Appendix 1. Technical Review Sheet for Federal Authorities - Impact Statement for the Shaakichiuwaanaan Mining Project[1]

Contact information

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[1] In case of inconsistency or discrepancy between the two versions of this document, the version written in the original language (French) shall prevail.

Federal authorities must complete Table 1 to list the comments noted in the Impact Statement and the corresponding recommended clarifications. The comments consist of missing information that is both required in the Tailored Impact Statement Guidelines (guidelines) and **essential for the Joint Assessment Committee to identify and assess the project's adverse federal effects[2] and the key issues relevant to decision-making[3]**. This determination includes, in particular, the significance of the adverse federal effects, the identification of appropriate mitigation and monitoring measures, and whether the adverse federal effects can be justified in the public interest[4] . Federal authorities should provide comments that are proportionate to the risks and solution-oriented.

Table 1. Determination of comments noted in the Impact Statement and recommended clarifications

Identification No	Reference to the Impact Statement	Reference to guidelines	Description of the comment (context and rationale)	Recommended clarification
Mine waste geochemical characterization				
NRCan-01	Volume 3 – Appendix 5-4 (geochemical characterization); Sections 3.2 and 3.3; Section 5.2.6 (materials management)	Section 3.3; Representative characterization of all mining and construction materials	The impact statement presents a geochemical characterization program for waste rock, ore and mine tailings. It does not demonstrate that the surface materials that will be disturbed (i.e., soils, overburden, and other loose materials) have been characterized, although these materials should be included in accordance with the *Guide de caractérisation des résidus miniers et du minerai*. These materials are present in large quantities and will be handled during stripping, construction and restoration activities. In the absence of representative geochemical characterization, it is not possible to assess their potential for leaching metals or their contribution to contaminant loads in drainage water. This introduces uncertainty in the water quality predictions used to assess potential effects on fish and fish habitat under the *Fisheries Act*. The level of concern is moderate, given the volume of materials involved and their potential role in the exposure pathways.	The guide states that the characterization of overburden may be omitted if a justification adequately demonstrates its low risk. The proponent must therefore provide a sound technical rationale. Tests including acid-base accounting, extractable metal analyses and overburden leaching tests are recommended. NRCan recommends detailing the geochemical characterization program for all surface materials (i.e., soil, overburden, and other loose materials) that will be disturbed. This includes: identification of material types and estimated volumes; a representative sampling plan; appropriate geochemical testing (e.g., acid-base accounting, leachate tests); an assessment of the potential for metal leaching under the expected environmental conditions; and how the results will be integrated into materials management and water quality models.
NRCan-02	Volume 3 – Annexe 5-4 (characterization program); Volume 4 – infrastructure design; Section 5.2.6 (materials management)	Section 3.3; Characterization of materials used for construction and infrastructure	The impact statement describes the construction of the site infrastructure (e.g., roads, platforms and foundations) as well as the management of the mining materials. However, it does not specify whether mine materials (e.g., waste rock, overburden) will be used for construction or how these materials would be selected. It also does not demonstrate that materials potentially used for construction (including waste rock, overburden, quarry materials and borrow materials) have been identified or characterized from a geochemical standpoint. Without that information, it is not possible to assess whether the construction materials can generate metal leaching or acidity, or contribute to the contamination of surface and groundwater during the life of the project. This gap limits the ability to assess potential federal effects and the associated mitigation measures. In addition, the classification criteria related to arsenic and sulphur are not presented. The level of concern is moderate, given the potential large-scale use of these materials in the site's infrastructure.	NRCan recommends first confirming the classification criteria presented in Table 5.3 of the impact study. Then, specifying whether mine materials (e.g., waste rock, overburden) will be used in infrastructure construction, identify all materials intended for this purpose (including quarry and borrow materials) and provide a representative geochemical characterization of these materials. This characterization includes: the source and estimated volumes; a sampling and testing program (e.g., acid-base accounting, leachate tests); an assessment of the potential for metal leaching under the expected site conditions; and a description of selection criteria, management and monitoring measures to prevent adverse effects on surface and groundwater quality.

