Department of Energy (DOE) Office of Legacy Management (LM) Comments on the *Safety Evaluation Report (SER) of License Amendment Request, dated September 24, 2018, United Nuclear Corporation (UNC) submitted a request to the U.S. Nuclear Regulatory Commission (NRC) to amend its Source Materials License No. SUA–1475 for the former UNC Church Rock uranium mill and tailings site under the requirements specified in Title 10 of the Code of Federal Regulations (10 CFR), Part 40, Domestic Licensing of Source Material*
Materials License No. SUA-1475, Docket No. 040-08907, United Nuclear Corporation, June 21, 2021

1. Settlement: *Reference:* Section 3.3 Settlement, Subsection 3.3.3 Staff Review and Analysis, NRC states "The NRC staff observes that the immediate settlement in this portion of the tailing cell will range from 0.1 to 1 ft." In its evaluation, "the NRC staff concludes that the settlement calculations present information needed to demonstrate compliance with 10 CFR Part 40, Appendix A, Criterion 6(1)."

   Comment: LM has seen depressions form at Bluewater, Maybell West and Sherwood. And, as detailed on pg. 63 ponding is already occurring on the disposal cell. At the midpoint of a 50-foot span with a 2% grade, a one ft differential settlement occurrence could create a grade reversal. NRC should ensure the impact of ponding and differential settlement is considered in the ET cover design enough so that NRC will either accept whatever settlement occurs and accept the impacts of that settlement or require differential settlement/ponding to be repaired. The potential for additional maintenance in the future should be considered in determining the long-term surveillance fee.

2. Borrow Source. *Reference:* Section 3.5 Disposal Cell Cover Engineering Design, Subsection 3.5.3 Staff Review and Analysis

   Comment: Side slopes of 5H:1V, or 20-percent, are concerning with the new cell cover because an identical gradient also exists at the northeast side slope on the Mexican Hat disposal cell. LM recently completed a forensic geotechnical investigation to understand why the northeast side slope is eroding at Mexican Hat. At the Mexican Hat site, the cover soil is silty fine sand, with low plasticity, low cohesive strength, low bulk-density (in the 105 pounds per cubic foot range), and the cover is subject to accelerated erosion because the soil is dispersive and susceptible to piping. The NRC's standard review plan does not specifically evaluate the question of dispersive soils. Similarly, the SER does not mention anything with respect to the cover soils and their suitability to resist piping erosion. DOE acknowledges the proposed Church Rock design does not include a layered side slope, or a sodium bentonite amended radon barrier, which are also likely contributing factors to the erosion at Mexican Hat.

Upon review of LAR (2018) Appendix H, and MWH (2014) Table 3-5 Summary of Geotechnical Laboratory Data – Borrow Areas, LM suggests that additional soil dispersion testing be performed on West Borrow, North Borrow, and Dilco Hill borrow sources. Pinhole dispersion tests (ASTM D4647) were performed on a subset of samples, with the majority keying out as slight-to-moderately dispersive (ND3/ND4). Upon review of MWH (2014) appendices, no lab reports for pinhole dispersion testing were found, and further analysis of results to determine specimen performance under variable hydraulic head and flow rate, was not possible.

Most authors consider it necessary to use more than one test to ascertain the dispersity of a soil, specifically transitionally dispersive soils common to the four corners region. Sherard and Decker (1977) suggest four tests should be performed: double hydrometer (ASTM D4221), pinhole (ASTM D4647), crumb test (ASTM D6572), and chemical tests (i.e. extractable cations by saturated paste, exchangeable complex, and cation exchange capacity, using agricultural methods to account for calcium interference).

