Request for Additional Information – Group 2
Safety Evaluation Report

Section 2 - Geology and Seismology

RAI 2.2-1 *Structural and Tectonic Features*

Provide additional information on the local structural features discussed in 'Application for Amendment' and Appendix G.1 and identified below.

The Church Rock site is in the vicinity of three local structural features. These local features are:
- Pipeline Canyon Lineament
- Fort Wingate Lineament
- Pinedale Monocline

Although Canonie (1987) describes both the Pipeline Canyon Lineament and the Fort Wingate Lineament as monoclinal hinge zones with sufficient fracturing to modify flow within the site, NRC staff is not clear on if the processes that formed the lineaments with associated fault zones are still active. If the lineaments are some type of faults, it is not clear why they were not included in the analysis similar to the previous analyses. Specifically, seismic hazard analyses were previously conducted by Lawrence Livermore National Lab in 1994 for the design of the uranium mill and the tailings site (NRC, 1997). This deterministic analysis was based on the presence of the Pipeline Canyon and Wingate Lineaments.

The information is required for the NRC staff to determine whether 10 CFR Part 40, Appendix A, Criterion 4(e) is met with respect to the proposed amendment, which requires that an acceptable alternate method of determination of seismic hazard has been used or that tailing impoundments are not located near a capable fault. This information is also needed to determine whether Criterion 6(1) is met.

RAI 2.4-1 *Seismicity and Ground Motion Estimates*

Identify the fault responsible for the closest seismic event to the Church Rock site: An M_w 4.7 event that occurred on January 5, 1976 approximately 16 miles (26 km) from the site.

Appendix G, Attachment G.1 presents the results of a seismic hazard analysis. Section 4.2 discusses the historic seismic record of the Colorado Plateau and the fault responsible for the closest seismic event to the Church Rock site. It is not clear to NRC staff why this fault was not identified and why it was not included in the seismic hazard analysis or described in Appendix G, Attachment G.1, Section 4.1.

The information is required for the NRC staff to determine whether 10 CFR Part 40, Appendix A, Criterion 4(e) is met, which requires that an acceptable alternate method of determination of seismic hazard has been used or that tailing impoundments are not located near a capable fault. This information is also needed to determine whether Criterion 6(1) is met.

RAI 2.4-2 *Seismicity and Ground Motion Estimates*

Provide the technical basis for not considering the tailings in estimating the shear wave velocity.

Appendix G, Attachment G.1, Section 4.3 explained that the tailings were not considered in estimating the shear wave velocity because this site-wide Seismic Hazard Analysis was performed to estimate peak accelerations at the original ground surface. The shear wave velocity was estimated in the top 100 feet (30 meters, V_{S30}) of the original ground surface. The mine waste repository will be placed over the existing tailings and in some locations the tailings are approximately 20 m thick. With regards to the mine waste repository, it is not clear why the top of the existing tailings would not be considered "the original ground surface."

The information is required for the NRC staff to determine whether 10 CFR Part 40, Appendix A, Criterion 4(e) is met, which requires that an acceptable alternate method of determination of seismic hazard has been used or that tailing impoundments are not located near a capable fault. This information is also needed to determine whether Criterion 6(1) is met.

Section 3 - Geotechnical Stability

RAI 3.2-1 *Mine Waste Characteristics*

More than 50 percent of the estimated mine site debris volume is composed of organic material, including logs. Provide the technical basis for why any void space created by organic decomposition will not create subsidence in the mine waste repository area or explain why the presence of voids would not be an issue.

Appendix C.4.2.2, Table C.4-3 gives estimated mine site debris volumes. 10,000 yd^3 is listed as vegetation debris type and 2600 yd^3 is given as wood. This is roughly 55 percent of the overall debris volume of 22,800 yd^3, or almost 2 percent of the total volume within the proposed mine waste repository. As this organic matter decomposes, that volume would be occupied, in time, by void space and, ultimately, by other mine spoils. Subsidence due to such a large volume could impact the integrity of the mine waste repository.

The information is required for the NRC staff to determine whether 10 CFR Part 40, Appendix A, Criterion 1, 3, 4(e), 5(G)(2), and 6(1) would be met.

RAI 3.8-1 *Disposal Cell Hydraulic Conductivity*

Provide electronic input and output files, including descriptive labels, of the UNSAT-H runs described in Appendix G, Attachment G.7 and in Appendix Y.

The simulations performed with UNSAT-H provide estimates of the rate of water infiltrating into the future repository, tailings, and aquifer. Electronic copies of these calculations with descriptive labels are needed for the NRC staff's review, as well as to focus staff efforts on risk significant features and processes.

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-2 *Disposal Cell Hydraulic Conductivity*

Provide a clear definition for potential evapotranspiration (PET), evaporation (E), and transpiration (T) calculated in UNSAT-H.

It is not clear to NRC staff why two definitions for PET were presented in both Appendix G, Attachment G.7 and in Appendix Y. Penman's equation on page 42 in Appendix G, Attachment G.7 does not include precipitation within the definition of PET while the definition for PET presented on page 47 includes precipitation as part of the definition, but does not include daily wind speed, relative humidity, and net solar radiation. Figures 14 and 15 in Attachment G.7 appear to present monthly PET rates that include precipitation since the two PET rates in the two figures differ. [In addition, although Appendix G, Attachment G.7, Fig. 14 and in Appendix Y, Fig. 12 are representing the same set of values, the figures are different.]

