January 18, 2019
NWB File #: 2AM-MEA1526
NRCan File #: NT-010

Richard Dwyer
Manager of Licensing
Nunavut Water Board
P.O. Box 119
Gjoa Haven, Nunavut
X0B 1J0

Sent via email: richard.dwyer@nwb-oen.ca

Mr. Dwyer,

Re: Amendment to Type "A" Water Licence No: 2AM-MEA1526 Associated with the In-Pit Tailings Disposal Modification Proposal at the Meadowbank Gold Mine; Agnico Eagle Mines Limited – Natural Resources Canada comments on results of Version 4 hydrogeological modelling.

Natural Resources Canada (NRCan) received a technical memorandum from Agnico Eagle Mines (AEM) on December 14, 2018. This memorandum's stated purpose was to address NRCan's comments on the third version of the thermal and hydrogeological modelling for AEM's proposed In-Pit Tailings Disposal Modification for the Meadowbank Gold Mine. NRCan's comments were provided during the Nunavut Impact Review Board's (NIRB) modification screening process, and culminated in a meeting with AEM and their consultants at the offices of the Geological Survey of Canada (GSC) on September 25, 2018. A summary of this meeting was submitted to the Nunavut Water Board (NWB) on November 21, 2018.

Please find NRCan's comments on the aforementioned technical memorandum below. Should you have any questions related to NRCan's review, please do not hesitate to contact me at peter.unger@canada.ca.

Sincerely,

Peter Unger

Senior Environmental Assessment Officer/Agent prinicipal d'évaluation environnementale
Office of the Chief Scientist/ Bureau du scientifique principale
Natural Resources Canada / Ressources naturelles Canada
peter.unger@canada.ca
588 Booth Street, Ottawa, Ontario, K1A 0Y

NRCan's Comments on Version 4 of hydrogeological modelling for Meadowbank In-Pit Tailings Disposal Modification – Submission to the Nunavut Water Board

Background

AgnicoEagle Mines Limited (the proponent) operates the Meadowbank Mine in Nunavut, and has proposed to modify the storage of mine tailings at the site by disposing them in the Goose and Portage A and E pits. Natural Resources Canada (NRCan) submitted Information Requests (IRs) to the Nunavut Impact Review Board (NIRB) on 9 July 2018 (NRCan, 2018a). The proponent provided responses to these IRs on 16 July 2018 (AEM, 2018a). NRCan submitted its Final Written Submission on 3 August 2018 (NRCan, 2018b). The proponent provided its response to the NIRB on 17 August 2018 (AEM, 2018b). NIRB closed the registry and later released its reconsideration report and recommendations on 31 August 2018 indicating that the proposed amendment may proceed to the licensing and permitting regulatory phase (NIRB, 2018). On 21 September 2018, NRCan submitted comments (NRCan, 2018c) outlining remaining concerns to the Nunavut Water Board (NWB). The proponent, their consultant (SNC-Lavalin), NRCan and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC, by phone) met on 25 September 2018 to discuss version 3 of their hydrogeological model and NRCan concerns. In order to resolve the remaining issues, SNC-Lavalin has prepared a memorandum summarizing the updated thermal and hydrogeological modelling (SNC-Lavalin, 2018). This report reviews this memorandum, comments on the resolution of issues, and provides recommendations related primarily to monitoring.

References

AEM, 2018a. In-Pit Disposition. NR-CAN information request responses. 16 July 2018.

AEM, 2018b. Agnico Eagle Mines Limited – Meadowbank Division, 2AM-MEA1526, Proposed Modification, NWB In-Pit Tailings Disposal, Comment Responses, August 17, 2018.

Golder Associates Ltd., 2014. Final Environmental Impact Statement (FEIS) – Meliadine Gold Project, Volume 7.0 Freshwater Environment.

Golder Associates Ltd., 2016. Hydrogeology Baseline Report -Whale Tail Project. Report Number: Doc 055-1541520, June 2016.

Knight Piésold Consulting, 2015. Agnico Eagle Mines Ltd.: Meadowbank Division – Whale Tail Pit – Permafrost and Hydrogeological Characterization, File No.:NB101-00622/04-A.01, 24 November 2015.

