May 30, 2016

Mr. Gord Macdonald
Suite 300, 5201-50th Avenue
Yellowknife, NT X1A 2P8

Dear Mr. Macdonald,

Re: DDMI’s Proposed Modification to the Spillway and Freeboard Limit of the Processed Kimberlite Containment facility

The Wek’eezhii Land and Water Board (WLWLB or the Board) met on May 18, 2016 to consider DDMI’s proposed modification to the spillway of the Processed Kimberlite Containment (PKC) Facility. DDMI proposed to change the design of the PKC Facility spillway, as per Part G, Item 2. The modification would require the Board to approve a change in the minimum freeboard stipulated in Part H, Item 21a of the Licence. This Licence condition authorizes the Board to approve a change to the minimum freeboard, without a Licence amendment.

The Board did not approve the modification (and therefore did not approve a change to the minimum freeboard), as explained in the Board’s Reasons for Decision (attached). In the Reasons for Decision, the Board has also described the information that DDMI would need to provide should the company wish to submit a revised modification request.

If you have any questions, please contact Patty Ewaschuk at (416) 432-6066.

Sincerely,

Violet Camsell-Blondin
Chair, Wek’eezhii Land and Water Board

Copied: DDMI Distribution List
Reference/File Number: W2015L2-0001 (Type A Water Licence)
Licensee: Diavik Diamond Mines (2012) Inc. (DDMI)
Subject: DDMI’s Request for Approval of a Modification of the Processed Kimberlite Containment (PKC) Facility Spillway

Decision from the Wek’èezhìi Land and Water Board
Meeting of May 18, 2016

1.0 Decision

On May 18, 2016, the Wek’èezhìi Land and Water Board (the Board) met to consider a request by Diavik Diamond Mines (2012) Inc. (DDMI) for the approval of a modification to the Processed Kimberlite Containment (PKC) Facility. At this time, the Board decided to not approve the proposed modification. The rationale for the Board’s decision is outlined in the Reasons for Decision section below.

2.0 Background

On December 10, 2015, DDMI submitted a proposed spillway modification1 under Part G, Item 2 of the Water Licence (see textbox). The submission included a cover letter and a technical memo prepared for DDMI by Golder Associates (the “Golder memo”).

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1 See WLWB (www.wlwb.ca) Online Registry for Diavik – Modification – Processed Kimberlite Containment Facility – Spillway and Freeboard Limit – Dec 10, 16
By submitting the spillway modification under Part G, Item 2, DDMI acknowledged that the modification would require Board approval.

2.1 An Explanation of the Proposed Modification

The current spillway design is described in DDMI’s PKC Facility Phase 6 Design Report. The key differences between the current design and DDMI’s proposed modification are:

- DDMI proposes to reduce the minimum freeboard from 1.5 metres (m) to 0.4 m.

- DDMI proposes to base the design of the PKC facility spillway on a smaller environmental design flood. The current design is based on a 1 in 500 year event, and DDMI proposes to reduce this to a 1 in 100 year event.

- DDMI proposes to design the PKC Facility spillway so that if an event greater than the environmental design flood occurs, water will pass through the PKC Facility spillway to Pond 3 and be stored there, rather than in the PKC facility.

- DDMI proposes that the normal operating water level be at the same elevation as the spillway invert (the bottom of the spillway).

- In its design calculations, DDMI reduced the area of the land surface that drains into the PKC Facility (e.g., the catchment area) from 4.16 square kilometres (km²) to 1.50 km². This means that the amount of run-off into the PKC Facility will decrease and the predicted flow volumes during a storm event are therefore lower than in the Phase 6 Final Design Report. DDMI explained that the

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reduction in catchment area is based on 12 years of operational experience related to site water management.³

None of these design elements will come into play for several years until the elevation of the tailings (and therefore the pond water) is much higher. For now, the pond water level is well below the bottom of the spillway, and the PKC Facility can hold both the inflow design flood and the environmental design flood.

2.2 Review Process

Board staff distributed the proposed modification for public review on January 4, 2016. The Board received comments from the Government of the Northwest Territories (GNWT) Department of Lands Inspector and the GNWT’s Department of Environment and Natural Resources (ENR) by the February 19, 2016 deadline. Board staff also submitted questions during the public review period. DDMI responded to reviewers’ comments and recommendations on March 2, 2016. Public comments and DDMI responses are available in the Review Summary and Attachments.⁴

The Board hired SRK Consulting to review the proposed modification and assist the Board with the technical issues related to it. On April 6, 2016, Board staff, DDMI, Golder, and SRK participated in a meeting to discuss the details of the modification. The notes for the meeting can be found in Attachment #2.

3.0 Reasons for Decision

Decision: To not approve the proposed modification

There are two main reasons why the Board did not approve the proposed modification. First, DDMI has not demonstrated that the 1 in 100 year storm⁵ is an appropriate basis for the environmental design flood (EDF). The EDF is the most severe flood that is to be managed without release of untreated water to the environment. During storm events that are more severe than the EDF, water would be released to the environment, even if it did not meet effluent quality criteria (EQC). A sufficiently conservative storm event must be selected to minimize the likelihood of this happening.

DDMI has proposed that the size of the EDF be reduced to a 1 in 100 year event, from the 1 in 500 year event used in the most recently submitted design.⁶

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⁴ See WLWB Online Registry for Diavik – Modification – PKC – Spillway and Freeboard Limit – Review Summary and Attachments – May 13_16
⁵ Golder calculated the EDF as a rain-on-snow event that includes runoff due to melting of the entire snowpack from an average year over a two-week period, where a 24-hour rainfall event would occur during the two-week snowmelt period.
The Canadian Dam Association’s (CDA) Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams, 2014 provides the following guidance regarding a suitable storm event for the EDF:

“Typical EDF return periods range from 1 in 50 to 1 in 200 years, but more stringent criteria may be required depending on the site conditions. The appropriate EDF duration is site specific and typically ranges from weeks to months depending on the assimilative capacity of the water treatment system to process the stored volume.”