NRC staff is also not clear about the transpiration and evaporation values as calculated by UNSAT-H and as described on page 47, e.g., "potential evaporation is estimated or derived from daily weather parameters." Both components are described as potential (i.e., T_p and E_p); however, the simulated values of "Transp" and "Evap" as presented in Tables A1 - A8 from Appendix Y do not equal the "PET" column from the tables and, instead, may be actual transpiration and actual evaporation.

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-3 *Disposal Cell Hydraulic Conductivity*

Provide additional information to support the claim made in Appendix G, Attachment G.7, Section 5.1 that even if infiltration events could potentially move deeper than the $CaCO_3$-bearing horizon, this moisture would likely move back up in the profile and be removed via evapotranspiration (ET).

Although pages 33 and 51 in Appendix Y state that there is no simulated percolation in the model, the application states that water that would infiltrate deeper would be pulled back up and removed as evaporation. Figure 20 presets the 63-year long run results including the first three years without vegetation. For those first years, the annual flux appears to drop especially fast (over 10 cm/yr) within the upper few centimeters of the proposed mine spoil repository. Since transpiration is no longer a mechanism without vegetation, the evaporation process is the most significant process by which water is removed from the cover during this period. Even with vegetation present, evaporation is still the dominant process to remove water from the disposal system in the simulation results presented in Appendix G, Attachment G.7, Appendix A, showing evaporation rates removing more than 50 percent of the rainfall per year for all sensitivity analysis runs including simulated wet years. Consequently, NRC staff is especially interested in the evaporation process and the significant factors that can influence Fick's law (used to calculate evaporation), such as soil compaction, hydraulic conductivity, soil type, and thickness of the 4-ft admixture / no-rock soil layer. A comparison with the existing cover and the surrounding area is also of interest: Is there recharge in the borrow areas and the area surrounding the Church Rock site? If yes, why is the evaporation rate insufficient to stop deep percolation in these areas and in the existing radon barrier cover on the Church Rock mill tailings cell (see, e.g., Appendix Y, page 38). That is, what factors enhance the evaporation rates for the future evapotranspirative (ET) cover design?

In addition, what is the depth limit for the effect of evaporation and what factor determines that limit? For example, Figure 22 in Appendix Y shows the mine spoils losing water and becoming drier down to circa 5 m. Appendix Y, Figure17 indicates that the upward movement of moisture and subsequent evaporation is responsible. The depth between upward movement of moisture and downward movement of moisture should be identified within the mine spoil repository. If the mine spoils are drying out by moving water to the upper ET layers, how much does this contribute in percentage to the overall water budget calculated by the UNSAT-H model? In addition, a technical basis and detailed explanation should be provided for the upward movement of water in the mine spoil repository layers?

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-4 *Disposal Cell Hydraulic Conductivity*

Provide water budget tables for the 4-foot "store and release" cover (i.e., the admixture and the soil cover without rock) showing the soil water storage capacity of this important unit over time. Current tables do not show what amount of water is stored in that layer, the amount of water infiltrating through the bottom of the store-and-release unit (i.e., 4 ft.), and the amount of water moving back up into the store-and-release unit by means of evaporation.

Tables in Appendix G, Attachment G.7, Appendix A do not provide this information. Using Table 64, Wet Year #1 as an example (and ignoring the PET value), inflow does not match the outflow and the difference (60.35 – 7.9 - 44.875 - 4.295 – 0 = 3.28 cm) may represent the storage capacity for that year, but it is not identified as such. What is the limit that the design store-and-release layer can hold as storage water before water moves downward into the mine spoils themselves?

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-5 *Disposal Cell Hydraulic Conductivity*

i. Provide additional information concerning the uncertainty involved with the UNSAT-H output. Produce additional sensitivity runs to provide reasonable assurance that the chosen parameter values conservatively bound performance and therefore bound uncertainty.
ii. Although validating the UNSAT-H model associated with the license amendment is not practicable, confidence that the model performs for the purposes for which it is designed is important. For example, documents describing other sites or projects that validated UNSAT-H percolation estimates (i.e., subsequent field studies verified that the simulated results for those sites were close to actual results) would support current UNSAT-H model results.
iii. Provide references or validation documents that UNSAT-H can meaningfully predict the amount of percolation or infiltration when the precipitation is in the form of snow.

