Yukon Environmental and Socio-economic Assessment Board
Mayo Designated Office
P.O. Box 297
Mayo, Yukon Y0B 1M0

August 8, 2018

RE: Project 2018-0087 Response to Information Request #1

The Government of Yukon, Assessment and Abandoned Mines Branch (AAM) has received and reviewed the May 8, 2018 information request and has compiled responses to the requested information in this letter. The questions are provided in advance of responses for context.

1. *Given that the WTP was not specifically designed to remove arsenic, what options exist to increase performance of arsenic removal, particularly Dissolved As?*

Bench-scale test results conducted by Veolia Water Technologies (Veolia) demonstrated dissolved arsenic (As) removal to a level of 0.003 mg/L (Appendix 5D, Appendix A: Veolia bench test), which is below the target of 0.005 mg/L and coincides with the water quality guideline (WQG) for the protection of aquatic life (CCME, 2005; and BC MOE, 2017). The technology used to demonstrate site-specific treatment performance (Veolia's Actiflo® technology) is demonstrated to achieve high performance efficiencies for total and dissolved As removal from mine wastewaters with elevated iron (Fe) and As. Veolia specifically indicated that removal of arsenic to target levels is not a concern for the proposed system provided As is present as an inorganic species (Veolia, Pers. Comm.).

In the event that an increase in the performance of arsenic removal is required, options for improving water treatment plant (WTP) efficiency (and related reagent selection) will be dependent on the oxidation state and speciation of As. In this regard, two reagents may be required: Fe addition and/or potassium (K) permanganate.

Dissolved Fe is currently elevated in discharge water from the seepage pond (which is the WTP influent) at stoichiometrically favourable concentrations to facilitate As removal. In the event that the dissolved Fe content of influent waters become deficient to support As removal, the treatment system could be readily modified to accommodate an Fe reagent dosing skid for addition into the Fe precipitation tank.

Potassium permanganate may be required to oxidize As and facilitate As precipitation with Fe. This oxidation process is identical to the process designed for manganese (Mn) removal, which has been defined, tested and designed as a WTP contingency (Appendix 5D, Appendix A: Veolia bench test, and Appendix 7A (parts 1 and 2)).

2. *Demonstrate consideration of alternatives to the proposed design of the WTP plant and describe why the selected option is preferred.*

When it was recognized that water treatment would become part of the Mount Nansen Care and Maintenance Project (MNCMP), key criteria were identified as to how seepage waters were to be managed at the site. These criteria, which had a direct bearing on the options available for and selection of a treatment process, included:

- Having year-round treatment (avoiding pump back to the tailings storage facility to the extent possible);
- Not creating any new water storage areas;

- Having a water treatment process that at minimum met the effluent limits set forth in the previous Water Use License;
- Using a water treatment process demonstrated to function in northern climates; and
- Preferring a turn-key, mobile process that can be applied across the Mount Nansen Site as necessary to support implementation of the MNCMP as well as the future implementation of a remediation project.

Based on these criteria, few options were suitable aside from a traditional flow-through, engineered treatment system, which was selected as the preferred option for the removal of Fe, Mn, and total suspended solids (TSS).

With regards to Fe, most Fe treatment systems operate on the principle of oxidizing dissolved ferrous Fe (Fe2+) to particles of Fe hydroxide (OH). In this regard, aeration represents a common method to oxidize dissolved Fe^{2+} according to the following reaction:

$$Fe^{2+} + ¼O_2 + 2OH^- + ½H_2O \leftrightarrow Fe(OH)_3(s)$$

The precipitated ferric hydroxide is subsequently removed from solution through solid/liquid separation methods. The removal of Mn from solution is also commonly achieved through the oxidation of dissolved Mn^{2+} and precipitation of Mn-dioxide, according to the following reaction:

$$Mn^{2+} + ½O_2 + H_2O \leftrightarrow MnO_2(s) + 2H^+$$

In contrast to Fe which shows relatively-rapid oxidation kinetics, the oxidation of Mn^{2+} is relatively slow, and therefore the addition of a strong oxidant may be required (*e.g.*, K permanganate).

As noted, Fe and Mn precipitates generated as part of the oxidation process must be removed from the treatment stream through solid/liquid separation. This can be accomplished through:

a. Traditional coagulation, flocculation and clarification;

b. Ultrafiltration (UF) or microfiltration (MF); and

c. Other enhanced coagulation and settling technologies.

Conventional clarification achieves TSS removal via gravity settling/sedimentation. Clarifiers may contain tube settlers or plate settlers (“lamella”) to increase surface area, decrease specific overflow rate, and promote settling.

