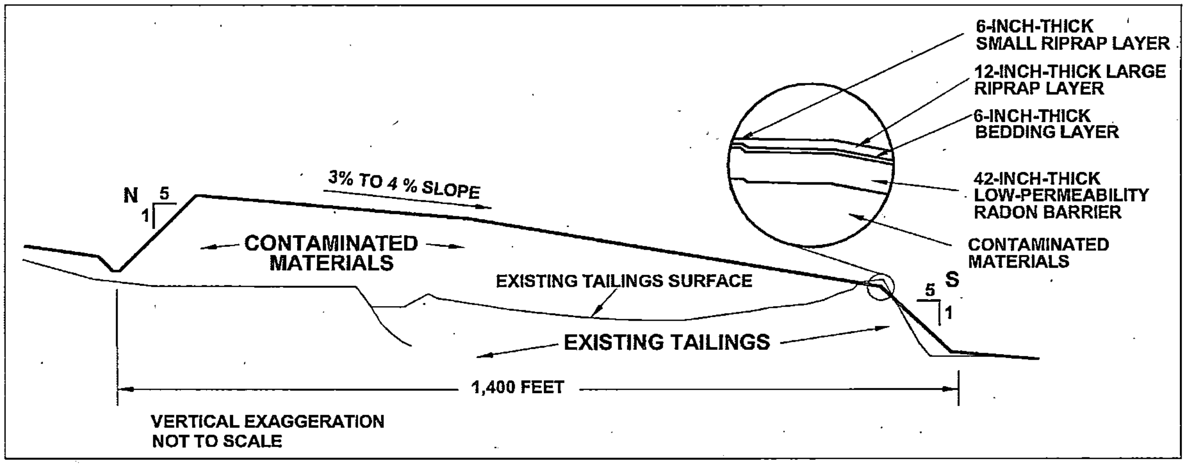

Figure 1. Cross-Section of a Disposal Cell and Cover Layers.

In addition to the 10 inactive mill sites where onsite cleanup was conducted, tailings piles left behind at 12 inactive mill sites were in locations that presented the potential for contaminants to be released and spread. These locations were close to rivers or in areas with shallow groundwater. DOE determined that the cleanup efforts at these sites would require the relocation of tailings (away from the former mill locations) to provide for the protection of human health and the environment. Surface cleanup for these sites involved moving the tailings and other mill-related waste followed by their placement in disposal cells offsite. In the 1980s and 1990s surface cleanup and construction of UMTRCA disposal cells were completed for all 22 of the inactive uranium mill sites originally identified in UMTRCA (DOE 2013). DOE's authority for surface remediation work under UMTRCA expired in 1998.

Table 1 provides an overview of the 22 original UMTRCA Title I sites. Final locations of disposal cells are noted, along with the proximity of the mill sites to surface water and residential areas and a brief summary of site groundwater conditions.

Some of the characteristics that are common to the 12 inactive mill sites where tailings were relocated are:

- Eleven of the 12 sites were close to rivers. The Monument Valley site is the one site from which tailings were removed that was not close to a river. Nine of the 12 sites were located close to residential areas. The Monument Valley and Slick Rock (East and West) sites are the three sites that were relatively remotely located. The proximity to surface water and residential population increased the potential for human health or environmental hazards through contaminant releases. This supported the decision to remove tailings and place them in an engineered disposal cell at a lower-risk, offsite location.
  - The Shiprock site is close to the San Juan River, but the tailings were left in place, contrary to the common strategy of moving piles that were left close to rivers. However, Shiprock is unique in that the mill site, though close to the river, is on an elevated terrace (50 feet above the floodplain) with a bedrock formation that isolates the tailings from the aquifer.

Eleven sites have persistent groundwater contamination despite tailings being removed. This indicates that contamination can be directly connected to the original placement of tailings piles and use of ponds for evaporation or storage of process solutions during the mill operations.