The 1 in 500 year storm that DDMI uses in the current design is therefore more conservative (i.e., safer) than what the CDA describes as typical. While DDMI’s proposed EDF (1 in 100 year event) is within the typical range identified by the CDA, it is unclear whether the 1 in 100 year event is sufficiently conservative.

The CDA provides the following guidance for selecting the appropriate EDF:

“The selection of return period and duration of the EDF must take into account factors such as the water quality that is being stored and could be released, regulatory requirements, frequency of overflow events, the rate and duration of overflows, the environmental sensitivity of the receiving environment, downstream flow in the receiver, downstream mixing characteristics, and public perception on the matter. The selection of an appropriate EDF is therefore site specific and should be derived through:

1. Consultation with regulatory agencies

2. Consideration of environmental effects associated with the frequency, magnitude and duration of an infrequent release.

3. Consideration of dilution that may be available from flood flows in the receiving water.

4. Consideration of the time needed to draw down the EDF volume from the storage area.

5. Consideration of the costs associated with varying degrees of environmental control.”

DDMI did not address any of these factors. The Golder memo simply notes⁷ that the 1 in 100 year EDF is within the typical range described by the CDA, and stated that since “the site run off collection ponds (Ponds 4, 5, 7, and 12) are designed to discharge flow above the 1:100 year event over emergency spillways... a 1:100-year return period should be used to determine the PKC Facility’s EDF volume.”

Based on a preliminary review of the Surveillance Network Program (SNP) data (see Attachment #1), it appears that collection pond water is less contaminated than PKC pond water, and so it is not clear that the PKC Facility and the collection ponds should be based on the same EDF. No other rationale for the 1

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in 100 year event was provided. The Board concludes that DDMI did not provide enough evidence that the 1 in 100 year event is a suitable EDF for the PKC Facility spillway design.

ENR recommended a more conservative EDF than the 1 in 100 year event, and noted that a wet period of a more sustained duration, such as a 90 day wet period (vs. a single short-term storm event), may be more appropriate: 8

“It is conceivable that during such a wet period that the water treatment facility and/or other storage ponds could be over-whelmed by water from other mine sources (e.g., pit, dump seepage) and it may not be feasible to reduce the pond inventory in this period. Designing the PKC Spillway and overall site water management for a wet period instead of a single precipitation event would provide a more conservative basis for the design and for site operations.”

DDMI responded that “longer-term wet events would provide a larger flow volume, but a smaller peak design flow, which would not be appropriate to use for designing the PKC spillway.” While the response addresses the design features for the PKC spillway, it does not provide any information about whether the current water management system (and in particular Ponds 3, 7, and 12 9 and the north inlet) will be able to handle excess water during the period leading up to the EDF to prevent contaminated water from being released into the environment. ENR’s point further supports the Board’s position that additional information is required to support DDMI’s proposed EDF.

In order for the Board to approve the spillway modification, DDMI would have to better support its selected EDF. The Board has not concluded that the 1 in 100 year storm is inappropriate, simply that there is insufficient information to support the smaller storm event.

The second reason that the Board rejected the proposed modification is that DDMI has not demonstrated that Pond 3 will be able to contain the EDF. In addition to the newly proposed EDF, DDMI proposed to pass the EDF from the PKC Facility to Pond 3, where it could be stored. The current spillway design is based on storing the EDF in the PKC Facility without passing it to Pond 3. DDMI’s proposal to store the EDF in Pond 3 would allow the increase of the normal operating water level in the PKC Facility and subsequently, increase the capacity to store more tailings and water within the PKC dams at their current crest elevation (465 m) before another dam raise would be required.

DDMI did not provide enough information about water management leading up to and during a storm event to demonstrate that Pond 3 will be able to store the EDF. Several collection ponds are currently pumped to and from the PKC Facility and the north inlet. The movement of water amongst these water storage areas during a storm event must be managed to ensure that water that does not meet EQC is not released to the environment. Board staff asked for more detail regarding water management during

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8 GWNT-ENR Comment #1. See WLWB Online Registry for Diavik – Modification – PKC – Spillway and Freeboard Limit – Review Summary and Attachments – May 13, 16

9 Ponds 7 and 12 are the only two ponds that can be pumped only to the PKC pond; other ponds can be pumped to other locations (e.g., the north inlet).
the public review \(^{10}\) and DDMI responded by referencing Section 2.3 (Catchment Area) of the Golder memo; however, the Board is of the opinion that the referenced section does not provide sufficient detail to demonstrate that Pond 3 will be able to store the EDF.

For the reasons above, the Board does not believe DDMI provided enough justification for the reduced size of the EDF and the storage of the EDF in Pond 3 and therefore, cannot approve of the proposed modification at this time.

