# Memorandum

To: John McCullum, Environmental Monitoring Advisory Board

From: Bill Slater, Slater Environmental
Rasheeda Slater, Core Geoscience Services

Date: December 13th, 2021

**Re: DRAFT Review: Diavik Diamond Mines – Request for Security Refund for North WRSA**

This memo provides details of the review conducted by Slater Environmental Consulting (SEC) and Core Geoscience Services (CoreGeo) of the request for security refund by Diavik Diamond Mines Inc. (DDMI) for progressive reclamation of the North Waste Rock Storage Area (NWRSA) submitted to the Wek'èezhii Land and Water Board (WLWB).

The scope of work provided by email on November 24, 2021 includes review of the documents submitted by DDMI related to the NWRSA, including the 2020 Completion Report with appendices, and updated RECLAIM estimate, and addressing the following questions:

- Has Diavik met all MVLWB guidelines and WLWB direction on requesting security refunds with respect to the NWRSA? In particular has Diavik addressed ICRP 4.1 RDF Security Decision #2.
- Should Diavik receive a refund for work completed to date on NWRSA? Is the proposed amount reasonable? Does the security refund requested by Diavik (and amount of security remaining) reflect the remaining liability for the NWRSA?
- Does till moisture and thickness meet design specifications? If not, have these issues been adequately addressed?
- Is there a sufficient amount of till moisture content data and till thickness sampling? Note: 4 TDR soil moisture probes have been placed in regions 4, 10, 27, and 42 of the NWRSA.
- Should performance report be required since Diavik has had some TDR moisture probes installed since 2019? No Performance Assessment Report was submitted because cover for NWRSA hasn't been completed.

Our review has considered these questions. As many of these questions are interrelated, the information provided in this memo may overlap and answers to questions may span across sections.

## 1.0 Maximum Till Moisture and Minimum Thickness Specifications and Data

The specifications outlined in the closure cover design require placed till to be 1.5m thick overlain by 3 m of Type I rockfill. The design specifies that till moisture must be less that 25% gravimetric water content, but the stability analysis for the cover considered water content of 17.8-20.0% and predicted that design factor of safety would not be met for the short-term condition where the till is not covered with rock.

Based on the information provided, more Quality Control tests for moisture and gradation were collected than specified in the design. However, less Quality Assurance tests were collected than specified. The list of till cover layer QA/QC samples by region appears to be missing from the 2020 Reclamation Completion report (Table 10).

Figure 2 in the 2020 Reclamation Completion Report shows the water content results for the Quality Control tests. The water content appears to be increasing with increasing test numbers. Assuming tests were numbered chronologically, this trend indicates that till moisture content increased as the year progressed. All but one sample met the design specification of 25%, but several samples had water contents near or above the contents considered in the stability analysis.

DDMI and the Quality Assurance Manager did identify areas with concerns regarding moisture and softness of till material, sometimes resulting in equipment operation challenges (e.g., getting stuck, rutting) and material sloughing down the slope. The QA Manager noted soft till, for example, on regions 9 and 10. Soft till with high water content was also noted in the lower portions of Regions 45 and 46. The softness was attributed to relocation and spreading of wet, surface layer till from an overbuilt upper areas to lower areas in these regions. This led to an accumulation of wet till on the lower portion, which had a water content 10% higher than the upper portion. The QA Manager provided recommendations to address the moisture issues, but no information is provided to confirm whether these recommendations were completed. The material did meet technical specifications, and as such, till placement was approved, but it is not clear if the till material was still soft.

Similar issues were identified on Regions 47- 50. In these areas, a line was delineated between the firm upper portion and soft lower portions. Test pitting was conducted in the lower portions of regions 47 – 50. The soft lower portions did not receive till placement approval.

The QA Manager noted that the inclusion of softer layers of till with higher water content may increase the potential for slope instability of the cover layers. He further noted that the maximum of 25% gravimetric water content was intended to prevent placement of low strength lakebed sediments on sloped areas, and that “where till has become wetted after placement and has low strength, evidenced by higher water content and rutting when trafficked, the same risks of potential instability exist.” He goes on to state that the “design report Diavik Diamond Mine North Country Rock Pile Closure Design Ref. 1521339-1471-R-Rev5-7000-NCRP, 20 February 2018 states that at water contents of 20%, instability of the cover layer should be expected, and will require maintenance.”