[2] Adverse federal effects: adverse effects falling within a federal jurisdiction and direct or incidental effects related to a federal authorization (permit or authorization issued by a federal authority)
[3] As set forth in the attachment and at on the project's CFEI Teams channel .
[4] Public interest considerations are described in section 63 of the *Impact Assessment Act*

NRCan-03	Volume 3 – Appendix 5-4 (geochemical characterization); Tables showing the distribution of samples lithology; Mine plan (open pit phases)	Section 3.3; Representative characterization and development of source terms	The impact study presents a geochemical characterization program and a summary of the samples by lithology. However, it does not demonstrate the spatial distribution of the samples within the deposit or their relationship to the mine plan. Specifically, the locations of the samples in relation to the waste rock sources, the open pit phases and the lithological domains are not presented. Without this information, it is not possible to assess whether the geochemical dataset is spatially representative of the materials that will be mined, including the lithologies that will be exposed at the closure. This introduces uncertainty in the characterization of the potential for metal leaching and acidity generation, and limits confidence in establishing source terms and water quality predictions.	NRCan recommends that cross sections and/or plans be provided illustrating the spatial distribution of all geochemical samples, including: the location of the samples in relation to the geological units and lithologies; their position in relation to the operating phases of the open pits and the mining sequence; and the identification of materials that will be exposed to the closure.
NRCan-04	Volume 3 – Appendix 4-5	Section 3.3; Analysis of alternatives for the management of tailings and waste rock	The open-pit mine excavation sequence is taking place from east to west, with two extraction areas mined simultaneously (Volume 3, Appendix 5-1, Section 8.4). In fact, there will be an excavated area during phases 1A, 1B and 2 (Figure 5.3, Volume 1) that could be considered as a management site for ultramafic waste rock and mine tailings. Given *Vision Geochemistry*'s suggestion to manage ultramafic lithology separately, best practices recommend maximizing backfilling from the open pit and underground excavations to reduce surface managed volumes (Mine Environment Neutral Drainage (MEND) 2.36.1b). Furthermore, the Mining Association of Canada's Tailings Guide recommends that tailings management options be assessed to consider all possible alternatives. The geochemistry reports in Appendix 5-4 indicate that this scenario is being considered.	In the analysis of alternatives updated during the development of the closure plan, NRCan recommends including the option of gradually backfilling the open pit with ultramafic waste rock and/or potentially acid generating (PAG) and leachable tailings.
NRCan-05	Volume 3 –Appendix 5-2	Section 3.3; Kinetic tests and drainage prediction	The proponent indicates that a portion of the mining residues will be used in the cemented backfilling of the underground galleries, which is a best practice. However, only two kinetic tests were submitted on the tailings (Appendix 5-2), which is insufficient given the total volumes to be managed. These tests indicate a pH between 6.0 and 6.5 and low alkalinity, indicating a limited buffer potential. Appendix 5-4-2; A.3 shows five column tests with tailings lasting one year. Arsenic values range from 0.1 to 20 mg/L above Directive 019 on the mining industry, uranium varies between 0.1 and 2 mg/L, lithium between 0.02 and 2 mg/L and antimony between 0.1 and 7 mg/L. Chen and Goulet (2022)[1] reported similar pHs for another lithium project assessed under the Impact Assessment Act. However, recent 40-week column tests on lithium mine tailings ponds indicate pH values around 7 (Knaack et al., in prep.). In this study, the leached lithium was also lower than reported in Appendices 5-2 and 5-3. This is likely due to the low lithium extraction efficiency reported for this project, which will result in a loss of lithium in the tailings. [1]R. Chen and Richard R. Goulet (2022), Identifying Potential Contaminants of Concern in Lithium Mine Waste to Limit Environmental Impacts, Proceedings of ICARD 2022, https://www.inap.com.au/icard/	The tailings monitoring program presented in Section 13.2.1 (Volume 2) indicates that the proponent undertakes to take tailings samples each year, which will be representative of the variability of the ore processed throughout the representative period of each sample. This should be included as a condition of the project. This information is critical to the design and operation of the waste rock pile 02, which will potentially include tailings, leachable waste rock and non-leachable rock. In addition, NRCan recommends that the proponent commits to conducting a characterization of the pore water every five years as part of the tailings monitoring program to guide the mitigation measures to be implemented during site reclamation.