### 3.1 Potential Re-submission of the Proposed Modification

If DDMI wishes to re-submit the modification for the Board’s consideration, the Board believes DDMI should include information that addresses the above concerns regarding the appropriate EDF and the ability of Pond 3 to hold the EDF. DDMI should provide:

1. more thorough supporting information of DDMI’s proposed EDF, that addresses the considerations identified in the Canadian Dam Association’s (CDA) Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams, 2014 (pages 23 and 24); and
2. additional information regarding water management, specifically:
   
   i. typical pumping arrangements for the collection ponds and the PKC pond once the normal operating water level reaches the spillway invert (El 464.6 m), with specific reference to the inputs and outputs for Ponds 3, 7, and 12, the north inlet, and any other relevant ponds;
   
   ii. the pumping arrangements for the collection ponds and the PKC pond leading up to and during freshet (if these are different from those described in response to the previous bullet), with specific reference to the inputs and outputs for Ponds 3, 7, and 12,\(^{11}\) the north inlet, and any other relevant ponds;
   
   iii. the pumping arrangements for the collection ponds and the PKC pond during the 1 in 100 year, 24-hr rainfall event, with specific reference to the inputs and outputs for Ponds 3, 7, and 12,\(^{11}\) the north inlet and any other relevant ponds;
   
   iv. a description of how DDMI will distinguish the 1 in 100 year, 24-hr rainfall event from lesser events, including triggers or action levels, if appropriate;
   
   v. a discussion about whether prolonged wet periods prior to the environmental design flood may compromise the pumping arrangements described above, and how DDMI plans to address this possibility;
   
   vi. a stage-volume curve for Pond 3;
   
   vii. confirmation that DDMI has verified the PKC facility catchment areas used by Golder in the spillway design; and

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\(^{10}\) WLWB Comment #1. See WLWB Online Registry for **Diavik – Modification – PKC – Spillway and Freeboard Limit – Review Summary and Attachments – May 13_16**

\(^{11}\) Ponds 7 and 12 are the only two ponds that can be pumped only to the PKC pond; other ponds can be pumped to other locations (e.g., the north inlet).
viii. any other relevant information that demonstrates that Pond 3 can hold the EDF.

In addition to including the information above, the company should clearly describe the minimum freeboard limit that it is requesting. The Golder memo does not address the specific regulatory wording that would be needed to authorize a change in the freeboard limit, and there is room for confusion about how the regulated freeboard should be described. Golder discusses a 0.2 m minimum freeboard (e.g., page 4, Table 4 and Figure 2) and in other locations in the memo, describes a 0.4 m minimum freeboard (e.g., updated drawing 14111-41D1-6123, entitled “Phase 6 Spillway Plan, Profile and Cross-sections”).

It is understood from the Golder memo that the larger freeboard (0.4 m) is the sum of the allowance for a water level increase during the inflow design flood and the allowance made for wind and wave run-up. As such, the Board believes it is most likely that DDMI is proposing that the Board approve a 0.4 m freeboard from the normal operating water level to the effective water containment crest of the PKC dam. DDMI should confirm what minimum freeboard it is proposing so that if the Board approves a re-submitted modification request, the Board, DDMI, the Inspector, and all other parties will share the same understanding of the minimum freeboard limit.

3.2 Board Acceptance of Section 4 of the Golder Memo

The Board accepts the calculations in Section 4 of the Golder memo, (e.g., those related to the influence of the inflow design flood (IDF) on the spillway design and minimum freeboard), for the following reasons:

1) The IDF selected for the PKC facility is conservative relative to CDA requirements. Based on its consequence classification, the IDF would correspond to the 1:1000-year flood event plus one-third of the difference between the 1:1000-year flood and the PMF (CDA, 2014). However, the PMF has been selected as the IDF, which is more conservative than the CDA recommendation.

2) The catchment area has been reduced. Due to controlled pumping, the catchment area used for the design calculations is about one third of the catchment area that was used for the IDF calculations in 2001 and 2013. This means that the selected IDF will have a significantly smaller volume of water than was the case for previous IDF calculations.

3) Based on the projected storage capacity of the PKC facility and the current pond and PK levels, the Board understands that the period of the remaining operational life for which the spillway would potentially have to pass the IDF is relatively short, i.e. perhaps a couple of years at the end of the operational mine life. This occurs because, in the short term, all or part of the IDF will be stored; and in the longer term, the perimeter dams at the PKC facility will be raised (along with the spillway invert) if the life is extended beyond current projections, or if the mine is closed either prior to or as the design capacity of the facility is reached, the spillway will be replaced or modified to suit the closure design requirements.
4) The Board’s consultant (SRK) completed an independent check of Golder’s wave run-up calculations (coinciding with the passage of the selected IDF through the spillway when the PKC facility is essentially full) and concluded that the calculations are correct.

5) Concerns related to the potential reliance on engineering calculations without the application of engineering judgement arose during the review of the Golder memo. However these concerns were addressed to the Board’s satisfaction. The details behind the concerns were linked to the following two considerations:

i. the calculated minimum freeboard (CDA definition) to contain wave run-up dropped significantly, i.e. from 1.4 m above the maximum extreme water level during passage of the IDF, to 0.2 m; and

ii. the 0.2 m allowance for wave run-up seemed ill suited to accommodate potentially exacerbating circumstances, such as ice jams at the entrance or within the spillway, which could raise the elevation of the IDF flood level at the expense of the minimum freeboard.

Despite these concerns, the Board accepts the design relative to the wave run-up calculations and freeboard primarily because of the windrow (“shoulder berm”) on the upstream edge of one of the dams. During the meeting on April 6th with DDMI, Golder, Board staff, and SRK, Golder presented a photo showing this berm, and provided subsequent assurances that this shoulder berm extends around the entire perimeter of the PKC facility, presumably for reasons related to vehicle safety. The design drawings indicate that a similar shoulder berm on the downstream crest is about 2.7 m high, suggesting the top of the downstream “shoulder berm” is approximately 467.7 m. In a separate note, DDMI indicated that the “upstream shoulder berms are not shown on the upstream side of the typical design cross-sections for clarity of the drawing.” While the actual height of the upstream “shoulder berms” has not been confirmed, the photo suggested the berms are approximately 1.5 m to 2 m higher than the dam crest.

The Board is informing DDMI that it accepts Section 4 of the Golder memo so the Board will not need to review this work again if DDMI re-submits the modification, and DDMI can be confident that it does not need to do any more work on this aspect of the modification. If DDMI wishes to revise aspects of Section 4 of the Golder memo, the company must draw the Board’s attention to the changes.

