Mount Rawdon Operation

Progressive Rehabilitation & Closure Plan

Environmental Authority EPML00712113

ML100059, ML1192, ML1203, ML1204, ML1206, ML1210, ML1231, ML1259, ML50119.

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Report Roadmap

This Progressive Closure Rehabilitation Plan has been developed in accordance with the Queensland Government Department of Environment and Science Progressive Rehabilitation and Closure Plans (**PRCP**) Guideline (ESR /2019/4964) and the Queensland Government Department of Environment and Science Application Form for Submission of a Progressive Rehabilitation and Closure Plan (ESR/2019/4957).

This document has been structured to align with the requirements of Appendix 1 – PRC Plan Structure of the DES Application Form. Sections 1 to 7 form the 'Rehabilitation Planning Part' of the requirements and aims to support and justify the proposed PRCP Schedule. All the information provided in these sections are required under Section 125C (1)(j) of the EP Act. Section 8 of the report contains the PRCP schedule and required reports and plans.

Legislative Requirements

This section of the document provides an overview of overarching Commonwealth and State environmental legislation which has been considered in the preparation of this PRCP. Legislation applicable to the Project has been summarised below in Table 1.

Table 1 Legislative Requirements and Guidelines

Legislation	Overview
Mineral Resources Act 1989 (**MR Act**)	The *Mineral Resources Act 1989* (Qld) establishes and regulates the process of obtaining exploration and production permits in relation to coal and other minerals in Queensland. Under section 107 (10) of this act, a mining claim shall only be surrendered once improvement rehabilitation (i.e. the tenement is returned to substantially the same condition it was prior to mining) has been completed and the environmental authority (EA) has been surrendered.
Environmental Protection Act 1994 (**EP Act**)	The *Environmental Protection Act 1994* is the mechanism by which the Department of Environment and Science ensures that the general duty of environmental care is taken by all mines and mine personnel and by which proposed projects licencing and Environmentally Relevant Activities are determined and assessed.
Mineral and Energy Resources (Financial Provisioning) Act 2018 (**MERFP Act**)	The *Mineral and Energy Resources (Financial Provisioning) Act 2018* replaces the previous financial assurance regime requirements. The purpose of the MERFP is to decrease the risks to Government on the occasion that an EA holder neglects to meet their environmental and rehabilitation commitments. The MERFP Act also appoints the Queensland Treasury as the regulatory body responsible for managing this new financial provisioning scheme.

Progressive Rehabilitation and Closure Plans Guideline	The Progressive Rehabilitation and Closure Plans Guideline provides information for the applicants to develop a Progressive Rehabilitation and Closure Plan (PRCP) which will act as part of a site-specific EA application for new mining activities. When deciding on a PRCP schedule the administering authority must consider this guideline under section 176A of the EP Act.
Rehabilitation Requirements for Mining Resource Activities Guideline	The Rehabilitation Requirement for Mining Resource Activities Guideline was prepared to assist mining companies to plan rehabilitation outcomes and strategies that are acceptable. When deciding on a PRCP schedule the administering authority must consider this guideline under section 176A of the EP Act.
Environmental Protection and Biodiversity Conservation Act 1999 (**EPBC Act**)	The *Environmental Protection and Biodiversity Conservation Act 1999* is the Commonwealth's key piece of environmental legislation regulating Matters of National Environmental Significance (MNES), Commonwealth land, listed marine species and cetaceans, and international trade of wildlife. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places, defined by the EPBC Act as MNES.

Other Resources

Other resources have been referred to or have assisted with the development of this PRCP. These are listed below:

- Environmental Protection (Rehabilitation Reform) Amendment Regulation 2019
- International Council on Mining & Metals Mining with Principles, Key Performance Indicators: Tool for Closure
- Mined Land Rehabilitation Policy, Department of Environment and Heritage Protection, Queensland Government; and
- North Burnett Regional Council 2014 Planning Scheme.

1 Project Planning

1.1 Project Description

Mount Rawdon Operation (**the MRO area**) is a gold mine, owned and operated by Evolution Mining (Evolution). This Progressive Rehabilitation and Closure Plan (PRCP) is developed in accordance with Sections 126C and 126D of the *Environmental Protection Act 1994* and to meet the requirements specified in the Queensland Government's Progressive Rehabilitation and Closure Plans Guideline (DES, 2019).

Location

The Mount Rawdon gold deposit is located in South East Queensland, approximately 80km south-west of the city of Bundaberg, and 300km north-north-west of Brisbane (**Figure 1**). Access to the operational site from Gin Gin on the Bruce Highway is via a sealed road for 52 km south-west to the township of Mount Perry, and then south-east by gazetted road which is unsealed for most of the 18 km length.

The deposit lies beneath the southern side of a hill known as Mount Rawdon, located between Mingham Creek and the Perry River which drain to the Burnett River. The Mount Rawdon Operations (**MRO**) Mining Lease area occupies a total area of 2,015.12 ha (**MRO area**) and is located within the North Burnett Regional Council area.

MRO was commissioned in January 2001 by Equigold. A merger between Catalpa Resources and Conquest Mining in 2011 saw the emergence of Evolution Mining. MRO is an active open-pit gold mine that utilises conventional open-pit mining methods. The processing plant incorporates primary and secondary crushing, semi-autogenous grinding (SAG) and ball milling, followed by conventional cyanide leaching. The mill throughout is maintained at 3.5 million tonnes per annum of ore with a gold recovery of approximately 90%. The current mine life extends until 2026 and is subject to change depending on mining rates and external factors.

The operation is currently approved to operate under following permits and licences:

- Environmental Authority EPML00712113 (dated 1 November 2022)
- EPBC 2013/6886.

Copies of the above are provided in **Appendices**.



Figure 1: Location of MRO within the Northern Burnett Region

Mining Tenements

MRO is comprised of nine (9) mining leases that total approximately 2,015 ha. The mining tenure at Mount Rawdon overlies land parcels (Lot 3 BN37400 and Lot 2 SP138073), which are owned by Mt Rawdon Operations Pty Ltd (See **Table 2**). The approved mining lease also covers Calliope Cattle Station (Lot 38 BON559) which has a current operational landholder agreement in place.

The MRO and land tenure north of the Burnett River is on land which is the subject of the Port Curtis Coral Coast Native Title Claim. Land tenure south of the Burnett River covers land subject to the Wakka Wakka four (4) Native Title Claim. The current mining leases are defined in **Table 2** and **Figure 2**.

Table 2: MRO Mining leases

Mining Lease	Area (ha)	Cadastre	Activity
ML1206	41.88	Lot 3 BN37400	Open-pit, waste rock storage (North WRD)
ML1210	16.09	Lot 3 BN37400	Open-pit, waste rock storage (North WRD), roads, infrastructure (incl. mineral processing)
ML1259	593.63	Lot 3 BN37400; Lot 2 SP138073; Lot 38 BON559	Open-pit, waste rock storage (West, North and Possible Acid Forming WRD), tailings storage, water management, borrow pit/topsoil storage, roads, infrastructure (incl. magazine, explosives batch plant, offices, workshops, laydown areas, pipelines, powerlines, landfill, waste burning area, ERT training area)
ML1231	8	Lot 3 BN37400	Open-pit, waste rock storage (West WRD), water management, topsoil storage, roads, infrastructure (incl. mineral processing)
ML1203	0.4	Lot 3 BN37400	Open pit
ML1192	1.801	Lot 3 BN37400	Open pit
ML1204	2	Lot 3 BN37400	Open pit
ML50119	485.5	Lot 3 BN37400	Waste rock storage (North WRD), water management, topsoil storage, roads, infrastructure (incl. pipelines, powerlines)
M100059	865.819	Lot 3 BN37400; Lot 2 SP138073; Lot 38 BON559	Open-pit, waste rock storage (West WRD), tailings storage, water management, borrow pit/topsoil storage, roads, infrastructure (incl. laydown areas, pipelines, powerlines)

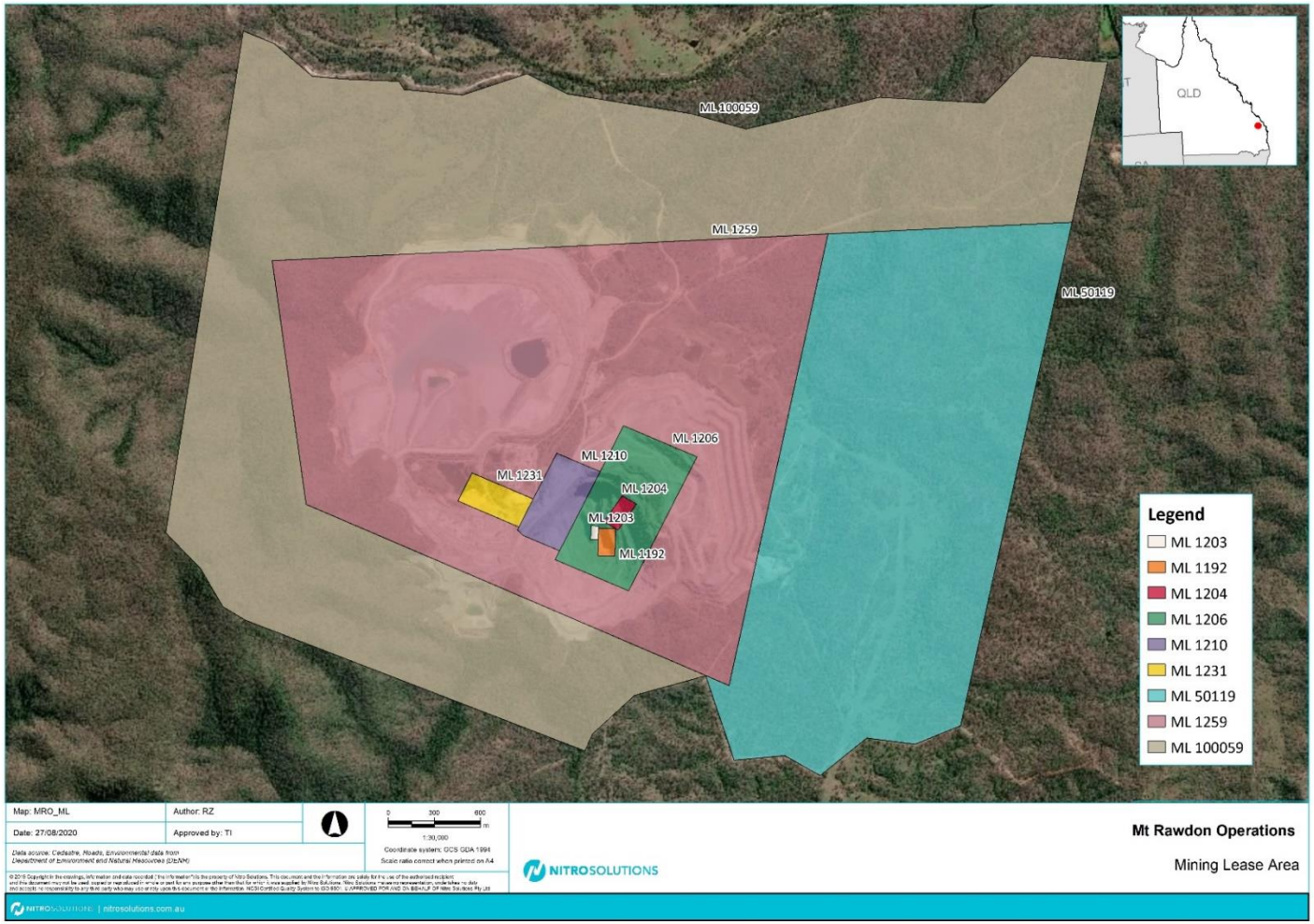


Figure 2: MRO Mining Lease

Mining Activities

The general layout of the MRO mining, processing and waste disposal activities within the mining leases is displayed in **Figure 3** below. The methodologies and process flows (relevant activities) undertaken at MRO can be seen in **Figure 4** below.

Mining Methods

The mining at MRO involves the extraction from a single open-cut pit using conventional drill and blast/load and haul methodologies are employed across 10 – 15 m benches with a remaining life of mine strip ratio of 2:1.

Ore Processing

Mt Rawdon processes ore through the processing plant which consists of a primary and secondary crushing, semi-autogenous grinding (SAG) and ball milling, followed by conventional cyanidation leaching. Gold feed is recovered through a gravity circuit before the flotation circuit.

Crushing

Run of mine ore is direct dumped or dumped via loader into a primary gyratory crusher. Approximately 70% of this material is passed through a secondary crusher then conveyed to an open conical stockpile.

Milling

Ore is drawn from the bottom of the stockpile by vibratory feeders onto the mill feed conveyor. This feeds a conventional SAG mill/pebble crusher/ball mill circuit with hydro-cyclones classifying the final product. Two (2) Knelson (centrifugal) concentrators are used in conjunction within the grinding circuit to remove coarse gold. The second Knelson concentrator and a 'Consep Acacia' leach reactor were introduced to decrease the reliance on retrieving gold from the cyanide leaching process.

Leaching

The slurry produced from the grinding circuit is passed through six (6) leach tanks which are each equipped with mechanical agitators and intertank screens. Activated carbon is used to adsorb leached gold and silver from the slurry and is moved counter current to the slurry flow until reaching the front of the leaching circuit.

Gold Recovery

Carbon is periodically removed from the leaching circuit and treated in an AARL stripping circuit to remove the adsorbed gold and silver. Electrowinning is used to recover precious metals from strip solution prior to smelting into bars.

Other Facilities

Discharged slurry is pumped to a tailings storage facility which undergoes treatment to recover water is used to supplement the processing plant, along with raw water.

The major reagents used in the gold processing plant include lime, sodium cyanide, steel balls, caustic soda, hydrochloric acid, activated carbon, liquid oxygen and LPG.

Dewatering

Dewatering of the site infrastructure and rehabilitation area features occurs when required. Pit dewatering usually occurs following significant rain events and is generally pumped to West or South Dams. Several pump back bores, interception drains and pump back wells have been installed to assist in dewatering across the site and this is discussed further in **Section 5.1**.

Waste Rock Disposal

As part of the excavation process, all waste material is classified into acid generating categories (non, medium and high). High waste material is placed into the internal structures of the TSF, medium is encapsulated in the North Waste Rock Dump and non-acid forming material is placed in the West Waste Rock Dump or used to construct the Tailings Storage Facility (TSF) buttress embankment. Both dumps have water runoff, seepage and infiltration management systems that are discussed later in **Sections 5.1**.

Mineralised Waste/Low Grade Ore

Ore stockpiling has been implemented at MRO for future processing. Sub-grade (0.2g/t-0.3g/t), Low Grade (0.3g/t-0.5g/t), and "Steel Load" stockpiles have been established on the northern waste rock dump and will be either processed or remain in situ and rehabilitated.

The stockpiling strategy enables better control of blending of rock type and grade control for the processing plant.

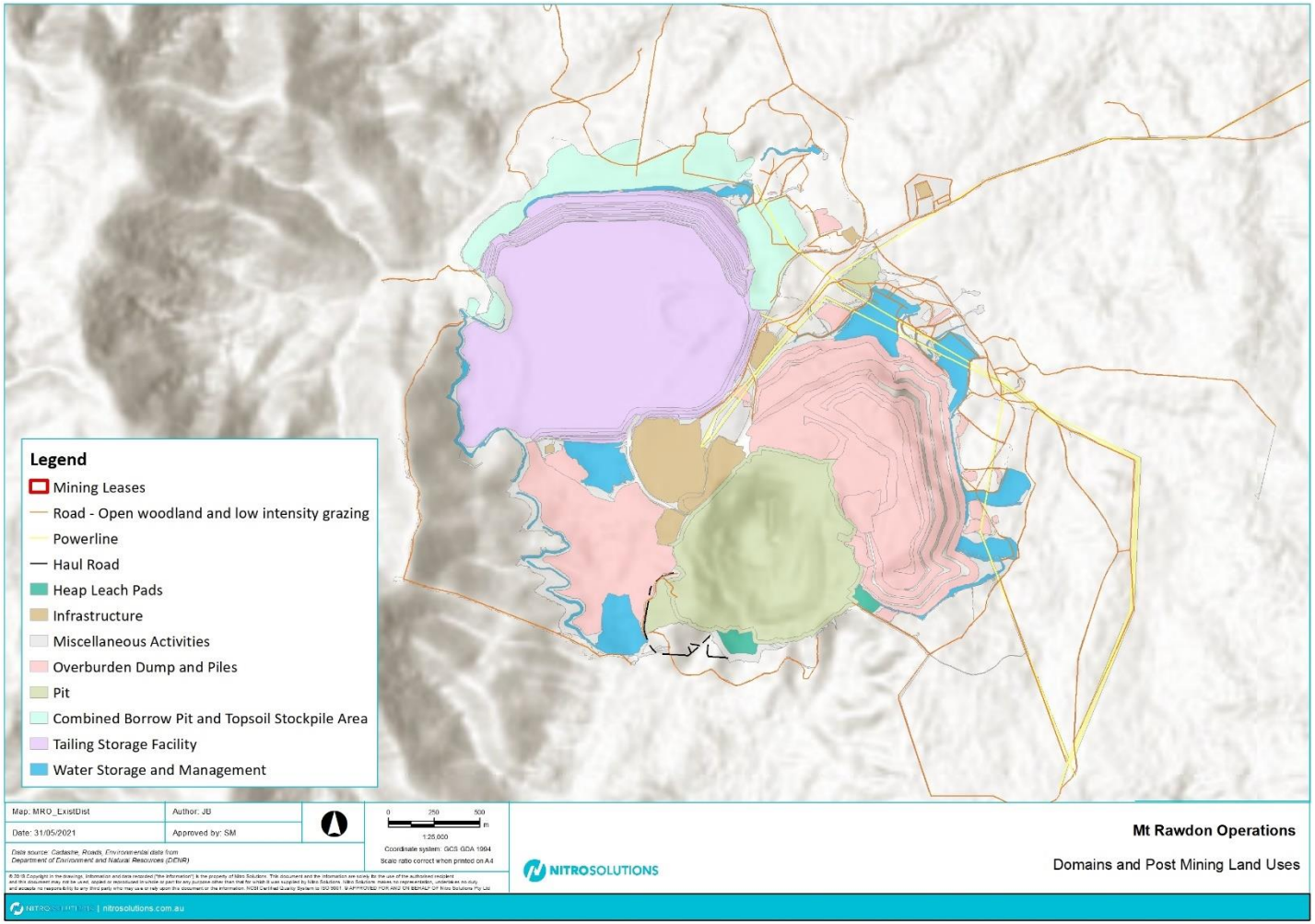


Figure 3: General Layout of MRO Mining Features and Infrastructure

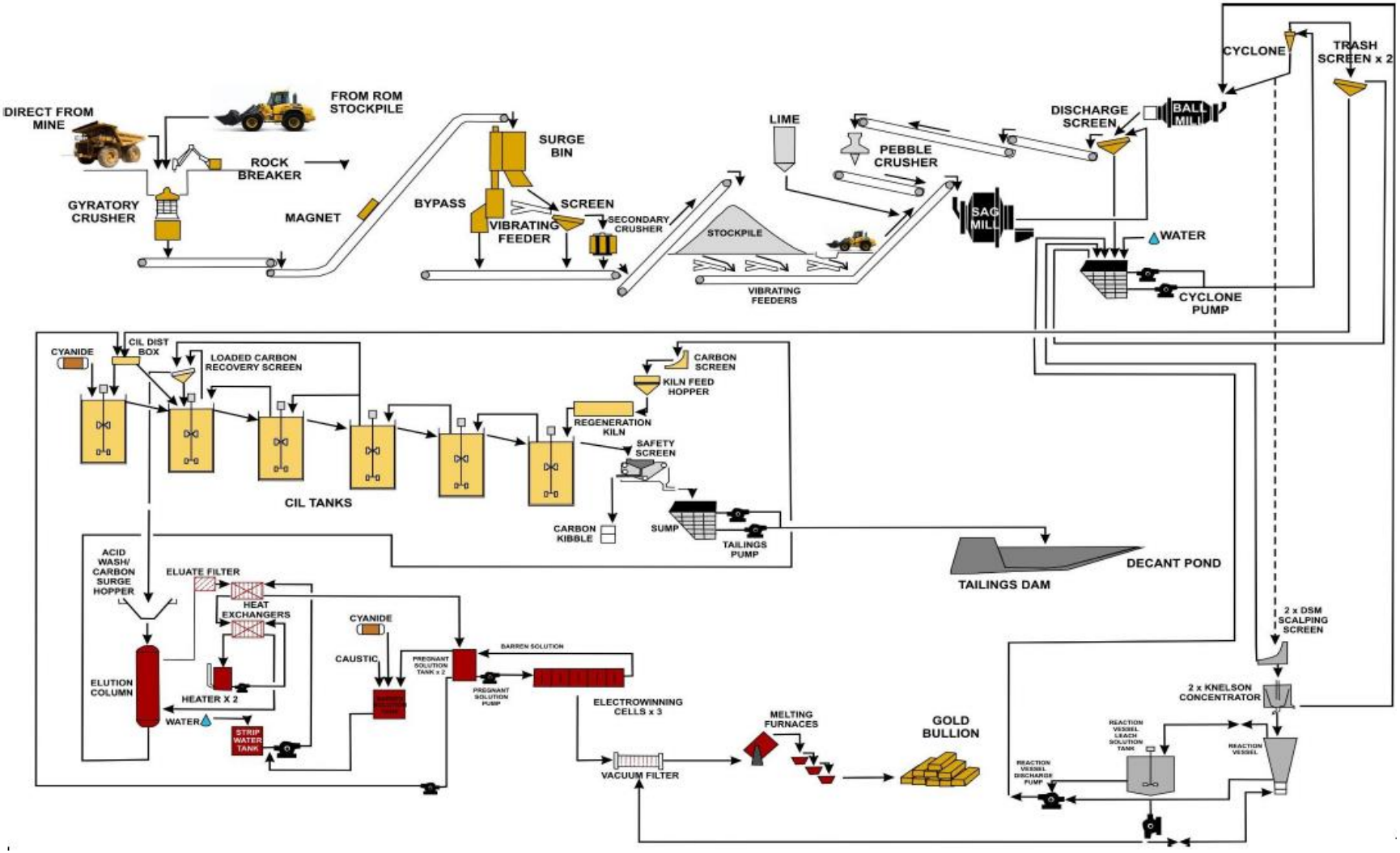


Figure 4: General Processes of Mining at MRO

1.2 Baseline Information

Regional Site Topography

MRO is situated within a regional land resources survey area undertaken by the then Queensland Department of Primary Industries, now the Department of Resources. The MRO area falls into the Aranbanga Unit of the regional land system classification. The landform consists of rolling hills to steep hills. **Figure 5** provides a regional topography map.

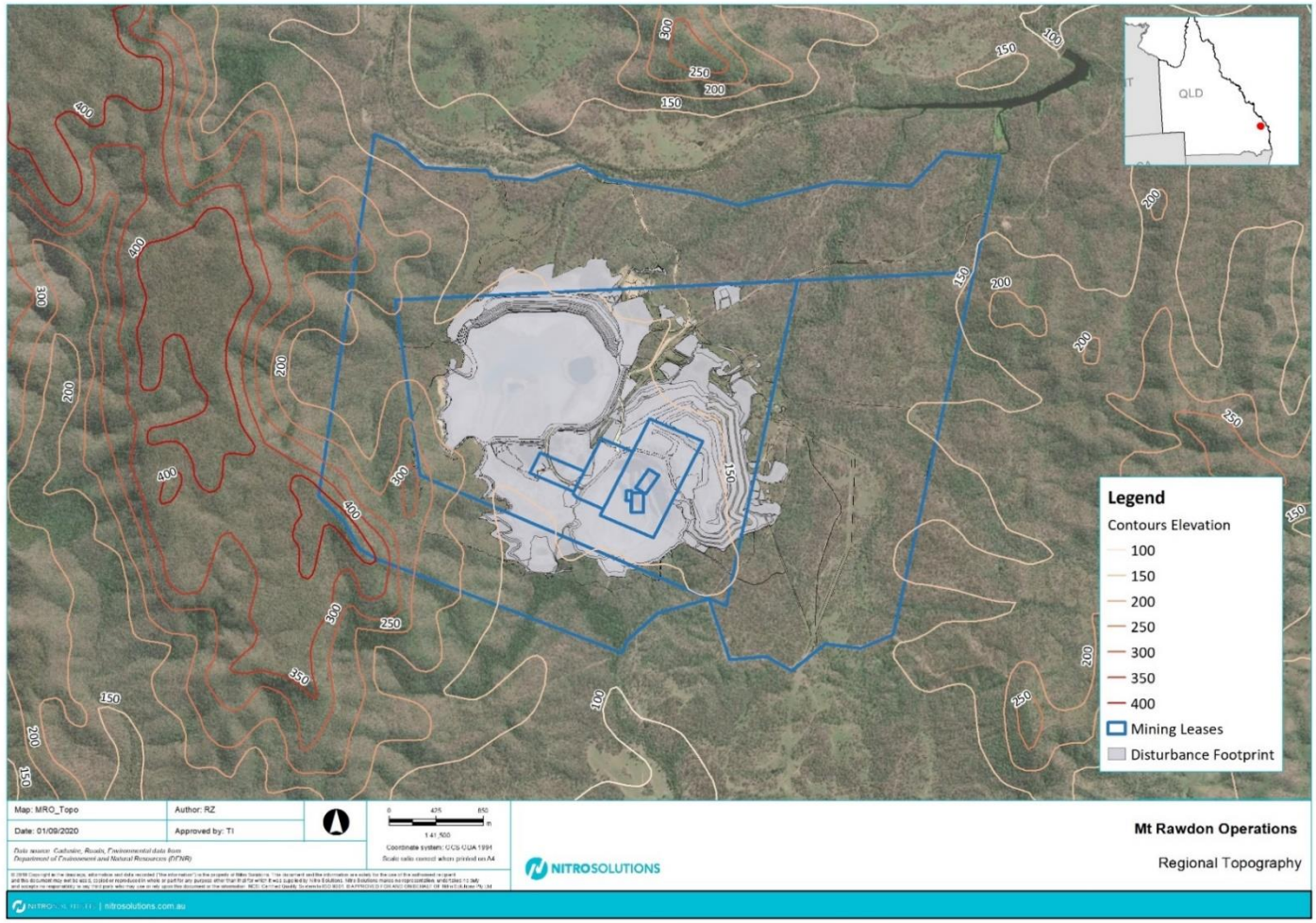


Figure 5: MRO and Regional Topography

Local Site Topography

The mineral deposit is located beneath Mount Rawdon hill. Weathering has resulted in down-cutting of the surrounding softer materials to gently undulating hills, and alluvial flats have formed by deposition along watercourses. The topography at the site falls away steeply from an elevation of 256 m Australian Height Datum (**AHD**) at the top of Mount Rawdon to undulating hills of about 150 m AHD elevation at its base. The land then slopes gently over three (3) km to alluvial flats along the Perry River where the elevation is approximately 120 m AHD. The drainage direction is predominantly to the north and east. Ephemeral creeks drain the deposit area north into the Perry River, and subsequently into the Burnett River. There is no natural permanent standing water in creeks, although several water holes occur along the Perry River which may contain small amounts of water year-round. Perry River Dam, which was constructed to supply raw water to MRO, contains permanent standing water.

Climate

Mount Rawdon is located within the subtropical region of Queensland, characterised by hot summers and mild winters. The region can experience droughts, floods, heatwaves and frosts. Rainfall in this area typically presents as short, intense rainfall events that occur primarily in the wet season, from November to April. Climatic data has been sourced from the Bureau of Meteorology (**BoM**) weather station Gayndah (BoM station number 95443) from May 1887 to August 2020. Data from this station has been used to characterise the climate in the region, as this weather station is the closest to MRO, approximately 20 km north-west of the mining tenement. The data from Gayndah (2020) is used predominantly in this plan as it is the second closest station to MRO and has over 100 years of data.

Temperature

Maximum average temperatures are approximately 32°C during the summer months (December to February) and 21°C during the winter months (June to August). Minimum average temperatures are approximately 20°C during summer and 6°C during winter. A mean daily minimum and maximum temperature graph for the area is shown in **Table 3**: Gayndah Mean Maximum and Minimum Monthly Temperature and **Figure 6**.

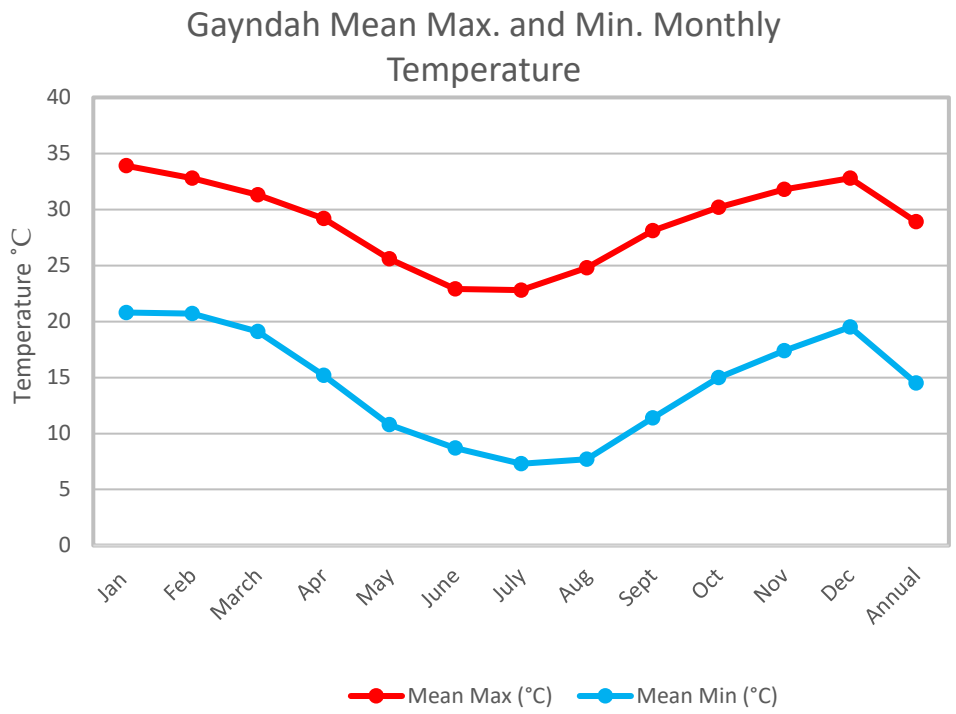


Figure 6: Gayndah Mean Maximum and Minimum Monthly Temperature (BOM, 2020)

Parameter	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean Max (°C)	33.9	32.8	31.3	29.2	25.6	22.9	22.8	24.8	28.1	30.2	31.8	32.8	28.9
Mean Min (°C)	20.8	20.7	19.1	15.2	10.8	8.7	7.3	7.7	11.4	15	17.4	19.5	14.5

Table 3: Gayndah Mean Maximum and Minimum Monthly Temperature

Rainfall

Rainfall averages were reviewed from the Gayndah weather station for a total period of 127 years (1893 to 2019). Annual rainfall is highly variable with a maximum 2,207.2 mm in 1893 and minimum rainfall of 397.4 mm in 1902. The mean annual rainfall is 593.2 mm. Rainfall is not evenly distributed throughout the year, with most (approximately 70%) of the rain falling in the wet season from November to April. **Table 4** and **Figure 7** provide a visual representation of average and highest recorded rainfall.

For the first eight (8) years of operations at MRO, the annual rainfall total was below average as the area experienced a significant and prolonged drought. The next eight (8) years of operation have been significantly wetter, with significant and widespread flooding in the region on two (2) occasions (2010/11 and 2013). Impacts of climate change are resulting in increased variability of predicted weather patterns and these impacts are considered throughout this document in terms of impacts to rehabilitation. Further detail for considerations can be found in **Section 3.1**.

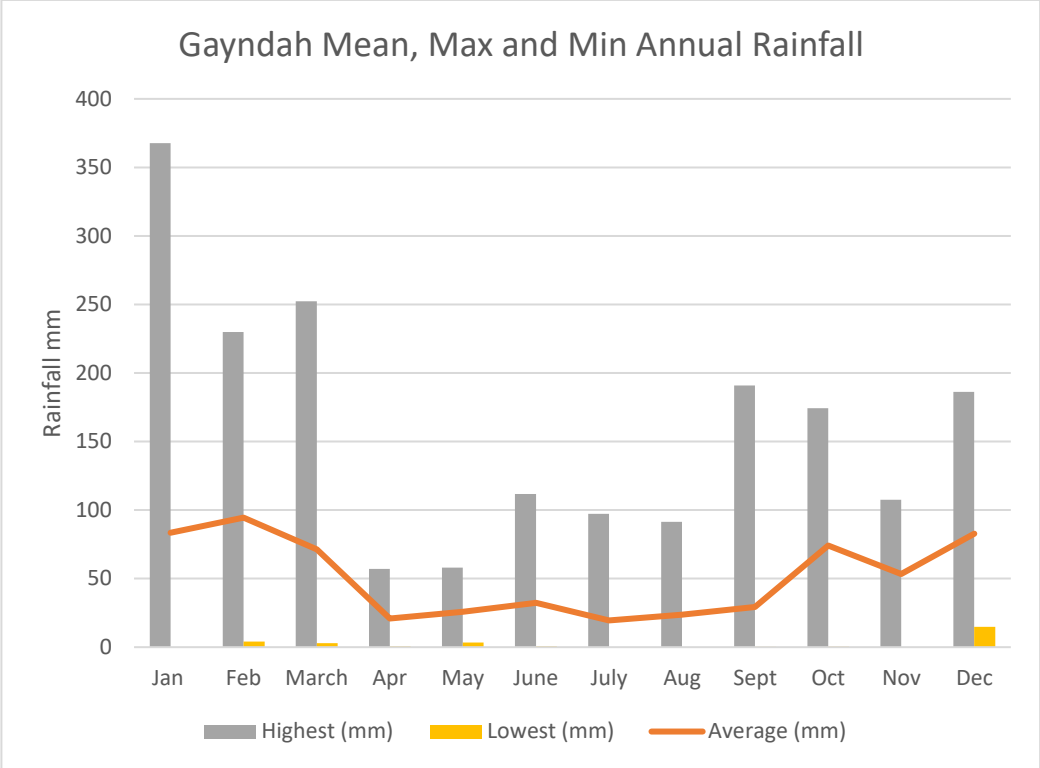


Figure 7: Gayndah Mean, Maximum and Minimum Recorded Rainfall (BoM, 2020)

Table 4: Gayndah Mean, Maximum and Minimum Recorded Rainfall (BoM, 2020)

Parameter	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Average (mm)	83.4	94.5	71.3	21	25.7	32.3	19.5	23.6	29.3	74.1	53.4	82.8	593.2
Highest (mm)	367.6	230	252.4	57.2	58	111.8	97.2	91.4	191	174.4	107.6	186.2	910.6
Lowest (mm)	0	4	2.8	0.6	3.4	0.6	0	0	0.2	0.4	0	14.8	294.4

It is important to note that the maximum yearly rainfall is more than double the average yearly rainfall, indicating that extreme isolated events occur in some years. These events are likely the product of depressions, cyclonic events, or other extreme meteorological conditions. Rainfall also varies spatially across the local region.

Annual pan evaporation has been sourced from Brian Pastures station (BoM station 040428), approximately 44 km south from MRO. Average annual evaporation is 2,035.4 mm, with significantly higher evaporation during the hotter summer months. This has been used to estimate evaporation losses from water storages.

Long-Range Climate Predictions

Short term climate predictions indicate an increased variability of impacts across the region that fluctuate according to season. The longer-term predictions for climate variability within the Wide Bay-Burnett Region leading up to 2030 (and beyond) include higher temperatures (0.6°C to 1.3°C above 1896 – 2005), reduced rainfall, increased frequency of hotter days, and fewer frosts (DES, 2019). These projections have been modelled from the Commonwealth Scientific and Industrial (CSIRO) and the BoM data based on 'high emission' scenarios.

Geological Setting

Regional Geology

MRO is located on the Maryborough 1:250,000 sheet as part of the Aranbanga Volcanic Group (**AVG**), which unconformably overlies rocks of the Curtis Island Group (CIG) and is intruded by Permo-Triassic granitoids. The AVG previously referred to as the Aranbanga Beds, lie within the Coastal Block, one of three (3) major stratigraphic blocks recognised in the region. These blocks trend eastward from the Carboniferous Coastal Block to the Late Carboniferous Goodnight Block and the Permian Gympie Block.

Local Geology

The primary geological feature in MRO is the extinct core of a shield volcano flanked by the Aranbanga Andesites to the west and silicified Curtis Island Metasediments to the east. The volcano's central core is an intensively fractured, collapse structure of dacite and dacite-rich volcaniclastics (Mine Sequence Volcanics) formed during the late Triassic (235 – 215 Ma) involving phases of tectonic reactivation, and intrusion of magmas through reactivated fractures that formed dacitic, rhyolitic and quartz-feldspar-biotite-porphyry (QFBP) dykes and sills. Trachyandesite and andesite dykes formed during the last phase of brittle fracturing.

- The Mine Sequence Volcanics - a complex of rhyolitic, volcaniclastics and dacite rock units. This formed the original mountain, which has subsequently been mined and is now an open pit mine;
- The Aranbanga Andesites - andesitic lavas, dacitic lavas and volcaniclastics. On the western flank of the TSF the volcaniclastics have been silicified;
- The Curtis Island Metasediments – silicified sedimentary rock that can feature relict bedding planes. The Curtis Island Metasediments occur on the eastern part of the MRO area, and cover the largest area of the MRO area; and
- Trachyte and granodiorite intrusives that penetrate the Curtis Island Metasediments.

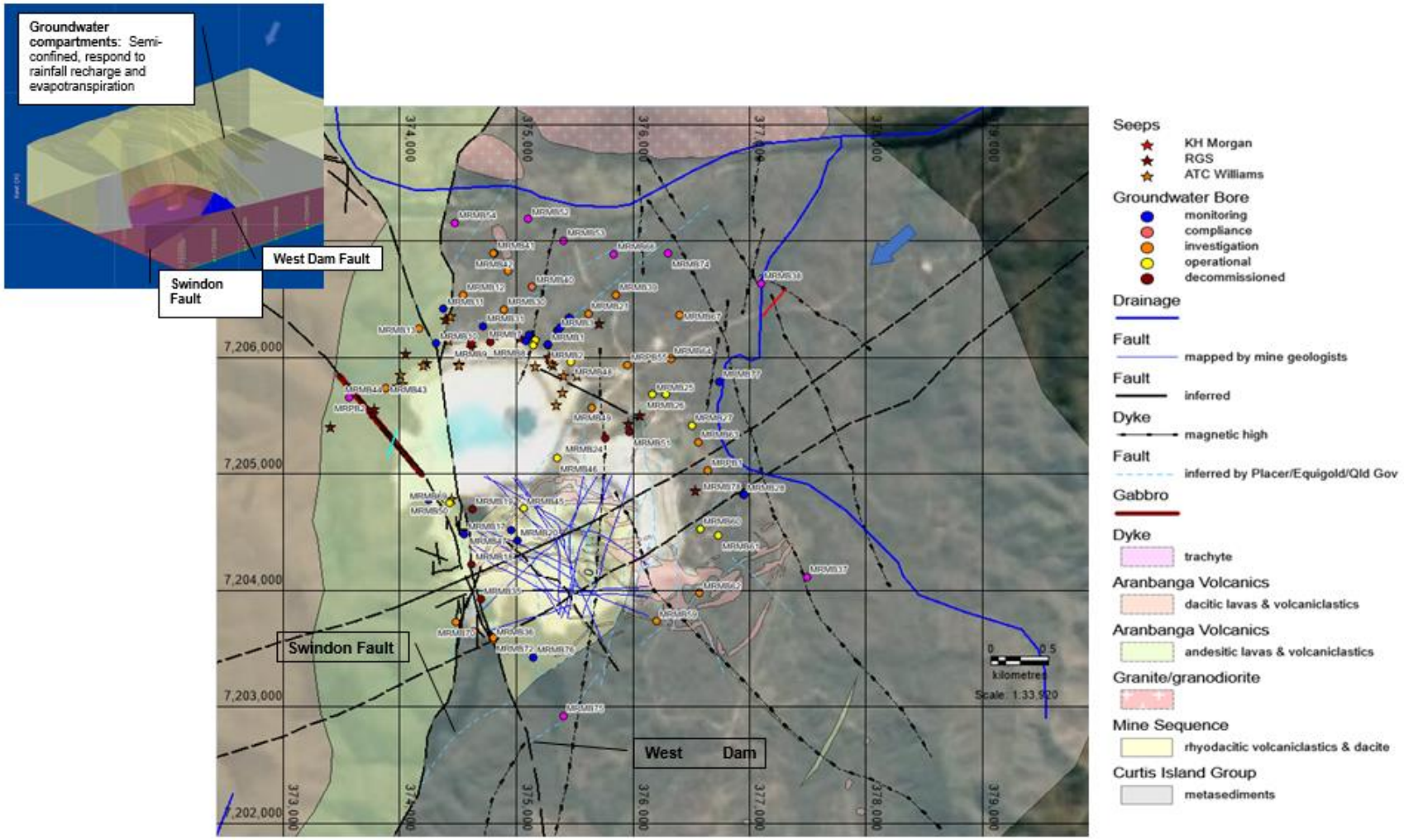


Figure 8: Geological Map

The major faults in the mine lease are:

- North-South structures subparallel to the regional scale Mount Perry Fault that reactivated early basement faults. The North-South set have moisture, but the fault is filled with gouge material and secondary minerals that impede water flows;
- East-North-East structures (Biggenden Set) have moisture and are important for water transfer because adjacent water types (granites and metasediment) with different permeabilities are juxtaposed that may affect the groundwater flow direction, and
- Late brittle faults through which the andesite intruded. The andesite dykes provide hydrogeological barriers, although there may be minor groundwater transmission parallel to the dykes through mm-wide crush zones that are occasionally observed at contacts between the dykes and country rock.

There are also water conducting joints observed in the pit (associated with the Mine Sequence Volcanics). Before mining they were water saturated and became drained when mining opened connections with the pit. Below 90 m RL in the pit there are fewer open joints. The joints respond to intermittent heavy rainfall events, but flow lasts only a few days.

The fault structures play a key role in hydrogeological interactions and the compartmentalisation of groundwater in the fractured rock aquifer.

Gold associated with pyrite is being mined. The insert in **Figure 8** provides a below-ground view of the mine lease (the blue arrow provides a reference point to the geological map), which shows the fault contacts between the Aranbanga Volcanics and the Curtis Island Metasediments (West Dam Fault), as well as between the Curtis Island Metasediments and the Mine Sequence Volcanics (Swindon Fault). The West Dam Fault is a North-South structure below West Dam and the TSF, which is filled with gouge material and secondary minerals and as such is impermeable to groundwater flow. The insert also shows the presence of fault structures within the Curtis Island Metasediments that contribute to groundwater compartmentalisation.

Evidence of the oxidation of pyrite (which weather to iron oxides) associated with water conducting joints that have been opened by mining can be seen along the pit wall (**Figure 9**). Further information is provided in **Section 5.5.**



Figure 9: Evidence of Pyrite Weathering to Brown Iron Oxide Along the Pit's North-Western Wall.

Hydrology and Fluvial Networks

Regional Hydrology

MRO is situated in the Lower Burnett sub-catchment of the Burnett Basin catchment as shown in **Figure 10.** The Burnett catchment is the third largest river basin on the east coast of Queensland, with a catchment area of approximately 34,500 km^2. The lower Burnett sub-catchment comprises an area of 3,874.9 km^2 which comprises of 5.9% of the Burnett Catchment. Surface runoff from MRO drains into the Burnett River towards the south of the site and into the Perry River towards the north of the site.

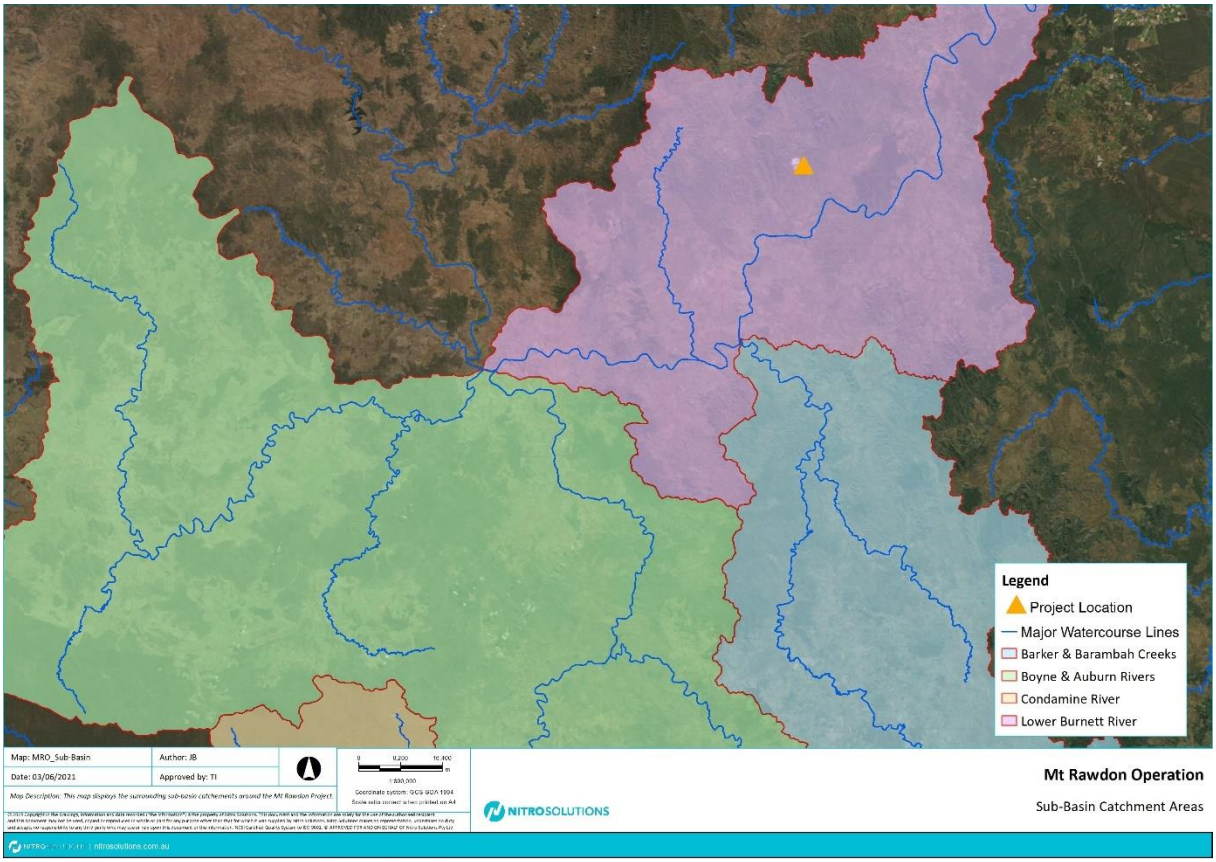


Figure 10: MRO Location to Burnett River Catchment

The Perry River is a tributary of the Burnett River and joins the Burnett River near Morganville, approximately 35km downstream from the site. The catchment area of Perry River at MRO is approximately 156 km^2.

The Burnett River flows from the Burnett Range to the mouth at Burnett Heads, a total of 420 km. The identified main tributaries of the Burnett River are the northern tributary (Three Moon Creek), the north-western tributary (Nogo River), the south-western tributary (Auburn River), the southern tributaries (Boyne and Stuart Rivers), the south-eastern tributaries (Barker and Barambah Creeks) and the eastern tributary (Perry River).

The mineral deposit lies on a catchment divide with the drainage direction predominantly to the north/east. Ephemeral creeks drain the deposit area north into the Perry River and subsequently into the Burnett River. There are no areas of permanent standing water in the ephemeral creeks. Runoff in creeks is usually of short duration and has high concentrations of suspended sediment, related to the flow intensity and disturbance of catchments by clearing of land for grazing.

Baseline and background water quality of the Perry River was reviewed by Placer Pacific Limited in 1996 and Equigold in 2001. Reports showed that the water quality is considered to be high and containing only very low concentrations of dissolved constituents, with high suspended sediment concentrations during flow events.

Site Drainage

The primary source of surface water on the site is the runoff caused after a rainfall event. Runoff flow paths are as follows:

- Northward surface runoff flows via Rawdon Creek and Twelve Mile Creek into the Perry River, which joins the Burnett River near Morganville 35 km downstream from MRO.

- Southward surface runoff flows into Mingham Creek via unnamed tributaries, into the Burnett River 8 km further south of MRO.

Runoff from MRO occurs rapidly and surface flow is sustained in creeks for several days following rainfall. These creeks are primarily ephemeral and have no areas of standing water. Water in the Perry River is limited to a series of low volume waterholes for a predominant portion of the year.

Designated creeks in mine-affected parts of the lease are:

- Swindon Creek;
- Rawdon Creek;
- Twelve Mile Creek; and
- Mingham Creek.

A network of drainage lines at the site feed these creeks after rainfall. Some drainage lines coincide with inferred fault structures that may provide groundwater flow-paths, this is discussed further in **Section 5**.

Surface runoff sheds rapidly as stormwater, and the ephemeral creeks flow for a few days after rainfall events with standing water remaining in a few isolated, low volume waterholes. These waterholes recharge annually in response to wet season rainfall.

Runoff from MRO can dissolve contaminants while it seeps through the various ore and waste storage landforms on-site or comes in contact with the exposed mineralised zones in the open pit. To prevent contamination of the receiving environments, such mine-affected stormwater is stored in containment structures constructed at MRO. These containment structures include the tailings storage facility (TSF) and seepage interception dams (**Figure 11**).

Existing water uses in the local region (not within the MRO lease) are restricted to livestock and fauna watering from earth dams and the limited waterholes along creeks. Further downstream on the Perry and Burnett Rivers, water is used for irrigation by numerous landholders. **Figure 12** provides a map of identified downstream residences that may utilise the Perry River for irrigation purposes.