Soil sections observed in the West Borrow and North Borrow areas display low plasticity (PI ranging from 3-11) and a high percentage of soil layers have SC-SM and SM USCS classifications that are not considered suitable for disposal cell construction (NUREG 1620, Section 2.5.3). Based on limited data reported for materials in these borrow areas, materials have moderate vulnerability to erosional piping (Sherard 1953) and high to extreme internal erosion risk (ICOLD 2015; USBR 2019). Such erosion risks are further elevated under duplex soil conditions, which likely include the textural transition from mine spoils to cover soil (at ~4.5 ft from ground surface), particularly for shallower cover soil profile locations. Should these materials be used, such impacts from any cover degradation from subsurface erosion are extremely unlikely to mobilize tailings given the very thick section of low contaminant mine waste rock above the tailings. However, impacts from erosional piping and soil loss may degrade vegetation and ET cover performance which could result in unwanted percolation of meteoric water into mine waste rock and potentially the tailings below. LM's concern for piping is over the entire cover, however, our primary concern is the 20% side slopes and where there are grade changes.

Based on review of 2018 Geotechnical Data Report Church Rock Mill Site Jetty, and amendments occurring throughout 2019, the exclusive use of Jetty excavation soils (as discussed in NRC 2020 Section 3.7.3) for ET cover materials could mitigate the above concerns with borrow materials from the West Borrow, North Borrow, and Dilco Hill areas given higher plasticity and fines content of Jetty soils. Given the presence of subsurface erosion in the region, LM recommends additional characterization of borrow soils for their vulnerability to erosional piping (e.g. Sherard 1953) and internal erosion risk (e.g. ICOLD 2015; USBR 2019).

3. Regulatory Requirements: *Reference:* Section 3.6 Construction Considerations, Subsection 3.6.1 Regulatory Requirements, NRC states "the mine waste material is not directly regulated by the NRC".

   Section 7.2 Applicable NRC Guidance states: "A concurrence and commitment from either DOE or the State to take title to the tailings impoundment after closure must be received before granting the license amendment to the 11e.(2) licensee."

   Comment: The statement regarding not directly regulated by NRC is not clear and needs additional clarification. Based on discussions between EPA, DOE, and NRC since the SER was provided to DOE for review, we are under the impression that all the parties agreed to view the entire cell as a system rather than having sections of cell regulated by one agency and not another. If maintenance was needed because of something that was detected during LTS&M of the site, DOE would be concerned that segmenting responsibility for portions of the disposal cell could delay action being taken.

4. Vegetation Requirements: *Reference:* Section 3.7 Infiltration and Hydraulic Conductivity of the Repository and Its Cover Subsection 3.7.3 Staff Review and Analysis, NRC states "Perennial vegetation initially established on the cover was unintentionally succeeded by annual species that had a lower wilting point potential (higher water content at the wilting point), shallower roots, and a shorter period of active transpiration, thereby allowing more water to stay in the water storage layer and eventually move downwards."

   Section 3.7 Infiltration and Hydraulic Conductivity of the Repository and Its Cover Subsection 3.7.4 Evaluation Findings, NRC states "Additionally, the documents in the LAR, its references, and the NRC staff's review also have provided sufficient evidence indicating that a full vegetative cover on the repository is likely to be self-sustaining in current climatic conditions."

   Comment: DOE would like clarification on what NRC will expect of the licensee in terms of vegetation establishment and maintenance at least prior to transfer of the site to DOE for LTS&M. Is unintentional succession anticipated to continue to occur? An evaluation of effect of climate change on vegetation and maintenance should be conducted. Maintaining vegetation on the cover for effective ET should be detailed in the scope for LTS&M and should include expected changes. The potential for additional maintenance in the future should be considered in determining the long-term surveillance fee.

5. Modelling Uncertainty: *Reference:* Section 3.7 Infiltration and Hydraulic Conductivity of the Repository and It's Cover, Subsection 3.7.4 Evaluation findings, NRC states "Although the range of parameters assumed in the LAR for future precipitation rates, precipitation duration, snow cover, temperature and sunshine, vegetation type, root depth,

and changing hydraulic conductivities due to developing soil structures will likely bound infiltration rates so that excessive seepage impacts will not be created, it cannot be excluded due to aleatory uncertainty, e.g., future meteorological phenomena may occur to drive infiltration rates higher and/or the cover may evolve in unexpected ways."