i. Provide additional information concerning the uncertainty involved with the UNSAT-H output. Specifically, how much uncertainty is involved with the Point of Diminishing Returns (PODR) calculation results as seen in Appendix G, Attachment G.7, Figure 18. A deterministic approach can be useful to bound uncertainty when the analysis can be demonstrated to be conservative. Appendix G, Attachment G.7, Section 7 states that although the varied input parameters such as soil, vegetation and cover profile geometry showed some sensitivity, the most sensitive item was the climatic variation. If precipitation is the dominant process influencing performance, additional sensitivities case should be run to provide reasonable assurance that the chosen parameter values conservatively bound performance. Appendix Y, Section 4.2.2 claims that the 20-year UNSAT-H run average-wet-average precipitation is conservative. Provide additional information to support this conclusion, since the reports do not show how the soil water storage capacity is reacting. Figures 21 and 22 do provide some information in this regard; however, the extremely high soil suction in the fill layers (initial suction is in the millions of -cm) prevents a close analysis of what is happening in the "store and release" cover. Because precipitation is assessed in the application to be the most sensitive item, various combinations of long-term dry, average, and wet cycles, for example, could show which combinations are the most plausible, and thus demonstrate conservatism in the approach. These could be combined with additional scenarios, e.g., fire or drought may destroy the vegetation so that transpiration is minimal for several years. The ranges in the parameters selected should be consistent with the variability and uncertainty in the parameters, and the selected ranges should provide the NRC staff with sufficient information to conclude that uncertainty on performance is bounded. If the factors that affect the evaporation rate are included in the UNSAT-H code as adjustable parameter variables, these factors should be varied and included in additional sensitivity runs.

ii. Gauging uncertainty through formal validation exercises, such as model calibration, history matching, and prediction, is difficult for long-term disposal projects. But confidence that the models perform as they are designed, capture relevant features and processes of the disposal system being modeled, and reflect the uncertainty in system knowledge remains central. Previous applications of predicting long-scale recharge using UNSAT-H may have been later validated by subsequent field studies. Providing such documentation would help support current model results.

iii. The Fort Wingate weather data set contained the wettest year on record (1906), having an annual precipitation volume of 23.8 inches (84.8 cm). Much of the precipitation came in as snow from January to April and October to December. This is a period when PET should be low and transpiration of moisture through vegetation is minimized or completely ceased in the modeling, although Appendix Y's Figures 12 and 13 still show relatively high PET for these months. Even on sunny days, evaporation from a layer of snow would be minimal, besides a small amount of sublimation, so that most of the snow thickness would melt and infiltrate unhindered into the soil. NRC staff is not clear during what time of the year potential evaporation rates at the Church Rock site are sufficiently high enough to draw water back up from the soil, but this appears to not be possible during the winter months.

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-6 *Disposal Cell Hydraulic Conductivity*

Cedar Creek (2014) documented vegetation characterization and biointrusion surveys. The biointrusion survey appears to have been confined to mammals. NRC staff have observed on several occasions that there are numerous ant colonies on the current Church Rock cover, so that one could assume that the future cover will also have such colonies. In addition, the report states that the root system of a fourwing saltbush may extend 2 to 6 m below the surface and the root system of big sagebrush may extend 1 to 4 m below the surface. Could deeper ant colonies and plants with longer taproots bring mine spoil material to the surface, or does the licensee believe that a lack percolation will affect the vegetation growing on the cover such that these characteristics would not be in common with the current cover; please provide the basis for this conclusion. Does the licensee have a basis for concluding that hydraulic conductivity values are not sufficiently altered so that UNSAT-H results are influenced, or if not, what would that impact be?

In addition, provide references for the projected communities that are expected to inhabit the repository for the following timeframes (page 2):
Reclaimed: 0 - 50 years; grassland: 25 - 100 years; shrubland: 50 - 1,000 years.

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

RAI 3.8-7 *Disposal Cell Hydraulic Conductivity*

There are several items in Appendix Y that require clarification. A statement or question is associated with each item below. NRC staff asks that the sufficient additional information be provided for each item.

From Appendix Y:

a) Table 9:

Why does the radon barrier have a higher K_s value than the fill ($3.6x10^{-5}$ vs. $2.5x10^{-5}$ cm/s)?

Why does the K_s value for the recompacted radon barrier after the construction of the repository ($3.6x10^{-5}$ cm/s in Tab. 11) have the same K_s value of the existing radon barrier ($3.6x10^{-5}$ cm/s in Tab. 9)?

b) Table 12:

Why are the initial suction values for the fill soil so high (4407686039.0-cm)?

Why is the initial suction value for the middle of the radon barrier/liner so high in Figure 23 (over 6000-cm)? Does the compacted radon barrier need to stay moist for it the function as a radon barrier?

c) Figure 16:

Why is there no wet 12th year in the simulation results for profile B2?

Why does the annual flux (cm/year) value drop below that of the 10th year?

d) Figures 21 and 22:

Provide labels for the units or layers presented in these figures.

e) Figure 24:

What occurs in the middle of the mine spoils to cause the relatively abrupt change in matric potential around the year 2025?

f) Table A3:

i. Why is T (transpiration) from the existing cover for Year 1 less than half of the T value from the future cover in Table A4?

ii. Why is there no change in T at Years 11 and 12?

iii. Some years have a combined value of T and E that is higher than Precipitation; do these values include contribution from upward movement of water from the mine spoils?

g) Table A4:

i. Why do values for E seem very high for years 11 and 12? Is any of the precipitation water not accessible for evaporation, or is all precipitation water available to the evaporation process at all times, and what is the licensee's basis for this assumption?

ii. For Year 11 there are 4.22 cm of precipitation that is not removed through transpiration, evaporation, or runoff. For Year 20 there are 0.391 cm of precipitation that is not removed through transpiration, evaporation, or runoff. Is this extra water storage within the 4 ft? Water storage data are needed.

iii. For most years, ET plus runoff does not balance out with precipitation, i.e., outflow does not equal inflow.

iv. Is "Drain" the same as percolation or deep infiltration?

v. Why are the transpiration values generally higher for the results presented in Appendix A of Appendix Y than for Appendix G, Attachment G.7, Appendix A?