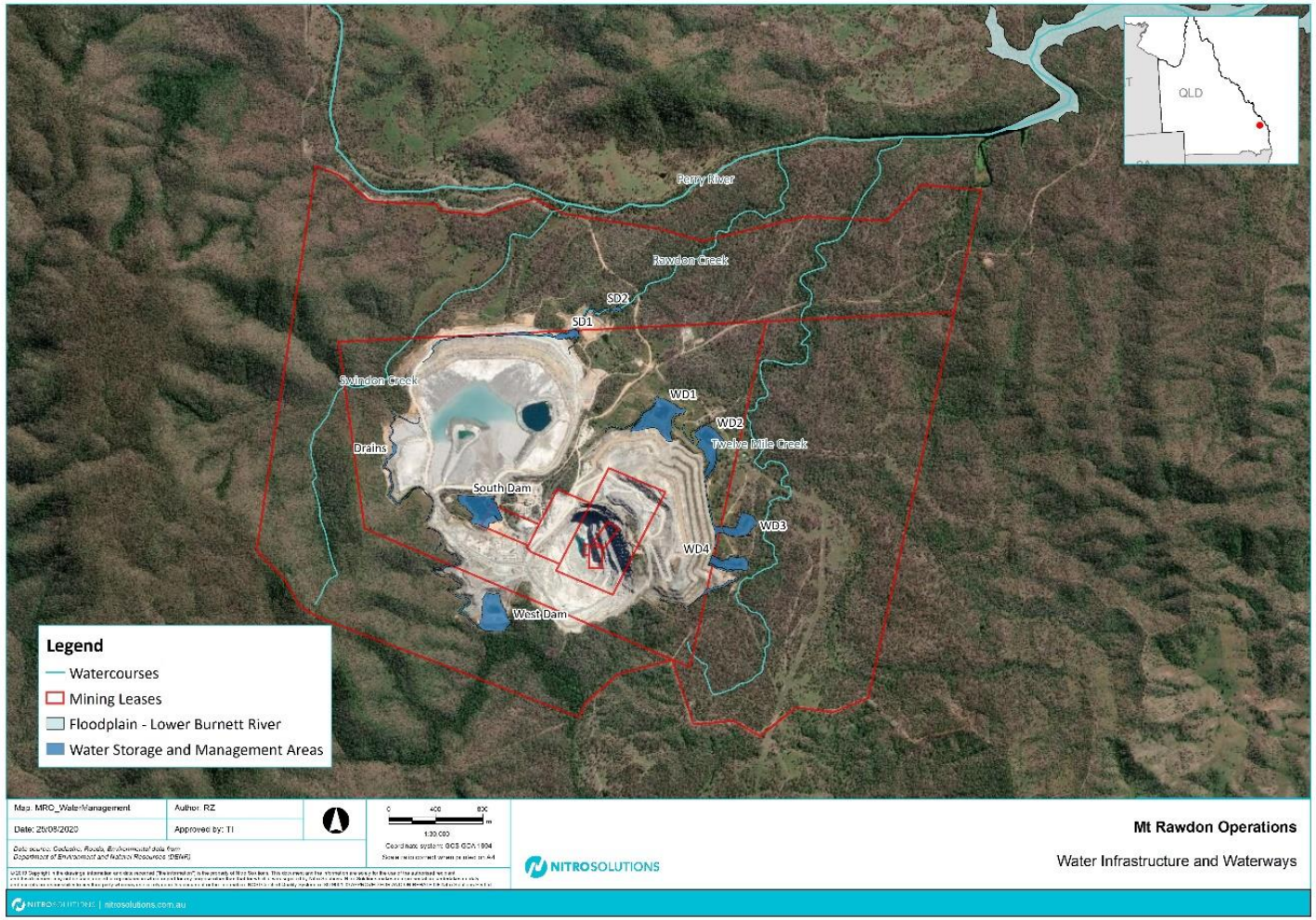


Figure 11: MRO Water Infrastructure and Waterways

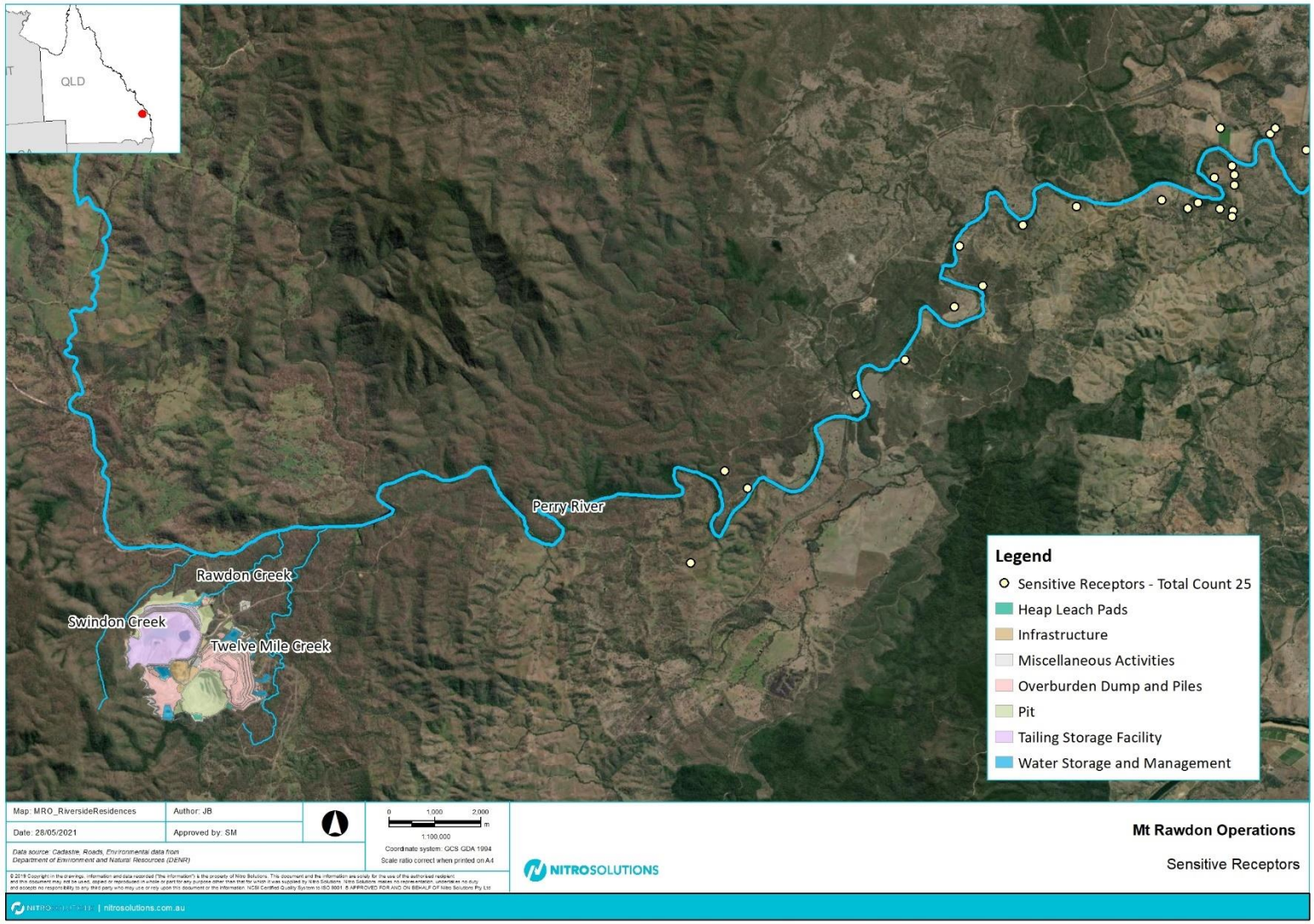


Figure 12 Downstream Riverside Residence Locations

Hydrogeology

Hydrogeology Groundwater Occurrence

At the MRO scale, groundwater is hosted in fractured rock that has been subjected to varying depths of weathering, with aquifer permeability being a function of the hydraulic conductivities of rock matrices (with weathered, foliated rock being more permeable than unweathered volcanic rock) as well as the density, aperture and connectivity of open fractures and joints within the rock mass. Three (3) types of groundwater storage have been identified in the MRO area:

1. Small pockets of alluvium in stream beds in the lower parts of the mine lease, below the hinge line of the spur-valley topographic profile. These pockets typically dry out each dry season;
2. Isolated deep pockets of soil, weathered rock (saprolite) and oxidation transition zones. Groundwater storage is subject to drainage after rainfall events on elevated sloping land. These storages typically become depleted in the dry season; and
3. Rock fractures with low storage capacity that recharge rapidly from rainfall, but also exhibit large water-level declines from evapotranspiration and downslope drainage. Due to limited volume, these structures are potentially fast response and may show a greater change in the hydraulic head than water stored in saprolite.

The depth to groundwater is shown in **Figure 13**.

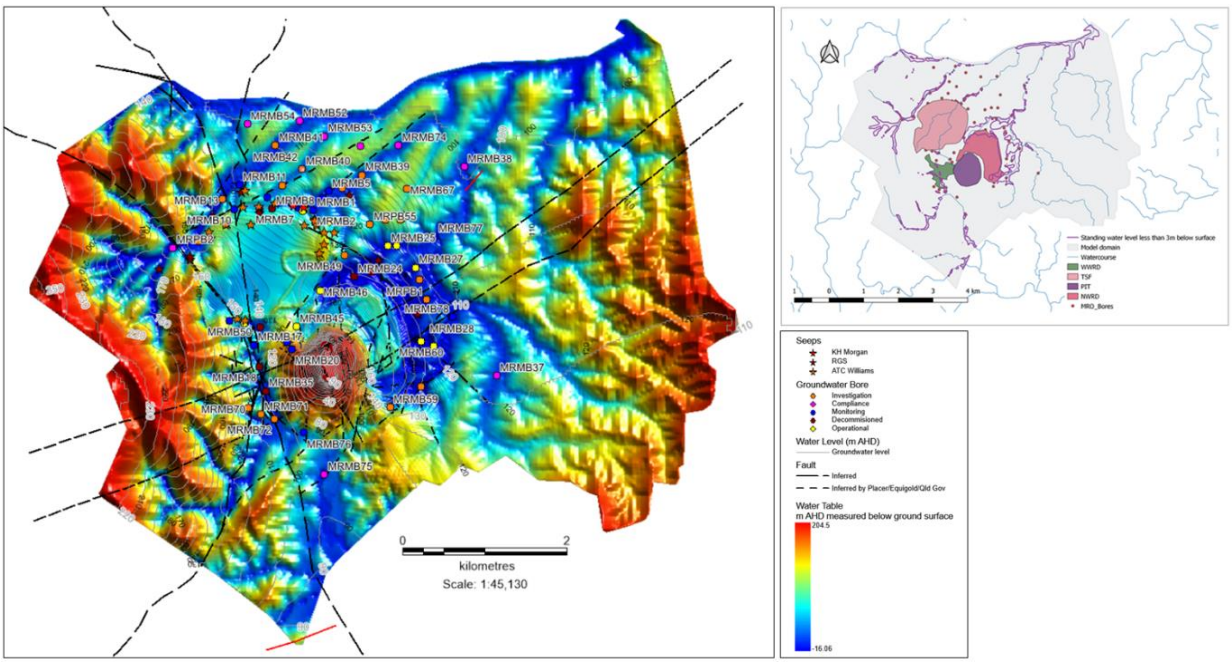


Figure 13: Groundwater Depths

The aquifer permeability at MRO ranges from impervious to semi-pervious rock (Saturated hydraulic conductivities of 4.2E-3 to 5.5E-1 m/d, Transmissivities of 1.2E-2 to 8.4E+0 m2/d). In parts of the MRO area, the aquifers are compartmentalized (**Figure 13**)being recharged by rainfall and dewatered by evapotranspiration. Groundwater may be stored in weakly connected pockets in deep fracture zones that extend beyond 80 m deep.

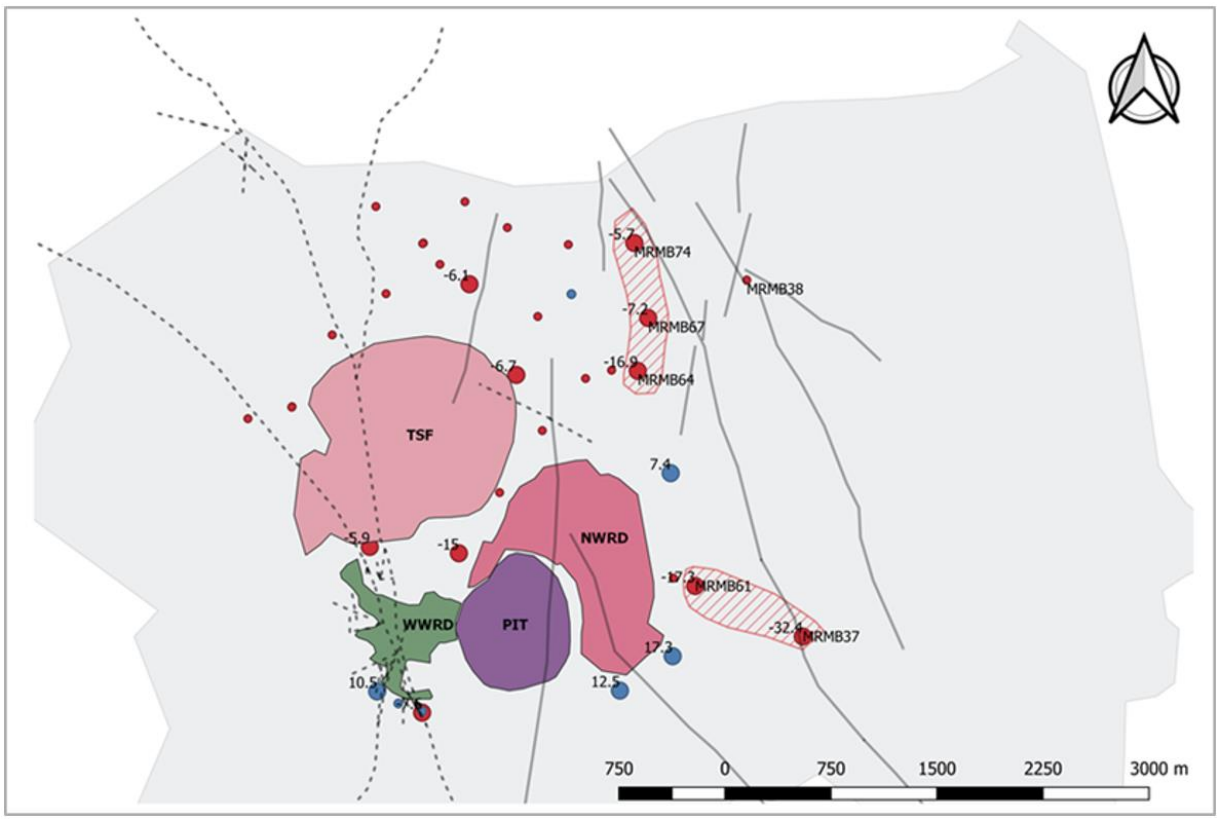


Figure 14: Zones of Compartmentalised Groundwater in the MRO area

Groundwater flow paths at MRO based on the model developed by NRC (2019) are shown in **Figure 16**. The model shows that topographic highs, which include landscape spurs as well as the NWRD and the TSF, are locations of groundwater recharge with groundwater moving downslope and exfiltrating on lower slopes or in creek lines. Intermittent groundwater seeps on lower slopes following high rainfall events have been identified in steep terrain (**Figure 16**). The seeps occur naturally in response to seasonal groundwater following rainfall events when groundwater recharge on upper slopes reports further downslope (**Figure 15**). The model identifies that a fault seal impedes groundwater flow from the TSF into the pit.

It is also noted that there is limited or non-existent connectivity between some groundwater compartments (**Figure 14**), The saprolite and the fractured rock have variable hydraulic conductivities in different parts of the mine lease (the calibrated model parameters assumed different hydraulic conductivities for soil/subsoil of landscape spurs, soil/subsoil of valleys, creek-beds, weathered rock, fractured rock and basement rock. The median hydraulic conductivity measured in saprolite is 3.15E-1 m./d., and in fractured rock is 4.36E-2 m./d. (NRC,2019).

Figure 16 is an excerpt from the MRO Environmental Evaluation and provides a visual depiction of the conceptual groundwater flow paths.

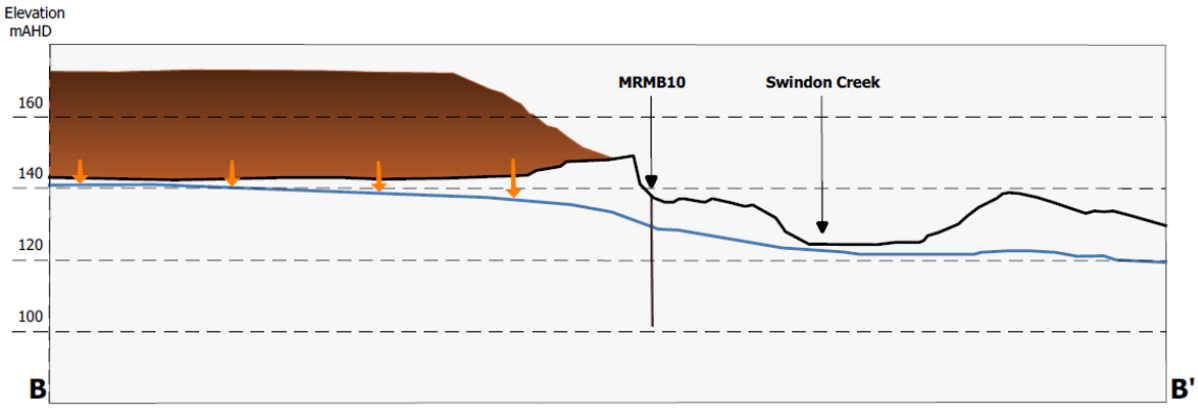


Figure 15: Steady-State Groundwater Model Outputs

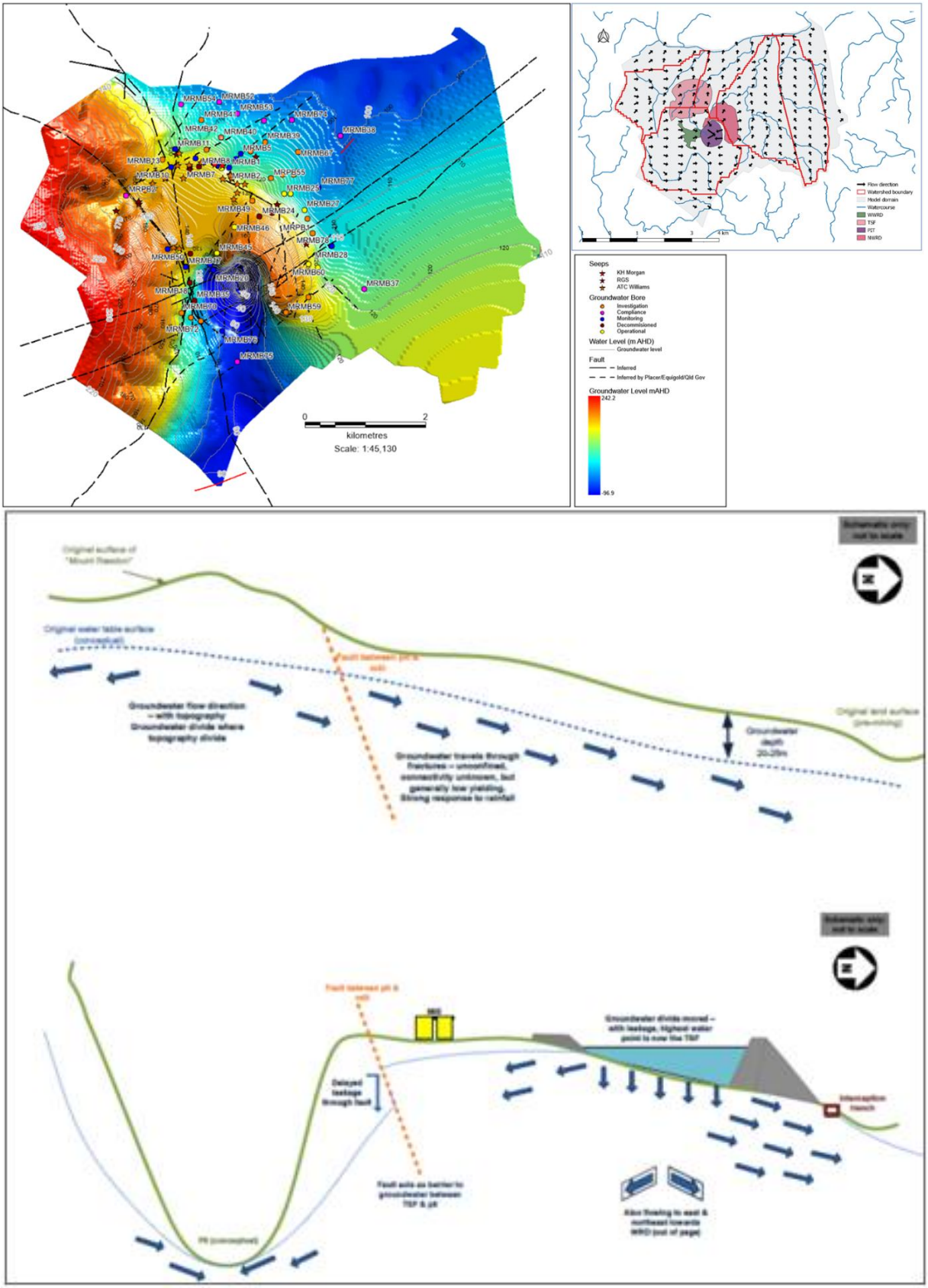


Figure 16: Conceptual Model of Groundwater Flow Paths

Groundwater Quality and Mine Influence

Groundwater is monitored using the established compliance monitoring network outlined in the EA. There are 27 locations for groundwater monitoring along flow-paths from the TSF and 9 monitoring bores for compliance monitoring, totalling 36 monitoring bores (**Figure 17**).

An Environmental Evaluation (**EE**) is a compliance tool under the EP Act that was conducted to better understand the hydrogeological influences on groundwater quality in the aim to condition appropriate compliance trigger limits within the EA. The EE provided three (3) reports on groundwater quality (MRO 2019, MRO 2020a, MRO 2020b) summarising the key parameters of groundwater quality. **Figure 16** indicates the extent of mining influence on groundwater within the mine lease. The term mine-influenced water means that solutes associated with mining activity have been detected in groundwater above threshold values that require investigation and potentially require management action but does not mean that environmental harm has been caused. Ecological monitoring of macroinvertebrates in creeks, and stygofauna in groundwater, have not found ecological impairment resulting from the mining influence.

Areas of groundwater that have been identified as being affected by mining are areas near the TSF and the North WRD. Concentrations of sulfate have been seen to increase near the TSF with conclusions from a 2010 geochemistry report as well as the Environmental Evaluation identifying that sulphide oxidation with the associated neutralisation reaction was the primary mining influence affecting water quality around the waste rock landform.

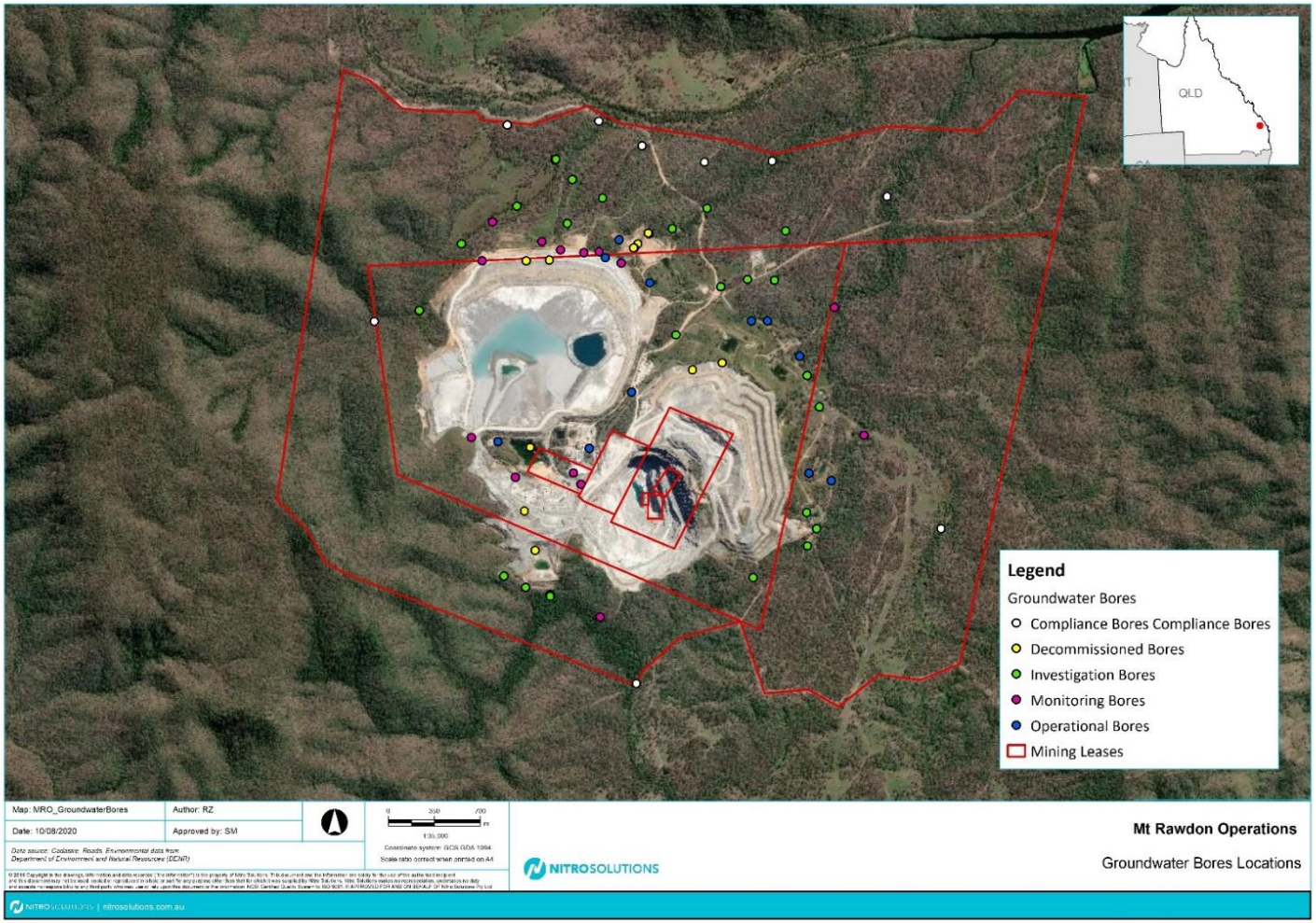


Figure 17: Geological Map and Bores at MRO

Groundwater Contaminants

Agriculture

The land that MRO is operated on was previously utilised as a farm, with cattle grazing on the outer areas of the mining lease. As a result, animal waste has been identified as a non-mining source of nitrate contamination.

Northern Resource Consultants (2015) investigated the sources of nitrate in groundwater of the Twelve Mile Creek catchment area using nitrogen isotopes. They concluded that nitrate inputs were in part contributed from animal excreta in the farming landscape. The high-density population of locally present wattles may also potentially contribute to the increased nitrate levels by acting as legumes and fixing nitrogen to the soil profile.

Natural Landscape

Due to the steep-sloped and undulating terrain of the MRO area, seepage occurs naturally and seasonally following significant rainfall events. This is particularly evident on the steeper terrain west of the TSF and South of the West Dam where the recharge on upper slopes reports down gradient to the lower slopes. Hydraulic heads also impose on adjacent groundwater and may draw lateral seepage from connected groundwater. This has also occurred downgradient of the West Dam on the lower slopes where evidence of groundwater seepage was found on the surface which was not linked to rainfall or water directly from the West Dam.

These forms of seeps transport naturally occurring contaminants that contain concentrations of iron to form stable oxide precipitates (goethite). The groundwater drawn to the surface undergoes evaporative processes that leaves behind concentrations of these contaminant materials standing on the surface. These contaminants are then easily transported and/or dispersed by surface water runoff and traces may be found within inception dams or may enter the receiving environment.

Soil Properties

Soil Types

The Australian Soil Classification (ASC) classifies the dominant soils across the site as brown Sodosols with Rudosols to the south, Chromosols to the west and Kandosols to the northeast. **Figure** 18 provides a map of soil type distribution at MRO.

Sodosol surface soils are characterised by a shallow sandy loam and sandy clay loam that is poorly structured with slight to moderate alkalinity, low salinity and non-sodic. However, the subsoil is typically poorly structured (sodic) medium to heavy clay, strongly alkaline with increasing salinity with depth. A typical description of brown Sodosols is as follows:

- Poorly structured allowing for erosion, waterlogging and poor plant emergence;
- Increased surface water runoff impact potential (dispersive, sodic); and
- Increased soil erosion potential.

The two (2) distinctive soils group present in **Figure** 18 comprise of:

- Tb88 - Steep hilly to a mountainous country on metasediments: chief soils are hard acidic yellow mottled soils (Dy3.41) with hard acidic red soils (Dr3.41) and (Dr2.41), all often stony. Associated are shallow loams (Um1.42) and (Um2.12) on the steeper slopes; (Dr2.21), (Dy2.21), and (Dy2.23) soils with smaller areas of (Uc1.21 and Uc1.23) on included granites, and (Uf6.41) and (Gn3.11) soils on included basic rocks.
- Tb103 - Low to moderately hilly lands on phyllites and schists; a close pattern of hills with short to moderate slopes: chief soils are gravelly hard acidic yellow mottled soils (Dy3.41) and (Dy2.41) with shallow gravelly loamy soils (Um2.12) and (Um4.1) on crests and upper slopes. Associated are gravelly (Dr3.41) soils. Minor soil occurrences include (Gn3.42)

Further discussion of the implications for rehabilitation can be found in **Section 5**.

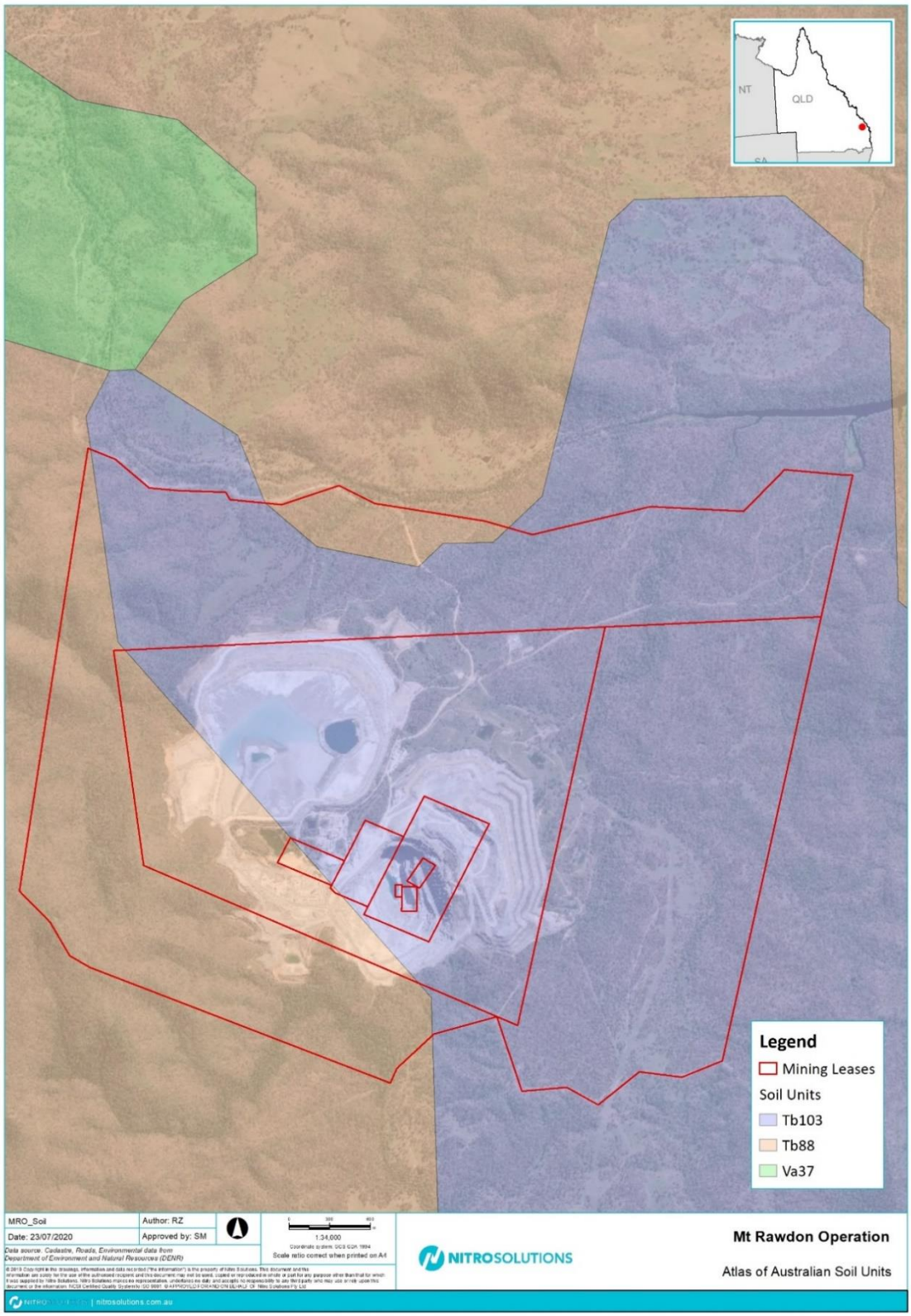


Figure 18: Dominant Soil Types Surrounding Mount Rawdon Operations.

Soil Nutrients

Sodicity

The identification of Sodosols being the primary soil type at MRO has implications for soil sodicity aka limited or poor soil structure and poor water infiltration. Seedling germination and plant germination in these type of soils is problematic as a result.

Additionally, sodic soils with few stabilising agents such as humus, clay or sesquioxide's, in the topsoil will be susceptible to erosion, especially when high in silt and clay content. Soil sodicity leads to reduced air and water permeability and poor soil drainage. Depending on clay percentage within the soil, soil dispersion problems can occur at a higher or lower value than 6%. Clay content at MRO typically ranges from 20-40% however a single test pit did identify 88% in a single location. Consideration for soil quality and specific analysis for nutrient and clay percentage will be undertaken immediately before the rehabilitation works being commenced. Using the broad understanding of sodic soil presence at MRO, it is expected that ameliorates will be utilised to improve soil structure and germination.

Nitrogen

Availability of nitrogen in soil controls plant growth. Most nitrogen in surface soil is immobilised and bound as organic nitrogen associated with humus. The nitrogen available to plants, however, is typically small in soils (compared to demand and store of other forms of nitrogen). Most organic nitrogen held up within the soils of the WRD is within the A1 soil horizon, as this is where plant roots typically extend and where nitrogen is allowed back into the system through decaying animal and plant residues and biological fixation by soil organisms (e.g., fungi and bacteria). A soil's organic nitrogen content usually falls in the range of 0.02 -0.5%. At MRO, soils typically contain 0.033 – 0.12% nitrogen in the surface soils within the normal range. The high naturally occurring levels of nitrogen could be as a result of the prior agricultural land use as identified in **Section 5.3**. Consideration of this naturally occurring level will impact the amount and type of fertiliser used in rehabilitated areas. This is discussed further in **Section 5.3**.

Phosphorus

Phosphorus is essential in the soil for plant and animal growth. Most phosphorous is held within the A1 soil horizons at MRO as this is where the majority of the phosphorous cycle occurs to promote plant growth and it accumulates through the decomposition of plant materials. At MRO, soils typically have low levels of phosphorous, containing 0.006 – 0.019% in the surface soils. Management of these levels will be managed through soil sampling prior to addition of fertilisers and ameliorants. This is discussed further in **Section 5.3**.

Other Nutrients

Several other soil nutrients are also required for plant and animal growth. While these nutrients are essential, a number of them are only required in minute concentrations i.e., cobalt, copper, manganese and zinc. These nutrients can be harmful in large concentrations, especially if they are contained within the most available forms. Manganese concentrations were above the NEPC ecological investigation levels for the soil in several locations, however, remained below National Environment Protection Council (NEPC) health investigation levels.

Two (2) key metals were identified in high levels in the soils at MRO; being Barium and Vanadium.

Barium concentrations within the subsoils (horizon B1 and C1) in two (2) locations exceeded Ecological investigation levels, however, it is expected that, given the depth of the soil depth this metal was encountered, that there will not be any outstanding impacts to plant growth during rehabilitation.

Vanadium has also been found to be present in the surface soils at four (4) locations across MRO. Despite these levels being identified as higher than ecological investigation levels, it is not expected that the presence of the metals will impact rehabilitation growth. As discussed in **Section 0**, soil sampling is to occur prior to rehabilitation works and addition of any fertilisers. This will ensure any changes to soil properties will be proactively managed.

Acid Sulfate Soils

Soils at MRO were assessed for pH during the 1996 Land Reclamation study. A summary of results indicated that soils were neutral to slightly acidic (pH 5-7) which is a common expectancy for mineralised soils in humid regions. It was also identified that surface soils were generally more acidic than the subsoils, suggesting that some areas at MRO may experience acid generation when disturbed. The acidic nature of the topsoils may be due to limited neutralising capacity (predominantly quartz sand) and humus.

A Soil and Land Suitability Assessment was conducted in 2013 by Northern Resource Consultants which reviewed the potential probability of acid sulphate soils (ASS) occurring at MRO. The Australian Soil Resource Information System (ASRIS) was used for the desktop review with findings concluding high probability of ASS occurring in a small area of the project (currently the location of the TSF) and no known ASS throughout the remainder of the MRO area (**See Figure 19)**.

The State Planning Policy for Planning and Managing Development (SPP2/02) refers to the state's interest concerning development in low-lying areas where acid sulphate soils may be impacted. MRO is located within the North Burnett regional council area which is listed in Annex 1. The disturbance at MRO is not included within this category and no assessment is required under the SPP2/02. Acid sulfate soils in Qld are usually associated with the coast. The only reason why the TSF is highlighted as Potential Acid Sulfate Soil is because it contains tailings (which host pyrite). MRO has ensured that the TSF contains enough calcite to neutralise the acidity generated by pyrite oxidation. Capping of the TSF should limit the ingress of oxygenated water into the TSF.

Erosion Rates

Erosion potential was examined during the 2013 Soil and Land Suitability Assessment (Northern Resource Consultants) and based upon the percentage presence of fine sand and silt within the A1 horizon. Overall, the soil present at MRO was determined to exhibit moderate to high erosion potential, typical of sodic soils with poor soil structure. The removal of vegetation during clearing works increases this potential significantly.

Soil Conservation Works

Soil conservation works at MRO involves a multitude of steps, including a Permit to Disturb process and a Growth Media Management Procedure. The Growth Media Management Procedure provides basic principles for the management of growth media, such as stockpiling of topsoil. Expansion of this procedure to include Quality Assurance (QA) processes for all stages of topsoil handling is incorporated into the rehabilitation milestones (**Section 8.1.3**).

The updated procedure will include the following but is not limited to:

- Quality Assurance processes for stripping and stockpiling of topsoil resources;
- Annual monitoring of topsoil stockpiles; and
- Sampling processes before rehabilitation.

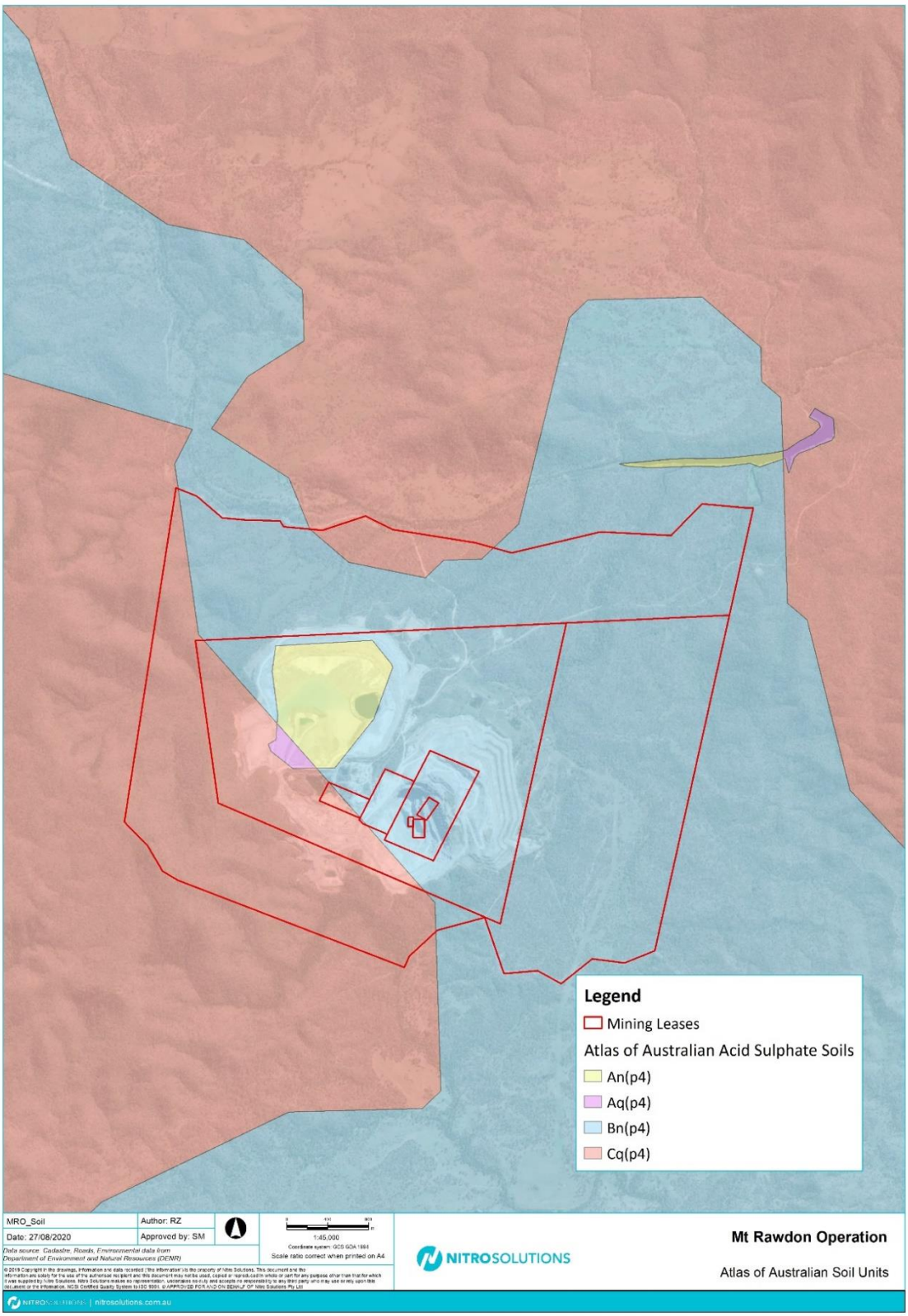


Figure 19: MRO Representation of Acid Sulphate Soils

Land Productivity

Initial assessment of land productivity at MRO (conducted in 1996 by Land Reclamation Services) determined that soils were nutritionally poor with little ability to retain nutrients and had a relatively low water holding capacity, restricting pasture growth.

Land Capability and Productivity

In 1996, Land Reclamation Services were commissioned to conduct a soil and land capability study at MRO.

Field surveys across 41 investigation sites were carried out from 2-6 October 1995 against the Land Capability Classes below in **Table 5.** The majority of land in the disturbance area was classed as land capability 7 and 8, with some marginal areas of class 6. The report identified that the land had previously been cleared and pasture improved with no superior classes of land, prior to any mining disturbance.

Table 5: Land Capability Classes and Descriptions

Capability Class	Description
Class 1	Land suitable for all agricultural and pastoral uses.
Class 2	Land suitable for all agricultural uses but with slight restrictions to use for cultivation in one or more categories.
Class 3	Land suitable for all agricultural uses but with moderate restrictions to use for cultivation in one or more categories.
Class 4	Land primarily suited to pastoral use but which may be safely used for occasional cultivation with careful management.
Class 5	Land that in all other characteristics would be arable but has limitations that, unless removed, make cultivation impractical and/or economic.
Class 6	Land that is not suitable for cultivation but is well suited to pastoral use and on which pasture improvement involving the use of machinery is practicable.
Class 7	Land that is not suitable for cultivation but on which pastoral use is possible only with careful management; pasture improvement involving the use of machinery is not practicable.
Class 8	Land that has such severe limitations that it is unsuited for either cultivation or grazing.

Soils were identified as having poor nutrient levels and relatively water holding capacity, restricting good pasture growth. Soils were also noted to dispersive especially in the subsoils.

The identified major limitations to land capability at MRO are:

- Moisture availability;
- Effective soil depth;
- Soil nutrient fertility;
- Topography; and
- Susceptibility to water erosion.

Consideration of these factors has formed the basis of the assessment of land capability in regards to defined Post Mining Land Use's (PMLUs). Further discussion pertaining to PMLUs is provided in **Section 3.**

Strategic Cropping and Priority Agricultural Land

A desktop assessment for land suitability under the relevant *State Planning Policy's (SPP) for Strategic Cropping Land (SCL)* and Good Quality Agricultural Land (GQAL) was conducted in 2013 by Northern Resource Consultants.

The local land use has been previously identified as rainfed broadacre cropping and conservation with no historic cropping within the MRO area. Any underlying tenures at MRO do not fall within the SCL Western Cropping Zone. **Figure 20** provides a map of the closest identified SCL and GQAL to MRO.

Pre-mining Land Uses

The main pre-mining land use of the MRO site was cattle grazing on native and improved pastures (LGL MRO 2010). Swindon Station and surrounding properties have been extensively grazed by sheep since the 1850s and by cattle since the 1880s (Royle, 1980). Aside from some temporary agisting of cattle by others, the property has remained as left.

Adjacent Land Uses

MRO has several adjacent and overlying properties which are primarily for low-intensity grazing purposes and are displayed in **Figure 21** and **Figure 22**.

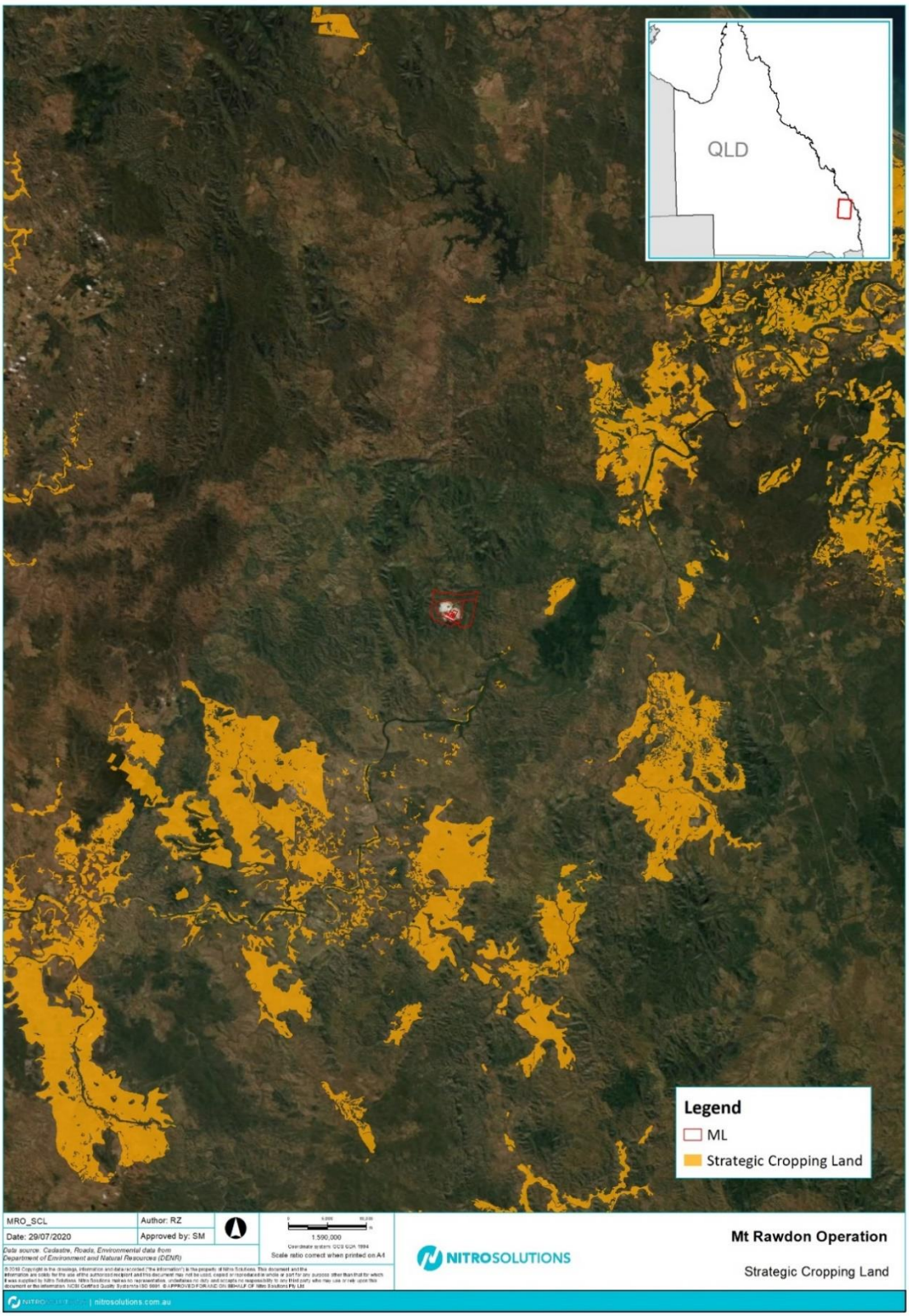


Figure 20: MRO and Strategic Cropping Land

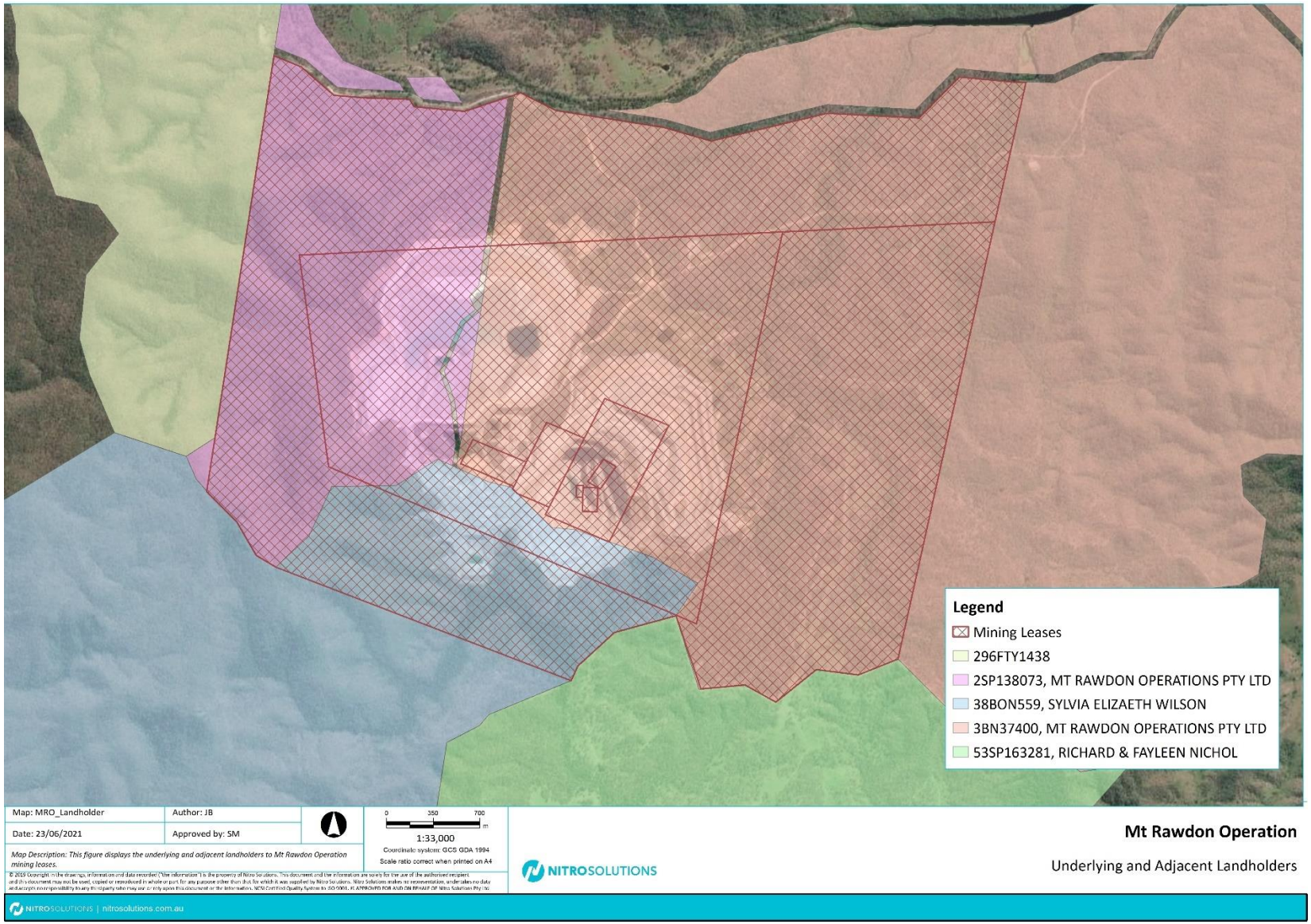


Figure 21: Underlying Landholder Properties



Figure 22: Underlying and Surrounding Land uses

Ecological Data

Threatened Ecological Communities

A Protected Matters Search Tool (PMST) was used to identify if Threatened Ecological Communities (TECs) were occurring within the MRO area. Three (3) TECs were identified using this tool and include:

- Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community;
- Lowland Rainforest of Subtropical Australia; and
- Poplar Box Grassy Woodland on Alluvial Plains.

Listed conservation advice, distributions and known associations with Regional Ecosystems (REs) were used to refine the likelihood of encountering these TECs within the MRO area (**Table 6**).

Table 6: REs Associated with Each Listed TEC

Threatened Ecological Community	Associated Regional Ecosystems
Coastal Swamp Oak (Casuarina glauca) Forest of New South Wales and South East Queensland ecological community	RE 12.1.1 and 12.3.20
Lowland Rainforest of Subtropical Australia	RE 12.3.1, 12.5.13, 12.8.3, 12.8.4, 12.8.13, 12.11.1, 12.11.10, 12.12.1 and 12.12.16
Poplar Box Grassy Woodland on Alluvial Plains	RE 11.3.2, 11.3.17, 11.4.7 11.4.12 and 12.3.10

Based upon the available information and known habitat associations none of these TEC are considered likely to occur within the MRO area.

Regional Ecosystems

The Prescribed Matters Report (NRC, 2018) provided RE's within MRO. According to the DES Regional Ecosystem mapping, several REs occur within the MRO area (see **Figure 23**). These REs are all associated with remnant vegetation however there are also numerous patches of non-remnant vegetation within the MRO area. These REs are outlined in **Table 7** along with their conservation statuses. Most of the vegetation within MRO is mapped as Category B vegetation under the *Vegetation Management Act 1999*, however, there are a few small patches of Category R and Category C also present (see **Figure 24**).

