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Subject: **Technical Memo – Review Comments on the Diavik Annual Interim Closure and Reclamation Plan (ICRP) Progress Report 2015**

INTRODUCTION

Further to your request we are pleased to provide our review comments on the DDMI 2015 Closure Plan Update submitted to the Wek'èezhìi Land and Water Board on 31 March 2016. The update contains extensive information on the status of the closure plan, changes to the plan and schedules, and the results of the Reclamation Research Programs. Of specific note is that DDMI has included new information including:

- North Country Rock Pile (NCRP) Final Closure Plan (Appendix IV-1 and design drawings Appendix X). The NCRP closure plan also includes a proposed set of closure criteria for the waste pile. It should be noted that the Board has not approved the closure criteria in DDMI's approved Interim Closure and Reclamation Plan (ICRP version 3.2, July 2012) and have invited reviewers to

comment on DDMI's proposed waste rock storage area closure criteria and whether the Board should approve them;

- A21 ICRP (Appendix IV-2), as required by the Board's August 19, 2015 directive; and,
- Updated RECLAIM Estimate (Appendix VIII), as required by the Board's August 19, 2015 directive.

The Environmental Monitoring Advisory Board (EMAB) requested that Arcadis conduct a technical review of the Annual ICRP Progress Report – 2015. The focus of this review was to:

- Use knowledge of current Best Practices for mining reclamation, restoration and closure, including use of traditional knowledge and community participation, to identify:
 - -Any critical components that have been left out or described in insufficient detail
 - -Fatal flaws
 - -Areas for improvement
 - -Components requiring further research
- Comment on the status of Reclamation Research Tasks and how well study objectives are being met
- Identify any issues the Report raises
- Conduct a technical review of Appendix IV-1 – NCRP Final Closure Plan

FINDINGS OF THE REVIEW

As a general comment, there is extensive information and research on the closure of the Diavik Diamond Mine and its related facilities. The work completed is world class with input from numerous universities and technical experts. It is clear, few mines in the world would have as an extensive data base upon which to base their closure plan. Having said this, there are still a number of outstanding issues that need to be addressed and finalized. These items are discussed in this section under the headings of:

- 1) Closure Plan for the NCRP
- 2) ICRP and 2015 Annual ICRP Update
- 3) Reclamation Research Tasks

1.0 NCRP Final Closure Plan

1.1 Overview

The NCRP contains waste rock from the development of both open pits and underground mining from the A154 and A418 kimberlite pipes. Waste rock was segregated during mining. Type I rock, which is non-acid generating, is segregated and used in construction or stored for later use. Type II and III rock, which is potentially acid generating (PAG), is permanently stored in the NCRP or used as underground mine backfill.

The final closure design for the NCRP as provided includes:

- *Re-shaping of the pile to flatten the angle of repose side slopes and to provide an appropriate surface for placement of a cover.* This typically involves grading the side slope to 3:1 (horizontal to vertical). A portion by the PKC facility will be left at the natural angle of repose in response to the TK Panel request to provide habitat for wolverine denning.
- *Construction of a thermal cover.* The thermal cover includes 1.5 m of till and 3 m of Type I waste rock. DDMI consultants have done extensive thermal modelling to demonstrate both the need for this thermal barrier and the design of the barrier. The results indicate that for the climate change scenario modelled, the pile below the thermal cap will remain frozen.
- *Caribou access ramps.* The TK Panel has stressed the need for safe passage of caribou through the site. The waste piles, being high hills, will tend to attract caribou seeking to get away from the flies. The original closure plan includes access ramps with till (fine material) placed at surface to assure the hooves of the caribou are not damaged. The revised plan makes no allowance for placement of fine material.

In the development of the plan, DDMI has used input from the TK Panel to guide the final closure concepts. Details of the discussions and DDMI's responses can be found in Appendix I – Community Engagement Documents.

