APPENDIX H  NORTH PILE CLOSURE DESIGN

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Distribution List
Electronic Copy - De Beers Group of Companies

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Executive Summary

The North Pile facility is the permanent surface location for the disposal of processed kimberlite (PK), waste rock, and non-hazardous waste (landfill waste) materials at the Snap Lake Mine and was to be developed in three cells: Starter Cell, East Cell, and West Cell. The West Cell was not developed, leaving the west perimeter embankment of the Starter Cell and East Cell exposed. The remaining perimeter embankments have been covered during mine operations and the care and maintenance phase. As a final closure measure, the North Pile closure cover is to be constructed over the Starter Cell, East Cell, and west perimeter embankment.

This report presents the North Pile closure cover detailed design, including the construction drawings, construction specification, and Construction Quality Assurance Plan. The detailed design of the closure cover for the Starter Cell, East Cell, and west perimeter embankment considers water management, physical stability, and availability of construction material from local borrow sources.

Activities for implementing the North Pile closure cover design will include reducing the overall slope of the west perimeter embankment, regrading and/or infilling the interior cells to promote drainage off the North Pile facility, and placing an erosion protection cover over the entire facility. A transition layer will underlie the erosion protection cover material in areas of deposited PK and landfill waste materials. The transition layer will be placed where it is needed for grain size compatibility between the erosion protection cover and the underlying deposited PK material, and to achieve the total closure cover thickness required over the landfill waste material.

A nominal 2% top surface gradient will be maintained over the closure cover to reduce the likelihood that differential settlement will produce areas of ponding or localized drainage reversals. Two swales will convey surface water flow from the entire Starter Cell and the east portion of the East Cell toward an outlet channel located east of Cell 5. One swale will convey surface water flow from the west portion of the East Cell toward an outlet channel located west of Cell 1. Additional surface water conveyance and water treatment structures will be constructed downstream of the North Pile facility and are presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d) and the draft North Pile Passive Treatment Systems Detailed Design Report (Golder 2018e).

Surface water management and slope stability analyses were completed to support the North Pile closure cover detailed design. A surface water management analysis of the closure cover was performed to adequately size swales and outlet channels on the North Pile to accommodate peak runoff flow rates and volumes. Results of the analyses determined the length, width, depth, side slope, and revetment for the Cell 1 channel outlet and three swales that will be constructed to convey surface water flow off the North Pile facility. The Cell 5 channel outlet is presented as part of the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d).

Slope stability analyses were performed at selected locations on the North Pile facility to confirm physical stability of the North Pile closure cover detailed design. Results of the stability analyses indicate the North Pile closure cover geometry satisfies the Canadian Dam Association and Anglo American standards’ minimum static and pseudo-static factor of safety requirements for a closed facility during the post-closure period. Slope stability analyses were also conducted to verify the stability of temporary excavations needed to remove deposited PK material from within Cell 2 and subsequent placement of deposited PK material in Cell 3. This excavation is needed to provide capacity for landfill waste material placement in Cell 1 and Cell 2.
Study Limitations

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List of Abbreviations

- g: acceleration due to gravity, 9.801 m/s²
- km: kilometre
- m: metre
- mm: millimetre
- m³: cubic metre
- xH:1V: x horizontal to 1 vertical
- %: percent
- °: degree
- Anglo: Anglo American
- C: Celsius
- CDA: Canadian Dam Association
- CMP: Closure Monitoring Plan
- CQAP: Construction Quality Assurance Plan
- De Beers: De Beers Group of Companies
- FoS: Factor of Safety
- Golder: Golder Associates Ltd.
- H: hour
- MVLWB/AANDC: Mackenzie Valley Land and Water Board and Aboriginal Affairs and Northern Development Canada
- PK: processed kimberlite
1.0 INTRODUCTION

The De Beers Group of Companies (De Beers) retained Golder Associates Ltd. (Golder) to prepare a detailed closure cover design for the North Pile facility at Snap Lake Mine. The North Pile facility is the permanent surface location for the disposal of processed kimberlite (PK), waste rock, and non-hazardous waste (landfill waste) materials. The North Pile facility was to be developed in three cells: the Starter Cell, East Cell, and West Cell. The West Cell was not developed, leaving the west perimeter embankment of the Starter Cell and East Cell exposed.

This report presents the detailed design for the North Pile closure cover to be constructed over the Starter Cell, East Cell, and west perimeter embankment. Cover on the remaining perimeter embankments has been placed during operations or during care and maintenance activities. The detailed design of the surface water conveyance and treatment structures downstream of the North Pile facility is presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d) and the draft North Pile Passive Treatment Systems Detailed Design Report (Golder 2018e). The North Pile closure cover detailed design and supporting construction drawings have been developed such that the closure cover:

- complies with the design criteria presented in Section 3.0 of this report
- accommodates the placement of 114,000 m$^3$ of additional landfill waste material (including 95,000 m$^3$ estimated by the demolition contractor to De Beers, with a 20% contingency)
- limits construction earthworks and revetment quantities
- meets applicable regulatory and Anglo American (Anglo) requirements for closure of mineral residue facilities

The North Pile closure cover design criteria, detailed design, construction material quantity estimate, and additional construction considerations are summarized herein. Engineering analyses have been performed to confirm physical stability of the closure cover and compliance with the design criteria. Detailed design construction documents and engineering calculations are presented in the following appendices:

- Appendix A Construction Drawings
- Appendix B Construction Specification
- Appendix C Construction Quality Assurance Plan (CQAP)
- Appendix D Surface Water Analysis
- Appendix E Slope Stability Analysis
2.0 SITE DESCRIPTION

The North Pile facility is the permanent surface location for the disposal of processed kimberlite (PK), waste rock, and non-hazardous waste (landfill waste) materials at Snap Lake Mine, located approximately 220 km northeast of Yellowknife, Northwest Territories. The North Pile facility includes the Starter Cell, East Cell, and west perimeter embankment, and covers an area of 510,000 m², as shown in Drawing A1-142221-6200-121-0801 (Appendix A). Waste rock and rockfill materials were used in the construction of the North Pile facility perimeter embankment and internal rib berms, and PK and landfill waste materials were deposited within the Starter Cell and East Cell.

2.1 North Pile Facility Configuration

The North Pile facility was to be developed in three cells: Starter Cell, East Cell, and West Cell. The West Cell was not developed, leaving the west perimeter embankment of the Starter Cell and East Cell exposed. The Starter Cell is divided into eight sub-cells: Cell A, Cell B, Cell C, Cell D, Cell E, Cell F, Cell SQ, and Cell LF. Landfill waste material was deposited in Cell LF, while PK was deposited in all remaining sub-cells of the Starter Cell. The East Cell is divided into five sub-cells: Cell 1, Cell 2, Cell 3, Cell 4, and Cell 5. Landfill waste material was deposited in Cell 1, while PK was deposited in all remaining sub-cells of the East Cell.

