

To:  
John McCullum, EMAB

Copies:  
1 electronic

Tel 905.614.1978  
Fax 905.614.1981

From:  
Jennifer Kirk, Barbara Hard

Date:  
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ARCADIS Project No.:  
351335-000

Subject:  
Review of Site-Specific Closure Criteria (SSRBCC) used in Diavik WRSA  
(Formerly Referred to as NCRP) – Final Closure Plan – Version 1.1 Closure  
Criteria

## Introduction

Arcadis was asked to review:

- DDMLs Site-Specific Risk-Based Closure Criteria (SSRBC) presented in the WRSA – Final Closure Plan – Version 1.1 (Plan).

In conducting the review, we:

- Evaluated whether the previous comments made by the EMAB on the SSRBC were addressed appropriately and/or if there were significant changes proposed to the approach in setting SSRBC.
- Provided our professional opinion on whether the proposed SSRBC are appropriate and whether they would be protective of all environmental components.

## Summary of Arcadis' Main Findings of the Proposed DDMI Approach

DDMI has decided not to propose the SSRBCC developed in the Phase I and Phase II reports and the NRCP Closure Plan as closure criteria but is instead proposing a different methodology as follows:

- Use a back-calculation to determine closure criteria protective of aquatic receptors assuming an effects magnitude and a dilution factor;
- Use Health Canada's Drinking Water Quality Guidelines for the protection of human health; and
- Use the SSRBCC developed in Phase I and Phase II reports for the protection of birds and mammals.

DDMI did not update the Phase I or Phase II reports and therefore all comments pertaining to these reports remain unaddressed. This could therefore influence the parameters chosen for the derivation of the closure criteria and the receptors that are protected by the SSRBCC.

For the protection of aquatic life, DDMI proposes to use the approved AEMP Benchmark values as the Water Quality Standards in a back-calculated equation considering an acceptable effects level and dilution factor.

Arcadis understands that the AEMP Benchmarks have been approved in the past, and appear to be based on the Canadian Council of the Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (WQG<sub>AL</sub>). By nature, the WQG<sub>AL</sub> are designed to be protective of the most sensitive species during their most sensitive life stage. There are some benchmarks that are based on water hardness and/or temperature, and it is not clear in the WRSA Closure Plan what assumptions were used for the setting of the DDMI AEMP benchmarks. In Arcadis' opinion, the use of the DDMI AEMP as water quality guidelines that would be protective of the aquatic environment is conservative, and are therefore acceptable for the protection of aquatic life in Lac de Gras.

For the closure criteria, DDMI has proposed to back-calculate a closure criteria by assuming a magnitude of effect concentration (20%) of the DDMI AEMP and a dilution factor (85). In addition, water quality conditions from reference locations in Lac de Gras are considered in the back calculation. The determination of an appropriate dilution factor or representative reference concentration is outside the scope of this review, and therefore Arcadis has not provided specific comments on these. The dilution factor and the reference concentrations will impact the overall closure criteria and future water quality of Lac de Gras and therefore the technical basis should be reviewed by EMAB prior to accepting the closure plan.

In general, the approach and assumptions used by DDMI to propose the closure criteria are not transparent. Therefore, it is difficult to evaluate the appropriateness of the approach. Arcadis does provide the following comments for consideration:

- The basis for adding 20% to chronic toxicity benchmarks to derive the effects magnitude is not clear. 20% appears to be an arbitrary number that is based on the significant effect level determined in the EA and is not based on science or toxicity endpoints. It is therefore not known whether this is protective of aquatic species from acute toxicity. A 20% effect level of a measured endpoint on a population is often acceptable to regulators if Species at Risk are not present, however, 20% increase of a toxicity benchmark does not translate to 20% effect in a population. The dose-response of each parameter would need to be evaluated individually and a concentration reflective of a 20% effect on the population (unless Species at Risk) should be used. Applying 20% to each AEMP benchmark assumes that all parameters dose-response is linear and of the same slope. This is likely an inaccurate assumption.

- The justification for multiplying the Effects Magnitude by a dilution factor +1 is not clear. It is assumed that the closure criteria should be based on an acceptable effects concentration that is to be met at the end of the mixing zone after consideration of the natural background concentrations. So, the closure criteria at the point of discharge would be equivalent to the dilution factor multiplied by the acceptable effects concentration minus the reference concentration.
- A one (1) km mixing zone seems excessive. Assuming that concentrations of parameters leaching from the WRSA will not meet WQG<sub>AL</sub> protective of aquatic life for one (1) km from entering into Lac De Gras will likely result in impacts to the aquatic environment over time. Arcadis has not reviewed the merit of the one (1) km mixing zone, but the appropriateness of this mixing zone should be critically evaluated.
- Taking into account natural background levels in the derivation of the closure criteria is appropriate. However, Arcadis has not reviewed the information used to develop the reference concentrations relied on as it was outside the scope of work.