Table 1. Overview of the 22 Original UMTRCA Title I Sites

Site	Uranium Mill Operations	UMTRCA Surface Remediation Complete	Disposal Cell Distance from Original Mill Site	Original Mill Site		Original Mill Site Groundwater Condition
				Proximity to Surface Water	Proximity to Residential Areas	
Green River, UT (DOE 2016h)	1958–1961	1989	On original mill site	0.5 mile from the Green River	1.5 miles from the city of Green River	Two groundwater zones were impacted by past ore-processing activities. Contamination persists but does not pose present or potential future hazard to human health or the environment.
Mexican Hat, UT (DOE 2016m)	1957–1965	1995	On original mill site	1 mile from the San Juan River	1.5 miles from Mexican Hat, 0.5 miles from Halchita	Site-related contamination exists in the upper unit of the Halgaito Formation, but occurrence of groundwater is sporadic and ephemeral. The aquifer has not been contaminated by uranium-milling activities.
Maybell, CO (DOE 2016l)	1957–1964	1998	On original mill site	3 miles from the Yampa River	5 miles from Maybell	Uppermost aquifer has widespread contamination not related to mill processing activities and cannot be cleaned up using treatment methods reasonably employed in public water systems.
Shiprock, NM (DOE 2016r)	1954–1968	1986	On original mill site	0.1 mile from the San Juan River	In Shiprock	Past milling operations left contaminants in the terrace groundwater system and in the floodplain alluvial aquifer.
Ambrosia Lake, NM (DOE 2016c)	1958–1963, 1970s–1982	1995	On original mill site	No nearby surface water	25 miles from Grants	Uppermost aquifer is contaminated but is low yield (water available for sustained continuous use is less than 150 gallons per day).
Falls City, TX (DOE 2016f)	1961–1973	1994	On original mill site	5 miles from San Antonio River	8 miles from Falls City	Uppermost aquifer has widespread contamination not related to mill processing activities and cannot be cleaned up using treatment methods reasonably employed in public water systems.
Tuba City, AZ (DOE 2017b)	1956–1966	1990	On original mill site	1.5 miles from Moenkopi Wash (ephemeral flow)	6 miles from Tuba City	Water draining from unlined process and evaporation ponds infiltrated into the subsurface, contaminating the uppermost part of the Navajo aquifer.
Lowman, ID (DOE 2016k)	1955–1960	1994	On original mill site	0.1 mile from Clear Creek	0.5 mile from Lowman	Site groundwater is not contaminated, because there was no use of process-related chemicals.
Canonsburg, PA (DOE 2016d)	1911–1957	1985	On original mill site	0.1 mile from Chartiers Creek	In Canonsburg	Processing of radioactive materials since the early 1900s resulted in contamination of the uppermost aquifer.
Salt Lake City, UT (DOE 2016q)	1951–1968	1989	Moved 80 miles away	On the bank of Mill Creek, close to the Jordan River	4 miles from downtown Salt Lake City	Uppermost aquifer has widespread contamination not related to mill processing activities and cannot be cleaned up using treatment methods reasonably employed in public water systems.
Durango, CO (DOE 2016e)	1942–1946, 1949–1963	1996	Moved 3.5 miles away	On the bank of the Animas River	0.25 mile from Durango	Alluvial groundwater beneath the tailings area is contaminated as a result of constituents leaching from the tailings pile.
Grand Junction, CO (DOE 2016g)	1950–1966	1994	Moved 20 miles away	On the bank of the Colorado River	In Grand Junction	Past milling activities contaminated the groundwater in the alluvial aquifer. There is also widespread non-milling-related contamination that cannot be cleaned up using treatment methods reasonably employed in public water systems.
Old Rifle, CO (DOE 2016o)	1924–1932, 1942–1958	1996	Moved 10 miles away	On the bank of the Colorado River	0.3 mile from Rifle	Alluvial groundwater is contaminated as a result of constituents leaching from the tailings pile and raffinate ponds.
New Rifle, CO (DOE 2016o)	1958–1984	1996	Moved 10 miles away	On the bank of the Colorado River	2 miles from Rifle	Alluvial groundwater is contaminated as a result of constituents leaching from the tailings pile and raffinate ponds.
Gunnison, CO (DOE 2016i)	1958–1962	1995	Moved 6 miles away	1 mile from the Gunnison River and Tomichi Creek	0.5 mile from Gunnison	Past ore-processing operations and leachate from the tailings piles contaminated the shallow groundwater.
Naturita, CO (DOE 2016n)	1930s–1958	1997	Moved 15 miles away	On the bank of the San Miguel River	2 miles from Naturita	Pore fluids from the tailings pile leached into the underlying soil and contaminated the alluvial aquifer.
Slick Rock East, CO (DOE 2016s)	1931–early 1960s	1996	Moved 5 miles away	On the bank of the Dolores River	22 miles from the town of Dove Creek	Milling operations resulted in contamination of the alluvial aquifer.
Slick Rock West, CO (DOE 2016s)	1957–1961	1996	Moved 5 miles away	On the bank of the Dolores River	22 miles from the town of Dove Creek	Milling operations resulted in contamination of the alluvial aquifer.