Table 7: RE's Mapped Within MRO

Regional Ecosystem	VM Act Status	Biodiversity Conservation Act Status	Short Description	Total Area
RE 12.11.6 / RE 12.11.12 / RE 12.11.8 *(70/15/15)	LC OC OC	NC OC OC	Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on metamorphics +/- interbedded volcanics Araucarian complex microphyll vine forest on metamorphics +/-	361.31

			interbedded volcanics; usually northern half of bioregion Eucalyptus melanophloia, E. crebra woodland on metamorphics +/- interbedded volcanics	
RE 12.11.6 / RE 12.3.7 / RE 12.12.5 *(70/20/10)	LC LC LC	NC OC NC	Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on metamorphics +/- interbedded volcanics Eucalyptus tereticornis, Casuarina cunninghamiana subsp. cunninghamiana +/- Melaleuca spp. fringing woodland Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on Mesozoic to Proterozoic igneous rocks	29.33
RE 12.11.6 / RE 12.12.5 / RE 12.3.3 / RE 12.3.7 *(50/25/15/10)	LC LC E LC	NC NC E OC	Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on metamorphics +/- interbedded volcanics Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on Mesozoic to Proterozoic igneous rocks Eucalyptus tereticornis woodland on Quaternary alluvium Eucalyptus tereticornis, Casuarina cunninghamiana subsp. cunninghamiana +/- Melaleuca spp. fringing woodland	36.86
RE 12.3.7	LC	OC	Eucalyptus tereticornis, Casuarina cunninghamiana subsp. cunninghamiana +/- Melaleuca spp. fringing woodland	42.34
RE 12.11.12	OC	OC	Araucarian complex microphyll vine forest on metamorphics +/- interbedded volcanics; usually northern half of bioregion	20.14
RE 12.11.6	LC	NC	Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on metamorphics +/- interbedded volcanics	169.62

RE 12.3.3	E	E	Eucalyptus tereticornis woodland on Quaternary alluvium	1.35
RE 12.12.5	LC	NC	Corymbia citriodora subsp. variegata, Eucalyptus crebra woodland on Mesozoic to Proterozoic igneous rocks	1.60

NC = No Concern at present, LC = Least Concern, OC = Of Concern, E = Endangered

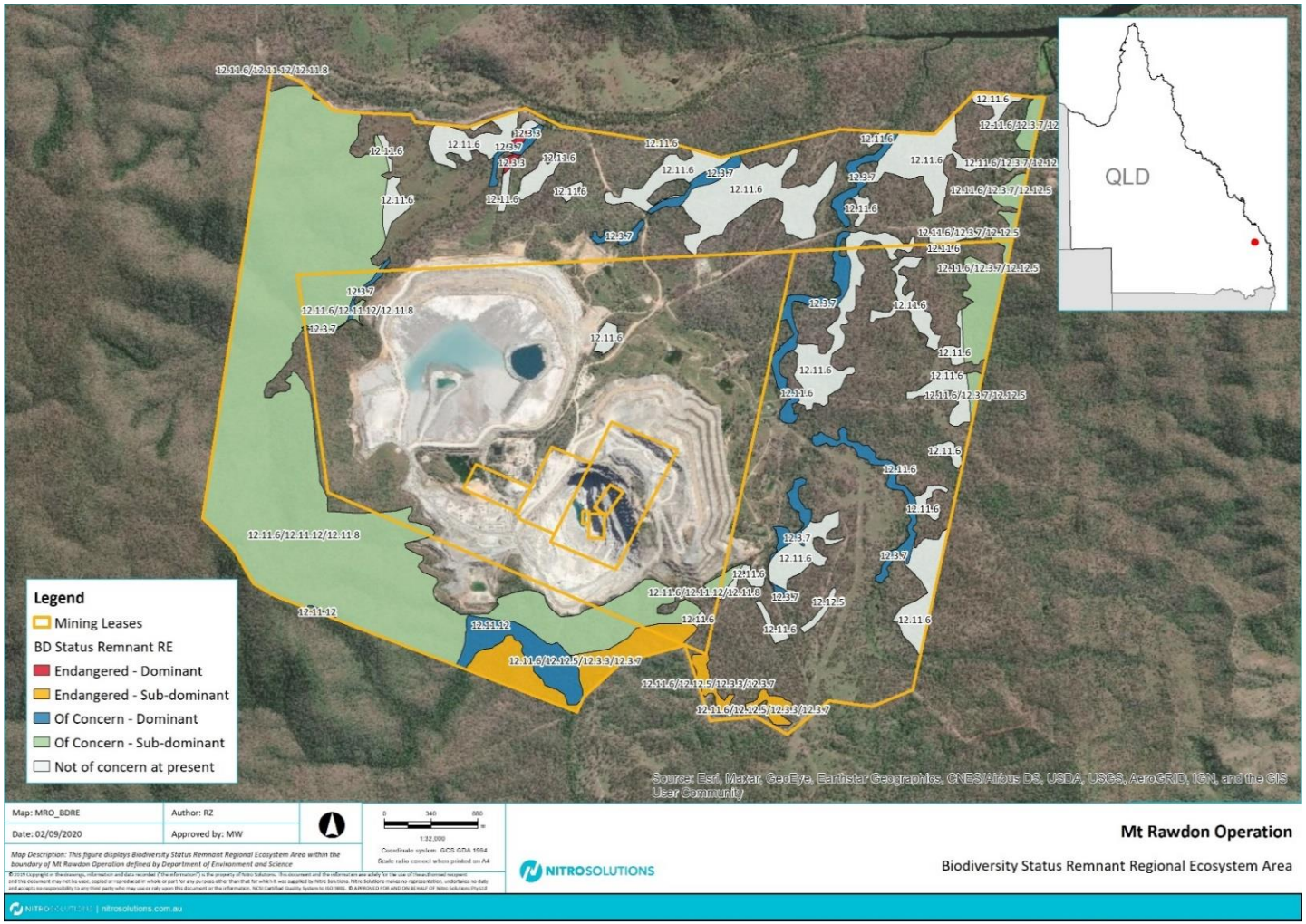


Figure 23: MRO Overlay of Regional Ecosystems

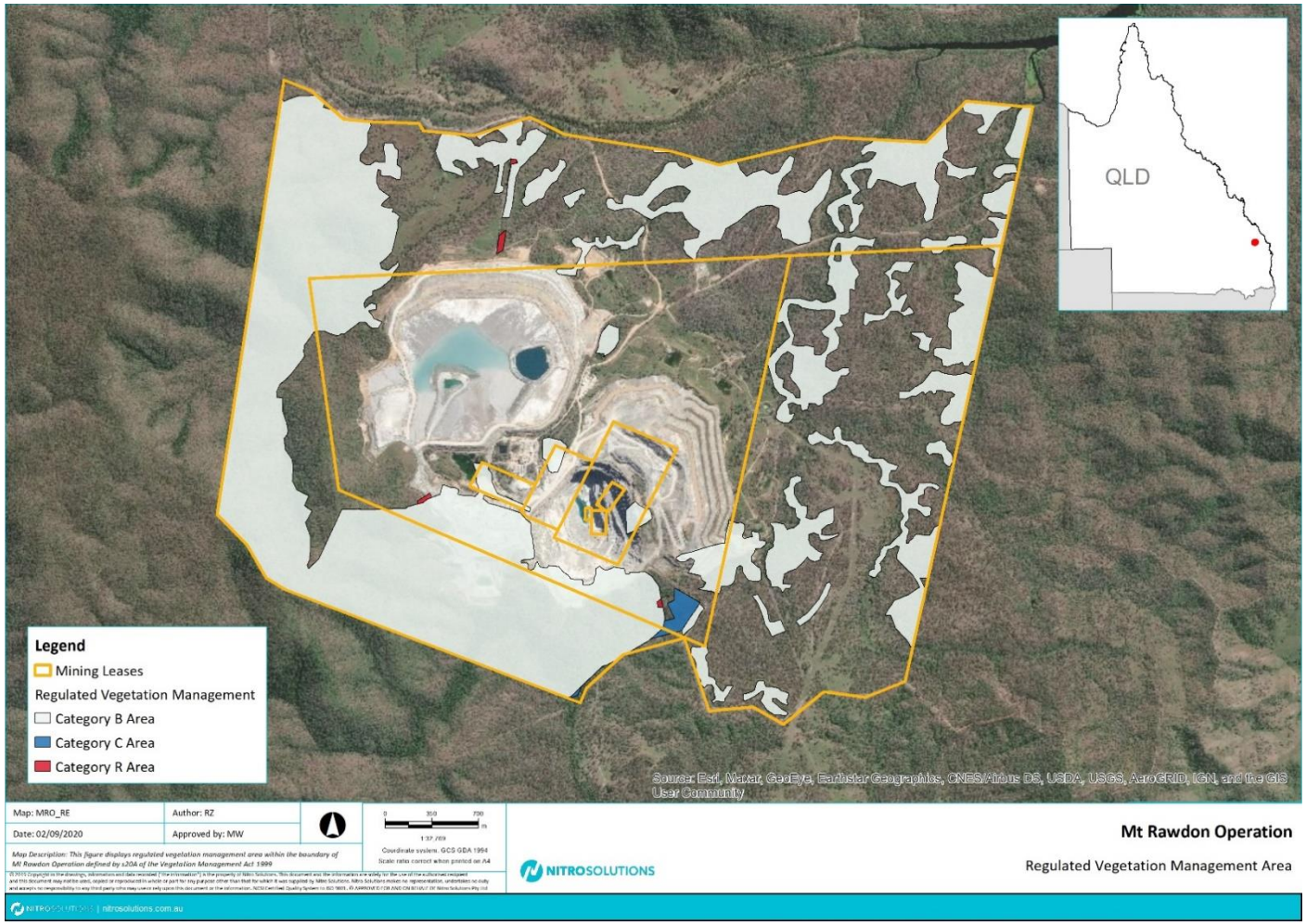


Figure 24: MRO Regulated Vegetation Mapping Overlay

Significant Fauna Species

In addition to historical ecological surveys, a desktop review of significant fauna species was undertaken using the EPBC PMST and the NC Act Wildlife Online search tool to identify fauna species potentially occurring within the MRO area. The PMST search, whilst incorporating known species records, relies upon a modelling program developed using suitable habitat for individual species and is predictive. The Wildlife Online search, on the other hand, is based solely upon known species observations.

Combining these search tools ensures that all State and Commonwealth threatened species within the vicinity of the MRO area have been identified. These searches identified a total of 11 bird species, one fish species, seven mammal species, four (4) reptile species, 20 migratory/marine species and 14 flora species as potentially occurring within the MRO area.

Field surveys were conducted over portions of the MRO area in 1995 and 2013. Most of the species observed during these survey events are considered to be relatively common species in the region and have a relatively high level of tolerance for the disturbance. In 2013, during the most recent study, 29 bird species, 12 mammal species, 9 reptiles and 5 amphibian species were identified within the MRO area. Of these species, only 3 were listed as threatened fauna species and are listed below in **Table 8**. No threatened flora species were identified.

Table 8: Threatened Fauna Species Identified During the 2013 Survey Event

Common Name	Scientific Name	EPBC Status	NC Status
Greater Glider	Petauroides Volans	V	V
Little Pied Bat*	Chalinolobus picatus	-	NT
Rainbow Bee-eater	Merops ornatus	Ma	-

*species has since been de-listed

EPBC Status: V = Vulnerable, Ma = Marine; NC Status: V = Vulnerable, NT = Near Threatened

In addition to these identified species, there are several other species which based upon nearby records and known habitat associations could potentially/likely be present within the MRO area. These species are discussed in greater detail in the following sections.

Greater Glider

Greater gliders are arboreal nocturnal mammals who favour eucalypt forests with a diversity of species due to seasonal variation in their preferred tree species (DAWE, 2020a). They are currently listed as Vulnerable under the EPBC and NC Acts. They utilise tree hollows as dens and as such, prefer vegetation along creek lines/watercourses. The Greater Glider was identified during both the 1995 and 2013 surveys undertaken across the MRO area, indicating that a healthy population resides within the MRO area or utilises the area for foraging.

Koala

Koalas are arboreal mammals who inhabit a range of temperate, subtropical and tropical forests, woodland and semi-arid communities typically dominated by Eucalypt species (DAWE, 2020). This species is listed as Vulnerable under both the EPBC and NC Acts. While this species was not identified during the 2013 field surveys, it was identified during the initial surveys undertaken in 1995. Given the abundance of suitable vegetation communities within the MRO area it is considered probable that this species utilises habitat within the area. The closest record of this species to the MRO area is only 40km to the south.

Little Pied Bat

The Little Pied Bat was previously listed as Near Threatened under the NC Act but has since been de-listed. Little is known about this rare species but they have been observed to roost in dry caves, mine shafts and abandoned houses (Strahan, 2002). Call data collected during the 2013 surveys within the MRO area indicates that this species is present however its distribution across the greater MRO area remains unknown. Given the absence of caves identified within the MRO area, it is conceivable that this species is simply a visitor to the MRO area and does not reside there, however, like many microbat species they may utilise tree hollows as suitable roosting locations.

Northern Quoll

The Northern Quoll is a nocturnal marsupial which occupies a diverse range of habitats across its range including rocky areas, eucalypt forests and woodlands, rainforests, sandy lowlands and beaches, shrublands, grasslands and deserts (DAWE, 2020c). This species is the smallest of the four (4) quoll species and are omnivorous.

There was a single anecdotal record of this species from May 2012, where an individual was supposedly found injured adjacent to the MRO haul road. In response to this incident, a Northern Quoll Management Plan was developed to investigate the presence of this species further and ensure they are protected. After five (5) years of data collection (both cage trapping and camera trapping) no additional sightings have been documented. Based on this information is has been determined that this species is unlikely to be present within the MRO area.

Grey-headed Flying-fox

The Grey-headed Flying-fox occurs in a range of habitats including subtropical and temperate rainforests, dry and wet sclerophyll forests, banksia woodland heaths and melaleuca swamps (Duncan *et al*, 1999). This species is listed as Vulnerable under the EPBC Act. While no individuals were identified during the 2013 field studies, this species was recorded during the 1995 studies done across the MRO area. Based on this information, the available habitat within the MRO area and the fact that the nearest record is approximately 25 km from the MRO area, it remains possible that this species could reside within or forage within the MRO area.

Powerful Owl

While the Powerful Owl was not identified in the desktop searches of this region, it has previously been documented within the MRO area and the closest record is less approximately 10 km away. The Powerful Owl is currently listed as Vulnerable under the NC Act. They primarily occur in tall open forests and woodlands, as well as along sheltered gullies in wet forests with dense understories, especially along watercourses. They will sometimes be found in open areas near forests such as farmland, parks and suburban areas (Birds in Backyards). Given the availability of suitable habitat for this species within the MRO area and nearby records, this species is considered likely to be present within the MRO area.

Squatter Pigeon

The Squatter Pigeon is currently listed as Vulnerable under the EPBC and NC Acts. This species preferred habitat is generally defined as open forests to sparse, open woodlands and scrub that is mostly dominated by *Eucalypts*, *Corymbia*, *Acacia* or *Callitris* species (DAWE, 2020d). While this species was not observed during the field surveys conducted in 2013, the abundance of suitable habitat for this species within the MRO area indicates that the species is likely to be present. The closest record of this species to the MRO area is only 46 km to the south-west.

Migratory and Marine Species

The desktop searches identified several migratory and marine species as potentially occurring within the MRO area. One of these species, the Rainbow Bee-eater (*Merops ornatus*), was identified during the 2013 field surveys indicating that suitable foraging habitat is present within the MRO area. Based

upon this evidence it is possible that the MRO area is also utilised by other migratory and/or marine species including:

- Black-faced Monarch (*Monarcha melanopsis*)
- Spectacled Monarch (*Monarcha trivirgatus*)
- Satin Flycatcher (*Myiagra cyanoleuca*)
- Rufous Fantail (*Rhipidura rufifrons*); and
- Black-eared Cuckoo (*Chrysococcyx osculans*)

Despite the potential presence of these species within the MRO area, the Project has been considered unlikely to affect any significant habitat for these species.

1.3 Design for Closure

MRO Operations falls under a transitional PRC plan and it is therefore not a requirement to demonstrate how the existing and approved disturbance has been designed for closure as it is not applicable in accordance with the PRCP Guideline and the EP Act. Additionally, MRO has minimal impacts on the surrounding areas as is situated far from any strategic cropping land (**Figure 20**) and is well outside any floodplain area.

Rehabilitation Planning

Existing Rehabilitation

The extent of current rehabilitation works conducted on MRO has been limited to the NWRD where clay seals have been placed along the Eastern berms (**See Figure 25**). These seals have been orientated to guide predicted surface water flows towards the water reticulation system of the WD1 or WD2 water storage facilities and associated infrastructure. Whilst the berms have not been completely rehabilitated to landform design, the clay seals reduce erosion on the NWRD and contribute to the site wide water management strategy by reporting surface water runoff to the feedback systems in place. The installation of the clay seals to the current design began in September 2012 and will continue progressively until mining in the pit is completed. As these areas are still under development these areas have not been applied for approval as progressively certified under the EP Act.

Proposed Rehabilitation

As seen in **Figure 25,** rehabilitation is proposed to continue for much of the NWRD until completion of mining in the pit and then processing of the temporary ore stockpiles. The proposed rehabilitation will be a continuation of the installation of clay seals and will also incorporate the dumping of the remaining waste rock to final landform. Further available NAF material from WWRD will be used to encapsulate the PAF material as per the NWRD final landform design. Further detail of final landform design can be seen in **Section 5.**

Progressive Rehabilitation

The static operational setting of the MRO site limits the possibility of progressive rehabilitation as all areas are required for operations to continue until closure. Progressive rehabilitation has been limited to the NWRD berms as discussed above and further rehabilitation has been planned to begin successionally in areas once operations have ceased. The proposed progressive rehabilitation strategy will begin once pit operations have been completed and all waste rock has been made available for deposition on NWRD or within the TSF and ore stockpiles have been processed.

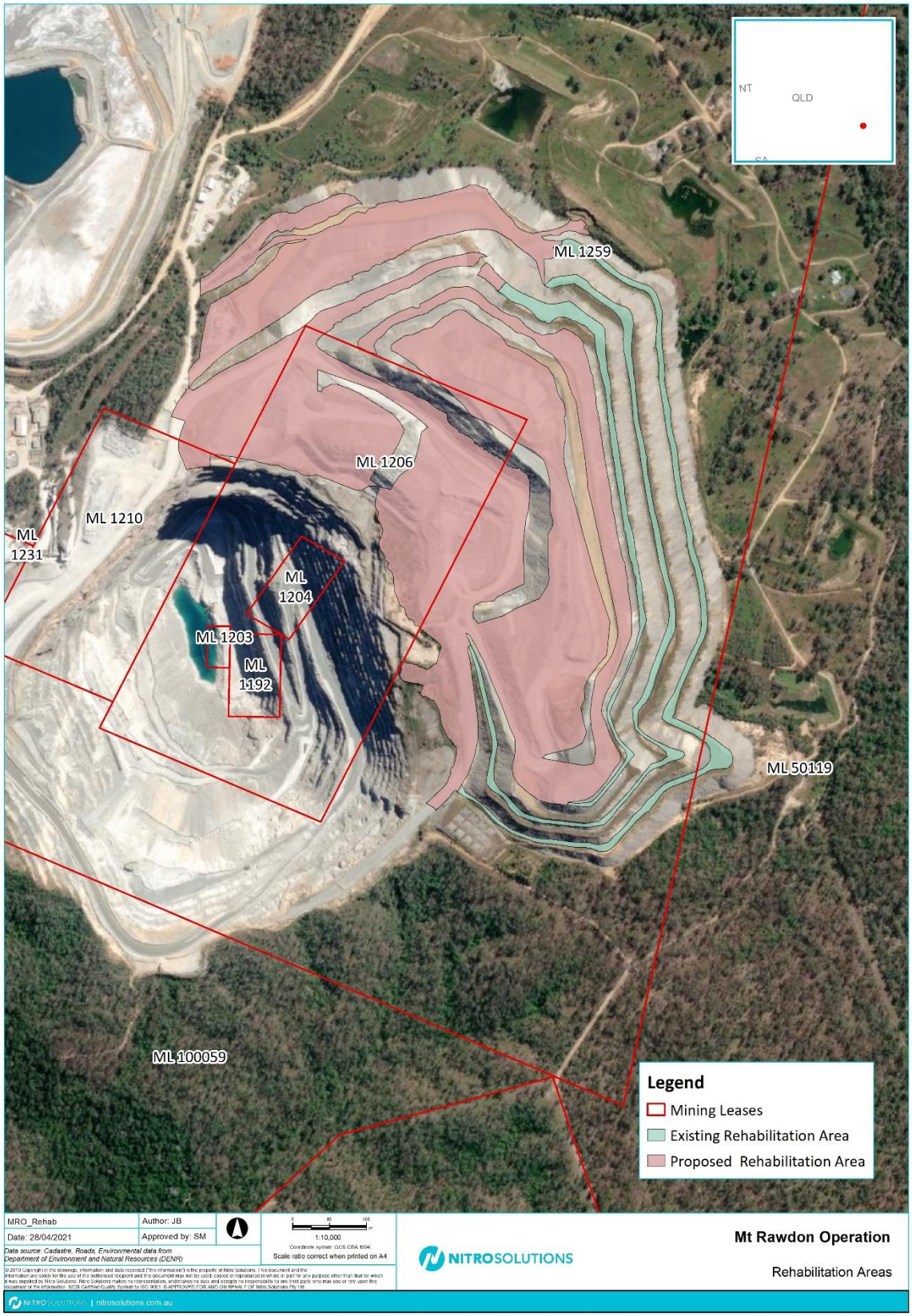


Figure 25: Existing Rehabilitation of NWRD Berms

Relevant Activities

As described above in **Section 1.1** MRO is an open-cut gold mining operation consisting of relevant activities including mining, ore processing, crushing, milling, leaching, gold recovery, waster rock and tailings disposal and storage of bulk chemicals, explosives, reagents, and fuels. The size and predicted duration of the relevant activities are listed below in **Table 9**:

Table 9: Duration of Relevant Activities and Progressive Rehabilitation

Mining Lease	Duration of Activity (operations)	Area (ha)	Opportunity for Progressive Rehabilitation
Processing Plant, Workshops, other Infrastructure areas	2026	53.65	Required for the entire LOM as it contains all processing equipment, workshops and supporting infrastructure areas required for operations and post-closure. Upon cessation of mining, infrastructure will be decommissioned, removed and land rehabilitated according to designated PMLU. Hardstand and laydown areas may be required for use in rehabilitation works post-closure for storage of equipment and machinery.
Haul Roads and Tracks	2026	16.09	Used for access and haulage, access tracks, roads and haul roads are required for the LOM unless otherwise not required. Progressive rehabilitation will take place on sections of haul roads (2ha) once large fleet access is no longer required. Access tracks and roads will remain for future landholder access.
NWRD	2026	103.92	Utilised to store PAF waste rock from the pit and temporarily store low grade and subgrade ore stockpiles for blending over the LOM. Therefore, the NWRD will remain operational until the completion of mining in the pit and processing of stockpiles. As outlined above progressive rehabilitation has begun on the clay seals on the berms and will continue until closure.
WWRD, ROM	2030	41.2	The WWRD is used to store NAF from the pit and is then rehandled for construction of the TSF embankment buttress, NWRD outer embankments, and other infrastructure areas as required. Remaining NAF material will be used to rehabilitate remaining domains at closure hence it is required until 2030. The ROM is used to store ore until processing and will be required until end of operations during 2026.
Open Pit	2024	71.35	Progressive rehabilitation of the open pit can begin once the final ore has been retrieved and suitable equipment is available. The pit will be rehabilitated to final landform requirements and safety bunds and fencing will be installed.

TSF	2026	203.92	The rehabilitation of the TSF will begin following the final processing of ore and deposition of PAF waste rock and tailings within the TSF. The installation of the cover and capping system will follow as soon as practicable. A period of drying may be required to allow for machinery to access the TSF.
Topsoil Stockpiles/Borrow pits	2031	65.23	The combined topsoil stockpiles and borrow pit areas will be progressively rehabilitated as the material resource is depleted as required for rehabilitation elsewhere onsite. Topsoil stockpiles will be chosen for use in rehabilitation based on their practical proximity to rehabilitation areas and so that progressive rehabilitation across the site can be maximised. This domain includes the NAF borrow area identified as West Hill which sits directly to the west of the Pit.
Water Infrastructure	2027	33.05	Water dams will remain operational until end of operations in 2026. The intended final land use for water management infrastructure and dams at MRO is to remain as a water storage for agricultural purposes such as stock water supply.

2 Community Consultation

2.1 Stakeholder Consultation Plan

In 2020, a Community Consultation Plan (CCP) was commissioned by Evolution Mining and designed by Coffey Services Australia Pty Ltd (Coffey). The community consultation report is a requirement of this PRCP under the EP Act.

The key objectives of the CCP include:

- A description of key stakeholder groups;
- Detailing the ongoing CCP engagement methodology and objectives for closure;
- Explaining how the CCP meets the requirements of the PRCP legislation;
- Highlighting any interests and potential issues raised through engagement;
- Outlining the stakeholder response to proposed PMLUs;
- Providing a history and summary of all stakeholder engagement in the form of the Community Consultation Register (CCR); and
- Addresses how grievances, comments and questions will be managed and actioned as required.

Legislative Requirements

A CCP is a requirement for all PRCPs under section 126C of the EP Act. The following guidelines have also been used to guide the planning of this CCP and the relevant outcomes:

- Progressive Rehabilitation and Closure Plans (PRC plans) Guideline (DES, 2019).
- Public participation concepts developed by the International Association for Public Participation (IAP2, 2018).
- AA1000 Stakeholder Engagement Standard 2015 (Account Ability, 2015).
- International Council on Mining and Metals Closure Maturity Framework (ICMM, 2020).
- International Council on Mining and Metals Integrated Mine Closure: good practice guide (ICMM, 2019).

Stakeholder Groups

In 2020, a Social Impact Assessment (SIA) was developed by Coffey to identify the primary and secondary stakeholders who are impacted by the closure of the Project. Primary stakeholders include those that are directly affected, and secondary stakeholders include all persons and parties that are indirectly impacted by the proposed closure strategy. This process highlights parties of particular concern and vulnerable groups. This process helps mitigate adverse societal impacts and guide the collaborative closure planning towards appropriate outcomes.

A list of relevant stakeholders is provided below in **Table 10.**

Table 10: Relevant Stakeholder Groups (Coffey, 2020)

Stakeholder Group	Description
Primary Stakeholders	
Landowners and communities	Comprises landowners with property adjoining the current mining lease, and other communities in the vicinity of the mine, such as Mount Perry and Gin Gin.
Employees, contractors and suppliers	Includes employees and contractors currently employed by Mt Rawdon Gold Operations and local businesses and service providers located in surrounding communities and townships.
Traditional Owners	Includes Traditional Owner groups in the area, including the Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people.
Landowners and communities	Comprises landowners with property adjoining the current mining lease, and other communities in the vicinity of the mine, such as Mount Perry and Gin Gin.
Secondary Stakeholders	
State and local government representatives	Representatives from the Queensland Government and the North Burnett and Bundaberg regional councils.
Representative bodies	Individuals elected to local representative bodies, such as industry groups (e.g., AgForce), business groups (e.g., local Chambers of Commerce) and development organisations (e.g., Regional Development Australia Wide Bay Burnett).
Interest groups	Local groups in the surrounding area with a special interest, such as sports and community clubs and environmental groups (e.g., Burnett Mary Regional Group).
Service providers	Emergency services (e.g., Rural Fire Service) and healthcare and education providers.
Regional community	Residents and local organisations present in the broader regional community, such as Gayndah.

2.2 Stakeholder Engagement

The overarching approach towards stakeholder engagement is guided by the International Association of Public Participation (IAP2) Public Participation Spectrum and the principles and practices contained in the AA1000 Stakeholder Engagement Standard (AccountAbility, 2015).

Engagement Objectives

The engagement process is aimed at identifying any concerns that stakeholders may have regarding current closure proposals and providing platforms for appropriate resolution of grievances. Engagement frequency will increase during critical phases of operations and when issues arise that require resolution and/or further consultation.

The CCP objectives related to stakeholder engagement throughout the closure planning process include:

- Ensure that stakeholders and involved parties are continually engaged and given all opportunities to be involved in mine closure planning;
- Stakeholder participation is encouraged throughout the planning process so that interests of all involved can be expressed and considered when determining the outcomes of the PRCP; and
- To understand general trends and common concerns that may factor into long term management and monitoring of mine closure.

Methodology

Methods of approach has varied according to stakeholder or stakeholder group and has required a mix of methodology to effectively engage with various stakeholders. Tailored communication methods were implemented using language that best translates to each specific stakeholders' background and relative interest. Special consideration has been given to underrepresented, at risk or vulnerable groups including women, youths, disabled and indigenous. The overall approach to engagement and support offered these groups will continue to appropriately reflect this. Additional support was given to various stakeholder groups to assist in understanding technical concepts where necessary.

History of Stakeholder Engagement

Stakeholder engagement began in July of 2020 and is planned to be executed throughout LOM until closure in 2030. The ongoing consultation process will be conducted in step with MRO progressive rehabilitation strategies and as operational planning evolves. The engagement of stakeholders has been undertaken in a variety of methods including phone call, one-on-one meetings, groups meetings, MRO Operations site visits, distribution of fact sheets, media statements and online forums.

A history of stakeholder engagement to date can be seen in **Appendices** and **Table 11** below. It should be noted that telephone conversations were the most appropriate and preferred method of contact held during periods of travel restriction imposed throughout Queensland by the COVID-19 pandemic.

Stakeholder Consultation Register

The Stakeholder Consultation Register can be found within the CCP in **Appendices.**

The register provides a complete record of when the consultation occurred, community or groups consulted, how they were consulted, information provided during the consultation, major issues raised, the overall outcomes of the discussions and actions Evolution Mining are committed to as a

response. This register will be updated ongoingly and records of consultation retained within INX Inform against the relevant stakeholder.

Community Consultation Materials

Table 11: Information Provided to the Community

Stakeholder Group	Information Provided
Primary Stakeholders	
State and local government	Indicative closure timeline; post-mining land uses; current procurement and employment data at MRO. Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.
Adjoining landowners and local communities	Presentation providing update on current operations and closure planning; post mining land uses. Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.
Service providers Representative bodies Traditional Owners Local businesses Interest groups	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.

2.3 Community Feedback

From a social impact perspective, there was a general concern that the closure of MRO would result in a reduction in participants for local sporting groups and a diminished network of community members, particularly volunteers to assist with community event, local working bees and tourism opportunities.

The most prevalent concern for the community surrounded the overall loss of income and employment. Serious concerns were raised regarding the negative impact of the MRO closure on the local economy and there was significant interest in alternative employment opportunities generated by closure planning and through the rehabilitation phases.

Whilst there was interest in the community involvement in the rehabilitation phases, the possibility of poor execution of planned rehabilitation was an issue that most groups were concerned with. Impacts on the environment and subsequent damage to livelihoods (i.e. The local grazing industry) was raised as a concern. Ongoing issues from legacy rehabilitation impacting liveability and local development was flagged as a potential risk by adjacent and overlying landholders.

The summary of findings from the stakeholder engagement process are listed in **Table 12** below.

Table 12: Stakeholders, Interests and Issues Raised from Stakeholder Engagement (Coffey 2020)

Stakeholder Group	Interests	Potentially relevant issues or concerns
Landowners and communities		
Adjoining landowners	• Management of invasive species. • Effective closure and site rehabilitation. • Compliance with state environmental legislation and regulations. • Post-closure end land uses (e.g., access to additional grazing land if possible).	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Disruptions to stock or farming operations during decommissioning and post-closure. • Impacts on land values.
Local community, i.e., Mount Perry	• Mount Perry town viability, including access to services, property values, population. • Compliance with state and commonwealth environmental legislation and regulations. • Post-closure end land uses.	• Loss of employment and procurement opportunities. • Population decline in Mount Perry and reduced liveability. • Loss of community financial support. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure.
Employees, contractors and suppliers		
Current Mt Rawdon employees and contractors	• Employment and business impacts. • Mine closure timelines. • Closure and site rehabilitation approaches and standards.	• Loss of employment and procurement opportunities. • Opportunity for participation in site rehabilitation.

Stakeholder Group	Interests	Potentially relevant issues or concerns
Local businesses and suppliers	• Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain. • Employment and business impacts. • Mine closure timelines. • Closure and site rehabilitation approaches and standards.	• Loss of employment and procurement opportunities. • Population decline in local area. • Opportunity for participation in site rehabilitation.
Traditional Owners		
Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people	• Maximising support from Mt Rawdon in the period leading to closure. • Native title and cultural heritage. • Effective closure and site rehabilitation. • Post-closure end land uses.	• Opportunity for participation in site rehabilitation. • Loss of community financial support. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure.
State and local government representatives		
Minister for Environment and the Great Barrier Reef Minister for Resources	• Closure and site rehabilitation approaches and standards. • State liabilities. • Industry environmental performance, reputation and support.	• Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of royalties.
Department of Environment and Science	• Closure and site rehabilitation approaches and standards.	• Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure.

Stakeholder Group	Interests	Potentially relevant issues or concerns
Department of Natural Resources, Mines and Energy Department of State Development, Tourism and Innovation Department of Communities, Disability Services and Seniors	• Local stakeholder satisfaction with the closure and rehabilitation process. • Compliance with state environmental legislation and regulations. • Industry and regional development.	• Loss of royalties.
Member for Callide Member for Bundaberg Member for Burnett	• Impact on local jobs and businesses. • Closure and site rehabilitation approaches and standards. • Local stakeholder satisfaction with the closure and rehabilitation process.	• Adequacy of regional infrastructure to support local development (agriculture and tourism) post-closure. • Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of community financial support.
North Burnett Regional Council	• Mount Perry town viability, including access to services, property values, population. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain, such as Gayndah and Eidsvold. • Post-closure end land uses. • Local stakeholder satisfaction with the closure and rehabilitation process.	• Loss of employment and procurement opportunities. • Population decline in Mount Perry and reduced liveability. • Loss of community financial support. • Local stakeholder support for closure approach.

Stakeholder Group	Interests	Potentially relevant issues or concerns
Bundaberg Regional Council	• Viability of Gin Gin and other regional towns that form part of the Mt Rawdon supply chain.	• Loss of employment and procurement opportunities.
Representative Bodies		
AgForce Queensland Resources Council Regional Development Australia Wide Bay Burnett Regional Organisation of Councils Gin Gin and District Chamber of Commerce Bundaberg and District Chamber of Commerce Gayndah Chamber of Commerce Inc.	• Closure and site rehabilitation approaches and standards. • Management of invasive species. • Industry environmental performance, reputation and support. • Industry and regional development. • Post-closure end land uses.	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of employment and procurement opportunities. • Disruptions to stock or farming operations during decommissioning and post-closure.
Interest Groups		
Burnett Mary Regional Group Burnett Catchment Care Association	• Post-closure end land uses. • Effective closure and site rehabilitation. • Closure and site rehabilitation approaches and standards.	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Opportunity for participation in site rehabilitation. • Membership decline due to population decline.

Stakeholder Group	Interests	Potentially relevant issues or concerns
	• Compliance with state environmental legislation and regulations.	
Mount Perry Community Development Board Mount Perry Tourist and Historical Society	• Post-closure end land uses. • Industry and regional development.	• Loss of community financial support. • Volunteer decline due to population decline. • Opportunity for use of decommissioned machinery.
Service Providers		
Service providers	• Mount Perry town viability, including access to services, property values, population. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain.	• Loss of community financial support. • Volunteer decline due to population decline. • Reduced demand for services.
Regional Community		
Regional communities, i.e., Gin Gin, Biggenden, Eidsvold and Monto	• Impact on local jobs and businesses. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain.	• Loss of employment and procurement opportunities.

2.4 Ongoing Engagement

Ongoing management of stakeholder engagement will be conducted according to the approaches listed in **Table 13** and according to the outline engagement objectives and methodology. Continued stakeholder engagement is a crucial part of collaborative closure planning and reaching appropriate land outcomes that meet the completion criteria of proposed PMLUs.

Table 13: Ongoing Stakeholder Engagement Approaches (Coffey 2020)

Stakeholder Group	Engagement approach
Landowners and communities	
Adjoining landowners	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Routine meetings (6 monthly or as required). • Continued town-hall meetings (12 monthly as required).
Local community, i.e., Mount Perry	• Continued town-hall meetings (12 monthly or as required). • Keep informed of key milestones through email updates, phone conversations or local media updates.
Employees, contractors and suppliers	
Current Mt Rawdon employees and contractors	• Quarterly presentations delivered to all employees and contractors. • Keep informed of key milestones through email updates, phone conversations or local media updates.
Local businesses and suppliers	• Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
Traditional owners	
Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or as required).
State and local government representatives	
Minister for Environment and the Great Barrier Reef Minister for Resources	• Routine meetings (12 monthly or as required).
Department of Environment and Science Department of Natural Resources, Mines and Energy	• Routine meetings (12 monthly or as required).

Stakeholder Group	Engagement approach
Department of State Development, Tourism and Innovation Department of Communities, Disability Services and Seniors	
Member for Callide Member for Bundaberg Member for Burnett	• Routine meetings (12 monthly or as required).
North Burnett Regional Council	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or as required).
Bundaberg Regional Council	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or as required).
Interest groups	
Burnett Mary Regional Group Burnett Catchment Care Association	• Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
Mount Perry Community Development Board Mount Perry Tourist and Historical Society	• Routine meetings (12 monthly or as required). • Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
Service providers	
Service providers	• Continued town-hall meetings (12 monthly or as required). • Keep informed of key milestones through email updates, phone conversations or local media updates.
Regional Community	
Regional communities, i.e., Gin Gin, Biggenden, Eidsvold and Monto	• Routine meetings (12 monthly or as required).

Closure Planning and Engagement

During the final stages of the MRO mining life, when decommissioning and progressive rehabilitation phases can be initiated, the frequency of stakeholder engagement and collaboration will increase throughout active closure events. These stages involve the development and negotiation of completion criteria, ongoing grievance resolution, logistical planning of closure execution and

ongoing monitoring post-closure. In the final years prior to closure, community members, landholders, traditional owners and interest groups will be engaged and encouraged to fulfill contractor positions as part of closure and decommissioning including assisting in the ongoing monitoring strategies and requirements.

The approach to stakeholder engagement during the stages leading up to and beyond closure, are listed in **Table 14.**

Table 14: Closure Planning Phases and Engagement (Coffey 2020)

Planning stage	Engagement Activity	Engagement tools
Operations (5 to 3 years until closure)	• Stakeholders engaged on post-mining land uses, including government representatives, landowners and local community. • Landowners and government representatives are engaged on the development of closure success criteria with documented agreement in place. • Community consultation plan updated annually to identify key affected people for engagement throughout closure process. • Scheduled periodic engagements (at least annual). • Grievances, comment and questions are recorded, managed and actioned as required.	• One-on-one meetings • Community information sessions • Focus group workshops
Pre-closure (Less than 3 years until closure)	• Final post-mining land uses are further discussed and reconfirmed with stakeholders and related rehabilitation methods align with the post-closure land use. • All employees and contractors have been engaged at the appropriate level of influence. • Key stakeholders (i.e., landowners, Traditional Owners, interest groups) are engaged and involved in the development of post-mining monitoring program. • Where interest exists, partnerships with stakeholders to assist monitoring activity required to achieve the closure objectives. • Scheduled periodic engagements (at least annual). • Grievances, comments and questions are recorded, managed and actioned as required.	• One-on-one meetings • Focus group workshops • Community information sessions • Community updates • E-mail distribution • Online website updates

Planning stage	Engagement Activity	Engagement tools
Closure execution and post-closure monitoring	• Where interest exists, partnerships with stakeholders for successful delivery of closure plan outcomes. • Agreed engagement process with stakeholders to provide details on progress on closure outcomes and achieving closure criteria. • Grievances, comments and questions are recorded, managed and actioned as required.	• Community information sessions • Focus group workshops • One-on-one meetings • Direct communication

PMLU Alignment

The proposed PMLUs align with stakeholder requests and support the resolution towards the general concerns raised throughout engagement (**See Table 15**). The purpose of the PMLUs is to support the local and broader community through economic, social, and environmental improvements. Where possible, MRO aims to provide employment opportunities and generate sustainable economic platforms to benefit the region post-closure. As discussed previously, the broader community was primarily concerned with employment loss, loss of financial support/donations from MRO, decline in population and reduction of members within community groups. MRO has prioritised these focal points throughout engagement and has actively investigated closure options.

Another point of concern surrounded the execution of rehabilitation and MRO has maintained transparency and involvement with the community in the planning processes. It has been widely accepted throughout stakeholder groups that MRO has satisfactorily met the expectations for the level of engagement.

Table 15: Alignment of PMLUs with Stakeholder Requests

Post-Mine Description	Consistency with CCP
Water storage for Agricultural Purposes	The addition of the water storage feature to the local landscape provides resource and economic opportunities for the community and broader region. This is achieved through providing the storage of water for the purpose of agricultural uses including, but not limited to, stock watering, cropping and general application on lands. Additionally, further opportunities exist in the form of tourism and the potential pumped hydroelectric system that is being investigated through a feasibility study. This will carry the added benefit of potential employment opportunities for the region which was a primary concern for residents.

Post-Mine Description	Consistency with CCP
Low-intensity grazing	The low intensity grazing landscape aligns with the landholders pre-mining land use and the landholders and the surrounding landscape. The underlying landholders gain economic benefit from the return of improved land and livestock grazing opportunity.
Open woodland	With ongoing support and development of associated community projects listed in the next section, open woodland provides opportunities to the community in the form of sustainable tourism, liveability and employment whilst also restoring ecological values to the area.
Stock water	Providing additional stock water resources to the underlying landholder improves grazing capabilities and the potential value of the land. The water resource has the potential of providing additional habitat and other ecological values to the area.

Ongoing Commitments

MRO has made commitments to relevant stakeholders to remain engaged throughout operation and the closure phases by ongoing meetings to review key concerns and impacts to the local and surrounding community. Annual meetings are also held collectively to address concerns, gather perspective, and gain insight into community expectations. This continued and inclusive dialogue with stakeholders allows for the objective review of actions taken and highlights where further attention is required for post closure outcomes.

Through this feedback, MRO has offered support to a wide array of stakeholders through donations, sponsorships and has encouraged groups such as the Mt Perry Community Development Board to work cooperatively with MRO in generating economically sustainable tourism opportunities such as the Mt Perry Summit walk and Tram restoration projects. The economic impact of closure on the broader community has been a flagged as a primary concern and MRO has taken proactive steps towards maximising employment opportunities through rehabilitation works and has encouraged the discussion of alternative PMLUs to generate future economic opportunities.

3 Post Mining Land Use

MRO prior land uses consisted of predominately grazing lands. It is proposed that once operations cease, to return lands to low-intensity grazing land where possible and open woodland to restore native ecosystems.

The following rehabilitation areas have been identified based on current operations and proposed PMLUs and objectives (see **Table 14**). ***Figure 27*** provides a map of MRO of the proposed PMLUs.

Table 16: Post-Mine Land Descriptions for MRO Rehabilitation areas

Rehabilitation area (RA)		Rehabilitation area description	Post-Mine Description
1	Residual Void (Pit)	MRO operates a single, open-cut pit with a surface area of 71.35 ha and a surface level of RL125 m AHD.	Water storage for low-intensity grazing/stock water
2	WRDs, Run of Mine (ROM) and stockpiles	The Northern WRD is utilised for the disposal of both NAF and PAF waste rock material. The facility covers an area of approximately 105 ha. The outer batters will remain at angle of repose as a rock face only. The Western Waste Rock Dump is utilised for temporary storage of NAF only. The final approved footprint of the facility is 73 ha however the current disturbance footprint is 49.1 ha. The ROM is utilised for temporary storage or ore until processing.	Low-intensity grazing/ open woodland Note: NWRD open woodland only as grazing is not practicable.
3	TSF	The TSF covers an area of 204ha.	Low-intensity grazing/ open woodland
4	Haul Roads and Access Tracks	The total disturbed area on site that has been allocated to haul roads (2ha), access roads, tracks and infrastructure corridors are approximately 25.69 ha.	Low-intensity grazing/ open woodland
5	Workshops and Infrastructure Management Areas	Most of the site infrastructure located at MRO is centralised to the processing area of the operation. The total disturbance area calculated for workshops and infrastructure management areas are approximately 17.86 ha	Low-intensity grazing/ open woodland
6	Water Management Infrastructure and Dams	Water management dams (excluding Perry River Dam) at MRO cover approximately 28.8 ha in total.	Stock Water

Low-intensity grazing / open woodland

The low-intensity grazing / open woodland PMLU areas within the Project area will be established primarily with pasture grasses in accordance with the key species identified in **Section 5.8** and **Section 7.1**. These areas will also include patches of sparse to moderately dense native canopy species and shrubs similar to that found in certain open woodland communities neighbouring the mining lease. These communities will provide shade for livestock and to a lesser degree, long term habitat for native fauna species.

Water Storage / Stock water

The storage of water within the residual void (pit) for the purpose of agricultural uses may include the application onto cropping lands through irrigation, frost control, pesticide and fertiliser applications and may also include stock watering (if water quality allows). Stock water PMLU will need to meet suitable water quality which can be of beneficial reuse for supplying water to cattle.

In accordance with Part 3 of the *Environmental Protection (Rehabilitation Reform) Amendment Regulation 2019*, each PMLU must meet the following outcomes:

- is viable, having regard to the use of land in the surrounding region, and
- satisfies at least one of the following-
    - the use is consistent with how the land was used before a mining activity was carried out on theland
    - the use is consistent with a development approval relating to the land
    - the use is consistent with a use of the land, other than a use that is mining, permitted under a Stateor Commonwealth Act, including, for example, a planning instrument under the Planning Act
    - the use will deliver, or is aimed at delivering, a beneficial environmental outcome.

The locations of the PMLUs are described in detail within the PRCP schedule. As the residual void is to be utilised as a water storage for agricultural use, there are no proposed Non-Use Management Areas (NUMAs).

The pre-mine land capability was assessed by Land Reclamation Services in 1996. This report assessed the land capability against Rosser *et al*. 1974, which continues to be the main method for land capability assessments today. Queensland Agricultural Land Classes can be seen in **Table 17.**

Table 17: Land Capability Classes

Class	Description
I	Suitable for permanent cultivation with few limitations
II	Suitable for permanent cultivation with slight limitations
III	Suitable for permanent cultivation with moderate limitations
IV	Suitable for occasional or limited cultivation with severe limitations
V	Unsuitable for cultivation; can be used for grazing when not flooded
VI	Unsuitable for cultivation; can be used for grazing and forestry with moderate limitations

VII	Unsuitable for cultivation but suitable for grazing and forestry with severe limitations
VIII	Unsuitable for cultivation, grazing and forestry

Land Reclamation Services (1996) classified the majority of land at MRO as Class VII and VIII. Class VIII land was mainly present on the deposit area itself (residual void). Some marginal Class VI existed on flatter slopes between drainage lines in the north and east of the MRO area. In general, the land was already cleared and pastures improved. No superior classes of land were noted to exist. Post-mine land capability classes for the rehabilitation areas at MRO are provided in the EA, included in **Table 18** and seen in **Figure 26.**

Table 18: Post-Mine Land Capability Classes for MRO Rehabilitation areas

Rehabilitation area	Post-Mine Land Capability Classification
Residual Void (Pit)	Water Storage
WRDs, Run of Mine (ROM), TSF and stockpiles	VII
Roads and Access Tracks	VI / VII
Workshops and Infrastructure Management Areas	VI
Water Management Infrastructure and Dams	Water Storage / VI

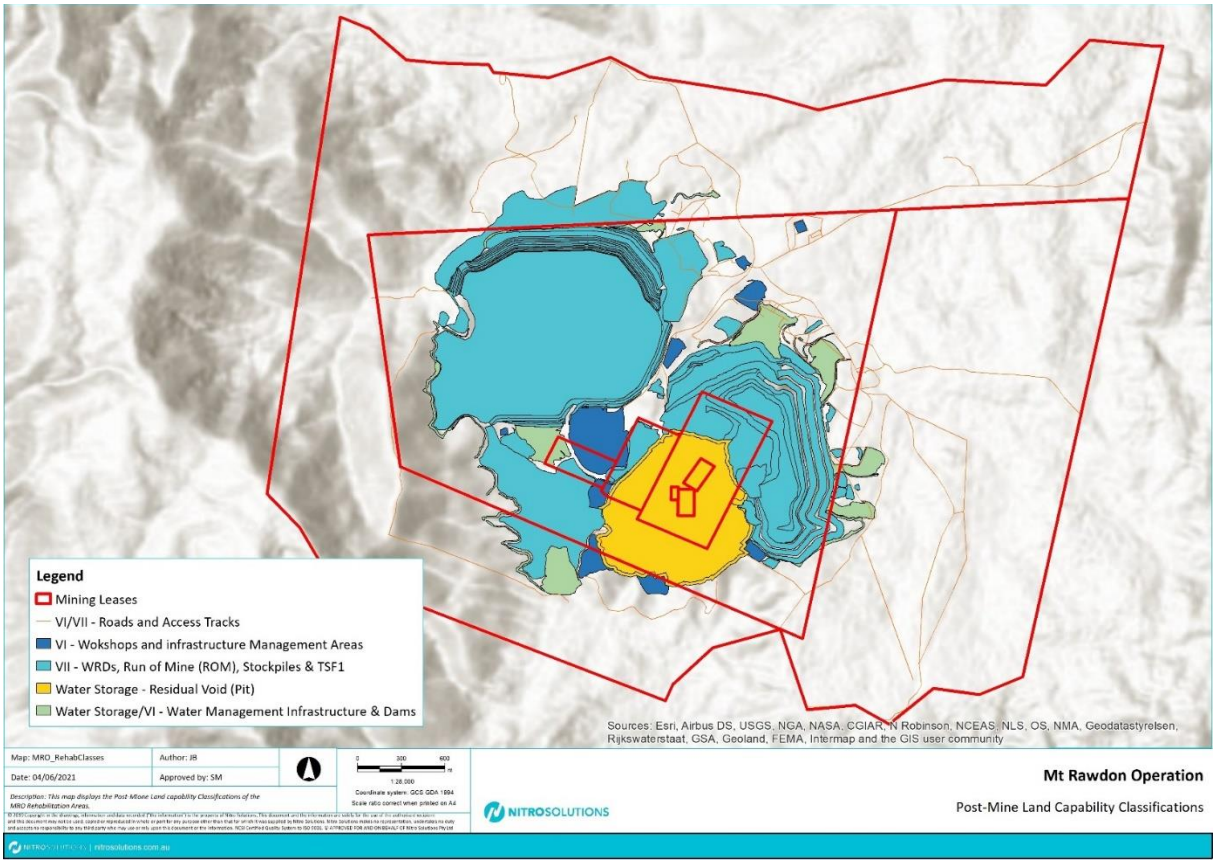


Figure 26: Rehabilitation Areas and Associated Land Capability Classification

3.1 Rehabilitation Goals

The rehabilitation goals for MRO have been developed to be consistent with the *EP Act*, that states that land must be rehabilitated to a stable condition (Section 111A) meeting the following:

- The land is safe and structurally stable;
- There is no environmental harm being caused by anything on or in the land; and
- The land can sustain a post-mining land use.

With reference to MRO baseline information, relevant guidelines and the EA, the following site rehabilitation goals have been developed for MRO:

- Compliance with statutory conditions and commitments is maintained;
- The site does not present a safety hazard to people, fauna or stock;
- Constructed landforms such as waste dumps and tailings storage facilities are geochemically stable and do not create significant impacts on surface water or groundwater quality;
- Landforms are stable and do not compromise post-activity land use;
- Any potentially contaminated areas are remediated according to the Land Management Plan;
- In rehabilitation areas not constrained by landform, post-activity land use will be bushland with the potential for low-intensity grazing (land suitability Class VI); and
- In rehabilitation areas constrained by landform (pit, WRD batters and TSF batters), post-activity land suitability will be Class VII.

The International Council on Mining and Metals provides a Key Performance Indicators Tool for Closure, which define key performance areas for assisting to define closure criteria of rehabilitated mines.

Key performance areas include:

- Closure risk and management systems;
- Financial;
- Stakeholder engagement and social impact; and
- Operational Management.

As recognised in the PRCP Guideline, it is reinforced that during the life of the mine continued rehabilitation monitoring, methodologies, technology and strategies may be refined based on advancements or limitations within the industry. The utilisation of a KPI framework supplements this approach enabling flexibility in rehabilitation criteria whilst still meeting the baseline requirements of closure management.

All of the key performance areas have been addressed within the risk assessment (**Section 5.7**) and integrated into the long term rehabilitation methodology.

MRO has taken a holistic approach to define objectives and principles that will underpin the rehabilitation process. Specific consideration has been given to accounting for external factors that may/likely impact rehabilitated areas achieving milestones. These impacts include and are not limited to, climate change resulting in unprecedented events (e.g. flooding, fire, extended drought, extreme temperatures outside of normal periods).

Rehabilitation Objectives and Completion Criteria

Objectives, indicators and completion criteria have been developed for each PMLU. These are outlined in **Table 19 - Table 22**. A description of each rehabilitation area, its current use and proposed PMLU is described below.

Based on the MRO rehabilitation goals, the below tables provide rehabilitation requirements and specifications for each MRO rehabilitation area as follows.

- Rehabilitation area number;
- Rehabilitation area name and area;
- Rehabilitation objectives for the rehabilitation area;
- Completion criteria that will demonstrate the achievement of the objective; and
- Rehabilitation indicators that are used to validate the achievement of the completion criteria.

Climate Change

Varying climatic conditions related to climate change presents significant implications on rehabilitation objectives, completion criteria and the PRCP schedule. It is discussed throughout this PRCP the requirement to include climate variability into all aspects of rehabilitation, to enable long term success of rehabilitated areas.

Where applicable, climate change has been addressed in the risk assessment (**Section 5.7**) to account for the associated risk of unprecedented events.