Section 3.7 Infiltration and Hydraulic Conductivity of the Repository and Its Cover Subsection 3.7.3 Staff Review and Analysis, NRC states "Unfortunately, the sensitivity runs end when the fill layer has reached a more average soil suction value, and a conceptual model of water flow after this point is unclear. Also unclear is why the fill layer in Profile B2 should become saturated as described above in a mere dozen years with an initial soil matric potential value of -2,692,958,106.4 cm, or -1,060,200,000 in, i.e., similarly dry as the fill in Profile. This lack of clarity is part of the reason the NRC staff is modifying the license condition related to ground water monitoring. This is further discussed below in Section 3.7.4."

Comment: LM agrees with the uncertainties in the modeling identified by NRC. Notable uncertainties and recommendations include:

Sensitivity analysis for UNSAT-H model simulations could be performed to include absolute worst-case scenarios to determine parameter values needed to reach the threshold of net seepage into mine waste and mill tailings. Such worst-case model parameters could include:

a) The seasonality of precipitation. "less than half of the annual precipitation occurs during the summer months when PET is highest."
   i. It is unclear if antecedent soil moisture conditions from the melting of snowpack, and subsequent early spring rainfall during low PET times of year, under worst case conditions were considered in the sensitivity analysis. It does not appear that such model output was reported.
   ii. If not, LM recommends a more conservative UNSAT-H model simulation be considered, on an annual time scale, to account for incremental worst-case scenario antecedent soil moisture conditions under snowpack and spring rains when PET is low.

b) Soil condition. Ksat values from natural analogs are used for model input parameters. These values are presented in Table 13 – Table 15 in SUA 2018 Appendix H. These values range from 2.12E-04 - 3.70E-04 cm/s in the top foot of soil, and 3.40E-05 - 7.00E-05 cm/s at depths ranging from 2-4.5 ft below ground surface. Given the limited cross-sectional area of the infiltrometer used in the study, larger and more widely spaced macropores (more common at depth in semi-arid environments) may not have been adequately captured in Ksat measurements. As such the use of larger diameter block samples are suggested. Large diameter block sample tests have been conducted at UMTRCA analogs and

Ksat values (at depths between 2-6ft) range from 3.69E-04 - 4.38E-04 cm/s at Bluewater, NM, 1.35E-04 – 4.06E-04 cm/s at Falls City, TX, and 3.06E-04 – 3.20E-04 cm/s at Lakeview, OR (NUREG/CP-0312). The analog at Bluewater is most representative of Church Rock conditions.

i. LM recommends that a conservative UNSAT-H model simulation consider Ksat values in the 3.0E-04 cm/s range through the depth of the ET cover profile.
ii. More conservative Van Genuchten parameters (the measured values at 1ft depth) could also be applied to all soil depths to generate the most conservative conditions.

c) Vegetation condition. Given uncertainties with climate change, it is possible that PET may decrease over cover design life given vegetation shifts.
   i. The inclusion of a climate change analog of the cover (hotter and drier conditions) could inform longer term vegetation condition.

6. Pipeline Arroyo Chute: *Reference:* Section 4.3 Water Surface Profiles, Channel Velocities, and Shear Stress, Subsection 4.3.3, Heading 4.3.3.1 Pipeline Arroyo, NRC states "Performance concerns with the riprap jetty in the Pipeline Arroyo have been documented (NRC, 2003a). These composited aspects of the site and performance to date make the integrity of the riprap chute, and potential need for maintenance more uncertain in the long term. The NRC staff therefore cannot conclude with reasonable assurance that the proposed design will provide control of radiological hazards for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. As discussed in more detail in SER Section 4.3.3.4, the NRC staff is therefore imposing a license condition requiring an observation period prior to license termination to verify that the design is function[al] as intended. Additionally, the observation period will allow for an informed decision related to the anticipated life span of the design and any long-term surveillance, maintenance, and funding needs for the revised approach to site stability, considering past performance and significant uncertainties discussed above. The license condition allows the licensee to demonstrate compliance using a performance-based approach."