The information is required for the NRC staff to demonstrate compliance with the following criteria in 10 CFR Part 40, Appendix A: Criterion 4(c), which provides requirements for the embankment and cover slopes for tailings and Criterion 6(1), which requires that impoundment designs provide reasonable assurance of control of radiological hazards to be effective for 1,000 years to the extent reasonably achievable, and in any case, for at least 200 years.

Section 4 - Surface Water Hydrology and Erosion Protection

RAI 4.1-1 *Hydrologic Description of Site*

Please either add Figure 4.2-12 in Appendix I or indicate a correct figure number for NRC's technical review.

Section 3.1.3 of the SRP directs the NRC staff to review the description of structures, facilities, and erosion protection designs to determine if they are sufficiently complete to allow for an independent evaluation of flooding. In Section 4.2.3, the licensee stated, *"…The chute will slope longitudinally at 5.3 percent for about 56 feet vertically, where the flood flows will discharge into a sunken riprap basin. A 5.3 percent slope was selected over steeper slopes that would have less excavation volumes because the 5.3 percent slope grades the chute beyond the steep drop in the arroyo bed (see Appendix I, Figure 4.2-12)."*

The Figure 4.2-12 is missing in Appendix I. The missing information is related to the flood flow analysis for the design of riprap chute and the hydraulic design for the sunken riprap basin.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1 is met, which relates to minimization of erosion, disturbance, and dispersion by natural forces.

RAI 4.2-1 *Flooding Determinations*

In attachment G.7 of the LAR, the licensee uses the Rational Method to estimate the amount of runoff in its calculation of the rock sizing for the top slopes of the final cover system over the mine waste repository. In the calculation, the licensee uses a runoff coefficient of 0.3, which is not consistent with the guidance in NUREG-1620 and not otherwise supported. Please justify the use of this value. Alternatively, the licensee can revise the calculation based on a runoff coefficient of 0.8.

NUREG-1620, Section 3.2.3, acceptance criteria states that correct model input parameters should be used in the analysis. The NRC staff observes that NUREG-1623 recommends using a value of 0.8 for the runoff coefficient (see page D-7). Additionally, the NRC staff observes that the calculation for rock sizing along the 20 percent slope in Attachment G.8 uses a runoff coefficient of 0.8.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1 is met, which relates to minimization of erosion, disturbance, and dispersion by natural forces.

RAI 4.2-2 *Flooding Determinations*

Please justify the use of the Brandt and Oberman method used to calculate the time of concentration in Attachment G.7 and in Attachment G.8 of the LAR. Neither the SRP or additional guidance in NUREG-1623 identify this method as one to consider when estimating the time of concentration. Alternatively, the licensee can consider using a method identified in the SRP or NUREG-1623 to calculate the time of concentration.

NUREG 1620, Section 3.2.3, acceptance criteria states that correct model input parameters should be used in the analysis and that the computational methods used for the design flood estimates are adequate. The time of concentration is a key factor in estimating the peak runoff. The NRC staff performed an independent check of the time of concentration calculations using a different method. The NRC staff's estimated times of concentration that were consistently shorter than what the licensee provided in Tables 3 and 4. As the relationship between time of concentration and peak discharge is inverse (a shorter time of concentration results in higher discharge), the licensee's calculations may not represent a conservative analysis.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1 is met, which relates to minimization of erosion, disturbance, and dispersion by natural forces.

RAI 4.2-3 *Flooding Determinations*

Please explain the 1.73 parameter that is used as a 'scale factor from 10-min to D' on the calculation worksheet in Attachment G.8. The NRC staff was not able to locate an explanation or source for this number.

NUREG-1620, Section 3.2.3 directs the staff to verify that model input parameters are accurate. It is not apparent to the NRC staff why the value of 1.73 was chosen or where it came from. This number is used in a calculation package to estimate the unit slope discharge for the 20 percent side slope on the proposed mine waste repository.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criteria 1, Criteria 4(a), Criteria 6(1) and Criteria 12 are met.

RAI 4.2-4 *Flooding Determinations*

Please correct the apparent inconsistencies indicated in the table below and provide this information to NRC. Because this correction is also related to RAI 4.2-5, please provide complete corrections related to the modeling input, output data, and modeling parameters where applicable.

NUREG-1620, Section 3.2.3 directs the NRC staff to verify that model input parameters and computational methods are accurate. The licensee provided the HEC-HMS model stored in a DVD for an amended Reclamation Plan. The HEC-HMS model is labelled as

"NECR_95_HMS4.2.1." The model, "NECR_95_HMS4.2.1," has been reviewed by the staff. It is found that some input parameters and data assigned to the model are not consistent with the data shown in Attachment I.1 to Appendix I, MILL SITE STROMWATER CONTROLS. The inconsistencies are summarized in the below table.

