Safety Evaluation Report
of
Homestake Mining Company of California
for the Large Tailings Pile Evapotranspiration Cover Design
License Amendment Request

December 2025

Materials License No. SUA-1471
Docket No. 040-08903

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1. INTRODUCTION

1.1 History and Site Status

Homestake Mining Company of California (HMC), a subsidiary of Barrick Gold Corporation, is the holder of U.S. Nuclear Regulatory Commission (NRC) License No. SUA-1471 for its former conventional uranium mill near Grants, New Mexico, known as the Grants Reclamation Project (GRP). HMC has been a licensee since the late 1950s. The GRP ceased active uranium recovery operations in 1990. The GRP is under U.S. Environmental Protection Agency (EPA) Superfund status and has a groundwater discharge permit from the State of New Mexico. Upon closure, the GRP will most likely be transferred to the U.S. Department of Energy (DOE) for long-term care and maintenance.

HMC has been performing decommissioning and reclamation activities at the GRP since 1995 in accordance with License Conditions 36 and 37. License Condition 37 requires performance of reclamation activities in accordance with the reclamation plan submitted by HMC on October 29, 1993 (HMC, 1993). The NRC staff reviewed and approved the reclamation plan in Amendment No. 22 to License No. SUA-1471 (NRC, 1995).

HMC constructed the final radon barrier and erosion protection layers on the side slopes of the large tailings pile (LTP) from early 1994 to August 1995 with measurement of the radon flux made for the north, south, and west sides in October 1994 and for the east side in August 1995 (ERG, 1996). For the top slope of the LTP, HMC placed an interim cover layer, but HMC had not placed the upper portions of the final cover system as of late 2023.

With respect to surface reclamation activities, activities remaining to be completed at the GRP include:

- construction of the radon barrier and erosion protection on top of the LTP
- decommissioning of existing evaporation ponds
- construction of the final cover system on the small tailings pile (STP)

HMC is also performing groundwater cleanup activities in accordance with License Condition 35. Resolution of these on-going activities will likely be the subject of a future licensing review.

1.2 Proposed Activities

In July 2023 (HMC, 2023c), HMC submitted a license amendment request (LAR) to the NRC to amend its GRP license by modifying the cover system on the top slope of the LTP from a resistive-type barrier to an evapotranspiration (ET) type cover, as shown in Figure 1 below (HMC, 2025b). The LAR included a design report addressing technical aspects of the proposal and an environmental report (ER) (HMC, 2023a and 2023b). HMC is not seeking to alter the cross section of the cover that has been installed on the side slopes since July 1995 (ERG, 1996). HMC's design change will maintain the slopes and grading plan outlined in HMC's October 1993 reclamation plan (WWL, 1993).

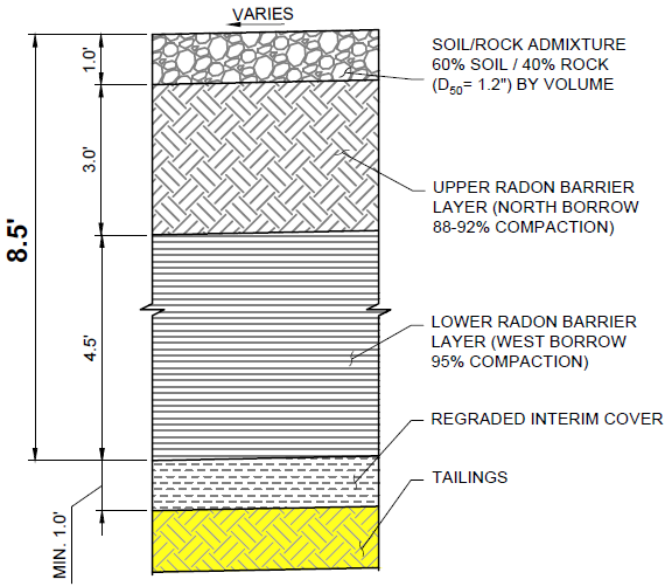

Figure 1: Proposed Final Cover System for the Top Slope of LTP (HMC, 2025b)

On October 18, 2023 (NRC, 2023), the NRC staff informed HMC that the LAR had been accepted for review and that the formal review process would begin. On April 25, 2024, the NRC published a request for additional information (RAI) document (NRC, 2024a). HMC responded to the environmental RAIs on July 12, 2024 (HMC, 2024a) and the safety RAIs on October 7, 2024 (HMC, 2024b). On June 3, 2025, HMC submitted a revised ET cover design report, including an updated design report and associated appendices and additional response to the RAIs (HMC, 2025b). This NRC safety evaluation report (SER) refers to the June 3, 2025 design report, RAI responses, July 2023 LAR to include the ER, and clarification submittals collectively as the LAR.

In the LAR, HMC proposes changes to three license conditions that would be impacted by the approval of its submittal. For License Condition 36A(3), HMC proposes to change the date to December 31, 2026, for the LTP (HMC, 2025c). For License Condition 36B(1), HMC proposes to change the date to December 31, 2026, for the LTP (HMC, 2025c). HMC also proposes updating the document referenced in License Condition 37A to refer to the submittal dated June 3, 2025.

1.3 Scope of Review

The Atomic Energy Act of 1954, as amended by the Uranium Mill Tailings Radiation Control Act of 1978, authorizes the NRC to issue licenses for the possession and use of source material and byproduct material. The NRC must license facilities in accordance with NRC regulatory requirements to protect public health and safety from radiological hazards. In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 40.44, "Amendment of licenses at request of licensee," the LAR shall specify the respects in which HMC requests the license to be amended and the grounds for such an amendment.

This SER documents the safety portion of the NRC staff's review of the LAR and includes an analysis to determine HMC's compliance with the applicable requirements in 10 CFR Part 40,

"Domestic Licensing of Source Material," including Appendix A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content." This SER also evaluates HMC's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection Against Radiation." The NRC is preparing an environmental assessment in parallel with this SER to address environmental impacts of the proposed action in accordance with 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," which contains the NRC's implementation regulations for the National Environmental Policy Act of 1969, as amended.

The NRC staff prepared this SER using the guidance in NUREG-1620, "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," Revision 1, issued June 2003 (SRP) (NRC, 2003).

HMC intends to modify the existing reclamation plan referenced in License Condition 37 to allow for construction of the ET cover on the top slope of the LTP, which will result in a changed condition from the previously approved 1995 reclamation plan. The proposed ET cover will use different materials in a different configuration than what is currently approved. The NRC staff focused its review on the aspects of the reclamation plan that would change, including an evaluation of settlement, erosion resistance of the ET cover, net infiltration/percolation of water through the cover system, and radon emanation. This SER also includes a brief discussion of the existing groundwater monitoring network and its ability to detect changes in the LTP.

In addition to the regulatory requirements, HMC's license contains several conditions related to construction of the final cover system on the LTP top. The NRC staff find that License Condition 37F has been satisfied and will be removed from the license. The NRC staff has reviewed settlement data collected by HMC since 1993. Section 3.2 of this SER documents the NRC staff's review and evaluation of these settlement data. As discussed in more detail in that section, the NRC staff agrees that 90 percent of the expected settlement has occurred and that placement of the radon barrier on the top slope of the LTP can proceed. As such, License Condition 37F has been satisfied and will be removed from the license.

In this SER, the NRC staff's review of HMC's LAR has identified a number of design aspects that require additional or modified license conditions to ensure the changes proposed in the reclamation plan would adequately protect public health and safety and meet applicable NRC requirements. Table 1 lists the added or modified license condition, as well as the section of the SER that identifies the regulatory need for the license condition.

Table 1: Conditions Added or Modified in License SUA-1471

License Condition Number	SER Section	Description of License Condition Addition or Modification
37A	1.3	37. The licensee shall reclaim the large and small tailings impoundments as stated in its October 29, 1993, submittal, including the following requirements. ~~A. The radon barrier for the large tailings pile shall be in accordance with material types, thicknesses and placement criteria described in Homestake Mining Company's *Final Radon Barrier Design for the Large Tailings Pile,* submitted June 16, 1995.~~ ~~A. The radon barrier for the large tailings pile shall be in accordance with material types, thicknesses and placement criteria described in Homestake Mining Company's *Final Radon Barrier Design for the Large Tailings Pile,* submitted June 16, 1995.~~ A. The radon barrier for the large tailings pile shall be in accordance with material types, thicknesses and placement criteria described in Homestake Mining Company's ~~*Final Radon Barrier Design for the Large Tailings Pile,* submitted June 16, 1995~~ *Design Report,* submitted June 3, 2025 (ML25163A319).
37F	3.2	~~The radon barrier shall not be placed on the top surface of the large tailings impoundment until the settlement has been demonstrated to be at least 90 percent of expected settlement, and the results of this determination have been reviewed and accepted by the NRC. The radon barrier may be placed on the large impoundment side slopes following final grading of the impoundment. Care shall be taken to preclude the possibility of ponding. Before the erosion protection is placed, it shall be verified that the radon barrier material meets the specifications.~~
36A(3)	3.4	A. To ensure timely compliance with target completion dates established in the Memorandum of Understanding with the Environmental Protection Agency (56 FR 55432, October 25, 1991), the licensee shall complete reclamation to control radon emissions as expeditiously as practicable, considering technological feasibility, in accordance with the following schedule: (1) Windblown tailings retrieval and placement on the pile For the Large Impoundment - December 31, 1996. For the Small Impoundment - May 31, 1997. (2) Placement of the interim cover to decrease the potential for tailings dispersal and erosion: For the Large Impoundment - December 31, 1996. For the Small Impoundment - May 31, 1997. (3) Placement of final radon barrier designed and constructed to limit radon emissions to an average flux of no more than 20 $pCi/m^2/s$.