2.2 Climate

Climate data are obtained from the climate station located at Snap Lake Mine and from regional climate stations in Yellowknife and Lupin, located approximately 250 km from Snap Lake. The average annual air temperature at the North Pile facility is -7.7°C, based on data from the 2001 to 2013 period (Golder 2014a). An average annual precipitation (rainfall and snowfall) of 148 mm has been calculated based on data collected at the Yellowknife regional climate station, and an average of 225 mm was based on the station at Lupin (Golder 2014a).

2.3 Hydrology

The North Pile facility is located within the continuous permafrost region. Peak surface water flows typically occur during the freshet season in late May due to a combination of rainfall events and snowmelt. Thermistors were installed on site, and the measured thickness of the active seasonal freeze and thaw layer ranges between 0 m and 20 m (Golder 2014a). High runoff coefficients are expected during the freshet season when the ground is frozen to the surface.

2.4 Dam Classification

The Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013) provides a classification system for dams and embankments according to the consequence(s) of failure, and consideration of the potential life, economic, environmental, and cultural losses. The North Pile facility is assigned a High consequence dam classification rating due to the potential for significant loss or deterioration of fish or wildlife habitat. The selected earthquake design ground motion is the 1-in-10,000-year return period for both the excavation and closure scenarios. Site-specific earthquake-induced seismic loading was obtained from the 2015 National Building Code Seismic Hazard Calculator by Natural Resources Canada (NRC 2018). The 500- and 2,500-year return periods provided by Natural Resources Canada were plotted in log-log scale to create a linear extrapolation for a 1-in-10,000-year annual exceedance probability event, and this approach resulted in a design peak ground acceleration of 0.092 g.
3.0 DESIGN CRITERIA

The North Pile closure cover detailed design criteria were selected based on Golder’s experience with Snap Lake Mine, development of closure designs for similar facilities, guidelines for closure and reclamation in the Northwest Territories (MVLWB/AANDC 2013), Anglo standards (Anglo 2016), and additional input from De Beers.

3.1 Design Objectives

Closure design objectives for the overall Snap Lake Mine, the North Pile facility, and the North Pile closure cover were considered in development of the North Pile closure cover detailed design.

Site-wide design objectives include the following:
- safe dust levels safe for people, vegetation, aquatic life, and wildlife
- physical stability of surface water runoff drainage pathways
- safe water quality for people, vegetation, aquatic life, and wildlife
- landscape features match aesthetics of the surrounding natural area
- safe passage and use for caribou and other wildlife

Facility-specific design objectives for the North Pile include the following:
- resistance to deposited PK migration into the terrestrial and aquatic environments
- physical stability and containment of the deposited PK

Closure cover specific design objectives include the following:
- physical isolation of deposited PK and landfill waste materials
- resistance to wind and water erosion
- conveyance of surface water away from the North Pile facility
- limitation of infiltration of water into the North Pile facility

3.2 Geochemistry

A geochemical stability analysis of the North Pile facility was submitted to De Beers on 10 May 2018 (Golder 2018a). Data indicated that seepage through the North Pile would not produce significant acidity due to the excess internal buffering capacity of the waste rock and deposited PK materials. The analysis also considered materials previously placed within the west perimeter embankment and concluded that the risk of acidic seepage was minimal.
A site-wide geochemistry review for Snap Lake Mine was submitted to De Beers on 11 September 2018 (Golder 2018b). Additional geochemical considerations for surface water runoff from the North Pile closure cover design are discussed in the draft *North Pile Passive Treatment Systems Detailed Design Report* (Golder 2018e).

### 3.3 Construction Materials

The North Pile closure cover will be constructed using non-acid generating rockfill and deposited coarse and grits PK materials. The non-acid generating rockfill and deposited PK materials will be sourced to the extent possible from excavated embankments and/or rib berms during the North Pile facility regrade. Where additional fill material is required to achieve the closure cover design contours and the cover profile shown in the construction drawings (Appendix A), non-acid generating rockfill material may obtained locally from identified borrow sources (Drawing A1-142221-6200-121-0801, Appendix A).

### 3.4 Water Management

The North Pile closure cover is designed to promote surface water drainage off the North Pile facility, toward conveyance and treatment structures downstream of the North Pile facility. During construction, water will be continually drained and not permitted to accumulate on the North Pile facility. The North Pile closure cover will be free-draining and not a point of water storage.

Components of the surface water management system for the North Pile closure cover are shown in Drawing A1-142221-6200-121-0806 (Appendix A) cover and include the following:

- west swale to convey surface water flow from the west portion of the East Cell toward the Cell 1 outlet channel located west of Cell 1
- Cell 1 outlet channel to convey surface water flow from the west swale toward the existing west perimeter drainage ditch
- east swale to convey surface water flow from the east portion of the East Cell toward the Cell 5 outlet channel located east of Cell 5
- Starter Cell swale to convey surface water from the entire Starter Cell toward the Cell 5 outlet channel located east of Cell 5

The Cell 1 outlet channel will convey surface water runoff from the west portion of the closure cover placed over the East Cell to the existing west perimeter drainage ditch and downstream west influent storage pond, as presented in the draft *North Pile Passive Treatment Systems Detailed Design Report* (Golder 2018e).

The Cell 5 outlet channel is presented in the draft *North Pile Surface Water Management for Closure Detailed Design Report* (Golder 2018d). The Cell 5 outlet channel will convey surface water runoff from the east portion of the closure cover placed over the East Cell and the entire closure cover placed over the Starter Cell to the downstream east influent storage pond, as presented in the draft *North Pile Passive Treatment Systems Detailed Design Report* (Golder 2018e).
3.5 Post-closure Land Use

The North Pile closure cover configuration was designed to maintain physical and chemical stability post-closure, and to provide safe access and egress for caribou and other wildlife. Locally sourced non-acid generating materials will be used for construction of the closure cover and will blend in with the surrounding natural landscape.

3.6 Closure Cover Design Criteria

A summary of North Pile closure cover detailed design criteria is presented in Table 1.