The Board notes that acceptance of Section 4 of the Golder memo is contingent on a number of revisions that would need to be made in the PKC Facility Plan to address concerns that arose during the Board’s review. These revisions, and the reasons for them, are as follows:

1) A statement that the windrows which extend along the upstream edge of the dams that define the entire perimeter of the PKC facility will be maintained with a crest elevation of not less than 465.8 m

Establishing the minimum crest elevation of the upstream shoulder berms at 465.8 m will provide 1 m of freeboard above the maximum extreme water level during passage of the IDF (464.8 m). This effectively means that the minimum freeboard would increase by 0.8 m and would address the issue of engineering judgement regarding the calculated minimum freeboard of only 0.2 m.
2) A statement that, when the pond reaches an elevation of 462 m, DDMI will maintain the PKC Pond in a centralized location with fine processed kimberlite (FPK) beaches around the PKC Facility’s entire perimeter that are at least 10 m long.

This requirement was recommended by Golder\(^\text{12}\) and DDMI affirmed its commitment to this requirement in its response to GNWT-Land Comment #1.\(^\text{13}\)

3) A statement that DDMI will maintain PKC Facility dam slopes at a beach slope of about 3%.

As explained in the Golder memo, the minimum freeboard calculations are only valid when the slopes are at 3% (pages 5 and 7 of the Golder memo). This requirement is necessary to ensure the PKC Facility can store the inflow design flood.

4) A commitment to review FPK beach development as the pond exceeds an elevation of 462 m confirm beaches are developed and maintained, or can be developed and maintained to meet the assumptions used to calculate freeboard presented in Table 4 of the proposed modification.

This review is necessary to ensure the basis for the spillway design remains valid as the tailings elevation increases, and is recommended by Golder.\(^\text{14}\)

5) A commitment to review the Pond 3 spillway to verify that it can pass the same inflow design flood as the PKC Facility. Review of the Pond 3 spillway is to be completed before the PKC pond exceeds an elevation of 462 m.

If the IDF occurs, it will pass through the PKC spillway into Pond 3, and out the Pond 3 spillway. Golder recommended that DDMI confirmed the Pond 3 spillway design will accommodate this event, and DDMI committed to this review in its cover letter.

6) An updated stage-volume curve for the PKC Facility, showing the current and predicted tailings levels, current and predicted pond water levels, and current and predicted freeboard volumes. Additionally, the PKC Facility Plan should include a commitment to provide an updated stage-volume curve for the PKC Facility in the Annual Water Licence Report required by Part B, Item 7, or the annually Geotechnical Inspection Report required by Part H, Item 21(f).

This will allow the Board and reviewers to understand when restrictions on the normal water operating water level will be of operational consequence, and when the requirements for beach slope, beach length, and other design features must be re-assessed.

DDMI does not need to submit a revised PKC Facility Plan unless and until the Board approves a re-submitted modification request. At that time, the Board would issue a directive to revise the PKC Facility Plan, which would include the revisions described above. The Board is advising DDMI of what these

\(^{12}\) Golder memo, page 7. See WLWB ([www.wlwb.ca](http://www.wlwb.ca)) Online Registry for Diavik – Modification – Processed Kimberlite Containment Facility – Spillway and Freeboard Limit – Dec 10_15

\(^{13}\) GWNT-ENR Comment #1. See WLWB Online Registry for Diavik – Modification – PKC – Spillway and Freeboard Limit – Review Summary and Attachments – May 13_16

\(^{14}\) Golder memo, page 7. See WLWB ([www.wlwb.ca](http://www.wlwb.ca)) Online Registry for Diavik – Modification – Processed Kimberlite Containment Facility – Spillway and Freeboard Limit – Dec 10_15
revisions would be to streamline a future review of a revised modification and so the company is aware of the potential need for a revised Plan.

Attachments:
1. Board Assessment of PKC Pond and Collection Pond SNP Data
2. Notes from the April 6, 2016 Meeting

Signed the 30th Day of May, 2016, on behalf of the Wek’èezhii Land and Water Board

Witness

Violet Camsell-Blondin
Chair, Wek’èezhii Land and Water Board
Board Assessment of PKC Pond and Collection Pond SNP Data.

The degree of contamination of water that could be released to the environment is one factor that can inform the selection of the appropriate EDF. For example, if PKC pond water were unlikely to exceed EQC during a storm, a less conservative (smaller) EDF may be more defensible, while highly contaminated water may call for a more conservative (larger) EDF. DDMI did not discuss water quality issues in the context of their proposed change to the EDF.

The Board evaluated 2008 and 2015 Surveillance Network Program (SNP) data\(^1\) to get a sense of how contaminated PKC pond and collection pond water is. The Board looked at data for the PKC pond and the collection ponds. Results are shown in Table 1.