Table 19: Performance Indicators/Completion Criteria for PMLU: Low-intensity Grazing

PMLU –Low-Intensity Grazing				
Landform Objective	**Rehabilitation Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be stable	Landscape Function Analysis (Tongway and Hindley, 2004) Stability Index	Landform is functional and performing as it was designed to do	Provides a measure of the stability of the site and trending toward surrounding landscape	Monitored at time of planting and every two (2) years following for a total of 10 years
	Landscape Function Analysis (Tongway and Hindley, 2004) Infiltration		Indicates the site infiltration ability and trend toward adjacent areas within the same soil units.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Nutrient Cycling		Indicates the sites ability to cycle nutrients and trending towards adjacent landscape	
	Landscape Function Analysis (Tongway and Hindley, 2004) Landscape organisation		Indicates the sites ability to retain resources and that is comparable to surrounding same land uses.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Erosion assessment	Areas of active erosion are limited	Provides an assessment of the number of gullies or rills within a 50 m transect and these are limited and stabilising	Monitoring at time of planting and annually post wet season for a total of 10 years

PMLU –Low-Intensity Grazing				
Landform Objective	**Rehabilitation Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be non-polluting	Levels of land contamination after removal of all infrastructure and remediation of land	Land is formally approved as free of contamination	A site suitability statement is provided by an approved auditor that the land is not contaminated and suitable for the intended use	To occur prior to topsoil placement
	Water quality at permanent downstream monitoring locations and retained water infrastructure	Surface water in downstream monitoring locations is to be representative of historical downstream water quality ranges.	Surface water sampled downstream indicates consistent trend of stabilised parameters of water quality consistent with surrounding or upstream water quality. No evidence of contamination present that impacts fauna and flora	Bi-annually (pre and post wet season) for the first five (5) years and then subsequently annually for each year up to year 10. Opportunistic sampling is encouraged after major rainfall events
	Groundwater quality within permanent monitoring bores	Groundwater quality is consistent with background reference data or modelled predictions	Groundwater quality is within modelled predictions and shows no evidence of contamination or leachate impacting water quality	Quarterly for the first four (4) years Bi-annually for years 5-8 Annually for years 9-10
Ecosystem and Land use Establishment	Pasture mass	Growth of pasture species	Pasture mass (t/ha) is trending towards a sustainable grazing site Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation	Sites are monitored within 12 months of planting and annually every year for 10 years, at the end of the growing season (April-May)

PMLU –Low-Intensity Grazing				
Landform Objective	**Rehabilitation Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
	Vegetation Diversity	Diversity of shrubs and juvenile tress	Diversity of shrubs and juvenile trees with stem diameter <5cm Minimum of 60% of target species established according to species list Percentage of shrubs and juvenile trees comparable to surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years
		Exotic species richness	Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas Weeds present no more than >5 individuals or 10 m^2	Sites are monitored within 12 months of planting and annually every year for 10 years
	Ecosystem Composition	Herbs and Grasses	The number of herb, forb and grass species is comparable to the surrounding similar land uses Minimum of 60% of target species established according to species list	Sites are monitored within 12 months of planting and annually every year for 10 years
	Protective ground cover	Perennial plant cover (<0.5 m)	Percentage of ground cover provided by perennial vegetation (<0.5 m) in height is comparable to surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years

PMLU –Low-Intensity Grazing				
Landform Objective	**Rehabilitation Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
		Total Ground Cover	Total ground cover is the sum of protective ground cover components (as above) and is comparable to surrounding similar land uses.	Sites are monitored within 12 months of planting and annually every year for 10 years
		Soil structure and chemical composition	Soil sampling is to determine the soil structure and chemical composition for optimal seed growth	Sites are monitored within 12 months of planting and annually every year for 10 years

Table 20: Performance Indicators/Closure Criteria for PMLU: Open Woodland

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be stable	Landscape Function Analysis (Tongway and Hindley, 2004) Stability Index	Landform is functional and performing as it was designed to do	Provides a measure of the stability of the site and trending toward surrounding landscape	Monitored at time of planting and every two (2) years following for a total of 10 years
	Landscape Function Analysis (Tongway and Hindley, 2004) Infiltration		Indicates the site infiltration ability and trend toward adjacent areas within the same soil units.	

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
	Landscape Function Analysis (Tongway and Hindley, 2004) Nutrient Cycling		Indicates the sites ability to cycle nutrients and trending towards adjacent landscape	
	Landscape Function Analysis (Tongway and Hindley, 2004) Landscape organisation		Indicates the sites ability to retain resources and that is comparable to surrounding same land uses.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Erosion assessment	Areas of active erosion are limited	Provides an assessment of the number of gullies or rills within a 50 m transect and these are limited and stabilising	Monitoring at time of planting and annually post wet season for a total of 10 years
Land is to be non-polluting	Levels of land contamination after removal of all infrastructure and remediation of land	Land is formally approved as free of contamination	A site suitability statement is provided by an approved auditor that the land is not contaminated and is suitable for the intended use	To occur prior to topsoil placement
	Water quality at permanent downstream monitoring locations and retained water infrastructure	Surface water in downstream monitoring locations is to be representative of historical downstream water quality ranges.	Surface water sampled downstream indicates consistent trend of stabilised parameters of water quality consistent with surrounding or upstream water quality.	Bi-annually (pre and post wet season) for the first five (5) years and then subsequently annually for each year up to year 10.

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
			Not evidence of contamination present that impacts fauna and flora	Opportunistic sampling is encouraged after major rainfall events
	Groundwater quality within permanent monitoring bores	Groundwater quality is consistent with background reference data or modelled predictions	Groundwater quality is within modelled predictions and shows no evidence of contamination or leachate impacting water quality	Quarterly for the first four (4) years Bi-annually for years 5-8 Annually for years 9-10
Ecosystem and Landuse Establishment	Pasture mass	Growth of pasture species	Pasture mass (t/ha) is trending towards a sustainable grazing site Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation	Sites are monitored within 12 months of planting and annually every year for 10 years, at the end of the growing season (April-May)
Vegetation Diversity	Diversity of shrubs and juvenile trees	Vegetation contains a diversity of species comparable to surrounding land uses	Diversity of shrubs and juvenile trees with stem diameter <5cm Minimum If 60% of target species established according to species list percentage of shrubs and juvenile trees comparable to	Sites are monitored within 12 months of planting and annually every year for 10 years

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
			surrounding similar land uses	
	Exotic species richness		Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas Weeds present no more than >5 individuals or 10 m^2	Sites are monitored within 12 months of planting and annually every year for 10 years
Vegetation Density	Density of shrubs and juvenile trees	Vegetation contains a density of species comparable to similar land uses	Density of shrubs or juvenile trees with a stem diameter <5cm is comparable to that of surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years
	Herbs and Grasses	The vegetation is comprised of a range of growth forms comparable to surrounding similar land uses Minimum If 60% of target species established according to species list	The number of herb, forb and grass species is comparable to the surrounding similar land uses	
	Trees and Shrubs		The number of tree species regardless of age comprising the vegetation community is	

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
			comparable to that of surrounding similar land uses	
Protective Ground Cover	Perennial plant cover (<0. 5 m)	Ground layer contains the protective ground cover and habitat structure comparable with surrounding similar land uses	Percentage of ground cover provided by perennial vegetation (<0.5 m) in height) is comparable to surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years
	Total Ground Cover		Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses	
Ecosystem Health	Live Trees	The vegetation is in a condition comparable to surrounding similar land uses	Percentage of the tree population which are in healthy condition and that the percentage is comparable to surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years
	Healthy Trees		Percentage of the tree population which are in health condition and that the percentage is	

PMLU – Open Woodland				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
			comparable to surrounding similar land uses	
	Flowers/Fruit Trees		Percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of surrounding similar land uses	Sites are monitored within 12 months of planting and annually every year for 10 years - the timing of monitoring may require adjustment based on opportunistic weather conditions for flowering/fruiting species

Table 21: Performance Indicator/Completion Criteria for PMLU: Stock Water / Low-intensity Grazing

PMLU – Stock Water				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be stable	Landscape Function Analysis (Tongway and Hindley, 2004) Stability Index	Landform is functional and performing as it was designed to do	Provides a measure of the stability of the site and trending toward surrounding landscape	Monitored at time of planting and every two (2) years following for a total of 10 years
	Landscape Function Analysis (Tongway and Hindley, 2004) Infiltration		Provides an indication of the site infiltration ability and trend toward adjacent areas within the same soil units.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Nutrient Cycling		Provides an indication of the sites ability to cycle nutrients and trending towards adjacent landscape	
	Landscape Function Analysis (Tongway and Hindley, 2004) Landscape organisation		Provides an indication of the sites ability to retain resources and that is comparable to surrounding same land uses.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Erosion assessment	Areas of active erosion are limited	Provides an assessment of the number of gullies or rills within a 50 m transect and these are limited and stabilising	Monitored at time of planting and every two (2) years following for a total of 10 years

PMLU – Stock Water				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be non-polluting	Levels of land contamination after removal of all infrastructure and remediation of land	Land is formally approved as free of contamination	A site suitability statement is provided by an approved auditor that the land is not contaminated and suitable for the intended use	To occur prior to topsoil placement
	Water quality	Water quality of water is within acceptable stock drinking limits	Water testing has been conducted on surface water (ANZECC 2000) to ensure livestock standards have been achieved	Bi-annually (pre and post wet season) for the first five (5) years and annual for each year after for 10 years
	Groundwater quality within permanent monitoring bores	Groundwater quality is consistent with background reference data or modelled predictions	Groundwater quality is within modelled predictions and shows no evidence of contamination or leachate impacting water quality	Quarterly for the first four (4) years Bi-annually for years 5-8 Annually for years 9-10
Ecosystem and Landuse Establishment	Pasture mass	Growth of pasture species	Pasture mass (t/ha) is trending towards a sustainable grazing site Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation	Sites are monitored within 12 months of planting and annually every year for 10 years, at the end of the growing season (April-May)

PMLU – Stock Water				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Vegetation Diversity	Diversity of grasses and herbs trees	Vegetation contains a diversity of species comparable to surrounding land uses	Percentage of shrubs and juvenile trees comparable to surrounding similar land uses Minimum If 60% of target species established according to species list	Sites are monitored within 12 months of planting and annually every year for 10 years
	Exotic species richness		Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas Weeds present no more than >5 individuals or 10 m^2	
Vegetation Density	Herbs and Grasses	The vegetation is comprised of a range of growth forms comparable to surrounding similar land uses	The number of herb, forb and grass species is comparable to the surrounding similar land uses Minimum If 60% of target species established according to species list	Sites are monitored within 12 months of planting and annually every year for 10 years
Protective Ground Cover	Perennial plant cover (<0.5 m)	Ground layer contains the protective ground cover and habitat structure	Percentage of ground cover provided by perennial vegetation (<0.5 m) in	Sites are monitored within 12 months of planting and

PMLU – Stock Water				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
		comparable with surrounding similar land uses	height) is comparable to surrounding similar land uses	annually every year for 10 years
	Total Ground Cover		Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses	

Table 22: PMLU - Water Storage Performance Indicators/Completion Criteria

PMLU – Water Storage				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be stable	Landscape Function Analysis (Tongway and Hindley, 2004) Stability Index	Landform is functional and performing as it was designed to do	Provides a measure of the stability of the site and trending toward surrounding landscape	Monitored at time of planting and every two (2) years following for a total of 10 years
	Landscape Function Analysis (Tongway and Hindley, 2004) Infiltration		Provides an indication of the site infiltration ability and trend toward adjacent areas within the same soil units.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Nutrient Cycling		Provides an indication of the sites ability to cycle nutrients and trending towards adjacent landscape	
	Landscape Function Analysis (Tongway and Hindley, 2004) Landscape organisation		Provides an indication of the sites ability to retain resources and that is comparable to surrounding same land uses.	
	Landscape Function Analysis (Tongway and Hindley, 2004) Erosion assessment	Areas of active erosion are limited	Provides an assessment of the number of gullies or rills within a 50 m transect and these are limited and stabilising	Monitored at time of planting and every two (2) years following for a total of 10 years

PMLU – Water Storage				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Land is to be non-polluting	Levels of land contamination after removal of all infrastructure and remediation of land	Land is formally approved as free of contamination	A site suitability statement is provided by an approved auditor that the land is not contaminated and suitable for the intended use	To occur prior to topsoil placement
	Water quality	Water quality of water is within acceptable stock drinking limits	Water testing has been conducted on surface water (ANZECC 2000) to ensure livestock standards have been achieved	Bi-annually (pre and post wet season) for the first five (5) years and annual for each year after for 10 years
	Groundwater quality within permanent monitoring bores	Groundwater quality is consistent with background reference data or modelled predictions	Groundwater quality is within modelled predictions and shows no evidence of contamination or leachate impacting water quality	Quarterly for the first four (4) years Bi-annually for years 5-8 Annually for years 9-10
Ecosystem and Landuse Establishment	Pasture mass	Growth of pasture species	Pasture mass (t/ha) is trending towards a sustainable grazing site Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation	Sites are monitored within 12 months of planting and annually every year for 10 years, at the end of the growing season (April-May)

PMLU – Water Storage				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
Vegetation Diversity	Diversity of grasses and herbs trees	Vegetation contains a diversity of species comparable to surrounding land uses	Percentage of shrubs and juvenile trees comparable to surrounding similar land uses Minimum If 60% of target species established according to species list	Sites are monitored within 12 months of planting and annually every year for 10 years
	Exotic species richness		Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas Weeds present no more than >5 individuals or 10 m^2	
Vegetation Density	Herbs and Grasses	The vegetation is comprised of a range of growth forms comparable to surrounding similar land uses	The number of herb, forb and grass species is comparable to the surrounding similar land uses Minimum If 60% of target species established according to species list	Sites are monitored within 12 months of planting and annually every year for 10 years
Protective Ground Cover	Perennial plant cover (<0.5 m)	Ground layer contains the protective ground cover and habitat structure	Percentage of ground cover provided by perennial vegetation (<0.5 m) in	Sites are monitored within 12 months of planting and

PMLU – Water Storage				
Landform Objective	**Performance Indicator**	**Completion Criteria**	**Completion Performance Indicators Description**	**Monitoring Requirements**
		comparable with surrounding similar land uses	height) is comparable to surrounding similar land uses	annually every year for 10 years
	Total Ground Cover		Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses	

Rehabilitation for Identified Threatened Fauna Species

Fauna species play an important part in the functioning of healthy native ecosystems and play an equally important role in their development. When it comes to the rehabilitation of disturbed land however, monitoring for the presence of various fauna species is often less common than monitoring of various structural vegetation characteristics. One of the reasons for this is due to the misconception that fauna will return unaided after the establishment of vegetation. This is commonly known as the 'flora equals fauna' paradigm as there is very little imperial evidence to support this trend (Critescu et al., 2012).

In considering this, rehabilitation completion criteria specifically related to the threatened fauna species identified within the MRO area (during the 1995 and 2013 survey events) have not been defined in this management plan. Given that the proposed monitoring period for the rehabilitated areas has been nominally set to 10 years, it is improbable to expect fauna species to reoccupy these areas within that timeframe. All efforts will be made to ensure that PMLUs are progressing towards becoming self-sufficient native ecosystems which will likely provide suitable habitat for fauna species once they have become properly established and mature over time.

The rehabilitation of these areas will aim to restore similar species and vegetation communities to these areas based on those communities present before their disturbance. These areas previously provided suitable habitat for the Greater Glider and Little Pied Bat in the form of suitable hollow-bearing trees. Rehabilitation efforts will aim to ensure that similar species are reintroduced and monitored as part of the completion criteria.

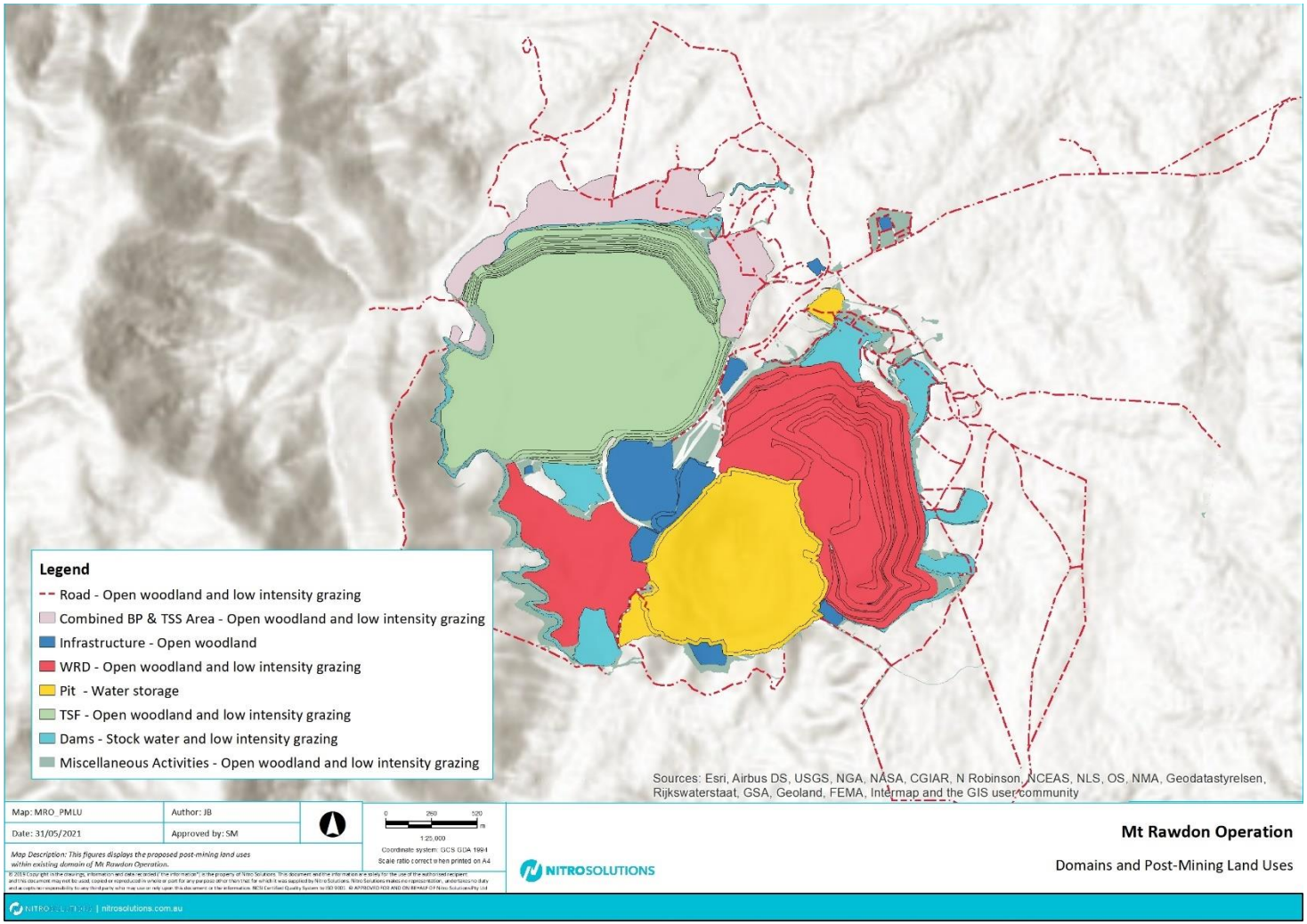


Figure 27: MRO Rehabilitation Areas and Post Mining Land Uses

3.2 Regulatory Constraints

Effective justification of a PMLU must consider regulatory constraints, including but not limited to local and regional land use plans, Indigenous Land Use Agreements, registered locations of European heritage, and endangered species. Based upon an assessment of these potential regulatory constraints (outlined below) only one, the *North Burnett Planning Scheme*, was identified as having any regulatory pressure across the MRO area.

North Burnett Planning Scheme

The MRO area is located within the *North Burnett Planning Scheme* (NBPS) and is listed as an Extractive Mineral Resource on their Strategic Framework Mapping. In accordance with this mapping, the dominant land uses in the areas surrounding MRO include:

- Rural;
- Nature Conservation or Open Space;
- Extractive Mineral Resource; and
- Waterbody, Waterway or Wetland.

Under the NBPS there is an Extractive industry code to ensure that all extractive industries operate in a way that benefits the local community and in a way that available resources are not overridden by adverse environmental and/or amenity impacts. *Table 9.3.5* of the NBPS goes as far as outlining two (2) Performance Outcomes (POs) which should be taken into consideration when rehabilitating extractive mineral resource areas. These objectives have been listed below in **Table 23**.

Table 23: Rehabilitation Performance Outcomes (POs) Listed in the Northern Burnett Planning Scheme

Performance Outcome	Acceptable Outcomes
PO8 Rehabilitation is carried out in accordance with a management plan providing for: a) Progressively staged rehabilitation works; b) Appropriate clean-up works (taking particular account of areas of possible soil contamination); c) Agreed landform and soil profiles; d) Suitable revegetation; and e) Establishment phase requirements.	No specific outcome defined
Rehabilitation allows for suitable use of any water bodies created through the extraction process, having regard to water quality, hydraulic conditions, landform and vegetation.	No specific outcome defined

In accordance with the NBPS, portions of the MRO are also located across areas identified as:

- Electricity Transmission Line Corridors (Infrastructure Overlay); and
- Bushfire Prone Areas – Medium, High and Very High Potential (Natural Hazards Overlay).

Bushfire Prone Area

Whilst there are no specific requirements for the implementation of a Bushfire Management Plan for rehabilitated lands within these Bushfire Prone areas, retaining water infrastructure will provide water resources in the landscape for bushfire management. Relevant bushfire management considerations and climate change impacts are discussed in greater detail in **Section 5.7.**

Cultural Heritage

European Heritage

An archaeological assessment was undertaken to identify any cultural heritage values present within the MRO area (Lilley, 1995a). This study included an investigation of any field archaeological evidence of previous mining operations, archived documentation, and local oral historical knowledge.

It was identified that following the discovery of alluvial gold in 1946, a small-scale mining operation was conducted between 1950 and 1953. Remains of this initial mining operation were discovered at MRO and included a stamping battery in poor condition and dry-stone walling in good condition. Despite this however, these findings rank low in scientific (archaeological), aesthetic, historical and social significance. The place is of local cultural heritage interest and is not considered to be of regional or national significance but may contribute to tourism opportunities for the area.

Aboriginal Significance

The region surrounding the MRO was once inhabited by the Gooreng people. Previous archaeological surveys (Lilley, 1995b) did not locate any sites of significance to contemporary Aboriginal people. A single flaked stone artefact was found at the edge of the tailings dam. The landscape in the MRO area has been substantially modified by clearing for grazing, earlier mining activities and exploration drilling. The types of rocks occurring in the MRO are unsuitable for stone implements that Aboriginal people utilised. Because of these factors, there is little likelihood of any significant cultural heritage site remaining undetected in the areas proposed for disturbance. A Cultural Heritage Management Agreement (CHMA) has been prepared in consultation with the First Nations Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda People Aboriginal Corporation RNTBC for the CHMA Area. The CHMA was developed to guide how best to manage any MRO impacts on Aboriginal Cultural Heritage in the CHMA Area.

Specific management procedures have been prepared to ensure that all MRO Activities will recognise, protect, and manage Aboriginal Cultural Heritage in compliance with the requirements of the CHMA and the First Nations Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda People.

Based on archaeological research and previous consultancy work the following site types have been identified as potentially occurring throughout the MRO:

- Occupation sites/campsites incorporating stone artefacts as isolates and in low to medium density scatters, particularly in proximity to fresh, permanent or semi-permanent water sources;
- Sources of raw lithic materials such as silcrete, siltstone and chert and associated artefacts relating to utilisation of these resources; and
- Scarred trees and other culturally significant trees (e.g. medicinal/food resources) in areas of remnant vegetation, particularly within riparian corridors;

It is predicted that the site types listed above are the most likely to occur across the MRO, especially artefacts as isolates and scatters of varying densities associated with ridge tops and creeks. Sites such as these reflect the general use of the area by Aboriginal people over time and may represent both transitory and more permanent campsites and activity areas.

A search of the State Aboriginal Cultural Heritage Database and Register did not reveal any recorded sites within the study area. The search results stated that it is probable that the absence of recorded Aboriginal cultural heritage places reflects a lack of previous cultural heritage surveys of the area.

3.3 Assessment

Multiple PMLUs were identified as potentially suitable for potential use at MRO, with each one assessed based on its applicability under the *Progressive Rehabilitation and Closure Plan Guideline* (PRCP Guideline) criteria of ten cost/benefit criteria. These potential PMLUs include:

- Low-intensity grazing;
- Woodland;
- Cropping – designated selection for TSF only;
- Native ecosystem;
- Wetlands – designated selection for water infrastructure only;
- Pasture; and
- Factory/Industrial Zone – workshop area with remaining infrastructure only.

Assessment of each PMLU and its applicability is outlined in **Table 24**. A scoring system was developed based against the cost/benefit criteria outlined in the PRCP Guideline. The sum of all scores across PMLUs was used to compare options. Of the various methods available for assessing different PMLUs (i.e. methodology and milestones), constraints are similar and based upon the long-term goal of a self-sustaining landform.

The assessment scale was based on a rating of 1 to 5; with 1 considered to be inconsistent or unachievable with in relation to the surrounding landscape; and 5 indicating a feasible and applicable outcome based on the surrounding landscape. These scores enabled an equal assessment of all the proposed PMLUs to identify the most acceptable and feasible option.

The results of this assessment identified three (3) potential PMLUs which could be discounted straight away: Cropping and Native Ecosystems (scores of 20 and 32 respectively). Cropping and Pasture as a PMLU, specifically on Tailings Storage Facility (TSF) areas, has been discounted due to the potential chemical limitations of the area. Heavy metals such as cadmium and arsenic can often lead to complications for gold mines as consideration for any surface water and contaminated lands that could contain harmful elements needs to be assessed prior to approving a cropping-based land use. Specific testing of persistent chemicals would be required as part of the *Livestock Production Assurance* (LPA), the *Biosecurity Regulation 2016* and in accordance with *the Australian Pesticides and Veterinary Medicines Authority*. The long-term feasibility of conducting this testing to achieve an approved PMLU was considered restrictive and high risk.

The use of Native Ecosystems as another PMLU was also discounted based primarily on the surrounding land uses. Establishing a fragmented native ecosystem in a grazing landscape was not considered suitable in terms of fauna and flora populations.

As shown in **Table 24**, three (3) potential PMLUs received high scores including; Low intensity grazing, woodlands and wetlands (40, 37 and 37 respectively). Based upon this analysis, a combination of these PMLUs is proposed in designated areas to improve habitat for flora and fauna whilst also remaining consistent with surrounding land uses. It is noted that the use of Wetlands will be restricted to final voids where suitable water storages will be located. The conversion to a wetland would also serve a dual purpose of restoring a native ecosystem and providing water for stock. Further discussion is provided in **Section 5.7** about a current rehabilitation trial of wetland development as a PMLU. Documented success of this trial may enable justification for other water storages to be retained as a wetland. This will evolve as the wetland trial is completed and monitoring is continued.

This assessment determined that low intensity grazing and open woodland are the most appropriate PMLUs for the majority of the rehabilitation areas and proposed within the MRO. These proposed

PMLUs fit within the 4th level of the rehabilitation hierarchy in comparison to Cropping zones as a PMLU which are considered to fall in the 6th level of the hierarchy.

Retaining partial infrastructure areas for factory/industrial use by future land managers has also been identified as a future option which needs to be considered. Potential contamination resulting from a high level of consistent hydrocarbon use within these areas will, however need to be considered and remediated before handover to land managers can occur.

Table 24: Assessment of PMLU options

Considerations	PMLU Options						
	Low-Intensity Grazing	Woodland	Cropping Zone (*TSF only*)	Native Ecosystem	Wetlands (water infrastructure only)	Pasture	Factory/ Industrial Zone (*Infrastructure*)
Physical constraints	4	4	2	4	4	3	3
Chemical constraints	3	4	1	4	3	3	3
Available materials	5	5	1	4	2	2	5
Relative Cost	4	4	1	3	2	1	4
Economic benefits for the community/ landholder	4	2	3	1	1	3	4
Environmental benefits	3	4	1	5	5	1	1
Social value	2	2	4	2	2	3	4
Compatibility with surrounding land uses	5	5	1	2	2	2	1
Prior land use	5	2	1	2	1	1	1
Compatibility with planning instruments under the *Planning Act 2016*	5	5	5	5	5	5	4
Total Score	40	37	20	32	27	24	30

The following score summary is listed in order of suitability and preference:

1. Low Intensity Grazing = 40
2. Woodland = 37
3. Native Ecosystem = 32
4. Factory Industrial Zone = 30
5. Wetlands = 27
6. Pasture = 24
7. Cropping (TSF) = 20

Whilst the NBPS does not specifically outline acceptable land uses for this region, based upon the available planning scheme mapping of the broader area, these PMLUs are consistent with

surrounding land uses. These PMLUs will be developed in accordance with the rehabilitation POs defined in the NBPS and outlined in **Table 23** for extractive mineral resource areas.

These proposed PMLUs were also assessed against the rehabilitation hierarchy of the Rehabilitation requirements for mining resources activities (ESR/2016/1875). The hierarchy provides a scale of decreasing capacity to prevent or minimise environmental harm and includes the following steps:

1. Avoid disturbance that will require rehabilitation;
2. Reinstate a "natural" ecosystem as similar as possible to the original ecosystem;
3. Develop an alternative outcome with a higher economic value than the previous land use;
4. Reinstate previous land use (e.g. grazing or cropping);
5. Develop lower value land use; and
6. Leave the site in an unusable condition or with the potential to generate future pollution or adversely affect environmental values.

Post Closure Infrastructure Retention

Selected infrastructure will remain onsite to provide economic benefits for the community or future landholders. A letter of intention of infrastructure for post-closure use was submitted to the Department of Environment and Heritage Protection by Evolution Mining in April 2017. The letter proposed that the PMLU of MRO is grazing, based on prior land use. As the owners of Swindon Station, MRO will retain the following infrastructure to be consistent with the requirement of the PMLUs:

- Site roads and tracks;
- Raw water dams and associated pipework;
- Sheds;
- Infrastructure to supply power to the site (powerlines, substation, switchyard); and
- Groundwater bores.

The additional retention of pumping infrastructure (e.g. pipelines) will also remain in place where possible, to improve water movement capabilities of the property.

A map of all proposed retained infrastructure is provided in **Figure 28.**

Roads and Tracks

Only site haul roads will be rehabilitated to reduce the width to allow for light vehicle access. Remaining l roads will be retained for future landholder use post mine closure.

Permanent Water Management Infrastructure

Infrastructure to supply water to the site including all Raw Water dams and associated pipework will be retained for landholder use post mine closure.

Rehabilitation of Raw Water Dams will commence once water qualities within each dam meet the completion criteria required for relinquishment.

Rehabilitation of dams includes the desilting and excavation of the floor of the dam up to 500 mm to remove any contaminants. The floor of each dam will then be assessed and analysed to determine if additional excavation is required to remove any further contaminated material or certified by an accredited Land Contamination assessor/auditor to confirm the absence of any land contamination.

This will contribute to providing suitable conditions for drinkable water for livestock in accordance with the EA water quality limits and *ANZECC Guidelines 2000*.

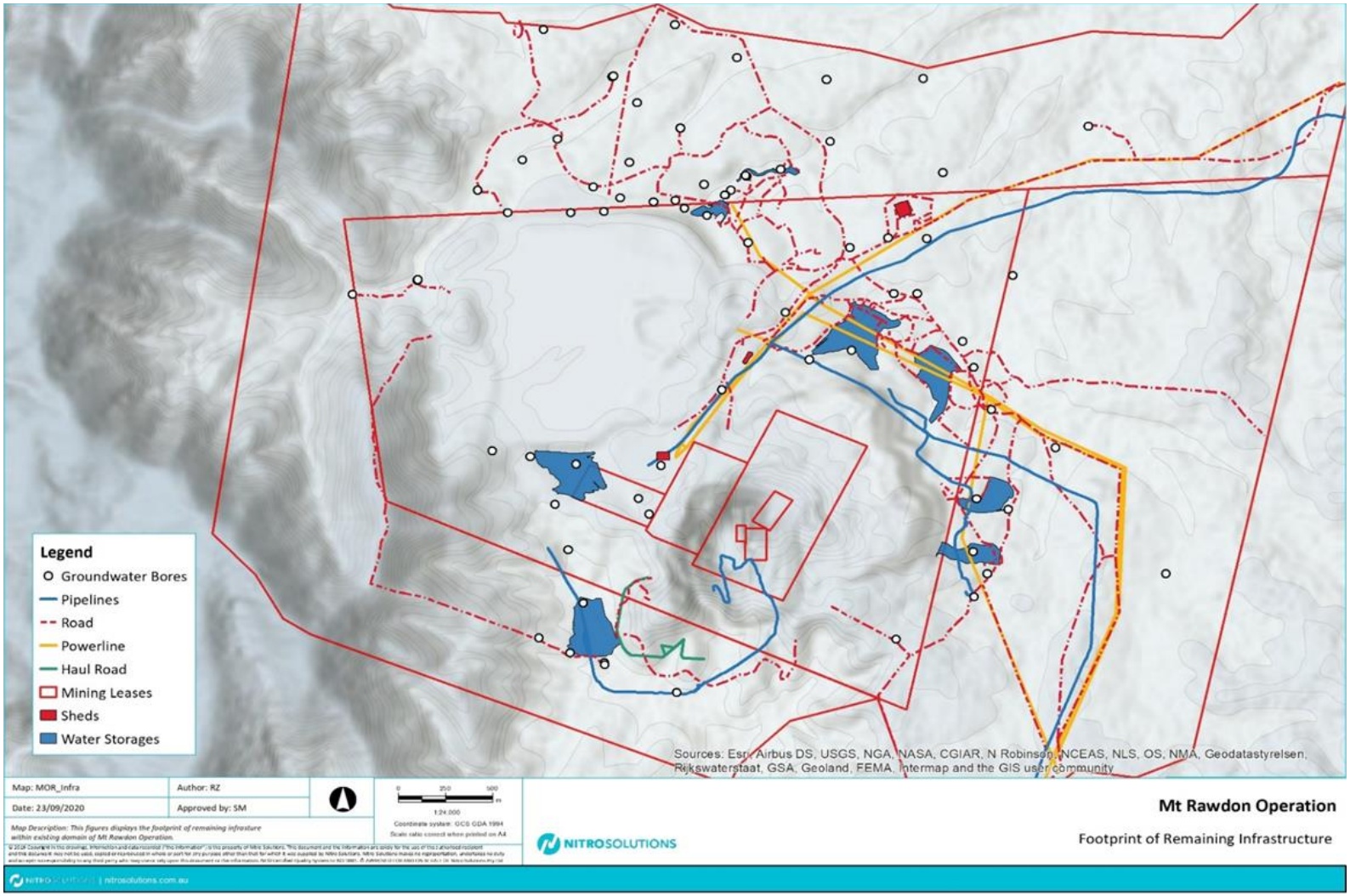


Figure 28: Intended retained infrastructure at MRO

Development of a Rehabilitation Procedure for Water Holding Structures will be developed upon decommissioning of the first available structure and will be used for rehabilitation management water quality for all retained structures. The procedure will include processes for scheduled water monitoring and dam inspections to ensure water quality is consistent with the required parameters. Where water quality is not within acceptable parameters, alternative measures to water purification/management will be explored.

Table 25 provides a summary of all proposed retained water-holding structures and their estimated final capacity based on final disturbance footprints and as constructed designs.

Table 25: Raw Water Dam Retained Volume

Dam	SD3	WD1	WD2	WD3	WD4	South	West	TOTAL
RL (m AHD)	117.5	119.4	115.5	123.5	127.8	135.5	108.9	
Area (ha)	2.8	1.13	1.17	0.89	0.33	1.46	1.26	9.41 ha
Max Retained Volume (ML)	60	221	102	36	72	330	397	1,218 ML

Sheds

The following specific sheds located across MRO site will be retained for landholder use post mine closure:

- Stores/ Warehouse Facility Shed;
- Fixed Plant Maintenance Workshop Shed; and
- Processing Area Storage Shed.

Services

The following specific infrastructure to supply power to the site will be retained for landholder use post mine closure:

- Powerlines;
- Substation; and
- Switchyard.

Internal powerlines and pipelines associated with the administration areas, workshops and other infrastructure areas being decommissioned will be dismantled and removed.

Groundwater Bores & Associated Pumping Infrastructure

All groundwater bores and any associated pumping infrastructure will be retained for landholder use post mine closure.

Statutory Constraints to be Imposed

Few statutory constraints are expected to be imposed on future land managers of MRO. Based on assessments and pre-existing land types and uses, low-intensity grazing has been selected due to the low availability of feed for grazing, based on the prior land use and existing environment (e.g. vegetation, rainfall, soil structure, etc.). This will incur limits on stocking rates to be appropriate for the final land-use type. Any future restrictions on stocking rates are to be described in a Land Management Plan that will be adopted by future land managers. It is recommended that the Land Management Plan be developed following pasture development and completion of a minimum of three (3) years of performance monitoring.

4 Non-use Management Area

There are no Non-use Management Areas (NUMAs) identified or planned for the MRO PRCP.

5 Rehabilitation Methodology

5.1 Hydrogeology and Surface Water Management

MRO has extensive water management systems in place to account for onsite operational requirements, for monitoring of surface and ground water flows and control mechanisms for contaminant pathways across the site which are discussed in the following sections. In addition to this, in 2022 RGS was commissioned to construct a WB/WQ model for the site and final void at MRO. The numerical WB/WQ model was developed for the MRO final void with the following objectives:

- To predict the pit water quality (dissolved concentrations) for a 'terminal sink'[1] at closure and understand how the water quality evolves 100 years into the future;
- To understand the demand for water to fill and maintain the pit lake based on several different closure scenarios; and,
- To understand how climate variability affect the water balance and water quality of the pit lake.

The findings of this assessment are outlined in following section under the Rehabilitation Areas (RA) – Residual Void (Pit).

Historical Contaminant Releases

Since the beginning of operations in 2001, the mining lease has seen several exceedances, seepages, and mine-affected water release events. Overtopping events contributed to these in 2003, 2010, 2012 and 2013 that affected downstream receiving environments. Tailing seepage also occurred in 2010 and 2012 after clay was removed from the toe of the Northern Wall as part of borrow pit operations.

Various management actions were employed such as modified blasting procedures, better handling of waste and low-grade ore, evaluation of the weathering characteristics of tailings and waste rock, and seepage interception downstream of the TSF and waste rock dumps.

Contaminants of Potential Concern

Potential mine related sources of contamination include seepage from tailings and seepage/runoff from waste rock dumps. MRO extracts gold from pyrite (FeS2). Heavy metals (As, Cd, Pb, Cu, Zn) are

[1] A 'terminal sink' for MRO is not considered a true terminal sink as there is likely to be some groundwater flux from the pit lake; however, there is no interconnection with external water bodies.

also hosted by sulfides in mineralized zones and are Chemicals of Potential Concern (COPC) that can have an influence on the receiving environment because of mining activity.

Sulfate (SO4), total cyanide (Tot. CN) and nitrate_N (NO3_N) are the best indicators of mining related activity at Mount Rawdon. Because there are satellite ore bodies in the Mine, it is plausible that some high concentrations of SO4, As, Cd, Cu, Pb and Zn can be found in groundwater which are expressions of unmined ore bodies or mineralisation haloes. There are other enriched sources of NO3_N in the landscape (wetland processes, nitrogen fixing plants, bushfires), so it is plausible that sources other than explosive residues contribute to high nitrogen concentrations in the receiving environment.

Potential Contaminant Source Pathways

Contaminant source pathways at MRO originate from tailings deposited into the TSF, from stored PAF in the WRDs and potentially from operational infrastructure areas.

Groundwater flow paths at MRO based on the model developed by NRC (2019) are shown in Figure 29 Groundwater exfiltration into surface drainages (Northern Resources Consultants, 2019). The model shows that topographic highs, which include landscape spurs as well as the NWRD and the TSF, are locations of groundwater recharge with groundwater moving downslope and exfiltrating on lower slopes or in creek lines. Intermittent groundwater seeps on lower slopes following high rainfall events have been identified in steep terrain (Figure 30). The seeps occur naturally in response to seasonal groundwater following rainfall events when groundwater recharge on upper slopes reports further downslope. The model identifies that a fault seal impedes groundwater flow from the TSF into the pit.

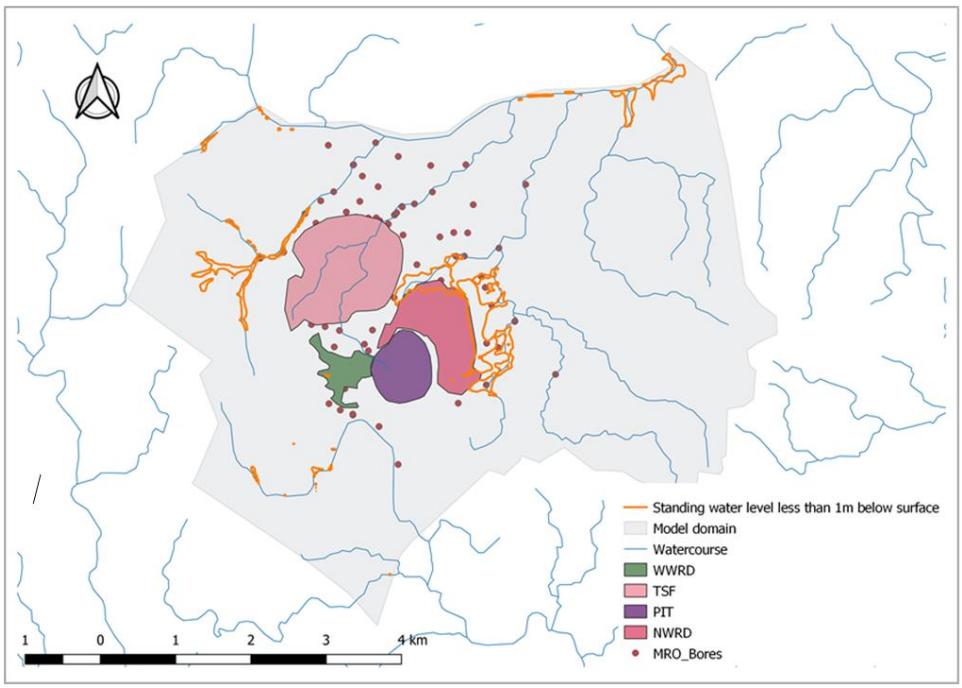


Figure 29 Groundwater exfiltration into surface drainages (Northern Resources Consultants, 2019)

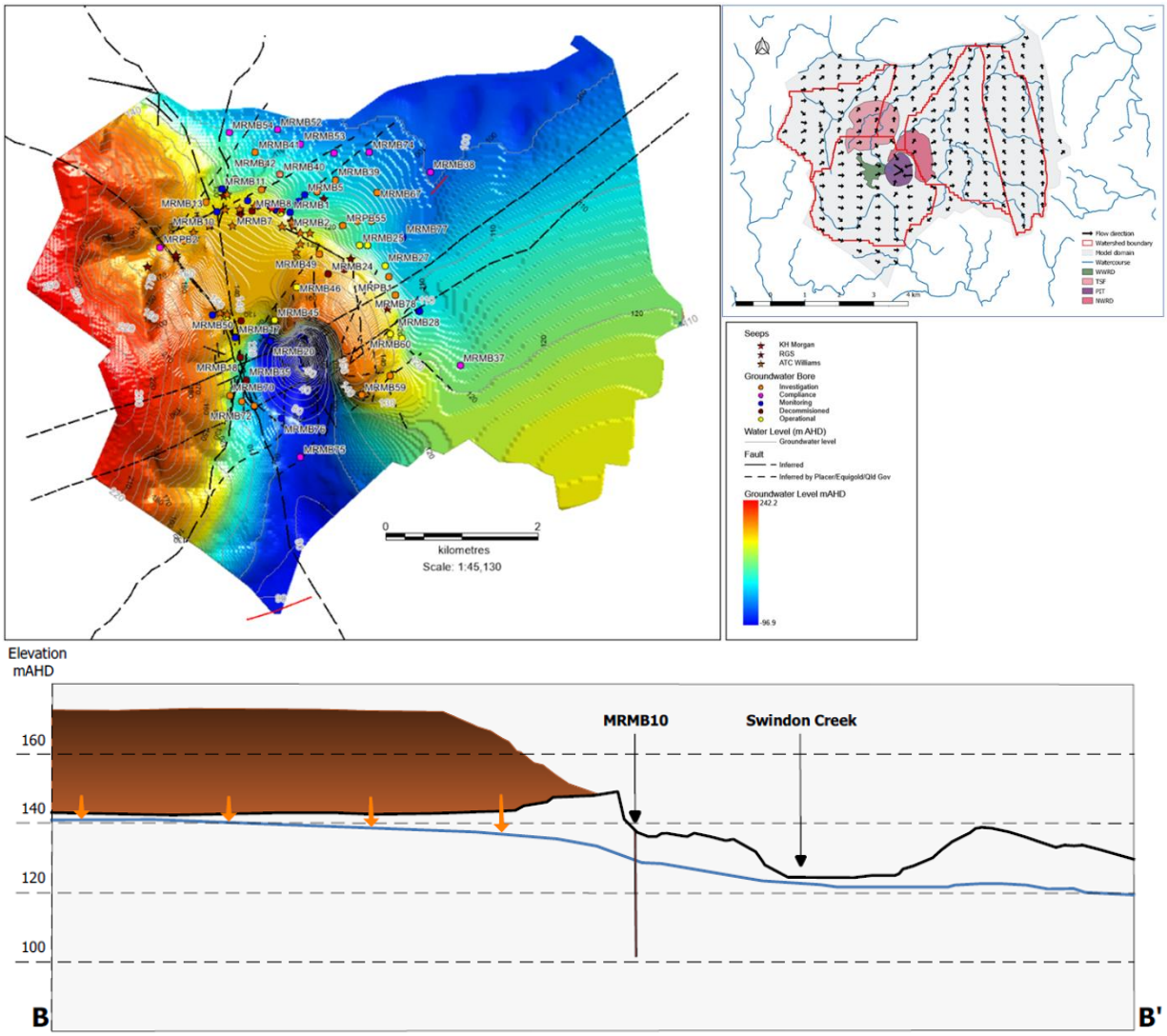


Figure 30 Steady-state groundwater model outputs showing the potentiometric surface and groundwater flow paths across the MRO mine lease, as well as the hydro stratigraphic cross-section across the Northern Seepage Zone from the TSF towards Swindon Creek (Northern Resource Consultants, 2019).

A contour map of mine influenced groundwater in 2017 and in 2021 and used a groundwater model to predict the future extent of mine influence on groundwater (Figure 31). The Environmental Evaluation identified remediation measures for containing and managing chemicals and their potential impacts on environmental values. Existing remediation measures include a combination of seepage interception trenches and wells, seepage/stormwater interception dams in drainage lines, and groundwater dewatering bores along identified seepage pathways. Between 2021 and 2025, another seepage/stormwater interception dam is being built and at least seven (7) additional groundwater seepage interception bores will be commissioned to slow the flow of mining affected groundwater towards creeks. After 2027 MRO will likely continue the seepage interceptions as well as decommissioning and capping the TSF, and rehabilitation of NWRD and look to commissioning constructed wetlands as water management units that remove chemicals of potential concern (sulfate, nitrogen, cyanide, metals) from mine affected water.

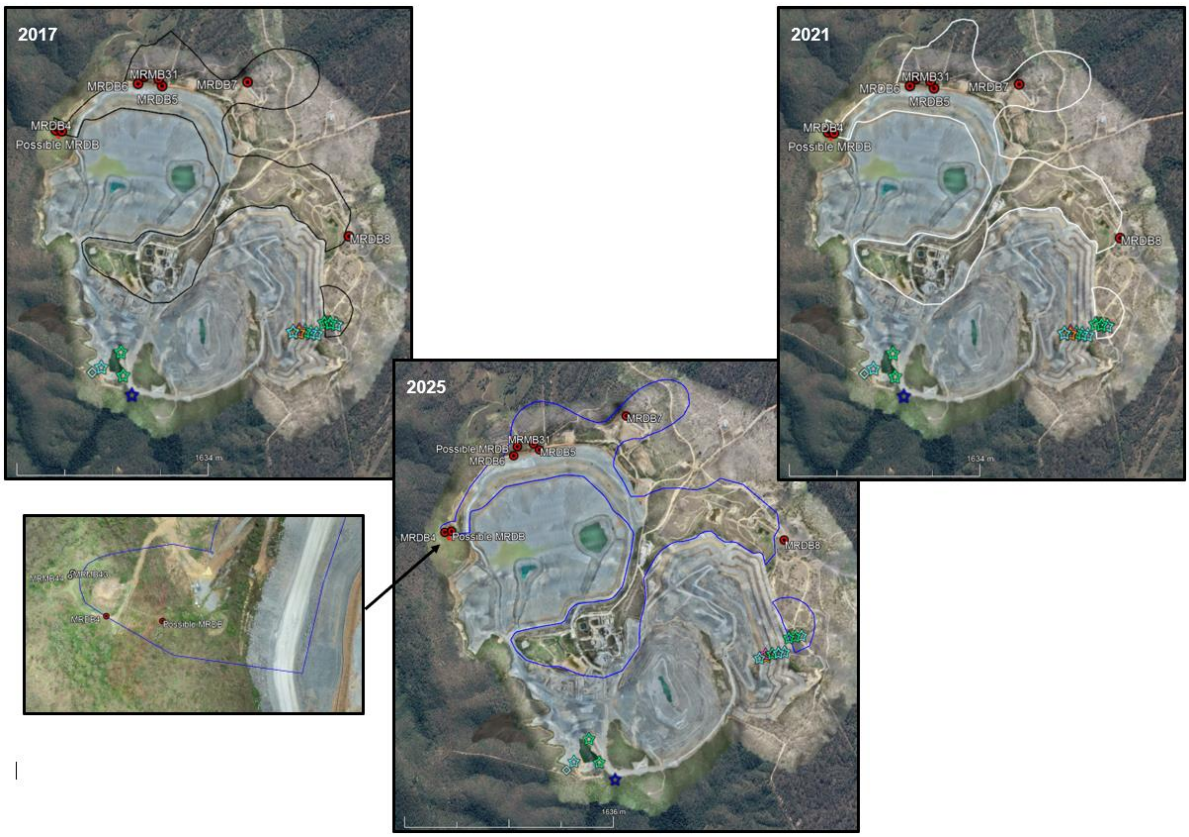


Figure 31 Future extent of mine influence on groundwater in 2025

Infiltration and Seepage Intervention and Collection Controls

Controls of Seepage from the Waste Rock Dumps

Acid forming waste rock is managed by identifying ranges of PAF and then encapsulating the material within structures using NAF material. This has been the construction method for the NWRD and management of PAF material across the site. The PAF material has also been encapsulated beneath the water blanket in the unconsolidated tailings within the TSF.

Seepage Control Applications

Four seepage drainage lines exist on the east of the NWRD that carry solutes through the rock pile. These seeps are managed by:

- Four water retention dams (WD1, WD2, WD3, WD4) that intercept stormwater and seepage. Water is transferred to WD1 from WD2, WD3 and WD4, and then returned to the Raw Water Dam for use as process water.
- Seepage interception systems downstream of WD1 and WD2, which drain into dewatering wells that return seepage water to the retention dams.
- Observing and recording groundwater standing water levels and water quality in monitoring bores MRMB25 and MRMB26 (downgradient of WD1) and MRMB27 (downgradient of WD2). Both bores MRMB26 and MRMB27 are equipped to also return intercepted seepage in groundwater to WD1 and WD2 respectively.
- Neutral mine drainage generated in the WRD flows southward into the West Dam. These seeps are contained by the dam and removed by enhanced mechanical evaporation.

Control of Seepage from Operational Areas

MRO requires management of seepage risk from the land disposal of wastewater generated from sewage systems. This is achieved either by removing wastewater from site or locally treating wastewater and disposing it on land, as approved by the EA.

Hydrocarbons, acids and cyanide are stored and handled in bunded and/or secure areas according to Australian Standards section 5.8 of AS 1940 (2004), section 5.7 of AS 3780 (2008) and section 5.7 of AS4452 (1997). The objective is to contain and manage potential spills so that disposal and treatment does not negatively affect environmental or human health.

Control Methods for Operational seepage

Sewage generated in the main administrative offices and the fixed-plant maintenance area is processed by the Wastewater Treatment Plant located adjacent to the main office area, and disposed onto the land application area in amounts that can be assimilated by soil and growing plants. This ensures that deep leaching of salts and nutrients does not occur. If required, there is also the option of removal by truck for off-site disposal.

If a spill of acid, cyanide or hydrocarbon occurs the Chemical Spills Procedure (MRO ENV PRO 0228), Cyanide Spill Response TARP (MRO_MIL_FOR_0533) or Hydrocarbons – Spill Clean- Up/Disposal Procedure (MRO ENV PRO 0204) are followed. These dedicated procedures contain, report, clean-up and if required rehabilitate the site.

Hydrocarbon spills in operational areas are recorded, and affected soil is excavated or removed and transported to a bioremediation facility (land farm) for aerobic biodegradation of the hydrocarbon.

The landfill area contains mainly inert materials that have been disposed of in a trench, except for a relatively small volume of timber and timber pallets that may putresce.