		For the Large Impoundment which has no evaporation ponds - December 31, ~~2012~~2026.
36B(1)	3.4	B. Reclamation, to ensure required longevity of the covered tailings and ground-water protection, shall be completed as expeditiously as is reasonably achievable, in accordance with the following target dates for completion: (1) Placement of erosion protection as part of reclamation to comply with Criterion 6 of Appendix A of 10 CFR Part 40: For the Large Impoundment - ~~September 30, 2013~~December 31, 2026. For the Small Impoundment - December 31, 2013.
New 45	4.3	The licensee shall implement the monitoring plan in Section 11 of the approved LAR for a minimum of 5 years after construction of the ET cover system is complete with the placement of the erosion protection layer. As part of the monitoring plan for the top surface of the LTP, for a minimum of five years the licensee shall: A. Observe the top slope of the LTP for signs of localized settlement or ponding. B. Observe the top slope of the LTP for signs of erosion/damage such as rilling, gullying, and deformation of rock armor at the side slope tie-in transition. Rilling or gullying greater than 7 inches in depth from the as-built ground surface shall require additional evaluation to determine if maintenance or design modifications are required. C. Document the condition of vegetation on the ET cover in the Engineer of Record report submitted as part of the Annual Performance Report until the vegetation meets the success criteria set forth in Section 10.3 of the approved design report.
New 46	4.4	The licensee shall provide a copy of the contractor's mixing methods for the rock/soil admixture. Additionally, the licensee shall provide the results of the gradation analysis performed during the mixing trials. Both of these submittals shall be provided to the NRC for review at least 15 days prior to placement of the rock/soil admixture layer.
New 47	6.1	Once the lower radon barrier is in place, HMC will measure the radon flux using EPA Method 115. If the average radon flux does not meet the 20 pCi/m^2-s limit, as described in 10 CFR Part 40, Appendix A, Criterion 6(2), HMC will identify hot spots using appropriate measurement procedures and amend the lower radon barrier by adding additional cover until subsequent Method 115 measurements demonstrate compliance.

2. GEOLOGY AND SEISMOLOGY

As discussed in Section 1.3 of this SER, the NRC staff's review focuses on aspects of the reclamation plan that HMC has proposed to change. The location of the LTP will remain unchanged. The NRC staff previously reviewed and approved the subsurface characteristics of the LTP, such as the geology and seismology (NRC, 1995). Therefore, the NRC staff is not re-reviewing the topics addressed in SRP Chapter 1, "Geology and Seismology," in this SER, as those previous findings remain valid.

3. GEOTECHNICAL STABILITY

This section describes the NRC staff's review of geotechnical stability of the ET cover system in the LAR. HMC's LAR proposes changes to (1) site characteristics, (2) settlement, (3) cover design, (4) construction considerations, and (5) hydraulic conductivity. HMC has not proposed any changes to the slope angles or slope lengths. Therefore, the NRC staff did not re-review the slope stability calculations and liquefaction potential in this SER. For these two aspects of the LAR, as discussed in Section 1.1 of this SER, the NRC staff's previous review and the unchanged aspects of the previous reclamation plan remain valid (NRC, 1995).

3.1 Site and Uranium Mill Tailings Characteristics

The NRC staff evaluated the site characteristics and uranium mill tailings properties of the LTP and the borrow areas in the LAR. Unless specifically stated otherwise, the NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criteria 5(G)(2) and 6(1), using the acceptance criteria presented in SRP Section 2.1, "Site and Uranium Mill Tailings Characteristics."

The NRC staff reviewed the information related to the subsurface conditions described in HMC's settlement calculations in Sections 4, 5, and Appendices A, B, and E of the LAR. For the LTP coarse and fine tailings, HMC used data and material properties from the 1993 radon barrier evaluation (WWL, 1993). For the soils proposed for use in the ET cover system, the NRC staff reviewed Sections 3 and 4.1 and Appendices A and B of the LAR. HMC's site investigation activities included test pits and bulk sample collection from two borrow sources. The LAR incorporates data and insights from previous site and field investigations, including a total of 26 test pits in the West Borrow Area and 20 test pits in the North Borrow Area. Figure A1 in Appendix A in the LAR shows the locations HMC utilized in its field investigation for soils used in the construction, as well as the location of the historical field investigations. The more recent field investigations relied on test pits; previous investigations relied on a combination of soil borings and test pits. HMC obtained soil samples from a variety of locations and depths within the borrow pit areas. As a result, HMC has bounded the potential soil conditions present at the site. The NRC staff finds that HMC described the LTP stratigraphy and borrow areas in sufficient detail to provide an adequate understanding of the site.

As discussed in Section 4.1.2 of the LAR, HMC identified that potentially dispersive soils should not be used for construction of the ET cover system. HMC's laboratory testing program included an evaluation of the dispersivity characteristics of the borrow pit soils. HMC included the available results of dispersivity testing from the historical field investigations in 1986, 1987, and 1993. HMC's laboratory testing included crumb testing and double hydrometer testing. The NRC staff agrees that dispersive soils can be highly susceptible to erosion and lead to the formation of gullies and rills if they are used as part of a cover system. As Test Pit 38 identified potentially dispersive soils in that portion of the borrow area, HMC identified the location of soils that should be avoided during construction and this is acceptable to the NRC staff.

The NRC staff reviewed the laboratory test data presented in Appendix B of the LAR. HMC's laboratory testing program for the borrow areas included the following tests: crumb test, pinhole dispersion test, double hydrometer, particle size analysis with hydrometer, gravimetric water content, Atterberg limits, standard Proctor (compaction), hydraulic conductivity, and soil moisture retention curve. The NRC staff observed that the laboratory testing of the borrow areas followed the relevant ASTM International methodologies. The NRC staff observed that the cover system uses the material properties determined in Appendix B. For the LTP tailings, Appendix E

of the LAR presents the consolidation characteristics and density information used in the settlement analysis. The NRC staff verified the use of the appropriate soil properties for the corresponding soil types in the engineering analyses.

HMC's settlement calculations in Appendix E of the LAR are based on effective stresses within the soil layers. Although the NRC staff is not presenting a new finding on slope stability, the NRC staff has evaluated the settlement of the LTP in Section 3.2 of this SER. Based on the review, the NRC staff determined that groundwater levels have been appropriately incorporated into the settlement analysis.

HMC followed standard practices in obtaining soil samples and when performing laboratory tests on the samples. Therefore, HMC's laboratory and field testing which characterizes the engineering properties of the soils is acceptable to the NRC staff.

On the basis of the information presented in the LAR and the NRC's staff detailed review, the NRC staff concludes that the geotechnical characterization of the borrow areas is acceptable. Additionally, HMC has provided detailed information on the subsurface conditions gathered from field investigations. The information gathered and presented in the LAR formed the basis for the NRC staff's evaluation related to the period of performance in 10 CFR Part 40, Appendix A, Criterion 6(1). Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criteria 5(G)(2) and 6(1).

3.2 Settlement

The NRC staff evaluated settlement resulting from placement of the ET cover. The NRC staff reviewed HMC's LAR for compliance with the applicable requirements of 10 CFR Parts 20 and 40, Appendix A, Criterion 6(1) using the acceptance criteria presented in SRP Section 2.3, "Settlement," specifically Section 2.3.3.

HMC discussed its approach to addressing total and differential settlement in Section 7.3 and Appendix E of the LAR. HMC's discussion in Section 4.4 of the LAR summarized the settlement data that have been collected since fall 1993, with a focus on the settlement that has occurred since the tailings flushing program ceased in 2015. In Appendix E, HMC presented, in graphical form, calculations of the anticipated settlement and cover cracking related to construction of the ET cover system. HMC also presented settlement data collected since 1993 at six monitoring locations.

HMC's LAR described the plan to construct a cover system on the LTP. The existing tailings will remain in place and placement of the cover will result in new overburden stress that could result in further consolidation and accompanying settlement of the existing tailings. The NRC staff focused on the possibility of cracking within the existing radon barrier and differential settlement of the final slopes on the LTP top.

As discussed in Section 1.3 of this SER, in addition to documenting HMC's compliance with the regulations, the NRC staff evaluated License Condition 37F. The NRC staff reviewed the observed settlement to date. HMC presented its analysis of four settlement profiles in Section 3.1 of Appendix E of the LAR. HMC provided data for locations C-3, C-4, C-7, C-8, C-9, and X-1. HMC determined that cumulative settlement at these locations since 1993 has varied from approximately 3.5 feet to more than 11.7 feet. To determine whether 90 percent of consolidation has occurred, HMC plotted cumulative settlement versus the square root of time at five locations. These plots are included in Appendix E of the LAR. HMC's analysis shows that 90

percent of consolidation was reached between 4 years and 5.5 years after the start of settlement monitoring, or roughly in 2000. The NRC staff reviewed HMC's data and agreed with HMC's assessment. The NRC staff reviewed this additional settlement data in HMC's annual monitoring reports (HMC, 2025a) and identified a similar pattern. The NRC staff finds that the rate of settlement did not change once the tailings flushing program stopped in 2015. The NRC staff observed that settlement monitoring across the LTP top shows that 90 percent of the anticipated settlement has occurred. Therefore, License Condition 37F has been met and HMC can proceed with construction of the ET on the LTP. Additionally, License Condition 37F pertaining to demonstration of 90 percent of the anticipated settlement can be removed from HMC's license. This change is shown in Table 1 of this SER.