<table>
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<th>SNP Station</th>
<th>Source</th>
<th>Parameter</th>
<th>Measured Concentration</th>
<th>WL EQC Criteria</th>
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<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>8.62</td>
<td>5.0-8.4</td>
<td>25-Aug-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>9.01</td>
<td>5.0-8.4</td>
<td>16-Jul-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>8.63</td>
<td>5.0-8.4</td>
<td>13-Jun-08</td>
</tr>
</tbody>
</table>

\(^1\) All SNP Data is available at the WLWB (www.wlwb.ca) Online Registry
<table>
<thead>
<tr>
<th>SNP Station</th>
<th>Source</th>
<th>Parameter</th>
<th>Measured Concentration</th>
<th>WL EQC Criteria</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>Total Suspended Solids, mg/L</td>
<td>33</td>
<td>25.0</td>
<td>16-Apr-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>Turbidity, NTU</td>
<td>62</td>
<td>15</td>
<td>16-Apr-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>9.86</td>
<td>5.0-8.4</td>
<td>16-Apr-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>Turbidity, NTU</td>
<td>39</td>
<td>15</td>
<td>05-Mar-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>9.54</td>
<td>5.0-8.4</td>
<td>05-Mar-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>16.6</td>
<td>15</td>
<td>06-Feb-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>Turbidity, NTU</td>
<td>9.5</td>
<td>5.0-8.4</td>
<td>06-Feb-08</td>
</tr>
<tr>
<td>1645-16</td>
<td>PKC pond water within the PKC</td>
<td>pH</td>
<td>9.4</td>
<td>5.0-8.4</td>
<td>09-Jan-08</td>
</tr>
<tr>
<td>1645-44</td>
<td>Pond 7</td>
<td>Total Copper, mg/L</td>
<td>0.354</td>
<td>0.04</td>
<td>09-Sep-15</td>
</tr>
<tr>
<td>1645-47</td>
<td>Pond 12</td>
<td>Turbidity, NTU</td>
<td>19.6</td>
<td>15</td>
<td>20-May-15</td>
</tr>
<tr>
<td>1645-76</td>
<td>Pond 3</td>
<td>Total Zinc, mg/L</td>
<td>0.0262</td>
<td>0.02</td>
<td>19-May-15</td>
</tr>
</tbody>
</table>

During 2008 and 2015, PKC pond water regularly exceeded EQCs for some parameters (e.g., pH, turbidity, occasionally for some metals), while most parameters remained below EQC during those years. Water in ponds 3, 7, and 12 had one exceedance each during these two years; and is arguably less contaminated than PKC pond water. If a storm event greater than the EDF occurred, water from these ponds could be released to the environment without treatment.

Our evaluation of SNP data showed that PKC pond water does not always meet EQC (although it is arguably not heavily contaminated) and that collection pond water, as expected, is less contaminated than PKC water. On their own, these results do not point to any clear answers about how conservative the EDF should be. Further, it is not clear how a storm event would affect water quality (increased turbidity, increased dilution, etc.). Without more information and analysis, we are not able to say what the impacts of a release of PKC pond water would be. In the end, our evaluation did not clearly support nor refute DDMI’s proposed EDF.
Meeting Notes:
DDMI Proposed Modification to the
Processed Kimberlite Containment Facility Spillway

Date: April 6, 2016

File: W2015L2-0001

In Attendance: Gord Macdonald, DDMI
John Cunning, Golder Associates (on behalf of DDMI)
Sean Habing, Golder Associates (on behalf of DDMI)
Jeffrey Kwok, Golder Associates (on behalf of DDMI)
Patty Ewaschuk, WLWB Staff
Cam Scott, SRK Consulting (on behalf of the WLWB)
Victor Muñez, SRK Consulting (on behalf of the WLWB)

Location: Golder office in Vancouver, and teleconference

Subject: Discussion about the normal and minimum freeboard calculations, principally the wave runup aspects

Background: Following the public review of DDMI’s proposed modification to the processed kimberlite containment (PKC) spillway, Board staff asked for clarification from DDMI regarding WLWB Comment #2. WLWB staff and DDMI agreed to have a meeting with DDMI’s consultant (Golder Associates) and the WLWB’s consultant (SRK Consulting). DDMI provided a pdf of a draft slide deck in advance of the meeting. SRK was able to complete a review of the wave runup calculations prior to the meeting. The slide deck was updated after the meeting and is attached.

These meetings notes were prepared by Board staff, and reviewed by DDMI, Golder, and SRK. Golder suggested revisions to the notes; which Board staff provided to SRK to ensure SRK was aware of any material changes. The revisions were incorporated by Board staff.

Email correspondence documenting follow-up conversations after the meeting are included after the meeting notes. Staff provided a copy of the correspondence to SRK.
SRK and Golder discussed the Mase 1989 paper that Golder used to calculate the wave runup (slide 15, step 5 of 6 in the calculation process). SRK suggested a more recent approach, as described in *Design Standards No. 13 Embankment Dams Chapter 6: Freeboard Phase 4 (Final)*, US Department of the Interior, Department of Reclamation (2012).

Golder agreed to look at the US Department of Interior paper, and share any conclusions with DDMI who will provide them to WLWB staff.

SRK asked Golder to discuss their engineering judgement regarding a freeboard of 0.4 m above the normal operating water level (0.2 m freeboard above the water level in the spillway when the IDF is being passed). Golder made the following points:

- The liner is at elevation 465 m and the liner is buried under coarse processed kimberlite (CPK) ballast material at the upstream crest with elevation between 465.3 and 465.4 m. If wave uprush is above the 465 m elevation, the CPK berm and rockfill material would likely deflect the water (break the wave) with the potential of some water seeping on the rockfill crest but would not be expected to erode the dam;
- There is a windrow of material (CPK and rockfill berms), 3-5 m wide near the upstream edge of the dam around the entire perimeter of the PKC facility;
- Until the pond reach an elevation of 463 m, the PKC facility will be able to store the IDF.
- The pond elevation is increasing about 1 m per year, and the pond level is currently around 455 m (processed kimberlite (PK) are at a higher elevation); it is expected that PK won’t reach an elevation of 463 for a few years, and it will only be a relatively short operational period for which the spillway will have to potentially handle the IDF if no dam raise is executed prior to this time.
- There has not been an upset water condition to date, and it is likely that water could be pumped to the north inlet during an inflow design flood (IDF) event; and
- Crest height can be adjusted for closure.

SRK asked about problems that may occur during the IDF event, such as an ice blockage. Golder responded that overtopping dam failure is not a credible scenario, because the rockfill dam shell crest is quite wide. While erosion may occur, it would not compromise dam stability.