Table 1: North Pile Closure Cover Detailed Design Criteria

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
</tr>
<tr>
<td>Regulatory and closure guidance</td>
<td>guidelines for closure and reclamation in the Northwest Territories</td>
</tr>
<tr>
<td></td>
<td>(MVLWB/AANDC 2013)</td>
</tr>
<tr>
<td></td>
<td>Anglo standards (Anglo 2016)</td>
</tr>
<tr>
<td>Deposited materials</td>
<td>fine PK landfill waste</td>
</tr>
<tr>
<td>Embankment / rib berm materials</td>
<td>coarse and grits PK non-acid generating waste rock</td>
</tr>
<tr>
<td>Construction materials</td>
<td>embankment / rib berm rockfill material from local borrow source</td>
</tr>
<tr>
<td>Dam classification</td>
<td>High (CDA 2013)</td>
</tr>
<tr>
<td><strong>Closure Cover Design</strong></td>
<td></td>
</tr>
<tr>
<td>Method</td>
<td>Civil 3D 2017 (Autodesk 2017)</td>
</tr>
<tr>
<td>Coordinate system</td>
<td>Snap Lake Mine Grid</td>
</tr>
<tr>
<td>Maximum temporary slope for Cell 1</td>
<td>4H:1V (input from De Beers)</td>
</tr>
<tr>
<td>deposited PK excavation</td>
<td></td>
</tr>
<tr>
<td>Maximum west perimeter embankment</td>
<td>3H:1V</td>
</tr>
<tr>
<td>downstream slope</td>
<td>(consistent with North Pile facility downstream embankment slopes)</td>
</tr>
<tr>
<td>Nominal top surface gradient</td>
<td>2%</td>
</tr>
<tr>
<td>Item</td>
<td>Criteria</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cover thickness</td>
<td>minimum 2 m over landfill waste material (regulatory commitment)</td>
</tr>
<tr>
<td></td>
<td>nominal 0.6 m over deposited PK material</td>
</tr>
<tr>
<td></td>
<td>0.3 m over embankment / rib berm material</td>
</tr>
<tr>
<td>Landfill waste storage capacity in Cell 1 and Cell 2</td>
<td>114,000 m³ additional material (95,000 m³ estimate provided by demolition contractor to De Beers, with a 20% contingency)</td>
</tr>
</tbody>
</table>

**Surface Water Analysis**

| Analysis method                                           | peak flows and volumes calculated using the US Army Corps of Engineers’ Hydrologic Engineering Center Hydrologic Modeling System computer rainfall and runoff program |
| Design storm event and design storm precipitation         | 24 h probable maximum flood (spring probable maximum precipitation over snowmelt) |
|                                                           | 460 mm total depth (309 mm rainfall and 151 mm snowmelt)                 |
| Riprap sizing method                                      | >20% gradient, shear stress equation (ASCE 1982a)                        |
|                                                           | <20% gradient, Olivier method (ASCE 1982b)                               |

**Stability Analysis**

| Method                                                    | two-dimensional limit equilibrium analysis using SLOPE/W (Geoslope 2012) to evaluate static and pseudo-static stability |
| Pseudo-static coefficient                                 | 0.092 g                                                            |
| Minimum FoS                                               | static: 1.5                                                       |
|                                                           | pseudo-static loading: 1.2                                         |

PK = processed kimberlite; FoS = factor of safety.
4.0 NORTH PILE CLOSURE COVER DESIGN

The North Pile closure cover design components include the cover profile, Cell 2 excavation plan, grading plan, and supporting engineering analyses. The cover profile describes the type of rockfill and placement thickness required. The Cell 2 excavation plan presents the excavation of deposited PK material from Cell 2 (Drawing A1-142221-6200-121-0804, Appendix A) for subsequent placement in Cell 3. This excavation is needed to obtain storage capacity in Cell 1 and Cell 2 for placement of the landfill waste material that will be generated during site-wide demolition activities. The grading plan presents the top of closure cover contours or top of riprap contours within the swales and channel outlets (Drawing A1-142221-6200-121-0806, Appendix A). Engineering analyses were performed to confirm compliance with the design criteria presented in Section 3.0.

4.1 Cover Profile

The two materials to be used in construction of the North Pile closure cover are:

- **Erosion protection cover**—non-acid generating rockfill material sourced locally from excavated embankments and identified borrow sources with a nominal 150 mm minus size, placed as erosion protection over the entire North Pile facility.

- **Transition**—coarse and grits PK material used for construction of the rib berms and perimeter embankments, placed between the underlying deposited PK or landfill waste materials and overlying cover material, where it is needed for physical material compatibility (grain size) between the erosion protection cover and the underlying deposited PK, and to achieve the total closure thickness over the landfill waste material.

Three cover design profiles have been developed for the North Pile. The applicable cover profile depends on the underlying materials, with different cover configurations for the deposited PK, landfill waste, and embankment/rib berm materials. The different materials to be covered have different technical and regulatory requirements, resulting in the different cover configurations. The placement locations for each profile are presented in the construction drawings (Drawing A1-142221-6200-121-0806, Appendix A). Profile components and thicknesses for each cover design are listed in descending order from the top of cover:

- **Deposited PK**—total cover thickness of up to 600 mm
  - 300 mm of erosion protection cover material, equivalent to twice the nominal grain size for cover material of 150 mm.
  - Nominal 300 mm of transition material—The 300 mm thickness has been carried from the feasibility design (Golder 2018c). The thickness of the transition layer will be optimized based on the results of field trials conducted in 2018/2019 and construction observations. The constructability of a thinner layer (minimum 150 mm) that still meets the design intent will be evaluated during construction of the closure cover by the geotechnical engineer.
- **Landfill waste**—total cover thickness of 2 m to meet regulatory commitment
  - 300 mm of erosion protection cover material, equivalent to twice the nominal grain size for cover material of 150 mm.
  - 1.4 m of non-acid generating material, which may be a combination of erosion protection cover and transition materials, depending on material availability.
  - Nominal 300 mm of transition material, assuming landfill material that is placed will be covered with a layer of fine PK material during deposition—Similar to the deposited PK cover profile, the constructability of a thinner layer (minimum 150 mm) that still meets the design intent will be evaluated during construction of the closure cover by the geotechnical engineer.

- **Embankment / rib berm**—total cover thickness of 300 mm
  - 300 mm of erosion protection cover material, equivalent to twice the nominal grain size for cover material of 150 mm.
  - Transition material is not required for placement between existing embankments / rib berms and the erosion protection cover material.

### 4.1.1 Deposited Processed Kimberlite Cover Profile

The cover profile for deposited PK material consists of the erosion protection cover material, underlain by transition material and placed over the deposited PK material. The layer of transition material is required for grain size compatibility between the erosion protection cover and underlying deposited PK materials. Placing coarse erosion protection cover material directly on the deposited PK material, characterized by a particle size of less than 0.125 mm (Golder 2014b), could result in filtration of fines through coarse material.