In considering the future settlement resulting from construction of the ET cover, HMC evaluated the immediate, primary, and secondary consolidation of the underlying tailings at four profiles in the middle of the LTP and near the crest of the LTP side slope. Based on its understanding of the tailings placement methods, the NRC staff understands that the center of the LTP is where the softer, fine-grained tailings are thickest. Near the side slopes of the LTP, the coarse-grained tailings become the thicker layer in the subsurface. Therefore, the NRC staff finds that HMC's focus on the differential settlement between these two areas of the LTP is appropriate. HMC has followed an approach that is similar to that described in the Naval Facilities Engineering Systems Command (NAVFAC) guidance referenced in the SRP.

In calculating primary and secondary consolidation, HMC's analysis considered the increase in overburden pressure resulting from placement of the ET cover on the LTP top. The NRC staff recognizes that no excavation of the tailings is planned. Additionally, the NRC staff understands that HMC does not plan to actively dewater the tailings. However, as discussed below, water levels in the LTP are expected to continue to decrease. HMC's analysis does consider water levels or pore pressure changes within the LTP. HMC performed a tailings flushing program within the LTP and this program ceased in 2015. Since that time, annual reports show that the water level within the tailings is decreasing. In its review of HMC's design calculations, the NRC staff considered changes in the water level within the tailings. In reviewing HMC's calculations, the NRC staff also analyzed the thickness of the cover system. Based on the NRC staff's review, the calculations are consistent with the cover system thickness shown in Figure 2 of the LAR. The thickness of the rock/soil admixture and upper and lower radon barriers in the calculations match the design drawings. The NRC staff observed that HMC's analysis is based on effective stresses, and as a result, changes in pore pressure are captured in the analysis. As both the change in stress resulting from the cover system construction stresses and the pore pressure changes discussed above were considered in the settlement analysis, the NRC staff determined that HMC's approach is acceptable.

The NRC staff reviewed the material properties and assumptions for the tailings layers and ET cover soils. The NRC staff finds that the material properties used in the settlement analysis are consistent with the known properties of the tailings. HMC used data from a 1993 report (WWL, 1993) for the coarse and fine tailings layers. For the cover system soils, HMC used the soil properties obtained during the field investigation and subsequent laboratory testing. In addition to reviewing the soil properties, the NRC staff evaluated the soil profiles to compare the thicknesses of the various soil layers considered in the analysis to the known subsurface conditions. The ET cover system will have a thickness of approximately 8.5 feet. For the profile within the LTP, HMC used layer thicknesses for the coarse and fine tailings layers that are consistent with the tailings placement methodology and this approach is acceptable to the NRC staff.

HMC's LAR addresses the installation of the final cover system on the LTP top slopes. This portion of the LTP is away from the perimeter embankment at the slope of the disposal cell. The LAR includes placement of any additional soils at the base of the disposal cell.

As discussed above, HMC's design does consider the pore pressures within the LTP in its settlement analysis. HMC's calculation appropriately considers the initial and current pore pressures within the tailings and is therefore acceptable to the NRC staff.

Appendix E of the LAR provides HMC's detailed settlement calculations. In its evaluation, HMC evaluated total settlement at four typical profiles at various locations on the LTP. In its calculation of primary and secondary settlement, HMC followed an approach similar to what is used in NAVFAC Design Manual 7.01. HMC included analyses of both static settlement and seismic settlement, should an earthquake occur. The NRC staff recognizes that HMC's approach considers both primary and secondary consolidation effects and is consistent with the guidance in the SRP and in NRC Regulatory Guide 3.11, Revision 3, "Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities," issued November 2008 (NRC, 2008). The NRC staff reviewed HMC's calculations and determined they were implemented correctly. Therefore, the NRC staff finds that HMC's evaluation is adequate for the purposes of calculating the settlement of the LTP resulting from placement of the cover system.

As presented in Table 4 of Appendix E of the LAR, HMC estimated that the total static settlement of the final surface of the ET cover would range from 1.19 feet to 2.31 feet. Should an earthquake occur with a peak ground acceleration of 0.32 g, HMC estimated that between 1.66 feet and 3.7 feet of settlement would occur, depending on the location on the LTP. This peak ground acceleration assumption is reasonable for the site. HMC estimated that slope reduction on the cover system would range from 0.18 percent to 0.23 percent under static settlement, depending on which soil profile is considered. As the LTP top slope is designed with a grade between 1 percent and 2 percent, HMC's calculations demonstrate that positive drainage will be maintained. The NRC staff reviewed HMC's detailed calculations and did not identify errors. Based on its review, the NRC staff determined that HMC used appropriate methods, evaluated settlement resulting from placement of the ET cover system, and presented the results. While HMC's design calculations are based on appropriate methods, there is uncertainty related to the material properties and loading conditions. To confirm that HMC's assumptions are valid and reflect performance in the field, the NRC staff will include a license condition requiring HMC to monitor the settlement of the ET cover, once construction is complete. HMC's assumptions can be found in Section 11 of the LAR. The NRC staff's license condition is located in Section 4.3 in this SER. The NRC staff's review and the license condition provide the basis for the reasonable assurance finding.

HMC presents an evaluation of cover cracking in Appendix E of the LAR. Construction of the cover system will result in increased overburden pressures on the existing LTP tailings. The NRC staff reviewed HMC's approach and calculations to address the potential for differential settlement and cracking of the radon barrier. HMC compared the settlement at five locations and assumed that no settlement would occur at the crest of the side slope. According to HMC, cracking of the ET cover is unlikely. The NRC staff reviewed the detailed calculations and did not identify any errors. Based on its review, the NRC staff finds that HMC used appropriate methods and calculations to evaluate differential settlement and cracking of the radon barrier.

HMC has acceptably evaluated settlement by presenting calculations based on material properties, thickness, and load increments that are representative of site conditions. HMC's

consideration of (1) increase in overburden pressure from addition of cover system soils, (2) excess pore pressure generated within the tailings, and (3) changes in groundwater levels within the tailings and the surrounding area is acceptable to the NRC staff. Methods used to calculate settlement are appropriate for the conditions present at the site. The results of the calculations have been properly documented. The settlement data provided information to assess the possibility of ponding water on the surface of the cover system or a gradient change resulting from settlement. As such, the NRC staff find that HMC presented an acceptable analysis for evaluating differential settlement and cracking of the cover system in the transition area between the existing cover and new cover atop the mine waste.

On the basis of the information provided in the LAR, the NRC staff's detailed review of anticipated settlement at the HMC site, and the license condition referenced above, the NRC staff concludes that the settlement data and calculations are acceptable. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 6(1).

3.3 Disposal Cell Cover Engineering Design

The NRC staff evaluated the engineering design of the ET cover. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Parts 20 and 40, Appendix A, Criteria 4(c) and 6(1) using the acceptance criteria presented in SRP Section 2.5, "Disposal Cell Cover Engineering Design," specifically in Section 2.5.3.

HMC presented the information on aspects of the design, investigation, and construction in Sections 3, 4, 5, 7, 8, 9, as well as Appendices G, H, and I. As shown in Figure 1 of this SER, HMC's proposed final cover system for the LTP top is an ET cover consisting of a rock/soil admixture (soil amended with rock with a D_{50} of approximately 1.2 inches present at 40 percent by volume). The rock/soil admixture is underlain by a 3-feet thick layer referred to as the upper radon barrier, which is intended to serve as a growth media layer. The lower radon barrier will have a thickness of 4.5 feet and lie beneath the growth media. The total remaining thickness of the final cover system to be installed is approximately 8.5 feet. Details 1 and 2 on Sheet C-8 show the cross section of the proposed final cover system and the tie-in with the existing cover system that was previously installed on the side slopes. As discussed in Section 3.1 of this SER, the NRC staff reviewed the borrow area characterization information. For the radon barrier, HMC plans to use soils identified as CL material (fine grained, low plasticity clay) under the Unified Soil Classification System. Use of this type of soil within the radon barrier is acceptable to the NRC staff. HMC considered potential biointrusion resulting from small animals in Section 6 and Appendix J.2 of the LAR.

As discussed in Section 3.1 of this SER, HMC's LAR discusses the borrow source investigation and laboratory results in Sections 4 and 5, as well as Appendices A and B. The NRC staff observed that HMC evaluated the index properties, compaction, gradation, permeability, dispersion potential, and information related to the soil water characteristic curve. HMC identified portions of the borrow areas that contain potentially dispersive soils and plans to avoid using soils from those areas. Based on a review of the detailed field and laboratory study, the NRC staff finds that HMC adequately characterized the borrow sources.