Items	The licensee's parameter values used in the "NECR_95_HMS4.2.1" model are inconsistent with the values presented in the LAR application report. The tables in the report relevant to the inconsistencies are shown in the third column of this table.	Attachment I.1 in Volume I report of the LAR application
1	Sub-watershed areas	Tables A2 and A5 of Attachment A to Attachment I.1
2	Existing Condition Rainfall Loss for watershed IDs, 19, 22, and 35.	Table C1 of Attachment C to Attachment I.1
3	Maximum Storage	Tables C4 and C5 of Attachment C to Attachment I.1
4	Pond Surface Areas	Table F6 of Attachment F to Attachment I.1
5	Area-weighted Averaged PMP Depth in the Pipeline Arroyo watershed is 6.543 inches for 6-hour duration.	Table 4 of Attachment I.1 presents 6.47 inches
6	Trapezoid Channel Bottom Widths	Table E3 of Attachment E to Attachment I.1
7	Channel Lengths	Table E3 of Attachment E to Attachment I.1

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1, Criterion 4(a), Criterion 6(1) and Criterion 12 are met.

RAI 4.2-5 *Flooding Determinations*

Please provide a corrected file of "NECR_95_HMS4.2.1" that can be executed by the NRC staff to check the consistency between Attachment G and the "NECR_95_HMS4.2.1" modeling results.

The model, "NECR_95_HMS4.2.1," has been reviewed by the staff. It found that some output data from "NECR_95_HMS4.2.1" model are not consistent with the data shown in Attachments G1 through G16 of Attachment G of Attachment I.1 to Appendix I MILL SITE STROMWATER CONTROLS. NUREG-1620, Section 3.2.3 directs the staff to verify that model input parameters and computational methods are accurate.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1, Criterion 4(a), Criterion 6(1) and Criterion 12 are met.

RAI 4.2-6 *Flooding Determinations*

Please correct the apparent inconsistencies as indicated in the table below. In reviewing the LAR, Appendix I, the NRC staff identified several apparent inconsistencies. The NRC staff provides the table below to show the inconsistencies in the LAR Volume I report. NUREG-1620, Section 3.2.3 directs the staff to verify that computational methods are accurate. With these inconsistencies, the NRC staff is not able to confirm the accuracy of the computational methods.

	Inconsistencies found by comparing		
Items	Place One	Place two	Inconsistency
1	Table 10 of Attachment I.1 shows PMF, 26,764 cfs. for the outlet of Pipeline Arroyo.	Table G1 of Attachment G to Attachment I.1 shows PMF, 26,443.5 cfs.	PMF values
2	Table 10 of Attachment I.1 shows peak flow for a 100-year flood is 4,766 cfs.	Table G2 of Attachment G to Attachment I.1 shows 4,826.2 cfs.	100-year peak flood
3	Table 10 of Attachment I.1 shows peak flows for Temporal Culverts 11 through 16.	Tables G10 and G13 of Attachment G to Attachment I.1 show different peak flows when compared to Table 10.	10-year peak flood
4	On page 2-2, Section 2.4.3 of Volume I, the licensee shows 1-hour PMP. That is 6.5 inches.	Table 2.9-1 of Volume 1 shows the PMP. That is 6.14 inches.	1-hour PMP depth
5	Table G1 of Attachment G to Attachment I.1 shows that a runoff volume is 31.302 inches for the model element "J-R16ds." This runoff volume is larger than 6.14 inches of the PMP depth.	Table 4 of Attachment I.1 shows that 1-hour PMP depth is 6.14 inches.	Runoff volume

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criterion 1, Criterion 4(a), Criterion 6(1) and Criterion 12 are met.

RAI 4.2-7 *Flooding Determinations*

Please add embankment elevations in Table 9 of Attachment I.1 of the LAR.

Table 9 of Attachment I.1, Pond Outlets Specified for Hydrologic Modeling, shows the crest elevations of auxiliary spillways for Ponds 1 through 4. The embankment top elevations of those ponds are not described. These unknown elevations need to be included so that the staff can compare the pond embankment elevations with maximum pond levels for a PMP event to ensure that overtopping flows would not appear in hydrologic simulations. NUREG-1620, Section 3.2.3 directs the staff to verify that model input parameters are accurate.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criteria 1, 4(a), 6(1) and 12 are met.

RAI 4.3-1 *Water Surface Profiles, Channel Velocities, and Shear Stresses*

In Attachment G.7, Tables 5 and 7, please explain how the term ‘dh’ is calculated. Alternatively, please provide a copy of these tables in a format such that the NRC staff can verify the equations used in the calculation. The NRC staff was not able to locate an explanation or source for this number.

NUREG-1620, Section 3.2.3 directs the staff to verify that model input parameters are accurate. Tables 5 and 7 in Attachment G are used in the calculation of the shear stresses for the design of the admixture of the final cover system. During its review, the NRC staff was not able to verify how this number was calculated.

This information is required for the NRC staff to determine whether 10 CFR Part 40 Appendix A, Criteria 1, 4(a), 6(1) and 12 are met.