NIRB, 2018. Nunavut Impact Review Board, Reconsideration Report and Recommendations, In-Pit Tailings Disposal Modification, Agnico Eagle Mines Ltd., NIRB File No.: 03MN107. 31 August 2018

NRCan, 2018a. Information Requests for Agnico Eagle Mine's In-Pit Tailings Disposal Modification (NIRB File No. 03MN107), Natural Resources Canada, Submission to the Nunavut Impact Review Board, 9 July 2018.

NRCan, 2018b. Final Written Submission, Agnico Eagle Mine's In-Pit Tailings Disposal Modification (NIRB File No. 03MN107), Natural Resources Canada, Submission to the Nunavut Impact Review Board, 3 August 2018.

NRCan, 2018c. NRCan's Final Comments on the Proposal for In-Pit Tailings Disposal at the Meadowbank Mine. Natural Resources Canada, Submission to the Nunavut Water Board, 21 September 2018.

SNC-Lavalin, 2018. Meadowbank In-Pit Tailings Disposal - Thermal and Hydrogeological Modeling Update to Address NRCan's Comments. Memorandum to AEM. 655183-000-4GCA-0001 Rev 01, 14 December 2018.

Introduction

Representatives from Agnico Eagle Mines (AEM) met with NRCan experts on 25 September 2018 to discuss outstanding issues related to hydrogeological modelling. NRCan had indicated in previous documentation and at the meeting that it had concerns with the approach used by AEM in the ground thermal modelling component. In particular, AEM had only considered time periods of 100 years post-closure in the thermal model which was used to determine future permafrost conditions and hydraulic connections between the pits and the Second and Third Portage Lakes. NRCan also indicated that the cross-sections used in the model may not be adequate and others could be considered. During the meeting, NRCan made a number of suggestions to improve the thermal modelling including:

- Extend the simulation period to 20,000 years to align better with the hydrogeological and contaminant transport models. NRCan also suggested that running the simulations to steady state beyond 100 years post-closure even if climate model simulations beyond 100 years were not used was an option as this would still allow consideration of thermal disturbance due to pit flooding.
- Consideration of additional cross-sections for modelling across Pit A, in particular in the southern portion of the pit.

AEM submitted a memorandum on 14 December 2018 (SNC-Lavalin, 2018) that presents:

1. Long term ground thermal modeling after in-pit tailings deposition and post closure for 20,000 years and steady state;
2. Updated boundary conditions and permafrost limits for use in hydrogeological modeling.
3. Updated hydrogeological and contaminant transport modelling (version 4);
4. Predictions of receiver water chloride and arsenic concentrations and fluxes using a water balance approach; and
5. Chloride breakthrough curves for the existing and proposed monitoring wells and comments on the adequacy of the proposed groundwater monitoring wells network.

NRCan Comments are provided below on the different components of this memorandum:

Thermal modelling

Thermal models are utilized to simulate future ground thermal regimes and therefore the configuration of permafrost and unfrozen zones or taliks. The spatial distribution of permafrost is important with respect to groundwater hydrology since flow in frozen materials is limited. An understanding of long-term permafrost conditions is therefore required to determine how groundwater flow may change over time and the development of hydraulic connections between pit lakes and other water bodies such as Second and Third Portage Lakes.

AEM conducted 2D transient modelling for five cross-sections including the one suggested by NRCan across the southern portion of Portage Pit A. Coupled seepage and thermal modelling was utilized to account for convective heat transfer due to groundwater flow in addition to conduction. The model considered the main mine activities including lake dewatering, pit excavation, tailings deposition and flooding. Since current climate simulations provided in the latest IPCC report do not extend beyond 100 years, air temperature changes due to climate change were only considered for 100 years post-closure with constant air temperatures for the rest of the simulation. Lake bottom temperatures were held constant at 4°C throughout the simulation to 20,000 years post-closure. Steady-state simulations were also run that only considered the impact of pit flooding (i.e. impact of climate warming not considered). In NRCan's view, the approach for the updated modelling provides a more realistic picture of future permafrost conditions. Even without consideration of long-term climate change, the simulations over longer time periods beyond 100 years do show the considerable impact of the thermal disturbance due to pit flooding. In particular, the results indicate the development of an open talik beneath Pit A including its southeastern tip which was not the case in the previous modelling results. NRCan notes that even without climate warming, the steady state modelling results also indicate that open taliks would eventually develop over time, although AEM has not indicated the time it would take to develop these taliks

The results of the updated thermal model have been used to update the permafrost conditions in the groundwater and contaminant transport models. A key finding from the simulations was that thawing of permafrost under Pit A would lead to formation of an upward vertical gradient which is higher at the northern end of Pit A. Incorporation of better information on permafrost conditions has also led to revised predictions of the timing of contaminant discharge to Second Portage Lake.