The engineering drawings in Appendix I show the existing conditions, proposed grading plan, a cut/fill diagram, LTP cross sections, and a detail of the ET cover cross section. Detail number 1 on Sheet C-8 shows the proposed ET cover and side slope rock cover tie-in. Detail 1 on Sheet C-8, as well as Figure 2 of the LAR show a uniform thickness of the ET cover. The total

thickness of the cover is 8.5 feet. The NRC staff observed that the ET cover system does contain a low permeability layer, referred to as the lower radon barrier in HMC's design, that is designed to limit radon flux from underlying tailings. The NRC staff observed that HMC's design does not include a bedding layer and this approach is acceptable to the NRC staff, given that the erosion protection layer will consist of a rock/soil admixture at a ratio of 40 percent rock to 60 percent soil, measured by volume. The NRC staff reviewed the design drawings and determined that the thickness of the layers comprising the cover system is clearly identified and this is acceptable to the NRC staff.

HMC plans to construct a 4.5 feet thick lower radon barrier on top of the existing tailings. As shown on Figure 2 and Detail 2 on Sheet C-8 in the LAR, HMC's design includes a total soil depth of 4 feet above the radon barrier. In Appendix J.2 of the LAR, HMC discussed assumptions related to density of the radon barrier as a result of freeze/thaw effects. HMC accounted for changes in hydraulic conductivity in the upper radon barrier layer. The NRC staff agrees with HMC's statement that the frost penetration depth in the Grants area is approximately 20 inches. The NRC staff observed that the lower radon barrier is located beneath the frost penetration depth and this is acceptable to the NRC staff. Section 6.1 of this SER presents the NRC staff's evaluation of radon flux from the ET cover.

HMC plans to extend several piezometers and settlement monuments through the cover system. Piezometers are used to measure water levels within and settlement of the LTP. Detail 3 on Sheet C-8 of the engineering drawings shows how HMC plans to complete these extensions. HMC's design calls for additional compaction around the extensions to preserve the function of the radon barrier. The NRC staff observed that HMC's design provides an adequate level of detail for penetrations through the radon barrier and this is acceptable to the NRC staff.

The NRC staff reviewed the information on the proposed cover system, including characterization of the borrow areas, as well as consideration of the ET cover's impact on settlement of the LTP. The NRC staff observed that the information used in various aspects of the design was consistent, reflected the known site conditions, and was correctly incorporated into the design calculations.

On the basis of the information presented in the LAR and the NRC staff's detailed review, the NRC staff concludes that HMC has acceptably described the cover system, including the soil and rock types needed for the cover, identified borrow sources, and considered soil quantities. HMC provided detailed cross sections showing the thickness of the different layers planned for the cover and details for how the top slope would tie into the previously constructed side slope. Additionally, HMC described the field samples and laboratory tests that were used to determine material properties for the borrow areas. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criteria 4(c) and 6(1).

3.4 Construction Considerations

The NRC staff evaluated the construction considerations of the ET cover design. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criteria 4(c), 4(d), 6(1), and 6A(1) using the acceptance criteria presented in SRP Section 2.6, "Construction Considerations."

HMC presented the information related to the cover system construction in Sections 8 and 9 and Appendices G, H, and I of the LAR. HMC included a set of 10 construction drawings in

Appendix I of the LAR. The construction drawings show the site location, the overall site layout, the existing conditions of the LTP, a demolition plan for existing features on the LTP top that will be removed, a grading plan showing the elevation of the interim cover on the LTP, a grading plan showing the final slopes and elevation of the ET cover on the LTP top, cross sections through the LTP, details of the ET cover, and development plans for the borrow areas. The NRC staff was able to discern the location and key features of the proposed design, such as how the proposed cover system will meet the existing LTP side slope cover, the extent of the cover system, the thickness of the various layers in the cover system, and erosion protection aspects of the design, and this approach is acceptable to the NRC staff.

As discussed in Section 3.1 of this SER, the HMC identified two borrow sources to use for construction of the ET cover system. Section 3.1 of this SER contains the NRC staff's review of HMC's field investigation and laboratory testing. With respect to soil quantities, Table 7 of the LAR identifies an estimate of soil needed for the different layers of the cover. The NRC staff performed an independent check of the volume of soils needed to construct the cover and arrived at similar quantities. The NRC staff recognizes that HMC has evaluated background levels of contamination in the borrow soils, along with index properties, compaction, gradation, and strength parameters. As HMC has identified sufficient quantities of material and demonstrated their adequacy, HMC's evaluation is acceptable to the NRC staff.

In Appendix H of the LAR, HMC included a set of technical specifications that contain detailed requirements for how the cover would be constructed. The NRC staff observed that the specifications contain information on the methods, procedures, and requirements for excavating from the borrow areas and placing the various layers of the cover system. The NRC staff observed that the specifications include requirements for mixing rock and soil within the erosion protection layer, material placement and compaction, target moisture contents, and the tie-in between the existing rock cover on the side slopes and the cover. The NRC staff notes that the technical specifications limit construction activities during adverse weather conditions. In its review of erosion protection aspects of the design, the NRC staff identified an observation related to placement of the rock/soil admixture at the desired 40 percent rock to 60 percent soil (by volume) ratio. The NRC staff has included a license condition related to this aspect in Section 4 of this SER, as explained below. Because they contain information on methods and procedures, the NRC staff observed that the specifications are consistent with those commonly used in engineering practice for earthworks projects and this is acceptable to the NRC staff. HMC's plans in the LAR do not include construction of a new embankment.

As discussed above and in Section 3.1 of this SER, HMC has performed compaction testing on the soil samples obtained from the borrow areas to understand the moisture-density relationship and this approach is acceptable to the NRC staff.

HMC provided a set of technical specifications for the cover system construction in Appendix H of the LAR. HMC's design included use of a rock/soil admixture as the uppermost layer of the cover. This layer, referred to as the erosion protection layer, is mixed at a ratio of 40 percent rock to 60 percent soil (by volume). The NRC staff observed that the specifications identify the gradation requirements for the rock and soil components of the admixture and contain requirements for both placement and compaction of the erosion protection layer and frequencies for quality control testing. The NRC staff determines that the technical specifications are consistent with generally accepted engineering practice. The technical specifications which contain information on methods and procedures and quality control testing related to the erosion protection layer are acceptable to the NRC staff. While HMC's specifications and quality control testing requirements are reasonable, the construction techniques to achieve the desired rock to

soil ratio are not described in the LAR. The construction techniques will be determined by HMC's contractor prior to construction. As discussed in more detail in Sections 4.3 and 4.4 of this SER, the NRC staff is aware of the need to maintain the desired rock to soil ratio during construction. To facilitate the NRC staff's understanding of the contractor's chosen construction techniques, the NRC staff is including a license condition requiring submittal of the contractor's plan for achieving the desired ratio in the rock/soil admixture. This condition is discussed in more detail in Sections 4.3 and 4.4 of this SER.

In Section 5 of the LAR, HMC discussed plans for sequencing construction activities related to the cover system. These activities include demolition of features currently on the LTP top, regarding the existing LTP surface, development of the borrow areas, and placement and compaction of the cover system layers. In a previous license amendment review, the NRC staff established target milestones for placement of the LTP radon barrier and erosion protection layers. These milestones are identified in License Conditions 36A(3) (December 31, 2012) and 36B(1) (September 30, 2013), respectively. In its cover letter that accompanied the LAR, HMC proposed revising these dates to December 31, 2024, and December 31, 2025, respectively. HMC revised these dates to December 31, 2026 (HMC, 2025c). The NRC staff considered these proposed dates and observed that the construction schedule provides for a sufficient amount of time to perform the required construction activities. Based on its review of the construction sequencing in Section 5 and the proposed completion dates, the NRC staff determines that HMC has developed a reasonable schedule for the project.

Sections 4.3 and 4.4 of this SER discuss the erosion protection aspects of the proposed cover. The NRC staff determined that the erosion protection aspects of the ET cover design are consistent with the applicable regulations.

In reviewing Appendix G of the LAR, the NRC staff observed that HMC identified roles and responsibilities for construction quality assurance and construction quality control. The Construction Quality Management Plan addresses observation activities, sampling requirements, testing methodologies, documentation of construction activities, as well as corrective measures. The NRC staff observed that HMC will perform daily recordkeeping of activities at the site, including generation of daily construction reports documenting specific activities, unresolved items, and non-conformance issues that need to be addressed. Additionally, the Construction Quality Management Plan includes preparation of a Construction Completion Report once construction is complete. The NRC staff reviewed the information in the technical specifications in Appendix H of the LAR and observed that they include material properties to be evaluated, acceptable ranges of engineering properties, and minimum testing frequencies, as well as testing procedures. HMC's Construction Quality Management Plan includes following standardized testing procedures developed by ASTM International. Based on its review of the information in Appendices G and H of the LAR, the NRC staff determined that HMC's approach to construction quality control and documentation is consistent with engineering practice, as it contains information on testing requirements, minimum testing frequencies, and documentation, and maintains clear roles and responsibilities to verify that construction activities are consistent with the design, and is acceptable to the NRC staff.