RAI 4.3-2 *Water Surface Profiles, Channel Velocities, and Shear Stresses*

This is related to the hydraulic jump length in the sunken basin at the bottom of the riprap chute and has two parts (see item a and b below). Please either provide a justification for the licensee’s calculated hydraulic jump length or provide corrected hydraulic jump lengths indicating that the hydraulic jump lengths of PMF and other floods (e.g. 200-yr and 1000-yr floods) are controlled within the sunken basin. Additionally, please either provide velocity distributions or warrant the submerged hydraulic jump within the sunken basin under various tailwater conditions to indicate that the submerged hydraulic jump condition is always in low flow velocity condition without riprap rock protection for the sunken basin.

NUREG-1620, review procedure (4) in SRP section 3.4.2 directs the staff to evaluate the outlet areas of channels to verify that the discharge area is adequately protected. In Section I.7.3 of Appendix I, the licensee stated, “*The sunken riprap basin is designed at the toe of the chute. The basin has a depth of 2 feet and a length of about 100 feet. The hydraulic modeling shows that the hydraulic jump on the chute will be a submerged jump and controlled by the downstream constriction (see Attachment I.7). Therefore, the jump length will not be influenced by the outlet basin length. To account for potential changes in downstream conditions, the length of the outlet basin was designed by assuming that a free jump would form at the toe of the chute and have a length of six times the sequent flow depth (Chow, 1959) for the PMF, approximately 15 feet.”*

a) The licensee calculated hydraulic jump length based on a free jump, which is six times the sequent flow depth. NRC staff independently calculated the hydraulic jump length and determined the length was 120 feet. The licensee’s calculated short hydraulic jump length may be incorrect and not provide enough design length (100 feet) for the sunken basin. Please correct the 100 feet of the basin length shown on Design Drawing 09-11 that should not include the sloping riprap chute length. The Design Drawing 9-11 shows that the riprap rock protection length of outlet apron of the basin is 50 ft and the basin length is 65 feet. Please justify or correct the licensee's computed hydraulic jump length to be confined within the design length (65 ft) of the basin plus the outlet apron length (50 ft).

b) The tailwater at the downstream location can affect the hydraulic jump location and length. Revise or provide additional information or analysis showing that the sunken basin length is sufficient to cover the lengths of hydraulic jump due to lower flows other than the PMF. The licensee may check other flows less than PMF with multiple tailwater conditions, not only a PMF condition. The licensee's design should encompass different hydraulic jump lengths in low flow conditions that are expected and controlled within the licensee's property boundary and the sunken basin.

This information is required for NRC staff to determine if the requirements in 10 CFR Part 40, Appendix A, Criteria 1, 6(1), and 12 are met.

RAI 4.3-3 *Water Surface Profiles, Channel Velocities, and Shear Stresses*

This RAI is related to the riprap chute design and has three parts.

Please either provide a justification as to why the significant variations of the depth-averaged flow velocity at the cross-section A-A exist in a uniform flow depth or provide changes to the modeling result with the corrected input parameters where applicable.

Please either provide a justification as to why the maximum flow velocity of 27 ft/sec is located near the west bank and not near the centerline of the channel or provide changes to the corrected maximum flow velocity and the relevant modeling parameters where applicable.

Please provide a sediment transport calculation to justify the sediment transport in the design channel of the Pipeline Arroyo between the upstream and downstream of the sunken basin limit to be in a natural balance regime. Please provide information to demonstrate that the design of the downstream channel at the sunken basin outlet can convey the sediment without a sediment deposition to migrate the channel alignment.

In Figure 2 of Attachment I.7, the licensee indicated a maximum depth-averaged flow velocity of 27 ft/sec near the west bank. In Figure 3, the licensee showed that the velocities varied from 27 ft/s to 5 ft/sec within a uniform flow depth of approximately 6 feet. The staff has the following questions about these hydraulic modeling results:

a) Figure 3 shows velocities in a trapezoid channel at cross-section A-A. The staff asks if the significant velocity change (27 ft/sec to 5 ft/sec) at the cross-section A-A of a straight channel is physically reasonable. The staff expects the prismatic channel cross section A-A should produce uniform velocity distribution. Please provide the licensee's rationale and technical basis for the significant velocity change in the cross-section A-A.

b) The licensee did not provide support for having the maximum velocity (27 ft/sec) near the west bank (see Figure 2). In general, a curved channel has a maximum velocity near the outer bank, but the licensee's design channel is not a curved. Please provide additional information to support the model results.
c) The sediment transport between the inlet and outlet of the sunken basin should be in balance after the new rock chute is installed in the Pipeline Arroyo or the accumulated sediment could create sand bars to block the narrow stream flow outlet if the sediment transport in the channel is not designed to meet a natural regime. Without calculating the proposed sediment transport, the license cannot have an estimated sediment deposit in and downstream of the sunken basin. The sediment may accumulate in the downstream riprap rock channel after a hydraulic jump in the sunken basin.

This information is required for NRC staff to determine if the requirements in 10 CFR Part 40, Appendix A, Criteria 1, 6(1), and 12 are met.

