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TECHNICAL MEMORANDUM

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TO: Ted Grandy, Catherine Clark
Lithium Nevada Corporation

FROM: Tyler Cluff
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RE: **Clay Tailing Filter Stack (CTFS) Unsaturated Flow Modeling Revision 1**

INTRODUCTION

This technical memorandum has been prepared at the request of Lithium Nevada Corporation (LNC) to estimate infiltration through the Clay Tailing Filter Stack Facility (CTFS) upon permanent closure. Seepage through the CTFS will be controlled by unsaturated flow governing equations because i) clay tailings will be mechanically and naturally dried to near optimal moisture content prior to stacking, and ii) a store and release cover will be placed upon closure to eliminate / reduce infiltration to the facility. The objectives of this analysis are:

- Estimate long term infiltration through the proposed store and release cover;
- Estimate draindown from residual pore water present in clay tailings for water management.

This analysis includes a sensitivity designed to consider sectors of the CTFS which may be exposed to greater precipitation and/or snow cover (i.e. north facing slopes) and addresses the effect of non-structural material on the hydraulic conductivity of the tailings.

The CTFS will be constructed on a single lined synthetic liner as proposed in the engineering design report (Newfields, 2020). The engineering design provides that the CTFS will be fully lined with an HDPE geomembrane, with two feet of material as overliner and underlain with a six-inch liner bedding material. The facility will include an underdrain collection system above the geomembrane to collect drainage from the stack. Drainage from the stack will report to the geomembrane lined reclaim ponds.

- 12-inch layer of run of mine waste rock will underlay the growth media. This material is designed as a coarser grained layer to reduce erosion, supply a material buffer should an isolated rill come in contact with surface runoff, and support deeper root growth.

Alluvium growth media and waste rock hydraulic properties were previously characterized in the Thacker Pass Project Water Quantity and Quality Impacts Report (Piteau, 2020). A schematic of the CTFS closure design is provided in Figure 1.

APPROACH

The analysis followed the approach and methodology utilized to simulated infiltration through Waste Rock Storage Facility (WRSF) and coarse gangue stockpiles in the Thacker Pass Project Water Quantity and Quality Impacts Report (Impacts Report) (Piteau, 2020). Model configuration was adjusted to reflect the CTFS geometry, including the modified store and release cover, and material properties. A summary of the model approach is as follows:

- Identical meteorological boundary conditions were used as in the Impacts Report.
- A seepage face was employed as the lower boundary conditions.
- Root water uptake was simulated using the same Feddes parameters; however, the root length density was adjusted to reflect the thicker store and release cover and truncated so roots would not extend into clay tailings. A root density to a depth of 0.6 m, following that found by Winkler for Nevada climate was used (Winkler, 1999).
- Hydraulic properties for growth media and waste rock materials were identical to those used in the Impacts Report (Table 2). CTFS materials were assigned hydraulic properties based on geometrically averaged values from soil testing.
- Two suites of Hydrus 1D models were developed to assess i) potential infiltration through the CTFS cover and ii) draindown from residual water within clay tailings present during stacking. Brief descriptions of the Hydrus 1D model are as follows:

  Infiltration models: A 10-meter thick model was developed to simulate long term infiltration through the CTFS store and release cover. Because of the very long equilibration period (due to the low hydraulic conductivity of clay tailings), it was more practical to breakout the infiltration model separately. Initial water contents were recycled through until equilibrium was reached in the clay tailings (i.e. water contents did not change). Equilibrium seepage rates were then estimate using the unsaturated models. Several sensitivities were run for this configuration to assess infiltration.

  Drain down model: A 58.5-meter thick (192 ft) model was developed to simulate the drain down from residual water content in clay tailings. Initial water content for materials was 23% - 46% as described in Table 2. The simulation was run for a 1,000 year period. All other model inputs were identical to the infiltration model.

  It should be noted that clay tailings will be dried and stacked at near optimal moisture content, thus the materials are unsaturated upon placement and are not anticipated to produce any meaningful seepage. The purpose of this exercise is to validate the concept.

A side-by-side summary of both configurations are shown in Figure 2. Flux values from the 1D Hydrus models were multiplied by the facility footprint to assess the total seepage rate.

- Six sensitivity analyses were run for the infiltration model configuration to evaluate the potential variation that may be encountered during closure. The sensitivities are described as:

  Alternate clay tailings: Clay tailings material were assigned hydraulic properties of silty loam from the HYDRUS database. The key element is that hydraulic conductivity was raised by two orders of magnitude to 1.2×10^{-4} cm/s.

  No transpiration: Plant transpiration was turned off in this sensitivity to assess the effect of root uptake in controlling infiltration.

  Decreased Potential Evaporation/Transpiration: PET rates were decreased by 15% to assess the effect on infiltration. This is more robust than adjusting precipitation rates because it does not need to account for the episodic occurrence of precipitation.

  12-inch cover: An alternative cover configuration utilizing only 12-inches of growth media was used to simulate infiltration. This is a similar cover design as the waste rock facilities and coarse gangue facilities.

  Cover only: This sensitivity only simulated the upper 24-inch cover material. No tailings were simulated. The lower boundary condition at the bottom of the cover was simulated using a deep drainage boundary condition, meaning that the lower boundary simulated the same water content and unsaturated hydraulic conductivity to permit pore water to drain out of the model.

  Precipitation x 2: This sensitivity multiplied daily precipitation by a factor of 2. The frequency of rainy days remained the same with double the magnitude. The cumulative effect doubles precipitation, but maintains the lower PET measured on rainy days. This sensitivity is designed to consider sectors of the CTFS which may be exposed to greater precipitation and/or snow cover (i.e. north facing slopes).

All Hydrus models conservatively simulate infiltration in the structural zone (i.e. clay tailings), because the clay tailing material has been shown to possess greater hydraulic conductivity than the composite salt / clay tailings. The non-structural zone will have less infiltration than the structural zone, owing to it's lower saturated hydraulic conductivity values. Additionally, physical processes associated with the dissolution of salts are anticipated to increase density contrasts between the tailings pore water and meteoric water, thus further reducing the saturated hydraulic conductivity of composite salt/clay tailings.