On the basis of the information presented in the LAR and the NRC staff's detailed review of the construction considerations, the NRC staff concludes that the information related to construction considerations in the LAR is acceptable. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criteria 4(c), 4(d), 6(1) and 6A(1).

3.5 Infiltration and Hydraulic Conductivity of the Repository and Its Cover

Section 5 of this SER contains the NRC staff's review of information related to the hydraulic conductivity of the ET cover and infiltration through the cover.

4. SURFACE WATER HYDROLOGY AND EROSION PROTECTION

This section describes the NRC staff's review of erosion protection related to long-term site stability of the ET cover design in the LAR. HMC's LAR proposes a change to the cross section of the ET cover. HMC has not proposed any changes to (1) the side slopes of the LTP, (2) the surface water management channels, or (3) diversion features located around the tailings impoundment. As discussed in Section 1.3 of this SER, the NRC staff focused its review on aspects of the LAR for which HMC has proposed a change. For surface water hydrology and erosion protection, HMC's changes are limited to the ET cover design. As discussed in Section 1.1 of this SER, the NRC staff's previous review and the unchanged aspects of the previous reclamation plan remain valid.

The design basis event for the erosion protection cover includes the probable maximum precipitation (PMP), which the NRC staff considers in NUREG-1623, "Design of Erosion Protection for Long Term Stabilization: Final Report," issued September 2002 (NRC, 2002) to have very low exceedance probabilities during the 1,000-year performance period.

4.1 Hydrologic Description of Site

The NRC staff evaluated the hydrologic description of the site. While the guidance in the SRP also focuses on flooding potential, the location of HMC's proposed changes to the ET cover on the LTP top make flooding unlikely. Therefore, the NRC staff focused its review on the hydrologic description and runoff potential from the LTP top, in light of previous reviews and approvals. Because the NRC staff's review focused on the changes proposed in the LAR, the NRC staff is not reevaluating the conditions of the areas surrounding the LTP. The design for that portion of the site will remain as currently outlined under the existing reclamation plan (HMC, 1995). The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR 40, Appendix A using the acceptance criteria presented in SRP Section 3.1.3, "Surface Water Hydrology and Erosion Protection."

The NRC staff reviewed information, data, and maps submitted by HMC in Sections 4.5, Appendix F (Erosion Protection) and Appendix I (Construction Drawings) of the LAR. The STP and the LTP are the main surface features that will remain at the site after decommissioning and reclamation activities are completed. The LTP, which is the focus of HMC's LAR, covers approximately 170 acres and is between 85 and 100 feet higher than the surrounding ground surface. The top surface of the LTP will have a maximum elevation of approximately 6,680 feet above mean sea level. As shown on drawing C-6 in Appendix I, HMC's proposed grading plan calls for a high point near the middle of the LTP. The LTP top will be graded so it sheds water to the existing rock covered side slopes in a controlled manner.

The NRC staff determined that HMC's LAR represents a sufficiently complete design that allows for an independent evaluation. HMC's narrative description of the design in Section 4 of the LAR, the detailed calculations in Appendix F, as well as the construction drawings in Appendix I contain sufficient information and detail for both existing and post-construction conditions to allow for the NRC staff's review.

On the basis of the information presented in the LAR and the NRC's staff detailed review of the hydrologic description of the LTP, the NRC staff concludes that (1) the flood analyses and investigations adequately characterize the flood potential at the site, (2) the analyses of hydraulic designs are appropriately documented, and (3) the LAR with respect to surface water hydrology and erosion considerations, represents a feasible plan that is acceptable. Therefore,

the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A.

4.2 Flooding Determinations

The NRC staff evaluated erosion protection aspects of HMC's proposed ET cover system for the LTP, including HMC's selection of the design storm, infiltration losses, runoff potential, and peak flow estimates resulting from the PMP. HMC used the Hydrologic Modeling System (HEC-HMS, 2000), version 4.2.1, published in 2017 by the Hydrologic Engineering Center of the United States Army Corps of Engineers, to simulate various peak flood discharges and hydrologic conditions at the locations of interest within the sites. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A using the acceptance criteria presented in SRP Section 3.2.3, "Flooding Determinations." The NRC staff reviewed information, data, and drawings in Section 4, Appendix F, and Appendix I of the LAR.

Design Rainfall Event

As discussed in Section 4.5.1 of the LAR, HMC used an updated PMP event in its erosion protection design. The World Meteorological Organization defines the PMP as "the greatest depth of precipitation for a given duration meteorologically possible for a design watershed or a given storm area at a particular time of year" (WMO, 2009). The PMP is the theoretical upper bound of rainfall depth that could occur under a series of adverse hydrometeorological conditions. The NRC staff considered the HMC's use of the PMP to be an acceptable design basis for long-term site stability as it is consistent with the recommended approach in NUREG-1623 and the review procedures in Section 3.2.2 of the SRP.

In the LAR, HMC based its design around using a 2-hour PMP from a local storm event. To estimate the PMP, HMC used the Applied Weather Associates (AWA) Colorado – New Mexico Regional Extreme Precipitation Study (AWA, 2018). This PMP value is intended to represent the theoretical maximum precipitation that could occur over the LTP top for a 2-hour duration. In using the AWA tool, HMC calculated a 2-hour PMP value of 8.8 inches, and a peak intensity of 14.4 inches per hour.

The NRC staff used the AWA study and the related web-based PMP Evaluation Tool to confirm HMC's precipitation estimates for the LTP top. The NRC staff created its own shapefile of the drainage basin and imported it into the web-based tool. In using the PMP evaluation tool, the NRC staff arrived at similar values for the PMP as HMC presented in its LAR. HMC's approach, based on the PMP, is acceptable to the NRC staff, and HMC's methodology for determining the PMP value to use in the design is adequate.

Infiltration Losses

Infiltration losses can result from surface retention (the presence of small depressions on the surface), evaporation, or transpiration from vegetation. HMC used the rational method (Chow, 1959) to estimate the amount of runoff resulting from the PMP event. In Appendix F of the LAR, HMC used a runoff coefficient of 0.8. The NRC staff reviewed HMC's approach and observed that using this value assumes that most of the precipitation that falls will turn into runoff. With the combination of rock and soil present in the uppermost layer of the cover, HMC's approach is acceptable to the NRC staff.

Time of Concentration

In general, the time of concentration is the amount of time required for runoff to reach the outlet of a drainage basin from the most remote point in that basin. HMC used the Kirpich method in estimating the time of concentration for the top slope of the LTP. NUREG-1623 identifies the Kirpich method as an acceptable method to meet applicable requirements. It is based on the length of the drainage path, as well as the elevation difference between the start and end of the drainage path. As shown on Figure 1 of the Appendix F in the LAR, HMC evaluated four distinct drainage paths, one drainage path for each sub catchment area on the LTP top. HMC's calculations estimated that the time of concentration for the top slope of the LTP would range from approximately 4.4 minutes (on the south facing top slope of the LTP) to 8.4 minutes (on the west facing top slope of the LTP).

The NRC staff reviewed HMC's use of the Kirpich method and finds that the assumptions used in the LAR are consistent with the planned final slopes of the LTP. The NRC staff performed an independent calculation to confirm HMC's implementation of the Kirpich method and arrived at the same results. The Kirpich method is acceptable to the NRC staff and HMC's parameters are adequate to describe the time of concentration for the top slope of the LTP.

Rainfall Intensity

In Appendix F of the LAR, HMC used a consistent rainfall intensity of 14.4 inches per hour for each of the four drainage paths it evaluated in its design. As discussed above in the "Design Rainfall Event" section of this SER, HMC used the AWA study to determine the rainfall intensity. This approach is acceptable to the NRC staff.

Computation of Runoff Quantities

HMC used the Rational Method to calculate the quantity of runoff. This calculation is based on the rainfall intensity, drainage area, and runoff coefficient. The NRC staff's review of rainfall intensity and runoff coefficient is discussed above. For the drainage area, HMC assumed that a gully has formed. In HMC's analysis, the drainage area contributing flow to the gully is equal to the slope length (L) in one direction and equal to 25 percent of the slope length in the other direction. The contributing flow area is equal to $\frac{1}{4}L^2$. Given the slope lengths on the LTP top, HMC's assumption around gully formation and contributing area is acceptable to the NRC staff as it represents a conservative assumption. HMC evaluated the runoff quantity for individual segments along each flow path; the results are shown in the LAR Appendix F, Table 3, in the column titled "Q (cfs)." The NRC staff reviewed HMC's calculations and determined they were implemented correctly. HMC's approach for computing runoff quantities is acceptable to the NRC staff.

On the basis of the information presented in the LAR and the NRC staff's detailed review of the runoff potential for the LTP top slope, the NRC staff concludes that the analyses adequately characterize the runoff potential at the site and that surface water hydrology considerations represent a feasible plan for meeting the relevant requirements of 10 CFR Part 40, Appendix A. Analyses by HMC demonstrate that this erosion protection is adequate based on (1) selection of the proper rainfall event; (2) selection of appropriate parameters for determining runoff; and (3) computation of runoff from the top slope of the LTP, using appropriate and/or conservative methods. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 6(1).