As well, sinkholes were reported in areas 108 – 111 (on the upper surface of the WRSA) that had been re-sloped and covered with a mixture of wet till and lakebed sediments. DDMI did not complete the QA recommendations of filling these sinkholes and regrading prior to covering the areas with the wet till and lakebed sediment material. Because the mitigation was not completed, QA required DDMI to monitor this area and regrade it, if needed, prior to approval of till placement ahead of rockfill cover layer.

**Recommendation: Given the evidence of construction and performance challenges associated with wet, soft till material, DDMI should consider revising the design specification for till water content.**

In some cases, till thickness did not meet specification. These included areas where till had been left exposed for up to two years. Areas 2, 7 and 8 were identified in 2020 to have less than 1.5 m of till thickness. In some regions, till thickness was rectified in 2020 and received re-approval including regions 2 – 6. However, based on the 2020 Reclamation Completion report it appears failure to meet the 1.5m till thickness criteria has yet to be addressed in some regions.

In request for information RFI-Golder-002, Golder requested till thickness verification at minimum of three locations by directly measuring the thickness. DDMI's response does not address this portion of the request. Overall, the reclamation completion report does not appear to provide details of any verification of till or rock depth through direct measurements.

**Recommendation: DDMI should conduct and report on direct measurements of till and rockfill cover thicknesses to confirm accuracy of surveys.**

Communications between DDMI and its consultants indicate instances where cover construction has varied from the initial design.

- DDMI requested Golder and Tetratech provide confirmation that maintaining an overall cover thickness while increasing till thickness and reducing rockfill thickness would not compromise the stability and thermal performance. Golder indicated a minimum of 0.75m of rockfill is required to maintain design factors of safety. Tetratech concluded that any such changes would not have a negative impact on the thermal performance.
- DDMI requested Tetratech conduct a thermal analysis using 1.4m of till versus 1.5m to determine if additional Type I rockfill could be used to achieve the desired thermal performance. This request arose because initial till placement in some areas did not meet the design specification of 1.5m thickness, and DDMI asserted that there would be construction challenges associated with placing a thin layer of additional till in those locations. Tetratech indicated that 3.3m of rockfill would be required to meet the thermal performance criteria if till thickness was only 1.4 m. Because the request occurred near the end of the 2020 reporting period, the completion report does not indicate whether DDMI completed construction in these areas with the below-specifications till layer and thicker rockfill.
- DDMI requested Tetratech confirm that lakebed sediments have similar thermal properties to till, as required by Board Decision # 2 on the DDMI request to WLWB for WRSA-NCRP Cover Modification. Tetratech indicated that it had not completed thermal analyses of the use of lakebed sediments. However, it stated that based on the particle size and water content presented in DDMI's request to the WLWB, that lakebed sediments have similar properties to the glacial till used in the previous analyses. Tetratech estimates that the lakebed sediments have a higher latent heat due to a higher fines content and higher water content. As such, Tetratech concluded that the predicated thaw depths used in the analyses are conservative when using lakebed sediment rather than till. This is likely a reasonable conclusion for the thermal analyses and predictions.

The information and analyses provided with the 2020 Reclamation Completion Report appear to indicate that the variations described should not compromise the design criteria that were considered in the analyses.

## 2.0 Minimum Till Moisture

The cover design does not specify a minimum till moisture. However, the thermal analysis predicts that "till with a minimum 10% water content would be required on the side slopes of the NCRP to prevent the thawing front from penetrating into the Type III rock." This means that the water content in the till layer needs to remain above 10% in the long-term. The water content in the till layer over time is related to soil properties, climate conditions and water balance.

The Reclamation Completion Report describes the installation of soil moisture instrumentation at four locations on north (1), west (1) and south (2) facing slopes of the NWRSA. The installation of the

instrumentation included collection of field water content tests, with 2-3 samples reported from each installation. All but one of these samples had water contents below 10%, with several samples at or below 7%. Initial readings from the instrumentation also reported water contents well below 10%.

While current data are limited, they indicated that the water content in the till layer may not meet the 10% minimum in the long-term. As a result, the thermal conditions may be different than what was predicted, including potential thaw to greater depths, possibly into the Type III rock. The implications of lower water content in the till should be considered now, and the design adjusted to address any potential failure to meet the design criteria for thaw depth. For areas that are already constructed, this could include requirements to add additional rockfill.