SRK asked about the current status of spillway construction. Golder responded that the invert is in place, and the spillway channel is roughed in but not fully lined. Liner installation for the spillway works are scheduled to be completed in 2016.

WLWB staff asked about the switch from a 1:500 year storm for the environmental design flood (EDF) in the original PKC Design Report, to a 1:100 year storm for the proposed modification. Golder indicated that CDA guidelines have been updated since then, and that more is known about the processed kimberlite, water management, and other operational factors.

**Action items:** DDMI will provide WLWB staff with an updated slide deck with the “draft” mark removed, with updated slides showing the photographs discussed during the meeting, and, as necessary, edits to reflect Golder’s conclusions regarding the US Department of the Interior paper.
Follow-up Correspondence After the Meeting

From: Macdonald, Gord (DDMI) [mailto:Gord.Macdonald@riotinto.com]  
Sent: April 8, 2016 5:38 PM  
To: Patty Ewaschuk <pewaschuk@wlwb.ca>  
Cc: Ryan Fequet <rfequet@wlwb.ca>; Wells, David (DDMI) <David.Wells@riotinto.com>  
Subject: RE: spillway

Patty,

Below are the responses to the additional questions you asked after our meeting with Golder and SRK:

<table>
<thead>
<tr>
<th>Questions</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. why the windrow is there (what is its primary purpose),</td>
<td>The primary purpose of the coarse PK windrow is to provide a ballast over the plywood that is protecting the liner crest and liner tie-in location for potential subsequent dam raises. The rockfill windrow downstream of the PK windrow is the required shoulder berm for traffic along the dam crest in accordance with Worker Compensation Board Mine Health and Safety Regulations.</td>
</tr>
<tr>
<td>2. whether the windrow goes around the entire perimeter of the facility,</td>
<td>The coarse PK liner cover and a shoulder berm goes around the entire perimeter of the facility, and is in place until the next dam raise design or to the closure configuration.</td>
</tr>
<tr>
<td>3. whether the windrow is always in place, i.e. will it be in place until the next raise, if it turns out DDMI requires an additional lift, and</td>
<td>see response for question 2.</td>
</tr>
<tr>
<td>4. is the windrow documented anywhere else (I don’t see a reference to it in the design docs or the PKC Ops plan).</td>
<td>The coarse PK cover over the liner crest is shown in the Issued for Construction Phase 6 design drawing No. 6105 detail 6 and detail 8. The CPK cover over the liner crest is sometimes placed in a 1.0 m thick lift to allow access and placement with heavy equipment. Drawing No. 6105 also shows the downstream shoulder berms and details. The upstream shoulder berms are not shown on the upstream side on the typical design cross-sections for clarity of the drawing.</td>
</tr>
</tbody>
</table>
Patty,

Our team has reviewed the United States Department of the Interior Bureau of Reclamation 2012 reference (attached) as suggested by SRK from our Vancouver meeting/conference call on April 6, 2016 with WLWB.

The method described in this paper is for water dams and apply to upstream slopes steeper than 20% (5H:1V or steeper, Section B.4.3 of the paper). This is not the case for Diavik PKC Facility with 3% beach slopes. Golder has use the guidelines for mining tailings dams in Canada in preparing the spillway calculations at Diavik.

Presume this response is sufficient
Gord

Processed Kimberlite Containment Facility Freeboard Calculations

Presented to Diavik, Wek'èezhìi Land and Water Board (WLWB) and their consultant

April 6, 2015
Reference No. 1648001-1513-PP-Rev0-2000
PKC Facility Freeboard Calculations

Introduction

- A spillway design and a freeboard assessment were completed for the Phase 6 of construction for the Processed Kimberlite Containment (PKC) Facility at Diavik Diamond Mine.

- The freeboard calculations for the PKC Facility are outlined in the following slides.

- Refer to the Processed Kimberlite Containment Facility Operations Spillway Review memorandum (Golder 2015) for design information.
PKC Facility Freeboard Calculations

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- Step 2: Calculate Wave Setup
- Step 3: Calculate Wave Characteristics
- Step 4: Calculate Surf Similarity Parameter
- Step 5: Calculate Wave Runup
- Step 6: Calculate Wave Uprush
- Results
- References
PKC Facility Freeboard Calculations
Step 1: Input Parameters

- Calculation Inputs
  - Fetch Lengths measured:
    - 1.89 km
    - 1.14 km
    - 1.11 km

PKC Facility Freeboard Calculations
Step 1: Input Parameters

### Calculation Inputs

- Input parameters for the calculations are as follows:

<table>
<thead>
<tr>
<th>Wind Direction</th>
<th>1:1000-Year Wind Speed (m/s)</th>
<th>Wind Duration (hr)</th>
<th>Fetch Length (km)</th>
<th>Average Water Depth (m)</th>
<th>Beach Slope</th>
<th>Beach Surface Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>20.3</td>
<td></td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northwest</td>
<td>21.3</td>
<td></td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>18.9</td>
<td>1.0</td>
<td>1.89</td>
<td></td>
<td></td>
<td>Smooth, Impermeable</td>
</tr>
<tr>
<td>Southwest</td>
<td>21.1</td>
<td></td>
<td>1.89</td>
<td>4 m</td>
<td>3.0% (Maximum)</td>
<td>Smooth, Impermeable</td>
</tr>
<tr>
<td>South</td>
<td>18.5</td>
<td></td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southeast</td>
<td>15.1</td>
<td></td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>17.8</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>20.4</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wind Direction</th>
<th>1:2-Year Wind Speed (m/s)</th>
<th>Wind Duration (hr)</th>
<th>Fetch Length (km)</th>
<th>Average Water Depth (m)</th>
<th>Beach Slope</th>
<th>Beach Surface Type</th>
</tr>
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<tr>
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<td>15.4</td>
<td></td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northwest</td>
<td>15.3</td>
<td></td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>14.3</td>
<td>1.0</td>
<td>1.89</td>
<td>4 m</td>
<td>3.0% (Maximum)</td>
<td>Smooth, Impermeable</td>
</tr>
<tr>
<td>Southwest</td>
<td>13.8</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>13.9</td>
<td></td>
<td>1.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southeast</td>
<td>12.6</td>
<td></td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>13.6</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>13.8</td>
<td></td>
<td>1.89</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Bold text denotes values for the two governing scenarios.
PKC Facility Freeboard Calculations
Step 2: Calculate Wave Setup

