U.S. Nuclear Regulatory Commission Staff's Comments on "Crescent Junction Disposal Site Alternative Final Cover System 90 Percent Design Report"

By letter dated April 6, 2022, the U.S. Department of Energy, Office of Environmental Management (DOE-EM) and Moab Uranium Mill Tailings Remedial Action Project submitted for the U.S. Nuclear Regulatory Commission (NRC) staff's review and comment, a report titled, "Crescent Junction Disposal Site Evapotranspiration Cover System 90 Percent Design Report," (Design Report) (NRC Agencywide Documents Access and Management System Accession No. ML22096A243). Consistent with the approach used in the review of the 2008 Remedial Action Plan (RAP) (ML080920459), the NRC staff's review process was informed by the "Final Standard Review Plan for Uranium Mill Tailings Radiation Control Act Title I Mill Tailings Remedial Action Plans" (ML110190562), and more recent applicable technical guidance in NUREG-1620, Revision 1, "Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act of 1978."

On November 2, 2021, the NRC staff provided feedback on DOE-EM's 60 percent design for the Crescent Junction cover system (ML21298A067). Staff reviewed the 90 percent design to understand how the design has changed in response to our comments. Staff's comments from the 60 percent design have not been repeated below, unless the comment pertains to an issue that remains relevant.

In its comments below, the NRC staff uses the terms "existing cover" and "proposed cover." The term "existing cover" refers to the rock cover approved in 2008 (and shown in Figure 1 of the Design Report). The term "proposed cover" refers to the evapotranspiration (ET) cover profile shown in Figure 5 of the Design Report. From top to bottom, the proposed cover consists of a 2-foot thick gravel/soil admixture, a 4-foot thick shale layer (which serves as the radon barrier), and a 1-foot thick interim cover layer on top of the residual radioactive material (RRM). Additionally, the staff understands that that DOE is not changing the angle of the side slope of the disposal cell, but is considering re-evaluating the minimum rock diameter and thickness to provide erosional stability. Staff appreciates that DOE is narrowing its design approach. The NRC staff continues to develop a better understanding of ET cover system design and performance. Our comments on the 90 percent design may focus on slightly different areas, as staff continues to gain knowledge and experience with ET covers.

Comments Related to Geotechnical Stability

1. In Section 6 and Appendix B of the Design Report, DOE discusses unsaturated modeling of the proposed cover. The Design Report describes the input parameters used in UNSAT-H and provides a summary of the output. The NRC staff appreciates the extent of the modeling that has been done to support the 60 percent design and understands the approach taken to design the proposed cover. ET covers rely on storage of water within the cover and removal of the water by evaporation and transpiration to limit percolation through the bottom of the cover. Conventional covers rely on a low permeability layer to limit percolation through the bottom of the cover. Because of these fundamentally different processes for management of water, the NRC staff offers the following comments for DOE's consideration.

a. The design of the cover system is based heavily on the moisture retention properties of the cover soils as well as the properties of the vegetation. The NRC staff's comments on the 60 percent design provided feedback on the relationship between the design calculations and the Technical Specifications. In addition to the particle size requirements that were in the 60 percent design, staff recognizes that DOE has modified the Technical Specifications to include agronomic testing to determine if organic material or other soil additives are needed to support vegetation. This change is helpful. It may be worth further discussion to better aid the NRC staff's understanding of the relationship between the design and the Technical Specifications.

2. As mentioned in the NRC staff's comments on the 60 percent design, settlement challenges have become apparent at several Title I and Title II disposal cells. This is potentially an issue at sites with relatively long and shallow top slopes. The settlement analysis approach used in Appendix D is reasonable as it considers the mixing of RRM that occurs prior to placement in the disposal cell. However, as currently presented, the settlement analysis is based on the conditions at one location. As a result, the analysis does not consider variability in the material properties that could become apparent over longer distances. The NRC staff recognizes that DOE-EM has significantly more control over the mixing of RRM and placement of RRM when compared to past practices at other Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I and Title II sites. This ability to mix materials may minimize variations in material properties and a corresponding decrease in the potential for differential settlement. The NRC staff is not asking for a new or additional analysis at this time, but it may be worth identifying a tolerable amount of differential settlement so that resources are appropriately focused for DOE-Office of Legacy Management (DOE-LM) during long-term surveillance.