Table 1. Overview of the 22 Original UMTRCA Title I Sites (continued)

Site	Uranium Mill Operations	UMTRCA Surface Remediation Complete	Disposal Cell Distance from Original Mill Site	Original Mill Site		Original Mill Site Groundwater Condition
				Proximity to Surface Water	Proximity to Residential Areas	
Riverton, WY (DOE 2016p)	1958–1963	1989	Moved 45 miles away	~1 mile from Little Wind River	2 miles from Riverton	Groundwater in the surficial aquifer was contaminated by ore-processing operations.
Converse County (Spook), WY (DOE 2016t)	1962–1965	1989	Moved to adjacent open mine pit	~3 miles from Willow Creek	32 miles from Glenrock	Milling-related contamination exists in the upper aquifer. There is also widespread contamination not related to mill processing activities that cannot be cleaned up using treatment methods reasonably employed in public water systems.
Lakeview, OR (DOE 2016j)	1958–1961	1995	Moved 7 miles away	~1 mile from Thomas Creek	1.5 miles from Lakeview	Contaminants from several sources (high salt content soils, geothermal springs, tailings leachate) are present in shallow groundwater.
Monument Valley, AZ (DOE 2017a)	1955–1968	1994	Moved 15 miles away	No nearby surface water	16.5 miles from Mexican Hat, 16 miles from Halchita	The alluvial and the De Chelly aquifers show evidence of milling-related contamination.

2.5 UMTRCA Groundwater Remediation

After the surface cleanup program was completed, DOE initiated cleanup strategies and methods to address mill-related groundwater contamination. When groundwater cleanup activities were initially planned (in the late 1990s), it was proposed that remediation efforts would continue through 2025 (Robinson 2004). The process of groundwater cleanup is much more difficult and different from disposing of tailings and mill-related material at the surface of inactive mill sites. Unlike mill wastes left on the ground surface, groundwater contamination cannot effectively be moved from one location to another. The following sections describe guidance and regulations governing groundwater remediation and present a specific example, the New Rifle, Colorado, Processing Site, to illustrate some aspects of a groundwater remediation strategy and implementation.

2.5.1 Groundwater Remediation Guidance and Regulations

Identifying an optimum groundwater cleanup strategy for a site requires a study of groundwater movement, geochemistry, geologic characteristics of the aquifer, the nature and extent of contamination, and knowledge of groundwater use in the vicinity of the site. However, once the site-specific characteristics are understood, compliance strategies defined in the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (DOE 1996) were used to guide the selection of an appropriate strategy for each site.

Site-specific groundwater compliance strategies as defined in the Programmatic Environmental Impact Statement for UMTRCA sites include:

- No remediation.
- Passive remediation (natural flushing with compliance monitoring and institutional controls).
- Active groundwater remediation.

The over-arching guidance in selecting the appropriate groundwater compliance strategy is "to achieve conditions that are protective of human health and the environment and that meet EPA ground water standards" through application of a risk-based framework (*Federal Register*, Volume 62, Number 81). EPA groundwater standards are defined in 40 CFR 192.04 (as amended 60 FR 2866, January 11, 1995) "Corrective Action, Table 1 to Subpart A – Maximum Concentrations of Constituents for Groundwater Protection". These standards are also known as the UMTRCA Maximum Concentration Limits (MCLs). A step-wise approach beginning with consideration of no remediation, and proceeding to passive and finally active remediation strategies is prescribed.