### Additional Considerations

DDMI considered the protection of aquatic life, protection of water exposure to birds and mammals, and the protection of human health through drinking water consumption in proposing a closure criteria for the WRSA. Arcadis assumes that the final closure criteria would be based on the protection of the most sensitive of the above receptors, but this is not clearly indicated in the report. While this approach would be acceptable, there are concerns and data gaps with the derivation of each of the receptor specific closure criteria developed. Specific comments regarding this are provided in the comment table attached with major concerns summarized below:

- Protection of aquatic life: Comments pertaining to the dilution factor and effects magnitude have previously been made.
- Some of the back-calculated closure criteria were lower than what was predicted to be leaching from the WRSA, DDMI therefore proposed to increase the closure criteria to the maximum predicted leaching concentration. This approach is not defensible and would not allow Diavik to meet their closure objectives or to protect the aquatic environment.
- For human health, some parameters were removed from consideration that should not have been. For example, lead was removed from consideration even though any exposure to lead above background conditions should be mitigated. In addition, only exposure from drinking water was considered in the derivation of the closure criteria. Potential exposure through fish and game consumption was not considered, but should have been.
- For mammals, the derivation of SSRBCC did not consider all potential guilds, and therefore may not be protective of all mammals potentially exposed at the Site.
- The derivation of receptor specific closure criteria did not consider the potential for parameters that will be discharged into Lac de Gras to partition out of surface water and impact sediment. Given the parameters that are expected to seep from the WRSA, this would be a major fate and transport pathway. Therefore, the closure criteria for the WRSA should be protective of partitioning to sediment and subsequent exposure to sediment for all potential receptors. This is a major data gap that needs to be addressed.

**Conclusions**

In closing, concerns regarding the SSRBCC and the closure criteria for the WRSA still remain. Arcadis suggests that the Board continues to work with Diavik until a scientifically defensible approach is proposed that would be protective of all environmental components that could be impacted by the WRSA.

If you have any questions or concern, please contact the undersigned.

Sincerely,

**Arcadis Canada Inc.**

DRAFT

DRAFT

Jennifer Kirk, Ph.D.,

Barbara Hard, Ph.D.

Senior Risk Assessment Specialist

Senior Risk Assessment Specialist

Table 1: Specific Review Comments on WRSA

TOPIC	COMMENT	RECOMMENDATION
Table 2-6 of Final closure and Reclamation Plan - revegetation, pg 22 of NCRP V1.1	The current closure plan does not consider revegetation of the NCRP.	Recommended that re-vegetation of the NCRP be considered to reduce amount of water infiltrating the NCRP and running off and impacting Lac De Gras.
Table V-1 Section 2: DDMI AEMP Benchmarks	The DDME AEMP benchmarks for arsenic, barium, chloride, iron, molybdenum, thallium, uranium and zinc are based on the CCME chronic exposures, and therefore, should be protective of aquatic receptors.	While the AEMP are appropriate for these parameters, the assumptions used in the back-calculated closure criteria require additional investigation. Based on the Time-Series Plots, the back-calculated closure criteria are orders of magnitude greater than the AEMP and may not be protective of aquatic life.
Table V-1 Section 2: DDMI AEMP Benchmarks	The DDME AEMP benchmarks for silver is less than the chronic CCME WQG, and therefore should be protective of aquatic receptors	While the AEMP are appropriate for these parameters, the assumptions used in the back-calculated closure criteria require additional investigation. Based on the Time-Series Plots, the back-calculated closure criteria are orders of magnitude greater than the AEMP and may not be protective of aquatic life.
Table V-1 Section 2: DDMI AEMP Benchmarks	It is not clear what the DDMI AEMP benchmark for aluminum is based on.	Please clarify the basis and the assumptions used in the determination of the DDMI AEMP. For example, assuming a pH of less than 6.5, the CCME WQG would be 5 ug/L. A discussion of whether the assumptions currently used will be expected to be applicable in the future should be provided.
Table V-1 Section 2: DDMI AEMP Benchmarks	It is not clear what the DDMI AEMP benchmark for cadmium, copper, nickel, lead and selenium is based on.	Please provide the assumptions used in the determination of the benchmarks. Toxicity for these parameters are dependent on water hardness. A discussion of whether the assumptions currently used will be expected to be applicable in the future should be provided.
Table V-1 Section 2: DDMI AEMP Benchmarks	The DDMI AEMP for chromium appears to be based on chronic benchmark for hexavalent chromium.	Please clarify the basis for the chromium DDMI AEMP and provide a rationale why hexavalent chromium would be the anticipated form of chromium in the aquatic environment.
Table V-1 Section 2: DDMI AEMP Benchmarks	The basis of the nitrite, nitrate and ammonia DDMI AEMP are not transparent. How is un-ionized ammonia accounted for in the closure criteria?	Please provide the rationale for the basis of these benchmarks.
Table V-1 Section 2: DDMI AEMP Benchmarks	The basis for sodium, sulphate, silicon and strontium DDMI AEMP are not transparent.	Please provide the rationale for the basis of these benchmarks.
Appendix V-1 Section 2: Achievability Silver and Copper	Closure criteria are meant to be criteria that are protective of environmental and human health, not representative of what is expected to be leaching from waste disposal over time.	Setting the silver and copper closure criteria to maximum concentrations expected to leach from the NCRP is not appropriate and does not confer any protection to aquatic life. Arcadis recommends that EMAB does not accept this approach.