4.3 Water Surface Profiles, Channel Velocities, and Shear Stresses

After estimating the peak discharges for the four drainage paths using the Rational Method, HMC evaluated the conditions for water flowing over the ET cover on the top slope of the LTP. HMC's design does not call for any purpose-built channels on the top slope of the LTP but it does anticipate the formation of gullies within the rock/soil admixture. HMC's evaluation, and the NRC staff's review, focused on the flow velocities, and accompanying shear stress acting on the ET cover. These parameters provide the basis for the required erosion protection features, including rock size and layer thickness. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in SRP Section 3.3.3, "Water Surface Profiles, Channel Velocities, and Shear Stresses."

The NRC staff reviewed information, data, and drawings in Appendix F, and Appendix I of the LAR using the review procedures in Section 3.3.2 of the SRP. In drawing C-6 in Appendix I, HMC's proposed grading plan calls for a high point near the middle of the LTP. The LTP top will be graded so it sheds water to the existing rock covered side slopes.

As discussed in Section 4.2 of this SER, HMC used the Rational Method to estimate the runoff quantity for the four drainage pathways evaluated. After calculating the runoff quantity, HMC used a design approach that assumed a gully shape based on mean annual flow and calculated the incipient particle size based on the gully flowing at full depth. The incipient particle size represents the particle size on the brink of movement based on the conditions present. According to HMC's design narrative, particles larger than the incipient particle size will be displaced or eroded and gullies will self-armor and be stable over the long-term. After calculating the incipient particle size, HMC determined the required depth of the rock/soil admixture. Appendix F of the LAR describes HMC's approach. HMC's calculations determined that a rock/soil admixture placed at a ratio of 40 percent rock (with a D_{50} of approximately 1.2 inches) to 60 percent soil placed to a depth of 12 inches will provide sufficient erosion protection. HMC uses the rocky soil slope approach in NUREG-1623 in its evaluation. As shown in Table 4 of Appendix F of the LAR, the flow paths HMC analyzed are stable slopes under the rocky soil slope evaluation.

The NRC staff reviewed HMC's approach and detailed calculations for the top slope of the LTP. From the NRC staff's perspective, considering gully formation in the erosion protection design represents a likely scenario for the top slope of the LTP given the long slope lengths. However, the NRC staff recognizes that there is uncertainty related to the size, shape, and corresponding flow in a gully that does form. HMC's design approach envisions relatively wide and shallow gullies. While HMC has used an established methodology to determine the gully shape, an actual gully that forms with a greater depth than anticipated could present a problem from an erosion protection standpoint as the incipient particle size could end up being larger than the rock present in the design.

The NRC staff recognizes the uncertainty related to gully size and shape and the applicability of using the rocky soil slope approach on a gap graded material. If the incipient particle size is larger than the rock present in the design, a gully will continue to grow in either in width or depth. Formation of a deeper gully is of concern to the NRC staff as it may start to compromise the underlying soils (upper and lower radon barrier), potentially resulting in exposure of the tailings. If gully formation occurs in a manner envisioned in HMC's design, this is unlikely to occur, however uncertainties remain for the NRC staff regarding the assumptions around gully size/shape, the gap graded nature of HMC's proposal, and how HMC will achieve the 40/60 rock to soil ratio. Therefore, the NRC staff is including a license condition requiring HMC to

observe, monitor, and document the performance of the ET cover to verify that the ET cover's performance is consistent with what was envisioned in the design. Note that the need for the settlement portion of this condition is explained in Section 3.2 of this SER. The NRC staff proposes the following as License Condition 45 in license SUA-1471:

> The licensee shall implement the monitoring plan in Section 11 of the approved LAR for a minimum of 5 years after construction of the ET Cover is complete with the placement of the erosion protection layer. As part of the monitoring plan for the top surface of the LTP, for a minimum of five years the licensee shall:
>
> A. Observe the top slope of the LTP for signs of localized settlement or ponding.
>
> B. Observe the top slope of the LTP for signs of erosion/damage such as rilling, gullying, and deformation of rock armor at the side slope tie-in transition. Rilling or gullying greater than 7 inches in depth from the as-built ground surface shall require additional evaluation to determine if maintenance or design modifications are required.
>
> C. Document the condition of vegetation on the ET cover in the Engineer of Record report submitted as part of the Annual Performance Report until the vegetation meets the success criteria set forth in Section 10.3 of the approved design report.

As discussed in more detail below, HMC's gradation for the rock/soil admixture includes larger particles that can help mitigate the concentrated flow that would exist within a gully. The NRC staff reviewed HMC's calculations and determined they were implemented correctly. However, as discussed in Section 4.4 of this SER, HMC's design for the rock/soil admixture will be a gap-graded material that could be more susceptible to the erosion of smaller particles within the admixture. The NRC staff understands that the rocky soil slope evaluation is typically used with well-graded mixtures of rock and soil where rock to rock contact is maintained, unlike HMC's design which is a gap-graded material. Therefore, there is some uncertainty related to the use of the rocky soil slope approach in situations where the mixture is gap-graded and rock to rock contact is not as prevalent, as in HMC's proposed design. Construction of the rock/soil admixture at the desired 40 percent rock to 60 percent soil is a critical aspect of HMC's design. As the rock/soil admixture properties are critical to the cover performance, the condition discussed in Section 4.4 of this SER will confirm the actual material and mixing process in the LAR.

On the basis of the information presented in the application, the NRC's staff detailed review of the flooding and surface water calculations, and the license condition referenced above, the NRC staff concludes that the velocities resulting from surface water runoff is acceptable. The presence of the ET cover, confirmed by the monitoring referenced above, will protect mill tailings from flooding and erosion. HMC's analysis demonstrated that adequate protection is provided by (1) selection of proper models to assess rainfall and flooding events, (2) selection of appropriate parameters for models for determining flood forces, and (3) computation of flood forces using appropriate and/or conservative methods. The NRC staff recognizes the uncertainties with respect to gully size and shape in HMC's calculations; the monitoring required by the license condition is intended to verify that the assumptions in the calculations are consistent with the design. The NRC staff will review the annual report required by the license condition and will also consider its inspection observations when considering the site's performance. This license condition will remain on the license for a minimum 5-year period. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A and Criteria 6(1) and 12 have been met.

4.4 Design of Erosion Protection

The NRC staff's review focused on the top slope of the ET cover. HMC's intent is to have the ET cover function to limit the infiltration of water into and ultimately through the mill tailings. The rock/soil admixture is designed to minimize erosion; while the upper radon barrier layer is designed to provide sufficient capacity to store water before evapotranspirative properties are able to remove it. Unless specifically stated otherwise, the NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in SRP Section 3.4.3, "Design of Erosion Protection."

The NRC staff reviewed the information related to the ET cover system for the top slope of the LTP in the Section 7, Appendix F, and Appendix J of the LAR. The NRC staff typically evaluates the banks of natural channels, top and side slopes, apron/toe of the slope, diversion channels, sedimentation, rock durability, and construction considerations based on Section 3.4.2 in the SRP. However, HMC's LAR only involves changes to the top slope of the LTP as there are no changes to the design for the banks of natural channels, side slopes, or diversion channels.

The NRC staff reviewed HMC's approach for design of the uppermost layer of the ET cover. HMC's design calls for a mixture of rock, with a D_{50} of approximately 1.2 inches, and soil. HMC plans to mix the rock and soil at a ratio of 40 percent rock to 60 percent soil, measured by volume. For the rock/soil admixture, HMC plans to use the same rock source that was used in past cover construction on the side slopes of the LTP. This rock was previously shown to meet the NRC's durability requirements (HMC, 1993); therefore, the NRC staff did not re-review this aspect of the design.

With regard to construction considerations, the NRC staff reviewed the particle size distribution information for the rock and soil components of the admixture in Table 1 of Appendix F. HMC estimates that the D_{75} of the rock/soil admixture will be approximately 1.07 inches. Based on its review of Table 1, the NRC staff anticipated that D_{50} value of the rock/soil admixture will be less than 0.01 inches. This difference between the D_{75} and D_{50} value indicates that the rock/soil admixture is gap graded. With the relatively low quantity of rock present in the admixture, it is possible that the rock/soil admixture functions more like soil than rock from an erosion perspective. The finer materials present in the matrix may be susceptible to erosion and the larger rock might be insufficient to limit erosion. Additionally, use of the rocky soil slope approach to verify stability is uncertain with lower quantities of rock present. To verify that the design is working as intended, the NRC staff has included the license condition discussed in Section 4.3. of this SER.

HMC is not planning for and has not requested approval of active maintenance in the LAR. Although HMC does not propose active maintenance, the NRC staff is proposing a license condition to require an observation period after construction is complete to monitor the performance of the ET cover system and verify that the field conditions are performance is consistent with what was considered in HMC's design. This observation period will help demonstrate that the ET cover will function as intended. Section 4.3 of this SER discusses this further.