In summary, the updated thermal modelling has facilitated better simulation of future permafrost conditions over periods of 20,000 years which is required to support groundwater and contaminant transport modelling over similar time periods. Although there are some limitations to the modelling such as lack of incorporation of changes in climate beyond 100 years, the simulations do provide a much improved representation of the impact of thermal disturbance due to pit flooding and development of potential groundwater flow paths between pits and the two Portage lakes.

Updated boundary conditions and permafrost limits

SNC-Lavalin has implemented new permafrost limits (i.e. extent of impermeable units) based on new thermal modelling. In the previous 100-year thermal modelling, permafrost remained beneath Portage Pits A and E. As anticipated by NRCan, longer term thermal modelling (20 000 years and steady state) results show that open talik develops beneath all the three pits.

Implementation of the thermal modelling results in the hydrogeological and contaminant transport modelling used a conservative approach in which the thermal solution at year 400 was used from years 0-400 in the hydrogeological model and the steady state thermal solution was used for years 400 to 20 000 (slide 72).

Updated hydraulic head boundary conditions were agreed upon during 25 September 2018 meeting as outlined on slide 76. As shown on Slide 77, the updated boundary conditions result in higher sub-permafrost hydraulic head (134.2 vs. 134.0 m) at the north end of Pit A and a slight shift in groundwater flow direction in the SE corner of the model. Note that the 133.6 m contour crosses the southern tip of Pit A indicating that nearly all of Pit A is predicted to receive sub-permafrost groundwater discharge once the permafrost beneath the pit thaws.

NRCan is satisfied that SNC-Lavalin has implemented the updated hydraulic head boundary conditions and the extent of permafrost in a manner consistent with the agreement from the 25 September 2018 meeting.

Hydrogeological and transport model (version 4)

SNC-Lavalin (2018) observes that version 4 contaminant transport paths are similar to those in the version 3 model. However, they report that the first arrival of chloride occurs sooner in the version 4 model (400 years) compared to the version 3 model (2000 years) mainly due to the increase in sub-permafrost hydraulic head boundary at the north end of the model. NRCan notes that this observation implies that contaminant transport in the model is very sensitive (5× change in time of first arrival) to hydraulic head values (0.6 m change in head at the northern boundary).

NRCan also observes that the plume in the version 4 model appears to progress more rapidly from Pit E to Second Portage Lake than in the version 3 model, likely due to the absence of permafrost beneath the pit.

The most significant difference between the version 4 model and the previous model versions results from the implementation of an open talik beneath Pit A after 400 years. As predicted by NRCan, hydraulic head in the sub-permafrost groundwater is higher than the water level in Third Portage Lake (Pit Lake) and, consequently, there is upward flow from sub-permafrost groundwater through the tailings and into Third Portage Lake (slides 87 and 89). Although SNC-Lavalin indicate the chloride and arsenic mass fluxes to the Pit A lake area, their concentrations are not mentioned.

Receiver water concentrations and fluxes

SNC-Lavalin (2018) has combined the contaminant transport modelling results with a water balance to estimate chloride and arsenic concentrations in receiving surface waters. The results indicate that groundwater is diluted between approximately 1000- and 2000-fold in surface water (Second Portage Lake and Pit A Lake (Third Portage Lake) respectively, slide 96). Consequently, the diluted surface water concentrations are predicted to be below guideline values and no significant impacts on fresh water are expected. NRCan notes that the groundwater arsenic concentrations discharging from the tailings directly into Pit A could be as high as the tailings pore water concentration of 0.9 mg/L subject to possible arsenic adsorption within the tailings. Hence, the benthic zone of the sediments/tailings at the contact with Pit A Lake (Third Portage Lake) could have an arsenic concentration above the CCME guidelines and the MDMER maximum average concentration shown in Figure 3.7. This could pose a challenge for monitoring as the groundwater flow that will displace tailings pore waters to Third Portage Lake (Pit A Lake) will not begin for approximately 600 years.