Northern Seepage Zone

A Seepage Interception Drain and the reconditioned Toe Interception Drain that has been commissioned to replace the four pump-back wells and two pump-back bores, currently limits the effect of the pressure from the hydraulic head of the TSF exerts on the downgradient receptors. The intercepted water is then returned to the processing circuit via Sediment Dam 1.

West of the TSF

This seepage drainage line (Seep 26) has been intercepted and redirected via pump-back bores and wells. Through improved pump capability these intercept and redirect shallow groundwater back to the Seepage Interception Drain or TSF.

South and southeast of the TSF

Stans Well, which limits the drawdown potential below the TSF eastern wall is now connected to an Interception Drain that returns water back to the processing circuit through South Dam.

Northern Waste Rock Dump and the West Waste Rock Dump

The drainage lines that run downstream from the WRDs have been mitigated by the installation of interception dams which also have sumps installed at WD1, WD2 and West Dam. Pump-back bores have been installed along the flow pathways from Waste Dam 1 and Waste Dam 2 to Twelve Mile Creek

The Interception Drain

The TSF Seepage Interception drain has been observed to lower the effective hydraulic head of seepage from the TSF by between 0.7 and 1.4 m during dry weather. The effect of lowering the effective head by 0.75 m was modelled.

Future Diversion drains

The original construction of the stormwater diversions was placed along the western edge of the TSF and later included the upgraded installation of the Reno Mattresses and Gabions at critical locations of gully inflows. The existing diversions surrounding the site are planned to be retained and the reinstatement of a western diversion drain along the western hill of the TSF may be required as determined by a detailed design.

Future Management

Existing mitigation and management of seepage is reviewed annually during Groundwater Management and Monitoring Plan reviews and further mitigation infrastructure will be put in place as required.

Upon further investigation, the commissioning of sulphate reduction wetlands as low maintenance and long-term seepage intervention program will also support the closure strategy for MRO.

5.2 Flooding

Topography within MRO rises onto the steep lower slopes of the Boolbunda Range to the west, with general stormwater drainage occurring to the north. Site drainage occurs via a series of defined drainage lines that discharge into the Perry River to the north of MRO.

Within the MRO, topography is undulating and rises significantly to the west, ranging in elevation from around RL 450 m on the western boundary to RL 100 m at the Perry River. Gully lines are typically incised and shallow (ranging in depth from 1.0 to 3.0 m deep). Vegetation cover over the site is typical of the historical grazing activities, which have occurred in this area, and comprises a mixture of open grass land and forested areas on the upper slopes. Flows in site drainages are ephemeral, responding to rainfall events of high intensity and/or extended duration, with limited residual base-flows observed.

The southern portion of the site, including the Plant Area, West WRD are situated in the headwaters of Mingham Creek and grades to the south towards the Paradise Dam storage within the Burnett River catchment.

Assuming the containment capacity (regulated structures) at MRO are exceeded, the majority of site catchments ultimately report to the Perry River system, however as noted above, some areas are expected to flow towards the south or be 'captive' in the central area of site, as described in **Table 26**.

Table 26: MRO Receiving Drainage/Pathways

System	Reporting Areas	Description of Downstream System
Perry River System	• Northern portions of the Mt Rawdon Site including: • TSF Spillway Flows; • TSF Northern Embankment; • North WRD and Associated WD1 to WD4 System; • TSF SD3.	Flow reports to the Perry River via Rawdon Creek or Twelve Mile Creek The Perry River is in turn dammed by the Perry River Dam Flow over the Perry River Dam is conveyed via the Perry River to the Burnett River confluence point
Paradise Dam System	• Minor southern areas of the site including: • West WRD and West Dam flows; • Southern Upper MRO pit Benches;	Flows from site would be conveyed southwards via a minor gully The gully joins Mingham Creek to the south Mingham Creek reports flows to Paradise Dam Paradise Dam discharges to the Burnett River
Centre of Site	• A central portion of the site is considered hydrologically contained comprising: • South Dam; • Process Plant Area; • Northern	Flow reports to South Dam If South Dam overtops, waters would spill to the MRO Pit in the first instance

Flooding Susceptibility

MRO is not located within a floodplain however a hydraulic assessment was completed (refer to supporting documents "Hydraulic Assessment June 2021, ATC Williams) to develop a flood risk profile for the operation under post closure conditions and in particular assess water depths and velocities surrounding site features including the TSF, West Dam, South Dam Fill Area, Southern Diversion Drain, Pit Bund, Perry River Dam, retained dams on site and downstream tributaries. The MRO site layout can be seen in **Figure 32.**

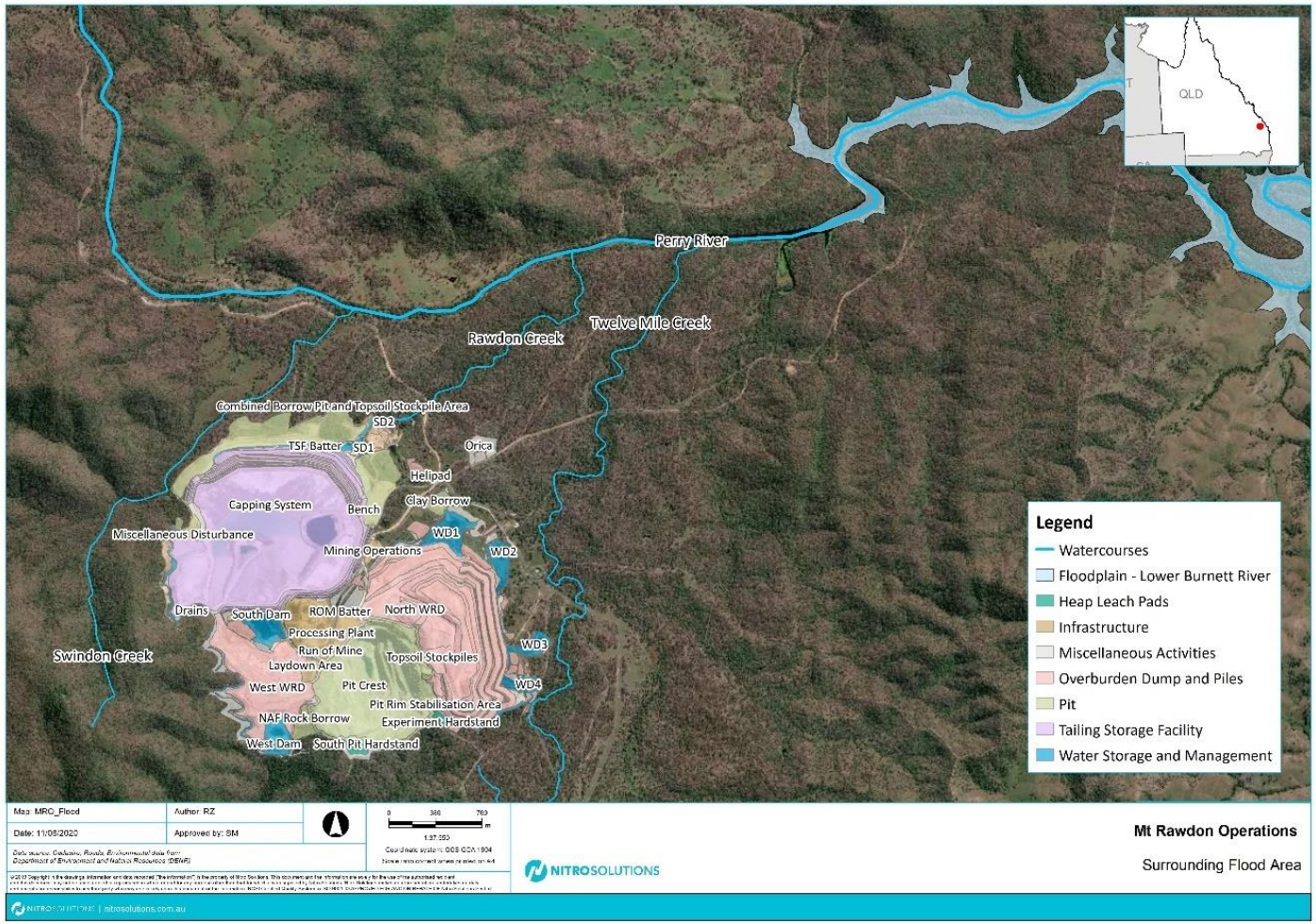


Figure 32: MRO Mine Features Site Layout and Regional Hydrology

The flood modelling completed was assessed against the following events:

- Probable Maximum Flood (PMF) resulting from the Probable Maximum Precipitation (PMP);
- 1:1,000 Annual Exceedance Probability AEP (0.1%) and 1:100 AEP (1%) storm events.

The hydraulic modelling demonstrated that none of the major infrastructure areas or final landforms will be impacted by the extents of PMF or 0.1% AEP flood plain. Overtopping of water storages will not result in any significant impacts on nearby infrastructure or downstream tributaries. The pre-mining flow regimes to the local watercourses across the MRO site have been maintained in the post closure design, as far as practicable.

5.3 Soil and Capping Material Assessment

In 2022 MRO commissioned RGS/Deswik to develop a whole of mine, progressive landform haulage schedule for the remaining life of mine plan and closure period. The Deswik.LHS work essentially allocates the movement of all materials on the mine on a truck-by-truck basis. The work completed by MRO exceeds existing requirements for PRCP Planning and Scheduling and reflects current best industry practice recommended by the ICMM (2019).

Suporting this Deswik.LHS model, RGS developed a Mine Material Management Plan (refer to supporting document Mine Material Management Plan, RGS, 2022) to inform the PRC Plan and encompasses:

- Soil capping material assessment
- Mine material characterisation
- Mine material balances and scheduling
- Landform and cover system design
- Land stability, erosion, and landform evolution
- Mine water management and final void assessment
- Performance monitoring

Soil stockpiles, soil, saprolite and saprock borrow areas have been identified, sampled, and analysed over the LOM. The soil quality, geochemical and physical properties of the topsoil and subsoil in the pedolith, combined with the saprolite and saprock in the regolith, and the available stockpile of NAF rock in the WWRD have been measured from test pit and drilling programs over the LOM.

RGS completed a test pit and drilling program in 2016 to quantify volumes and soil quality, geochemical and physical properties of pedolith units that could be used to construct the cover system on the TSF (RGS, 2016b). The data was subsequently used to develop a pre-feasibility level tailings cap design.

In September 2022, RGS commenced additional soil quality, geochemical and physical characterisation of five bulk ($1m^3$) samples of:

- topsoil provided from an existing stockpile,
- topsoil from a location to the north of TSF, and
- topsoil, saprolite and saprock form West Hill

Splits of these bulk samples are undergoing soil quality, geochemical and physical characterisation. These bulk samples are also being used to quantify erosion rates to enable erosion modelling of proposed soil cover systems for the TSF and NWRD using MinErosion v.4.

Should the MinErosion v.4 indicate there is a need for landform evaluation modelling this work can be using $CAESAR_{LISFLOOD}$ or SIBERIA.

The key rehabilitation materials identified within the local soil zones and borrow areas that will be used for construction of a cover system include (but not limited to) the following broad material types.

- Soil that includes;
    - Topsoil (nominally 0 to 50 cm depth bgl) - top layer of the native soil profile recognised by higher organic carbon content, some development of soil structure, the presence of plant roots, and typically containing the soil seed bank. A valuable resource suitable for use during the rehabilitation program.
    - Subsoil (nominally 50 to 100 cm depth bgl) - soil layer underlying the native topsoil, typically identified by a decrease in organic carbon content and fewer (and finer) roots. The characteristics of subsoil materials vary markedly depending on the soil type.
- Overburden that includes oxide and transition material.
    - Oxide overburden - typically highly weathered materials with minor partially-weathered rock
    - Transition overburden - weathered materials with minor partially-weathered rock and some competent fresh rock
- Fresh competent rock that may be suitable for armouring drains or being used as rock mulch in the soil cover e.g. NAF waste rock from the western WRD

As described above the available soil resources and capping material has been quantified and scheduled into the Deswik.LHS model to illustrate how the material requirements meet the needs of the rehabilitation design objectives for all domain areas.

Based on current cover designs for the North Waste Rock Dump, and Tailings Storage Facility, and topsoil requirements for all other domain areas there is sufficient materials available. Borrow areas and topsoil stockpiles are identified within the Deswik.LHS model, as illustrated below.

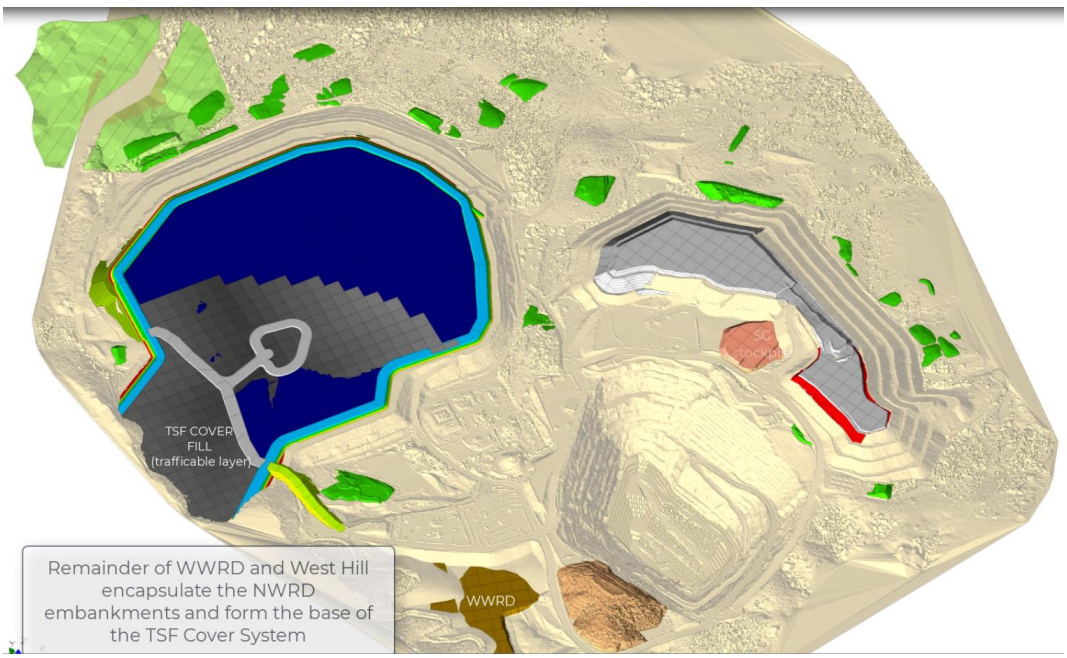


Figure 33: West Hill NAF borrow area (located to west of pit)

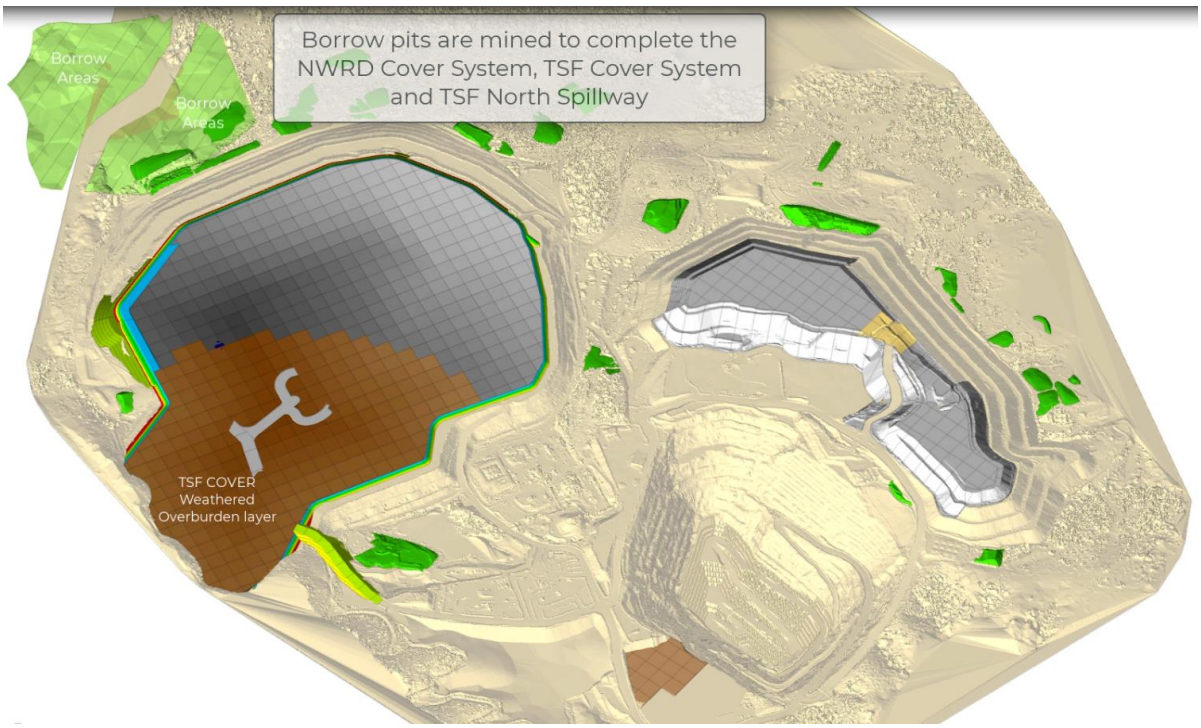


Figure 34: Borrow areas 1 and 2 located to the north east of the TSF

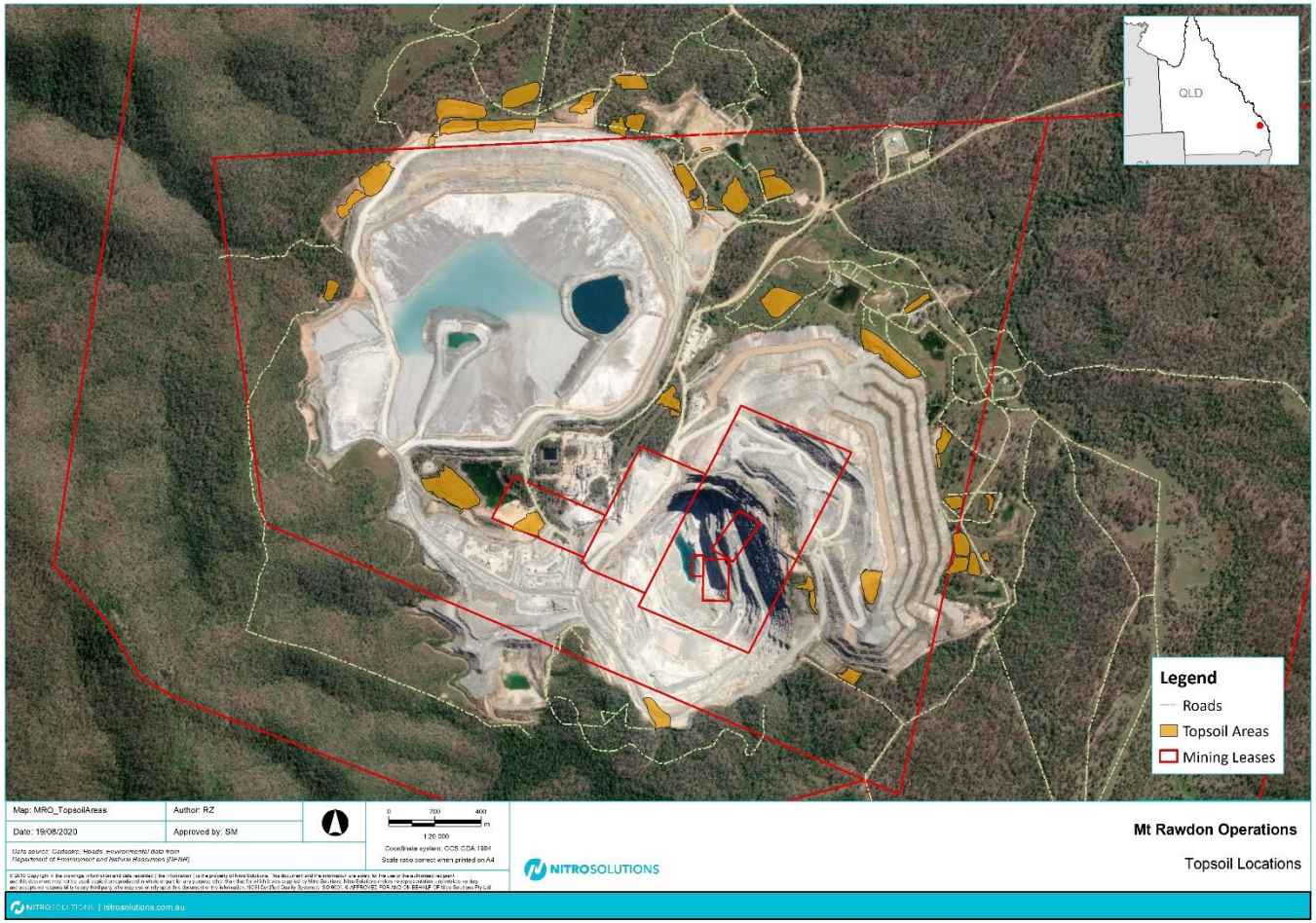


Figure 35: MRO Topsoil Stockpile Locations Relative to Haul and Access Roads

Stockpile Management and Inspection Test Plans (ITPs)

Topsoil resources have been allocated for rehabilitation programs and plans according to the relative post-mining land use to ensure that these limited resources are optimally utilised. Following analysis, suitable growth media must be stockpiled according to topsoil management procedures. While the topsoil present in stockpiles throughout MRO are suitable for use in topdressing, several management practices should be adopted to minimise soil degradation:

- Soils must be stripped to appropriate depths to harvest nutrient rich soils;
- Once material is stripped it should ideally be placed on areas immediately ready for rehabilitation or areas soon to be rehabilitated to avoid stockpiling;
- Stripped soils should be respread or separated into windrows for later collection;
- The surface of all stockpiles should be left rough or lightly scarified to allow infiltration and reduce erosion;
- Topsoil stockpiles should not exceed two metres in height and clay soils should be stored at lower heights to minimise dispersion from wind or water.
- If the topsoil is to be stored for a period of less than six months, no additional treatment of the stockpile(s) is required;
- If storage is planned for greater than six months, cleared vegetation from the same location as the topsoil should be spread to encourage stability through vegetation;
- If long term stockpiling (greater than two years) does not "self-seed" it should be appropriately seeded and fertilised to mitigate the impact of erosive forces;
- For rehabilitation to postmining land uses, soils should be spread to the appropriate depths for the intended post-mining land uses and land suitability.

Ameliorants and Fertilisers

The requirement to apply fertiliser or soil ameliorants will be determined through insitu stockpile soil assessments and testing by the appropriate Manager prior to topsoil spreading. Fertilisers and soil ameliorants such as lime or humic acid will be used where required to assist with successful rehabilitation.

Sodicity

The surfaces of sodosols are prone to surface crusting and require management strategies to ensure the soil resources are maintained for the purpose of rehabilitation and revegetation. Successful treatments for sodic soils include the application of gypsum, organic matter and fertiliser.

Gypsum application improves soil structure whilst long term stability and retention of water and nutrients is promoted by organic matter. Applying organic matter such as manure, straw, mulch and wood chips increases biological setting within soil structure and offers improved conditions for the growth of plants by stimulating root function.

Erosion and Low Nutrient status

The sodic nature of the soils on site requires ameliorants to minimise the dispersive and low nutrient nature. Application improves the stabilisation of soils and assists in establishing plants. Whilst soils within the site have shown to be able to support good plant growth, the disruption to soils from stripping and stockpiling can decrease the reduce fertility, slowing the establishment of plants which, coupled with increased dispersion can negatively impact rehabilitation efforts.

Minimising incorrect handling and stockpiling timeframes and stockpile gradients will help minimise disturbance and increase likelihood of achieving land rehabilitation outcomes and associated PMLUs.
The application of lime also aids plant establishment and stabilisation of soils by neutralising acidic soils and by improving the structural stability through increased sodium and magnesium. Increased alkalinity promotes the availability of some nutrients including phosphorus.
Further, application of nitrogen, phosphorus and potassium (NPK) fertiliser is recommended for use in revegetation areas to promote nutrient increase in soils. Fertilisers should be applied according to the specific seed mix for intended for associated PMLUs.

Surface Preparation

Appropriate ripping and scarification of the available land for rehabilitation prior to the spread of topsoil and subsoils is essential to increase the binding of soil layers, retention of water, increases infiltration, reduces runoff and promotes the germination of seed.

Prior to the re-spreading of the topsoil, the ground surface should be ripped to assist with binding of the soil layers, water penetration and plant establishment. The ripping depth of surface soils will be site specific depending on the domain and intended PMLU.

Topsoil Preparation

Before utilising topsoil stockpiles, a soil nutrient analysis will be conducted to determine if the topsoil resources require the application of ameliorants or fertilisers.

All planned rehabilitated surfaces should be ripped according site specifics and the relevant rehabilitation management plan increase the success of seeding. Topsoil should be applied to a minimum of 100 mm and ESC (erosion and sediment control) should be in place where necessary.

Surface contouring should be undertaken as part of ESC to minimise dispersion and reduce the impact of runoff. Scarification of topsoils is to be completed prior to seeding and appropriate machinery should be used to avoid ripping sodic subsoils to the surface.

5.4 Waste Characterisation

MRO has had a history of comprehensive static and kinetic waste characterisation and trials carried out over the life of mine (see **Table 27** below). The results from these tests provide valuable insights into closure design and rehabilitation methodology of the waste rock dumps and TSF. A summary of the static and kinetic waste characterisation work completed to date is listed in the subsequent sections below.

Table 27: MRO Waste Characterisation

Report title	Finding
RGS (2009). *Geochemical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials at Mt Rawdon Gold Mine – Stage 1*. Report No. R001-A (890013) prepared by RGS Environmental Pty Ltd for Mount Rawdon Gold Mine. 28 August.	• Initial surface runoff and leachate from waste rock and low-grade ore materials is likely to be alkaline and non-saline. • Total metal concentrations in waste rock and low-grade ore materials are unlikely to present any concerns related to mine operation and final rehabilitation. In particular, the low risk waste rock materials appear to be amenable for use as

Report title	Finding
	the final surface and batters of the WRD and as part of a final cover system over tailings at the TSF. • The selective handling and encapsulation control strategies employed by Mt Rawdon Mine (MRM) for the management of waste rock and low-grade ore materials currently appear to be successful, as indicated by ongoing surface and groundwater monitoring programs downstream of the NWRD facility.
RGS (2011b). *Geochemical and Mineralogical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials at LGL Mt Rawdon Gold Mine – Stage 2*. Report prepared by RGS Environmental Pty Ltd for LGL Mt Rawdon Gold Mine, 8 November.	• KLC test results suggest that surface runoff and seepage from waste rock and low grade ore materials will remain slightly alkaline to pH neutral and contain a low concentration of salts and trace metals for a significant period of time (> 20 years).
MRO (2016). 2016 geochemical (total sulfur and total carbon) database generated from tailings sampling program (3 August to 8 September 2016) using on-site Leco analyser. September.	• Interpretation of the MRO total sulfur and total carbon databases from 2003 to 2016 indicates that these data sets can be used to accurately predict the NAF, PAF-MC and PAF-HC waste rock materials.
RGS (2020). *Geochemical Assessment of Waste Rock and Tailings Materials. Mt Rawdon Gold Mine*. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 4 December.	• Kinetic Leach Column (KLC) test work on six columns from 2016-2018 including NAF Waste Rock, Medium PAF Waste Rock, High PAF Waste Rock, Tailing, Tailing on top of High PAF Waste Rock, and Tailings mixed with High PAF Waste Rock • NAF waste rock materials have negligible sulfur content, elevated ANC and a high factor of safety with respect to potential for Acid and Metalliferous Drainage (AMD) (including Neutral Metalliferous Drainage (NMD) or Saline Drainage (SD)). • Initial surface runoff and seepage from NAF and PAF waste rock materials (and ongoing surface runoff and seepage from NAF waste rock materials) is likely to be pH neutral to slightly alkaline and have a low level of salinity. Initial and ongoing surface runoff and seepage from NAF waste rock materials is likely to contain excess alkalinity.
Mt Rawdon Operations Waste Rock Test Pile Review RGS Environmental Pty Ltd, 2018.	• Review of design, construction, and sampling results of the Waste Rock Test Pile field leaching project.

Report title	Finding
RGS (2016b). *Conceptual Closure, Decommissioning and Rehabilitation Plan: Mount Rawdon Tailings Storage Facility: Mount Rawdon Operations.* Report Number 003 RevG prepared by RGS Environmental Pty Ltd for Evolution Mining, 13 December.	• NAF waste rock is placed into the Western NAF WRD. The NAF waste rock can contain some sulphide minerals but the concentrations of acid neutralising minerals and overall alkalinity significantly exceed the acid producing potential of the rock. Nevertheless, exposed sulfide minerals in NAF rock can oxidise and weather and produce neutral to alkaline pH drainage containing major ions such as sulfate and calcium. RGS has completed a review of the waste rock characterisation methodology and acid waste model used at MRO (RGS, 2016). This work demonstrates that NAF waste rock generated at MRO is likely to have an average ANC:MPA ratio greater than 6, if a simple sulfur cut-off value of < 1 %S is used to delineate NAF waste rock materials and these materials are therefore suitable for use as part of the TSF soil cover system.
RGS (2021). *Assessment of Long-Term Geochemical Characteristics of Mt Rawdon Tailing Materials – Final Report*. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.	• Static testing on four tailings samples and kinetic test work of four columns containing tailings from 2014-2018. • Tailing materials tested to date have relatively consistent static geochemical characteristics and are classified as NAF. • Contact water and leachate from tailing materials are likely to be pH neutral (in the range pH 7 to 8) and contain excess alkalinity. • The quality of the tailing pore water and any TSF seepage is likely to gradually improve when supernatant/fresh tailings (and waste rock materials) are no longer added to the TSF following closure of this facility. • Whilst tailing solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to relatively immobile and sparingly soluble at neutral pH. • The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site. • It is expected that the concentration of major ions (including sulfate) in any seepage from the

Report title	Finding
	TSF will gradually decrease over time following closure and rehabilitation of the TSF.
RGS (2021). Geochemical Assessment of MRO Tailing Materials, Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.	• RGS completed an intensive investigation into the geochemical characteristics of tailing materials generated at MRO over a period of 12 months. • Daily tailing samples generated at the MRO processing plant have variable geochemical characteristics and these materials range in classification from NAF, Uncertain, PAF-LC through to PAF. However, most samples are classified as NAF and/or Uncertain and PAFLC and PAF materials appear to be generated for a small proportion of the time. • Results from weekly and monthly composite tailing samples indicate that when most tailing materials are mixed at the TSF, the resulting tailings blend is likely to be mostly NAF. • There is a strong correlation between the total sulfur content of the tailing samples and their geochemical classification. The total sulfur content of the tailing materials generally has to be consistently greater than 1.5 % for tailings batches to be classified as PAF. • The tailing materials have a significant amount of readily available alkalinity and buffering capacity that neutralises any acidity generate from sulfide oxidation and generally maintains an alkaline pH. • Based on the static geochemistry results in this report, previous long term kinetic leach column (KLC) test results (RGS, 2020, 2021), and field monitoring data on tailing materials currently stored at the TSF, the risk of any acid generation now and following closure and rehabilitation of the TSF is expected to be very low. • Whilst tailing solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to relatively immobile and sparingly soluble at neutral to alkaline pH. • The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site.

Report title	Finding
	• It is expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure and rehabilitation of the TSF.

Field Scale Waste Characterisation Test Work

As part of MROs ongoing commitment to understanding waste rock geochemical characteristics and to assist with the development of rehabilitation and closure strategies for waste rock facilities, MRO designed and constructed a field test pile project in 2016 (**Figure 36** and **Table 28**). The aim of the project is to "determine how specific waste rock dump design types will affect water quality characteristics of leachate produced from rainfall events".



Figure 36 Field Test Pads

Table 28 Field test pad schedule

Report title	Code	Replicate	First Leach	Description
Control: Non-Acid	C-N	R1	4/06/2016	NAF Waste Rock
	C-N	R2	4/06/2016	NAF Waste Rock
	C-N	R3	4/06/2016	NAF Waste Rock
Control: Medium-Acid	C-M	R1	4/06/2016	PAF-MC Waste Rock
	C-M	R2	4/06/2016	PAF-MC Waste Rock
	C-M	R3	4/06/2016	PAF-MC Waste Rock
Control: High-Acid	C-H	R1	20/03/2017	PAF-HC Waste Rock
	C-H	R2	4/06/2016	PAF-HC Waste Rock
	C-H	R3	4/06/2016	PAF-HC Waste Rock
Treatment	T1	R1	31/03/2017	PAF-MC encapsulated with NAF Waste Rock
	T1	R2	19/07/2016	PAF-MC encapsulated with NAF Waste Rock
	T1	R3	19/07/2016	PAF-MC encapsulated with NAF Waste Rock

In general, test pile experiments are typically designed to:

- Assess the sulfide oxidation/metal leaching rates and weathering rates of waste rock materials under site-specific field conditions;
- Assess leachate quality generated under site-specific field conditions;
- Provide information that can be used to understand and scale sulfide oxidation, weathering reaction rates from laboratory tests to site-specific field conditions;
- Provide information that can be used for water quality estimation; and,
- Evaluate the effectiveness of various treatments (eg. cover design; alkaline dosing, etc.) on oxygen ingress and water infiltration as an engineered strategy to minimise/mitigate acid and metalliferous drainage (AMD) [including metalliferous leaching (ML) and saline drainage (SD)].

In 2018, RGS Environmental carried out a review of the construction of the test pile and made recommendations. An interpretation of the leachate data obtained was also carried out along with a comparison to waste rock dump seepage (NRWD) and pit water quality, refer to the supporting document *Mt Rawdon Operations Waste Rock Test Pile Review RGS Environmental Pty Ltd*, 2018.

5.5 Rehabilitation Areas (RA) and Landform Designs

Six rehabilitation areas (RA1-6) and five main mine domains are identified and referenced throughout this PRC Plan. These include:

- RA 1 – Residual Void (PIT)
- RA 2 – North Waste Rock Dump (NWRD), West Waste Rock Dump (WWRD), Run of Mine (ROM), and Long term ore stockpiles (LTSP) consisting of various low ore grades
- RA 3 – Tailings Storage Facility (TSF)
- RA 4 – Haul Roads and tracks
- RA 5 – Processing Plant, Workshops, and Infrastructure Management Areas
- RA 6 – Water Management Infrastructure and Dams (excluding Perry River Dam).



Figure 37: Major site domains

RA 1 – Residual Void (Pit)

The pit is proposed to be retained as a water storage facility to support the PMLU of the surrounding areas which includes grazing (e.g. additional water for pumping to surrounding stock dams). A perimeter exclusion bund and fence around the perimeter of the pit will also be installed to restrict the entry of wildlife, livestock and public access.

Rim stabilisation activities will be conducted along the pit crest where design requires to counter any possible landslip of the pit edge into the pit.

Final Void Water Balance and Water Quality Assessment

In 2022 RGS was commissioned to construct a WB/WQ model for the site and final void at MRO (refer to supporting document *Attachment D: 01_2021092_MRO Mine material management plan_FINAL A_11112022).* The numerical WB/WQ model was developed for the MRO final void with the following objectives:

- To predict the pit water quality (dissolved concentrations) for a 'terminal sink'[2] at closure and understand how the water quality evolves 100 years into the future;
- To understand the demand for water to fill and maintain the pit lake based on several different closure scenarios; and,
- To understand how climate variability affect the water balance and water quality of the pit lake.

The WB/WQ model was developed using GoldSim and the Contaminant Transport (CT) module. The modelling includes three key closure scenarios:

- **Scenario 1**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment.
- **Scenario 2**: All runoff and seepage water diverted to pit during closure and post closure.
- **Scenario 3**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

The key conclusions from the water balance are summarised in Table 29 and Figure 38**.**

Table 29: Summary of Water Balance Results

Scenarios	Summary
Scenario 1: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment	Pit lake water level never reaches capacity (RL + 120 m AHD) over the 100-year simulation period. The pit filled to a maximum RL of approximately +77 m AHD (mean probability) at year 2123 (100 years) and approximately +113 m AHD (maximum probability) at year 2034 (11 years).

[2] A 'terminal sink' for MRO is not considered a true terminal sink as there is likely to be some groundwater flux from the pit lake; however, there is no interconnection with external water bodies.

Scenarios	Summary
Scenario 2: All runoff/ seepage water diverted to pit during closure and post closure.	Pit lake water level reaches capacity for the maximum probability and 95th percentile probabilities at years 2032 (9 years) and 2045 (22 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity).
Scenario 3: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit	Pit lake water level reaches capacity for the maximum probability and 95th percentile probability at years 2032 (9 years) and 2057 (34 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity). The water balance results are very similar to Scenario 2, albeit the fill and overflow times are longer due to the TSF runoff being release to the environment post closure.

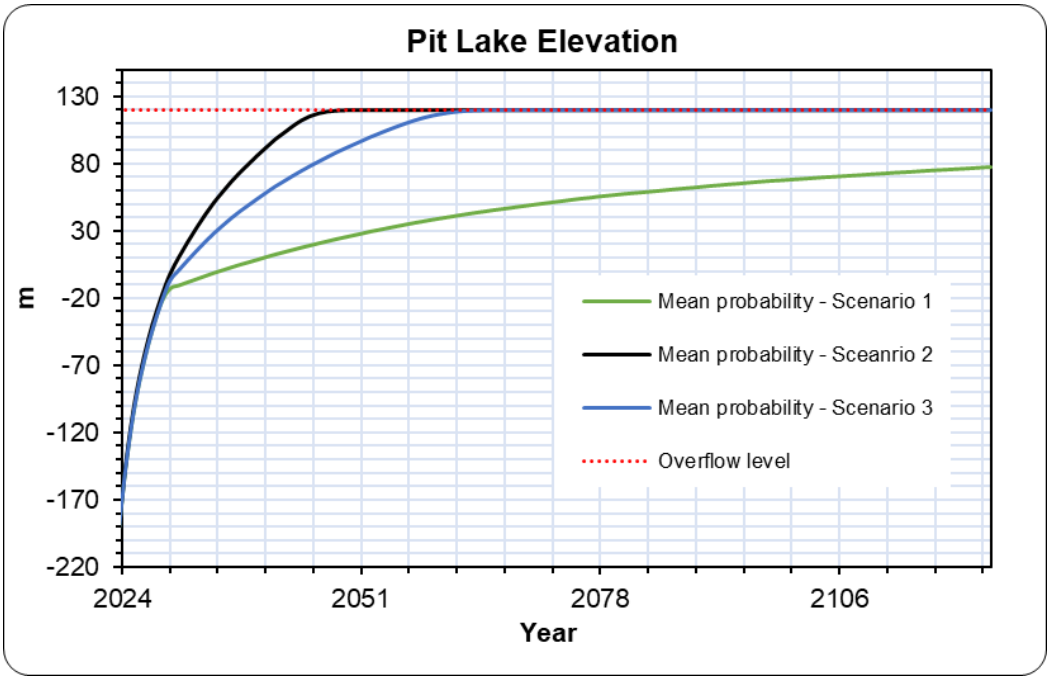


Figure 38: Pit lake water level versus time. Note: overflow height is RL +120m AHD.

The key conclusions from the pit void water quality modelling are summarised in the following points:

- The modelling results for each of the scenarios and sensitivities indicate that pH is near neutral over the simulation period with a pH of ~pH 6.5.
- The TDS ranged from around 2,280 mg/L to 250 mg/L (mean probability) for each of the scenarios and sensitivities over the assessment period.
- The general water quality concentration trends vary slightly for different modelled species and reflect the water balance inputs and geochemical source terms. The general water quality concentration trends can be separated into different phases: i) initial sump water quality phase, where the first-time step in the model reflects the pit sump water quality which is present in the pit void before the commencement of the simulation; ii) pre-closure phase, where runoff and seepage water from the non-rehabilitated landforms is directed to the pit and generally results in a gradual increase in concentration of a particular species

within the pit lake over this time; and, iii) post closure phase, which shows some variation between chemical species and the scenarios due to either of the following: evapoconcentration effects on pit lake water quality, runoff water from the rehabilitated landforms dilute pit lake water quality, or overflow of the pit lake releases solute from the pit lake stabilising concertation increases.

- The longer-term post closure phase for Scenario 1 (which simulates a 'terminal sink' since it does not overflow) generally shows a steady increase in concentration of solutes over the simulation period reflecting the effects of evapoconcentration. In reality, bio-geochemical processes (e.g. nutrient cycle, carbon cycling, etc.) would be expected to supress increasing concentrations and some form of equilibrium would be attained.
- The water qualities for each of the scenarios and sensitivities are dominated by the major ions (namely SO_4, Cl and Na), with metals and metalloid concentrations relatively low in comparison.
- The modelled mass balance results for Al, As, Cd, Cr, Cu, Pb (Scenario 3) and Zn concentrations are slightly elevated when compared to ANZG (2018) (freshwater ecosystem; 90% species protection) (Table 30). Similarly, comparison of the modelled water qualities to site release limits (for WD3, WD4 and spillway of Sediment Dam 3) indicate that TDS (occasionally) and particularly SO_4 are above the release limits.
- Atmospheric equilibration and consideration of thermodynamic constraints on the water quality through geochemical modelling typically had very little effect on the mass balance results due to the generally low concentration of salts and metal(loid)s in the pit lake.

Table 30: Summary of select model predicted (inferred) water qualities for each scenario.

Scenario		Scenario 1				Scenario 2				Scenario 3			
Time (years)		0	25	50	100	0	25	50	100	0	25	50	100
TDS (mg/l)	Me	2285	524.	584.	662.	2280	269.	228.	205.	2285.	389.	377.	369.
	Min	292.	355.	392.	485.	284.	239.	210.	198.	292.5	322.	330.	350.
	Max	2854	691.	707.	754.	2854	302.	246.	214.	2854.	456.	409.	388.
Sulfate (mg/l)	Me	628.	252.	233.	223.	625.	195.	179.	170.	628.5	209.	193.	180.
	Min	201.	229.	210.	203.	194.	187.	170.	164.	201.3	198.	180.	171.
	Max	731.	284.	258.	250.	731.	204.	188.	176.	731.4	222.	204.	190.
Aluminium (mg/l)	Me	0.01	0.06	0.06	0.08	0.01	0.33	0.41	0.45	0.013	0.46	0.64	0.82
	Min	0.00	0.04	0.05	0.06	0.00	0.29	0.39	0.44	0.005	0.36	0.57	0.79
	Max	0.11	0.12	0.13	0.16	0.11	0.35	0.42	0.47	0.115	0.50	0.67	0.84
Arsenic (mg/l)	Me	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.021	0.01	0.01	0.00
	Min	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.016	0.01	0.01	0.00
	Max	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.040	0.02	0.01	0.01
Cadmium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Max	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.003	0.00	0.00	0.00
Chromium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Max	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
Copper (mg/l)	Me	0.07	0.24	0.19	0.15	0.07	0.09	0.04	0.01	0.076	0.14	0.08	0.04
	Min	0.00	0.20	0.14	0.10	0.00	0.07	0.02	0.00	0.001	0.11	0.06	0.03
	Max	0.35	0.30	0.29	0.30	0.34	0.13	0.06	0.01	0.358	0.19	0.13	0.05
Lead (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
	Max	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00
Zinc (mg/l)	Me	0.08	0.13	0.11	0.09	0.08	0.23	0.25	0.27	0.088	0.33	0.41	0.49
	Min	0.05	0.10	0.08	0.06	0.05	0.22	0.25	0.26	0.054	0.28	0.38	0.48
	Max	0.21	0.17	0.18	0.19	0.20	0.24	0.26	0.28	0.212	0.34	0.42	0.51

Note: Highlighted orange cells represent those values that exceed ANZG (2018) – freshwater aquatic ecosystem (90%), while those in shaded blue exceed site release limits (for WD3, WD4 and spillway of Sediment Dam 3)

Geotechnical Assessment

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the Mt Rawdon Mine Operations (MRO) Open Pit. Geotechnical stability was assessed for post-closure and long-term stability as indicated by the landform modelling results. For the open pit, the geotechnical stability considered the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events.

Rocscience software RS3 (Version 4.025) and Slide 3 (Version 3.020) were used to analyse the deformation and stability of the final void conditions using provided site-specific rockmass domains. Domains were first assigned by dividing the pit geometry with all structural surfaces. These domains' parameters were assigned according to the domains presented by Itasca and mapped and defined by SRK (2017).

Two analysis methods were applied: the Spencer and Morgenstern-Price Global Limit Equilibrium (GLE). These methods were selected as they resolve both horizontal and vertical force equilibrium and moment equilibrium. Because of this, the failure surfaces calculated resolve well against weak layers. As the site is heavily faulted, failure surfaces are likely to plane against the weaker fault zones, and therefore these methods are more suitable for this analysis. Results were assessed for both to ensure a similar result and thus validate the failure surfaces.

The Slide3 model was built and run, with the associated RS3 model, to validate other failure surfaces and areas of lower Factor of Safety (FoS) to determine displacement across the pit.

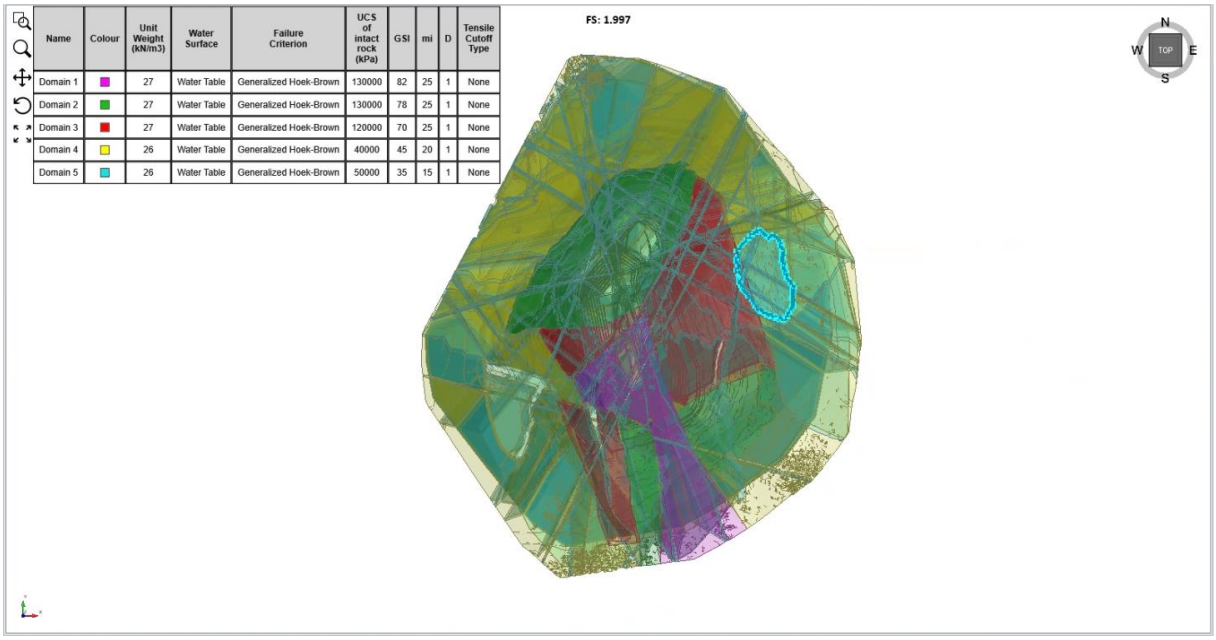
Based on the undertaken approach, it can be concluded that the geotechnical void analysis for the planned MRO post-closure pit conditions meets the post-closure slopes and will exhibit stability characteristics consistent with the planning and design of the post-closure mine void. The mechanisms to achieve acceptable stability were detailed in the report to align with the best available leading practices.

<u>Stability Analysis (Slide3)</u>

The factor of safety results for the static and dynamic scenarios of the Slide3 Limit Equilibrium analysis is shown below in Table 31 and in Figure 39 to Figure 42. A suitable factor of safety was achieved for static conditions. Spencer's results for the dynamic seismic analysis were marginally below the assessment criteria, however, considering the likelihood of the event, this is considered acceptable.

