Graphitecorp Operations Pty Ltd

Mount Dromedary Graphite Project

Concept Design Study for Mine Waste and Water Management

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1 INTRODUCTION

1.1 Background

Graphitecorp Operations Pty Ltd (Graphitecorp) is currently undertaking feasibility and environmental studies to develop a mining operation at the Mt Dromedary proposed development area, located some 125 km north-northwest of Cloncurry in northern Queensland. The proposed development includes the following:

- Open Cut Pit to extract the graphite ore.
- Process beneficiation plant to produce a graphite concentrate.
- Integrated waste-tailings landform (IWTL), a co-disposal structure comprising PAF and NAF waste rock with fine grained thickened tailings placed centrally.
- Low grade ore stockpile area.
- Water management system to contain mine impacted waters to minimise the risk of release from site and divert clean upstream water.
- Water supply dam/buffer storage.
- Site general waste landfill.

1.2 Scope

Graphitecorp has commissioned ATC Williams Pty Ltd (ATCW) to complete conceptual design for mine waste and water management at the Mount Dromedary site for the purpose of obtaining an Environmental Authority.

The scope of work associated with engineering for mine waste management and surface water management is as follows:

- Characterise waste properties to be contained within the IWTL.
- Confirm the proposed layout and configuration for IWTL and water management structures.
- Compile relevant data to support engineering for the IWTL and water management structures.
- Undertake engineering analyses to confirm sizing and configuration of IWTL and water management structures.
- Provide details on proposed construction, operational approach and associated closure concepts.

2 PROPOSED PROJECT DEVELOPMENT

2.1 Project Basis

2.1.1 Mineral Description

The Mount Dromedary Graphite area indicates a graphite resource with substantial, near surface, high grade ore. A significant portion of the resource is very high grade compared to typical graphite deposits.
2.1.2 Life of Mine Schedule

Material quantities have been adopted based upon the following documents:


Total life of mine quantities are summarised in **Table 1**:

<table>
<thead>
<tr>
<th>Life of Mine Material</th>
<th>Weight</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Grade Ore</td>
<td>5.91 Mt</td>
<td>Report_Client Schedule Sumary.xls</td>
</tr>
<tr>
<td>Medium Grade Ore</td>
<td>1.33 Mt</td>
<td></td>
</tr>
<tr>
<td>Low Grade Ore</td>
<td>2.14 Mt</td>
<td></td>
</tr>
<tr>
<td>Mine Waste Rock</td>
<td>14.70 Mt</td>
<td></td>
</tr>
<tr>
<td>Product Concentrate</td>
<td>1.20 Mt</td>
<td></td>
</tr>
<tr>
<td>Thickened Tailings</td>
<td>6.04 Mt</td>
<td></td>
</tr>
</tbody>
</table>

This resource amount would allow for a life of mine (LOM) time frame of 25 years at an average process throughput of 300,000 tonnes per annum.

2.1.3 Process Description

Mineral ores from the Mt Dromedary pit have been categorised into High Grade, Medium Grade and Low Grade. It is proposed that High Grade and Medium grade ores will be milled and processed, with low grade ores (currently considered uneconomical to process) stockpiled and/or returned to the mine pit as ongoing development allows.

Processing the mined ore would involve going through a comminution circuit comprising crushing, milling and flash flotation. The extracted ore material would then go through the separation circuit, which involves flotation and regrind. At this stage, the ore concentrate would be sent to the concentrate thickener and processed such that the material would be caked, dried and packaged for transport.

The waste material, currently in a tailings slurry state, would be transferred via pipeline to a tailings thickener, located adjacent to the disposal location. Thickening would be undertaken to dewater the tailings, with recovered water returned directly to the Process Water Pond for reuse in processing operations.