In contrast to conventional clarification, UF and MF are membrane-based technologies that achieve TSS removal via size exclusion. UF and MF are effective for the treatment of low turbidity effluents characterized by fine and colloidal-size particles (conditions to be expected at Mount Nansen).

Enhanced coagulation and settling technologies are variations on conventional clarification methods that can offer advantages with respect to footprint and performance. ACTIFLO®, the process used to demonstrate treatment feasibility for the Project, uses a combination of chemical precipitation, microsand enhanced flocculation, and lamella clarification.

3. *Discuss the potential effects to aquatic life due to exposure to lead concentrations.*
4. *Demonstrate consideration of a site-specific water quality objective (SSWQO) or water treatment for lead.*

Observations of existing water quality within Victoria Creek and Dome Creek indicate that elevated concentrations of lead in Victoria Creek are not attributed to Dome Creek or discharge from existing Site infrastructure such as the tailings storage facility (Surface Water Quality Existing Conditions Report, Appendix 6D). Concentrations of lead (Pb) in Dome Creek and in discharge from the tailings facility and seepage collection pond have been shown to be consistently below WQG. Concentrations of Pb exceeding WQG in Victoria Creek occur downstream of the confluence with Back Creek and coincide with elevated TSS. These elevated Pb concentrations are associated with Back Creek and placer mining activity within the Back Creek drainage and are not attributable to the Project. As a result, the implementation of Pb treatment on discharge from the seepage collection pond or on discharge from Dome Creek to Victoria Creek would not provide a benefit to Pb concentrations in Victoria Creek.

Effects on Pb concentrations in Victoria Creek are a result of upstream placer activity and are not attributable to the Project. As a result, a site-specific water quality objective (SSWQO) has not been developed for Pb and assessing the potential effects of Pb is not considered to be relevant to the Project.

5. *Given that freshet is a short-duration environmental influence, demonstrate consideration effects to aquatic receptors from short-term acute exposure to elevated metal and TSS concentrations and describe how effects will be mitigated.*

Elevated total metal concentrations and total suspended solids (TSS) are indicative of naturally occurring erosion processes that occur throughout Victoria Creek, including upstream of Back Creek at stations VC-Ref and VC-U (Appendix 6D). Observed high TSS events coincide with high flow such as freshet, and are exacerbated by placer activity in Back Creek, which has resulted in an increase in the occurrence of disturbed ground and erosion and sediment transport. High flow events are typically short-lived for summer rainstorm events (days) and freshet (weeks).

The toxicity of metals in aquatic environments is generally controlled by the dissolved fraction of these elements (free ions) rather than by their total fractions (i.e., particulates). Dissolved fractions are more readily available and more easily taken up by aquatic organisms compared to particulates. Where metal guidelines have been derived for the dissolved metal fraction (e.g., Fe, cadmium (Cd), and zinc (Zn)), dissolved metal concentrations are typically lower than WQG. Where only total metal guidelines exist (e.g., As, chromium (Cr), Mn, and Pb), the dissolved fraction is typically lower than the WQG.

Given the most prominent sources of elevated metals and their association with TSS events and relatively short-lived high flow events, observed concentrations are not expected to cause adverse toxicological effects in aquatic biota.

The potential Project related effects resulting from elevated total metals and TSS will be mitigated through implementation of water treatment and mitigations outlined in the sediment and erosion control plan (Appendix 5F). The aquatic environment monitoring plan (AEMP) is intended to evaluate the potential for effects in the receiving environment (Appendix 7E). Observations from the AEMP will be used to inform the adaptive management plan (AMP; Appendix 7C) to ensure best management practices and environmental compliance.

6. *Please explain what corrective actions would be in place should water quality not meet expected standards for a parameter of concern such that effects to aquatic resources would be likely.*

The AMP (Appendix 7C) defines the framework for identifying root causes and corrective action as necessary to protect aquatic resources. In this regard, monitoring of surface water quality and aquatic resources as specified in the AEMP (Appendix 7E) provide the basis from which decision-making is made. As an example of the success of this framework in the past, the decision to implement water treatment as part of the proposed Project was in part informed through action triggered by the AMP, demonstrating the successful implementation of the AMP.