The NCRP Final Closure Plan is being put forward for approval at this time to coincide with the development of the A21 pit. The A21 pit will be the source of the till and waste rock that is to be used as the thermal cover for the pile. This allows DDMI to haul waste directly from the pit for use as cover rather than having to store the waste in a new location and re-handle the material at a later date. This is a rational progressive closure strategy.

The following are our key findings from the review of the NCRP Final Closure Plan.

1.2 Findings NCRP Final Closure Plan.

1.2.1 Closure Criteria

The proposed closure criteria for the waste rock piles are provided in Tables V-1, V-2 and V-3 of the NCRP Final Closure Plan. The objectives for closure appear to be reasonable but some of the closure criteria lack clarity in that they don't relate to the objective. For example, as shown in the table below, the criteria to meet the objectives for W2 and SW9 are to build the NCRP facility as designed. We don't see how building the facility as designed relates to the stated objectives:

- Objective W2 – Create a closure condition where the *rock and till pile features (shape and appearance) match aesthetics of the surrounding natural area;*
- Objective SW9 – Demonstrate that *landscape features (topography and vegetation) match aesthetics and natural conditions of the surrounding natural area.*

Furthermore, we don't understand how the submission of the reclamation completion report will provide assurance the objectives are met.

Closure Objective	Closure Criteria	Measurements	Monitoring Reference
W2 Rock and till pile features (shape and appearance) that	NCRP As-Built Report conforms adequately with Golder (2016).	Reclamation Completion Report	Appendix VI-2

match aesthetics of the surrounding natural area.			
SW9. Landscape features (topography and vegetation) that match aesthetics and natural conditions of the surrounding natural area.	NCRP As-Built Report conforms adequately with Golder (2016).	Post Closure Reclamation Completion Report	Appendix VI-2

It is clear that the objectives such as W2 and SW9 are desirable and consistent with best practice where applicable. It is also clear that a barren pile at closure will not match aesthetics and natural conditions of the surrounding natural area. Attaining pre-mine conditions for the NCRP is neither practical nor possible. However, there does not appear to be any effort towards *landscape design* or any attempt to meet the objectives in W2 and SW9. The pile is simply graded to 3:1 and covered. Certainly some efforts such as selective vegetation and landscape design modifications to better address the aesthetics and natural conditions of the surrounding natural area are reasonable.

It is recommended that additional discussion is required to improve the design to address objectives W2 and SW9 (or to change the objectives and criteria).

1.2.2 Caribou Ramps

Caribou ramps and transit pathways for the NCRP are shown on Figure 5.9 of the NCRP closure plan. An allowance of 6,400 m³ has been provided in the RECLAIM estimate to provide fine material on the ramps to minimize the potential for injury to caribou hooves as they transit the pile. Construction drawings have no mention of till placement on caribou trails and drawings and sections show no caribou trails. Furthermore, there is no reference to caribou ramps or trails in the Golder Design Report.

It is apparent that DDMI has deleted the application of till on the caribou ramps. In discussion with the TK Panel, they have indicated their preference to have fine material on the ramps and even suggested that coarse PK may be a consideration. DDMI has indicated they would assess application of coarse PK to the ramps but we understand no work has been completed.

It is recommended that till (or coarse PK) be included as fine cover material for the caribou ramps as was committed to in the original closure plan, requested by the TK Panel, and as contained in the 2015 RECLAIM estimate.

1.2.3 Vegetation of the NCRP

The closure plan provides no allowance for any re-vegetation of the waste pile. This is not consistent with the reclamation objectives W2 and SW9 as previously discussed. The Mackenzie Valley Land and Water Board's Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories sets forth a template for closure plans and requirements. The guide is not specific on vegetation requirements but states options that include:

- Revegetate using native species, or use other bioengineering measures (use of living organisms or other biological systems for environmental management) to reduce surface erosion, provide physical stability, and **meet future use targets**.
- Monitor revegetation activities such that they meet technical needs (e.g., maintaining physical stability), **aesthetic needs (e.g., blends with surroundings), and future use targets**, and do

not impact the effectiveness of selected closure activities or become a source of metals due to uptake.