NRCan-06	Volume 3 – Appendix 5-2	Section 3.3; Kinetic tests and drainage prediction	The 100-week kinetic tests carried out on ultramafic material (*Humidity cell test* (HCT); HCT 36, 59 and 62) indicate high rates of leaching of arsenic (As), antimony (Sb), nickel (Ni), uranium (U) and phosphorus (P), in the order of mg/L. Since the Metal and Diamond Mining Effluent Regulations do not provide for P and Sb release limits, managing these risks is the responsibility of provincial authorities.	NRCan recommends that the proponent and the provincial government work closely together to identify and implement appropriate mitigation measures for the management of ultramafic material.
NRCan-07	Volume 3 – Appendix 5-2	Section 3.3; Kinetic tests and drainage prediction	The proponent's consultant recommends designing a future sampling program involving a greater number of static and kinetic tests to better characterize the distribution of As concentrations, while assessing the variability in sulphide content. However, this program for managing metal leaching and acidity generation does not provide for the inclusion of P, Sb and Ni, contaminants that can have significant impacts on the aquatic environment.	In the metal leaching and acid generation management program, it is recommended that additional static and kinetic tests, as well as more representative barrel tests, be included to optimize its As and sulphide rejection rates. It is also recommended that P, Sb and Ni be included.
NRCan-08	Volume 3 – Appendix 5-3	Section 3.3; Kinetic tests and drainage prediction	The geochemical dispersion model estimates the leaching rate of As as a function of HCT leaching rates, scaling factors related to particle size, temperature and hydraulic insulation, as well as the rainwater infiltration rate. A sensitivity analysis of these factors is therefore essential. Doubling one or more scaling factors results in a proportional increase in predicted As concentrations, with a cumulative effect (×2, ×4 or ×8 depending on whether one, two or three factors are doubled). However, although a graph illustrates this effect, predictions of As concentrations under conservative conditions are not presented, i.e. predictions combining these scaling factors when assessing co-disposition at waste rock pile 02, complete segregation of ultramafic material, or an 85% scenario. Furthermore, the hypotheses retained remain uncertain: the literature review is limited in the absence of mineralogical characterization; infiltration variations are based on data from the La Grande site; the grain size is based on only two studies; temperature effect is based on an annual mean of −2°C rather than the summer conditions more representative of kinetic testing (i.e., 22.5°C); and there is no reference to justify the variations related to the hydraulic insulation. Therefore, the predicted As concentrations may be overly optimistic.	The proponent currently estimates that approximately 62% of the ultramafic materials present a significant risk of leaching as and should, therefore, be managed separately. However, the uncertainties noted here must be mitigated by improving the leaching rate model and conducting a more in-depth sensitivity analysis as the project progresses. NRCan recommends the following: 1. Include P, Sb and Ni in the model. 2. Perform quantitative mineralogical characterizations (QEMSCAN, MLA, X-ray diffraction) to identify As-carrying phases and their mineral association and then determine the release mechanisms and their kinetics in response to temperature and surface variations. 3. Conduct more kinetic studies to better characterize the leaching potential for As, P, Sb and Ni, as well as include barrel studies on excavated material rather than crushed core. 4. Further investigate the effects of particle size on a wider range of particle size distribution and assess the effect of specific surface area. 5. Include conservative infiltration rates from literature and *in situ* measurements, and compare different climate scenarios. 6. Document, measure *in situ*, and justify hydraulic insulation parameters such as permeability, anisotropy, and stratigraphy to provide an empirical basis for hydraulic insulation scale factors. 7. Develop simulations combining scaling factors in cumulative and worst-case scenarios, and explicitly present the predicted As, P, Sb and Ni concentrations for various scenarios, including pit backfilling. NRCan recommends that the characterization program for waste rock and mine tailings be accompanied by a monitoring program that includes characterization of materials during their generation (Section 13.2.1, Volume 2), as well as monitoring the quality of mine effluent (13.2.2.7), surface water (13.2.2.8) and sediment (13.2.2.9) and groundwater (13.2.210). This monitoring would make it possible to