RAI 4.4-1 *Design of Erosion Protection*

Please either provide a justification as to why the riprap rock protection was not designed for an extension near the downstream narrow channel or provide the extension of the riprap rock zone at the downstream narrow channel between Stations 15+80 and 21+00 shown on the Design Drawing 9-09 of Volume II. Please either provide the design flow velocity at the constriction flow area at the end of sunken riprap basin or provide riprap rock layers for erosion protection. Although Figure 3 of Attachment I.7 shows depth-averaged velocity distribution of Flow-3D modeling results, please provide the similar figures for the constriction flow area at the downstream channel near the outlet of sunken basin, (Stations 16+00 and 22+00). Figure 1 of Attachment I.7 of Appendix I shows the plan view of riprap chute. Design Drawings 9-09, 9-10, and 9-11 of Volume II show details for the riprap chute. This is related to the riprap chute design. Please provide technical documentation supporting the licensee's assumption using 12-inch roughness height for the channel surface to simulate flows in the Flow-3D model.

Lack of scour protection design is observed in the downstream channel at the sunken riprap basin outlet (Approximately at Station 15+80, Design Drawing 9-10 of Volume II).

The contraction flow at the constriction section (Station18+00, Design Drawing 9-09 of Volume II) near the end of the riprap chute can create concentration forces that cause erosion and scouring on the downstream narrow stream banks. The NRC staff observes that the recommended flow velocity for a vegetated channel in NUREG-1623 is 2.5 to 3 ft/sec maximum. NUREG-1620, review procedure (4) in SRP section 3.4.2 directs the staff to evaluate the outlet areas of channels to verify that the discharge area is adequately protected.

This information is required for NRC staff to determine if the requirements in 10 CFR Part 40, Appendix A, Criteria 1, 6(1), and 12 are met.

RAI 4.4-2 *Design of Erosion Protection*

Please evaluate the sediment transport capacity of the channels around the mine waste repository or justify why sedimentation of the channels is not expected to impact transport.

The NRC staff observes that sediment transport of the east repository channel is addressed in Attachment I.4 of the LAR. However, only a brief mention of the potential sedimentation in the North diversion channel is made in Attachment I.5 and it does not appear that potential sedimentation was considered for other drainage features on or adjacent to the mine waste repository. NUREG-1620, review procedure (4) in SRP section 3.4.2 directs the staff to consider potential sedimentation in drainage features.

This information is required for NRC staff to determine if the requirements in 10 CFR Part 40, Appendix A, Criteria 1, 6(1), and 12 are met.

RAI 4.4-3 *Design of Erosion Protection*

Please demonstrate that the lack of a riprap apron where the mine waste cover system meets the existing ground surface will not result in damage to the cover system. Alternatively, the design could be modified to include a riprap apron. The NRC staff's request should be considered for where the 2 percent, 5 percent, and 20 percent slopes meet the existing ground surface.

During its review of the engineering drawings and calculations in Attachment I, the NRC staff was not able to identify the presence of a riprap apron where the cover system over the mine waste repository meets the existing ground surface. The SRP directs the NRC staff to verify that the design follows the guidance that is available in Appendix D of NUREG 1623. The NRC staff observes that NUREG-1623 discusses riprap sizing at the toe of embankment slopes to minimize the potential for damage to the cover system. NUREG-1623 contains recommendations on the size of the rock that should be considered in a riprap apron, as well as the lateral distance the apron should extend from the toe of the slope.

This information is required for the NRC staff to determine if the regulations in 10 CFR Part 40, Appendix A, Criteria 1, 4(c), 4(d), 6(1), and 12 are met.

RAI 4.4-4 *Design of Erosion Protection*

Please revise the LAR to include the results of a petrographic evaluation of the basalt rock considered as a potential rock source. Additionally, please describe the experience and qualifications of the individual who performed the petrographic analysis.

During its review of the rock durability results in Attachment I.8 of the LAR, the NRC staff observed that a petrographic analysis was performed for the Tampico Pit limestone and the Page pit granite. However, the NRC staff was not able to locate the results of petrographic analysis for the basalt rock source. Additionally, the LAR does not appear to describe the background, qualifications, or experience of the individual who performed the petrographic analysis for all of the rock durability test results. The guidance in NUREG-1623, Appendix D suggests that a petrographic analysis should be performed for all potential rock sources and that the evaluation should be performed by a geologist or engineer experienced in this type of analysis.

This information is required for the NRC staff to determine if the regulations in 10 CFR Part 40, Appendix A, Criterion 1, Criterion 4(c), Criterion 4(d), Criterion 4(f), Criterion 6(1), and Criterion 12 are met.

RAI 4.4-5 *Design of Erosion Protection*

Please revise the technical specifications included with the LAR to include: (1) a methodology and testing frequency for gradation of the riprap and cover soils; and (2) a methodology and testing frequency for layer thickness testing. Alternatively, please describe to the NRC staff where or how the existing technical specifications address these issues.

During its review of the proposed technical specifications included in Appendix J of the LAR (specifically specification 02200 for earthwork and 02273 for riprap), the NRC staff was not able to identify the specifications for the gradation for the materials used in the cover system and riprap used in the channel linings and Pipeline Arroyo. Additionally, the NRC staff was not able to locate where the specifications addressed verification of the in-place thicknesses of the cover system soils or the rip rap placed in channel linings around the mine waste repository (and Pipeline Arroyo). The review procedures in Section 3.4.2 of the SRP direct the NRC staff to consider construction considerations of the proposed activities. Without this information, the NRC staff is unable to verify that the licensee will be able to construct the mine waste repository in a manner that is consistent with the proposed design.