7. *Describe the program in place to monitor potential barriers to fish movement on Dome and Pony creeks.*

The assessment of fish bearing status of Dome Creek was based on field investigations performed in 2009 (by EDI Environmental Dynamics Inc.) and in 2012 by Ecological Logistics & Research Ltd. (Appendix 6E), while a similar assessment for Pony Creek was performed by Ecological Logistics & Research Ltd. in 2012. These streams were considered to be non-fish bearing based on these assessments. Both watercourses have similar characteristics at their outflows into Victoria (Dome Creek) and Back (Pony Creek) Creeks; Victoria and Back Creeks are undergoing streambed erosion (lowering of the streambed over time through erosional processes) and have relatively steep, eroded banks at the location the other stream enters. In contrast to this, Dome and Pony Creeks were observed to have much more stable streambeds that were supported by vegetation, and streambed erosion was not observed. This results in feeder streams that are "perched" above the level of the streams that they flow into, creating barriers to fish movement.

The overall assessment of fish bearing status of the project was conservative in stating that the barriers to upstream fish movement were not permanent, as only features based in bedrock (such as a bedrock waterfall) would be truly permanent features. With that said, the outlets of Dome and Pony Creeks appear to be very stable and while not considered *permanent* according to the description above they would not be expected to change for a long time given the flow regime and existing vegetation on each. While remote, the potential does still exist for large enough physical changes to occur at these stream junctions that would allow fish into them. Based on this factor and YESAB's request, monitoring programs for Dome and Pony Creek have been considered.

A monitoring program is proposed to document the state of the outlets of Dome and Pony Creeks for the life of the project, which will be completed as part of the ongoing water quality sampling program. During monthly monitoring efforts during the open water season, the two barrier areas will be visited and a visual check completed to determine whether any observable changes have occurred that may affect fish passage.

Either once annually as part of the aquatic monitoring program or following any suspected change during monthly observations, each of the outlets will be assessed more thoroughly. For this thorough assessment, a photographic record of the outlet cascades will be collected along with measurements of the cascade heights and general status of the cascades. The photographs and data will be compared with the prior years' data to assess for changes, and the professional opinion on the status of the barriers will be provided by the professional compiling the monitoring program. The project stakeholders will be provide with this information, and the results included in the annual aquatics monitoring report to regulators and stakeholders.

If a change in one or both of the outlets is observed to the degree that the ability of fish to access upstream fish habitat is suspected, fish usage could not be automatically assumed as other factors may preclude or limit their use. Therefore, in the case that the annual monitoring program identifies the potential for upstream fish access, an assessment of fish presence would then be completed in subsequent years of the project to determine the presence and degree of fish habitat use.

8. *Demonstrate consideration of effects to fish in the event that erosion events result in the ability of fish to access upstream fish habitat and describe how effects will be mitigated.*

We have considered the potential for effects on fish to be realized in the event that they are able to access habitat in Dome and Pony Creeks. In the case of habitat use, the potential effects on fish would be related to effects of water quality directly on fish, potential metals uptake due to feeding in the system, as well as the potential for reduced heath due to reduced feeding efficiency due to chemical or visual stimulus. At this time, however, we are of the opinion that an effects assessment would be difficult to conduct for the following reasons:

- As a result of improved water quality, an improvement in aquatic life health in Dome Creek is expected as a result of the project, however it is not known how rapidly this make take place, or at what stage of this improvement that fish could access the system. Improved aquatic health could provide for improved feeding conditions for fish, but could also lead to an increased degree of metals uptake.

- It is unknown how many fish could access the system, and whether any fish would enter even if it were possible. It would also be necessary to know the species and life stages of these fish, which would be assessed on site should access become possible.

Based on this information, should it be determined that barriers are reduced on the two streams in question, further investigations into fish usage would be conducted to determine the characteristics of fish usage. At that time, an assessment of potential effects would be conducted based on the information available at the time (fish usage, water quality, aquatic life health), with response mechanisms being tied to this information.

Should it be determined that significant effects on fish could be realized, mitigations would be implemented, the most likely of which would be to limit fish from entering these watercourses through some type of artificial barrier (e.g. weir) for the duration of the project.

9. *The Project will be supported by an existing camp on site. It is unclear to the Designated Office how many people the camp will support. Please specify the maximum amount of people that will be staying at the camp at any given time.*

The camp has a maximum capacity of 12, four of which are reserved for care and maintenance staff and eight of which are available for contractors and support workers. The expected camp usage is less than the maximum; there are generally two care and maintenance staff on site at any given time, and additionally two to three contractors, for a total of four to five.

References:

BC MOE, 2017. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife, and Agriculture. Water Protection and Sustainability Branch, Ministry of Environment, British Columbia. January 2017.

CCME, 2005. Canadian Environmental Quality Guidelines. Update 5.0. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba. MB. www.ccme.ca/publications/cegg_rcge.html.

Marc Laliberté (Veolia Water Technologies), personal communication, May 11, 2018.