2.1.4 Waste & Low Grade Ore Characterisation

Based on Graeme Campbell and Associates (November 2016), the waste rock material from the pit was geochemically characterised as follows:
• **Weathered Zone (Waste-Regoliths)**

Waste rock material containing negligible sulphides, and therefore characterised as non-acid forming (NAF). Generally located near surface at depths of less than 20m. Predominantly consisting of Meta-Arenite, Siltstone and Dolerite. Assayed data indicates that the weathered zone will comprise 30% of the total waste rock material.

• **Fresh Zone (Waste-Bedrocks)**

Waste rock material generally located at depths greater than 20m. Predominantly consisting of Meta-Arenite, Siltstone and Dolerite and Altered Dolerite, as well as a smaller component of limestone. Assay data indicates that the Fresh Zone will comprise 70% of the total waste rock material. Classified as Potentially Acid Forming (PAF) material.

Low Grade Ore, which is not proposed to be processed, can similarly be classified as Weathered or Fresh:

• **Weathered Zone (Low Grade Oxide Ore)**

Low Grade Ores contain negligible sulphides, and therefore characterised as non-acid forming (NAF). Generally located at depths of less than 20m and consisting of Meta-Arenite and Siltstone. Assay data indicates the Low Grade Ore weathered zone will comprise 20% of the total Low Grade Ore material.

• **Fresh Zone (Low Grade Primary Ores)**

Low Grade Ore generally located at depths greater than 20m. Consisting of Meta-Arenite and Siltstone. Assay data indicates the Low Grade Ore Fresh Zone will comprise 80% of the total low grade ore material. Classified as Potentially Acid Forming (PAF) material.

As NAF Low Grade Ore and Waste Rock material located near the surface, initial development of the Mt Dromedary Pit will generate predominantly NAF material, available for use in construction and development of site infrastructure. Over the life of the mine, the estimated quantities of NAF generating material is as follows:

- Low Grade Oxide Ores (NAF) 0.43 Mt
- Weathered Waste Rock (NAF) 4.41 Mt

3 **SITE DESCRIPTION**

3.1 **Climate**

The Mount Dromedary site is subject to a semi-arid environment with highly variable rainfall conditions. Mean annual rainfall is 490.2mm (Bureau of Meteorology - Cloncurry), with an obvious seasonal pattern of lower rainfall conditions during the winter months and highest rainfall occurring during January and February.

Mean monthly rainfall and evaporation data is summarised in Table 1. In the absence of evaporation records, monitored in close proximity to the site, two monitoring stations were selected to represent site specific conditions, one in Mt Isa and the other in Julia Creek, located 120 km south west and 195 km south east, respectively.
Table 2
Average Monthly Rainfall and Evaporation Data (mm) for the Cloncurry Region

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall*</th>
<th>Evaporation**</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Cloncurry</td>
<td>Mt Isa</td>
</tr>
<tr>
<td>January</td>
<td>139.8</td>
<td>297.6</td>
</tr>
<tr>
<td>February</td>
<td>111.1</td>
<td>249.2</td>
</tr>
<tr>
<td>March</td>
<td>76.35</td>
<td>275.6</td>
</tr>
<tr>
<td>April</td>
<td>19.4</td>
<td>249.0</td>
</tr>
<tr>
<td>May</td>
<td>13.1</td>
<td>198.4</td>
</tr>
<tr>
<td>June</td>
<td>7.85</td>
<td>159.0</td>
</tr>
<tr>
<td>July</td>
<td>4.9</td>
<td>170.5</td>
</tr>
<tr>
<td>August</td>
<td>4.2</td>
<td>213.9</td>
</tr>
<tr>
<td>September</td>
<td>6.7</td>
<td>267.0</td>
</tr>
<tr>
<td>October</td>
<td>15.9</td>
<td>325.5</td>
</tr>
<tr>
<td>November</td>
<td>29</td>
<td>330.0</td>
</tr>
<tr>
<td>December</td>
<td>69.65</td>
<td>325.7</td>
</tr>
<tr>
<td>Yearly</td>
<td>490.2</td>
<td>3,068</td>
</tr>
</tbody>
</table>

Source: Bureau of Meteorology
* Cloncurry Station: #029009 and 029141
** Mt Isa Station: #029127
Julia Creek Station: #029025

Table 1 indicates that within the region, mean evaporation far exceeds mean rainfall for each month.