HMC's technical specifications call for the contractor to develop a mixing method to achieve the desired ratio of 40 percent rock to 60 percent soil in the admixture. Additionally, the specification calls for verifying the in-place gradation for the rock/soil admixture at a frequency of once per acre. The NRC staff recognizes that placement of the admixture at the desired ratio will be critical to achieving the anticipated performance. The NRC staff recognizes that the admixture

placement technique has not been determined at this time. As the rock/soil admixture properties are critical to the cover performance, the condition discussed below will confirm the actual material and mixing process in the LAR. The license condition requiring submission of the contractor's proposed mixing methods and the results of the mixing trials will allow the NRC staff an opportunity to review the placement techniques planned for this layer and the results of the mixing trials. The NRC staff proposes the following License Condition 46 in license SUA-1471:

> The licensee shall provide a copy of the contractor's mixing methods for the rock/soil admixture. Additionally, the licensee shall provide the results of the gradation analysis performed during the mixing trials. Both of these submittals shall be provided to the NRC for review at least 15 days prior to placement of the rock/soil admixture layer.

On the basis of the information provided in the application, the NRC's staff detailed review of the erosion protection design, and the license conditions referenced above, the NRC staff concludes that the design is acceptable. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criteria 1, 4(c), 4(d), 4(f), 6(1), and 12.

4.5 Design of Erosion Protection Covers

This section of the SRP focuses the NRC staff's review on soil or vegetated ET Covers. HMC's erosion protection design consists of a rock/soil admixture. While HMC anticipates that vegetation will be present on the rock/soil admixture, HMC's erosion protection design does not rely on the presence of vegetation to meet the regulations. Therefore, this section of the SRP is not applicable to this review. Section 4.4 of this SER documents the NRC staff's review of the rock/soil admixture.

5. PROTECTING WATER RESOURCES

This section describes the NRC staff's review of information related to infiltration through the ET cover and groundwater monitoring to verify site performance in the LAR.

5.1 Infiltration

The NRC staff's review focused on the top slope of the ET Cover. HMC's intent is to have the ET cover limit the infiltration of water into and ultimately through the mill tailings. The rock/soil admixture is designed to minimize erosion; while the upper radon barrier layer is designed to provide sufficient capacity to store water before evapotranspiration can remove it. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criteria 5F and 6(1) using the acceptance criteria presented in SRP Sections 2.7, "Disposal Cell Hydraulic Conductivity" and 4.0, "Protecting Water Resources."

In 10 CFR Part 40, Appendix A, Criterion 5F states that where groundwater impacts occur at an existing site due to seepage, action must be taken to alleviate conditions that lead to excessive seepage impacts and restore groundwater quality. In addition, 10 CFR Part 40, Appendix A, Criterion 6(1), requires placement of an earthen barrier over tailings that provides reasonable assurance of the control of radiological hazards for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The NRC staff evaluated whether infiltration through the ET cover would lead to excessive seepage impacts from the mill tailings and into the groundwater over the performance period.

Traditional resistive, or rip rap, earthen barriers consist of a low-permeability layer to limit infiltration through the cover. SRP Section 2.7 calls for field testing or sufficient technical analyses for hydraulic conductivity values of 1E-7 centimeters per second or less as a design basis, which equates to approximately 1 inch per year. Although HMC is not relying on a low permeability layer to limit infiltration, HMC is proposing to rely on the ET cover to limit infiltration to similar values over the performance period. Based on HMC's 2022 groundwater modeling results (HMC, 2022), HMC established a performance criterion for net infiltration through the ET cover of 0.41 inches per year, which equates to less than 1E-7 centimeters per second. Furthermore, in the revised 2025 ET cover design report, HMC projected that the average annual net infiltration through the cover is at or less than 0.01 inches per year. HMC's model projections depend on a series of assumptions related to meteorological conditions, soil, and vegetation. HMC's proposed ET cover design relies on the water storage capacity of the upper radon barrier, primarily, to store and then remove seasonal precipitation via evapotranspiration with the presence of vegetation.

For vegetation, HMC proposed a seed mix of native species that have been evaluated for the cover soils, revegetation performance, and climatic conditions. In Appendix J of the LAR, HMC discussed annual vegetation monitoring, including qualitative and quantitative evaluations to facilitate tracking and progress towards revegetation success standards. HMC defined success criteria according to the following:

- revegetation equal to or exceeding 50 percent of the saltbrush/grassland community analog
- species diversity representing a minimum of three perennial grass species, one perennial forb species, and one shrub species
- woody plant density equal to or exceeding 200 stems per acre

On the basis of the information provided in the LAR, the NRC staff's detailed review of the ET cover design with respect to infiltration and a review of similar cover systems at similar sites (e.g., Grand Junction, Monticello), the NRC staff determined that HMC's ET cover performance criteria of 0.41 inches per year is reasonable because (1) HMC's assumed infiltration criteria is similar to or greater than observed infiltration at similar ET cover sites and (2) the vegetated ET cover is designed to mimic the surrounding environment, which adds confidence in long-term cover performance. Accordingly, the NRC staff concludes that the design is acceptable and has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criteria 5F and 6(1).

5.2 Groundwater Compliance and Monitoring

The NRC staff's review focused on the top slope of the ET cover. HMC's intent is to have the ET cover limit the infiltration of water into and ultimately through the mill tailings. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 7A which states, in part, that groundwater monitoring is to be conducted to determine that hazardous constituent concentrations in the groundwater comply with the site standards and to demonstrate the effectiveness of the corrective action program.

License Condition 35 states that HMC shall implement a groundwater compliance monitoring program to assess the performance of the groundwater restoration program in License Conditions 35 A through F. The groundwater monitoring network at the HMC site, which the NRC approved by license amendment on November 12, 2019 (NRC, 2019), is designed to monitor and evaluate the impacts of seepage from mill tailings. HMC's annual monitoring reports illustrate the impacts to the groundwater beneath the GRP site in the uppermost aquifer (i.e., the Alluvial aquifer) and the underlying Chinle aquifers (i.e., Upper, Middle, and Lower Chinle aquifers). These reports document historical and ongoing groundwater corrective actions, as well as groundwater monitoring data.

Impacts to the groundwater have occurred largely due to seepage from the LTP. Seepage has decreased since the cessation of milling and the tailings flushing program. However, seepage continues due to ongoing drain down and infiltration from precipitation. HMC's ET cover is designed to limit infiltration into and through the tailings to limit impacts to the groundwater.

On the basis of the existing groundwater corrective action program and the monitoring plan being developed to evaluate impacts due to seepage, and because ET covers have been demonstrated to significantly reduce seepage due to infiltration, the NRC staff determined that the existing well locations are adequate to assess potential impacts and that the proposed ET cover design has demonstrated compliance with 10 CFR Part 40 Appendix A, Criterion 7A.

6. RADIATION PROTECTION

This section describes the NRC staff's review of radiation protection of the ET cover system as described in the LAR. HMC has not proposed any changes to (1) its approach for the cleanup of contaminated soil; or (2) radiation safety controls and monitoring. As discussed in Section 1.3 of this SER, the NRC staff focused its review on aspects of the LAR where HMC has proposed a change. Therefore, this section of the SER focuses on the proposed radiation protection of the design for the LTP cover.

6.1 Disposal Cell Cover Radon and Gamma Attenuation and Radioactivity Content

The NRC staff evaluated the radiation protection aspect of the HMC's proposed ET cover system for the LTP. The proposed ET cover would be additional cover material over the existing interim cover of the LTP. The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Part 40, Appendix A, Criterion 6, using the acceptance criteria presented in SRP Section 5.1, "Disposal Cell Cover Radon and Gamma Attenuation and Radioactivity Content."

The NRC staff evaluated whether the emplacement of the ET cover provides stabilization and containment of the LTP, and a level of protection for public health, safety and the environment from radiological hazards associated with the site, which is equivalent to the extent practicable, or more stringent than 10 CFR Part 40, Appendix A, Criterion 6 and the standards promulgated by the EPA in 40 CFR Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," Subpart D, "Standards for Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended," and Subpart E, "Standards for Management of Thorium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as Amended." The NRC staff's review focused on determining whether the proposed cover design features provide adequate protection of public health, safety, and the environment per 10 CFR Part 40, Appendix A. Specifically, the NRC staff evaluated whether the proposal satisfies the requirements of 10 CFR Part 40, Appendix A Criterion 6.

The NRC staff reviewed the LAR for compliance with the applicable requirements of 10 CFR Parts 20 and 40 using the acceptance criteria presented in SRP Section 5.1, "Disposal Cell Cover Radon and Gamma Attenuation and Radioactivity Content." In Attachment A of the LAR, HMC described its cover design for the proposed mill tailings waste repository. HMC proposed to remove a nominal 6-inch-thick layer of erosion barrier (i.e., top layer) atop the existing LTP, thereby exposing the underlying radon barrier, and explained that the top 6 inches of exposed radon barrier would be compacted to meet a hydraulic conductivity of no more than 10^{7} centimeters per second.

In the final supplement to the LAR (HMC, 2025b), HMC proposes that the existing LTP would be capped with an 8.5 feet thick ET cover consisting of a gravel-amended soil erosion protection layer (1 foot), an upper radon barrier soil cover (3 feet) and a lower radon barrier (4.5 feet). Figures 1-5 and 1-7 of the LAR show the cover system cross sections for the approved 1995 design and the proposed final ET cover design (HMC, 1995 and HMC, 2025b). The lower portion of the ET cover system consists of soil and ranges in thickness from 22.5 inches to 40 inches. The remaining thickness of the top layer would be a uniform mixture of cover soil (60 percent by volume) and rock (40 percent by volume). The top layer is designed to mitigate

erosion by creating an armored surface with rock large enough to resist the erosive forces created during a PMP event.