3. Section 10 of the Design Report addresses slope stability. The current design has the same slope and material properties as what was evaluated in the 2008 RAP and accepted by the NRC staff. There is no expectation for an updated slope stability analysis at this time. This comment is included as a reminder or placeholder in the event that a change is made to the design that is different from what was considered in 2008 (i.e., thicker, heavier soils are used, or the cover system on the 5H:1V side slopes is modified), the slope stability analysis should be updated.

Comments Related to Surface Water Hydrology and Erosion Protection

1. The NRC staff reviewed the erosion calculations in Section 3 and Appendix F of the Design Report and appreciates the explanations and modifications that DOE has provided in the 90 percent design. The NRC staff is familiar with the methodology used to design the surface admixture. However, the NRC staff remains concerned about the erosion control aspects of the cover at Crescent Junction, particularly given the relatively thin amount of soil on top of the radon barrier. The staff understands that the design calls for a gravel/soil admixture at a 30 percent rock to 70 percent soil uniformly mixed through the 24-inch depth. The gravel/soil admixture will overlie the 48-inch-thick shale layer that will serve as the radon barrier. Staff remains concerned in the ability of the gravel/soil admixture to resist erosion without forming gullies or erosion rills. The design calls for the rock component of the admixture to have a D_{50} of 2.3-inches. Staff has not been able to identify an overall gradation of the gravel/soil matrix; the Design Report and Technical Specifications do not clearly articulate what the final grain size distribution will be for this component of the cover system. Further input on this topic is available in the

comments related to soil properties below. Without understanding the final grain size distribution of this layer, staff is concerned that it may be susceptible to erosion and the formation of gullies. This may represent a long-term maintenance issue for DOE-LM. Although not explicitly stated in the guidance document, NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization," was developed around the concept of rock-to-rock contact. With a gravel/soil matrix consisting of 30 percent gravel, the rock-to-rock contact will not be as prevalent as was envisioned in NUREG-1623. As a result, the design may be more susceptible to erosion. Guidance from the U.S. Army Corps of Engineers (USACE) in Engineering Manual 1110-2-1601, Hydraulic Design of Flood Control Channels (USACE, 1994) suggests that well graded riprap be used and identifies target values for the D_{85} to D_{15} ratio. Options to consider with the design to make it more resistant to erosion include: increasing the rock size in the gravel/soil matrix; concentrating the gravel in the upper portion of the admixture and filling in the voids with smaller diameter particles (similar to what was done at the Monticello, UT site); or utilizing a shallower slope on the top deck of the disposal cell. Staff recognizes the need to consider erosion resistance, the ability to support vegetation, and the ability to limit percolation can be counter to each other. Further discussion may be warranted to arrive at a design that satisfies each of those goals.

2. As discussed in our comments on the 60 percent Design Report, the potential for the presence of dispersive soils within the cover at Crescent Junction is not addressed in the submittal. The presence of dispersive soils may make it more challenging to meet the longevity requirements in Title 40 of the *Code of Federal Regulations* Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," and also represents a long-term maintenance concern for DOE-LM. This is an issue that needs to be resolved for the NRC to be able to concur on the revision to the design. A joint discussion between DOE-EM, DOE-LM, and NRC may be helpful in addressing this issue.

3. The NRC staff reviewed the drainage rock calculations in Appendix C of the Design Report. As presented in the 90 Percent Design Report, the NRC staff understands that the rock cover on the 20 percent (5H:1V) side slope is not being altered, but DOE plans to modify the rock contained in the drainage trenches at the base of the side slopes. Additionally, the NRC staff understands that DOE intends to resize the rock for the trenches at the base of the side slopes. The narrative discussion in Section 4 of the Design Report only discusses modifying the rock around the perimeter of the final cover system. If the intent is to modify the rock diameter on the side slope, please clearly communicate that intent in the next iteration of the design.