3.2 Topography and Drainage

The Mount Dromedary site is located over two river basins, namely the Leichhardt and Flinders Basins. Excepting the proposed Mine Camp, site infrastructure is located within the Leichhardt Basin, which comprises a catchment of approximately 33,000 km². The Leichhardt River is ephemeral and originates to the south of Mt Isa, before flowing in a generally northern direction passing to the west (approximately 15 km) of Mount Dromedary and eventually reporting to the Gulf of Carpentaria.

Site drainage paths and topography within the proposed mine lease are shown in Figure 1:
Within the site, the Dromedary Ranges form a catchment divide reporting surface runoff flows to the east (Flinders Basin) and west of the site (Leichhardt Basin).
In the northern extent of the proposed mining lease, two drainage paths report eastwards, passing flows across the Burke Developmental Road. The northernmost of these is located nearby the current proposed Mine Camp.

At the southern extent of the site, an unnamed drainage path reports flows between Mt Dromedary and Black Mountain. The proposed Mt Dromedary Pit is located in the northernmost headwaters of this drainage path. A less defined minor tributary is also located at the southern limit of the proposed mining lease. Both of these drainage paths flow westwards into the Leichhardt basin. Drainage paths to the west are well defined through the Dromedary Ranges, however are poorly defined over the Leichhardt flood plain.

At the site location, these drainage paths are ephemeral.

3.3 Geology

The Mount Dromedary site lies within the Dobbyn [1] Geological Series (1:250 000 scale -1972, respectively). This map indicates that the site is underlain with Pre Cambrian Age metamorphic rocks including quartzite, schist, some granulite, gneiss and granofels, primarily of the Corella Formation. The Coolullah fault line extends along the site’s western extent, trending North-South.

3.4 Hydrogeology

Hydrogeological investigations at the site location have been undertaken by Rob Lait & Associates and are detailed in Mount Dromedary Graphite Project - Water Resource Investigations (August 2016) and Points of Clarification for DEHP (December 2016).

The hydrogeological investigation concluded that the site location is limited to the Proterozoic Corella Formation and Boomarra Horst, indicating that site areas are not hydrogeologically connected to the Great Artesian Basin. Falling head permeability tests, performed in the general proximity of the proposed pit location, indicate generally low hydraulic conductivity. An aquifer, comprised of fractured calc-silicates was present between 15m-25m in depth proximate to the proposed pit location. Low airlift yields from this aquifer indicates generally low connectivity and permeability.

Rob Lait & Associates (2016) also concluded that the Mt Dromedary Pit is likely to comprise a groundwater sink over the longer term.

4 PROPOSED SITE ELEMENTS DESIGN CRITERIA

4.1 Regulatory Environment and Basis

It is proposed that the site will operate in accordance with conditions outlined in the following relevant legislation:

- Environmental Protection Act 1994 (EP Act)
- Environmental Protection (Water) Policy 2009
- Water Act 2000
- Environmental Authority Mining Lease.

The Objective of the EP ACT is to protect Queensland’s environment while allowing for development that improves the total quality of life, both now and in the future in a way that
maintains the ecological processes on which life depends. The EP act outlines the general duty to take all reasonable and practical steps to avoid harm to the environment.

The purpose of the Environmental Protection (Water) Policy 2009 is to:

- Identify environmental values and management goals for Queensland waters.
- State water quality guidelines and water quality objectives to enhance or protect the environmental values.
- Provide a framework for making consistent, equitable and informed decisions about Queensland waters.
- Outline monitoring and reporting on the condition of Queensland waters.

The Water Act (2000) provided guidelines for failure impact assessment in addition to providing sustainable and integrated management procedures for the utilisation of water sources in QLD for the benefit of both present and future generations.