The following are sample calculations of the wave uprush components for the governing scenarios:

- **Calculate Wave Setup (CDA 2007)**

  \[ S = \frac{U^2 \cdot F}{K \cdot D_{avg.}} \]

  - Where, \( S \) is the wave setup (m);
  - \( U \) is the wind speed (m/s);
  - \( F \) is the fetch length (km);
  - \( K \) is a constant, equal to 4,850; and
  - \( D_{avg.} \) is the average reservoir depth (m), assumed to be 4 m

- **Normal Freeboard Scenario**

  \[ S = \frac{21.1^2 \cdot 1.89}{4850 \cdot 4} = 0.04 \text{ m} \]

- **Minimum Freeboard Scenario**

  \[ S = \frac{14.3^2 \cdot 1.89}{4850 \cdot 4} = 0.02 \text{ m} \]
PKC Facility Freeboard Calculations
Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics

- Calculate Equivalent Neutral Wind Speed (USACE 1984)
  \[ U_E = R_T \times R_L \times U_{10} \]
  - Where, \( U_E \) is the equivalent neutral wind speed (m/s);
  - \( R_T \) is a factor to adjust for air-sea temperature differences, assumed to equal 1.0;
  - \( R_L \) is a factor to convert to wind speed over water, assumed to equal 0.9; and
  - \( U_{10} \) is the wind speed at 10 m height (m/s), taken to equal the measured wind speed

- Normal Freeboard Scenario
  \[ U_E = R_T \times R_L \times U_{10} = 1 \times 0.9 \times 21.1 \]
  \[ U_E = 19.0 \text{ m/s} \]

- Minimum Freeboard Scenario
  \[ U_E = R_T \times R_L \times U_{10} = 1 \times 0.9 \times 14.3 \]
  \[ U_E = 12.9 \text{ m/s} \]
PKC Facility Freeboard Calculations
Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics

- Calculate Constant Drag Coefficient (Vickers and Mahrt 1997)
  \[ C_D = 0.001 \times (0.75 + (0.067 \times U_{10})) \]
  - Where, \( C_D \) is the drag coefficient; and
  - \( U_{10} \) is the wind speed at 10 m height (m/s), taken to equal the measured wind speed

- Normal Freeboard Scenario
  \[ C_D = 0.001 \times (0.75 + (0.067 \times U_{10})) = 0.001 \times (0.75 + (0.067 \times 19.0)) = 0.00216 \]

- Minimum Freeboard Scenario
  \[ C_D = 0.001 \times (0.75 + (0.067 \times U_{10})) = 0.001 \times (0.75 + (0.067 \times 12.9)) = 0.00171 \]
PKC Facility Freeboard Calculations

Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics

- Calculate Adjusted Wind Speed with Drag Coefficient (USACE 2006)

\[ U_A = U_E \times \frac{C_D}{\sqrt{0.001}} \]

- Where, \( U_A \) is the adjusted wind speed (m/s);
- \( U_E \) is the equivalent neutral wind speed (m/s); and
- \( C_D \) is the drag coefficient

- Normal Freeboard Scenario

\[ U_A = U_E \times \frac{C_D}{\sqrt{0.001}} = 19.0 \times \frac{0.00216}{\sqrt{0.001}} = 27.9 \text{ m/s} \]

- Minimum Freeboard Scenario

\[ U_A = U_E \times \frac{C_D}{\sqrt{0.001}} = 12.9 \times \frac{0.00171}{\sqrt{0.001}} = 16.8 \text{ m/s} \]
Calculate Wave Characteristics

- Calculate Wave Height (USACE 1984)

$$H_{mo} = 0.0016 \times \frac{U_A^2}{g} \times \sqrt{\frac{g \times F}{U_A^2}}$$

- Where, $H_{mo}$ deep water wave height (m);
- $U_A$ is the adjusted wind speed (m/s);
- $F$ is the fetch length (m); and
- $g$ is the gravitational acceleration constant (m/s²), equal to 9.81

- Normal Freeboard Scenario

$$H_{mo} = 0.0016 \times \frac{U_A^2}{g} \times \sqrt{\frac{g \times F}{U_A^2}}$$

$$H_{mo} = 0.0016 \times \frac{27.9^2}{9.81} \times \sqrt{\frac{9.81 \times 1890}{27.9^2}} = 0.62 \text{ m}$$

- Minimum Freeboard Scenario

$$H_{mo} = 0.0016 \times \frac{U_A^2}{g} \times \sqrt{\frac{g \times F}{U_A^2}}$$

$$H_{mo} = 0.0016 \times \frac{16.8^2}{9.81} \times \sqrt{\frac{9.81 \times 1890}{16.8^2}} = 0.37 \text{ m}$$
PKC Facility Freeboard Calculations
Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics
  
  - Calculate Wave Period (USACE 1984)
    
    \[ T = 0.286 \times \frac{U_A}{g} \times \left( \frac{g \times F}{U_A^2} \right)^{1/3} \]
    
