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Nov. 24, 2020

Elenore Arend
Chief Executive Assessment Officer
BC Environmental Assessment Office
Via Email Only: Elenore.Arend@gov.bc.ca

Dear Ms. Arend,

Please accept this as the second submission on behalf of the Gitanyow Hereditary Chiefs ("Gitanyow") for the second request for an extension to the Environmental Certificate (the "Certificate") for KSM Mining Inc ("KSM") for their proposed mine north and upstream of the Gitanyow Lax'yip. New and material information relevant to the KSM request has recently come to our attention.

Gitanyow first wrote to the BC Environmental Assessment Office ("BCEAO") on Oct. 16, 2020. In the submission we outlined an assessment of the KSM request for a further extension to their Certificate, based on their claims of the COVID19 pandemic as affecting their project. We also attached a summary report prepared by Ecojustice Canada, detailing their legal opinion that a second extension to the Certificate was not legally permissible under the *Environmental Assessment Act*, even on an emergency basis.

Since that time, Gitanyow has been attempting to undertake a visual representation of a potential tailings dam failure at the proposed mine to better inform our members on the potential risks associated with the project. Gitanyow has retained Lynker Technologies ("Lynker") to conduct a two-phase initiative that includes first an assessment of the data and assumptions behind the original information in the environmental assessment application, and second, if that information is acceptable, to then use it to provide a visual representation of a tailings dam failure.

Upon completion of the first phase, Lynker has found there are several instances of deficient information relied upon in KSM's projection of a tailings dam failure, including out of date information and modelling. A Technical Memo outlining these issues is attached for your reference. What you will see in the Memo is that since the original Certificate was granted in 2014, there have been advancements in the scientific literature and modelling approaches to assessing a potential tailings dam failure.

These deficiencies are preventing Gitanyow from proceeding to the next phase of the work, because our expert advisors do not believe that a visual representation based on the KSM work will provide an accurate portrayal to better inform our members. Throughout our engagement with our members, there have been concerns about what a potential tailings dam failure could look like and what the long-term impacts would be to the waters and ecosystems downstream of the mine. We are simply trying to provide those answers to our members in an accurate visual format.

The information provided here is another example, and a crucial one, of how this Certificate is not passing the test of time. With the effects of climate change, the introduction of the *United Nations Declaration on the Rights of Indigenous Peoples* into law in British Columbia, and the emerging methods and scientific studies around tailings dam failures, the BCEAO must heed this and acknowledge that it constitutes <u>new and material information</u> that has a bearing on the original assessment of significance of impacts to water quality, fish and fish habitat, and Indigenous rights. Before KSM's application can be considered, the material deficiencies in the data provided must be addressed, so that both the BCEAO and our members can make an informed decision around the risk of a tailings dam failure.

The longer it takes the proponent to secure a financial partner for the development of the project, the more out of date the Certificate becomes. This further heightens the risk of an already risky project. Gitanyow is calling on the BCEAO to reject the current request for a further extension, and that if a financial partner is found for the project a new assessment should occur with proper participation by Gitanyow.

Thank you for your consideration of our second submission and we look forward to hearing from you.

Sincerely,

Glen Williams/Malii
President & Chief Negotiator

Cc: Scott Bailey, Assistant Deputy Minister
Nathan Cullen, MLA Stikine

MEMORANDUM

To: Tara Marsden, Gitanyow Hereditary Chiefs

cc: Jill Weitz, Salmon Beyond Borders

From: Cameron Wobus and Bill Szafranski, Lynker Technologies

Subject: KSM Dam Failures Modeling Review

Date: November 24, 2020

Lynker was retained by the Gitanyow Hereditary Chiefs to review modeling results from Seabridge Gold related to potential dam failures at the proposed KSM mine. We focused this review on a Seabridge modeling report that summarizes results from tailings transport simulations resulting from a failure of tailings management facility (TMF) dam:

- Klohn Crippen Berger, 2012. Dam Break and Inundation Study for TMF. Appendix 35-C of KSM Environmental Assessment (herein referred to as KCB, 2012)

Our review focused on the model and assumptions used, the parameters and data used to feed the model, and the general results of the modeling studies. This memorandum summarizes four key findings, described below.

1. The Simulated TMF Release is Smaller than Available Data would Predict

The assumed size of the release from the tailing management facility (TMF) is a key assumption that is fundamental to the TMF failure modeling results. Specifically, the fraction of the tailings that would be released if the dam fails controls the downstream impacts.