The Environmental Authority for a Mining Lease, issued by the Queensland Department of Environment and Heritage Protection, is a license to cause environmental harm with limitations.

4.2 Consequence Categories

The site water management features are subject to the assessment of a Consequence Category, as per the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (DEHP, 2016). It is envisaged that the assessment of consequence categories for site water management features will be performed as part of the detailed design phase. Notwithstanding, it is recognised that the water contained within the Mine Water Dam and Process Water Pond would likely result in these structures being regulated.

5 MINE WASTE DISPOSAL MANAGEMENT

5.1 General

An initial assessment was undertaken for mine waste management to optimise the proposed infrastructure in terms of the following parameters:

- Process Infrastructure
- Mine/Development economics
- Water use and recovery
- Area of disturbance
- Environmental impacts

Options considered included conventional tailings and waste rock dumps, dry stacking and thickened tailings disposal into an integrated landform.

The outcome of this assessment indicated that the current preferred methodology would be co-placement creating an Integrated Waste-Tailings Landform (IWTL). This methodology involves the placement of benign waste rock such that an open void space is created within for tailings storage.

This methodology was chosen for the following reasons:
• Preference to contain the acid producing material in one area
• There would be sufficient NAF material to encapsulate a single PAF cell
• Simplify water management (Single dirty water dam)
• Reduced Land Disturbance:
  o Reduced impact on wildlife habitat and agricultural uses
  o Reduced watershed disturbance
  o Reduced impact to local waterways
• Enhanced landform stability and erosion performance
• Closure related issues including:
  o Reduced closure area
  o Reduced surface water and groundwater impact to monitor
  o Reduced number of visual landforms
  o Reduced post-closure maintenance requirements.

5.2 IWTL Design Sizing

The IWTL will be developed as a single integrated structure to contain the following mine wastes:

- Thickened Tailings Waste
- Unprocessed Low Grade Ore (NAF Component)
- Waste Rock material (PAF and NAF)

It is noted that disposal of the PAF component of the Low Grade Ore will include stockpiling adjacent to the pit and in-pit stockpiling as development of the Mt Dromedary pit allows.

For the design of the IWTL, material densities have been estimated as follows:

- Assumed Densities
  o Thickened Tailings 1.6 t/m³
  o Low Grade Oxide Ores (NAF) 2.0 t/m³
  o Waste Rock Material 2.2 t/m³

Based upon the schedule presented in Section 2.1.2, and the densities above, a total disposal volume has been calculated of some 10.7 million cubic metres. Notwithstanding this, the total design volume adopted for the IWTL is some 12.5 million cubic metres- conservatively allowing a contingency.

5.3 IWTL Design Configuration

The proposed IWTL will have a crest elevation of RL 164.0 m AHD and an embankment slope of 3:1 (H:V). The layout and cross section of the IWTL is shown on Figures 002 and 004.

All PAF waste rock materials will be encapsulated within NAF materials. This will include at least a 1 m layer of well compacted low permeability basal zone at the base of the IWTL. The basal zone shall be graded to the MWD to intercept seepage/infiltration water and allow recovery from the MWD. The top of the IWTL will be sealed with a compacted low permeability layer of suitable NAF waste rock or other material.
Staged development of the IWTL throughout the life of mine of the project is expected to comprise a celled approach, allowing for progressive rehabilitation throughout the project development. Additional benefits of this approach include; reduced capital expenditure costs and a reduced footprint exposed to rainfall, minimising mine-impacted runoff. It is anticipated that design of IWTL staging will be performed in the detailed design phase.

6 SITE WATER MANAGEMENT

6.1 Description

Two water management facilities will be constructed to manage water needs for the mine site, a Raw Water Dam (RWD) and a Mine Water Dam (MWD).

It is envisaged that the RWD will contain water pumped from a pipeline that runs from Lake Julius to the Ernest Henry Mine Site. This pipeline crosses the Burke development highway approximately 60 km south of the mine site. Additional water could be collected from field production bores, subject to water quality.