				compare the measured concentrations with the concentrations predicted by the geochemical model. In the event that the concentrations observed are higher in the mine effluent, surface water, sediment or groundwater, the proponent may react quickly and implement adaptive management measures.
NRCan-09	Volume 3 – Classification criteria for waste rock and mine tailings	Section 3.3; Kinetic tests and drainage prediction	The proponent has not proposed any criteria for segregating waste rock. However, the kinetic assays lasted 100 weeks and it is clear that the ultramafic lithology should be managed separately because of its high As, Sb and Ni contents (Figure 13; Appendix 5-4-1), as recommended by *Vision Geochemistry*.	NRCan recommends proposing waste rock segregation criteria for project authorization, with the understanding that these may be refined over time through the waste rock and mine tailings characterization program proposed under the mine operations monitoring program in Section 13 (Volume 2).
Hydrogeology				
NRCan-10	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit	Section 3.3; Effects on groundwater quantity	There are very few wells located south of the pit site and the underground mine, whereas the numerical model appears to show that baseflows there would be more affected by dewatering than the lakes to the north (p. 28/35). In Figure 13, the water levels (provided as elevations) of the five observation wells are shown, but the initial level (before pumping) in the pumping well (CV24-696) and the depths of these wells are not specified. The water level elevations of the five observation wells do not appear to be consistent with the general piezometric surface, which shows flow toward Lake 001 (p. 16/35; “Figure 14 presents a piezometric map of the study area. Groundwater flow directions follow topography and converge toward Lake 001.”). This could be due to local topography, although this is difficult to confirm based on the map in Figure 14. Otherwise, this could be attributable to the depth of the wells. Moreover, the fact that these observation wells are not affected by pumping from well CV24-696 likely indicates a near hydraulic disconnection between deep and shallow layers due to low hydraulic conductivities and a poorly connected fracture network. It is unclear whether the piezometric map accounts for this. The piezometric map should probably use only shallow wells to show water levels in the first 50 meters, and another piezometric map could be produced using deeper boreholes. A statistical analysis (between piezometry and topography) would help determine the best approach for producing the piezometric map(s).	NRCan recommends providing information for all wells used in this study.
NRCan-11	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit	Section 3.3; Effects on groundwater quantity	Information is missing, which limits the ability to evaluate the numerical model results. In particular, information is lacking regarding the modeling of the “proposed dyke” shown in various figures in the report. It is not possible to confirm whether the dyke was modeled, how it was modeled, or to what depth. It is difficult to understand how Lake 001 could still exist without representation of this dyke in the model.	NRCan recommends developing 2D conceptual models (cross-sections): one parallel to the long axis of the pit and underground mine, and the other perpendicular. NRCan recommends using wells located within 1 km on either side for constructing these models. About ten wells could be used in one section and slightly fewer in the other. This would allow visualization of topography, stratigraphy, depth, and water levels in the different wells, as well as fault positions, to better understand hydrodynamics (e.g., vertical and horizontal hydraulic gradients, flow). These cross-sections should show initial conditions, then conditions with the pit and underground mine dewatered.

