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Memorandum

To: Chris Kennedy – Technical Specialist - Geochemistry & Mine Closure, Agnico Eagle Mines Ltd.

From: Mike O'Kane, Senior Technical Advisor

Our ref: 948-011-M-012 Rev3

Date: July 23, 2019

Re: **Summary of CIRNAC Meeting during the NIRB Technical Meetings**

Representatives from O'Kane Consultants Inc. (Okane) and Agnico Eagle Mines Ltd. (Agnico Eagle) held an informal meeting with Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) at Baker Lake during the recent Nunavut Impact Review Board (NIRB) Technical Meetings. The meeting took place on Thursday, June 13th, 2019 from approximately 4:00 pm to 5:00 pm CDT and was attended by three representatives from CIRNAC as well Chris Kennedy of Agnico Eagle and Mike O'Kane of Okane. The discussion centred around the design, construction, and operation of the Amaruq Whale Tail and IVR waste rock storage facilities (WRSFs) and cover systems. The following sections summarize the discussions that took place during the meeting.

The general discussion focused on the hydrologic behaviour of the Whale Tail WRSF and cover system specifically:

- wetting up and drain down behaviour of the WRSFs;
- physical and hydraulic material characteristics of the waste rock and cover system material; and
- the performance for a WRSF in a temperate climate as compared to a cold region.

An understanding of the effective depth of interaction (EDI) and the thickness of cover material as it relates to interflow was established, as well as a discussion on the potential for contaminant transport from the thermal cover post-closure.

Discussion Point #1: Hydrologic Behaviour

Based upon the discussion of the hydrologic behaviour of the WRSF, it was agreed that little to no basal seepage from the WRSF will occur since the first lift of waste rock is expected to freeze back shortly after placement.

It is expected that a very long time (in the order of hundreds of years) will be required for the WRSF to 'wet up' as thawing occurs from the surface down. Infiltration to the WRSF is due to spring melt as well as summer infiltration during rainfall events. Spring melt generally occurs while underlying waste rock remains frozen, leading to significant portions of melt water contributing to runoff or interflow above the frozen zone. Surface infiltration in summer will lead to net percolation (NP) into the underlying waste rock. As NP occurs, the WRSF slowly wets up and freezes back, forming ice rich zones in the WRSF. The potential load added from the WRSF to the site wide load balance model is a therefore function of runoff rates and the effective depth of interaction as NP is not expected to exit the landform.

Discussion Point #2: Effective Depth of Interaction

The effective depth of interaction (EDI) of runoff was previously assumed to be 1 m based upon initial load balance modelling (Golder, 2018). However, this depth was determined to be overly conservative based on the findings in Sharpley (1985) and Okane's site experience at other mine WRSFs. As a result, the EDI was updated to be 0.3 m.

Sharpley (1985) summarizes typical depth of interaction for different soils, slope aspects and rainfall intensities. Sharpley indicates a typical interaction depth of 2 cm for sandy loam on a 20% slope with rainfall intensity of 50 mm/hr. Baker Lake A (Environment Canada, 2019), intensity-duration-frequency (IDF) curves suggest the maximum rainfall intensity (1:100 5-minute storm) would be 50 mm/hr. Given the relative conservative depth selected by Golder (1m depth of interaction), Okane selected a depth of interaction approximately one order of magnitude greater than suggested by Sharpley (1985) for finer-textured soils for similar rainfall intensity to maintain a high degree of conservatism due to the uncertainty around this parameter.

During the NIRB session, references for Sharpley (1985) as well as Zhang & Zhang (2009) were provided to support a 0.3 m EDI. It was noted that the references indicated that the EDI could be even shallower than the 0.3 m selected for incorporation to the site-side load balance.

Discussion Point #3: Cover Thickness and Interflow

Annual temperature cycling dominates the freeze-thaw mechanisms in the thermal cover system. Modelling (Okane, 2019) suggests the active zone is primarily contained within the 4.7 m thermal cover thickness. As the WRSF freezes back, ice rich zones form near surface (approximately 7 m to 10 m below surface), which can inhibit convective cooling by significantly decreasing air permeability in these areas.

Interflow is defined as water moving laterally within the active zone. In the case of the Whale Tail and IVR WRSFs, this generally occurs above low permeability frozen and/or ice rich zones. When interflow occurs, it was assumed to interact with the entire 4.7 m thick thermal cover system. The depth of interflow should not be confused with the 0.3 m EDI for runoff.

Discussion Point #4: Contaminant Transport

As interflow occurs, the load added to the site-wide load balance is a function of the interflow rate and the arsenic leaching load from the 4.7 m thermal cover. In reality, interflow depth would be far less than 4.7 m, as the thermal cover would not flow full.

For example, the storage capacity or available water holding capacity of the cover system material is estimated to be 0.05 cm^3/cm^3, which is equivalent to 50 mm of water per 1 m thickness. This is approximately 235 mm of water holding capacity for the proposed 4.7 m cover system thickness. The predicted precipitation for a 1:100 year 5-minute summer storm for the Amaruq site totals approximately 50 mm; hence there is substantive storage capacity in thermal cover. For lateral interflow, any flow resulting from this event would not occur through the full thickness of the thermal cover material. Therefore, using 4.7 m overestimates the arsenic leaching potential as any potential interflow would take place through only a fraction of rock present in the 4.7 m cover system.

The possibility of a large rainfall event was also discussed, where summer rainfall would be released as a single event once the WRSF is frozen and the cover material is wetted up. Okane anticipates that the hydrologic response will be highly dampened due to transit times across the WRSF and that any ‘fast release’ will be limited to the slope of the first lift. This dampening effect is demonstrated in Kelln (2008). Kelln (2008) illustrates the mechanisms and site-specific controls on mechanisms of groundwater flow at Syncrude’s 30 Hill South Bison Hill Watershed. Though climate and texture of the study area differs, the governing mechanisms are the same.

We trust information provided in this memorandum is satisfactory for your requirements.

References

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