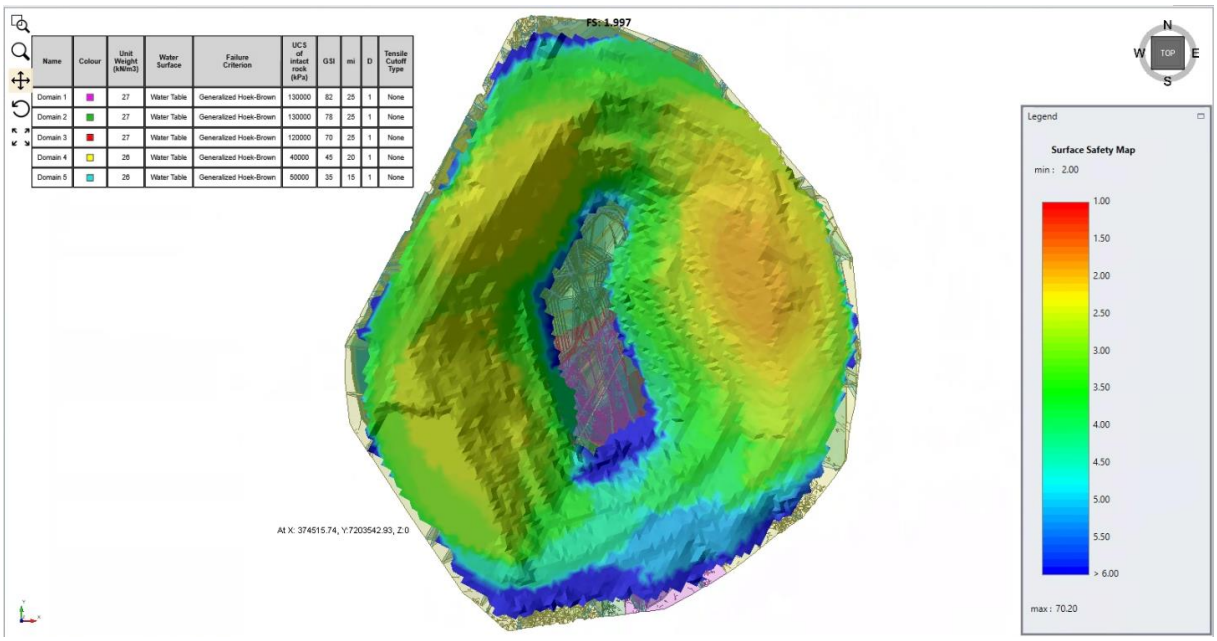
Table 31: Limit Equilibrium Slide3 results under static and dynamic conditions

Model	FoS (Spencer)	FoS (GLE/Morgenstern-Price)
Static Model	**2.01**	**1.99**
Dynamic Model (PGA: 0.25g or 1:10000)	**1.09**	**1.10**



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	UCS of intact rock (kPa)	GSI	mi	D	Tensile Cutoff Type
Domain 1		27	Water Table	Generalized Hoek-Brown	130000	82	25	1	None
Domain 2		27	Water Table	Generalized Hoek-Brown	130000	78	25	1	None
Domain 3		27	Water Table	Generalized Hoek-Brown	120000	70	25	1	None
Domain 4		26	Water Table	Generalized Hoek-Brown	40000	45	20	1	None
Domain 5		26	Water Table	Generalized Hoek-Brown	50000	35	15	1	None

Figure 39: Limit Equilibrium Slide3 results under static conditions, showing global minimum failure surface on the east wall



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	UCS of intact rock (kPa)	GSI	mi	D	Tensile Cutoff Type
Domain 1		27	Water Table	Generalized Hoek-Brown	130000	82	25	1	None
Domain 2		27	Water Table	Generalized Hoek-Brown	130000	78	25	1	None
Domain 3		27	Water Table	Generalized Hoek-Brown	120000	70	25	1	None
Domain 4		26	Water Table	Generalized Hoek-Brown	40000	45	20	1	None
Domain 5		26	Water Table	Generalized Hoek-Brown	50000	35	15	1	None

Figure 40: Limit Equilibrium Slide3 Spencer's under static conditions safety map

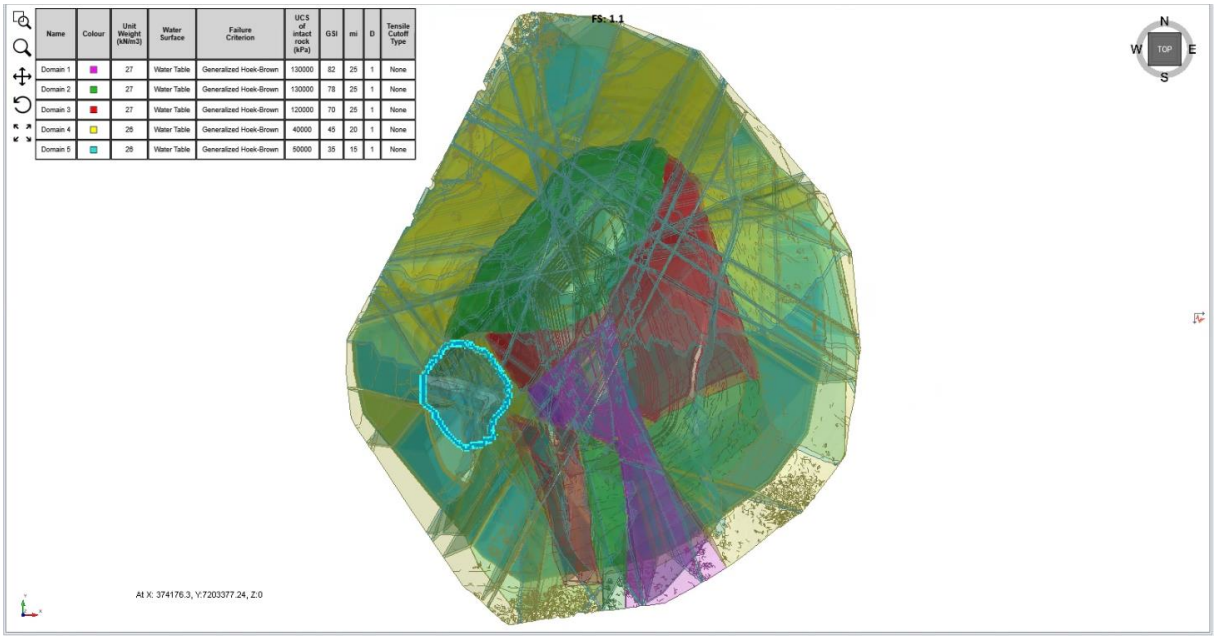


Figure 41: Limit Equilibrium Slide3 result,lts under dynamic seismic conditions, sh, owing global minimum failure surface on the west wall

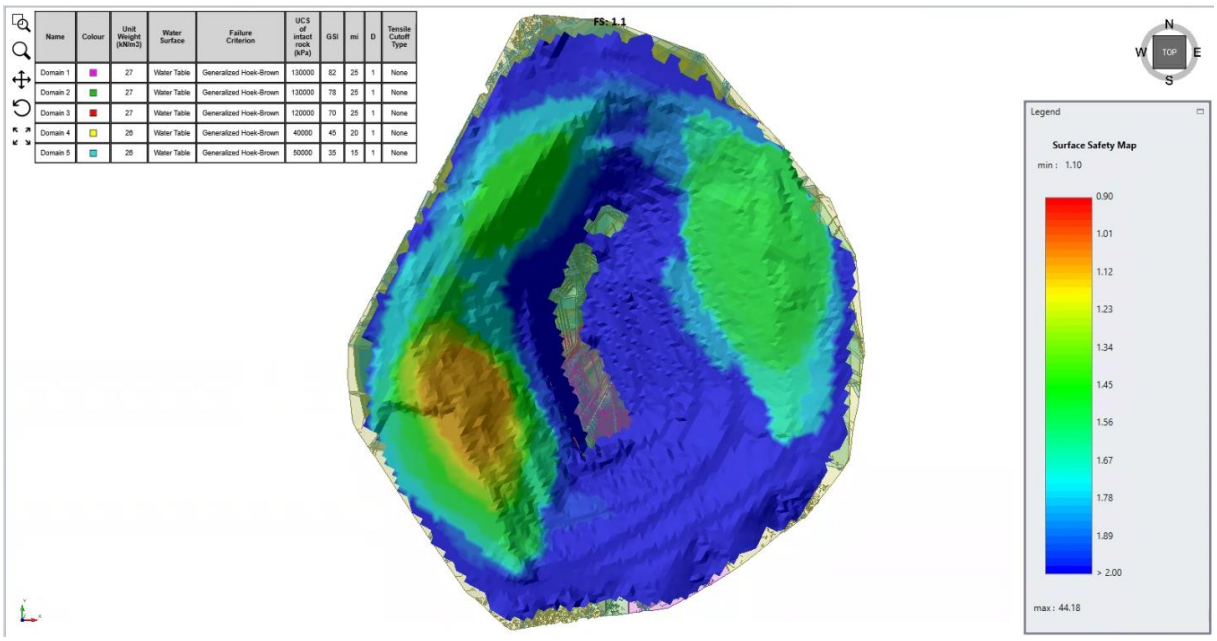
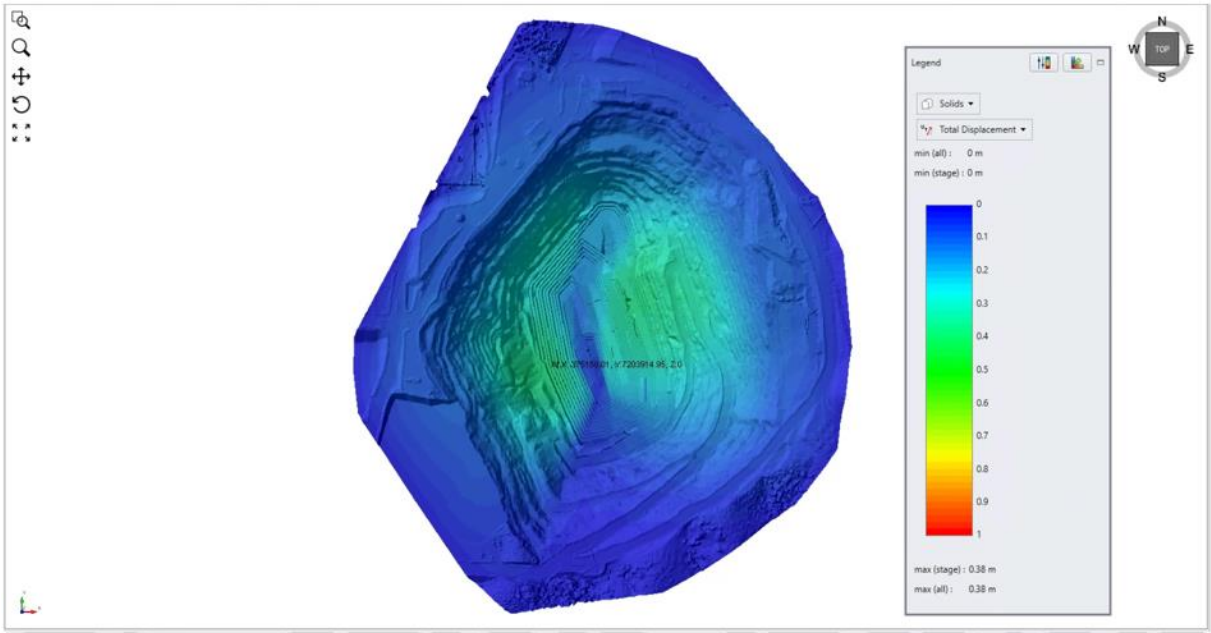


Figure 42: Limit Equilibrium Slide3 results under dynamic seismic conditions

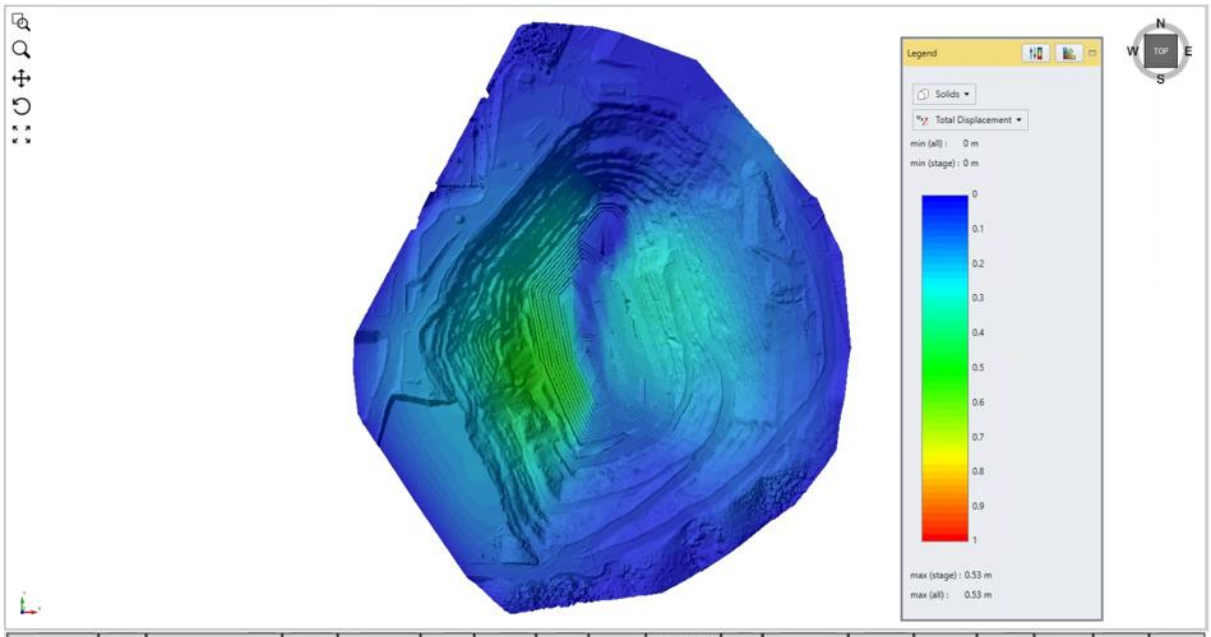
Deformation Analysis (RS3)

Finite element analysis using the Rocscience software RS3 was used to assess the deformation of the pit slope under closure conditions. The modelling results, as shown below in Figure 43**Error! Reference source not found.** and **Error! Reference source not found.**, illustrate a correlation with Limit Equilibrium (LE) analysis results, with a maximum total displacement of approximately 400 mm (an equivalent strain of 0.23%) recorded more on the west wall and east within range, under static conditions, and 530 mm (an equivalent strain of 0.32%) on the west wall under dynamic conditions, respectively. This displacement will be around areas known to have marginal stability during the operational phase of the mine and caused some instabilities during the operational phase of the Mine. However, this deformation estimate is not expected to instigate large scale failures.



Name	Colour	Initial Element Loading	Unit Weight (MN/m3)	Failure Criterion	Material Type	Peak Cohesion (MPa)	Peak Friction Angle (°)	Peak Tensile Strength (MPa)	Unsaturated Shear Strength Angle (°)	Air Entry Value	Elastic Type	Use Unloading Condition	Poisson's Ratio	Young's Modulus (MPa)	Material Behavior Type	Porosity Type	Porosity
Joints		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Domain 1		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	3822	57	0.937	0	0	Linear Isotropic	No	0.2	21000	Drained	Porosity	0.3
Domain 2		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	2741	57	0.64	0	0	Linear Isotropic	No	0.2	18000	Drained	Porosity	0.3
Domain 3		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	1339	54	0.276	0	0	Linear Isotropic	No	0.22	13000	Drained	Porosity	0.3
Domain 4		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	201	37	0.024	0	0	Linear Isotropic	No	0.25	2000	Drained	Porosity	0.3
Domain 5		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Faults structures		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	27	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3

Figure 43: Result showing total displacement of 380 mm at post-closure conditions s under static conditions



Name	Colour	Initial Element Loading	Unit Weight (MN/m3)	Failure Criterion	Material Type	Peak Cohesion (MPa)	Peak Friction Angle (°)	Peak Tensile Strength (MPa)	Unsaturated Shear Strength Angle (°)	Air Entry Value	Elastic Type	Use Unloading Condition	Poisson's Ratio	Young's Modulus (MPa)	Material Behavior Type	Porosity Type	Porosity
Joints		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Domain 1		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	3822	57	0.937	0	0	Linear Isotropic	No	0.2	21000	Drained	Porosity	0.3
Domain 2		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	2741	57	0.64	0	0	Linear Isotropic	No	0.2	18000	Drained	Porosity	0.3
Domain 3		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	1339	54	0.276	0	0	Linear Isotropic	No	0.22	13000	Drained	Porosity	0.3
Domain 4		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	201	37	0.024	0	0	Linear Isotropic	No	0.25	2000	Drained	Porosity	0.3
Domain 5		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Faults structures		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	27	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3

Figure 44: Result showing total displacement of 530 mm at post-closure conditions under dynamic conditions

RA 2 – WRD, ROM and stockpiles

Rehabilitation area 2 includes the North Waste Rock Dump (NWRD), West Waste Rock Dump (WWRD), Run of Mine (ROM), and associated ore stockpiles. The post-mine land use objectives for the waste rock rehabilitation area areas are fully revegetated, natural-looking landforms of open woodland and capable of sustaining low intensity cattle grazing where the steepness of the slopes allow it. The steepness of the slopes on finished landforms such as waste rock dumps will be conducive to a geotechnically stable structure, with erosion and sediment control landscaping that ensure erosion rates will not interfere with the achievement of proposed PMLU.

North Waste Rock Dump (NWRD)

A Mine Material Management Plan has been developed for the North Waste Rock Dump (NWRD) and includes a Landform evolution assessment, landform cover design and water balance/quality assessment (refer to supporting document *Mine Material Management Plan, RGS 2022*).

The Northern WRD, with a final approved footprint of 103 ha, contains PAF material encapsulated by NAF, coupled with low permeability clay layers on the benches that limit the ingress of water into the NAF embankments and a low permeability cover system on the top of the final landform.

The landform design objectives and key design criteria for the NWRD including the external batters include the following.

- The NWRD was designed and built to produce neutral pH drainage via encapsulating of PAF waste in within an outer core of neutralising rock, thereby acid runoff formed within the centre of the dump is neutralised as it passes through the outer ring of neutralising rocks.
- The NWRD was built in four lifts of up to 25 m height.
- The inner PAF core of the NWRD was covered via the construction of external NAF batters built at the angle of repose utilising competent rock comprising gravel ~ 20 mm diameter up to boulders in the range of 1 m diameter. The nominal PSD is P80 > 250 mm.
- The purpose of the NAF rock armour is to provide long term, geotechnical stability, minimise (avoid) erosion so that mineralised sediment is not moved from the NWRD into the receiving environment, avoid the need for soil cover systems on external batters that can be prone to long term failure.
- The NAF external batters utilised placement of 30 m (horizontal) and 25 m (vertical) cover over the internal waste rock in the NWRD **(**Figure 45**).**
- Each batter was underlain by compacted low permeability clay/silt/sand graded at 5% to collect batter interflow **(**Figure 45**)** and direct surface flow along contour to a drop structure that will be designed and built on the NE face of NWRD to direct surface flow to the WD1 dam. The design objective of the contour drains is to minimise the amount of water falling onto or flowing through the external batters.

The capping system for the berms was designed in alignment with the *Waste Rock Dump Berm Design for the North Dump* (Haymont, R., NRC, 2013) as illustrated in figures below.

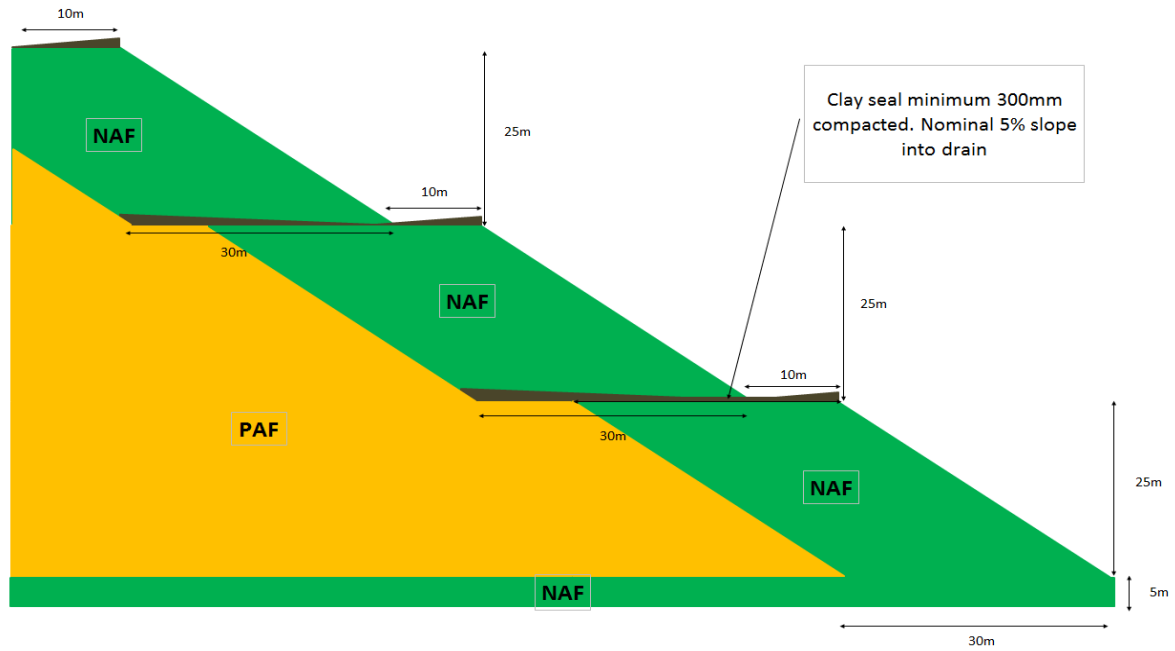


Figure 45: Cross-Section Illustration of Conceptual NORTH WRD Berm Design

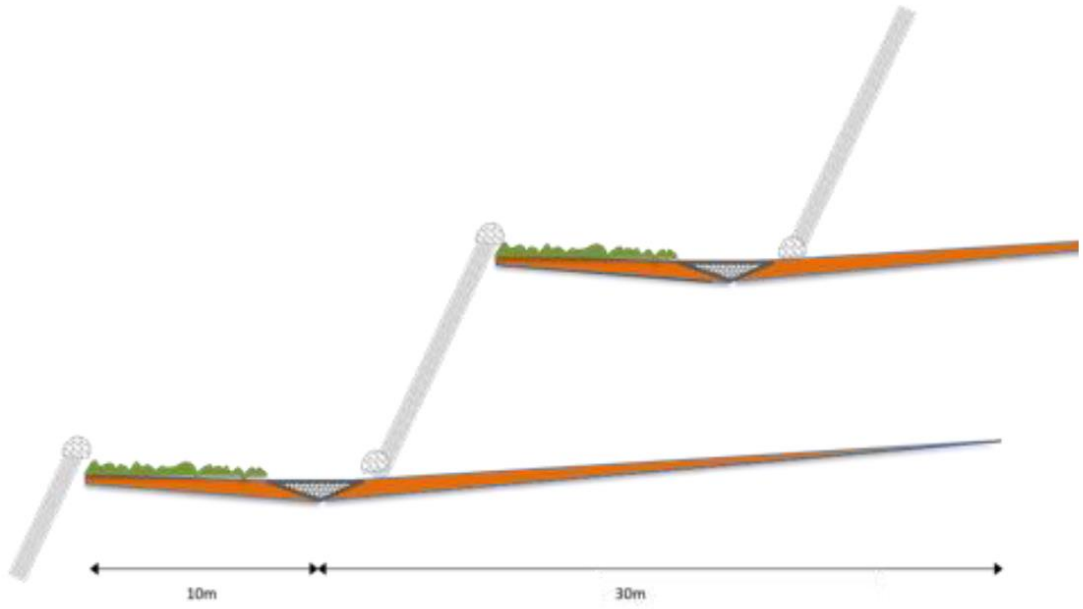


Figure 46: Rehabilitation of Exposed Berm

NWRD Cover system design

RGS completed unsaturated zone modelling (SEEP/W, GeoStudio, 2018) of a range of cover system options - Figure 48) that could be constructed using available material within the site material balance. The preferred cover system design was considered to be Option 1B.

The landform design objectives and key design criteria for the top of the NWRD include the following:

- The final NWRD landform will be profiled during the reshape to direct surface flow towards the western access ramp.
- After low grade ore and PAF material on the top and western side of the NWRD has been removed the NWRD final landform will be covered with an engineered cover system comprising the following.
  - NAF competent rock will be placed over the exposed waste rock to provide a basal layer (the $PRC_{PLAN.LHS}$ model allows for up to 3 m of NAF rock). This is referred to as the interim NAF rock cover.
  - Fine grained clay/silt/sand (low permeability layer) will be placed over the NAF rock interim cover layer (the $PRC_{PLAN.LHS}$ model allows for 2 x 0.25 m compacted layers). Each 0.25 m layer will be conditioned and compacted.
  - NAF oxide regolith dominated by saprolite is placed over the fine-grained clay/silt/sand low permeability layer (the $PRC_{PLAN.LHS}$ model allows for 2 m of material).
  - NAF waste rock is placed over the NAF oxide regolith (the $PRC_{PLAN.LHS}$ model allows for 1 m of > 75 mm and < 250 mm PSD.
  - Topsoil is placed over/ within the NAF waste rock to fill voids in the rock cover (the $PRC_{PLAN.LHS}$ model allows for 0.2 m of soil).
  - Surface flow from the top of the cover system will flow to the western access ramp. Part of the ramp will be retained as an access road and the remainder of the access ramp will be converted into a rock armoured drain to direct surface flow to the base of the NWRD.
  - Surface flow can then be diverted to the:
    - Open pit

- Southern side of the NWRD toe and then into
  - WD4, or
  - into the receiving environment.

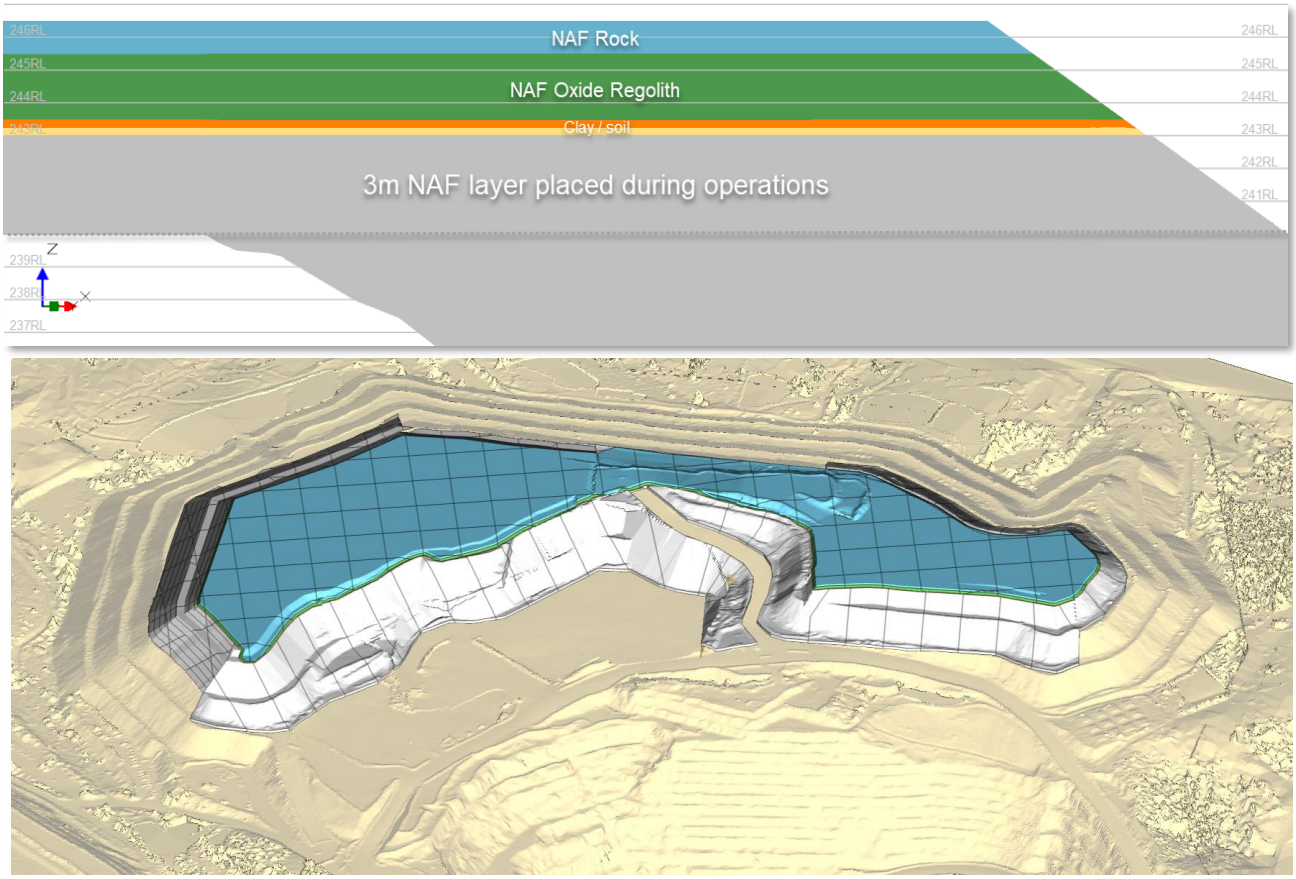


Figure 47: NWRD cover configuration

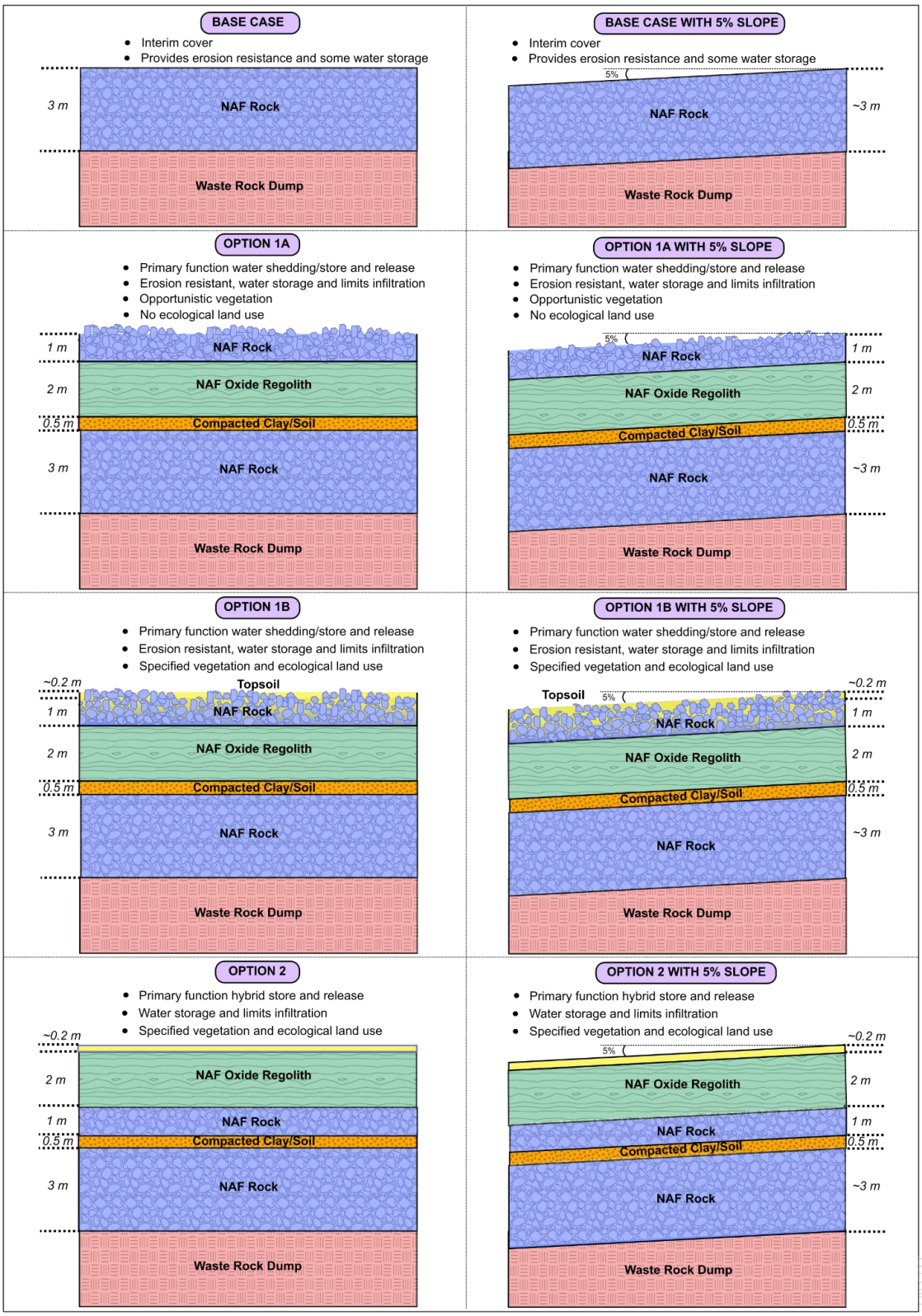


Figure 48: NWRD cover system concept level cover configurations

A cover system performance monitoring plan for the NWRD has been developed, refer to supporting document – *Mine Material Management Plan – Attachment C: Cover trial and performance monitoring plan, RGS 2022.*

NWRD schedule and sequencing of material placement $PRC_{PLAN.LHS}$

The scheduling of materials to progressively rehabilitate the NWRD to the final landform design has been simulated and optimised using Deswik.CAD and Deswik.LHS ($PRC_{PLAN.LHS}$). The following figures show the configuration of stockpiles within the NWRD and sequencing of the material placement to the final landform design.

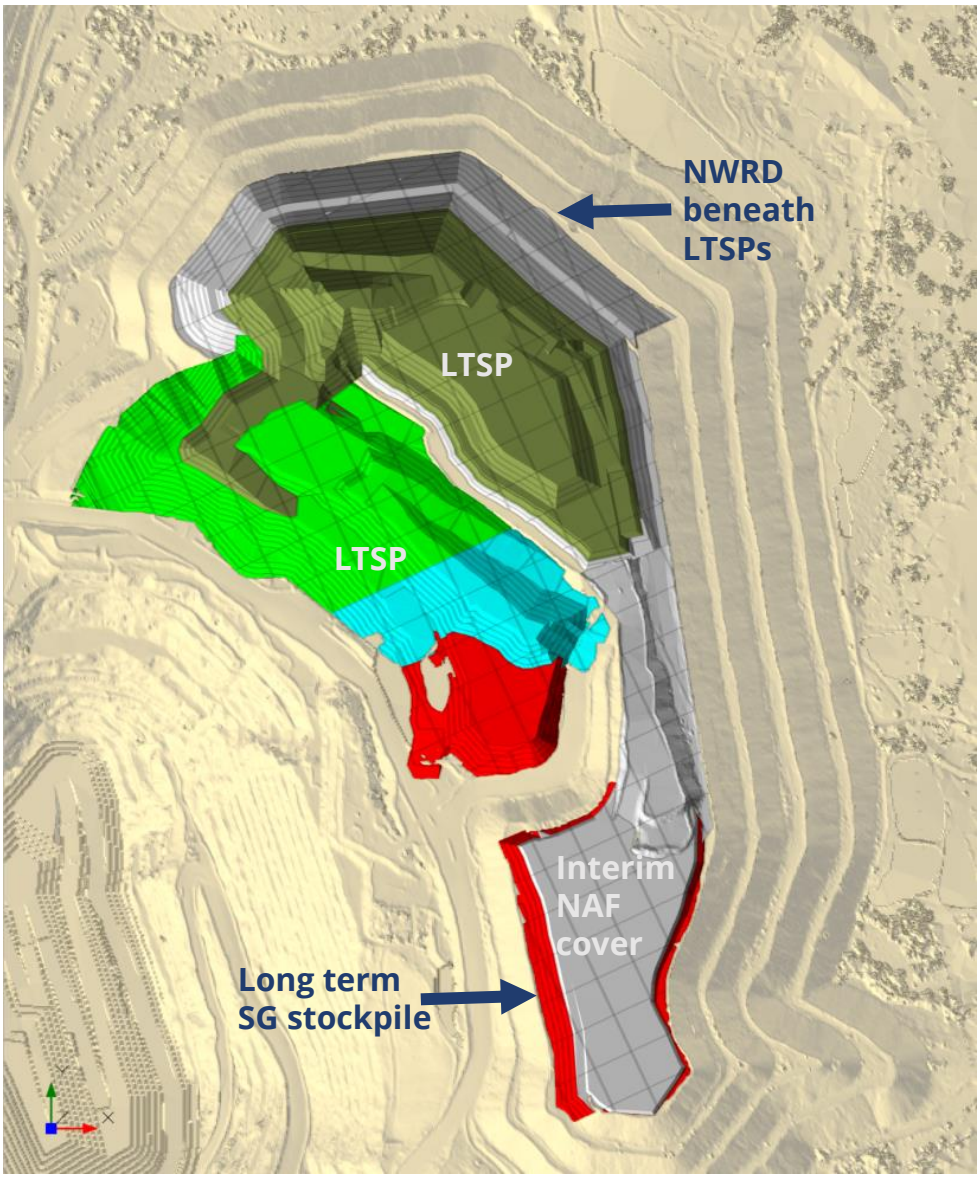


Figure 49: Stockpiles within the NWRD

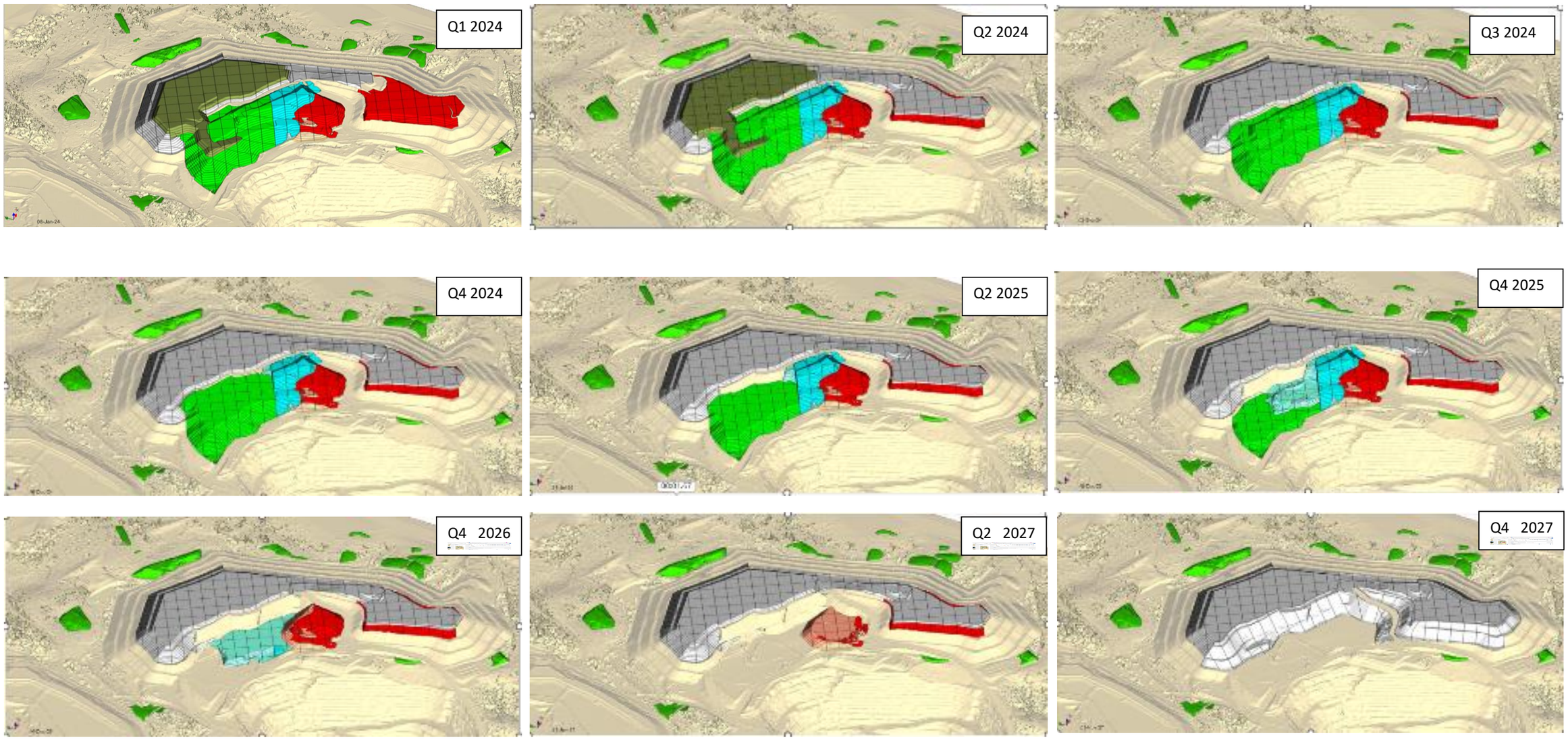


Figure 50: NWRD PRCPLAN.LHS sequence Q1 2024 to Q4 2027

NWRD Landform erosion evolution assessment

As describe above, the $PRC_{PLAN.LHS}$ work has verified that the material balances are sufficient to complete documented rehabilitation work at MRO. Additionally RGS is developing a soil capping and stability report to support the PRC Plan. Laboratory analyses being conducted by RGS using a Rainfall and Erosion Simulator (RGS_RaE_{SIM}) on the 5 x $1m^3$ samples in Q3 of 2022 include measurement of the erosion rate of each bulk sample at 5% slope and 30 mm/hr, 60 mm/hr and 90 mm/hr rainfall intensity, and a sample also being measured at a 20% slope.

RGS will also be collecting water samples and measuring filterable and unfiltered water quality parameters to verify probable water quality that occur from rehabilitated cover systems on the NWRD and TSF: water quality parameters will include pH, EC, acidity, alkalinity all major ions and 45 metal(loids). The soil quality, geochemical and physical properties are being verified throughout Q3 2022 to Q1 2023 by external laboratories including Trilab, ALS, Levay and Co and Soil Water Consultants.

The RGS_RaE_{SIM} results will be evaluated using MinErosion v4 to document a probable range of erosion rates for the TSF and NWRD cover systems for as-placed material and for established cover systems. This level of erosion assessment uses methods and approaches developed by the Australian Coal Association Research Program (ACARP), University of Queensland (UQ) and Griffith University over fifteen years and provides significant advantages over USA agricultural software such as the Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE) and Water Erosion Prediction Project (WEPP). Results will be incorporate into this PRC Plan upon completion.

NWRD Geotechnical assessment

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the NWRD, refer to supporting document - *EVO010006 - MRO PRCP Geotechnical Assessment-Waste Dump_Final*.

The adopted assessment criteria for the slope stability analysis are based on the overall slope scale under the high consequence of failure, as listed in Hawley and Cunning (2009). This is summarised below based on a static and pseudo-static factor of safety values. A minimum FoS of 1.5 and 1.15 has been adopted for static and dynamic analyses. Based on the waste dump stability rating discussed in section 4.8, the MRO waste dump waste is classified with a stability rating of WHC 3, moderate hazard. From this classification, it can be followed that the consequence of the dump will be moderate, and the target factor of safety (FoS) for static and pseudo-static conditions be determined. With an assumption of moderate confidence in Table 32, the target factors of safety are shown below.

Table 32: Typical FoS and PoF acceptance criteria values (Hawley & Cunning, 2009)

		Static analysis		Pseudo-static analysis	Maximum allowable
Consequence[1,3]	Confidence[2,3]	Minimum FoS	Maximum PoF[4]	Minimum FoS	strain[5]
Low	Low	1.3–1.4	10–15%	1.05–1.1	≤1%
	Moderate	1.2–1.3	15–25%	1.0–1.05	≤1.5%
	High	1.1–1.2	25–40%	1.0	≤2%
Moderate	Low	1.4–1.5	2.5–5%	1.1–1.15	≤0.75%
	Moderate	1.3–1.4	5–10%	1.05–1.1	≤1%
	High	1.2–1.3	10–15%	1.0–1.05	≤1.5%
High	Low	≥1.5	≤1%	1.15	≤0.5%
	Moderate	1.4–1.5	1–2.5%	1.1–1.15	≤0.75%
	High	1.3–1.4	2.5–5%	1.05–1.1	≤1%

The factor of safety results for the static and dynamic scenarios of the Slide3 Limit Equilibrium analysis is shown below. A minimum global factor of safety values is below the prescribed criteria. However,

these failure surfaces include all intra-bench slumps. Small-scale slumping of the final WRD can be expected over time and is not considered high severity.

No inter-bench failure surfaces were noted below the acceptance criteria for static analysis.

Table 33: Stability analysis results

Scenario	FoS (Spencer)*	FoS (GLE/Morgenstern-Price)*
Static	**0.45**	**0.45**
Pseudo-static (PGA: 0.25g or 1:10000)	**0.46**	**0.45**

*Results show the global lowest calculated FoS. No FoS <1.5 for static or <1.15 for dynamic scenarios was found to create deep-seated instabilities

It should be emphasised that the highlighted global minimum factor of safety (Figure 51) is localised, due to the shape and geometry of the bench, for the static analysis and does not affect the overall stability of the dump. Figure 52 indicates that the majority of the dump will have a factor of safety greater than 1.3, which Is a minimum requirement per **Table 32** for dumps of moderate consequences as classified for the MRO NWRD.

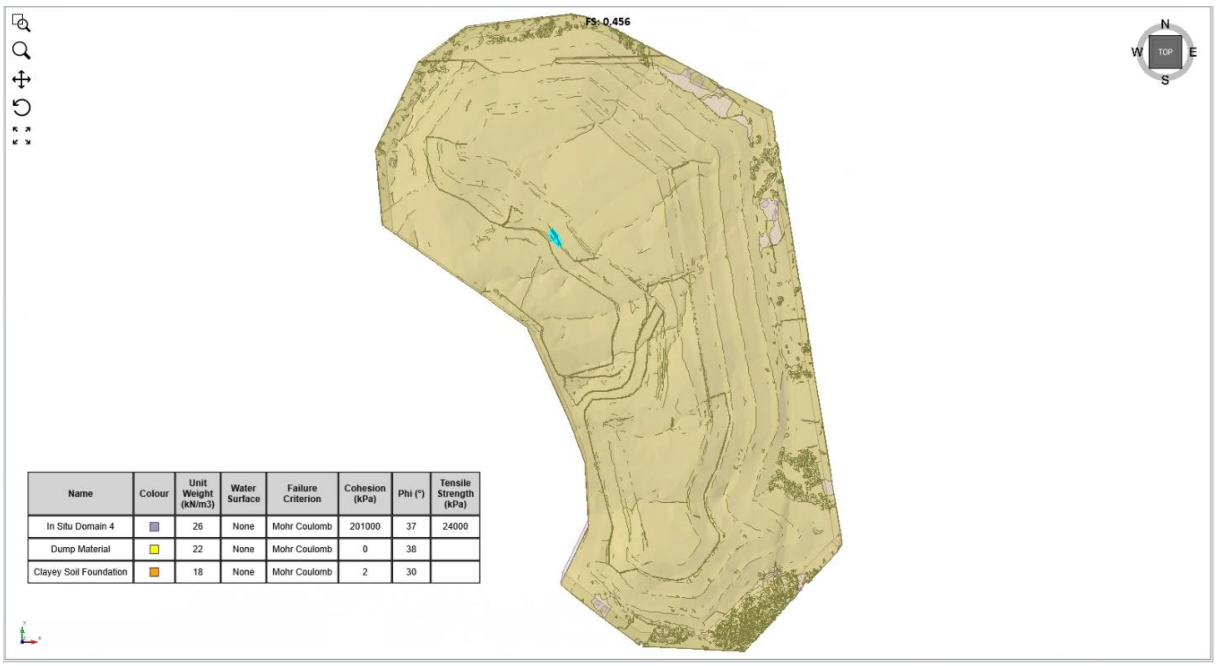


Figure 51: Limit Equilibrium Slide3 results under static conditions, showing global minimum failure surface

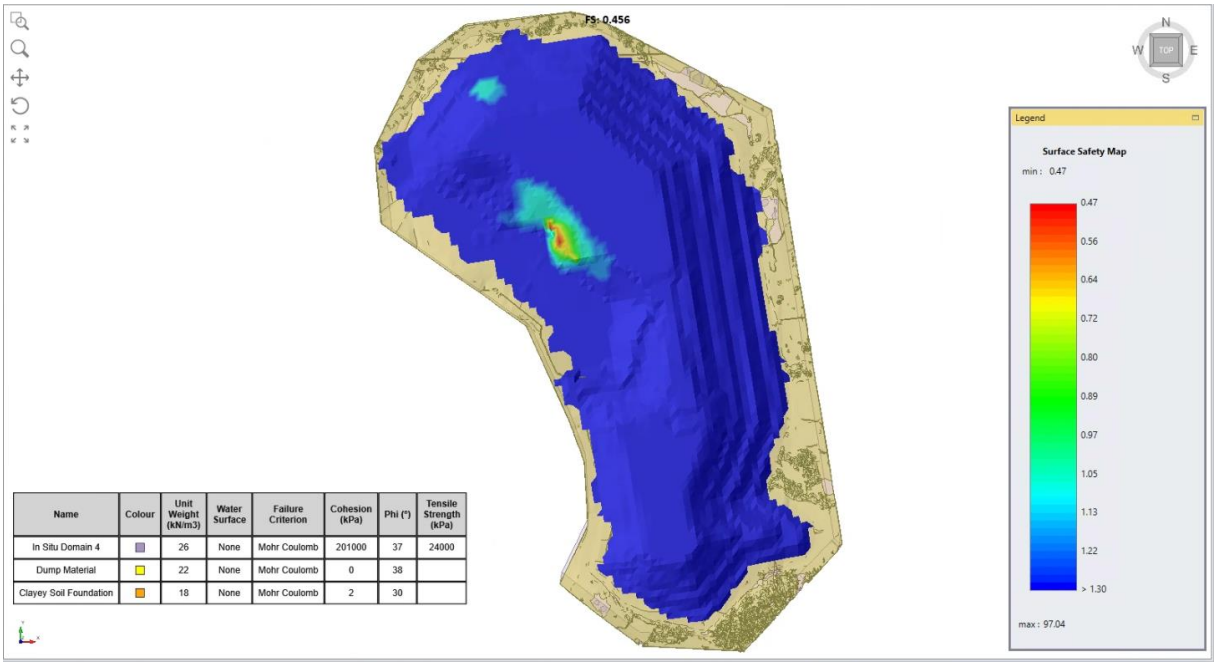


Figure 52: Limit Equilibrium Slide3 results under static conditions safety map, showing location with a factor of safety less than 1.3 as per Table 32 requirement for long-term static conditions

For pseudo-static seismic analysis, the global minimum indicates a localised failure surface on the north wall middle bench where the phreatic surface intersects the wall. However, other locations along the eastern wall also indicate a factor of safety of less than 1, indicating failure. Considering the localised areas where there is a marginal factor of safety, buttressing these areas can be implemented to enhance the factor of safety for long-term stability.



Figure 53: Limit Equilibrium Slide3 results under pseudo-static seismic conditions, showing global minimum failure surface

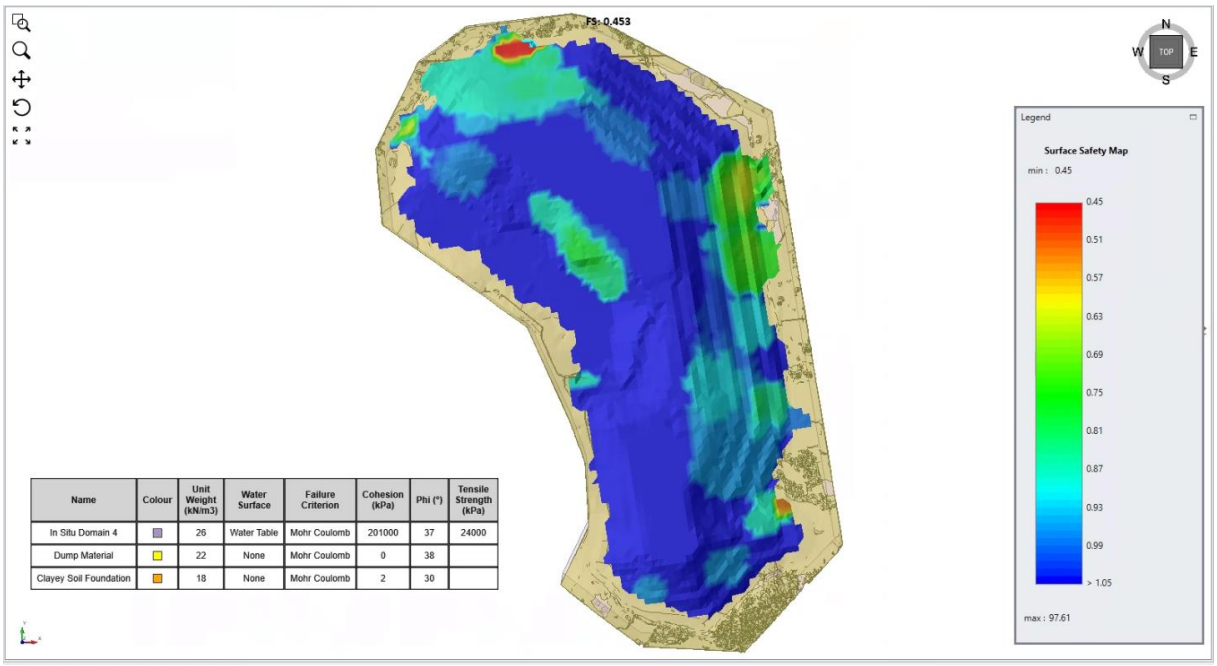


Figure 54: Limit Equilibrium Slide3 results under pseudo-static seismic conditions safety map, showing location with a factor of safety less than 1.05 as per Table 32 requirement for long-term static conditions

The final waste dump model elements were incorporated into the Waste dump and stockpile stability rating and hazard classification system (Hawley & Cunning, 2017). This system requires the evaluation of 22 key factors or attributes that are thought to affect stability. These factors have been organised into seven groups. Numerical ratings are assigned to each factor, and the sum of these ratings defines the waste dump and stockpile stability rating (WSR). The waste dump stability rating was scored against all factors to resolve the Engineering Geology Index (EGI) and the Design and Performance Index (DPI).

Table 34: Waste Dump Stability Rating Summary

	Rating	Group Score	Index Score
Engineering Geology Index (EGI)			
Regional Setting	Neutral	3.5	25.5
Foundation Condition	Neutral	7.0	
Material Quality	Good	15.0	
Design and Performance Index (DPI)			
Geometry and Mass	Medium	4.0	32.0
Construction	Very Favourable	13.0	
Performance	Very Good	15.0	

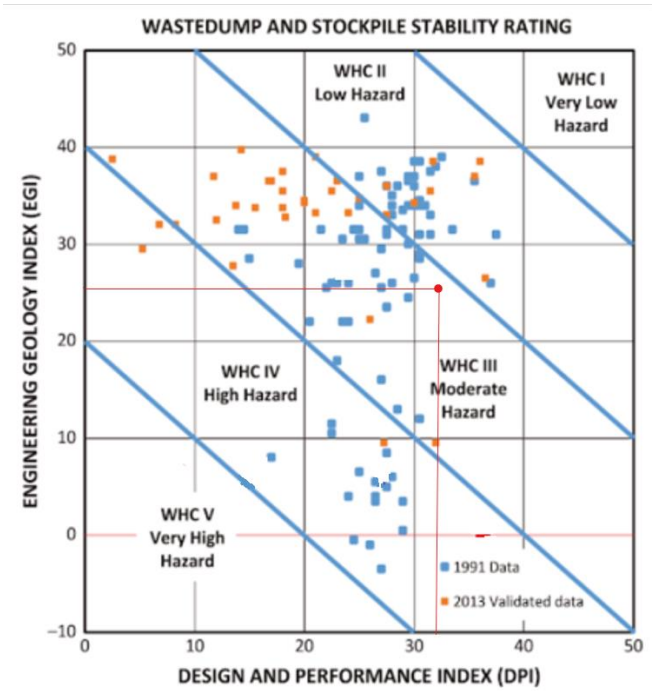


Figure 55: Waste dump stability and hazard chart showing MRO NWRD stability rating (red dot)

As per the WRS classification system (Hawley & Cunning, 2017), the intersection of the EGI and DPI results places the MRO final waste dump within the moderate hazard classification (red dot).

The analyses demonstrated that the NWRD is globally stable under post-closure conditions. Localised sections require reshaping or buttressing on the upper western bench and the north and eastern lower benches under dynamic conditions.

The final waste rock dump shell analysed for geotechnical stability does not include the effects of erosion. Given the competent nature of the rock on the NWRD embankments and slopes, the effects of erosion on the modelled results are likely to be negligible. However, any detailed erosion modelling should be fed back into this model to determine the long-term slope stability of the waste rock dump.

West Waste Rock Dump (WWRD)

The WWRD is comprised of entirely NAF material and is currently acting as a stockpiled reserve of NAF for use across the site where required including the construction of the TSF embankments. The material has many uses across site rehabilitation areas including capping, construction of berms, ESC structures and for rehabilitation purposes. Progressive rehabilitation of the WRD cannot be initiated given the extensive use of the NAF material under current operational strategy. Under the current materials balance for the site, the entire WWRD will be consumed for rehabilitation of other domains, such as the TSF and NWRD. Therefore, the remaining disturbed footprint surface will be prepared and revegetated to an open woodland/low intensity grazing post mine land use.

A NAF rock land bridge is retained from the TSF to the open pit to enable the movement of water from the TSF to the open pit during Phase 2 to Phase 4 of the water management planning. The West Dam is also retained during and post rehabilitation work.