NRCan is not aware of groundwater chemistry measurements in the sub-permafrost groundwater at the Meadowbank site. However, the Hydrogeology baseline report for the Whale Tail Project (Knight Piésold Consulting, 2015 as Attachment A in Golder Associates Ltd., 2016) summarizes the statistics for the groundwater quality data collected at the Meadowbank Gold Mine (Attachment A, Table 2). The summary indicates that groundwater concentrations in the talik zones in the vicinity of the mine facilities have groundwater quality that (Attachment A, p. 14)

> "is generally described as being hard to very hard, with neutral to slightly basic pH and good buffering capacity. TDS concentrations range from 193 mg/L to 1,900 mg/L (mean 625 mg/L; median 496 mg/L). Concentrations of fluoride, copper, iron, and selenium were elevated in comparison to guidelines for the protection of aquatic life and drinking water. Only the higher percentile values for nitrogen-containing compounds, aluminum, arsenic, boron, hexavalent chromium, molybdenum and zinc exceeded the CEQGs. Additionally, several of these parameters as well as chloride, manganese and sodium exceeded aesthetic drinking water guidelines."

NRCan points out that the thawing of the permafrost beneath Pit A will not only result in the displacement of tailings pore water into Third Portage Lake (pit lake), but eventually will also result in the discharge of sub-permafrost groundwater into Third Portage Lake. Consequently, knowledge of the sub-permafrost groundwater chemistry is also important to assess the potential impacts of new discharge of sub-permafrost groundwater to Third Portage Lake. Generally, sub-permafrost groundwater is more saline than talik water and can, in some locations such as AEM's Meliadine mine site (Golder Associates Ltd., 2014), exceed sea water concentrations.

Issues with the monitoring wells

SNC-Lavalin re-assessed the groundwater monitoring well (MW) network based on the updated contaminant transport modelling and concludes that (p. 13) "the current monitoring well network can also be used for long term monitoring (closure & post-closure)" and that "The monitoring wells network will be used to confirm contaminant transport model prediction in operation and closure. Calibration on transport parameters will be assessed at that time." They present the predicted chloride breakthrough concentrations at seven existing monitoring wells and state that "All 4 new installed MW intercept contaminant plume from Pit A, Pit E and Goose Pit" and that "Existing MW network will be use for model calibration at closure" (slide 100).

1) Effectiveness of the groundwater monitoring network: breakthrough curves

NRCan is concerned about the effectiveness of the groundwater monitoring network, particularly for model validation and calibration. NRCan welcomes the use of the breakthrough curves as an approach to present the modelling results but interprets the predicted breakthrough curves differently than SNC-Lavalin (2018). In NRCan's opinion, they appear to demonstrate that at least six of the eight existing monitoring wells will not be of any practical value for plume monitoring, model verification and calibration at closure.

The predicted chloride concentration wells IPD-17-01 (d), IPD-17-01 (s), MW08-02, MW-16-01, ST8-North and ST8-South all remain below 1 mg/L for more than 6000 years (slides 100 and 101). The change in any contaminant concentrations will not be measurable at these sites within the operation and closure periods. Given that background groundwater concentrations are not zero as assumed in the contaminant transport modelling, the very small predicted increases in chloride concentrations at these monitoring wells may not even be observable for thousands of years into the post-closure period. Also, it is not clear that changes in chloride (or other contaminants) concentrations due to the plume would be measurable in monitoring wells IPD-07-07 and IPD17-09 during the operation and closure periods (slide 100).

2) Effectiveness of the groundwater monitoring network: well locations with respect to flowpaths

It appears that most (if not all) monitoring wells are not located along the direct flowpaths of the groundwater plumes. Monitoring wells IPD-17-01 (d), IPD-17-01 (s), ST8-North, MW-08-02 and ST8 South are all located inside (west of) the East Dike. Whereas the Pit A groundwater plume at 4000 years has a peak groundwater chloride concentration between 12 and 24 mg/L (slide 87) beneath the East Dike, the breakthrough curves for these wells indicate a chloride concentration of less than 0.5 mg/L at this time. These wells are therefore not along the main flowpath of the plume and concentrations are increasing as a result of hydrodynamic dispersion (i.e. the gradual spreading of the plume). The cross-section at 4000 years (slide 87) also shows that recharge of fresh water from non-tailing areas within the dike results in a wedge of (almost) uncontaminated (chloride < 1 mg/L) water immediately west and east of the East Dike. These monitoring wells appear to be screened within this uncontaminated wedge at elevations above -50 masl (slides 87 and 101). Therefore, the groundwater that these monitoring wells will be sampling appears to originate predominantly from the uncontaminated portions of the flooded pit rather than from the flooded tailings. Similarly, monitoring well MW-16-01 is located southwest of Pit A and is outside of the flowpath and the plume (except for very low concentrations due to dispersion). Although monitoring wells IPD-07-07 and IPD17-09 are located closer to the Goose Pit and Portage Pit E respectively, the flowpaths for these plumes are predominantly downward (slide 81). Even after 400 years, these wells only experience the fringes of the plumes and are not along the main axes of the plumes which occur much deeper and closer the middle of the pits. These wells may also be experiencing "edge effects" resulting from uncontaminated recharge outside the pits.