NRCan-12	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.2.1, Figure 15 5.4, Table 11	Section 3.3; Effects on groundwater quantity	Information is missing, which limits the ability to evaluate the model results. In particular, the boundary conditions of the hydrogeological model are overly numerous. Constant heads (Dirichlet) appear to have been imposed everywhere on lakes and various watercourses (Figure 15). If this is the case, it overly constrains the model such that, regardless of what is simulated, hydraulic heads at those locations would remain unchanged (lakes and streams could not be drained). Were these heads imposed only on the surface layer nodes of the model? It is surprising that RMS values and hydraulic heads (Table 11) do not vary more with changes in hydraulic conductivity (e.g., if all K values in the rock are multiplied or divided by 5).	NRCan recommends running simulations without all these imposed heads to see how the model behaves. First simulate steady-state conditions (without pumping and without the pit/underground mine), then simulate selected sensitivity scenarios to determine whether results change significantly (static hydraulic heads and percentage variations by scenario, as well as drawdowns and infiltration rates).
NRCan-13	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.4	Section 3.3; Effects on groundwater quantity	It should be noted that sensitivity analyses are generally conducted using scenarios that include variations of at least one order of magnitude (×10 and ÷10) for hydraulic conductivities, given the high variability of this parameter. In this report, the scenarios use only half an order of magnitude.	NRCan recommends modifying Sensitivity Scenarios 1 and 2 in Table 10 to use one order of magnitude (×10 and ÷10) instead of half an order relative to the initial scenario.
NRCan-14	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.2.2	Section 3.3; Effects on groundwater quantity	Information is missing, which limits evaluation of the model results. In particular, the model does not appear to consider anisotropy in hydraulic conductivity, and there is no information demonstrating that KH = KV.	NRCan recommends providing information to demonstrate that KH = KV.
NRCan-15	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.5	Section 3.3; Effects on groundwater quantity	Information is missing, which limits evaluation of the model results. In particular, infiltration flow rates into the pit and underground mine appear high (Tables 12 and 13: 3,200 m^3/day corresponds to 37 L/s, and 5,800 m^3/day to 67 L/s), and supporting information is lacking.	NRCan recommends justifying these values by answering the following questions: • Do these infiltration rates correspond to conditions when the pit is dewatered to 200 m and the mine to 435 m depth? • Do the values increase over time because the surface area of the pit (and mine) increases (until 2049)? • Have these values been confirmed with order-of-magnitude checks based on available field data? For example, for the pit, are these values on the same order as the sum of precipitation over the area and the product of the surface watershed area containing the pit and 255 mm/year (estimated surface recharge)?
NRCan-16	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.6; Figure 19	Section 3.3; Effects on groundwater quantity	Information is missing, which limits evaluation of the model results. In particular, drawdown values appear low near the pit, and supporting information is lacking.	NRCan recommends providing cross-sections (north–south and east–west) showing the modeled water table and justifying these values by answering the following questions: • Were drawdowns (Section 5.6) estimated for maximum dewatering of the pit and underground mine (i.e., 200 m for the pit and 435 m for the underground mine, as given on p. 4/35)? • Could this be related to imposed hydraulic heads, i.e., significant infiltration ("seepage") through boundary conditions? Why does the title of Figure 19 specify "at bedrock top"? Does the model properly simulate a single water table?
NRCan-17	Volume 6 – Appendix 6-11; Hydrogeological assessment	Section 3.3; Effects on groundwater quantity	Information is missing, which limits evaluation of the model results. In particular, there appears to be an error in the text regarding boundary conditions: the north and south boundaries are no-flow because they	NRCan recommends revising the text on boundary conditions and correcting the information if necessary.

	for the underground mine and open pit; 5.2.3; p. 20		correspond to topographic ridges and thus watershed divides, but the east and west boundaries likely correspond to heads derived from the piezometric map.	
NRCan-18	Volume 6 – Appendix 6-11; Hydrogeological assessment for the underground mine and open pit; 5.5; p.27	Section 3.3; Effects on groundwater quantity	Information is missing, which limits evaluation of the model results. In particular, it is mentioned that "Sensitivity Simulation 3, in which recharge rates were increased by 20% to account for this potential impact and assess its effect on model results, does not indicate a significant increase in groundwater infiltration into the pit and underground mine openings." Contrary to what is stated, a large portion of this additional water should reach the pit and mine, as it flows through overburden deposits and the upper meters of bedrock.	NRCan recommends further justifying the results of this simulation and the distribution of additional water within the model and correcting the information if necessary.
NRCan-19	Volume 6 – Appendix 6-8; Hydrogeological study; 4.2.2; p.16-17	Section 3.3; Effects on groundwater quantity	Three well hydrograph curves are presented in Annexe 6-8, but these appear to reflect semi-confined conditions rather than unconfined conditions as indicated in the report. For two of the three hydrographs, there is a notable increase due to spring snowmelt, but they do not seem to react (or very little) to rainfall events. This could indicate that the rock itself is semi-confining the aquifer, where fewer or even no fractures are present.	NRCan recommends clarifying the differences in aquifer conditions.