KCB (2012) simulates two different types of failures of the TMF dams: overtopping failures and piping failures. The volumes released from these two failure types are different: approximately 7% for the piping failure, and approximately 27% for the overtopping failure. The overtopping failure volume is based on a KCB assumption that the tailings remaining in the impoundment after failure would settle at an angle of repose of 5 degrees, and all tailings above this angle would be released. Based on KCB's calculations, which are not included in the report, the release of all material above this angle results in a release volume of 27% of the full TMF contents. KCB contends that this volume is in general agreement with two references, Azam and Li (2010) and USCOLD (1995), which suggest that historical tailings dam failures typically release 20-25% of the stored tailings. However, there are at least two problems with the 27% release assumption, described below.

First, this release volume apparently relies on the assumption that the tailings remaining behind the dam would settle at an "angle of repose" of 5 degrees. This number is based on an unpublished dissertation from 1981 (Lucia, 1981), whose conclusions are at odds with both this 5 degree angle of repose and the estimated release volume. Chapter 6 of Lucia (1981) summarizes the five main conclusions of the dissertation. The two conclusions relevant to tailings release volumes are conclusions 2 and 5, which are as follows:

> 2) A review of case histories of failures shows that liquefied mine tailings composed primarily of sand and silt sizes have some small residual strength after liquefaction, and they will come to rest at slopes of ***one degree to four degrees***. […]
> 5) The volume of tailings involved in a flow failure is usually considerably less than the total volume impounded, although in some cases, especially where the tailings are extremely fluid, the entire volume of tailings in the pond did flow, therefore, ***in the absence of evidence to the contrary, it appears that the most appropriate assumption will often be that 100% of the tailings will flow***. (Lucia, 1981, p. 106-107; *emphasis added*)

Thus, the main reference KCB (2012) draws on to arrive at its 27% release assumption actually concludes that the tailings remaining would settle at much lower angles than 5 degrees (thus releasing a larger fraction of the total tailings); and that the most appropriate approach may be to assume that *all* of the tailings will be released.

The second problem with the 27% release assumption is that it is not well-supported by more recent information on tailings dam failures. The USCOLD (1995) dataset cited by Seabridge is more than 25 years old, and the Azam and Li (2010) study does not explicitly link release volumes to storage volumes. Available data from two comprehensive studies suggest that the release volume could be much larger than 27%. For example, a well-cited study by Rico et al., (2008) suggests that on average, the volume released in a tailings dam failure event is closer to 40% of the stored tailings, larger than the largest release volume assumed by KCB (2012). Empirical data from 35 historical tailings dam failures compiled by Concha Larrauri and Lall (2018) also suggest an average release volume closer to 40%, with a range between 1% and 100%.

All of the historical failures studied by Rico et al. (2008) and Concha Larrauri and Lall (2018) are from much smaller tailings management facilities than those proposed for KSM (at 74 Mm^3, the facility that failed at Mt Polley is the largest in the historical dataset, but the storage volume behind the proposed North Dam at KSM is more than 7 times as large as this). Thus, there is considerable uncertainty in using these historical failures to estimate what could happen if the KSM facility were to fail. Because there is ample evidence that the release volume could be much larger than 27%, however, Seabridge should at a minimum include larger failures in their simulations to evaluate how those releases would affect downstream risks.

Key Point #1: The tailings release volume from a TMF failure would likely be much larger than the 27% release assumed by KCB (2012). Since all of the downstream impacts of a TMF will scale with the assumed volume of the release, the study should evaluate impacts from larger failure volumes.

2. The Context for Presenting Failure Results is Misleading

The results of the overtopping failure simulations are shown in Figures 5.1 and 5.2 of KCB (2012). Notably, the flood depths and discharges for these failure scenarios are superimposed on the probable maximum flood, or PMF. In the context of the PMF, many of these dam failure results do not look particularly large: the flood depths on the Bell Irving River below the Bowser River confluence are on the order of 50% higher than the "baseline" PMF. This gives the impression that the dam failure scenario is not far outside the range of otherwise normal flooding. KCB (2012) explicitly cites this as an indication that the risks from a TMF failure are not very large:

> Results shows that Bell 2 Lodge, New Aiyansh, Gitwinksihlkw (Canyon City), Laxgalts'ap (Greenville), 10 highway sections, as well as existing cabins and outfitter/guide facilities located on riverbanks, floodplains or close to natural floodplains will likely be inundated by an overtopping failure of the Ultimate Southeast Dam. ***However, most of these locations would also be flooded under naturally occurring flows (PMF), therefore the incremental consequence of an Ultimate Southeast Dams overtopping failure is small***. (KCB, 2012a p. 39; *emphasis added*)

The problem with this depiction is that the PMF is such an extremely unlikely event that it dwarfs any reasonable metrics of flood risk. The PMF is defined as the theoretically largest flood that could occur in a given area, and is estimated by combining the most severe conceivable hydrologic conditions that could plausibly occur (LaRocque, 2013). Although it is difficult to estimate the probability of a PMF, various authors have estimated that it is an event with a 1:100,000 to 1:1,000,000 probability of occurring in any given year (e.g., Shalaby, 1994).