It is recommended that DDMI provide a clear rationale for its decision not to include any vegetation of any portions of the waste rock piles.

2.0 Findings of Review of the ICRP and 2015 Annual ICRP Update

2.1 Overview

There are a number of findings that relate to the NCRP and the overall ICRP. These relate to:

- 1) Funding and Responsibility for Long-Term Care and Monitoring of the Site
- 2) Strategy for Site-Wide Vegetation
- 3) Fine PK Management
- 4) A418 Pit High Wall Safety
- 5) PK Closure Plan
- 6) A21 Closure Plan
- 7) RECLAIM Estimate

The findings regarding these aspects are addressed in the following sections.

2.1.1 Funding and Responsibility for Long-Term Care and Monitoring of the Site

DDMI has provided in their closure budgets allowances for monitoring and maintenance of the site for a period of 7 years post-closure. During that period, monitoring is required to assure the closure systems function as designed and meet all closure criteria. Funding allocated to complete the programs would appear to be appropriate. After the 7-year period all monitoring and care and maintenance of the site stops.

The need to monitor the site is certainly reduced after final closure but is certainly not eliminated. For example:

- The closed PK facility has an engineered dam which is a water retaining structure retaining both a pond and fine/coarse PK. Monitoring frequency during the 7-year closure period included annual geotechnical inspections.
 - *It is recommended that DDMI should seek guidance from the Engineer of Record as to long-term monitoring requirements consistent with the Canadian Dam Safety Guidelines.*
- The closed PK facility includes a spillway to pass runoff from the drainage basin within the PK facility to the environment. This spillway could be glaciated (plugged with ice) which could cause a large backwater pond to form during the spring freshet. A sudden failure of the ice plug could result in erosion of the spillway and possible loss of fine PK.
 - *It is recommended that DDMI should assess the consequences of the spillway plugging and determine what (if any) monitoring/action is appropriate over the long-term to assure failure of the spillway does not occur.*

- The cover on the waste pile may deteriorate and require maintenance over the long-term. Golder, in their 2016 design report for the NCRP, state "*Based on temperature measurements collected from a large-scale test pile built at Diavik Mine and numerical simulations (Pham, 2013), the active layer may penetrate the 3 m thick Type I rockfill layer and into the till cover layer. Therefore, solifluction, skinflows and bimodal flows are considered credible failure modes for the cover system. Similarly, should water pond on the till layer, and the active layer fully penetrate the till, then loss of finer particles from the till into the underlying waste rock is possible due to filter incompatibility.*" These comments by Golder demonstrate there is a potential future need for long-term monitoring and potential maintenance of the cover.

The major concerns and questions that need to be answered include:

- 1) Who is responsible for the long-term monitoring, care and maintenance of the facility?
- 2) Who bears the cost for long-term care and maintenance of the facility?

Jurisdictions such as Saskatchewan have recognized the need for long-term care of mine waste facilities. In this regard, Saskatchewan Environment has established an Institutional Care Program (ICP) that addresses all aspects of mine closure. It has been designed to be revenue neutral and sustainable and to ensure that future generations are not burdened with the costs of the long-term monitoring and maintenance of former mine sites in the province. In addition, the Saskatchewan Ministry of the Environment now includes the cost for transferring a closed site into the ICP as a component of the financial assurance required for operating sites. In other words, **the mining company is required to provide funding for long-term Institutional control.**

It is recommended DDMI assess the costs for institutional care and maintenance of the closed facility and include these costs in the financial assurance funding.

2.1.2 Strategy for Site-Wide Vegetation

DDMI has undertaken active research and development programs on vegetation since 2004. To date, no allowances are included in the reclamation estimates for vegetation. It is understood that the Version 4 ICRP will address vegetation. It is noteworthy that at the neighbouring Ekati Diamond Mine, revegetation costs of more than \$6 million are anticipated, including for the vegetation of exposed PK beaches.

It is recommended that DDMI provide a clear rationale for where and how they will adopt the site-wide vegetation plans and provide costs for revegetation in the RECLAIM financial security estimate.