   And Heading 4.3.3.4 Stability of Riprap Chute in Pipeline Arroyo, NRC states "The NRC staff performed an independent assessment and recognizes there is uncertainty with the forces acting on the riprap in a hydraulic jump. The NRC staff considers that the erosion protection features will likely require active maintenance over the performance period because of the unique aspects of the site. The NRC staff further concludes that the licensee has not demonstrated that hydraulic design features can sustain the impact forces resulting from hydraulic jumps at the narrow outlet channel near the end of the riprap chute."

Comment: Because the performance period for the design is effectiveness for 1000 years to the extent reasonably achievable, and, in any case, for at least 200 years, observing the performance for only five years may not be sufficient to identify deficiencies that would affect long term performance. Designing for the PMP requires the engineering remedy is overbuilt to withstand the forces of nature for the long term. What is the probability that a low-frequency storm event will carry a high-enough intensity to test the design over a period of five years? DOE recommends that it would be more prudent to test the design with a percent-of-PMP approach rather than a fixed period.

LM recommends considering climatic conditions during the observation period. If the NRC is unsure about the forces resulting from the hydraulic jump, shouldn't this require additional analysis then by the licensee? The potential for erosional issues and costly maintenance in the future should be considered in determining the long-term surveillance fee.

7. Pipeline Arroyo Chute: *Reference:* Northeast Church Rock Project, Revised 95% Design Submittal – July 2018, Volume 2 – Design Drawings.

   Comment: The following are additional comments regarding the Revised 95% Design Drawings.

   a. Sheet 9-10, Mill Site Repository Area Stormwater Controls, Riprap Chute Sections: Design drawings should include a cross-section of the crest of the rundown, providing details of station location, elevations, crest width, riprap side slopes, and water surface elevation (WSE) of the PMF. As the long-term custodian, DOE can utilize this important information without having to retrieve it from electronic CAD data interpolation.
   b. Sheet 9-09, Mill Site Repository Area Stormwater Controls, Riprap Chute: The area of disturbance delineated on this drawing does not realistically provide the actual area of disturbance. A constructability review will determine potential access roads, temporary staging areas, and other requirements to safely and efficiently construct the riprap chute. These constructability requirements will alter the geometry of the channel and the area of disturbance. The proposed models used to design the channel may be compromised, depending on the extent of disturbance required. A constructability review should be performed and subsequently, the design re-evaluated for applicability. In addition, access for future maintenance along the chute needs to be part of the design which may mean making "temporary" construction roads permanent.
   c. Sheet 9-11, Mill Site Repository Area Stormwater Controls, Riprap Chute Details, Detail #2B, Typical Chute Riprap and Bedding Detail, and Appendix I, Attachment I.3, Filter Compatibility Calculations for Mill Site and Mine Site Stormwater Controls: There is a large gradation gap between the top filter layer and the 27-inch riprap. Our concerns are the interstitial velocities in the area of

the hydraulic jump where the top filter layer could effectively become a wearing layer as particles are slowly removed. NUREG 1623 was used to design the filter at the bottom of the Pipeline Arroyo Chute. DOE does not believe that NUREG 1623 is the correct design guidance criteria for this application. DOE suggests you consider the following references as well: *U.S. Department of the Interior, Bureau of Reclamation (BOR), 1987. Design of Small Dams* https://www.usbr.gov/pn/programs/ea/wash/potholes/techreport-alta-attachmentK.pdf and Mishra, S.K., J.F. Ruff, 1998. *Riprap Design for Overtopped Embankments. Final Report*. Prepared for U.S. Bureau of Reclamation. https://www.usbr.gov/tsc/techreferences/hydraulics_lab/pubs/PAP/PAP-0809.pdf. Both could be useful.