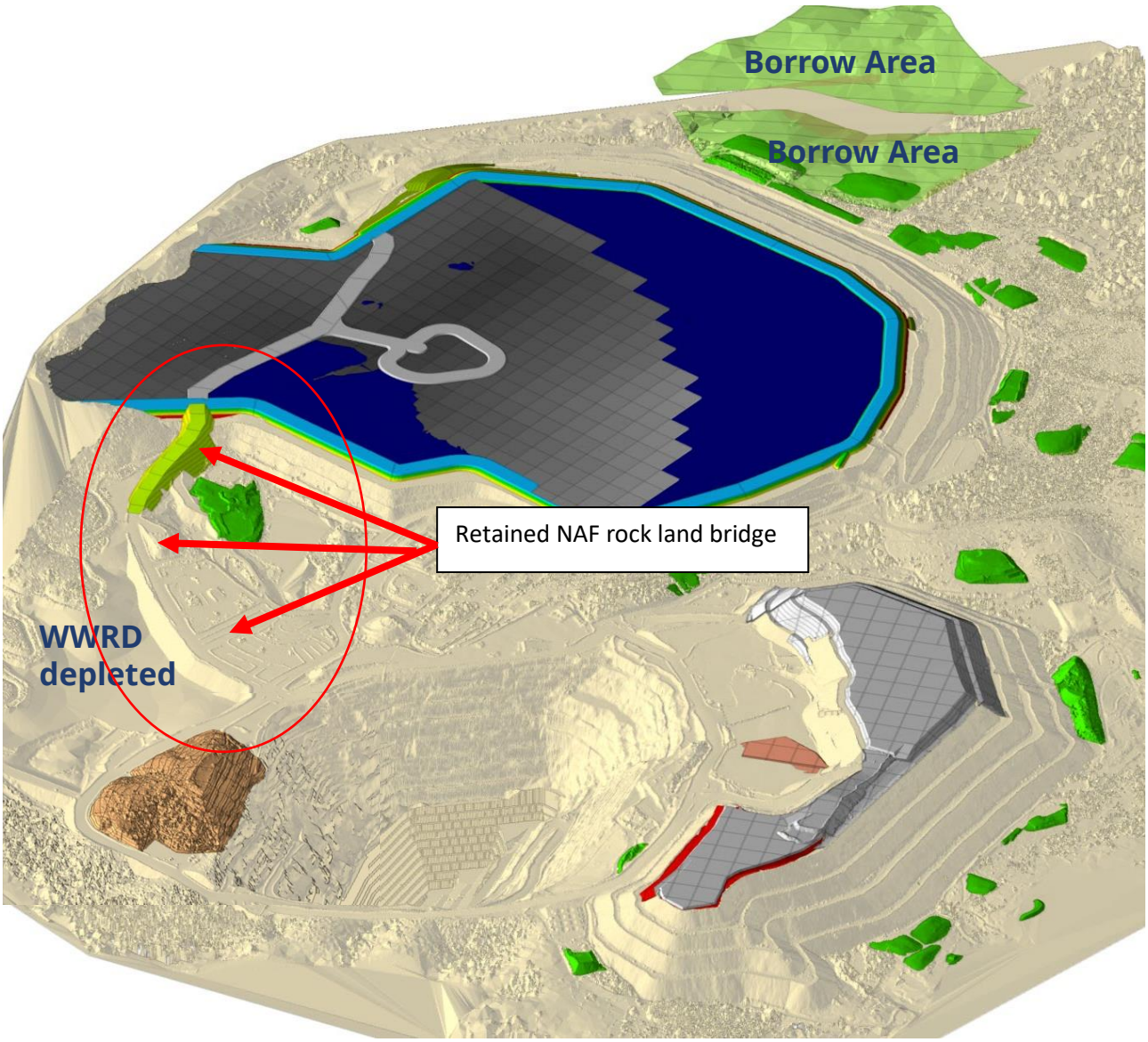


Figure 56: West WRD final constructed mine landform

Run of Mine

The decommissioning of the Run of Mine (ROM) will be towards the end of closure as access will be required to remove remaining infrastructure such as the crusher bin. The rehabilitation of the NAF area will include being reshaped, topsoiled, ripped to specified depths and seeded with appropriately selected species. The area will be revegetated to an open Eucalypt woodland capable of supporting low-intensity grazing.

RA 3 – Tailings Storage Facility (TSF)

The Tailings Storage Facility (TSF) comprises valley-type storage, formed by a primary embankment at the northern end of the site (referred to as Northern Embankment), an embankment at the southern end that extends around the eastern perimeter (referred to as Southern Embankment), and a saddle embankment formed on the western perimeter (referred to as Western Saddle Embankment). The proposed ultimate design configuration is detailed below in **Table 35**. The TSF will be rehabilitated to the final land use of open woodland and low-intensity grazing purposes where practicable. This involves the decommissioning and removal of pumping and piping infrastructure followed by the installation of an appropriate cover system and revegetation. Ongoing dewatering is required until the closure of the TSF and seepage is expected to be minimal following closure and reshaping of the TSF final landform.

Table 35: TSF Design Details

Parameter	Final Year Ultimate Design
Embankment Crest Level	RL 197.5 m
Total Storage Capacity (tailings, waste rock, water & airspace)	64,838ML
Maximum Northern Embankment Height	81m
Maximum Southern Embankment Height	62m
Maximum Western Embankment Height	27m
Spillway invert level RL	RL 192.0 m
Spillway width	10 m

TSF Landform design and material placement sequencing

The concept closure, decommissioning and rehabilitation plan for the TSF includes the following key components (RGS, 2016):

- Continued placement of PAF-HC waste rock into the decant structure(s) within the TSF to fully encapsulate this material within fine grained NAF low permeability tailings to eliminate oxygen entry into bulk PAF-HC waste rock materials and reduce/ negate sulfide oxidation.
- Placement of PAF-MC waste rock into a series of low-profile benches on the western TSF cell that will be encapsulated progressively within NAF tailings. The key design criteria for this are that PAF-MC waste rock will not be placed within 25 m horizontal of the natural ground to the west of the TSF, 50 m of the external final TSF landform, and the top of the waste rock will be covered with at least 3 m of NAF tailings.
- Consideration will be given to increasing the acid neutralising capacity of the tailings stream to maintain an ANC:MPA ratio of > 2 within the TSF from the existing to final elevation of the tailings beach.
- The PAF-MC waste rock stockpiles may require reshaping / relocating as this is the zone where surface runoff is not proposed to be directed so it can be released to the north or south of the TSF.
    - The final landform design for the TSF will require surface water flow from the hills to the west of the TSF to be directed:
        (i) via perpetual surface water diversion drains to the West Dam
        (ii) via perpetual surface water diversion drains to the West diversion drains around West Dam to the receiving environment
        (iii) onto the TSF so the water can be released to the south or north via perpetual release points (drop structures) to the
            a. toe of the TSF into the receiving environment
            b. West Dam
            c. Open Pit.

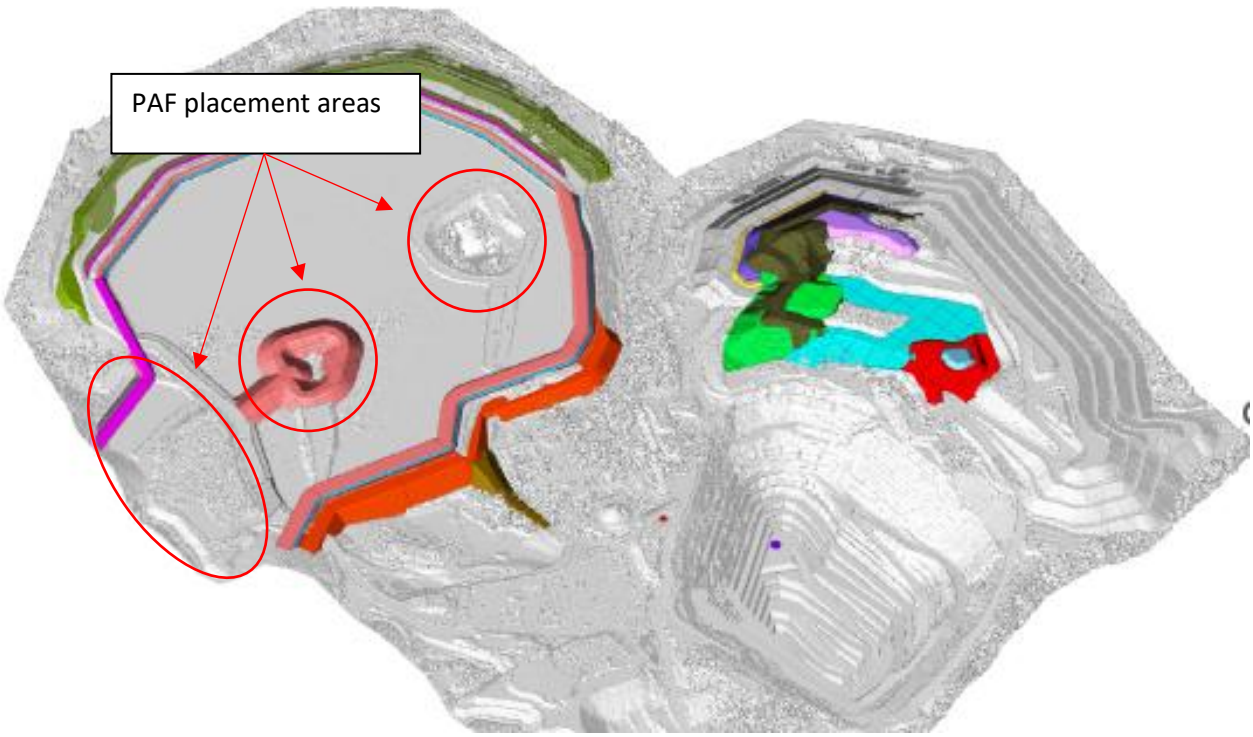


Figure 57: TSF PAF placement

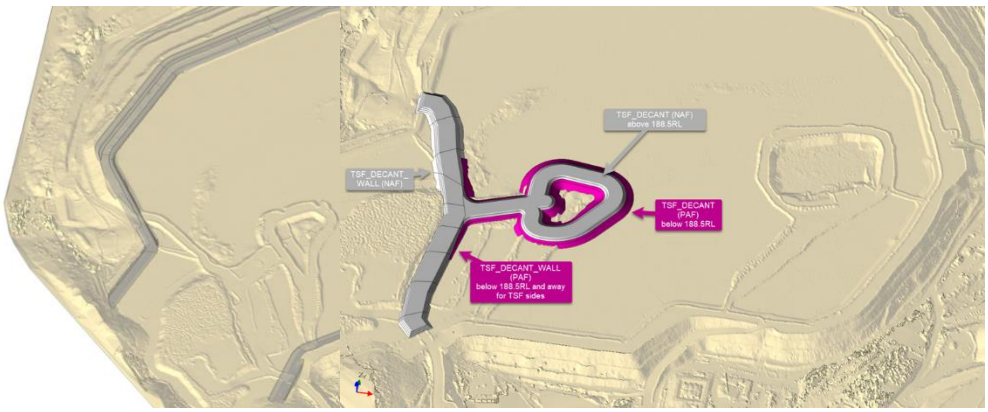


Figure 58: PAF closure zones post 2024

Note PAF will not actually be allowed to be placed adjoining the TSF embankment. There will be a set back of 25 m from the embankment.

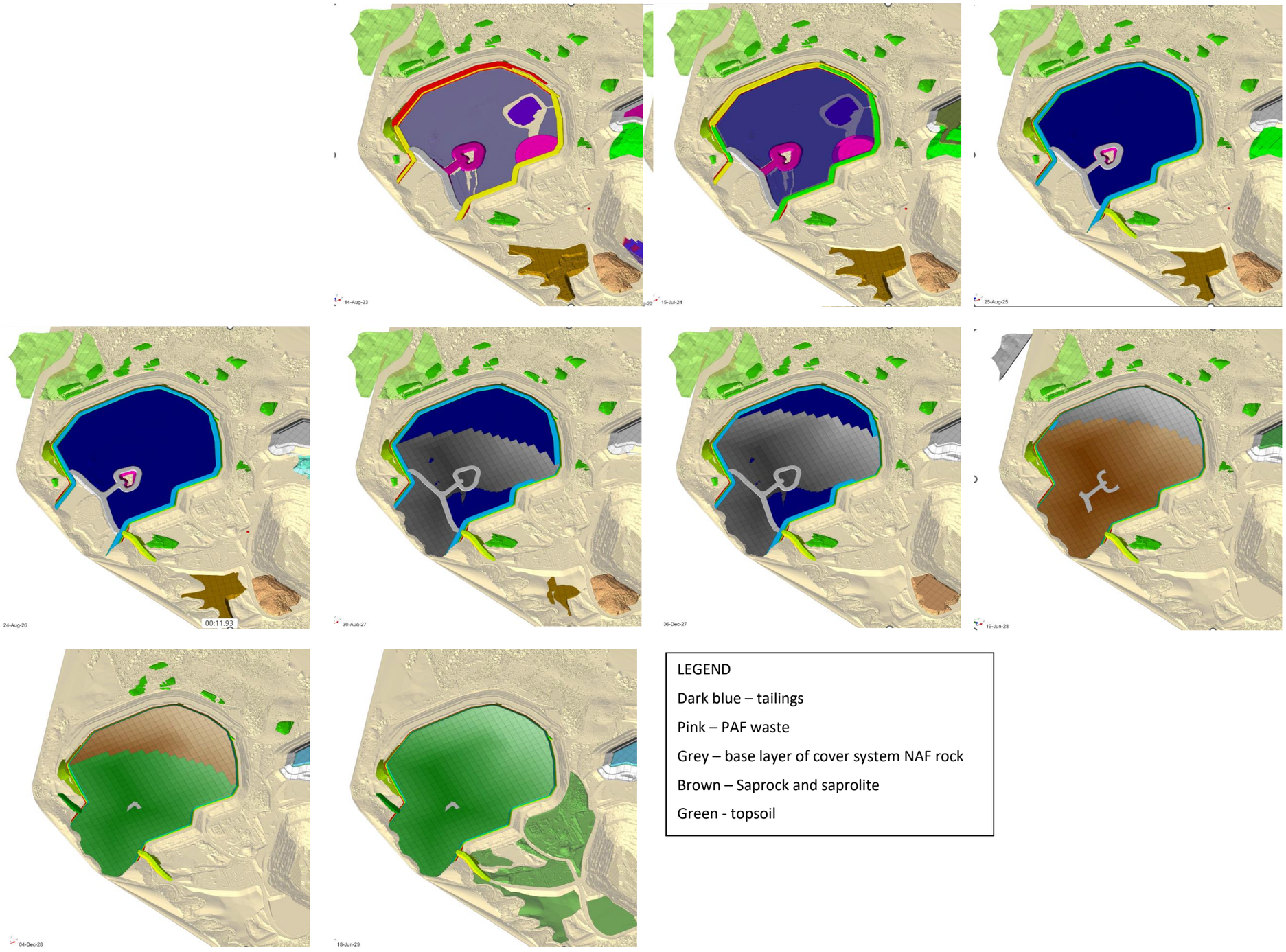


Figure 59: TSF PRCPLAN.LHS timestep

TSF Operational water management moving into rehabilitation phase

There are three phases of water management for the TSF as it transitions from operations to rehabilitation that will need to be developed to detailed design.

1. *Phase 1 – processing and mine operations*

There is a requirement to move the TSF supernatant pond from the centre of the TSF to the western end of the TSF over the remaining LOM, as this is the probable location where surface water will be released to (i) the open pit, or (ii) the receiving environment. The geometry of the tailings beach profile will:

- increase the slope of the tailings beach from the TSF embankment perimeter to the tailings supernatant pond, and,
- reduce the volume of "fill" required to be placed in the basal layer on the tailings (fill could include rock, saprolite, saprock and pedolith units).

This process is likely to require changes to the TSF design and tailings deposition strategy and needs to be integrated into the TSF operations by MRO and ATCW.

2. *Phase 2 – cessation of tailings deposition and transition to rehabilitation*

MRO will need to develop a detailed water management plan to maintain the design storage allowance (DSA) of the TSF (approx. 2 GL) as the TSF transitions through rehabilitation.

RGS understand that the TSF must maintain the DSA until rehabilitation of the cover is complete and the cover system is functioning in an as-designed manner i.e. that the cover system can sustain the desired land use and surface runoff from the cover system can be released directly to the environment.

3. *Phase 3 – basal layer construction*

During this phase of work the:

- water storage within the TSF is progressively reduced as it is replaced with rock, and regolith units
- the TSF needs to be kept as empty of water as possible
- DSA must be maintained within the TSF or be available in an external dam or the open pit.

If external DSA is viable then a pipe/pump/drainage system will need to be put in place during this phase of work to enable adequate transfer of water from the TSF to the open pit.

During this phase of work the following actions are required:

- A NAF basal layer will be placed over the tailings beach
- Consideration of the rate of deposition will be taken during the placement of the NAF rock layer due to previous concerns relating to deformity of the design structure from an increased rate of deposition
- Profiling the tailings may include pushing up to 1 m of NAF waste rock into the tailings to:
  - provide a structurally competent base with low permeability, and,
  - increase the ANC in the upper profile to ensure the tailings remain NAF.

Tailings cover system design

The initial phase will require the water storage within the TSF to be further reduced as it is replaced with rock, regolith units and the final cover system. The TSF will be dewatered, and DSA maintained within the TSF or be available in an external dam or the open pit.

A geochemical and physical sampling and analytical program has been completed (GaPSaAP (RGS, 2016)) to verify the properties of the soil that could be used for rehabilitation of the TSF.

- Test pit and diamond core drilling at six locations at MRO in mid-2016 verified the presence of approximately 2.5 million bulk cubic metres (BCM) of soil and weathered granitoid/schist/gneiss and gneiss/meta sediment within a borrow area to the east of the TSF.
- Chemical and physical analyses of the rehabilitation units verify they are suitable for construction of a 2.5 m deep soil cover system over the tailings.
- Analysis of the drill core using HyloggerTM has identified kaolinite, mica and chlorite group minerals: montmorillonite was identified, but is considered to be an artefact of the drilling fluid.
- The field permeability testing of the in-situ soil in Borrow Area 1 verify that it has low permeability under field conditions: under saturated conditions the tailings also have very low permeability.
- Laboratory testing of the soil and weathered overburden samples and geochemical analyses verify the materials are susceptible to compaction and very low rates of permeability. This gives MRO the flexibility of constructing a soil cover with low permeability, or higher rates of infiltration if the materials are placed in a way that compaction is minimised.

After the basal layer has been built and the tailings beach has been profiled to achieve the required slope angles and geomorphology the cover system will be placed onto the basal layer.
Design objectives of the proposed cover system include:

- reduce the movement of excess water into the tailings;
- store water during rain events;
- establish and maintain vegetation for opportunistic native fauna habitat; and,
- release water through evapotranspiration.

The cover construction sequence (figure below) includes sourcing, hauling, and placing:

- 1 m of saprolite (weathered rock/overburden)
- 1 m of subsoil to form the pedolith
- 0.5 of topsoil

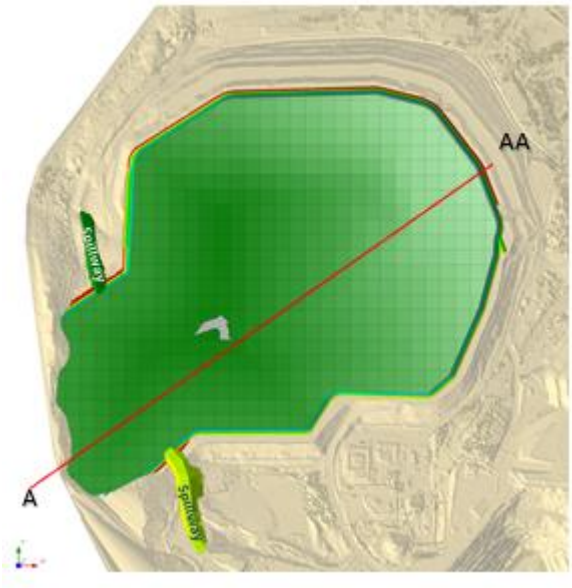


Figure 60: TSF plan view with surface water release points

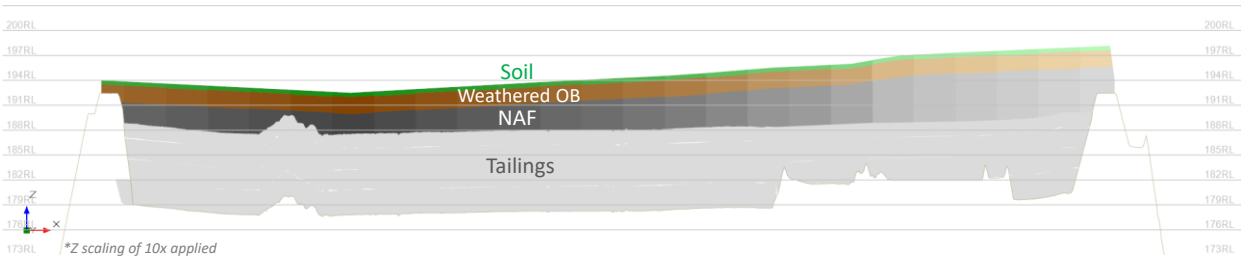


Figure 61: TSF cover systems cross section

TSF Landform erosion evolution assessment

As describe above, the $PRC_{PLAN.LHS}$ work has verified that the material balances are sufficient to complete documented rehabilitation work at MRO. Additionally RGS is developing a soil capping and stability report to support the PRC Plan. Laboratory analyses being conducted by RGS using a Rainfall and Erosion Simulator (RGS_RaE_{SIM}) on the 5 x $1m^3$ samples in Q3 of 2022 include measurement of the erosion rate of each bulk sample at 5% slope and 30 mm/hr, 60 mm/hr and 90 mm/hr rainfall intensity, and a sample also being measured at a 20% slope.

RGS will also be collecting water samples and measuring filterable and unfiltered water quality parameters to verify probable water quality that occur from rehabilitated cover systems on the NWRD and TSF: water quality parameters will include pH, EC, acidity, alkalinity all major ions and 45 metal(loids). The soil quality, geochemical and physical properties are being verified throughout Q3 2022 to Q1 2023 by external laboratories including Trilab, ALS, Levay and Co and Soil Water Consultants.

The RGS_RaE_{SIM} results will be evaluated using MinErosion v4 to document a probable range of erosion rates for the TSF and NWRD cover systems for as-placed material and for established cover

systems. This level of erosion assessment uses methods and approaches developed by the Australian Coal Association Research Program (ACARP), University of Queensland (UQ) and Griffith University over fifteen years and provides significant advantages over USA agricultural software such as the Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE) and Water Erosion Prediction Project (WEPP). Results will be incorporate into this PRC Plan upon completion.

TSF Geotechnical assessment

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the TSF, refer to supporting document - *MRO PRCP Geotechnical Assessment-Tailings Storage Facility.*

Rocscience software RS2 (Version 11.017) and Slide2 (Version 9.025) were used to analyse the deformation and stability of the final TSF conditions.

Five sections in the 2020 TSF LOM Stability Assessment, completed by ATC, were replicated for this study with the updated final shell design for the TSF.

Three scenarios were analysed for each chainage section:

- Long-term drained, considering stability under steady-state seepage conditions
- Undrained, considering poor drainage
- Post-seismic, considering liquefaction of TSF material

Two analysis methods were applied: the Spencer and Morgenstern-Price Global Limit Equilibrium (GLE). These methods were selected as they resolve both horizontal and vertical force equilibrium and moment equilibrium. Results were assessed for both to ensure a similar result and thus validate the failure surfaces. The adopted assessment criteria for the slope stability analysis are based on ANCOLD guidelines (2019) for the expected range of stability conditions for the embankment.

Table 36: ANCOLD Guidelines factor of safety (ANCOLD, 2019)

Loading Condition	Recommended Minimum FoS for Tailings Dams	Shear Strength to be used for Evaluation
Long-term drained	1.50	Effective Strength
Undrained	1.30	Consolidated Undrained Strength
Post-Seismic	1.00	Post-Seismic Shear Strength

All analysed sections returned acceptable FoS results as required by the ANCOLD guidelines for long-term, undrained and post-seismic global stability conditions as shown in table below.

Chainage Section	FoS (Spencer)	FoS (GLE / Morgenstern-Price)
Long-Term Stability Scenario		
CH359m	**1.88**	**1.87**
CH898m	**2.50**	**2.51**
CH2059m	**2.32**	**2.32**
CH3128m	**2.41**	**2.40**
CH3536m	**1.94**	**1.91**
Undrained Scenario		
CH359m	**1.92**	**1.92**
CH898m	**2.23**	**2.22**
CH2059m	**2.27**	**2.27**
CH3128m	**1.93**	**1.92**
CH3536m	**2.16**	**2.14**
Post-Seismic Scenario		
CH359m	**1.07**	**1.05**
CH898m	**1.96**	**1.98**
CH898m (with additional buttressing)	**1.09**	**1.07**
CH2059m	**1.19**	**1.16**
CH3128m	**1.30**	**1.28**
CH3536m	**1.05**	**1.30**

Table 37: Stability Analysis Results

All sections analysed met the acceptable FoS criteria, demonstrating required geotechnical stability during closure and post-closure periods before the effects of erosion lead to reprofiling of the analysed final landform conditions. Changes to the profile analyses require further analyses to ascertain the inherent stability conditions.

The final TSF shell analysed for geotechnical stability does not include the effects of erosion, and results only indicate conditions during the closure period. Long-term effects need to be integrated into the analyses to investigate the associated effects on stability.

RA 4 – Haul Roads and Access Tracks

Rehabilitation works conducted across the site must involve the return of all haul roads (2ha) and access tracks, excluding those to remain for landholder use, to a satisfactory state that will meet the criteria of land suitability class VI and VII low-intensity grazing and the desired PMLU of open woodland. All road surfaces and heights will be remediated to align with natural contours and appropriate ESC measures or design for the landscape. Should this require the removal or scalping of road surfaces to regrade contours, the material will be appropriately placed or stockpiled for reuse.

“Clean” surface water runoff from these areas and drainage lines will be managed in accordance with site water management guidelines and will be, where necessary and appropriate, redirected to remaining dams for the landholder. Should erosion persist in these areas, appropriate preventative measures will be considered.

Following minimum reprofiling requirements, topsoil should be applied to a minimum of 100 mm using available topsoil stockpile resources and should then be ripped to a minimum of 300 mm to promote the establishment of vegetation whilst allowing for infiltration and adequate drainage. Following the initial implementation of revegetation practices, invasive species will be managed concurrently according to the weed management plan to allow the successful establishment of native species.

RA 5 – Processing Plant, Workshops, and other Infrastructure management areas

All infrastructure will be removed apart from selective sheds and buildings that will be beneficial to the landholder and remain for use. The post-mining land use will be non-polluting, safe for animals and humans and remain self-sustaining as open woodland. The land will be left in a suitable condition to support a native species ecosystem similar to surrounding areas and will also be capable of supporting low intensity grazing of land capability class VII. Final landform will incorporate appropriate ESC measures and design that will direct runoff water to restore or regenerate remaining water infrastructures where appropriate or return clean water to the receiving environment through appropriate structures.

Decommissioning and Contamination Management

The decommissioning of all infrastructure will include the removal of all hazardous substances and will be surveyed by an accredited Land Contamination Assessor. Prior to decommissioning, where practical, a systematic reduction of fuel supplies will be implemented to minimise storage and prevent the risk of environmental harm that may require additional remediation, rehabilitation, or disposal. Potential areas of contaminated land are identified at the figure below. Any identified contaminated land or material surrounding or within proximity to infrastructure will be handled and removed according to legislative requirements. Any contaminated soils or land will be reported to the Contaminated Lands Register (CLR) and follow with appropriate remediation. Any residual concrete footings or benign material remaining from the removal of building infrastructure will be buried or disposed of in an approved and appropriate manner. Should the remaining landform post

infrastructure removal not be suitable or not meet the terms of the landholder agreement, reshaping and reprofiling will occur where necessary.

Following minimum reprofiling requirements, topsoil should be applied to a minimum of 100 mm using available topsoil stockpile resources and should then be ripped to a minimum of 300 mm to promote the establishment of vegetation whilst allowing for infiltration and appropriate drainage. Following the initial implementation of revegetation practices, invasive species will be managed concurrently according to the weed management plan to allow the successful establishment of native species.

The management of residual contamination will be initiated during the process of decommissioning of all infrastructure. A site Contaminated Land Assessment (CLA) will be conducted and may include areas such as:

- Processing Plant area;
- ROM Area and associated waste rock stockpile areas;
- Experimental Hardstand/Heap Leach Pad areas;
- Orica and Explosive Magazine;
- MIA area; and
- Dams and associated drains.

Any spillage or accumulation of hazardous substances that has occurred during operations or as part of the decommission process will be flagged for remediation. Material deemed to be contaminated will be ripped and pushed for disposal into a void onsite. It is estimated that approximately 50,000 m^3 of material will be removed from the processing area and ROM and disposed of as part of the remediation process. All infrastructure areas, dams and associated drains remaining for the landholder may be included under the CLA to confirm that no remediation is required.

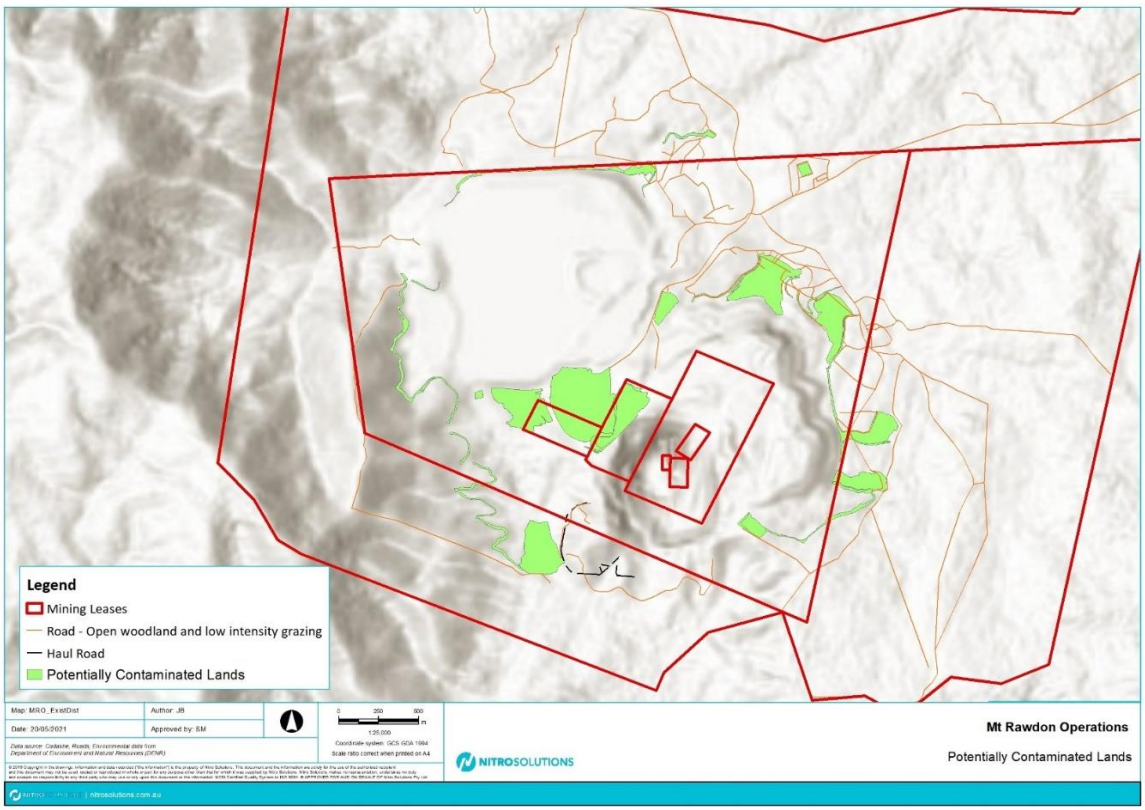


Figure 62 Areas of Potentially Contaminated Land

Landholder Agreement

Evolution Mining has a written agreement with the underlying landholder of Swindon Station (Refer to letter: Retention of Infrastructure for Post-closure Use April 2017 in the Appendices).

The following infrastructure is to remain for the landholder for post-closure use:

- Site roads and tracks;
- Raw water dams and associated pipework;
- Sheds;
- Infrastructure to supply power to the site (powerlines, substation, switchyard); and
- Groundwater Bores.

Ongoing Maintenance

Ongoing maintenance of infrastructure is required throughout operational and closure phases until the landholder assumes ownership of the infrastructure planned for retention. From this point onwards, the landholder also assumes responsibility for the upkeep and maintenance of the remaining infrastructure.

RA 6 – Water Management Infrastructure and Dams

The intended final land use for water management infrastructure and dams at MRO is to remain as a water storage for agricultural purposes such as stock water supply.

To achieve this, the water in the dams must not pose any harm to the receiving environment. The safety risk of a water body of this nature also needs to be managed, so the water body poses minimal risk to people, wildlife, and stock.

The water dams can be considered successfully rehabilitated when:

- Dam walls and bypass channels are stabilised with adequate vegetation or rock.
- Erosion does not compromise dam wall integrity.
- In the case of a person or animal accessing the water body, egress from the dam should be manageable through reasonable means
- Water quality meets the intent of the post mine land use i.e. stock water

Remediation measures to improve the water quality of water holding structures may include desilting (removal of heavy metals) and or installation of adequate stormwater and ESC structures (improve de-sedimentation). The floor of each dam will then be assessed and analysed to determine if additional excavation is required to remove any further contaminated material or certified by an accredited Land Contamination assessor/ auditor to confirm the absence of any land contamination (refer s4.7.1.2 Rehabilitation Milestone 2 – Remediation of Contaminated Land).

The sampling program for water quality monitoring within water holding structures will be established for each structure prior to mine closure. As a minimum, sampling of all rehabilitated structures will be completed bi-annually at pre-wet season (September – November) and post wet season (February – May) for a total of 10 years. Sampling biannually will assist with identifying water quality trends during differing seasons. Opportunistic sampling performed post major rainfall event will result in a significant inflow of water that will impact water quality and potentially establish a new baseline or identify an unknown contamination source.

Appropriate diversion/ containment structures are designed to the appropriate risk event and constructed to minimise potential for scouring or dam wall failure. Where inspections identify that a dam wall requires re-profiling to improve drainage and or stability, it will be assessed by a Registered Professional Engineer of Queensland (RPEQ) with subsequent 'as-constructed' design certification obtained. As Constructed Designs shall be maintained in the Regulated Structures Register.

5.6 Revegetation

Revegetation Objectives

The following are the revegetation objectives for MRO, which are consistent with the proposed PMLUs:

- To enable the rapid establishment of vegetation on exposed areas to prevent erosion in the early stages of rehabilitation.
- To establish effective and robust vegetation/ecosystems consistent with the PMLUs
    - Light-intensity grazing: the establishment of pasture grasses with the balanced density of native and exotic species to support low-intensity grazing long term.

- Low-intensity grazing and Open woodland: the establishment of pasture grasses and moderate density of native trees and shrubs to provide shade for livestock and provide long term habitat for native fauna.
- Stock water storage: the establishment of stable structure with adequate vegetation cover for bank stabilization and suitable water quality for stock consumption. Water storage: the establishment of a structurally safe and geotechnically sound structure for water storage that provides economical benefit to the community and future landholders.

Site Preparation Strategies

Site surface preparation is dependent on the rehabilitation area and will be detailed in the Closure Plans for relevant rehabilitation areas. Surface preparation activities will be required to follow the relevant quality assurance processes detailed in the rehabilitation area-specific ITPs. Ripping will be implemented to break up compacted areas (e.g. hardstands) and scarifying to be used along contours to prepare a seedbed.

Amelioration and Fertilising

Amelioration and fertilising of rehabilitation areas are dependent on the topsoil being utilised for the rehabilitation area. Topsoil sampling is to be conducted prior to placement on prepared landforms. Sampling is to be used to determine the existing basic parameters and nutrient level of the selected stockpile. Professional advice from an agronomist will then be obtained to determine the most appropriate type of fertiliser and level. Where possible, locally sourced fertiliser will be utilised where applicable e.g. local feedlots.

Seed Management

Purchasing of seed will occur from locally based seed suppliers, where applicable. Seed gathering or collection at MRO and surrounding areas may be required should seed availability be limited and is to be completed by suitably qualified personnel. In instances where specified seed species are unavailable, a reference to rehabilitation trials will be made for use of alternative species.

Seeds requiring storage prior to planting out should be maintained in cool, dry conditions and protected (if necessary treated) from insects. A suitable place to store seeds would be in air-tight containers in an air-conditioned room. Seed not stored with these conditions will have a shortened viability period and germination rates may decrease.

It is recommended that purchased seed be treated with a fungicide prior to delivery to protect the seed and also extend potential storage periods. Prior to using the seeds, first, determine any pre-treatment that may be required to enhance or facilitate germination.

Seed Broadcast

Areas to be direct-seeded should be prepared for seeding before the commencement of the wet season. Seeding should occur in late December or early January when soil moisture is sufficient to stimulate germination and there is a high probability of two (2) to three (3) months of rainfall to support establishment. Key environmental conditions where seeding is to be avoided are:

- When wind speeds exceed 15km/h;
- When the surface is fully saturated;
- When temperatures are exceeding 37˚C;
- During heavy rain or when significant rainfall is forecast within five (5) days; or

- During any other significant weather event or a forecasted event is to occur within five (5) days. (events include fire, dust storms, localised flooding).

Periods of extended drought are a significantly limiting factor for successful rehabilitation practices. Rehabilitation during periods of drought will require additional resources such as watering to seeded areas until vegetation is considered established or rainfall occurs. The associated additional resources come at a significant financial cost and it is recommended that long-range forecasts be used to review and amend the PRCP Schedule to appropriate weather conditions.

A minimum seeding rate is proposed at 10 kg/ha of native grass seed and 2–5 kg/ha of native tree seed. Higher levels of seeding rate offer increased opportunity for successful levels of sustainable seed germination.

Rehabilitation trials will sample varying seeding rates and where successes are recorded, seeding rates for rehabilitation areas will be amended.

Establishment Period

Germination should be visually monitored one (1) month after seeding. If germination has failed it may be necessary to reseed while there is a probability of follow-up wet season rain. Long-range weather forecasts can assist in making this decision. Reseeding should not be undertaken later than 1 April unless unseasonal wet weather is forecast. In such event, retreatment should be scheduled for the following wet season.

Weed treatment will be required during the establishment period (the first two years). Weed control is to be targeted by spot spraying of weeds. Newly established rehabilitation areas shall be protected from fires that may negatively impact on rehabilitation viability. Firebreaks shall be established around rehabilitation areas as required and fuel reduction burning shall be carried out in accordance with the Fuel Reduction Burning Procedure (MRO_EVN_PRO_0262).

Key Flora Species

The proposed flora species to be planted in disturbed areas is presented in **Table 38** and is based on a review of existing regional ecosystems (REs) and current existing vegetation communities. The species proposed are subject to change based on outcomes from rehabilitation trials.

Table 38: Preferred Species for Use in Rehabilitation and Associated Regional Ecosystem

Story Type	Species Name	Common Name	Notes & Reference RE
Tree	*Corymbia tessellaris*	Moreton Bay Ash	Dominant – associated with RE 12.12.5 (Ryan 2012)
	Corymbia citriodora subsp. *variegata*	Lemon-scented Gum	Dominant – associated with RE 12.12.5
	Corymbia trachyphloia	Brown Bloodwood	Sporadically occurring – associated with RE 12.12.5
	Eucalyptus crebra	Narrow Leaved Ironbark	Dominant – associated with RE 12.12.5

Story Type	Species Name	Common Name	Notes & Reference RE
	Eucalyptus moluccana	Gum-topped Box	Subdominant – associated with RE 12.12.5
	Eucalyptus tereticornis	Forest Red Gum	Dominant – associated with RE 12.12.5
	Lophostemon confertus	Brush Box	Sporadically occurring - associated with RE 12.12.5
Shrub	*Acacia disparrima* subsp. *disparrima*	Hickory Wattle	Frequently occurring – associated with RE 12.12.5
	Acacia leiocalyx	Black Wattle	Dominant – associated with RE 12.12.5
	Alphitonia excelsa	Red Ash	Dominant – associated with RE 12.12.5
	Acacia falcata	Sickle Leaf Wattle	Nitrogen-fixing, good for soil improvement (Maslin and McDonald 2011; Brockwell et al. 2005).
	Leptospermum polygalifolium	Tantoon	Frequently occurring – associated with RE 12.12.5
Legume	*Glycine tabacina*	Glycine Pea	Braodscale applciation
	Crotalaria montana	Rattlepod	Braodscale applciation
Grass	*Bothriochloa decipiens*	Pitted Bluegrass	Erect, perennial grass that is widespread across communities in Southeast Queensland. Low weed potential, tolerant of low nitrogen levels, well adapted to areas that receive over 500 mm of rainfall, but will persist in drier areas also
	Cymbopogon refractus	Barb Wire Grass	Prefers poor soils, low forage value, drought tolerant.
	Eriochloa pseudoacrotricha	Cupgrass	Naturally colonises topsoil. Potentially salt tolerant. Can form extensively – creating good groundcover. Good forage value.
	Heteropogon contortus	Black Spear Grass	Dominant – associated with RE 12.12.5

Story Type	Species Name	Common Name	Notes & Reference RE
	Themeda triandra	Kangaroo Grass	Associated with woodland vegetation communities in the Southeast Queensland region
	Eragrostis leptostachya	Paddock Love Grass	Associated with woodland vegetation communities in the Southeast Queensland region

Topsoil Stockpiles

The primary goal of topsoil management is to store and preserve topsoil resources for optimal recovery and application for rehabilitation. Where possible, topsoil stockpiles should be placed within the catchment of a sediment dam and within the range of adequate ESC measures. These will be employed on and surrounding stockpiles to prevent loss of nutrient and resources through erosion. This is also achieved through the construction of stockpiles with a scoured surface to increase infiltration and promote the growth of vegetation whether seed mix has been applied or is left to naturally revegetate.

Should stockpiles remain for longer than one year, seeding will be applied if adequate self-seeding does not occur. Accurate surveying of topsoil stockpiles is required to assess quantity, condition of resource and presence of weed species, to determine whether any amelioration is required. Invasive species will be managed routinely in accordance with site procedures and the *Queensland's Land Protection (Pest and Stock Route Management) Act 2002*. Continued management of invasive weed species is necessary to successfully reduce seed stock within the soils.

Species of Conservation Significance

Where it is consistent with the PMLUs, habitat for threatened fauna or species of significance is to be incorporated into the landscape as suggested below.

Koala

Habitat for Koalas will be incorporated into the open woodland and low-intensity grazing PMLU. This will be achieved by ensuring that selected tree species will provide adequate shade for stock and also be relevant food trees for Koalas. The tree species selected that meet these criteria are listed in **Table 39**.

Table 39: Koala Preferred Food Tree Species to be Used in Selected PMLUs

Scientific Name	Common Name	Preference Level for Koalas
Eucalyptus tereticornis	Forest Red Gum	Primary
Eucalyptus crebra	Narrow Leaved Ironbark	Primary
Lophostemon confertus	Brush Box	Secondary

Greater Glider

Greater Gliders habitat occurs in high-basal areas of over-story and requires large areas of old-growth forest that includes hollows. The average establishment of naturally occurring hollows takes place within an ecosystem from 10 years and onwards. Given that the proposed monitoring period for the

establishment of PMLUs is 10 years, it is not expected that Greater Gliders will occur within the monitoring period. Long term establishment of trees will promote naturally occurring habitat at later stages.

Little Pied Bat

The Little Pied Bat prefers dry open forest and open woodland for habitat. The PMLU incorporation of open woodland will support habitat for this species with no additional management inputs.

Quoll

In 2020, ARE was commissioned to provide a review of the MRO Quoll Management Plan, the site area and data collected during annual monitoring. A recommendation has been provided that given the limited available evidence of Quoll presence with the MRO area and the high level of predator species, it is unlikely that Quoll's would utilise the MRO area as suitable habitat, therefore further monitoring of the species be ceased. Under this recommendation, no additional measures have been implemented into the PMLUs for supporting specific Quoll habitat requirements.

Grey-headed Flying Fox

The Grey-headed Flying Fox utilises eucalypt forests and woodlands for habitat and flowering gum tree species for food. The PMLU Open-woodland and light-intensity grazing supports the development of habitat for this species, by providing long term habitat (open woodland) and also food trees (refer to **Table 38** for species list of selected trees). No additional management inputs are required.

Powerful Owl

Whilst no specific habitat requirements have been incorporated into the proposed PMLUs for the Powerful Owl, the Open woodland and Low-intensity Grazing PMLU will support the species return with no additional management inputs required.

Squatter Pigeon

Habitat for Squatter Pigeons is to be incorporated into the PMLU Open woodland and low-intensity grazing and also low-intensity grazing. This species requires two (2) main aspects of habitat to sustain a population; a diversity of native and introduced pasture species and herbs for food supply and also a minimum tree cover that generates mid-range story cover for habitat. The relevant PMLUs seed selection is likely to meet the requirements for the support of a Squatter Pigeon population with no additional management inputs.

Revegetation Approach

Rehabilitation methodology for MRO is discussed below in the corresponding sections. The development of Quality Assurances processes and documents is discussed about Milestones; specifically the development of a Rehabilitation Quality Assurance Procedure that will include the development of rehabilitation area-specific Inspection Test Plans (ITPs) for each stage of rehabilitation works (e.g. Landform Design and Construction, Drainage construction, Topsoiling, Fertilising and Seeding and Landform Approval).

Reference Sites

Reference sites will be used as a baseline for rehabilitated areas, in terms of achieving the proposed PMLU.

General reference sites for rehabilitation areas have been provided in the EA and are displayed in **Table 40**, rehabilitation areas have been refined from the EA to reflect identified rehabilitation areas

within this PRCP. Specific locations for the relevant reference sites will be determined upon closure of each rehabilitation area.

Table 40: Reference Sites for Relevant Rehabilitation Areas

Rehabilitation area	Post-Mine Land Description	General Reference Site
Residual Void	Water Storage for Agricultural Use	N/A
Residual Void batters	Rock face. Must demonstrate long term geotechnical stability. Top of the pit to be safely bunded.	N/A
TSF	Open woodland/Low intensity grazing	MRAS_OW / MRAS_LIG
North WRD	Open woodland/Low intensity grazing. excluding outer batters (rockface only).	MRAS_OW / MRAS_LIG
West WRD	Open woodland/Low intensity grazing. excluding	MRAS_OW / MRAS_LIG
Plant	Open woodland/Low intensity grazing. excluding	MRAS_OW
Site roads	Open woodland / Low intensity grazing	MRAS_LIG
Sediment dams and WRD containment dams	Stock water	N/A
Water supply corridor	Open woodland / Low intensity grazing	MRAS_OW

MRAS_OW represents 'Mt Rawdon Analogue Site_Open Woodland', and MRAS_LIG represents 'Mt Rawdon Analogue Site_Low Intensity Grazing

Locations of land use reference sites are provided in **Table 41** with GPS coordinates and **Figure 63** as a map.

Table 41: Land Use Reference Sites

Land Use Reference Type	Reference Site	GPS Coordinates
		Easting / Northing
Open Woodland	1	375219 / 7206470
	2	377823 / 7206480
	3	379206 / 7207660
Grazing Pasture	1	374443 / 7206590
	2	375069 / 7203500
	3	376602 / 7204950

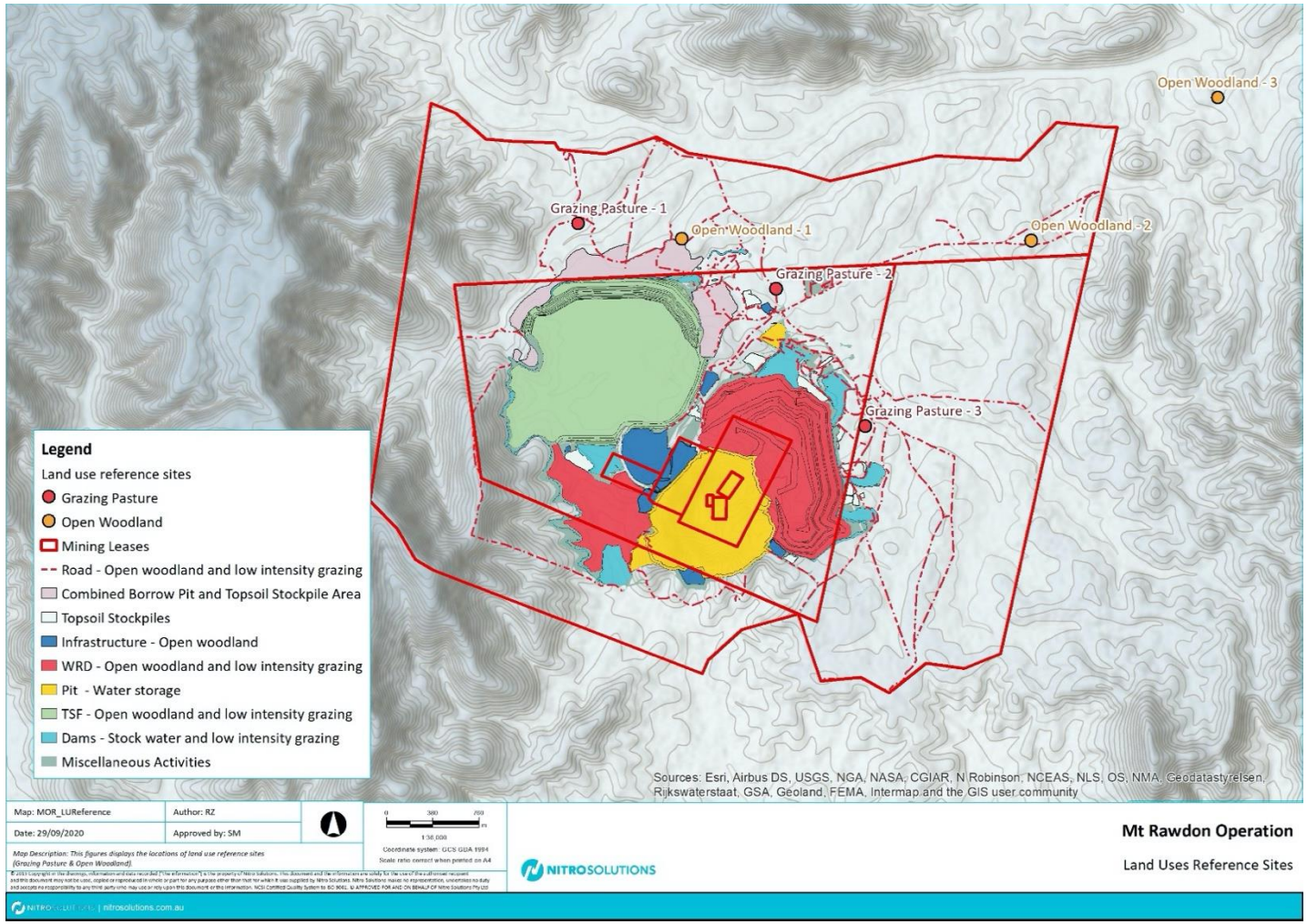


Figure 63: MRO Land Use Reference Sites

5.7 Rehabilitation Trials

Three broad rehabilitation trials are planned leading up to the end of mine life to test the design attributes outlined within this PRC Plan, these include:

1. Cover trials and performance monitoring – includes cover systems for the TSF and NWRD
2. Passive water treatment of mine wastewater – wetlands water treatment
3. Revegetation and seed viability – to test various seed types and revegetation methods

NWRD and TSF Cover system trial and performance monitoring

As part of the Mine Material Management Plan (MMM Plan), a Cover Trial and performance monitoring plan has been developed for the TSF and NWRD cover systems (refer to Attachment C of the MMM Plan).

The NWRD and TSF cover designs are considered by RGS to be at PFS level because:

- Material locations have been identified (but not confirmed).
- Material specifications have been determined in 2016 and more work is being done in 2022.
- Material balances required have bene quantified.
- Material scheduling has been confirmed to be viable.
- Numerical modelling has been completed on both cover systems to quantify the probable performance of 1 x configuration of the TSF and 4 x configurations for the NWRD.

The NWRD and TSF cover systems will need to developed to feasibility and then detail design.

There are three viable locations for the cover trials.

- On top of the NWRD
- On the PAF cell within the TSF
- Waste rock trial pad area

NWRD

The cover trails may evaluate layers of the cover system and / or 2 or 3 cover configurations.

This site would not be able to provide long term monitoring as it would have to be decommissioned.

TSF – PAF Cell

If the TSF cell is not required for PAF storage it could be reshaped, capped with NAF tailings, and developed into a trail area.

This site would not be able to provide long term monitoring as it would have to be decommissioned.

Waste rock trial area

Waste rock trial pads were designed and built by MRO.

This site could be repurposed (i) to provide PAF mine waste for the base layer of the cover trails and (ii) to build two or three cover trail pads for the NWRD and TSF: tailings could be trucked in for the base layer of a tailings cover trial.

This site **could be used** to provide long term monitoring as it would **not** have to be decommissioned.

This site would allow for 3 or 4 x 50 m x 20 m cover trails to be established and monitored for > 5 years before major commitments are made to build covers on the MRO TSF and NWRD.