### 4.1.2 Landfill Waste Cover Profile

As per the commitment listed in the existing site permit, a minimum non-acid generating cover thickness of 2 m will be placed over deposited landfill waste material. Similar to the deposited PK cover profile, the landfill waste cover profile will include 300 mm of erosion protection as the uppermost layer of the cover. The remaining 1.7 m of the required 2 m thickness will be non-acid generating material. The specific composition of this 1.7 m profile will be selected based on material availability of erosion protection cover and transition material, and on the condition of landfill material that has been placed. If fine PK is used to cover the landfilled waste, a minimum 300 mm layer of transition material will be required above the fine PK, unless a reduction in transition layer thickness is approved by the geotechnical engineer based on results of the 2018/2019 field trials.

### 4.1.3 Embankment / Rib Berm Cover Profile

The embankment / rib berm material is expected to be compatible with the erosion protection cover material, and no additional transition material placement is required. The underlying embankment / rib berm materials include coarse and grits PK and waste rock. The coarse PK materials are classified by a particle size range of 1.5 to 6 mm, and the grits PK materials by a range of 0.125 to 1.5 mm (Golder 2014b).
4.2 Grading Plan
The North Pile closure cover grading plan includes the following:

- East Cell
- Starter Cell
- West perimeter embankment
- Borrow sources

The detailed design grading plan (Drawing A1-142221-6200-121-0806, Appendix A) was developed based on existing ground topography for the North Pile facility. The topography used as a basis was provided by De Beers as a contour file produced from an October 2018 aerial survey. The three-dimensional civil design software AutoCAD Civil 3D 2017 (Autodesk 2017) was used to optimize the configuration and to develop the construction drawings (Appendix A) and construction quantity estimate for the North Pile closure cover. The design grading surface shown in the construction drawings represents the top-of-cover grades and elevations, or top-of-rip rap grades and elevations within the swales and channel outlets. Details for the closure cover and riprap requirements are included with the construction drawings (Appendix A).

The North Pile closure cover grading plan (Drawing A1-142221-6200-121-0806, Appendix A) shows the configuration of the North Pile after placement of landfill waste material in Cell 1 and Cell 2 of the East Cell, regrading activities to ensure positive surface water drainage away from the North Pile, and placement of the closure cover. Potential borrow sources identified for use as erosion protection cover and transition materials are also depicted in the North Pile closure cover construction drawings (Drawing A1-142221-6200-121-0801, Appendix A). Closure of the North Pile in accordance with the grading plan will provide a final configuration that resists erosion and conveys a majority of the surface water runoff from the North Pile closure cover to the east, with a small portion of runoff conveyed to the west.

Design criteria for the North Pile closure cover design is presented in Section 3.0. A nominal top surface gradient of 2% was established to provide positive surface water drainage away from the North Pile facility and to allow continued positive drainage in the case of minor differential settlement during the post-closure period. The surface gradient of the closure cover will direct surface water flows away from the embankment crest (except at designed channel outlets) to mitigate the potential for surface water flow to overtop and erode the North Pile facility perimeter embankment slopes. Two channel outlets will be constructed on the East Cell to convey surface water flow off of and away from the North Pile facility. Two swales will convey flow from the Starter Cell and the east portion of the East Cell toward the Cell 5 channel outlet located east of Cell 5, and one swale will convey flow from the west portion of the East Cell toward the Cell 1 channel outlet located west of Cell 1. The design of the Cell 5 outlet channel is presented in the draft *North Pile Surface Water Management for Closure Detailed Design Report* (Golder 2018d). Material available for construction of the North Pile closure cover from the excavation to construct the Cell 5 outlet channel was considered in the North Pile closure cover construction material quantity estimate, presented herein.
As stated in the design criteria (Section 3.0), the North Pile closure cover design was developed to accommodate placement of an additional 114,000 m³ of landfill waste, and will require excavation of deposited PK material in Cell 2 to provide adequate capacity for landfill waste material placement within Cell 1 and Cell 2 of the East Cell. The landfill waste material quantity assumption includes a 20% contingency for the 95,000 m³ estimate provided by the demolition contractor to De Beers.

4.2.1 East Cell

The East Cell is located within the northern portion of the North Pile facility and was constructed as five sub-cells: Cells 1, 2, 3, 4, and 5. Rib berms and perimeter embankments separate each sub-cell and were constructed using the combined coarse and grits PK, and/or waste rock materials. Cell 1 is currently used for the disposal of landfill waste material. Cells 2, 3, 4, and 5 were used to store deposited PK material.

To accommodate 114,000 m³ of landfill waste material within the fewest cells of the East Cell, the closure cover configuration incorporates an excavation of deposited PK material in Cell 2 and excavation of Rib Berm 1 (Drawing A1-142221-6200-121-0804, Appendix A). The excavated PK material from Cell 2 will be placed within Cell 3. The excavated rib berm material will be placed along the slope of Rib Berm 2, above the Cell 2 excavation, to increase stability of Rib Berm 2 and maintain a 4H:1V slope as shown in the stability analysis (Appendix E). The landfill waste material from site-wide demolition activities will be placed in Cell 1 and Cell 2 only.

The closure cover detailed design for the East Cell is presented in the construction drawings (Drawing A1-142221-6200-121-0806, Appendix A) and includes a nominal 2% gradient directed away from the embankment crest to mitigate the potential for surface water flow to erode the slope below, and two swales to convey surface water flows toward the Cell 1 (west) and Cell 5 (east) outlet channels. The Cell 1 outlet channel design is presented herein; the Cell 5 outlet channel is presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d).

The west swale will be constructed on the closure cover surface north of the landfill waste material deposition within Cell 1 and Cell 2 to convey surface water flow west, toward the Cell 1 channel outlet located at the northwest corner of the East Cell. Placement of the west swale outside of the landfill waste material placement footprint will avoid likely differential settlement typically observed with deposited landfill waste material. The Cell 1 channel outlet will be constructed as part of the west perimeter embankment regrade.

The east swale will be constructed on the closure cover surface over Cell 4 and Cell 5 to convey surface water flow east, toward the Cell 5 channel outlet located at the southeast corner of the East Cell. The Cell 5 outlet channel design is presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d).

Riprap will be placed within the west and east swales to reduce erosion potential and promote long-term stability of the cover system. Riprap will be placed on top of the constructed closure cover, where the underlying erosion protection cover will serve as the transition layer for grain size compatibility between the riprap and the transition or embankment / rib berm materials. Dimensions and revetment requirements for the swales and channel outlets are shown in the construction drawings (Drawing A1-142221-6200-121-0814, Appendix A).
4.2.2 Starter Cell

The Starter Cell is located within the southern portion of the North Pile and was constructed as eight sub-cells: Cells A, B, C, D, E, F, SQ, and LF. Rib berm and perimeter embankments separate each sub-cell and were constructed using the combined coarse and grits PK, and/or waste rock materials. Cell LF was used for the disposal of landfill waste material. Cells A, B, C, D, E, F, and SQ were used to store deposited PK material.