The corollary of the wells not being along the main contaminant flowpaths is that none of the monitoring wells can serve as sentinel wells that would indicate the first early arrival of a contaminant plume before it reaches the Second Portage Lake. For example, at 4000 years contaminant plumes from all the three pits are discharging to Second Portage Lake (slides 87 and 89), yet few of the monitoring wells have even registered a measurable increase in chloride concentration.

3) Proposed locations for new monitoring wells.

One problem with the existing monitoring network is that there are no monitoring wells located along the shallow groundwater flowpath between Pit A and Second Portage Lake where first arrivals of chloride and arsenic are modelled to occur in 400 and 250 years respectively (slide 90). Proposed monitoring well MW_PitA_01 appears to be intended to address this shortcoming. NRCan is supportive of a location close to Pit A so that it could provide an early warning of contaminant transport along this pathway. However, the information provided in the memorandum is not sufficient to determine if the proposed location is along the main axis of this shallow groundwater plume. NRCan is also concerned about the proposed screen length of the monitoring well (slide 102). Although a long screen has a better chance of intercepting a groundwater plume, the sampled concentrations will be diluted due to mixing of the plume with uncontaminated groundwater above and/or below the plume.

Proposed monitoring well MW_PitA_02 is located to the southwest of Pit A. The rationale for this monitoring well location is not clearly indicated. It appears to NRCan that the monitoring well is located along the periphery of the groundwater plume from Pit A. The screen length is also of concern for this monitoring well.

The proposed location and depth of monitoring well MW_GPit_01 (slide 102) appear to be selected to intercept the groundwater plume as it descends from Goose Pit on a flowpath towards Second Portage Lake (slides 87 and 89). There is not enough information in the memorandum to assess whether the monitoring well is sufficiently deep to intercept the main axis of the plume. NRCan again questions the rationale of a long screen for this well and whether or the use of packers along the screen is intended (i.e. to allow for multilevel sampling). It is evident from the plumes in slides 87 and 89 that a monitoring well located on the edge of Goose Pit inside the dike could intercept a large range of groundwater concentrations along the length of the screen.

No monitoring wells have been proposed to help assess the potential effects of groundwater discharge to Third Portage Lake when permafrost thaws beneath Pit A.

4) Model verification/validation prior to closure

Due to the ineffectiveness of the groundwater monitoring network (discussed above), it is unlikely that the data anticipated from the current and proposed monitoring network will provide information that will be useful to validate or improve the existing contaminant transport models, particularly prior to post-closure. As demonstrated by the breakthrough curves, most of the wells are located too far from the pits and/or are off the main flowpaths from the pits to encounter the plume prior to post-closure. Tracking a contaminant plume in time and space requires numerous monitoring points located along and adjacent to the main flowpath. Because of the small number of monitoring wells and because most of the wells are located off the main axis of the plume migration, it will not be possible to validate either the directions or velocities of the plumes and hence of groundwater flow. Furthermore, evaluating the dispersion (spreading) of a groundwater plume requires knowledge of the location and concentrations along the main axis of the groundwater plume (over time) which will be lacking. Consequently, the sparse monitoring network will be unable to provide information useful for model validation, particularly prior to post-closure.