**Recommendation: DDMI should update the thermal modelling for the covers to incorporate results of monitoring for till moisture content, and revise the cover design to address any potential future thaw of Type III rock.**

## 3.0 State of Completion, Remaining Liability, and Performance Reporting

Construction of the NWRSA cover is completed in three steps, re-sloping Type II/III material, placement of till, and placement of Type I rockfill. For each region of the NWRSA the requirements for each step were estimated by volume. DDMI reported the work completed for each step by region and provided an estimation of completion based on the total volume completed versus total volume planned for each step. When making this calculation, DDMI relies on optimized volumes that are less than the volumes stated in the original design:

- Re-sloping: Original design of 1,532,000 $m^3$ in design versus 1,465,811 $m^3$ in optimization; a reduction of 4.3%.
- Till Placement: Original design of 2,000,000 $m^3$ in design versus 1,795,145 $m^3$ in optimization; a reduction of 10.2%.
- Rockfill Placement: Original design of 3,980,000 $m^3$ in design versus 3,591,630 $m^3$ in optimization; a reduction of 9.8%

Based on the optimized volumes, DDMI reports that 75% of re-sloping, 72% of till placement, and 11% of rockfill placement are complete on the NWRSA.

However, in some regions, DDMI reports re-slope and placement volumes that are higher than the planned volume. For example,

- Re-slope volume for regions 48 – 54 of 128,985 $m^3$ versus a planned volume of 115,662 $m^3$, an increase of 11.5%.
- Till volume for regions 78 – 85 of 155,578 $m^3$ versus a planned volume of 109,392 $m^3$, an increase of 42.2%.

There are, of course, many areas for which DDMI reports volumes that are less than the planned volume, but these are most likely for areas where re-sloping and material placement are incomplete.

Further, it is unclear whether or not the reported volumes re-sloped/placed represent an approved state or if additional volume is still required to receive approval for each of the regions. Regions 55 – 66 and 78 – 85 and are examples of regions where the placed till volume exceeds the planned volume, but it appears based on Table 15, Appendix B, and Appendix C of the 2020 Reclamation Completion Report that additional volume may still be necessary to complete the reclamation work in these areas.

In particular, some areas received re-sloping or till placement approval, but it is not clear the next step was initiated within 2-months of approval. After 2-months, re-approval must be sought, and it is possible that additional material volume could be required. Limitations of the 2020 reporting period did not allow for a complete understanding if construction was advanced within 2-months following approval.

The measure DDMI used to determine percent completion does not consider the areas where additional volume was required to complete the work. Further, DDMI did not provide any updates to the planned volume to account for additional volume needed or anticipated additional volume needed in these or any other areas. Therefore, DDMI's use of the optimized volume to determine percent work completed fails to account for placement beyond the planned volume and new information indicating future need for additional volumes. Overall, DDMI's calculations likely overestimate the proportion of re-sloping and material placement that has been completed when comparing with what will likely be required overall for completion of the NWRSA reclamation.

**Recommendation: DDMI should update its estimates of percent complete to consider volumes of re-sloping and material placement that exceeded the expected volumes, and revised predictions of future volumes based on lessons learned from work completed to-date.**

## 4.0 Implications for Security Refund Request

With respect to CRP Version 4.1 – Reasons for Decision, Security Decision #2, DDMI states that "There were no discrepancies or uncertainties with respect to work completed. Holdback amounts were not changed from the current approved RECLAIM." However, as outlined in the sections above, there appear to be some discrepancies from the design criteria used to develop the proposed closure cost estimate. These discrepancies include quantity of material required to complete re-sloping and material placement, performance of cover material with high moisture content, and performance of till that has long-term moisture contents lower than 10%.

Any refund of security associated with DDMI's progressive reclamation work completed on the NWRSA in 2020 needs to consider three key factors. Based on the information provided in the 2020 Reclamation Completion report there are remaining uncertainties associated with all three of these factors, each of which is discussed below.

1. *The proportion of the overall NWRSA reclamation work that has been completed.*

   As described above, DDMI's calculations appear to overestimate the proportion of the overall NWRSA work that has been completed. Additional information is needed to accurately estimate the proportion of actual required re-sloping and material placement that has been completed. Re-sloping excesses in the range of 11% have occurred in some areas. For areas with noted excess till placement, average excess was 19%. If excesses are similar to these, then overall reclamation costs for the NWRSA could be 10-20% higher than expected.