The closure cover design for the Starter Cell is presented in the construction drawings (Drawing A1-142221-6200-121-0806, Appendix A) and includes a nominal 2% gradient directed away from the embankment crest to mitigate the potential for surface water flow to erode the slope below, and a single swale to convey surface water flows toward the Cell 5 outlet channel. In general, the closure cover construction for the Starter Cell will be performed as an earthworks local cut to fill operation. The Starter Cell swale will be constructed on the closure cover surface to convey surface water flow east, toward the Cell 5 channel outlet located at the southeast corner of the East Cell. The Cell 5 outlet channel design is presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d). The gradient of the Starter Cell swale will be greatest through the Cell D to Cell 5 transition, prior to the Cell 5 channel outlet confluence. Riprap will be placed within the Starter Cell swale to reduce erosion potential and promote long-term stability of the cover system. Riprap will be placed on top of the constructed closure cover, where the underlying erosion protection cover will serve as the transition layer for grain size compatibility between the riprap and the transition or embankment / rib berm materials. Dimensions and revetment requirements for the swales and channel outlets are shown in the construction drawings (Drawing A1-142221-6200-121-0814, Appendix A).

4.2.3 West Perimeter Embankment

The west perimeter embankment is located along the western portion of the East Cell and Starter Cell and was intended to be covered by the West Cell construction as material placement and fine PK deposition advanced. However, the West Cell was not fully developed, leaving the approximately 1.5H:1V west perimeter embankment of the Starter and East cells exposed.

The closure cover design for the west perimeter embankment is presented in the construction drawings (Drawing A1-142221-6200-121-0806, Appendix A) and includes a 3H:1V slope regrade to promote long-term stability of the cover system and allow wildlife access and egress. The west perimeter embankment has been designed as a cut to fill slope regrade to the extent practicable.

The Cell 1 channel outlet will be constructed at the northwest corner of the East Cell and continue along the west perimeter embankment to convey surface water runoff from the west portion of the closure cover placed over the East Cell to the existing west perimeter drainage ditch and downstream west influent storage pond, as presented in the draft North Pile Passive Treatment Systems Detailed Design Report (Golder 2018e). Riprap will be placed within the Cell 1 channel outlet to reduce erosion potential and promote long-term stability of the cover system. Riprap will be placed on top of the constructed closure cover, where the underlying erosion protection cover will serve as the transition layer for grain size compatibility between the riprap and the transition or embankment / rib berm materials. Dimensions and revetment requirements for the channel outlet are shown in the construction drawings (Drawing A1-142221-6200-121-0816, Appendix A).
4.2.4 Borrow Sources

Transition, erosion protection cover, and riprap materials are required for construction of the North Pile closure cover. These materials will be sourced as follows:

- Transition materials will be locally sourced from the coarse and grits PK material generated by excavation of the embankment and rib berms, or from suitable borrow areas surrounding the North Pile as identified in Table 2.
- Erosion protection cover and embankment construction materials will be locally sourced from the excavation of suitable borrow areas surrounding the North Pile as identified in Table 2.
- Riprap will be locally sourced from excavation of on-site borrow areas, including the coarse fraction of material screened from the organic stockpile borrow area.

Potential borrow area locations for use in construction of the closure cover are shown in the construction drawings (Drawing A1-142221-6200-121-0801, Appendix A). Borrow materials required for construction of the North Pile closure cover are expected to be locally available in sufficient quantities. The closure of identified borrow sources after extraction of the needed borrow material will be assessed by others during development of the overall site-wide closure plan. Off-site material will not be required for construction of the North Pile closure cover. Quantities of available borrow have been estimated for each borrow source using the existing ground topography and are presented in Table 2. Table 2 includes key assumptions used in the development of these estimates. Note that specific ground truthing to confirm borrow volumes and characteristics has not been conducted.

Table 2: North Pile Closure Cover Design Borrow Area Quantity Estimate

<table>
<thead>
<tr>
<th>Borrow Area</th>
<th>Location</th>
<th>Primary Use</th>
<th>Available Quantity Estimate (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crusher stockpile</td>
<td>west of North Pile</td>
<td>erosion protection cover material</td>
<td>11,200(a)</td>
</tr>
<tr>
<td>Explosive management bunker</td>
<td>west of East Cell</td>
<td>erosion protection cover material</td>
<td>1,700(b)</td>
</tr>
<tr>
<td>Laydown area</td>
<td>southeast of North Pile</td>
<td>erosion protection cover and/or transition material</td>
<td>256,000(c)</td>
</tr>
<tr>
<td>Organic stockpile</td>
<td>former AN storage facility</td>
<td>riprap</td>
<td>29,400(d)</td>
</tr>
<tr>
<td>SP5 quarry</td>
<td>north of East Cell, Cell 1</td>
<td>erosion protection cover and/or transition material</td>
<td>68,200(e)</td>
</tr>
<tr>
<td>West Cell divider dyke</td>
<td>north Pile West Cell</td>
<td>erosion protection cover materials</td>
<td>81,000(f)</td>
</tr>
</tbody>
</table>

(a) Quantities were provided by De Beers on 25 April 2018 and include the following sizes (quantities): 150 mm (5,900 m³), 75 mm (2,500 m³), 50 mm (900 m³), and 19 mm (2,000 m³).
(b) The explosive management bunker was identified as a potential borrow source during a site visit to Snap Lake Mine on 31 May 2018.
(c) Quantity assumes only 80% of the total volume of material within the borrow area will be available and suitable for use following grizzly screening.
(d) Quantity assumes only 20% of the total volume of material within the borrow area is considered oversized and will be available and suitable for use following grizzly screening. The remaining 80% of the total volume of material estimated is assumed to be undersized and may be reserved for site-wide revegetation efforts.
(e) Quantity accounts for the estimated volume of material (provided by De Beers) that was removed during 2016 and 2017.
(f) Quantity assumes the total volume of material will be available and suitable for use.
Additional borrow areas may be considered based on feedback received from De Beers and during construction. Activities associated with construction of the perimeter surface water conveyance channels and the passive treatment system construction may also generate material suitable for use as borrow (Golder 2018d,e).

4.3 Engineering Analyses

The following sections describe the engineering analyses that were performed to confirm compliance of the North Pile closure cover detailed design with the design criteria. Surface water management and slope stability analyses were completed to support the North Pile closure cover design.

4.3.1 Surface Water Management

A surface water management analysis was performed to determine the length, width, depth, side slope, and revetment for the swales and channel outlets included in the closure cover design. The probable maximum precipitation 24-hour storm event plus snowmelt was selected as the design storm event required to satisfy the criteria per the Anglo (2016) and CDA (2013) standards for the closure passive care phase. A detailed description of the surface water management analysis is included as Appendix D.