Radon Attenuation

In 1995, after demonstrating that the radon flux was below the 20 picocuries per meter squared per second (pCi/m^2·s) EPA limit, HMC installed the final radon barrier for the LTP aprons and sides. The radon flux measured and calculated in 1995 for the sides and aprons was a mean radon flux of 16.7 pCi/m^2-s, including the measured flux on the top which only had an interim cover.

The NRC staff evaluated HMC's use of the RADON computer code to model the radon flux based on emplacement of the final radon barrier on the LTP top and the tie-ins on the sides. HMC assumed the background concentration of radon^{222} was zero. The NRC staff determined that this was consistent with acceptance criteria presented in SRP Section 5.1.3.1(2), which states that the radon concentration above the top of the cover is either set to a conservative value of zero or a measured background value.

HMC used the following site-specific parameter values in its radon flux calculations: (1) design thicknesses of the tailings waste and the ET cover, (2) long-term average moisture content of the tailings waste and the ET cover layer, (3) average radium-226 concentration in the tailings waste, and (4) porosity of the tailings waste and the ET cover layer. The NRC staff evaluated HMC's site-specific parameter values and determined whether they were either (1) consistent with reference values described in Regulatory Guide 3.64, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," issued June 1989 (NRC, 1989), or (2) conservative, based on an adequate number of samples, measured with appropriate quality assurance, and representative of long-term conditions.

In addition, the NRC staff evaluated HMC's approach by independently calculating radon fluxes using the methodologies described in NUREG/CR-3533, "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," issued April 1984 (NRC, 1984), and Rogers and Nielson (1991). The NRC staff used a Microsoft Excel spreadsheet to perform the calculations. Using HMC input data, the NRC staff calculated a range of modeled radon fluxes, based on the assumption made when modeling, and values ranged from 20 to 33 pCi/m^2·s. These NRC numbers were compared to a radon flux of 19.6 pCi/m^2·s modeled by HMC.

In the LAR, HMC modeled radon flux for the aprons, for each side of the LTP, and for the side tie-ins and top of the LTP. As the results of this remodeling are consistent with what was modeled in 1995, the NRC staff has no concerns associated with the remodeling of the 1995 data. However, the model results for the proposed emplacement of the final radon barrier for the ET cover top and side tie-ins (may exceed the 20 pCi/m^2·s limit on their own). This is acceptable for the radon flux modeling required under Criterion 6(1) since the modeled radon flux averaged across the entire pile using a weighted average is below 20 pCi/m^2·s, but is potentially problematic under Criterion 6(2), which requires measurement of the radon flux after placement of the radon barrier to verify that the radon flux limits are met "prior to placement of the erosion protection barriers or other features necessary for long-term control of the tailings."

The growth media layer, recharacterized as the upper radon barrier for modeling purposes, is subject to bioturbation, animal intrusion and bio-intrusion due to native animals and native plants that can impact the performance of the upper radon barrier in limiting radon emissions.

Cover Soil Radon Diffusion Coefficients

HMC calculated radon diffusion coefficients using an updated method by Rogers and Nielson (1991). The NRC staff determined that this assumption meets acceptance criterion presented in SRP Section 5.1.3.1(9).

Soil Cover Thickness

The NRC staff agrees that the proposed soil cover thickness of 4 feet for the erosion protection layer and growth media layer, both above the final radon barrier, could result in an average radon^{222} flux of 19.63 pCi/m^2·s as modeled by HMC in the original LAR (HMC, 2023a). In the RAI responses, HMC made changes to the cover design, specifically, they recharacterized the growth media layer as the upper radon barrier for the purposes of the modeling parameters, added an additional 1.25 feet of soil to the final radon barrier increasing the cover at this layer to 4.25 feet, recharacterized the final radon barrier as the lower radon barrier, removed the erosion protection layer from its model and modeled the LTP with these changes. These changes reduced the radon flux for the LTP top from 26.02 pCi/m^2·s to 25.5 pCi/m^2·s, the side tie-ins from 56.64 pCi/m^2·s to 55.92 pCi/m^2·s, and the total radon flux from 27.87 pCi/m^2·s to 26.91 pCi/m^2·s, resulting in a weighted average across the entire pile of radon flux of 19.2 pCi/m^2-s. In the 2025 ET cover design report (HMC, 2025b), HMC increased the cover on the lower (final) radon barrier from the 4.25 feet in the RAI responses to 4.5 feet, and added apron ties-ins which covered approximately 2.2 acres, increased the acreage for the side ties from 6 acres to 14.1 acres, decreased the acreage for the top from 91.6 acres to 80 acres and averaged the side tie-in flux with the apron tie-in flux rather than the top flux. These changes reduced the overall size of the LTP by 1.3 acres and resulted in a calculated radon flux for the top of 23.35 pCi/m^2-s, a calculated radon flux for the side tie-ins of 59.85 pCi/m^2-s, a calculated radon flux of 26.52 pCi/m^2-s for the apron tie-ins and an applied weighted average across the entire pile of 19.95 pCi/m^2-s. The weighted average numbers were not adjusted for the portions of the LTP that are under final cover – but adjustment of those weighted averages for the 1.3 acre reduction in total area of the LTP results in a calculated weighted average of 20 pCi/m^2·s.

Based on HMC's modeling assumptions and results, the radon flux may not meet 10 CFR Part 40, Appendix A, Criterion 6(2). Under both the original ET cover design, the RAI response, and the 2025 ET cover design, the average calculated radon flux for the top and side tie-ins exceeds the 20 pCi/m^2·s criterion. Therefore, given the uncertainty in HMC's modeled radon flux, HMC will measure the radon flux at the top of the lower radon barrier using Method 115 (EPA, 2017), and if the radon flux criteria is not met, HMC further agreed to perform a series of field verification measurements to identify and remediate hotpots and remeasure the radon flux. Once the required radon flux rate is achieved for the lower radon barrier, HMC will complete construction of the ET cover, specifically, placement of the upper radon barrier and the erosion protection layer. Given HMC's modeling results and consistent with the 2025 ET cover design report, the NRC staff is including a license condition for measuring radon flux after the lower radon barrier is emplaced to ensure HMC meets the requirements in 10 CFR Part 40, Appendix A, Criterion 6(2). The NRC staff proposes the following License Condition 47 in license SUA-1471:

> Once the lower radon barrier is in place, HMC will measure the radon flux using EPA Method 115. If the average radon flux does not meet the 20 pCi/m^2-s limit, as described in 10 CFR Part 40, Appendix A, Criterion 6(2), HMC will identify hot spots using appropriate measurement procedures and amend the lower radon barrier by adding additional cover until subsequent Method 115 measurements demonstrate compliance.

Once the lower radon barrier demonstrates that radon flux rate is achieved for the lower radon barrier, HMC will complete construction of the ET cover, specifically, placement of the upper radon barrier and the erosion protection layer.

Gamma Attenuation

In the LAR, HMC stated that, “a direct gamma radiation survey will be performed following placement of the ET cover to verify that the direct gamma exposure attains the required ambient background levels.” HMC explained that it would compare the results of the survey completed after placement of the ET cover to the survey conducted following removal of the 6-inch erosion protection layer on the existing interim cover for the LTP top. HMC will perform measurements at the same 102 locations as the radon flux measurement locations.

The final survey of the lower radon barrier will consist of charcoal measurements of radon flux in accordance with EPA Method 115. If the lower radon barrier measurements under Method 115 do not meet the radon flux criteria, HMC will conduct appropriate measurement techniques to identify and remediate hot spots until compliance with the radon flux criteria is achieved, HMC will include the results of the individual direct gamma exposure rate measurements in the as-built report for the ET cover and the lower radon barrier, if gamma exposure rate surveys are needed to achieve compliance with the radon flux criteria The NRC staff determined that this approach meets acceptance criterion presented in SRP Section 5.1.3.2.

Cover Radioactivity Content

The NRC staff evaluated HMC’s descriptions of radioactive material in the proposed cover soils against 10 CFR Part 40, Appendix A, Criterion 6 of 10 CFR Part 40, Appendix A. HMC stated that radiologic testing was completed on each borrow area, which indicates that radium^{226} concentrations are between 0.8 and 2.15 pCi/g (NRC, 2024b). The NRC-approved Reclamation Plan (HMC, 1993, 1995) indicates that the background concentration of radium-226 in soil is 5.5 pCi/g. The NRC staff determined that the testing results for the proposed borrow areas are within the range of background.

The NRC staff is including a license condition requiring measuring as the lower radon barrier is emplaced to ensure HMC meets the requirements in 10 CFR Part 40, Appendix A, Criterion 6(2). The NRC staff proposed the LC as discussed above.

Based on the LAR and the proposed LC to measure the radon flux after the lower (final) radon barrier is completed to demonstrate compliance with Criterion 6(2), the NRC staff has reasonable assurance that the radon flux release limit will be achieved.

On the basis of the information provided in the application, the detailed review of the radiation protection conducted by the NRC staff, and the license condition referenced above, the NRC staff concludes that the design is acceptable. Therefore, the NRC staff has reasonable assurance that HMC has demonstrated compliance with 10 CFR Part 40, Appendix A, Criterion 6 requirements.

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