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TOPIC	COMMENT	RECOMMENDATION
Appendix V-1 Section 2: Achievability Nickel and Zinc	The back-calculated closure criteria for nickel and zinc are above the Metal Mining Effluent Regulation (MMER) limits, therefore DDMI is proposing to set the closure criteria to the MMER. The MMER is an end of pipe effluent for active mines that is accompanied by acute and chronic toxicity testing, along with Environmental Effects Monitoring (EEM) data. The closure criteria are criteria that the mine needs to meet to meet the objectives of no adverse effect to the aquatic environment.	MMER are not appropriate closure criteria as they are set at levels where adverse effects are expected, but acute lethal toxicity is not observed. Arcadis recommends that the closure criteria for nickel and zinc be revised to be protective of the aquatic environment.
Appendix V Section 2: Achievability Nitrogen Compounds - Nitrogen, Nitrate and Ammonia	DDMi is recommending that the MMER for unionized ammonia be used as the closure criteria because nitrogen will not be a lasting contaminant of mining waste.	Ammonia is very toxic to aquatic organisms and excess nitrogen can cause nutrient imbalances in aquatic ecosystems creating considerable damage. MMER are not appropriate closure criteria and are not protective of aquatic ecosystems. Arcadis recommends that DDMI develop alternate closure criteria for nitrogen compounds that are protective of aquatic environments.
Appendix V Section 2: Criteria Not Proposed -	DDMi is recommending a number of parameters do not require criteria as the predicted concentrations are much lower than the proposed closure criteria.	As the predicted concentrations are based on models and assumptions, Arcadis recommends that closure criteria be proposed and monitoring of these parameters for a pre-determined length of time is completed to ensure that the predicted concentrations are accurate and that the assumption that there is no future concern is supported.
Appendix V-1 Section 3: Relevant Comments Made by Arcadis on Phase I and Phase II Reports	None of the comments made by Arcadis were addressed, even though the response to comments indicated they would be. Some of these comments are minor in nature (i.e., transparency) but others warrant consideration. The following comments are relevant to human health.	<p>i) it does not appear that non-threshold toxicity was considered in the derivation of SSRBCC protective of human health. This should be considered.</p> <p>ii) Lead was removed as a COPC based on the reliance of information that is considered non-protective. The inclusion of lead for closure criteria should be considered.</p> <p>iii) Diavik specific benchmarks for the protection of human health and drinking water were used preferentially over Health Canada's drinking water quality guidelines. Information regarding the derivation of these Diavik specific benchmarks was not provided, therefore the suitability of the use of these to identify COPCs requiring closure criteria cannot be made.</p> <p>iv) It does not appear that Indigenous people were consulted to verify the assumptions used in the derivation of the closure criteria, it is recommended that this occur.</p> <p>v) Consumption of fish or waterfowl was not considered in the protection of human life in the back-calculated closure criteria proposed in Appendix V. This pathway must be considered.</p>