No remediation. "If a site risk assessment and Site Observational Work Plan indicate that the strategy of 'no remediation' would be protective of human health and the environment, a more complex and potentially environmentally disruptive strategy involving active cleanup methods would not be necessary" (FR, vol. 62, no. 81). The no remediation strategy also has the flexibility to allow interim actions such as providing alternate water sources, if necessary, to reduce risk or support institutional controls. No remediation also equates to the requirement under the National Environmental Policy Act to assess a no action alternative.

Passive remediation. The passive strategy typically involves reliance on natural flushing and natural geochemical processes to decrease contaminant concentrations. It is applicable for sites at which groundwater modeling predictions indicate that contaminant concentrations will reach regulatory standards through natural attenuation within 100 years. Passive remediation (natural flushing) may also involve determination of and compliance with alternate concentration limits (ACLs) during the remediation time period.

Active remediation. The active remediation strategy is intended to restore groundwater at former processing sites to background levels, or as close to background as possible "without regard to risk or cost of implementation" (FR, vol. 62, no. 81). This strategy is based on the assumption that groundwater at most processing sites was of better quality before uranium processing occurred and should be restored to its preprocessing quality. Active remediation to restore groundwater to background levels is generally not identified as the preferred alternative at UMTRCA sites, because restoration of background level water quality would only in rare cases be needed as part of a risk-based strategy for protection of human health and environment. The preferred remedy is typically identified in evaluation of the no remediation or passive remediation alternatives

In some cases, natural conditions or other factors may lead to consideration of supplemental standards or ACLs. In accordance with 40 CFR 192.11(e), supplemental standards may be applied at locations where groundwater is not a current or potential source of drinking water. The criteria defining this "limited use groundwater" include a total dissolved solids concentration in excess of 10,000 milligrams per liter; widespread ambient contamination not due to milling activities, which cannot be cleaned up using methods reasonably employed in public water systems; or low yield, defined as less than 150 gallons per day available for sustained continuous use.

In accordance with 40 CFR 192.02(c), ACLs may apply if, after considering remedial or corrective actions to achieve the regulation's MCLs, it is determined that the dissolved constituents will not pose a substantial present or potential hazard to human health and the environment as long as they remain below their ACLs. ACLs may be monitored at a point of compliance, as an indication that the contaminant concentration at a downstream point of exposure meets applicable standards (e.g., potable or agricultural water quality).

The ACLs for contaminant concentrations may be higher than the MCLs documented in 40 CFR 192.04. Supplemental standards or ACLs must be shown to be protective through controls to reduce exposure risks. The ultimate cleanup strategy employed at any site is tailored to recognize the unique circumstances of the site setting, the affected public, and the overarching goal for all cleanup actions under UMTRCA: protection of human health and the environment.

2.5.2 Persistence of Groundwater Contamination after Relocation of Tailings

The New Rifle site in western Colorado is an example of the long-lasting groundwater impacts resulting from mill operations despite the removal of tailings. The processing site was located on the bank of the Colorado River, 2 miles from downtown Rifle, Colorado, with commercial and residential development in the immediate surroundings. Tailings were removed from the processing site in 1996 and placed in a disposal cell, which was located about 10 miles from

Rifle. The surficial aquifer under the mill site was contaminated during the time of mill operations (DOE 2016b).

At the New Rifle site, DOE conducted studies from 1997 through 1999 to develop an understanding of groundwater contaminant fate and transport and to evaluate risks to human health and the environment related to groundwater contamination. It was determined that five contaminants of concern (COCs)—arsenic, molybdenum, nitrate, selenium, and uranium—could be remediated through natural flushing within 100 years. Another COC, vanadium, was present in dissolved form and as a residual sorbed to subsurface soils. DOE studies conducted from 2000 through 2002 revealed that the sorbed form was predicted to act as a continuing source of groundwater contamination, through gradual long-term release. Vanadium contamination would not be successfully remediated by natural flushing or through any reasonably implementable pump-and-treat alternatives. As a result, the currently proposed groundwater compliance strategy for this site is no remediation with application of ACLs for all six COCs. Mill-related contamination has persisted in the groundwater for decades after cessation of mill operation and despite the removal of tailings from the mill site. The application of ACLs with no further remediation includes long-term monitoring of groundwater quality at point-of-compliance wells. The ACLs for the site have been developed with reasonable exposure scenario assumptions and are protective of downgradient water quality at the point-of-exposure locations, where groundwater discharges to surface water in the Colorado River and in the East and West Roaring Fork Ponds (formerly used in gravel mining operations). (DOE 2016b).