2.1.3 Fine PK Management

The management of fine PK is a major concern of the TK Panel. The Panel indicated it was their preference that all fine PK be removed from the site. Given the impracticality of removal of the fine PK from the site, DDMI retained the Toxicology Center at the University of Saskatchewan to undertake an independent assessment of the toxicity of the extra fine PK tailings (EFPKTs) that would ultimately form the bottom of a closure PKC Pond (see Appendix II-5). The report states:

- "Whole EFPKTs, extracted pore water and leachate produced from the EFPKTs had mixed effects on the aquatic organisms used in this study. Biological endpoints such as growth and survival were reduced in the highest concentrations of whole tailings, tailings pore water, or tailings leachate tested for some organisms and test durations, but the differences were often not statistically significant compared to the respective controls. However, whole EFPKTs clearly reduced *C. dilutus* survival."

- “Based on their relative ease of extraction using dilute acid, metals such as chromium and nickel are potentially available through both aqueous and dietary routes of exposure for deposit feeders such as *C. dilutus*, and could possibly have contributed to toxicity.”

It is recommended that DDMI provides an evaluation of these and other findings by the Toxicology Center at the University of Saskatchewan and what this means for closure of the site. For example, are there issues such as a toxicity concern or metal exposure for deposit feeders?

2.1.4 A418 Pit High Wall Safety

The TK Panel had indicated a concern over the high wall of the A418 pit. They stated “an approximately 1 kilometre section of pit wall would become a cliff over the water/ice that could be dangerous for animals.” The Panel recommended that this section be broken up with some sloped areas that would allow for safe passage. The issue remains outstanding and it is uncertain that a plan has been developed to address the concern.

It is recommended that DDMI address the A418 pit high wall closure in the Version 4 ICRP.

2.1.5 PK Closure Plan

The TK Panel raised concerns over the closure plan for the PK facility and has requested that the PK closure include:

- Sufficient travel-ways for caribou and muskox over the dam through re-sloping and topping with smaller material. This approach would create safe access for wildlife, as it is assumed that wildlife will try to use this area after closure.
- Re-vegetation of the PKC area according to baseline TK and science.

The current closure plan does not include any allowances for the addition of fine material for travel-ways for caribou and muskox or any revegetation of the PKC area.

It is recommended that DDMI provide a clear rationale as to why travel-ways for caribou and muskox are not a component of the plan and why revegetation of the PK site has not been adopted.

2.1.6 A21 Pit Closure

A conceptual plan and costing for the A21 pit closure is provided in the 2015 ICRP Update, in Appendix IV-2. The conceptual plan is consistent with the closure plans for the A418 and A514 pits.

The report indicates that “A separate South Country Rock and Till Storage area is being designed for the waste rock and till from A21.” It is uncertain how facility designs are being prepared when we have been told that no site has been selected. Additional financial assurance will be required for the reclamation of the South Country Rock and Till Storage areas.

2.1.7 RECLAIM Estimate

The RECLAIM estimate is generally well prepared. Deficiencies as identified previously in this memo include the lack of the following:

- Allowances for vegetation
- Allowances for Institutional Care and Long-Term Monitoring

- Allowances for travel-ways for caribou and muskox for the PK facility
- Allowances to address safety issues with the A418 pit high wall.
- Allowances for closure of the South Country Rock and Till Storage areas.

3.0 Reclamation Research Tasks

The reclamation research programs have contributed greatly in advancing the closure plan. Key findings have evaluated and demonstrated:

- Methods for site-wide vegetation;
- The adequacy and validity of the thermal cover design for NCRP;
- The effectiveness of the community engagement programs; and,
- Validation and improvement to water quality predictions (pit lakes, seepage, porewater, etc.)

The one significant area of research which remains outstanding relates to metals uptake by vegetation. This work has been initiated but not completed and will be a key program to support the site wide vegetation program.

The overall research programs are extensive and we would propose no additional studies.