d. All Sheets, Mill Site Repository Area Stormwater Controls: There are no details providing tie-in information of the proposed improvements to existing ground. (i.e., riprap and filter tie-in to existing ground along graded slopes and base of structures). If this is not addressed during the bidding process, it may prompt an RFI (request for information) during construction and subsequently lead to a change order. Leaving this detail to the construction contractor's discretion could potentially be problematic.
e. Sheet 9-10, Mill Site Repository Area Stormwater Controls, Riprap Chute Sections, Detail D, Section D: At Station 3+00, the armoring of the inlet apron above the crest of the rundown may need to be longer than 50 feet. The velocities shown in Appendix I, Attachment I.7 could cause significant scour.
f. Will there be specific notes or information describing how riprap should be placed in the channel? What Quality Assurance and Quality Control measures/requirements are being proposed for construction activities to ensure the riprap bedding filter layers are placed to specification?

8. Report Figures: *Reference:* Subsection 5.3.2 Mill Tailings Impacted Hydrogeologic Units and Subsection 5.3.4 Groundwater Monitoring Network

   Comment: Either referencing reports or adding figures to show potentiometric maps of Zone 1 and 3 and figures with different symbols for wells in each unit (alluvium = circle, zone 3 = triangle, zone 1 = diamond) and color code by contaminant concentration, if applicable, would help**.**

9. Additional Groundwater Monitoring: *Reference:* Subsection 5.3.1 Groundwater Compliance, NRC staff observes that "the mill tailings and groundwater would not be impacted by the disposition of mine spoils at the current impoundment, but with unacceptably large uncertainties." To address the uncertainties primarily due to the parameters associated with climate, vegetation and hydraulic properties, NRC proposed additional groundwater monitoring wells be added to the current groundwater monitoring network at the site, with water level measurements along with water quality monitoring as well.

Section 5.4 Evaluation Findings, NRC requires: "that quarterly measurements of water levels and water quality sampling results from the following monitoring wells, EPA 5, 614, 515A, and 604 in Zone 1, EPA 23,509D, 802, 803, 807, and 808 in SW Alluvium, and 613, 701, and 702 in Zone 3 be used to measure any seepage resulting from the placement of the mine waste. These wells are located immediately downgradient of the mill tailings impoundment in each Zone. Wells that go dry should also continue to be checked for the reemergence of water on a quarterly basis. The findings should be included in the annual site monitoring report."

Comment: NRC neither indicates how long this activity is to continue, nor whether it will be incumbent on LM to perform this activity after the license is terminated. LM requires clarification concerning NRC's objectives on this and to what extent EPA will be a partner. DOE asks NRC to discuss with EPA whether this scope will be part of and what it may require of the licensee under its CERCLA authority.

If NRC expects LM to continue quarterly monitoring in the long term, then we request that NRC require the licensee to submit forecasts that "require robust technical bases with supportive evidence to significantly reduce associated uncertainty." LM must be assured that either EPA or NRC will exercise enforcement authority and reengage the licensee if there is unacceptable performance of the groundwater remedy. LM requests EPA and NRC attorneys participate in discussions with DOE attorneys to find acceptable resolution to this unacceptable risk. Dual regulation could work if LM had a teaming arrangement with EPA, who can then reengage the licensee to cure latent defects.

In addition, LM recommends the use of transducers to monitor groundwater levels at selected locations rather than quarterly sampling. Transducers will not only provide a more complete record of long-term water level changes but also monitor short-term variations that can be missed by quarterly measurements. An example would be a flood event that could significantly raise water levels temporarily. Transducers can also be used to monitor key wells that are transitioning to permanently dry as water levels drop over the long-term. Episodic periods of saturation may be missed by quarterly measurements.