3.0 UMTRCA Disposal Cell Relocation Evaluation Factors

As discussed above, disposal cell locations were originally chosen with the goal of reducing risk to human health and the environment as a primary consideration; thus, no UMTRCA disposal cells have ever been moved. Disposal cell covers, constructed under UMTRCA requirements, are designed to safely contain waste for up to 1000 years, to the extent achievable, and in any case, for at least 200 years (40 CFR 192.02(a)). Cells are designed to withstand a range of naturally occurring extreme events, including intense storms, floods, and earthquakes. Groundwater and surface conditions at disposal cell locations are routinely monitored to ensure that their protective features are working as designed.

The technical consideration of relocation of an UMTRCA disposal cell should be based on cell performance, including a determination that the cell is not functioning as designed and further, that the resulting site conditions present unacceptable risks to human health or the environment. A study (human health and ecological risk assessment) to confirm that unacceptable risks are present and that moving the cell would reduce this risk, would be the first step in the process. Unacceptable risks may include human exposure to airborne or water-borne contaminants, or contamination of land or water resources. Economic and social considerations should also be taken into account.

A comparative risk assessment study must be conducted when considering cell relocation, for example new risks that may be created in removing a disposal cell compared to risks of leaving the disposal cell in place. In general, the new risks would include the exposure of workers to occupational hazards including contamination, the potential for exposure of the surrounding community to contamination during relocation activity, and transportation accidents. Removing a cell cover would also expose the contaminated material to rainfall, potentially becoming an additional source of groundwater contamination via infiltration.

3.1 Environmental Considerations for Relocation of Mill Tailings

In addition to the risk study, environmental issues would also be considered in the decision to either relocate mill tailings or keep them in place. To illustrate the decision-making process, Table 2 and Table 3 present case studies related to two UMTRCA sites. These sites reveal the environmental issues associated with an onsite tailings pile with an interim cover placed as a short-term protective measure in comparison with mill tailings that have been encapsulated in a constructed disposal cell (DOE 2015a, 2015b, 2016a).

Table 2. Comparative Attributes of Uranium Mill Tailings for Two Sites

Attributes of Tailings	Site 1: Mill Tailings at Original Site Under Interim Cover	Site 2: Mill Tailings Contained in Onsite Disposal Cell
Source	Uranium milling 1956–1984	Uranium milling 1954–1968
Total volume	12 million cubic yards	1.8 million cubic yards
Height of pile/cell	100 feet	48 feet
Footprint area	130 acres	77 acres
Contaminants of concern	Ammonia, uranium	Ammonia, manganese, nitrate, selenium, strontium, sulfate, uranium
Local surroundings	The tailings pile is near a major highway and near local residents. The interim cover was not fully compliant with 40 CFR 192 requirements and presented some increased risk of public exposure.	The cell is near a major highway and local residents. The cell cover eliminates risk of public exposure.

Table 3. Comparative Environmental Settings for Two Sites

Environmental Setting	Site 1: Mill Tailings at Original Site Under Interim Cover	Site 2: Mill Tailings Contained in Onsite Disposal Cell
Nearby surface waters	The tailings are near the outer edge of a river bend. Gravel deposits near the tailings indicate that the main river channel has been considerably closer to the pile location in the past.	The cell is located on a terrace approximately 50 feet higher in elevation than the nearest river. Migration of the main river channel will not impact the cell.
Storm water	Storm-water runoff could erode the interim cover over time and carry contaminants away from the site.	Storm water has minimal impact due to the engineered cell cover.
Floodplain	Tailings are located at the same elevation as the river and within the floodplain for a 100-year storm event.	The cell is not in a floodplain.
Flood history	Floodwaters have had an impact, rising to a height of 4 feet above the toe of the tailings pile in a 1984 event.	Floodwaters have never reached the cell.
Flood projections	A probable maximum flood would submerse the tailings under 29 feet of water.	A probable maximum flood will have minimal impact on the cell.
Groundwater depth	Groundwater occurs at a depth of 20 feet and discharges into the river.	A bedrock formation isolates the cell from the underlying aquifer.