Comments Related to Radon Attenuation

The NRC staff has reviewed the radon attenuation aspects of the ET cover design, but has not updated its confirmatory analysis for radon attenuation at this time. Staff plans to update those calculations at the next iteration of the design. Staff will consider the long-term moisture content of the radon barrier as well as freeze-thaw impacts to the radon barrier at that time.

Comments Related to Biointrusion

1. Discuss the potential for biointrusion at the site by documenting the types of burrowing animals or insects that have been observed in the site vicinity or could potentially inhabit the site in the future. For instance, a burrowing example (assumed to be at the site), is shown on page 6 of Attachment 2 of the Post Construction Monitoring Plan report. This discussion should include information on deepest depths and volumes of burrows they might be expected to excavate, and maximum rock sizes that have been shown to deter such burrowing by these animals at other sites (if available). The impact of deep-rooted plants (i.e., invasive species or proposed ET cover species) over the service life of the cover should also be considered in this discussion; as shown in Table 1, several of the plant species proposed for the ET cover have maximum rooting depths that could damage the radon barrier and potentially exceed the depth to the tailings, which are located at a depth of ~7-feet.

Table 1. Proposed Seed Mix (from Section 2.01, Bullet E of the Technical Specifications) and Potential Maximum Rooting Depths.

Common Name	Maximum Rooting Depth
Tall Wheatgrass	2.46 ft (Nie et al., 2008) 4.33 ft (Nie et al., 2008)
Basin Wildrye	>6.56 ft (Reynolds and Fraley, 1989)
Russian Wildrye	6-8 ft (nrcs.usda.gov) 8-10 ft (fs.fed.gov) 4.26 ft (Table 5.4 of Hauser, 2009)
Alkaligrass	0.997 – 1.93 ft (mean rooting depth, umces.edu)
Inland Saltgrass	9.02 ft (Young, 2015)
Alkali Sacaton	1.33 ft (minimum, usda.gov)
Galleta Grass	0.98 ft (Peace et al., 2004)
Four-wing saltbush	39.37 ft (Stromberg, 2013) 6.66 ft (Lee and Laurenroth) 1.97 ft (Wallace et al., 1980) 12.86 ft (average; Foxx et al., 1985)

2. Based on the information regarding the potential for biointrusion at the site, as requested above, justify the removal of the biointrusion rock layer at a depth of 3.5-foot as shown in Figure 1 of Section 1, “Existing Final Cover System." Furthermore, discuss the protective measures (e.g., rock material, adequate soil thickness) that will be incorporated in the cover design to minimize cover degradation from the anticipated burrowing and root penetration. Section 11, “Biointrusion,” states that the “rock/soil admixture layer of 2.3-inch-diameter D_{50} rock, which composes 30 percent of the volume of this surface layer, will discourage burrowing of small mammals.” However, Albright et al., 2010, referencing Cline et al., 1981, note that prairie dogs and ground squirrels have burrowed more than 200 millimeters into crushed rock layers with a D_{50} of 60 millimeters or less. They further note that “larger rock would be needed to stop larger animals such as prairie dogs and badgers.”

3. Discuss the impact of a potentially degraded cover (i.e., resulting from biointrusion) on the performance of the cover including the including the impacts on the radon flux calculations provided in Section 5. “Radon Attenuation.” In addition to unearthing buried waste, burrowing animals and invertebrates can alter physical and hydraulic soil properties that influence erosion and the soil water balance of covers (Albright et al., 2010). Williams et al., (2022) observed that radon fluxes were higher in regions where woody vegetation or aggressive insects had established on select UMTRCA covers. They attributed these higher fluxes to soil structure induced by root activity and insect burrowing in the radon barrier, as well as higher radon diffusion coefficients associated with lower water saturation in areas influenced by root water update.

Comments Related to ET Cover Vegetation

1. Discuss the ecological basis (e.g., a reference or analog site) for the proposed ET cover seed mix that is shown in the table in Part 2, Section 2.01, Bullet E, of the Technical Specification Report. One of main objectives of cover revegetation is to create a soil environment that is similar to nearby undisturbed areas (i.e., reference areas or analog sites) and establish plant communities that are well adapted to that environment (Albright et al., 2010). The reference area or analog site can also be used to assess the revegetation success of the ET cover. As such, this discussion should include detailed information regarding the native vegetation and soils in nearby undisturbed areas.