This information is required for the NRC staff to determine if the regulations in 10 CFR Part 40, Appendix A, Criterion 1, Criterion 4(c), Criterion 4(d), Criterion 4(f), Criterion 6(1), and Criterion 12 are met.

RAI 4.5-1 *Design of Erosion Protection Covers*

Please either clarify that the analyses related to erosion control in the Attachments G.7, G.8, I.1 (for the mill site post-RA conditions), I.2, I.3, I.4, I.5 are based on the cover and associated drainage features for the mine waste repository in an optimal condition or whether the analyses reflect a degraded scenario. The NRC staff recognizes that a degraded scenario could occur either when no vegetation is present on the cover system, potentially leading to higher peak flows; or when vegetation is present in the repository drainage channels, potentially leading to decreased flow capacity. Alternatively, revise the LAR to include an analysis of the erosion control aspects of the cover system that reflect potential changes.

In reviewing the calculations in Attachments G and I of Appendices G and H of the LAR, it appears that the licensee has only considered a situation where the cover is functioning as intended. However, Section 3.5.2 of the SRP provides that the NRC staff evaluate the shear stresses and permissible flow velocities over the cover with potential changes that could occur in the long term. Examples of this would include: lack of vegetation; vegetation succession; or general cover degradation. The NRC staff understands that the licensee has designed the mine waste repository to not require active maintenance. The NRC staff observes that the lack of vegetation on the cover system could result in significantly higher peak flows over the cover system and in the drainage features surrounding the mine waste repository than would otherwise occur assuming normal cover performance.

This information is required for the NRC staff to determine if the regulations in 10 CFR Part 40, Appendix A, Criterion 1, Criterion 4(b), Criterion 4(c), Criterion 6(1), and Criterion 12 are met.

Section 5 - Protecting Water Resources

RAI 5.1 *Protecting Water Resources*

Please revise the application to include a groundwater monitoring program to detect additional contaminant seepage from the tailings as a result of the overlying weight of the mine spoils and compaction of the tailings.

The results of Consolidation and Groundwater Evaluation Report (Dwyer Engineering, 2018) concluded that the estimated amount of consolidation and reduction in porosity in the tailings due to added weight from placement of the mine spoils and ET Cover on the existing impoundment will not result in an increase in groundwater flux into the underlying groundwater from the tailings impoundment. The analysis, however, involved certain assumptions (e.g., constant permeability in the tailings, and time-invariant relationship between void ratio and effective stress among others) that were not fully supported in the LAR. The report also stated that any drainage from the tailings will be captured within the underlying alluvium, but no further detailed analysis was provided.

The staff notes that the water holding capacity of the unsaturated alluvium material below the tailings may also be reduced during consolidation due to the weight of mine spoils. In addition, the significance of capturing the drainage in the alluvium beneath the mill tailings material may be questionable because the alluvium is not consistently present beneath the mill tailings. For example, mill tailings located in the north and east of the North Cell were placed directly on the Zone 3 outcrop and Borrow Pit No. 2 was excavated into the Zone 1 subcrop (Canonie Environmental, 1987).

Other evidence of mill tailings seepage directly migrating into Zone 3 includes persistently low pH values observed in the groundwater just downgradient of North Cell due to lack of alluvial materials that have significant amount of acid-buffering capacity whereas Zone 3 itself has little acid-buffering capacity (Hatch Chester, 2019; Canonie Environmental, 1991). Given the large uncertainties and inconclusive aspects of the consolidation analysis with regards to assessing additional water flux and associated contaminant transport from the future impoundment to the groundwater, and given that the groundwater (with seepage from mill tailings) in Zone 3, for example, had historically followed different flow paths (Canonie Environmental, 1987), the current site groundwater monitoring program needs to be re-evaluated and modified if necessary to be able to verify impacts on the groundwater and to assess the performance of the ET Cover after mine spoil disposal and ET Cover completion.

The licensee could propose a groundwater monitoring program, including a monitoring well network (number of monitoring wells, well depths, and locations), and sampling schedule and monitoring parameters. The proposed groundwater monitoring program would account for the geologic and hydrogeologic features near the tailings impoundment. The geometry of mine spoils placement and the contacts with the alluvium materials and Gallup Sandstone may have significant influence on future groundwater flow and contaminant migration possibly to the SW Alluvium, Zone 1 or Zone 3 if release of additional groundwater from the mill tailings occurs.

UNC needs to evaluate and determine whether the current groundwater monitoring network for the mill tailings impoundment is adequate or needs to be modified in order to monitor the potential groundwater impact possibly resulting from the placement of mine spoils and ET Cover in the mill tailings impoundment.

This information is required for the NRC staff to determine if the regulations in 10 CFR Part 40, Appendix A, Criterion 7.

References

10 CFR Part 20. *Code of Federal Regulations*, Title 10, *Energy*, Part 20, "Standards for Protection Against Radiation."

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US Nuclear Regulatory Commission (NRC), 1997. Seismic Evaluation of Church Rock Tailings Impoundments, September 1997. [ML19198A003]

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US Nuclear Regulatory Commission (NRC), 2002. NUREG-1623, "Design of Erosion Protection for Long-Term Stabilization," September 2002. ADAMS Accession No. [ML022530043]