Table 3. Comparative Environmental Settings for Two Sites (continued)

Environmental Setting	Site 1: Mill Tailings at Original Site Under Interim Cover	Site 2: Mill Tailings Contained in Onsite Disposal Cell
Groundwater contamination	A groundwater contaminant plume underlies the tailings pile. Because the interim cover is not as robust as a 40 CFR 192 disposal cell cover, infiltration through the tailings could be an ongoing source of groundwater contamination.	A groundwater contaminant plume is present, but it is a remnant of past milling practices, not connected to the disposal cell.
Geology	The tailings are located above a salt dome, which is settling at an estimated rate of 2 feet per 1000 years. The tailings could be in direct contact with groundwater within 10,000 years.	The bedrock formation is stable and provides a thick barrier between the cell and groundwater.
Impact on use of river water	Existing recreational opportunities (boating, fishing) could be impacted if contamination related to tailings reached the river via storm runoff or flood. Groundwater discharge to the river is considered a risk to endangered fish species.	As noted above, flooding of the disposal cell location leading to impact at the river is extremely unlikely. The primary recreational use of the river is fishing. River water is also used for crop irrigation.
Threatened and Endangered Species	The river provides habitat for endangered fish species including the Colorado pikeminnow, razorback chub and humpback chub.	The riparian zone provides habitat for an endangered bird species, the southwest willow flycatcher. There are no endangered fish species in the river.
Nearest town, residences, businesses	A town with a population of about 5000 is immediately adjacent to the tailings site. Businesses are primarily tourism-related.	A town with a population of about 8000 is immediately adjacent to the disposal cell site. A variety of commercial and retail businesses and a residential neighborhood are nearby.

On the basis of the site conditions summarized above, the decision was made to move the Site 1 tailings pile to a more suitable location, where a containment cell will be constructed to provide long-term protection. In comparison, the attributes of the tailings and environmental setting at Site 2 reveal little risk to the environment and human health. At Site 2, relocating the disposal cell could actually increase the exposure risks to workers and the community, as opposed to leaving it in place. And in either case—moving mill tailings or constructing a disposal cell at the former mill site location—groundwater contamination related to milling remains at the locations where milling occurred. Site-specific studies are required to develop and implement an effective groundwater remediation strategy for the protection of human health and the environment at both sites.

3.2 Risk Factors Related to Disposal Cell Relocation

The decision-making process for relocation of a disposal cell would include, but not be limited to, consideration of:

- **Locating a new site.** As illustrated in the comparison of Site 1 and Site 2 above, there are many environmental and policy factors to consider in determining the suitability of a new location for long-term disposal of tailings. Even when suitable sites are identified, there will be public concerns and opposition to the proposed site location; in other words, "not in my backyard" responses, loss of resources, concern that exposure risk was moved but not reduced, and lengthy environmental policy determinations that may span the course of several years.

- **Environmental impact.** The environment, including plants, animals, and their habitats, may be impacted. Air and water quality may also be temporarily impacted by cell relocation at the removal site and the proposed new site. Environmental benefits realized at the former site of a disposal cell may not offset the environmental costs incurred at the new site.

  Relocation of a disposal cell would require preparation of an Environmental Impact Statement (EIS). The EIS essentially involves study of all of the risk factors described above, for a range of alternatives, and always includes a no-action alternative. In the case of disposal cell relocation, the EIS alternatives may include evaluation of multiple relocation sites or disposal cell design features. Public review and comment on a draft EIS is required before a final EIS can be issued. The EIS process would likely take place over a period of about 3 years.

- **Worker exposure to contaminants.** Demolition and decommissioning (D&D) would involve removing cover material, excavating tailings, and reclaiming the UMTRCA disposal cell site. These requirements would present increased risk of worker exposure to radon and other contaminants, which could lead to short- or long-term health problems. These risks could be largely mitigated through the use of protective measures to reduce exposure, but they would not be eliminated.