In the Bell Irving River basin, the PMF discharge is approximately 19,000 m^3/s downstream of the Bowser River confluence, and the tailings failure increases the magnitude of this flood wave by approximately 10,000 m^3/s, or about 50% (Figure 5.2 of KCB, 2012a). For comparison, based on streamflow data from the nearest gage site on the Bell-Irving River, we estimate that the 100-year flow is on the order of 4,000 m^3/s. Thus, while the flood wave due to the tailings dam failure is less than half the PMF, it is approximately 2.5 times the magnitude of the 100-year flood event.

Key Point #2: Presenting the failure simulation relative to the probable maximum flood (PMF) is misleading, as the PMF is an extremely large event that is not commonly used in flood risk delineation.

3. HEC-RAS is an Inappropriate Tool to Simulate a TMF Failure

For its modeling of a tailings dam failure, KCB chose to use the software HEC-RAS, a model that was primarily developed to simulate "clear water" floods (i.e., floods with low sediment concentrations). However, because the thick, sediment-laden flows common in tailings dam failures have different physical properties than "clear water" flows, this model choice could introduce significant uncertainties into the model results.

In the mining industry, it has become more common to use a code like FLO-2D to simulate the release and downstream routing of tailings, because these other codes can simulate "non-Newtonian" fluids like mudflows:

> Mudflows are non-homogeneous, non-Newtonian, transient flood events whose fluid properties change significantly as they flow down steep watershed channels or across alluvial fans. Mudflow behavior is a function of the fluid matrix properties, channel geometry, slope and roughness. The fluid matrix consists of water and fine sediments. At sufficiently high concentrations, the fine sediments alter the properties of the fluid including density, viscosity and yield stress. (FLO-2D, 2017, p. 70)

KCB (2012) states that they modeled tailings releases with 65% solids by weight, which means that the tailings are likely to exhibit non-Newtonian, mudflow behavior. Since HEC-RAS was developed only to model water flows, the model simulation is unable to capture the non-Newtonian properties of a tailings release with these sediment concentrations. Seabridge states that this is a "conservative assumption since the tailings would be more viscous than water and not flow as easily." (KCB, 2012, p. 18). However, this assumption is overly simplistic and calls the overall results into question, as sediment-laden flows will behave fundamentally differently from "clear water" flows with much lower sediment concentrations.

Key Point #3: Tailings floods flow in a way that is fundamentally different from water floods. HEC-RAS is an inappropriate tool for simulating tailings floods.

4. The Model Sensitivity Analyses are Insufficient

Because numerical modeling is inherently uncertain, it is important for the modeler to understand how the choice of different parameter inputs will affect model outputs. For a tailings dam failure simulation, assumptions like the physical characteristics of the flow, the total volume of the release, and the duration of the release could all significantly influence the model outcomes.

KCB's (2012) sensitivity tests focused on only two parameters – the roughness characteristics of the channels downstream of the release ("Manning's n"), and the breach formation time. Both of these parameters are adjusted upward and downward by approximately 50%, and the results of these sensitivity analyses are shown in tabular form in Table 5.13 of KCB (2012).

KCB found that the model was highly sensitive to the choice of Manning's n – peak flow increased by as much as 60% when Manning's n was decreased by 50%, and peak flow decreased by as much as 30% when Manning's n was increased by 50%. Similarly, the model is very sensitive to the breach formation time: decreasing the breach formation time by 40% increased the peak flow near the dam by 70%, and increasing the breach formation time by 40% decreased the peak flow by 30%. However, TMF breach failures can often occur much faster than 3 hours. Eyewitness accounts of historical TMF failures have demonstrated that tailings dam failures, when they do occur, can happen in a matter of seconds or minutes, rather than hours (Petley, 2019). There is no information provided as to how the peak discharge would increase due to a much faster breach like this. Given the variability in outputs based on breach formation times from 3-8 hours, a much shorter breach would generate a much larger flood peak.

Finally, there are a number of other parameters the model may be sensitive to, but which are not evaluated at all. These include the total volume of the release, the resolution of the digital elevation model used, the characteristics of the flow (sediment concentration, the yield stress, etc.), and other items. Note that many of these sensitivity tests cannot be performed using HEC-RAS because this code can only simulate 'clear water' flows. As noted in bullet #3 above, the tailings dam analysis should be updated to use a modeling package that can explore model sensitivity to these additional parameters.

Key Point #4: Both the number and range of parameters evaluated in the sensitivity analysis is extremely limited. Thus, the study does not explore a wide enough range of potential outcomes to fully evaluate risk.

References

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