5) Background groundwater concentrations in the talik and sub-permafrost groundwater flow systems

The transport models assume that the background chloride and arsenic concentrations are equal to 0 mg/L. As noted above, the background groundwater concentrations in the talik are variable and above guidelines for some parameters. Variable and elevated (with respect to surface water) groundwater concentrations have potential consequences:

- First, it makes it more difficult to observe and interpret changes in concentrations in the monitoring wells. For example, the predicted changes in chloride concentrations of a few mg/L in a monitoring well would be difficult to attribute to a plume given background concentrations that may vary by several hundred mg/L.
- Second, background concentrations would influence the modelling and interpretation of breakthrough curves since higher background concentrations of some parameters such as chloride would result in diffusion into the plume rather than away from it. Given the magnitude and variability of background chemical concentrations in groundwater, small concentration changes in monitoring wells due to the approach of a plume may not be readily observable making it difficult to quantify the movement of the plume over time.

6) Goals and duration of monitoring

It is unclear to NRCan what the duration of monitoring is intended to be: decades, centuries or millennia. The duration of the monitoring program influences not only the achievable goals of the monitoring program but also practical issues such as the positioning of monitoring wells. The type of monitoring required also influences the duration of monitoring.

The modelling results demonstrate that first arrivals of shallow groundwater plumes may occur in hundreds of years (slide 90) whereas first arrivals of deeper groundwater plumes (e.g., flowing beneath permafrost) could take a few thousand years (slides 87 and 89). Furthermore, groundwater concentrations and mass fluxes into Second Portage Lake will continue increasing beyond 20000 years (slide 95).

If the intended goal is to monitor groundwater concentrations discharging into Second and Third Portage Lake, some form of monitoring may be needed in hundreds to thousands of years when the permafrost beneath Pit A thaws or when a plume arrives at Second Portage Lake. If the goal is to ensure surface waters do not exceed water quality guidelines, then validating estimates of water and mass fluxes may be more useful. Therefore, it is useful to define the goals of the monitoring program keeping in mind the specific variables to be monitored and the duration that are implicit to the variables that are monitored.

Conclusions

1) Thermal modelling is sufficient

NRCan concludes that the updated thermal modelling takes into consideration the long-term thawing of the permafrost beneath the pits following the flooding of the pits by the Third Portage Lake.

2) Updated permafrost limits and hydrogeological model boundary conditions

NRCan concludes that the permafrost limits and hydrogeological model boundary conditions were updated as agreed in the 25 September 2018 meeting.

3) Hydrogeological modelling is acceptable

NRCan concludes that the hydrogeological modelling (and contaminant transport modelling) was updated as agreed in the 25 September 2018 meeting.

4) Impacts of thawing permafrost beneath Pit A

The thermal modelling demonstrates that the thawing of permafrost initiates a hydraulic connection between sub-permafrost groundwater and the Third Portage Lake (Pit Lake) in approximately 600 years that subsequently extends to the entire extent of Pit A. The hydrogeological modelling predicts that hydraulic heads in the sub-permafrost groundwater will exceed Third Portage Lake water levels over most of the Pit A area resulting in groundwater discharge through the tailings into Third Portage Lake. As previously suggested by NRCan, this can result in the displacement of tailings pore water directly into Third Portage Lake such that the benthic zone (of Pit A tailings in contact with the lake) may become contaminated. The memorandum does not report the concentrations of groundwater that are anticipated to discharge into Third Portage Lake but does estimate the mass fluxes of chloride and arsenic. Another potential impact, not previously discussed, is that sub-permafrost groundwater could have elevated concentrations of some parameters which will also flow into Third Portage Lake. The potential effects of sub-permafrost groundwater discharge into Third Portage Lake has not been assessed.

5) Ineffective monitoring well network

NRCan considers the monitoring well network to be ineffective. Based on the results presented in the memorandum (and appended slides), NRCan believes that data from at least six (and possibly all eight) monitoring wells will not be of any practical value for plume monitoring, model verification and calibration at closure. Better justification of the locations and well screen lengths of the three proposed new monitoring wells is required. The sparse monitoring network will be unable to provide information useful for model validation, particularly prior to post-closure. The magnitude and variability of background chemical concentrations in groundwater will make it more difficult to quantify the movement of the groundwater plumes over time. The goals and intended duration of monitoring are not clearly stated in the SNC-Lavalin (2018) report.

NRCan's Recommendations

1) State expectations, goals and duration of monitoring.