- **Worksite accidents and injuries.** In addition to the risk of exposure to radon and other contaminants, the normal occupational risks associated with construction work (falls, cuts, physical overexertion, worksite vehicle accidents, etc.) should be considered.

- **Public exposure.** Work would be performed with controls in place to minimize the potential for environmental releases. Protective controls may include temporary fencing around the site, dust control, surface-water runoff control, and a well-defined process to stop work when hazardous weather conditions such as high wind or heavy rain are imminent. Even with controls in place, disposal cell relocation fieldwork would present some increased risk of public exposure if the cell is located near a residential community, or risk of impact to natural resources the community uses, such as grazing lands. Exposure could lead to short- or long-term public health problems or degraded opportunity for land and water use.

- **Traffic and the potential for traffic-related accidents.** Relocating a disposal cell would involve a steady flow of large haul trucks carrying contaminated material on public highways and through communities over a time period of several years. Potential exposure risks and impacts may include increased occurrence of traffic accidents, injuries, and fatalities; overturned haul trucks, road damage, noise, or the spilling of contaminated materials such as tailings, soil, and materials.

- **Groundwater impacts.** Groundwater contamination exists at many of the former mill sites primarily due to the milling practices of the times (1950s and 1960s). Liners were not placed under tailings or process ponds, and contaminants infiltrated through the surface into groundwater until construction of disposal cells effectively restricted the contaminant movement. Although the contaminant source has been reduced or eliminated by surface cleanup efforts, the existing contaminated groundwater plume will remain after mill-related waste is moved to another location for disposal or after waste containment has been completed by the construction of a disposal cell at the former mill site. Protective measures to prevent exposure may still be needed at many sites.
- **Legal Liabilities.** Legal liabilities for DOE and/or contractors may arise in the event of an accidental release or spill of contamination as a result of activities related to the removal of tailings or cell. Furthermore, legal liabilities may arise for DOE and/or contractors for employees who may be injured or incur wrongful death as a result of activities related to the removal of tailings or cell.

3.3 Positive Impacts Related to Disposal Cell Relocation

In addition to the risk evaluation factors discussed above, positive impacts of relocating a cell would also be considered and may include:

- **Jobs.** Employment in construction trades would increase for several years. An increase in indirect employment such as that from support services and retail sales may occur within the community.
- **Infrastructure.** Road and bridge improvements may be needed to accommodate increased haul truck traffic. The improvements would remain after the cell relocation work is complete. Other community resources may also be upgraded as a result of economic growth.
- **Reclamation.** The land formerly occupied by the cell may be redeveloped for beneficial reuse. Even as an undeveloped open space, the land may become a community resource rather than a liability.
- **Environmental ethics.** Past mill operations and placement of milling wastes were careless by today's standards and have impacted local communities for 60-plus years. Removing the mill tailings may be perceived as a basic necessity of environmental stewardship and community restoration.

4.0 Decision-Making Authority

The U.S. Congress has the legislative authority to direct the removal of an UMTRCA disposal cell. DOE's authority to perform remedial action for surface contamination (tailings and other mill-related waste and debris) terminated in 1998 (Public Law 95-604 [UMTRCA], Section 112(a) Termination; Authorization). DOE's Office of Legacy Management (LM) has responsibility for long-term monitoring and surveillance of former mill sites and disposal cells. For some sites with groundwater contamination issues, LM is responsible for operation of active remediation systems (water-treatment plants). However, LM does not have the decision-making authority to relocate a disposal cell. Only by a legislative act of the U.S. Congress, reinstating DOE's authority to perform surface remediation, could a disposal cell be relocated.

5.0 The Future for Disposal Cells

LM is committed to the protection of human health and environment for sites in its area of responsibility. LM does not favor or oppose the relocation of disposal cells. Cleanup projects performed under UMTRCA at the 12 sites mentioned above have involved movement of tailings piles away from the original mill site locations to locations that present less risk. Through continual monitoring of environmental conditions at all LM sites over a period of more than 20 years, there has been no determination that moving an existing disposal cell would be warranted for technical reasons (i.e., the cell is not functioning as designed). LM will continue its mission to provide continued monitoring and surveillance to ensure that the public and the environment are protected from the hazards associated with mill tailings. When monitoring and surveillance reveal a need, LM will act within its authority to provide new or different protective measures at an UMTRCA site to protect human health and the environment.