Two swales will be constructed on the East Cell closure cover surface to convey surface water toward the Cell 1 (west) and Cell 5 (east) channel outlets. One swale will be constructed on the Starter Cell closure cover surface to convey surface water toward the Cell 5 (east) channel outlet. The Cell 5 outlet channel design is presented in the draft North Pile Surface Water Management for Closure Detailed Design Report (Golder 2018d). Riprap will be placed within all three swales and the Cell 1 outlet channel. Channel dimensions and riprap requirements are summarized in Table 3.

Table 3: North Pile Closure Cover Surface Water Management Structure Summary

<table>
<thead>
<tr>
<th>Hydraulic Structure</th>
<th>Longitudinal Slope (%)</th>
<th>Side Slope (H: V)</th>
<th>Bottom Width (m)</th>
<th>Minimum Depth (m)</th>
<th>Riprap Size ($D_{50} = $) mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>West swale</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>0.5</td>
<td>150</td>
</tr>
<tr>
<td>East swale</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>0.5</td>
<td>150</td>
</tr>
<tr>
<td>Starter Cell swale (shallow)</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>0.5</td>
<td>150</td>
</tr>
<tr>
<td>Starter Cell swale (steep, Cell D to Cell 5)</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>0.5</td>
<td>300</td>
</tr>
<tr>
<td>Cell 5 Swale (East swale and Starter swale combined)</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>300</td>
</tr>
<tr>
<td>Cell 1 outlet channel (maximum slope)</td>
<td>30</td>
<td>3</td>
<td>5</td>
<td>0.5</td>
<td>600</td>
</tr>
<tr>
<td>Cell 1 outlet channel (minimum slope)</td>
<td>11</td>
<td>3</td>
<td>5</td>
<td>0.5</td>
<td>600</td>
</tr>
</tbody>
</table>

$D_{50} = $ average particle size, where 50% is greater and 50% is less than the particle size.
4.3.2 Slope Stability

The final geometry of the North Pile closure cover requires an excavation of the deposited PK material in Cell 2 and rib berm material from Rib Berm 2 to accommodate placement of landfill waste material within a minimal footprint of the North Pile facility. A slope stability analysis was required to assess the allowable excavation slope for the deposited PK within Cell 2 and to confirm the long-term stability with additional landfill waste placement in Cell 1 and Cell 2. Additionally, the west perimeter embankment will be regraded to a 3H:1V slope to promote the long-term stability of the closure cover system. A detailed description of the slope stability analyses is included as Appendix E. Based on the results of the assessment, excavation geometries have been developed that meet conservatively selected factor of safety (FoS) criteria, including where applicable the Anglo (2016) and CDA (2013) standards for the closure passive care phase.

Results of the stability analysis indicate that the temporary excavation with a 4H:1V slope from the crest of Rib Berm 2 and the Cell 2 perimeter embankment to the bottom of deposited PK material meet the required minimum static and pseudo-static FoS requirements with the following construction considerations:

- **Rib Berm 2**—Rib berm material will be removed to the bottom of the cover elevation shown in the construction drawings (Drawing A1-142221-6200-121-0809 and 0810, Appendix A) and placed at a 4H:1V against Rib Berm 2 to the top of the deposited PK material. The deposited PK material will be subsequently excavated from Cell 2 in horizontal layers of approximately 1 m thickness, leaving a 4H:1V slope against the remaining Rib Berm 2 as the deposited PK material is removed.

- **Cell 2 perimeter embankment (interior)**—Coarse and grits PK and/or waste rock material will be excavated from the upstream side of the embankment at a maximum steepness of 4H:1V. The deposited PK material will be subsequently excavated from Cell 2 in horizontal layers of approximately 1 m thickness, leaving a 4H:1V slope against the upstream perimeter embankment of Cell 2 as the deposited PK material is removed.

Stability analysis results show that the regraded 3H:1V exterior slope of the Cell 1 west embankment also satisfies the minimum required FoS to meet the closure cover design intent describe below:

- **Cell 1 west perimeter embankment (downstream slope)**—The downstream slope of the west perimeter embankment was originally intended to be covered as the West Cell construction advanced. The West Cell was not fully developed, leaving a 1.5H:1V downstream embankment exposed. The closure cover includes a 3H:1V slope regrade to promote the long-term stability of the cover system.
5.0 CONSTRUCTION MATERIAL QUANTITY ESTIMATE

A construction material quantity estimate was developed for the North Pile closure cover construction using AutoCAD Civil 3D 2017 (Autodesk 2017). Quantities have been estimated separately for the East Cell, Starter Cell, and the west perimeter embankment components of the closure cover, and are divided into three categories:

- earthworks for grading
- earthworks for cover placement
- riprap placement

Earthworks and revetment quantities were calculated to estimate the amount of deposited PK, rib berm, and embankment material excavation; transition and erosion protection cover material placement; swale and channel outlet revetment placement; and borrow materials required to meet the design grades, contours, and placement locations as outlined in the construction drawings (Appendix A). Earthworks and revetment quantities are presented in Table 4 and are neat line and do not account for swell, shrinkage, waste, or loss.

Material available for construction of the North Pile closure cover from the excavation to construct the Cell 5 outlet channel was included in the North Pile closure cover construction material quantity estimate. Additionally, cover and revetment requirements for construction of the Cell 5 outlet channel were also included in the estimate.