2. *The consistency of the work completed with the design*

   For the most part, the Reclamation Completion Report demonstrates that re-sloping and material placement has been in accordance with the design. However, there are some areas where wet and soft till material, while meeting design specifications, may not be sufficient to meet the design intent. Also, there are some areas where measures required under QA appear not to have been completed. Field verification of till and rockfill thickness is not reported. Finally, initial evidence

indicates that water content in the till may not be sufficient to achieve the thermal design criteria. Addressing the implications of lower till moisture may require the placement of additional rock cover thickness to achieve the thermal criteria.

3. *Uncertainty related to the performance of the work completed.*

The design of the cover was based on modelling to predict physical stability and thermal performance. While these designs relied on appropriate methods, there is remaining uncertainty about performance of the actual closure measures once they are built. Will the active layer remain in the cover? Will the cover be physically stable under field conditions? Will there be unexpected performance issues related to wildlife or other environmental values? Will water quality be consistent with expectations? Ultimately, these questions need to be addressed in a Performance Assessment Report, which will have to rely on monitoring conducted once the reclamation of the NWRSA is complete, and in some cases (e.g., wildlife, water quality) once the overall reclamation plan is complete.

There is no doubt that NWRSA progressive reclamation work completed in 2020 and in previous years has some value. Re-sloping and till/rockfill placement are costly and important components of completing the NWRSA reclamation. However, any refund for 2020 progressive reclamation activities needs to consider the amount of holdback that should be in place for the overall NWRSA reclamation. Currently, the security estimate includes a maintenance holdback of $2,569,349 for future maintenance of the cover.

Using the current rates and DDMI's optimized volumes, the direct costs for re-sloping and material placement on the Type II/III rock would be $42,124,514. This would increase to $46,634,436 using the original design volumes. DDMI is requesting that the security be adjusted to reflect $32,971,395 in direct costs for the NWRSA, based on its calculated proportions of re-sloping and material placement (75% of re-sloping, 72% of till placement, and 11% of rockfill placement), a reduction of $7,106,097 from the current security.

Because the uncertainties apply to the whole NWRSA reclamation, not just the 2020 work, a holdback should be established that is related to the cost for completed re-sloping and material placement on the whole NWRSA.

**Recommendation: DDMI's security refund request for progressive reclamation on the NWRSA should only be approved after it is adjusted to include appropriate holdbacks for discrepancies related to the proportion of work completed and consistency with design criteria and intent, and uncertainties about performance.**

**The uncertainty related to calculation of proportion of work completed suggests overestimates of approximately 15-20%. On this basis the total cost for the remaining re-sloping and material placement could be greater than expected by $4,577,594 to $6,103,459 assuming optimized volumes.**

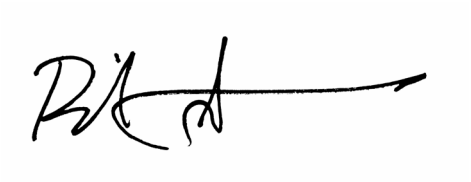
**Placement of additional rockfill to address uncertainties about long-term till moisture below 10% water content could add significantly to costs, but the amounts are uncertain until additional thermal analysis is conducted. Given that Tetratech has concluded that an additional 0.3 m of rockfill is required to meet thermal criteria if till is 1.4 m instead of 1.5 m (6.7% reduction), it is not unreasonable to assume that 0.5 m of additional rockfill could be required. This would be a 17% increase in rockfill placement, with a cost of approximately $4,000,000.**

**Finally, there should be some holdback related to the long-term performance of the closure measures. As noted above, DDMI's security estimate includes a holdback of $2,569,349 for cover maintenance. Costs for future maintenance are important and should be part of any post-closure cost estimate. Maintenance should be expected even on facilities that initially meet performance expectations. However, there is also uncertainty about whether the facility, even if constructed as designed, will meet performance expectations. Amounts for this type of uncertainty are difficult to estimate because they are associated with future conditions with variable likelihoods. At a minimum, a holdback that is equal to the contingency amount for the completed work (15% in this case) is likely a reasonable starting point. Using DDMI's numbers for cumulative volumes to the end of 2021, the direct cost of the completed work is $11,607,220, and a holdback of the 15% contingency would be $1,741,083.**

## 5.0 Closing

Thank you for the opportunity to review this security refund request submitted by DDMI. Please let us know if you wish to discuss any of the comments provided.

Sincerely,



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