2. Provide the following information related to the establishment of cover vegetation:

    a. The revegetation success criteria as well as the ecological basis for the selection of the revegetation criteria.

    b. The time frames for the revegetation target values.

    c. Details regarding how the proposed revegetation success criteria will compare to the reference area of analog site.

Comments Related to Soil Properties

1. Section 6, “Unsaturated Modeling of Cover System,” and Section B.1.2, “UNSAT-H Input Parameters,” state that the “input parameters utilized in the computer simulations for the ET cover were developed based on values reported in the Final Remedial Action Plan (FRAP), (DOE, 2008), various literature cited, laboratory analyses (Development Bank of Southern Africa ((DBSA), 2020), and experience.” This report should be provided to support the NRC’s review of the proposed ET cover soil properties (i.e., DBSA, 2020, Laboratory Report for Dwyer Engineering LLC, Project: Crescent Junction, performed by Daniel B Stephens & Assoc, September 9, 2020).

2. Section B.1.7, “Soil Properties,” states that because varied soil properties were reported in the FRAP (2008), the computer simulations attempted to bound the reported soils. This report is referred in several places in Appendix B. For example, Table B-3, “Soil Samples Hydraulic Properties,” refers to the FRAP, Attachment 5, Volume 1, Appendix K, Table 1). According to the FRAP, Volumes I and II of the Field and Laboratory Results are provided in Attachment 5 of the Draft RAP and were not submitted with the FRAP. This information should be provided for NRC to review in the context of the proposed ET cover.

3. Table B-3, "Soil Samples Hydraulic Properties" refers to alluvium and shales samples from the DOE report "Cover Performance Enhancement Tests at the Grand Junction, Colorado Disposal site: Construction Documentation Material Testing, and Instrument Calibration," report number LMS/GRJ/SO7112 dated February 2013. Since the hydraulic properties of these samples were used in the water balance modeling sensitivity analyses, this report should be provided for NRC staff to review.

4. As stated in the Section B.1.7, "Soil Properties," the computer simulations attempted to bound the reported soils due to their variability. Section 2.4 of the Technical Specifications states that: "cover soil to be used with this surface admixture layer shall be tested prior to placement for agronomic properties to determine whether nutrient and/or organic material amendment is required and to what extent." However, the target soil properties, the appropriate ranges, and the specific borrow source(s) for the ET cover soils should be clearly defined (i.e., in Section 6 and/or Appendix B as well as in the Technical Specifications). Sufficient volumes of available material should also be identified. The specified target properties should include the following: soil pH; organic content, $CaCO_3$ content; nitrogen, potassium, and phosphorous content; electrical conductivity; salt content; cation exchange capacity; clay content (and type); soil texture (U.S. Department of Agriculture (USDA)); particle size distributions and limits; porosity; Atterberg limits; bulk density; moisture content. A reference or analog site[1] may be used to help determine the target bulk densities and any necessary soil amendments for the borrow source (Waugh et al., 1994).

5. Justify the selection of an alluvial soil with 30 percent rock and a D_{50} of 2.3-inches for the entire layer thickness of the water storage layer, rather than just the upper portion (i.e., as a gravel mulch layer). Typically, loamy soils are recommended for ET covers and soils containing gravel and rock (i.e., particles larger than 2 mm) may be unsuitable for use in ET cover soil as they can reduce the water holding capacity and dilute the nutrient-supplying capacity of the soil (Hauser, 2009). ET cover guidance developed by the State of Colorado (Colorado Department of Public Health and Environment (CDPHE), 2013) recommends that the soil used for the cover contain less than or equal to 15 percent gravel (i.e., greater than 2 mm, retained on the No. 10 sieve) in addition to limiting the maximum particle size to less than 2-inches in the longest dimension. One of main objectives of cover revegetation is to create a soil environment that is similar to nearby undisturbed areas (reference areas or analog sites) and establish plant communities that are well adapted to that environment (Albright et al., 2010). As such, an appropriate reference area or analog site can also be used to assess the suitability of the proposed ET cover soils.