Table 4: North Pile Closure Cover Construction Material Quantity Estimate

<table>
<thead>
<tr>
<th>Construction Activity</th>
<th>Quantities (m³)</th>
<th>East Cell</th>
<th>Starter Cell</th>
<th>West Perimeter Embankment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Earthworks for Grading</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excavate deposited PK material from Cell 2 and place in Cell 3</td>
<td>37,300</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate Rib Berm 1 and place in Cell 2 (against Rib Berm 3)</td>
<td>11,600</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate Rib Berm 1 and place in Cells 3, 4, or 5</td>
<td>2,600</td>
<td>n/a</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate and place embankment / rib berm (local cut to fill)</td>
<td>23,500</td>
<td>5,800</td>
<td>14,000</td>
<td></td>
</tr>
<tr>
<td>Excavate embankment / rib berm (excludes Rib Berm 1) and place in Cells 3, 4, and 5</td>
<td>43,300</td>
<td>73,300</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate embankment / rib berm and place in Starter Cell</td>
<td>n/a</td>
<td>6,100</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate embankment / rib berm and place in west perimeter embankment</td>
<td>n/a</td>
<td>4,900</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Construction Activity</td>
<td>East Cell</td>
<td>Starter Cell</td>
<td>West Perimeter Embankment</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------</td>
<td>-----------</td>
<td>--------------</td>
<td>----------------------------</td>
<td></td>
</tr>
<tr>
<td>Excavate embankment / rib berm and stockpile for cover</td>
<td>n/a</td>
<td>29,000</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Excavate Cell LF and place in Cells 1 and 2</td>
<td>n/a</td>
<td>29,600</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td><strong>Earthworks for Cover Placement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place transition material</td>
<td>28,600</td>
<td>49,800</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Place transition and/or erosion protection cover over landfill waste</td>
<td>53,600</td>
<td>22,500</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Place erosion protection cover over North Pile</td>
<td>47,500</td>
<td>67,000</td>
<td>5,800</td>
<td></td>
</tr>
<tr>
<td><strong>Riprap Placement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place riprap for swales ($D_{50} = 150$ mm)</td>
<td>2,100</td>
<td>3,500</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Place riprap for swales ($D_{50} = 300$ mm)</td>
<td>n/a</td>
<td>800</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Place riprap for Cell 1 channel outlet ($D_{50} = 600$ mm)</td>
<td>n/a</td>
<td>n/a</td>
<td>800</td>
<td></td>
</tr>
</tbody>
</table>

PK = processed kimberlite; $D_{50} =$ average particle size, where 50% is greater and 50% is less than the particle size; n/a = not applicable.

A summary of total earthworks and revetment quantities required for construction of the North Pile closure cover and the available borrow material sources is presented in Table 5. Excess embankment / rib berm material excavated will be used for construction of the North Pile closure cover in addition to the available borrow material sources. A material balance is demonstrated and confirms all construction material can be locally sourced.
<table>
<thead>
<tr>
<th>Construction Material</th>
<th>Total Construction Material Quantity (m³)</th>
<th>Available Borrow Source(s)</th>
<th>Total Available Borrow Source Quantity (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erosion protection cover</td>
<td>120,300</td>
<td>laydown area Embankment / rib berm SP5 quarry crusher stockpile explosive management bunker West Cell divider dyke</td>
<td>256,000 29,000 68,200 11,200 1,700 81,000</td>
</tr>
<tr>
<td>Erosion protection cover and/or transition</td>
<td>76,100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition(a)</td>
<td>78,400</td>
<td>rib berms</td>
<td>89,800</td>
</tr>
<tr>
<td>Riprap (Dₕ₀ = 150 mm)</td>
<td>5,600</td>
<td>organics stockpile(b)</td>
<td>29,400</td>
</tr>
<tr>
<td>Riprap (Dₕ₀ = 300 mm)</td>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riprap (Dₕ₀ = 600 mm)</td>
<td>800</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Transition quantity is based on a nominal 300 mm thickness and may be reduced if a thinner transition layer can be constructed.
(b) Specific ground truthing to confirm borrow volumes and characteristics has not been conducted and the riprap borrow source will be reviewed prior to construction to confirm availability of suitable material. Other sources can be processed to meet requirements if needed.
PK = processed kimberlite; Dₕ₀ = average particle size, where 50% is greater and 50% is less than the particle size.

Additional borrow areas may be considered based on feedback received from De Beers and during construction. Activities associated with construction of the perimeter surface water conveyance channels and the passive treatment system construction may also generate material suitable for use as borrow (Golder 2018d,e).
6.0 CONSTRUCTION CONSIDERATIONS

Construction activities will be performed using construction drawings (Appendix A), construction specifications (Appendix B), CQAP (Appendix C), and existing equipment available on site. Existing equipment available on site includes:

- 2 excavators: Komatsu 650 and 400
- 3 loaders: Komatsu 500, 450, and 250
- 3 haul trucks: Komatsu 350
- 1 grader: Komatsu 655
- 3 dozers: Komatsu 155 and 65, John Deere 450
- 1 Bobcat: S300
- 3 Genie Man Lifts: 110 ft, 60 ft, 40 ft
- 1 crane: Knuckle Boom Fat Deck
- 2 telehandlers
- 1 forklift: 50 ton
- 1 compactor: vibratory smooth drum [available compaction equipment to be confirmed by De Beers and/or construction specification revised by Golder]

A water source for dust control will be needed during construction. Dust control will be needed on the North Pile facility and surrounding staging, borrow, and haul road areas. Dust control management will include periodic wetting of the work areas and may be more frequent during excavation into deposited PK material on the East Cell.

6.1 Sequence

A construction sequence has been developed to present the order of major construction activities that will be performed to achieve the intent of the North Pile closure cover detailed design. Construction activities are listed in progressive order:

1) **West perimeter embankment grading**—includes reducing the slope angle to 3H:1V, maintaining a cut to fill balance where practicable, and constructing the Cell 1 channel outlet.

2) **West perimeter embankment erosion protection cover and riprap material placement**—includes placing erosion protection cover material atop the graded footprint and placing riprap material atop the erosion protection cover (functioning as a transition material to riprap) within the Cell 1 channel outlet.

3) **East Cell excavation/grading**—includes excavating Rib Berm 1 and deposited PK material from Cell 2, placing excavated fine PK material from Cell 2 into Cell 3, and local cut to fill grading.
4) **East Cell landfill waste material placement**—includes placing additional landfill waste material in Cell 1 and Cell 2. Landfill waste material placement is assumed to occur through much of the duration of Starter Cell and west perimeter embankment closure cover construction activities.

5) **Starter Cell grading**—includes local cut to fill grading and constructing the Starter Cell swale.

6) **Starter Cell transition material placement**—includes placing transition material atop the graded footprint.

7) **Starter Cell erosion protection cover and riprap material placement**—includes placing erosion protection cover material atop the transition material and/or the graded footprint, and placing riprap material atop the erosion protection cover within the Starter Cell swale. Under the riprap, the closure cover will function as an additional transition layer.

8) **East Cell transition material placement**—includes placing transition material atop the graded footprint and/or landfill waste material.

9) **East Cell erosion protection cover and riprap material placement**—includes placing erosion protection cover material atop the transition material and/or the graded footprint, and placing riprap material atop the erosion protection cover within the Cell 1 outlet channel and the east and west swales.

A detailed construction sequence may be required to evaluate the East Cell grading, specifically the potential for concurrent landfill waste material and closure cover placement. This was not included in the North Pile closure cover detailed design scope of work.

### 6.2 Schedule

A preliminary construction schedule for North Pile closure cover design tasks is summarized in Table 6. Cover design tasks will be completed during the first quarter (Q1) of 2019, and construction activities are anticipated to commence in the second quarter (Q2) of 2021, after regulatory approval of the North Pile closure cover final design. Estimated durations for the individual construction activities identified in Section 6.1 were not included in the North Pile closure cover detailed design scope of work.