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<u>TOPIC</u>	<u>COMMENT</u>	<u>RECOMMENDATION</u>
Appendix V-1 Section 3: Human Health SSRBCC	The report indicates that "the human health SSRBCC for uranium of 0.02 mg/L is lower than the AEMP Benchmark for the protection of aquatic life (0.015 mg/L)".	As 0.015 mg/L is lower than 0.02 mg/L, this statement must be corrected.
Appendix V-1 Section 3: Human Health SSRBCC	The report indicates that with the exception of uranium, all COPCs should be met locally (within 1 km) within Lac De Gras. Based on the seepage/run-off predictions, uranium may still exceed the back-calculated closure criteria within the 1 km. DDMI indicates that measures may be required to restrict human consumption if the predictions are accurate.	It is not clear how DDMI would restrict consumption of water within this area. For the protection of human health, the closure criteria should be reduced to account for the protection of potable water quality.
Appendix V-1 Section 3 Table V3	The SSRBCC for manganese is not consistent with the Health Canada Drinking Water Quality Guideline (DWQG) nor the Diavik Water Quality Benchmark, nor the SSRBCC identified in Table 3.2-1 of the Phase II Report.	Health Canada's DWQG for manganese is 0.05 mg/L, Table V3 indicates the SSRBCC for manganese for the protection of drinking water as 0.59 mg/L for adults and 0.301 mg/L for toddlers. Diavik should verify and provide a rationale for the number proposed.
Appendix V-1 Section 3 Table V3	The SSRBCC for mercury is not consistent with the Health Canada Drinking Water Quality Guideline (DWQG) nor the Diavik Water Quality Benchmark, nor the SSRBCC identified in Table 3.2-1 of the Phase II Report.	Health Canada's DWQG for mercury is 0.001 mg/L, Table V3 indicates the SSRBCC for mercury for the protection of drinking water as 0.0011 mg/L for adults and 0.0007 mg/L for toddlers. Diavik should verify and provide a rationale for the number proposed.
Appendix V-1 Section 3 Table V3	The SSRBCC for nitrate is not consistent with the Health Canada Drinking Water Quality Guideline (DWQG) nor the Diavik Water Quality Benchmark, nor the SSRBCC identified in Table 3.2-1 of the Phase II Report.	Health Canada's DWQG for nitrate is 10 mg/L, Table V3 indicates the SSRBCC for Nitrate for the protection of drinking water as 17.6 for toddlers and 30.2 mg/L for adults. Diavik should verify and provide a rationale for the number proposed. In addition, Diavik assumed in the Phase II report that 100% of the daily dose of nitrate, nitrite and sulphate could come from drinking water. This does not allow for dietary exposure of these parameters which are high in some foods (i.e., processed meats, smoked meats). DDMI should revisit this assumption of 100% allocation to drinking water as it is not defensible.

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TOPIC	COMMENT	RECOMMENDATION
Appendix V-1 Section 3 Table V3	The SSRBCC for sulphate is not consistent with the Health Canada Drinking Water Quality Guideline (DWQG) nor the Diavik Water Quality Benchmark, nor the SSRBCC identified in Table 3.2-1 of the Phase II Report.	Health Canada's DWQG for sulphate is 500 mg/L, Table V3 indicates the SSRBCC for Nitrate for the protection of drinking water as 669 for toddlers and 266 mg/L for adults. Since toddlers are typically more sensitive than adults, DDMI should confirm the numbers reported in Table V-3. In addition, DDMI should verify and provide a rationale for the number proposed. DDMI assumed in the Phase II report that 100% of the daily dose of nitrate, nitrite and sulphate could come from drinking water. This does not allow for dietary exposure of these parameters which are high in some foods (i.e., processed foods, smoked meats) and used in personal care products. DDMI should revisit this assumption of 100% allocation to drinking water as it may not be defensible.
Appendix V-1 Section 3 Table V5	Water closure criteria protective of mammals does not consider all guilds. For example a small carnivorous/insectivorous mammal (i.e., shrew) is not considered nor are aquatic mammals.	The closure criteria must be protective of all possible receptors. Additional receptors should be considered.
Appendix V-2	Based on examination of the Time Series Plots and the data of parameters measured, the difference between the AEMP benchmark, which is considered protective of the aquatic environment and the back-calculated closure criteria, leads to concern over the impacts of this continuous loading into Lac de Gras over time. It is unlikely that the back-calculated closure criteria, if put in place, will be protective of the aquatic environment.	The assumptions used in the back-calculated closure criteria need to be supported by scientific data and critically reviewed. Particular attention should be given to the determination of the dilution factor and the determination of the Effects Magnitude. The Effects Magnitude is based on a 20% increase over a benchmark and is considered a significant effect in the EA. Closure criteria need to be protective of aquatic life. Multiplying an environmental criteria by an arbitrary 20% does not take into account toxicity, dose responses or effects on aquatic organisms. The use of 20% is not appropriate as it has been used in the derivation of closure criteria.
Appendix V-2	Interpretation of the 2012-2015 data in the Time Plots should be done with care, as it appears that the number of samples have decreased from previous years and the plots could be biased based on the sampling plan.	Care in interpreting the results should be given. It should also be understood why the sampling plan has decreased over the last few years.
Appendix V	The closure criteria proposed in Appendix V are based on the potential for seepage and run-off waters to impact Lac De Gras. There has been no consideration for the partitioning of the chemical loading to sediment in the derivation of the closure criteria.	Closure criteria should be protective of all potential fate and transport pathways, exposure pathways and receptors. Additional considerations need to be given in the derivation of the final closure criteria.



Table 1: Specific Review Comments on WRSA

<u>TOPIC</u>	<u>COMMENT</u>	<u>RECOMMENDATION</u>
Appendix V	There should only be one closure criterion per parameter.	Therefore the lowest of the applicable criteria for each parameter should be selected as the closure criterion.