ATTACHMENT E

Peer Review of Stantec (2021) and INTERA (2021) Technical Memoranda by Dr. Leslie Smith, Professor Emeritus, University of British Columbia

To: Mr. Lance Hauer, United Nuclear Corporation

From: Leslie Smith, Ph.D., P.Geo.

Date: November 9, 2021

Re: Assessment of Hydrogeologic Impacts of Backfilling St. Anthony Mine Pit 1, New Mexico

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In this memo, I provide my comments on the assessments undertaken to evaluate the potential hydrogeologic impacts of backfilling the St. Anthony Pit 1 to an elevation above the contact between the Jackpile Sandstone and Dakota Sandstone. The concept includes incorporation of a horizontal layer of very low hydraulic conductivity within the backfill to reduce upward flow of poor-quality groundwater from the Jackpile to the Dakota Sandstone. Two memos were reviewed to prepare this opinion:

INTERA - Pit 1 Backfill at St. Anthony Mine, Groundwater Rebound in the Jackpile Sandstone and Flow into the Dakota Sandstone, memo dated November 5, 2021.

Stantec - Evaluation of Constructing a Hydraulic Barrier to Prevent Vertical Groundwater Migration in St. Anthony Pit 1, memo dated November 4, 2021.

INTERA Memo on Groundwater Rebound in the Jackpile Sandstone

Two important features of the current hydrogeologic setting are relevant to the backfill concept. First, the existing groundwater flow pattern in the vicinity of Pit 1 reflects the effect of evaporative losses from the water pool located on the floor of the pit, creating a hydraulic sink in the regional potentiometric surface for the Jackpile Sandstone. On the pit floor, the water table is approximately at elevation 5850 feet. Second, beyond the immediate region of the open pit, kaolinitic cements in the upper part of the Jackpile Sandstone limit upward flow of poor-quality groundwater into the Dakota Sandstone. If Pit 1 is backfilled with mine waste materials to an elevation above the base of the Jackpile / Dakota contact, the potentiometric surface for the Jackpile will rebound and trend toward the pre-development condition set by the regional hydraulic gradient in the area.

It is understood that INTERA previously developed a three-dimensional groundwater model that indicates for a pit backfill elevation of 5975 feet, the potentiometric surface in the Jackpile would rebound to an approximate elevation of 5960 feet, a level well above the Jackpile / Dakota contact at elevation 5924 feet. This model prediction is considered reasonable, given the regional groundwater head map for the Jackpile Sandstone.

The rebound in the potentiometric surface will create a vertical hydraulic gradient driving seepage upward through both the pit backfill and the excavation damage zone located behind the pit wall. Two conditions are then established: 1) a hydraulic gradient that drives upward groundwater flow; and 2) a pathway through the backfill material that creates a hydraulic connection between the Jackpile Sandstone and Dakota Sandstone that currently does not exist. In addition, seepage will occur in the excavation damage zone behind the pit wall as the water table rebounds. The quantity of the seepage along each pathway will depend upon the vertical hydraulic conductivity of the backfill material and of

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the excavation damage zone, and any barriers that might be constructed to impede that flow.

INTERA, using a Darcy Law calculation, has estimated for different values of hydraulic conductivity the volume of seepage through the pit backfill incorporating the concept of a 10-foot thick barrier layer and sealing of the damage zone. I view this calculation as well suited to demonstrate the potential magnitude of the flow that could eventually enter the Dakota Sandstone. The Darcy law calculations suggest that a barrier constructed at the limits of demonstrated technology with a low vertical hydraulic conductivity of 10^{-8} cm/s, a seepage flow of about 1000 m^3/year from the Jackpile Sandstone to the Dakota Sandstone could occur.

INTERA indicates groundwater entering the unsaturated Dakota Sandstone for a backfilled pit can be expected to migrate as a wetting front in a down dip direction toward the region where the regional water table creates saturated conditions in the Dakota Sandstone. I concur with this conclusion.

Stantec Memo on Constructing a Hydraulic Barrier to Prevent Vertical Groundwater Migration

The findings presented in the Stantec memo concerning the ability to construct a hydraulic barrier within the pit backfill, and to seal the excavation damage zone behind the pit wall, are sound. My experience indicates hydraulic barriers constructed using state-of-the-practice construction techniques, appropriate materials and rigorous quality control / quality assurance procedures, typically achieve hydraulic conductivity values in the range from 10^{-8} to 10^{-7} cm/s. I support Stantec's conclusion that an effective vertical hydraulic conductivity of 10^{-8} cm/s is at the lower end of demonstrated technology. Increasing the thickness of a hydraulic barrier will delay the arrival of the wetting front at the contact with the Dakota Sandstone but would not prevent the eventual upward movement of groundwater into the Dakota Sandstone. Note that backfill placed below the barrier would need to retain sufficient hydraulic conductivity to transmit the regional flow component in the Jackpile Sandstone.

Localized cracking of a horizontal barrier, due to differential settlement of backfill material placed between the current pit floor and the base of the hydraulic barrier, is a risk to barrier performance that cannot be discounted, even with a high standard of construction. This cracking could markedly increase the effective hydraulic conductivity of the barrier layer. Furthermore, it could take several decades after backfilling for the effects of differential settlement to be expressed, so it would not be possible in the near term to confirm the numeric value of hydraulic conductivity of a constructed barrier which controls the long-term hydraulic behavior of the backfill.

Sealing an extensive damage zone in the upper Jackpile Sandstone around the pit wall using grout techniques will not be able to reasonably achieve a hydraulic conductivity that is sufficiently low to prevent upward seepage through the damage zone. Further, the scope of such an effort would be immense, with worker safety a paramount concern. I support Stantec's view that reducing the hydraulic conductivity in fractured rock to about 10^{-6} cm/s is a common circumstance, when following a well-executed grouting program. Values of hydraulic conductivity orders of magnitude lower than this do not seem achievable, and confirmation of seal performance likely not feasible in this setting.

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Geomembrane liner installation on the pit walls would require considerable effort to develop a suitable bedding layer for liner placement and to form a secure seal to the wall, all in a challenging work environment. With respect to using a geomembrane liner to form a horizontal barrier within the backfill material, I concur with Stantec's discussion of liner leakage characteristics.

Setting aside the lack of precedent in constructing such low permeability barriers using mine waste materials, a final important issue, in my view, concerns the difficulties associated with confirming that hydraulic conductivities of the in-pit barrier and the excavation damage zone at or below demonstrated values have been achieved. The residual uncertainty in declaring that design values to prevent seepage have been achieved is likely to be uncomfortably large.

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