    - Where, \( T \) is the deep water wave period
    - \( U_A \) is the adjusted wind speed (m/s);
    - \( F \) is the fetch length (m); and
    - \( g \) is the gravitational acceleration constant (m/s²), equal to 9.81

  
  - Normal Freeboard Scenario
    
    \[ T = 0.286 \times \frac{27.9}{9.81} \times \left( \frac{9.81 \times 1890}{27.9^2} \right)^{1/3} = 2.34 \, s \]

  
  - Minimum Freeboard Scenario
    
    \[ T = 0.286 \times \frac{16.8}{9.81} \times \left( \frac{9.81 \times 1890}{16.8^2} \right)^{1/3} = 1.97 \, s \]
PKC Facility Freeboard Calculations

Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics

  - Calculate Wavelength (CDA 2007)
    \[ L = \frac{T^2 \cdot g}{2 \cdot \pi} \]
    - Where, \( L \) is the wavelength (m);
    - \( T \) is the wave period (s); and
    - \( g \) is the gravitational acceleration constant (m/s²), equal to 9.81

  - Normal Freeboard Scenario
    \[ L = \frac{T^2 \cdot g}{2 \cdot \pi} = \frac{2.34^2 \cdot 9.81}{2 \cdot \pi} = 8.52 \text{ m} \]

  - Minimum Freeboard Scenario
    \[ L = \frac{T^2 \cdot g}{2 \cdot \pi} = \frac{1.97^2 \cdot 9.81}{2 \cdot \pi} = 6.08 \text{ m} \]
PKC Facility Freeboard Calculations
Step 3: Calculate Wave Characteristics

- Calculate Wave Characteristics

The calculated wave characteristics for the governing scenarios are as follows:

<table>
<thead>
<tr>
<th>Wave Characteristic</th>
<th>Normal Freeboard Governing Scenario (Southwest Wind Direction)</th>
<th>Minimum Freeboard Governing Scenario (West Wind Direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave Height (m)</td>
<td>0.62</td>
<td>0.37</td>
</tr>
<tr>
<td>Wave Period (s)</td>
<td>2.34</td>
<td>1.97</td>
</tr>
<tr>
<td>Wavelength (m)</td>
<td>8.52</td>
<td>6.08</td>
</tr>
</tbody>
</table>
PKC Facility Freeboard Calculations
Step 4: Surf Similarity Parameter

- Calculate Surf Similarity Parameter (USACE 2003)

\[ \xi_{op} = \frac{\tan \alpha}{\sqrt{H_{mo}/L_{op}}} \]

- Where, \( \xi_{op} \) is the surf similarity parameter;
- \( \tan \alpha \) is the beach slope;
- \( H_{mo} \) is the wave height (m); and
- \( L_{op} \) is wavelength (m)

- Normal Freeboard Scenario

\[ \xi_{op} = \frac{\tan \alpha}{\sqrt{H_{mo}/L_{op}}} = \frac{0.03}{\sqrt{0.62/8.52}} = 0.11 \]

- Minimum Freeboard Scenario

\[ \xi_{op} = \frac{\tan \alpha}{\sqrt{H_{mo}/L_{op}}} = \frac{0.03}{\sqrt{0.37/6.08}} = 0.12 \]
PKC Facility Freeboard Calculations
Step 5: Calculate Wave Runup

- Calculate Wave Runup (Mase 1989)
  \[ R_{2\%} = 1.86 \times H_{mo} \times \xi_{op}^{0.71} \]
  - Where, \( R_{2\%} \) is the wave (m) (runup exceeded by 2% of waves);
  - \( H_{mo} \) is the wave height (m); and
  - \( \xi_{op} \) is the surf similarity parameter

- Normal Freeboard Scenario
  \[ R_{2\%} = 1.86 \times 0.62 \times 0.11^{0.71} = 0.24 \ m \]

- Minimum Freeboard Scenario
  \[ R_{2\%} = 1.86 \times 0.37 \times 0.12^{0.71} = 0.15 \ m \]

- Field measurements of runup (Holman 1986, Nielsen and Hanslow 1991) are consistently lower than predictions of runup from the Mase (1989) equation. The equation roughly forms an upper envelope of the data scatter (USACE 2003), and is therefore conservative for the design.
PKC Facility Freeboard Calculations
Step 6: Calculate Wave Uprush

- Calculate Wave Uprush
  - Equal to the sum of Wave Setup and Wave Runup

- Normal Freeboard Scenario
  \[ \text{Wave Uprush} = S + R_{2\%} = 0.043 \text{ m} + 0.242 \text{ m} \]
  \[ \text{Wave Uprush} = 0.29 \text{ m} \]
  - Normal Freeboard set to 0.30 m

- Minimum Freeboard Scenario
  \[ \text{Wave Uprush} = S + R_{2\%} = 0.020 \text{ m} + 0.155 \text{ m} \]
  \[ \text{Wave Uprush} = 0.18 \text{ m} \]
  - Minimum Freeboard set to 0.20 m

- Freeboard Requirements (CDA 2014)
  - Normal Freeboard – No overtopping by 95% of waves caused by the most critical wind with a frequency of 1 in 1,000 years, when the reservoir is at its maximum normal elevation.
  - Minimum Freeboard – No overtopping by 95% of the waves caused by the most critical wind, with an annual exceedance probability (AEP) of 1 in 2, when the reservoir is at its maximum extreme level during the passage of the IDF.
Results

- Normal Freeboard set to 0.30 m
- Minimum Freeboard set to 0.20 m

As presented in sealed technical memorandum from Golder (2015)

Limitation

- The wave uprush calculations assume that the beach slope is no steeper than 3.0%. A steeper beach slope will increase the predicted wave uprush.
References