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimated Duration (days)</th>
<th>Estimated Commencement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submit North Pile Closure Cover Detailed Design Report</td>
<td>0</td>
<td>Q1 2019 (March)</td>
</tr>
<tr>
<td>Closure plan submission to MVLWB by De Beers</td>
<td>up to 730</td>
<td>Q1 2019 (30 March)</td>
</tr>
<tr>
<td>Commence construction activities</td>
<td>TBD</td>
<td>Q2 2021 (anticipated)</td>
</tr>
</tbody>
</table>

MVLWB = Mackenzie Valley Land and Water Board; TBD = to be determined.

### 6.3 Construction Quality Assurance / Quality Control

Construction monitoring and testing will be performed during construction of the North Pile closure cover to monitor construction activities and maintain quality control and assurance that the design intent is met. A CQAP for construction of the North Pile closure cover is included as Appendix C.
6.4 Site-Wide Demolition and Landfill Waste Material Placement

The North Pile closure cover detailed design assumes 114,000 m$^3$ of landfill waste material will be generated during site-wide demolition activities and will be placed in Cell 1 and Cell 2, prior to construction of the North Pile closure cover over the East Cell. An estimate of 95,000 m$^3$ was provided by the demolition contractor to De Beers, and a 20% increase was applied to account for uncertainty.

All closure cover elevations, depth of excavations, and embankment / rib berm excavation elevations presented in this report have been calculated based on the estimated 114,000 m$^3$ volume of landfill waste material. This estimated landfill waste volume carries an inherent uncertainty, and variations in the amount of landfill waste may result in variations in the calculated values. However, the overall flow conveyance strategy for the North Pile closure cover is robust, and can be maintained and adapted to variances in the design volume of landfill waste. Lower volumes of landfill waste can be accommodated to the current design with reduced or no excavation of PK in Cell 2, while greater volumes can be accommodated with excavation of additional Cells and/or changes in grading. Significantly greater volumes (100% or more increase over current estimate) could be accommodated through a revised design that maintains the current flow conveyance strategy, and incorporates excavation of Cell 3.

Once total volumes of landfill waste are defined, a check on the design grading plan should be conducted.

6.5 Instrumentation and Monitoring

The North Pile closure cover instrumentation and monitoring plan is presented in the construction drawings (Drawings A1-142221-6200-121-0802 and -0803, Appendix A). Details regarding instrumentation and monitoring requirements will be presented in a separate Closure and Post Closure Monitoring Plan (CPCMP), scheduled for mid-March 2019.

6.6 Cover Trials

Closure cover trial pads were constructed on the North Pile facility in 2018 and will be monitored until construction of the North Pile closure cover. Observation data will be used to evaluate settlement under cover loading within the North Pile and results may be used to re-evaluate the cover profiles prior to construction of the closure cover. Details regarding construction of the cover trial pads and a summary of initial data obtained will be presented in a separate technical memorandum: *North Pile Closure Cover Field Trial, Snap Lake Mine* (Golder 2018f).
7.0 POST-CONSTRUCTION MONITORING AND MAINTENANCE

Post-construction monitoring and maintenance will be detailed in a CPCMP. The CPCMP will detail monitoring areas, existing and proposed monitoring instrumentation, monitoring frequencies, inspection protocols, data collection and assessment procedures, trigger levels, corrective actions, and reporting requirements. The subsections below are intended to convey major elements that will be detailed in the CPCMP. A draft of information to be included with the CMP was provided to De Beers on 28 September 2018. The CMP will be submitted mid March 2018.

Proposed monitoring instrumentation may be installed after the closure cover is placed to monitor thermal conditions and the anticipated freeze-back of the North Pile, piezometric levels, settlement, and other parameters. The specific instrumentation required, installation locations, and the post-construction monitoring period and frequency will be defined in the CPCMP during the permitting process and detailed design.

7.1 Monitoring Areas

The North Pile closure cover, embankment slopes, and surface water conveyance structures (i.e., swales, channel outlets) will be inspected by the geotechnical engineer to confirm stability and performance achieve the design intent. This monitoring will include visual inspection and review of any data obtained from instrumentation on the North Pile. Any areas of visible closure cover erosion, instability of the embankment slopes, or areas of ponded water or obstructed conveyance will be documented.

7.2 Monitoring Frequency

Visual inspection of the North Pile closure cover, embankment slopes, and surface water conveyance structures will be performed by De Beers and supported by periodic quality assurance inspections by the geotechnical engineer at a frequency and for a post-construction monitoring period defined in the CPCMP. Instrumentation data collection will also be performed by De Beers and provided to the geotechnical engineer for review for the post-construction monitoring period.

7.3 Data Assessment and Corrective Action

The performance of the North Pile cover will be assessed during the post-construction monitoring period based on data collected from site instrumentation and observations made during site inspections. Areas of visible closure cover erosion will be repaired if required by regrading and replacement of the transition and/or cover materials; areas of unstable embankment slopes will be flattened or supported to meet closure cover design stability requirements, and areas of ponded water or obstructed conveyance will be steepened by regrading and/or clearing of debris to achieve the surface water conveyance design intent.

If significant movement of the North Pile or closure cover is identified, the frequency of inspections may be increased to assess the extent, rate and cause of movement. If the extent or rate of movement is considered unacceptable, such that the North Pile closure cover no longer meets the design intent, corrective action will be undertaken. The nature of the corrective actions will depend on the type of movement observed and its causes.
If surface water flow conveyance obstruction or ponded water is identified, the frequency of inspections may also be increased to assess the extent and nature of the issue. Corrective actions may include a review of the North Pile design and assessment of the closure cover construction records to develop potential corrective measures.

7.4 Reporting

A post-construction monitoring and maintenance report will be prepared annually for a period to be defined during the permitting process and detailed design. The report will summarize all data collected, observations, and corrective action for the North Pile from the previous year.
8.0 CLOSING

The reader is referred to the Study Limitations section, which precedes the text and forms an integral part of this report.

We trust the information in this report is sufficient for your present needs. Should you have any additional questions regarding this report, please contact the undersigned.
Signature Page

Golder Associates Ltd.

Abdul Sattar Khan, M.A.Sc.
Project Manager

Björn Weeks, Ph.D., P.Eng.
Principal, Geo-Environmental Engineer

ASK/BW/HNL/no/cf/cmm

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REFERENCES


ASCE. 1982b. Sedimentation engineering processes, measurements, modeling and practice B.8.5.2.


# APPENDIX A

## Construction Drawings

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De Beers Group

SNAP LAKE MINE
NORTH PILE CLOSURE COVER
DETAILED DESIGN

INDEX OF DRAWINGS

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