The proponent, in consultation with appropriate regulators (e.g., Nunavut Water Board (NWB), Department of Fisheries and Oceans (DFO)), should clearly state the explicit goals of the groundwater monitoring program within the context of the overall monitoring expectations of the regulators. For example, NRCan expects that the discharge of tailings pore water from Pit A may result in groundwater discharge concentrations that exceed water quality guidelines (i.e. in the benthic zone where Pit A tailings are in contact with Third Portage Lake). If this is a concern to regulators from a fishery habitat point of view, then groundwater monitoring goals and methods should address this issue. If not, NRCan is satisfied with the proponent's approach to quantifying groundwater mass fluxes for use in their water balance model.

It would be helpful if the groundwater monitoring program could specifically indicate what parameters or variables are to be measured or validated (e.g., contaminant fluxes to lakes, contaminant concentrations in lakes or contaminant concentrations in groundwater discharge). For instance, validating groundwater mass flux is more useful for use in the proponent's surface water quality modelling whereas measuring groundwater concentrations might be required to meet specified groundwater quality criteria. The selected variables will have a significant influence on the effort required.

The proponent, in consultation with appropriate regulators, should also indicate the anticipated duration of the monitoring. Any potential impacts due to groundwater contaminant migration at this site are predicted to occur after several centuries rather than within years or decades. Consequently, the goals, instrumentation and locations of groundwater monitoring should be consistent with the expected duration of sampling (and vice versa).

2) Assess the current groundwater monitoring network

NRCan disagrees with SNC-Lavalin's assessment of the adequacy of the current groundwater monitoring well locations. It appears to NRCan that several monitoring wells are not located directly downflow of the tailings and therefore are poor sentinels of contamination migration. NRCan recommends that the proponent assess the 3-D groundwater flowpaths and travel times to each monitoring well screen. This can be easily accomplished in FEFLOW using backwards pathlines (i.e. reverse particle tracking, with the option of random-walk to include the effects of dispersion). Wells with backwards particle tracks that do not cross the tailings or originate near the edge of the tailings are likely of limited value to the monitoring network.

3) Strategically locate new monitoring wells

It is not possible to monitor the groundwater plumes from three pits with such a small number of wells. The data from existing wells will do little to improve the contaminant transport modelling. With such a sparse network, the most useful wells will be those that indicate the first arrivals of groundwater contaminants and help define the maximum groundwater and contaminant velocities along the main axis of the groundwater plume. NRCan suggests that the proponent install monitoring wells that will intercept the main axis(es) of each groundwater plume during the monitoring period. The purpose, location and screen interval of each new monitoring well should be justified and initially guided by modelling results (including pathlines as in recommendation 2). NRCan is not convinced of the effectiveness of the proposed new wells and recommends that the current model be used to assess pathlines, travel times and breakthrough curves for these wells. The proposed use of long well screens should be justified.

4) Assess the potential impact of sub-permafrost groundwater discharge to Third Portage Lake

The thawing of permafrost below Pit A will not only allow tailings pore water to discharge to Third Portage Lake but will also allow sub-permafrost groundwater to discharge. The potential effects of sub-permafrost groundwater discharge to Third Portage Lake have not been considered or discussed to date. NRCan is not aware whether sub-permafrost groundwater chemistry has been measured at Meadowbank. If so, these values should be used to assess whether there is the potential for impacts to receptors in Third Portage Lake. If not, conservative estimates of sub-permafrost groundwater chemistry could be used to assess the potential for impacts.

5) Suggestion for sub-permafrost groundwater

A slight increase in the modelled sub-permafrost groundwater heads appears to have greatly reduced the predicted time for contaminant first arrivals in Second Portage Lake. This suggests that groundwater transport may be sensitive to sub-permafrost heads. One measurement that has the greatest potential to reduce the uncertainty in the groundwater modelling and improve transport prediction is the sub-permafrost hydraulic head at the north end of Pit A. This value is currently estimated using groundwater modelling based on the water levels of lakes assumed to have open taliks. Installing a monitoring well beneath the permafrost at the north end of Pit A would define the vertical hydraulic gradient (for upward flow into Third Portage Lake) and would effectively constrain the horizontal hydraulic gradient in sub-permafrost groundwater. This data may prove to be more useful for improving the groundwater modelling than the data obtained from most of the existing monitoring wells. Such a well could also be sampled to define sub-permafrost water chemistry. As useful as such data would be, NRCan also realizes the expense and difficulty of installing such a well and therefore only mentions it as a suggestion rather than as a recommendation.