6. Provide the basis for the porosity values in listed in Table 4, "Radon Flux Calculations Summary," in Section 5, "Radon Attenuation," and discuss these values with respect to the saturated water contents provided in Table B-3. In Table 4, the porosity of the top layer (Admixture) is 0.27, while the porosity of Mancos Shale soil layer is 0.31. In Table B-3, "Soil Samples Hydraulic Properties," the saturated water contents listed for the top layer and radon barrier are higher than the porosities shown in Table 4. For example, the saturated water contents of the existing radon barrier samples 5 and 6 are 0.4171 and 0.4203, respectively, while the reported values for shale from TP154 and the Grand Junction site are 0.4803 and 0.38, respectively. The saturated water content of

[1] See comment 1 under Comments Related to ET Cover Vegetation.

alluvium samples range from 0.3584 to 0.42. The saturated water content should not be larger than the porosity since water can only fill the pore space. Furthermore, discuss how using higher porosity values would impact the calculated exit radon fluxes that are provided in Table 4.

7. Section 3.07 (C) of the Technical Specifications states that, for the surface admixture cover soil, the compacted soil density is to be 90 percent of the maximum dry density as determined by American Society for Testing and Materials (ASTM) D698 and that the tolerance for this placement density is plus or minus 5 pcf. However, CDPHE (2013) notes that "for most soil textures, the growth-limiting bulk density is in the range of about 83 to 88 percent of the maximum standard Proctor density (ASTM, D698)." Justification for specifying a compacted soil density at the upper end of the recommended range should be provided. Details regarding the placement specifications of this layer to prevent over-compaction should also be provided. For instance, CDPHE, 2013 and Interstate Technology Regulatory Council, 2003 recommend placing cover soil in relatively thick lifts (i.e., 18-inches to 2-foot) to control compaction along with the use of low-ground-pressure equipment during soil placement.

Comments Related to Water Balance Modeling

1. Provide a detailed discussion of the performance objectives of the ET cover. This discussion should specify the ET cover design percolation rate (i.e., <u>percolation from the base of the cover</u>), the basis for the selection of this rate, and how the ET cover will be monitored in the short-term to ensure that it performs as designed. The NRC staff recognizes Crescent Junction is a relatively dry site, but understanding the design percolation rate may help inform any monitoring needs.

2. Section B.1.7, "Soil Properties," notes that the computer simulations attempted to bound the reported soils and used "worst-case" soils. What are the implications of these "worst-case" soils on the vegetation success and how vegetation is modeled in the computer simulations? In other words, can credit be taken for the selected vegetation-related parameters as described in Sections B.1.5, "Vegetation Data" and B.1.6, "Soil Properties Related to Vegetation."

3. Section B.1.5, "Vegetation Data," states that measured vegetation parameters are not available for the Crescent Junction sites and that vegetation parameters utilized in the simulations are based on those obtained from the Northeast Church Rock, NM site (Cedar Creek, 2014). Although corrections are applied to account for the observed reduced vegetation surface coverage, justification for the reliance on the Northeast Church Rock site for vegetation parameters (including vegetation succession) should be provided since the Crescent Junction site is approximately 300 miles to the northwest of the Northeast Church Rock site. Supporting information should include a detailed comparison of the soils and native vegetation between the Church Rock Mill site and the Crescent Junction site. However, given that the distance between these two sites is substantial, vegetation parameters should ideally be obtained from a reference site that is similar to the Crescent Junction site and borrow source areas (or a similar nearby undisturbed area).

4. The potential impacts of climate change on the ET cover vegetation should be considered. For example, potential drought conditions on the performance of the ET cover, associated with a significant amount of vegetation dieback, and followed by extreme precipitation events.

5. Is the monthly distribution of precipitation, shown in Figure B-2 and Figure B-3 based on data?

National Environmental Policy Act

1. Staff appreciates understanding DOE-EM's approach to the National Environmental Policy Act (NEPA) with this revision to the RAP for Moab as it will inform the NRC's approach going forward. Staff has not made any decisions on how it plans to comply with NEPA for this action at this time.