The MWD will contain water pumped from the pit, mine impacted surface runoff, and seepage and surface water runoff from the IWTL.

Water required for the process plant will be first taken from the MWD and then make up water drawn from the RWD.

6.2 Design Assumptions

For the design of the site water management structures, the principle design assumptions for the concept are:

- Significant consequence category structure
  - Wet season containment (DSA) is 1:20 AEP
  - Spillway capacity requirement of 1:100 AEP to 1:1000 AEP
- Low consequence category structure
  - No DSA requirement
  - Spillway capacity requirement conservatively chosen as 1:1000 AEP
- RWD sized to contain water sufficient for supplying the process plant for a month.
- A pump back system will be utilized to send water to the process plant for both the RWD and the MWD.

Conceptual sizing of emergency spillway structures has been performed assuming all diversions fail. Flow depth was determined using the Broad Crested Weir equation. Rainfall data was adopted from the CRC Forge Intensity-Frequency-Duration program.

6.3 Raw Water Dam

A Raw Water Dam (RWD) will be constructed to the east of the IWTL, in an adjacent catcment. A layout and cross section of the RWD is shown on Figures 002 and 004. It is envisaged that the RWD will be comprised of zoned embankment with the following configuration:
- Embankment Crest Level: RL 134.0 m AHD
- Embankment Slopes: 2:1 (H:V), both upstream and downstream
- Embankment Crest Width: 8 m
- Embankment Footprint: 1.2 ha
- Spillway Invert (Full Supply) Level: RL 133.0 m AHD
- Emergency Spillway Width: 10.0m
- Storage Capacity: 280 ML
- Area at Full Supply: 11.1 ha

**Figure 2**
RWD Storage Curve

6.4 Mine Water Dam

A mine water dam (MWD) will be constructed directly downstream of the IWTL. It is envisaged that the MWD will be comprised of a zoned embankment with following configuration:

- Embankment Crest Level: RL 122.0 m AHD
- Embankment Slopes: 2:1 (H:V), both upstream and downstream
- Embankment Crest Width: 8 m
- Embankment Footprint: 1.3 ha
- Spillway Invert (Full Supply) Level: RL 121.0 m AHD
- Emergency Spillway Width: 15.0m
- Storage Capacity: 188 ML
- Area at Full Supply: 10.1 ha
A layout and cross section of the MWD is shown on Figures 002 and 004.

6.5 Diversion Drains and Bunds

Diversion drains and bunds will be constructed around the pit to limit surface runoff entering the pit and to divert clean water. The layout of the drain and bunds are shown on Figure 003 and typical sections are shown on Figure 004.

Diversion drains will also be constructed around the Low Grade Ore stockpile(s) to direct clean water around the stockpile.

7 MONITORING AND INSPECTIONS

The minimum suggested frequency of site surveillance and monitoring, broadly adopted from the Guidelines on Dam Safety Management (ANCOLD, 2003), if site water management dams are assessed to be “Significant” in the detailed design phase, is as follows:

Significant Consequence Dam

- Routine Visual inspection (by site personnel) to be performed on a weekly basis.
- Monitoring of rainfall, storage level and seepage to be performed on a monthly basis.
- Inspection by certified dam engineer to be performed on an annual basis.
8 OPERATIONS

The structures should be operated in the following manner:

- Minimise water stored in the MWD.
- Maximise reuse of water for the process plant.
- Maintain the diversion system.

9 CLOSURE / REHABILITATION

The final landforms will be subject to investigation works and detailed assessment in the years prior to closure and would typically include assessment of the water chemistry and the surrounding environment and consideration of infrastructure to remain post closure (subject to relevant agreements).

The typical objectives to be adopted for rehabilitation of the IWTL, RWD and MWD would be to create landforms that are:

- Stable and sustainable;
- Safe to humans and wildlife;
- Of minimum long-term environmental impact (i.e. non-polluting); and
- Able to sustain an appropriate land use after rehabilitation.
REFERENCES