6.0 References

40 CFR 192 (as amended Federal Register, Volume 60, January 11, 1995). "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*.

DOE (U.S. Department of Energy), 1986. *Environmental Assessment Remedial Action at the Tuba City Uranium Mill Tailings Site, Tuba City, Arizona,* DOE/EA-0317, November.

DOE (U.S. Department of Energy), 1989. *Technical Approach Document, Revision II,* UMTRA-DOE/AL 050425.0002, Uranium Mill Tailings Remedial Action Project, December.

DOE (U.S. Department of Energy), 1996. *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project*, DOE/EIS-0198, UMTRA Project Office, Albuquerque, New Mexico, October.

DOE (U.S. Department of Energy), 2013. *Uranium Mill Tailings Radiation Control Act Sites Fact Sheet*, Office of Legacy Management, July.

DOE (U.S. Department of Energy), 2015a. *Moab UMTRA Project Annual Site Environmental Report for Calendar Year 2014*, DOE-EM/GJ2181, Office of Environmental Management, September.

DOE (U.S. Department of Energy), 2015b. *UMTRCA Title I, Shiprock, New Mexico, Disposal Site Fact Sheet*, Office of Legacy Management, December.

DOE (U.S. Department of Energy), 2016a. *Overview of Moab UMTRA Project Fact Sheet*, Office of Environmental Management, May.

DOE (U.S. Department of Energy), 2016b. *Draft Groundwater Compliance Action Plan for the New Rifle, Colorado, Processing Site*, LMS/RFN/S01920, Office of Legacy Management, September.

DOE (U.S. Department of Energy), 2016c. *UMTRCA Title I Ambrosia Lake, New Mexico, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016d. *UMTRCA Title I Canonsburg, Pennsylvania, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016e. *UMTRCA Title I Durango, Colorado, Processing and Disposal Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016f. *UMTRCA Title I Falls City, Texas, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016g. *UMTRCA Title I Grand Junction, Colorado, Disposal and Processing Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016h. *UMTRCA Title I Green River, Utah, Disposal Site Fact Sheet.* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016i. *UMTRCA Title I Gunnison, Colorado, Processing and Disposal Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016j. *UMTRCA Title I Lakeview, Oregon, Processing/Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016k. *UMTRCA Title I Lowman, Idaho, Disposal Site Fact Sheet,* Office of Legacy Management. November.

DOE (U.S. Department of Energy), 2016l. *UMTRCA Title I Maybell, Colorado, Disposal Site Fact Sheet.* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016m. *UMTRCA Title I Mexican Hat, Utah, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016n. *UMTRCA Title I Naturita, Colorado, Processing and Disposal Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016o. *UMTRCA Title I Rifle, Colorado, Processing Sites and Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016p. *UMTRCA Title I Riverton, Wyoming, Processing Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016q. *UMTRCA Title I Salt Lake City, Utah, Processing and Disposal Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016r. *UMTRCA Title I Shiprock, New Mexico, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016s. *UMTRCA Title I Slick Rock, Colorado, Processing Sites and Disposal Sites Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2016t. *UMTRCA Title I Spook, Wyoming, Disposal Site Fact Sheet,* Office of Legacy Management, November.

DOE (U.S. Department of Energy), 2017a. *UMTRCA Title I Monument Valley, Arizona, Processing Site Fact Sheet,* Office of Legacy Management, January.

DOE (U.S. Department of Energy), 2017b. *UMTRCA Title I Tuba City, Arizona, Disposal Site Fact Sheet,* Office of Legacy Management, February.

NNEPA (Navajo Nation Environmental Protection Agency), 2015. Correspondence from Dr. Donald Benn, Executive Director, Navajo Nation Environmental Protection Agency to Richard Bush, UMTRCA Program Manager, U.S. Department of Energy, Office of Legacy Management, September 14.

Robinson, Paul, 2004. *Uranium Mill Tailings Remediation Performed by the US DOE: An Overview*, Southwest Research and Information Center, May.