The concept level drawing below provides an indication of the possible dimensions of 3 x cover trial configurations that could be built in the area shown next to the NWRD in Figure 64: Conceptual cover trial configuration - approx. 100 m x 50 m

1. NAF tailings base + HDPE liner + tailings + NAF rock (1 m) + saprolite (2 m) + soil (0.5 m) @ 1% slope
2. NAF tailings base + HDPE liner + PAF rock (1 m) + saprolite (2 m) + soil (0.5 m) @ 5% slope
3. NAF tailings base + HDPE liner + PAF rock (1 m) + NAF rock (2 m) + clay (0.5 m) + saprolite (2 m) + NAF rock & soil (1.0 m) @ 5% slope

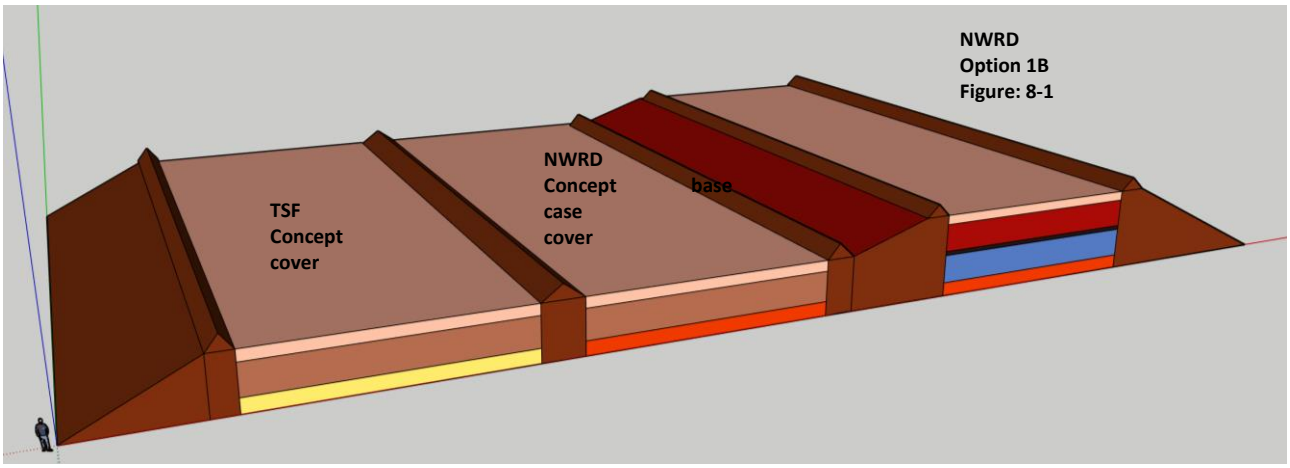


Figure 64: Conceptual cover trial configuration - approx. 100 m x 50 m



Figure 65: Potential cover trial location

For further detail refer to *Attachment C: Cover trial and performance monitoring plan, MMM Plan, RGS 2022.*

Passive Water Treatment - Wetlands

In partnership with CSIRO and Australian Wetland Consulting (AWC), MRO has undertaken rehabilitation trials to improve water quality within the intercepting dams for reuse within the process water circuit or release into the receiving environment. For rehabilitation, the proposed final constructed wetland is planned to be very low maintenance and mostly self-sustaining. The combination of the various projects is aimed at managing future runoff and leaching from the final landform so that waters can safely be returned to the receiving environment.

Two main projects that are being trialled include:

- A "Virtual Curtain" water treatment product; and
- A constructed wetland utilising Sulphate-reducing Bioreactors (SRB), and Ferrosol Soil Treatment.

The trials are aimed at assessing the feasibility of systems to remove contaminants through the application of the three (3) methods that will potentially operate in conjunction to improve water to meet minimum quality standards.

The overarching goal is to reduce sulphate concentrations and other Contaminants of Potential Concern (COPC) within the captured mine stormwater runoff before the controlled release of any waters into the receiving environment. The summary analysis of the rehabilitation trials can be found in the Appendices.

Rehabilitation Trials Conceptual Design

The proposed trial is designed to improve rehabilitation methodology and develop alternative methods for management of runoff and leaching from mine waste areas such as the North WRD and TSF. The trial involves the application of the *Virtual Curtain®* as an initial treatment within WD2, followed by the installation and implementation of three (3) concept sulphate 'filtration' technologies, operating in conjunction, for the treatment of site stormwater for eventual release into the receiving environment.

Given successful results from the trials, the final design for implementation would involve a holding dam for site stormwater that would be treated by the *Virtual Curtain®*. This would then feed into a constructed wetland dominated by Typha spp. required for optimal sulphate reduction. Iron (Fe) rich soils sourced from the region would then be used in for the final ferrosol treatment system to remove sulphate in the form of Pyrite. The designs and schematics are discussed in the following sections.

Virtual Curtain Concept

The *Virtual Curtain®* trial involves the preliminary application of hydrogen peroxide as an algicide. This process releases Phosphorus (P) and heavy metals bound to the algal filaments into a chemically available form that the *Virtual Curtain®* specifically targets. The next stage of the trial can begin approximately 2-4 weeks after the removal of algal biomass from WD2.

The chemical application of *Virtual Curtain®* required WD2 to be filled to a design volume of 4ML. A water pump was installed to spread the *Virtual Curtain®* chemicals (Sodium Aluminate liquid, Sodium Hydroxide liquid and Magnesium Hydroxide liquid) across the entire surface area of WD2. This developed a white clay precipitate or 'curtain' in the water column, which sequestered dissolved P and COPC from the water column and settled them on the base of the dam. The precipitate also provides a buffering system that locks P and COPC into the sediment floor and prevents the future release of P making it biologically unavailable to algae, thus limiting future and potential growth. Additionally, any heavy metals that inhibit the sulphate reducing bacteria crucial for the constructed wetland trial will also become biologically unavailable.

Constructed Wetland/Bioreactor Concept

After the treatment of WD2 with *Virtual Curtain*, the project aims to investigate dissimilarly sulphate reduction "naturally" through the application of three (3) broad technologies involving four (4) treatment units:

- High carbon bioreactor bed;
- Horizontal bioreactor column (in a pipe or drain);
- Typha spp. Wetland trial; and
- Ferrosol soil treatment.

The combination of trial systems consists of flushing the site impacted stormwater generated from the North WRD through two (2) models of sulphate reducing bioreactors and a Typha spp. inhabited wetland, which is designed to also reduce sulphate to sulphide at a lower rate. These systems are all linked to individual ferrosol soil treatment systems that will precipitate the sulfide as iron sulphide. Zinc and Cadmium are also planned to be removed in the process through coprecipitation with the iron sulphide.

The trial aims to achieve this sulphate reduction process on small scale operations successfully, to then if proven to be feasible be redesigned and implemented on a scale large enough to address the site-wide water quality issues for release into the receiving environment.

Constructed Wetland

The constructed wetland trial is based upon the condition and function of the WD2 in which the Typha spp. (bulrush) is prevalent, and seasonally goes into senescence during winter months when leaf matter dies off. Decay of Typha spp. leaf is known to actively reduce sulphate in low oxygen or anaerobic conditions. The 12 m x 4m constructed wetland is designed to allow 10- 50 cm deep stormwater to flow through the densely populated Typha spp. enriched substrate to reduce the sulphate. This occurs due to the significant growth of the Typha and subsequent production of organic material that reduces dissolved oxygen to levels where sulphate removing bacteria is generated.

To achieve this level of diminished dissolved oxygen within the wetland quickly, mature Typha root balls are to be harvested from WD2 and planted within the constructed wetland to reach this the anaerobic environment necessary for the balance of sulphate removing bacteria and high organic material coupled with suitable water flow to actively remove sulphate at appropriate levels.

A larger, permanent wetland may be constructed to secure ongoing water treatment issues from stormwater runoff and any leaching intercepted by WD2. A potential location for the constructed wetlands has been proposed for the Homestead Dam, situated upstream of WD2. However, should the trials be successful and implemented on a large scale for site-wide water treatment, this location could be located downstream of WD2. The final design is subject to the outcomes of the field trial, and the professional opinion of the wetland engineer.

Sulphate-reducing Bioreactor (SRB)

"Dissimilatory sulphate reduction is a microbially mediated anaerobic reaction that converts sulphate (and other oxidized forms of Sulphur) to hydrogen sulphide (by bacteria) under anaerobic conditions and with the readily available supply of electron donors (basic organic compounds)" (AWC 2019).

Biosolids or organic material must be added to the solution to facilitate this process. The application or use of various organic/carbon-based material such as blended woodchip, soil/gravel and biosolids have been considered. Optimally these materials must be readily available, provide a range of carbon matrixes that are permeable and can interact with the system, then pass through.

The labile nature of the carbon media has been linked to increased sulphate reduction rates in similar experiments. Coarser carbonaceous material (woodchip) tends to have slower sulfate reduction rates than more labile forms of carbon (e.g. Typha spp. Leaf), but offer the advantage of supplying physical structure and a permeable medium. Therefore, a blend of materials is being targeted as the optimal composition to expose sulphate material to an anaerobic environment rich in carbon.

Typha spp. (when oven-dried and ground) is such media that has been identified as a suitable is very labile with a high reduction rate for sulphate compared to woodchip or sawdust (66.9 – 75.8 g/m^3/day compared to 5.6 – 7.4 g/m^3/day). Typha organic material will be potentially harvested from WD2 and the constructed wetland for use in the bioreactor. The original design shows the sulphate reduction bioreactor in the form of a pipe, however, a drain may be utilised at similar dimensions.

Ferrosol Soil treatment

The design of the Ferrosol Soil Treatment systems involves a series of 1000 L tanks filled with Ferrosol or iron-rich soil linked to the Bioreactor/wetland system as the final step to removing sulphates from the stormwater as it passes through the concept system. All of the processes operating within the Ferrosol treatment tanks must operate in a completely anaerobic environment. As stormwater passes through the system, upward flow is generated through the filter and the reduced sulfide will coprecipitate with iron within the soil. This process forms pyrite thus removing the sulphate from the water column.

Success Criteria

Rehabilitation trial success will be assessed once the findings have been analysed against the potential for full-scale operations to be implemented. Quality assurance and controls will be used to assess each stage of the project and development. Completion criteria are based upon achieving desired water quality results consistent with the post mine land use of stock water (see Section 7.1). The release criteria will need to meet design WQO/EV's, either on release from the wetland or after flowing through a mixing zone into receiving waters. The receiving environment includes ephemeral creeks that drain north to the Perry River Weir, and south to Paradise Dam in the Burnett River. The relevant Environmental Values for the Perry River Weir are:

1. Aquatic Ecosystems. The applicable guidelines are the current EA requirements, Burnett-Baffle WQIP (BMRG, 2019) and ANZECC/ARMCANZ (2000) guidelines for a 95% level of protection.
2. Stock watering. The applicable guidelines are the current EA requirements, Burnett-Baffle WQIP (BMRG, 2019) and ANZECC & ARMCANZ (2000) guidelines – Livestock drinking water for all surface waters. Cattle access and drink from creeks in the mining lease.
3. Aquaculture and human consumption of aquatic foods. The applicable guidelines are the Burnett-Baffle WQIP (BMRG, 2019) and ANZECC & ARMCANZ (2000) guidelines. This guideline will be protected with aquatic ecosystem protection.
4. Visual appreciation. The applicable guidelines are the Burnett-Baffle WQIP (BMRG, 2019) and ANZECC & ARMCANZ (2000) recreational guidelines – Visual use no contact. There has been historic use of the Perry River Weir as a picnic area.
5. Industrial use. Suitability of water supply for industrial use.

The relevant Environmental Values associated for the Paradise Dam storage are these listed above plus:

6. Human consumption. The applicable guidelines are the Burnett-Baffle WQIP (BMRG, 2019), DEHP (2009) and the Australian Drinking Water Guidelines (NHMRC, NRMMC 2011).
7. Irrigation and Farm Supply. The applicable guidelines are the Burnett-Baffle WQIP (BMRG, 2019), DEHP (2009) and ANZECC & ARMCANZ (2000).
8. Primary and Secondary Recreation. The applicable guidelines are the Burnett-Baffle WQIP (BMRG, 2019), DEHP (2009) and NHMRC (2008) to manage risk in recreational waters.
9. Cultural and Spiritual Values. The applicable guidelines to protect and restore indigenous and non-indigenous cultural heritage consistent with relevant policies and plans (DEHP, 2009).

Revegetation methods and seed viability

Rehabilitation trials of vegetation performance of proposed PMLU's will be conducted to evaluate specified seeding rates and selection of seed species in terms of success in the landscape. Findings of the rehabilitation trials will be included in successive reviews of the PRCP.

Rehabilitation trials will be monitored bi-annually for a period of five (5) years having regard for the Landscape Function Analysis methodology (CSIRO, 2004), to refine guiding principles for final rehabilitation completion.

The main elements to be monitored in the PMLU rehabilitation trials include:

- Alternative seed species that meet the completion criteria
- Density and structure of seeding mixes
- Assessment of the soil and overburden/interburden mix on vegetation establishment and growth

As the rehabilitation trials progress, additional elements may be identified and incorporated if applicable. The rehabilitation trials are not designed to delay the onset of rehabilitation works according to the PRCP Schedule.

6 Risk Assessment

6.1 Surrender of the Environmental Authority

A surrender application must comply with the requirements of Section 262 of the *EP Act 1994*.

MRO must provide a progressive or final rehabilitation report which includes a compliance statement. The final rehabilitation report is to contain an environmental risk assessment for the land that complies with section 264(2) pf the *EP Act 1994*. The environmental risk assessment must have used a methodology that has been approved by the administering authority; this will be used as a key step for identifying any residual risks and costs associated with MRO. The associated costs will be representative of potential repairs (for structures that may fail), requirement monitoring and long-term maintenance costs for the ongoing management of the rehabilitated land.

The identified residual risks will incur a payment as a pre-condition to the surrender of the EA, allowing the administering authority to address the identified residual risks.

MRO is also required to develop and provide a post-mining management plan that outlines all the specific requirements for ongoing maintenance of the rehabilitated land.

6.2 Risk Assessment Matrix

Under section 126C(1)(f) of the *Environmental Protection Act 1994* and the *PRCP Guideline*, a risk assessment has been completed to assess the risks of a PMLU not meeting the required completion criteria. The risk assessment provides tools and processes that will be implemented to manage or minimise the identified potential risks.

The risk assessment (**Table 42**) has been developed on the prescribed milestones for the PMLUs. The risk matrix used for the risk assessment is provided in the Appendices.

Table 42: Risk Assessment for Residual Rehabilitation Risks

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
Cessation of major mining and processing operations	Pit, Waste Rock dump and TSF Closure	Un-identified change of operations/mine plan resulting in an extension of operational activities not consistent with Rehabilitation Schedule	Failure to complete operational activities within designated areas Delay of Rehabilitation Schedule - the amendment of PRCP required	Likely	Moderate	**H**	Review of Mine Plan and tracking against closure dates for each rehabilitation area to be completed bi-annually until six (6) months prior to initial rehabilitation area closure. Monthly planning meetings are to commence six (6) months prior to rehabilitation area closure and take place between management (i.e. responsible personnel) and operational area Supervisors to ensure works are progressing as scheduled. Schedule of operational mine activities is to be documented against PRCP Schedule and provided to Management each month for approval at 6 months prior to initial rehabilitation area closure. Development of individual Closure Plans for each Waste Rock Dump, the TSF and Pit to be developed six (6) months prior to the cessation of operational works within that rehabilitation area.	The proposed actions will enable the early identification of potential deviations from the PRCP Schedule and adjust mine plans/schedules if required.	Adequate time allocated for planning and progress meetings; if required, additional financial costs associated with changes to schedules.	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
RM1	Infrastructure Decommissioning and Removal	Infrastructure decommissioning takes longer than planned	Failure to remove all infrastructure in accordance with PRCP schedule - delay of Milestone 5 Delay of Rehabilitation Schedule - required amendment of PRCP	Possible	Minor	**M**	Infrastructure decommission schedule to be incorporated into annual and monthly mine planning Monthly progress meetings to occur between operational departments and management to track progress against PRCP Schedule. Additional resources may be procured if process s taking longer than scheduled. Register of infrastructure is to be used to track removal and retention of infrastructure	The proposed actions will enable early identification of deviances from PRCP schedule and time to make adjustments as required	Adequate timing allocation for planning and progress meetings Adequate personnel resource for management of the register	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**
RM3,4,5	Landform Development and Reshaping/Reprofiling	Incorrect removal of infrastructure or failure to remove designated infrastructure	Failure for consistency with Schedule and required changes to Mine Plan/PRCP Delay of Rehabilitation Schedule - required amendment of PRCP	Unlikely	Minor	**L**	Development of individual Closure Plans for each Waste Rock Dump, the TSF and Pit to be developed six (6) months prior to the cessation of operational works within that rehabilitation area. Closure plans are to be approved by Management. Closure Plans are to include stringent Quality Assurance processes to be incorporated into Landform development Prior to the commencement of landform development, operators are to be briefed on quality assurance processes of rehabilitation works e.g. daily works, no-go zones.	The proposed actions will enable the early identification of potential deviations from the PRCP Schedule and adjust mine plans/schedules if required.	Adequate time allocated for planning and progress meetings Additional financial costs associated with changes to schedules Time and resources for the development of Closure Plan for relevant rehabilitation areas Time allocated for operator debrief and training	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
		Unprecedented weather events (e.g. rainfall, flooding, fire)	Water quality impacts (downstream environments) Water quality impacts (onsite structures) - Delay of Milestone 7	Likely	Moderate	**H**	Slope designed with approved gradient Earthworks timed to coincide with the dry season, where practicable Long-range weathers forecasts are monitored quarterly to review the applicability of timed works Sediment management systems (drains and sediment dams) to be operational during construction of final landform	Design of slopes will limit the capacity for water to carry material ESCP controls measures will limit/reduce material entering waterways and will be designed/installed with reference to the Best Practice Erosion and Sediment Control (IECA 2008) guidelines Rainfall forecasts and long-range forecasts will assist with the prediction of significant events that may impact the landform development. Schedules can be amended to accommodate.	Adequate time allocated for regular review of weather forecasts and the ability to modify operations Adequate time for the development of ESC tools and processes The appropriate time, personnel and materials for installation of ESC structures	Refer to Section 7.1	Refer to Section 11	Unlikely	Moderate	**M**
			Significant failure of landform - failure to meet design criteria Reduced safety and/or stability of final landform - failure to meet closure criteria Financial costs associated with rework	Likely	Moderate	**H**	Stringent Quality Assurance process to be implemented as part of the development of rehabilitation area Closure Plans. Quality Assurance is to include Inspection Test Plan (ITP) checkoff process that confirms landform consistency with design. Pre and Post wet season and major weather event inspections are to be completed as part of QA	QA processes will enable early detection of failures and also prevent the progression of works if landform is not consistent with the design.	Scheduled time allocation for inspections/audits Adequate timing for development of QA processes and training provided to all relevant personnel	Refer to Section 7.1	Refer to Section 11	Unlikely	Moderate	**M**

Milestone	Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
			Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
						processes. Inspections must be approved by site Management Identified areas of failure must be remediated (unless unprecedented conditions exist) and approved by site Management Annual audits of landforms to be completed for early identification of design inconsistencies							
	Failure to achieve PMLU that is approved and consistent with surrounding landholders/stakeholders requests	Regulatory non-compliance (under approved PRCP) and impacts from the decline in relationships with community/stakeholders	Unlikely	Moderate	M	Undertake community consultation process as per PRCP Guideline requirements Provide PMLUs with economic and social benefits to the community and surrounding landholders	PRCP outlines a formalised process of community consultation that meets the requirements to fulfil the development of the PRCP. Engagement of technical expertise ensures the process is undertaken as required.	Adequate timing and personnel resources to conduct a community consultation process.	Refer to Section 7.1	Refer to Section 11	Rare	Minor	L
	Timing and design specifications for final landform not adequately implemented	Achievement of Milestone 2 delayed	Possible	Minor	M	Stringent Quality Assurance process to be implemented as part of the development of rehabilitation area Closure Plans. Quality Assurance is to include Inspection Test Plan (ITP) checkoff process that confirms landform consistency with design. Monthly meetings are to take place between management (responsible personnel) and work crews regarding landform construction	The proposed actions will enable the early identification of potential deviations from the PRCP Schedule and adjust mine plans/schedules if required. The QA process will also prevent works from progressing if it is not compliant with the designs.	Scheduled time allocation for inspections/audits Adequate timing for development of QA processes and training provided to all relevant personnel. Adequate timing for planning and progress meetings.	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
RM7	ESC and Stormwater Measures	Variation from design resulting in non-compliant landform	Significant failure of landform - failure to meet design. Financial costs associated with rework	Possible	Moderate	H	Quality Assurance process to be implemented as part of the development of rehabilitation area Closure Plans. Quality Assurance is to include Inspection Test Plan (ITP) checkoff process that confirms consistency with design. Monthly meetings are to take place between management (responsible personnel) and work crews regarding design construction Pre and Post wet season and major weather event inspections are to be completed as part of QA processes. Inspections must be approved by site Management Identified areas of failure must be remediated (unless unprecedented conditions exist) and approved by site management	The proposed actions will enable the early identification of potential deviations from the PRCP Schedule and adjust mine plans/schedules if required. The QA process will also prevent works from progressing if it is not compliant with the designs.	Scheduled time allocation for inspections/audits Adequate timing for development of QA processes and training provided to all relevant personnel.[Adequate timing for planning and progress meetings. Financial resources for sampling regime	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M
			Water quality impacts (downstream environments) Water quality impacts (onsite structures) - Delay of Milestone 7	Likely	Minor	M				Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L
		Unavailability of rock or materials for the development of structures	Non-compliant landform resulting in a delay of Milestone 3 Impacts on surrounding water qualities with increased sedimentation	Unlikely	Minor	L	Early procurement of required resources Conduction of a risk assessment of viable other alternatives and review of consistency best practice designs. Alternatives to be approved by Management Onsite available equipment for remediation	Adequate timing allocated for planning and alternatives evaluation.	Timing allocated for procurement of resources and exploration of alternative options	Refer to Section 7.1	Refer to Section 11	Rare	Minor	L

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
RM8	Installation of cover system/capping	Insufficient material available for the adequate cover system	Potential for acid mine drainage, neutral metalliferous mine drainage or saline mine drainage to reduce water quality in groundwater and surface water The increased financial cost of remediation	Unlikely	Moderate	M	Development of individual Closure Plans for each Waste Rock Dump, the TSF and Pit to be developed six (6) months prior to the cessation of operational works within that rehabilitation area. Closure plans are to be approved by Management. Completion of a materials balance and annual review to ensure adequate material is available.	An annual review will enable early identification of issue with materials balance and alternative measures can be sought	Adequate timing allocation for development of Closure Plans for relevant rehabilitation areas Adequate timing allocation for completion of materials balance	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M
		Cover system/capping does not sufficiently contain required material	Potential for acid mine drainage, neutral metalliferous mine drainage or saline mine drainage to reduce water quality in groundwater and surface water The increased financial cost of remediation	Possible	Major	H	Adequate material placed as per design Monitoring will be conducted to review the effectiveness of the capping system. Geochemical analysis has previously been completed. Additional analysis will be conducted if changes are identified in the landscape.	Geochemical analysis has been conducted by SQP, advice to be followed accordingly	Resources for capping Adequate timing allocation for monitoring and resources for additional monitoring if required	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M
		Overburden and waste rock are more reactive than anticipated	Potential for acid mine drainage, neutral metalliferous mine drainage or saline mine drainage to reduce water quality in groundwater and surface water The increased financial cost of remediation	Unlikely	Major	M	Monitoring to be conducted of soil capping system to identify potential unexpected leaching Continued monitoring of groundwater and downstream environments	Geochemical analysis has been conducted by SQP, advice to be followed accordingly	Adequate timing allocation for monitoring and resources associated with required sampling.	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
RM2	Remediation of Contaminated Land	Remediation work not completed to schedule	Delay of Rehabilitation Schedule	Possible	Moderate	H	PRCP schedule to be incorporated into the mine planning schedule Monthly progress meetings are to take place between management (responsible personnel) and operational work crews during remediation operational works	the proposed actions will enable the early identification of potential deviations from the PRCP Schedule and adjust mine plans/schedules if required.	Adequate timing allocation for planning and progress meetings	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L
		Previously un-identified contamination source discovered	Delay of Rehabilitation Schedule and Milestone 6 Additional financial implications for additional remediation	Possible	Minor	M	Onsite training is conducted for spill management and reporting and communicated through site induction. All spills are recorded in a relevant Register and will be provided to Land Contamination Auditor at the commencement of Audit The land will be assessed by a Suitably Qualified Person (SQP) for Land Contamination and a formal report will be provided confirming remediation.	The assessment is to be completed by a SQP and approved auditor (as per the *Environmental Protection Act 1994*)	Resources for an approved auditor to complete audit Additional financial resources if contamination requires remediation	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L
RM6	Remediation of Water Holding Structures (water quality)	Water quality is not suitable for intended PMLU due to unforeseen external contamination	Delay of Milestone 7 achievement Increased financial costs to review PRCP or alternative remediation options	Unlikely	Moderate	M	Monitoring schedule of water quality will be developed upon decommissioning of structure. Initial water quality assessment will determine required measures for remediation If remediation measures do not succeed within the defined period, alternative measure (chemical amelioration) will be risk	Water quality will be monitored in accordance with the D*epartment of Environment and Science Monitoring and Sampling Manual 2018*. All samples will be analysed by a NATA accredited laboratory. Water quality must meet the specified	Resources for monitoring regime. If required, additional resources for remediation alternatives	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
							assessed to determine the feasibility	stock watering specifications within Environmental Authority (where applicable) and *ANZECC Guidelines*						
		Water quality is not suitable for intended PMLU due to existing contamination of water quality	Delay of Milestone 7 achievement Increased financial costs to review PRCP or alternative remediation options	Possible	Moderate	**H**	MRO wetland trial underway; methodology from the trial will be reviewed and implemented into other locations, if applicable Monitoring schedule of water quality will be developed upon decommissioning of structure. Initial water quality assessment will determine required measures for remediation If remediation measures do not succeed within the defined period, alternative measure (chemical amelioration) will be risk assessed to determine the feasibility	Water quality will be monitored in accordance with the D*epartment of Environment and Science Monitoring and Sampling Manual 2018*. All samples will be analysed by a NATA accredited laboratory. Water quality must meet the specified stock watering specifications within the Environmental Authority (where applicable) and *ANZECC Guidelines.*	Resources for monitoring regime. Resources for review of wetland trials and implementation into additional areas (if applicable) If required, additional resources for remediation alternatives	Refer to Section 7.1	Refer to Section 11	Unlikely	Moderate	**M**
RM9	Surface Preparation	Unprecedented weather event - heavy rainfall occurring before the establishment of vegetative cover	Loss of topsoil Increased siltation to the downstream environment Limited revegetation on eroded slopes Increased financial costs for re-work	Possible	Moderate	**H**	Long-range forecasts are to be monitored quarterly and compared against relevant PRCP schedule for identification of applicable weather events. Short-range forecasts are to be completed weekly upon commencement of rehabilitation works; identified high rainfall events may delay scheduled works.	Long-range and short term forecasts will be reviewed from the Bureau of Meteorology. Rehabilitation is to be conducted in accordance with industry best practice	Time allocation for review of weather forecasts and the ability to alter work schedules	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
							Surface preparation works are to be conducted not within two (2) weeks of major rainfall events Extended droughts may require a review of PRCP schedule or alternative watering sources may be implemented							
		Inadequate topsoil cover	Exposure of dispersive subsoils to rain Increased risk of erosion Reduced chance of germination increased financial costs for landform reshaping and surface preparation	Unlikely	Moderate	M	Minimum topsoil placement meets design criteria and will be managed through ITPs. QA is to be completed on all top soiled areas to confirm the adequate placement of topsoil (e.g. site inspection/measurement and survey review).	Implementation of ITP process ensures a thorough QA process of all works.	Adequate time allocation for development of QA processes and training provided to relevant personnel	Refer to Section 7.1	Refer to Section 11	Rare	Minor	L
		Inappropriate topsoil or subsoil management whilst stockpiled	Reduced viability of topsoil, limiting plant establishment at rehabilitated sites Topsoil heavily infested with weed propagules, impacting plant growth	Likely	Moderate	H	Development of a Topsoil Management Procedure is to be implemented across all operations, which includes: maintenance of a topsoil inventory, annual review of topsoil inventory, annual monitoring of subsidence of topsoil stockpiles and QA processes for topsoil stripping and placement. An annual inspection of topsoil stockpiles during site weed inspection, and control methods implemented if required	Implementation of a Topsoil Management Procedure enables a thorough QA process for all topsoil resources	Adequate time allocation for development of QA processes and Topsoil Management Procedure. Training allowance for relevant personnel Adequate timing allocation for inspections and audits	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
		Inadequate capping system implemented	Failure of suitable surface preparation for uncontaminated landform and vegetation growth	Possible	Major	**H**	Minimum capping requirements must be achieved for relevant rehabilitation areas as prescribed by Technical Experts Monitoring of landform is to be conducted through all stages of revegetation and during the prescribed monitoring period. Quality assurance process (ITPs) to be developed and implemented for each relevant rehabilitation area. Works may not progress until formal completion and approval of relevant ITP Additional geochemical testing to be conducted if required Rehabilitation trials to be conducted and necessary amendments made to methodology if required	Utilising the technical advice per the relevant geochemical reports provided ensures scientifically-based methodology Undertaking rehabilitation trials will enable a process of trial and error to amend methodologies	Adequate timing for review of methodology process and monitoring requirements	Refer to Section 7.1	Refer to Section 11	Unlikely	Major	**M**
		Vehicles contaminated with weed seeds used for earthworks	Weed establishment in rehabilitated areas, minimising the growth of desired species. Delay of Milestone 10	Possible	Minor	**M**	Strict vehicle wash down procedures for any vehicle entering rehabilitated areas (e.g. Weed Inspection certification or adequate training) Annual site audit and inspection for weed species identification. Control methods implemented if required (e.g. new infestations)	Annual weed inspections are occurring as part of standard environmental management The limiting of access into rehabilitated areas significantly reduces the potential occurrence	Training resources for a new process Adequate timing allocation for inspections and audits	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
							Limited access of any vehicle into rehabilitated areas and site-wide communication							
RM10, RM11	Revegetation	Unprecedented weather event immediately post-seeding (e.g. rainfall, flooding, drought, fire)	Loss of topsoil Increased siltation to the downstream environment Limited revegetation on eroded slopes Increased financial costs for re-work Poor seedling growth and development	Possible	Moderate	**H**	Long-range forecasts are to be monitored quarterly and compared against relevant PRCP schedule for identification of applicable weather events. Short-range forecasts are to be completed weekly upon commencement of rehabilitation works; identified high rainfall events may delay scheduled works. Seeding works are to be coincided with rainfall events to ensure maximum germination opportunities (high rainfall events are to be avoided) Extended droughts may require a review of PRCP schedule or alternative watering sources may be implemented Fire breaks and backburning conducted as per site management plans	Long-range and short term forecasts will be reviewed from the Bureau of Meteorology. Rehabilitation is to be conducted in accordance with industry best practice	Time allocation for review of weather forecasts and the ability to alter work schedules	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone	Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
			Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
	Inappropriate quantity of grass/tree seed used in mix	Inhibited establishment of tree or grass species due to overgrowth of other types Insufficient variability in species resulting in failure to achieve Milestone 10	Unlikely	Moderate	**M**	Implementation of a ITP process which includes a review of seed selection Seed verification certificate must be sighted prior to commencement of seeding Rehabilitation trials to be conducted to verify most resilient and regionally appropriate seed species	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Adequate timing allocation for development of ITP process and training to relevant personnel Resources and costs associated with conduction of rehabilitation trials	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**
	Selected seed unavailable	Lack of seed of specified species will result in non-compliant ecosystem/PMLU	Rare	Moderate	**M**	Seed collection and procurement is to commence at the start of the project, to ensure supplies are available Seed stores can be maintained onsite, with appropriate conditions Rehabilitation trials will trial alternative seed species where applicable	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes	Resources for appropriate seed storage Resources and costs associated with conducting rehabilitation trials	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
		Introducing livestock	Premature grazing could result in damaging vegetation establishment Impacted land stability, especially at water-holding structures	Possible	Moderate	**H**	Fencings are to be maintained and inspected routinely. Repairs conducted immediately and stock removed immediately. Re-introduction of cattle grazing will be dependent on rehabilitated area ability to meet completion criteria Re-introduction of cattle grazing will be staged (where applicable) and monitoring	surrounding land uses includes cattle grazing, therefore regular and consistent inspections of fences ensures limited access for stock	Adequate timing allocation for inspections and when required, resources for required repairs	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	**L**
RM12	Establishment of target vegetation type	Insufficient density of designated vegetation types (e.g. tree/shrubs or grasses)	Landform and ecosystem does not meet designated PMLU Financial costs for rework	Unlikely	Moderate	**M**	Seed mixes are based on surrounding land types and professional recommendations by agronomists where applicable Rehab trials will be conducted to trial resilient and relevant species. Trials will also explore seeding methodology Methodology and processes will be reviewed after each completed rehabilitation area and updated to more appropriate and successful methodology Regular monitoring of rehabilitated areas will identify early insufficiencies with vegetation types Sites with identified insufficient densities of designated vegetation may	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Resources and costs associated with conducting rehabilitation trials Timing allocation for review processes Resources and financial cost if additional seeding/tube stock is required	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
							undergo planting of tube stock (trees and shrubs) or re-seeding within two (2) years							
		Uncontrolled establishment of weed species	Establishment of weed species may impact the establishment of desired species resulting in the delay of Milestone 11	Unlikely	Minor	L	Strict vehicle wash down procedures for any vehicle entering rehabilitated areas (e.g. Weed Inspection certification or adequate training) Annual site audit and inspection for weed species identification. Control methods implemented if required (e.g. new infestations) Limited access of any vehicle into rehabilitated areas and site-wide communication	Annual weed inspections are occurring as part of standard environmental management The limiting of access into rehabilitated areas significantly reduces the potential occurrence	Training resources for a new process Adequate timing allocation for inspections and audits	Refer to Section 7.1	Refer to Section 11	Rare	Minor	L

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
		Poor pasture development	Insufficient pasture density to meet completion criteria Insufficient species richness to meet completion criteria Increased risk of erosion and weed species establishment	Unlikely	Moderate	**M**	Seed mixes are based on surrounding land types and professional recommendations by agronomists where applicable Rehab trials will be conducted to trial resilient and relevant species. Trials will also explore seeding methodology Methodology and processes will be reviewed after each completed rehabilitation area and updated to a more appropriate and successful methodology. Additional analysis of nutrient cycling and soil composition may be conducted to determine causing factor Regular monitoring of rehabilitated areas will identify early insufficiencies with vegetation types Sites with identified insufficient densities of designated vegetation may undergo planting of tube stock (trees and shrubs) or re-seeding within two (2) years Surrounding and connected grazing properties will support grazing, reducing reliance on rehabilitated	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes Planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Resources and costs associated with conducting rehabilitation trials Timing allocation for review processes Resources and financial cost if additional seeding/tube stock is required	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
							areas for pasture productivity							

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
			Inability to meet final PMLU; social and economic impact to surrounding landholders and community	Likely	Moderate	H	Seed mixes are based on surrounding land types and professional recommendations by agronomists where applicable Rehab trials will be conducted to trial resilient and relevant species. Trials will also explore seeding methodology Methodology and processes will be reviewed after each completed rehabilitation area and updated to a more appropriate and successful methodology. Additional analysis of nutrient cycling and soil composition may be conducted to determine causing factor Regular monitoring of rehabilitated areas will identify early insufficiencies with vegetation types Sites with identified insufficient densities of designated vegetation may undergo planting of tube stock (trees and shrubs) or re-seeding within two (2) years	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes Planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Resources and costs associated with conducting rehabilitation trials Timing allocation for review processes Resources and financial cost if additional seeding/tube stock is required	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	M
		Introducing livestock	Premature grazing could result in damaging vegetation establishment Impacted land stability,	Possible	Moderate	H	Fencings are to be maintained and inspected monthly. Repairs conducted immediately and stock removed immediately.		Adequate timing allocation for inspections and when required,	Refer to Section 7.1	Refer to Section 11	Unlikely	Minor	L

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
			especially at water-holding structures Financial costs associated with remediation works						resources for required repairs					
		Unprecedented weather event - fire or flood	Any major unprecedented weather event can severely impact the effective establishment of designated species and delay Milestone achievement Financial costs associated with re-work and/or weed control	Possible	Moderate	**H**	Long-range forecasts are to be monitored quarterly and compared against relevant PRCP schedule for identification of applicable weather events. Short-range forecasts are to be completed weekly upon commencement of rehabilitation works; identified high rainfall events may delay scheduled works. Seeding works are to be coincided with rainfall events to ensure maximum germination opportunities (high rainfall events are to be avoided) Extended droughts may require a review of PRCP schedule or alternative watering sources may be implemented Fire breaks and backburning conducted as per site management plans	Long-range and short term forecasts will be reviewed from the Bureau of Meteorology. Rehabilitation is to be conducted in accordance with industry best practice	Time allocation for review of weather forecasts and the ability to alter work schedules	Refer to Section 7.1	Refer to Section 11	Rare	Moderate	**M**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
RM14	Achievement of stable PMLU	Low pasture productivity	Failure to support economically viable cattle grazing PMLU not achieved, significant financial cost implications for rework/remediation	Unlikely	Moderate	**M**	Seed mixes are based on surrounding land types and professional recommendations by agronomists where applicable Rehab trials will be conducted to trial resilient and relevant species. Trials will also explore seeding methodology Methodology and processes will be reviewed after each completed rehabilitation area and updated to more appropriate and successful methodology Regular monitoring of rehabilitated areas will identify early insufficiencies with vegetation types Sites with identified insufficient densities of designated vegetation may undergo planting of tube stock (trees and shrubs) or re-seeding within two (2) years Surrounding and connected grazing properties will support grazing, reducing reliance on rehabilitated areas for pasture productivity	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Resources and costs associated with conducting rehabilitation trials Timing allocation for review processes Resources and financial cost if additional seeding/tube stock is required	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**

Milestone		Risk / Hazard (Triggers / Indicators)	Impacts	Initial Risk Rating			Proposed Actions	Justification of treatment option	Resource Requirements	Performance measures	Reporting and Monitoring	Residual Risk Rating		
				Likelihood	Consequenc	Risk Rating						Likelihood	Consequenc	Risk Rating
		Low pasture diversity	Failure to meet the completion criteria of PMLU Failure to support economically viable cattle grazing PMLU not achieved, significant financial cost implications for rework/remediation	Unlikely	Moderate	**M**	A multitude of pasture species are to be included in seed mix and high seeding rate to improve seed germination rates --rehab trials Seed verification must be reviewed and approved by management before seeding Regular monitoring of rehabilitated sites will track pasture diversity and enable early identification of poor diversity. Additional seeding may occur if applicable Surrounding and connected grazing properties will support grazing, reducing reliance on rehabilitated areas for pasture productivity	Seed selection is based upon surrounding landscape species presence, proposed PMLU and review of rehabilitation trials successes planting methodology is to be based on industry best practice (e.g. *Department of Agriculture and Fisheries Establishing Sown Pastures*) Monitoring against indicators and completion criteria will enable early identification and patterns of plant establishment	Resources and costs associated with conducting rehabilitation trials Timing allocation for review processes Resources and financial cost if additional seeding/tube stock is required	Refer to Section 7.1	Refer to Section 11	Rare	Minor	**L**
		Failure to achieve PMLU in accordance with completion criteria	Regulatory non-compliance	Possible	Major	**H**	Completion of all Milestones and completion criteria for all rehabilitation areas Quality Assurance processes (ITPs) Monitoring of all rehabilitated sites for consistent tracking and early identification of concerns	All proposed actions within Risk Assessment coincides with Milestones for all PMLUs to ensure the final landform is successfully achieved	Adequate scheduling of resources and timing to complete all Milestones and processes associated with PRCP	Refer to Section 7.1	Refer to Section 11	Rare	Major	**M**

7 Monitoring & Maintenance

7.1 Rehabilitation Milestone (RM) Monitoring

The rehabilitation milestones for each PMLU are discussed in the following section. Milestones are significant events or steps towards rehabilitating the land to a stable condition and achieving the final land use of each rehabilitation area. These milestones support the PRCP schedule milestone criteria. Milestones and milestone criteria will evolve and develop over the life of mine as new information is determined from technical studies.

A total of 16 milestones have been identified for rehabilitation processes at MRO, these include:

- RM 1: Infrastructure decommissioning and removal
- RM 2: Remediation of Contaminated Land
- RM 3: NWRD Waste Rock Landform development and reshaping/reprofiling
- RM 4: Pit Landform development and reshaping/reprofiling
- RM 5: TSF Landform development and reshaping/reprofiling
- RM 6: Remediation of water holding structure (water quality)
- RM 7: ESC and stormwater measures
- RM 8: Installation of cover system/capping
- RM 9: Surface preparation
- RM 10: Revegetation – Low Intensity Grazing
- RM 11: Revegetation – Open Woodland
- RM 12: Establishment of target vegetation
- RM 13: Achievement of stable PMLU – Open Woodland
- RM 14: Achievement of stable PMLU – Open Woodland & Low Intensity Grazing
- RM 15: Achievement of stable PMLU - Water Storage to support low-intensity grazing (Residual Void – Pit)
- RM 16: Achievement of stable PMLU – Water Storage to support low-intensity grazing (WD1-4, West Dam, South Dam, Sed Dam3)

It is key to note that not all milestones will be required for each rehabilitation area; this is described below.

A monitoring program has been developed to determine whether milestones and completion criteria have been achieved for each PMLU. Each rehabilitation area has a scheduled point for closure or cessation of operational activities. When operational activities have ceased within the respective rehabilitation area as per the PRCP schedule and mine planning, it will be considered “available for rehabilitation” and rehabilitation tasks will commence as soon as practicable.

RM 1: Infrastructure Decommissioning and Removal

Prior to the commencement of demolition, infrastructure assets will be identified for removal (suitable for sale / re-use) or retention as per agreement with landholder. A schedule of associated works (completion dates) is to be established in accordance with the approved PRCP schedule and recorded on the sites Infrastructure Removal Register. Once infrastructure to be removed has been identified, all underground services are to be located on the site services plan. Energy sources must be decommissioned, depressurised, and isolated prior to demolition. Where removal works are not completed to the schedule or not undertaken, alternative measures and resources must be implemented.

Scrap metals will be collected onsite in designated scrap metal skip bins and removed by an appropriately licenced contractor for further separation according to scrap metal grade levels. Smaller scrap metal items containing regulated waste such as steel drums, will be treated for waste stream found within and subsequently crushed for recycling. Larger scrap metal items such as steel rods, reinforcing steel, aluminium products and pipes will be shredded for ease of separation and melted (according to it's properties) for recycling.

Regulated waste materials shall be appropriately removed by a licenced waste contractor for recycling, treatment or disposal and a Contamination Land Assessment conducted once infrastructure is removed. A subsequent Contamination Land Assessment Report shall be prepared to verify that potentially contaminated land has been remediated prior to the commencement of rehabilitation.

All water infrastructure including groundwater bores, seepage management structures and pumping infrastructure will be inspected before remaining and TSF or mine-affected water has been transferred to the final void. Inspections will be carried out Quarterly for the first 4 years, Bi-annually for the next 5 - 8 years and then Annually from years 9 – 10.

Boreholes that are not to remain for the landholder (or used for the purpose of monitoring) shall be decommissioned as per the *Minimum Construction Requirements for Water Bores in Australia*. As per these requirements, all bores and test holes that are to be decommissioned must be permanently sealed to prevent the entry of any surface fluids and contaminants, the intermixing of fluids and pressures between aquifers and injury and harm to people and animals. Where possible, boreholes to be decommissioned shall be fully grouted from the top to the bottom to eliminate physical hazards, prevent contamination and prevent the vertical mixing of waters. A register of decommissioned bores shall be kept by MRO.

RM 2: Remediation of Contaminated Land

The key target of this milestone is to develop a comprehensive contaminated land investigation report which is required to be prepared by a Suitably Qualified Person (SQP) upon completion of remediation of contaminated lands. The report is required to include the following elements:

- A site investigation report, scientifically assessing whether contamination exists;
- A validation report, describing works undertaken as part of remediation activities; and
- A site suitability statement, stating that land is not contaminated and is suitable for the proposed PMLU.

All rehabilitation areas are required to undergo an assessment for identification of contaminated lands under the National Environment Protection Measure (NEPM). Rehabilitation areas where no contamination is identified, are not required to complete this milestone in full.

Under these obligations preliminary contaminated land investigations will be completed by a Suitably Qualified Person (SQP) or approved Auditor. This will be assessed through soil, air, surface water and groundwater sampling and monitoring following sampling standards for inspection attributes (AS

1199.1-2003). The initial site investigation report must include all contaminants on the Contaminated Lands Register (CLR) and Environmental Management Register (EMR). A Validation Report must be completed to document the extent of all remediation activities completed on site.

Treatment of all contaminated material must be undertaken and if possible treated onsite. Treatment of material onsite does not require a permit and is preferable to removal.

AS 4482.1–2005 and AS 4482.2–1999 are examples of best practice in soil sampling and site characterisation. Chemical and physical characteristics of the soil for all hazardous contaminants (including any hazardous transformation products) proposed for removal (this should reference the sampling locations and depths, and testing results for individual samples—an averaged result for the site will not be sufficient).

Finally, a site suitability statement is required, stating that the land is not contaminated and is suitable for the proposed PMLU and a Contaminated Land Investigation Document (CLID) is required to remove the land from the EMR and CLR.

RM 3: NWRD Landform Development and Reshaping/Reprofiling

This milestone applies to rehabilitation area RA2 – North Waste Rock Dump.

All reshaping/reprofiling earthworks for the NWRD will be carried out in line with the Mine Material Management Plan (RGS 2022) and supporting design and Deswik.LHS model. The NWRD berms and benches will be progressively shaped and capped with a soil and NAF rock layers as per design. Some reshaping will be required once the long-term ore stockpiles situated on the NWRD are processed or rehandled.

Once the earthworks milestone has been completed, a Landform Development Inspection Test Plan (ITP) will be completed. Cross-sections, provided by an appropriately qualified surveyor, will be provided in the ITP to confirm adherence to the design as will a geological assessment of the waste materials present at the surface of the shaped landform to determine final rock armouring requirements. Deviations between design and construction are to be identified and highlighted. Sign-off of the ITP by management will be required to verify compliance with nominated construction designs and records maintained.

RM 4: Pit Landform Development and Reshaping/Reprofiling

This milestone applies to rehabilitation area RA1 – Residual void (pit).

To ensure that the void meets the completion criteria for successful rehabilitation, the following monitoring and QA/AC activities should be conducted regularly at determined intervals:

- Surface water quality;
- Slope and wall stability;
- Safety bund stability and location;
- Engineer certification of construction and maintenance to specified design;
- Evidence in the final rehabilitation report that monitoring data meets specified guideline values;
- Assessment within the final rehabilitation report that non-vegetated slopes comply with the appropriate angles and height;
- Certification that the non-vegetated slopes are now safe and will remain so; and
- Evidence that monitoring data has complied with specified guideline values.

The berms widths and slope angles of the pit will undergo a continual review and monitoring process throughout all geotechnical studies and data collection during development.

Completion of an assessment report by an RPEQ must be undertaken to certify that long term stability is not compromised by erosivity and geotechnical issues. Completion of the geotechnical study must be completed prior to closure and will be repeated every two (2) years, for a period of 10 years.

Geotechnical assessments of the highwalls will be completed prior to installation/construction of safety bund and exclusion fencing. The proximity of the safety bunds and the perimeter exclusion fencing will be chosen at an adequate distance from the highwall crest to ensure the long-term function and integrity of the structures.

The extent of any potentially unstable highwall edge is related to the depth of clay and weathering. The following guide is in place to be used to determine the location of highwall safety bunds at a distance from any potentially unstable edges however this may be changed once a detailed design is completed. Offset distance for safety bunds should consider highwall slope angles as per below:

- An angle of 30 degrees for clay and completely weathered rock;
- And angle of 45 degrees for highly weathered to slightly weathered rock; and
- An angle of 60 degrees or greater for fresh rock.

Surface and slope stability monitoring will be conducted annually by either the MRO site Geotechnical Engineer or third-party consultants.

Inundation of the void sufficiently minimises the exposure of geochemically adverse material within the void wall and limits any potential for chemical reactions resulting in acid mine drainage (AMD).

Monitoring of stored water quality will be conducted annually to assess opportunities for additional potential uses of the water resource. Validation and calibration of completed hydrological modelling for the pit void will also be conducted annually and groundwater quality monitoring will be conducted quarterly for the first four (4) years.

RM 5: TSF Landform Development and Reshaping/Reprofiling

This milestone applies to rehabilitation area RA3 – Tailings Storage Facility.

This milestone relates to the development of the final landform including and reshaping and reprofiling of the embankments, drainages, and beach slopes to achieve the design prior to the cover system placement.

All reshaping/reprofiling earthworks for the TSF will be carried out in line with the Mine Material Management Plan (RGS 2022) and supporting design and Deswik.LHS model. Deposition of tailings will be completed in line with the TSF Operations Plan and meet the design objects of the Mine Material Management Plan and MRO TSF Decommissioning and Rehab Plan.

Characterisation of TSF material has been completed and will continue as required to support detailed closure designs for the TSF including geochemistry, rheology and geotechnical parameters that influence the rehabilitation or management strategies and the capacity of the site to support revegetation.

Water quality monitoring data will be collected *quarterly* and used to verify that the water quality modelling predictions within surrounding receiving dam storages. As described in the rehabilitation methodology section above, the direction of water from the TSF will involve a phased approach until the final cover system is in place and monitoring against water quality objectives are achieved to allow for release to the environment. Therefore, whilst landform reprofiling and reshaping is being undertaken water may be directed to the pit and/or pumped back from surrounding water storage dams.

Groundwater seepage interception systems (drains, recovery/pump-back bores, dams, and well infrastructure) will be maintained and remain in place for monitoring purposes. Recovery bores will be maintained until the seepage head within the TSF has been lowered to the design level. Groundwater levels around the perimeter of the TSF will be monitored for a minimum period of five years after the recovery bores have been decommissioned, to ensure that the ongoing seepage performance meets the design expectations, with limited impacts to the regional groundwater regime. In addition, routine inspections of embankments shall be undertaken to record evidence of seepage change.

RM 6: Remediation of Water Holding Structure (Water Quality)

This milestone applies to rehabilitation areas RA1 (residual void) and RA6 (water management infrastructure and dams). The intended final land use for water management infrastructure and dams at MRO is to remain as a water storage for agricultural purposes such as stock water supply.

To achieve this, the water in the dams must not pose any harm to the receiving environment. The safety risk of a water body of this nature also needs to be managed, so the water body poses minimal risk to people, wildlife, and stock.

The water dams can be considered successfully rehabilitated when:

- Dam walls and bypass channels are stabilised with adequate vegetation or rock.
- Erosion does not compromise dam wall integrity.
- In the case of a person or animal accessing the water body, egress from the dam should be manageable through reasonable means
- Water quality meets the intent of the post mine land use i.e. stock water

Remediation measures to improve the water quality of water holding structures may include desilting (removal of heavy metals) and or installation of adequate stormwater and ESC structures (improve de-sedimentation). The floor of each dam will then be assessed and analysed to determine if additional excavation is required to remove any further contaminated material or certified by an accredited Land Contamination assessor/ auditor to confirm the absence of any land contamination (refer Rehabilitation Milestone 2 – Remediation of Contaminated Land).

The sampling program for water quality monitoring within water holding structures will be established for each structure prior to mine closure. As a minimum, sampling of all rehabilitated structures will be completed bi-annually at pre-wet season (September – November) and post wet season (February – May) for a total of 10 years. Sampling biannually will assist with identifying water quality trends during differing seasons. Opportunistic sampling performed post major rainfall event will result in a significant inflow of water that will impact water quality and potentially establish a new baseline or identify an unknown contamination source.

Appropriate diversion/ containment structures are designed to the appropriate risk event and constructed to minimise potential for scouring or dam wall failure. Where inspections identify that a dam wall requires re-profiling to improve drainage and or stability, it will be assessed by a Registered Professional Engineer of Queensland (RPEQ) with subsequent ‘as-constructed’ design certification obtained. As Constructed Designs shall be maintained in the Regulated Structures Register.

RM 7: ESC and Stormwater Measures

This milestone applies to all rehabilitation areas, RA1-RA6.

Exposed soil results in an increased risk of temporary soil destabilisation and potential water contamination from rainfall and runoff. Installation of erosion and sediment control and drainage structures shall be established as per the MRO Erosion and Sediment Control Plan and/or specific

detailed landform designs based on the International Erosion Control Association best practice designs and methodologies where practicable. Permanent erosion and sediment controls will be installed as per detailed designs for the relevant structure or area, in erosion prone areas where landform development demands strategically placed drainage and redirection structures (i.e. steep slopes or where sodic soils are encountered). All material sourced for ESC structures shall be constructed with impermeable material with appropriate chemical and physical properties by suitably qualified persons, using appropriate machinery and validated with survey / GIS technology across multiple locations and cross-sections (provided in the Drainage Construction ITP).

Upgrade and or repairs will made where improvements are identified, using multiple methods such as rock armouring, geofabric, sediment basins, and will be validated with survey/GIS data collection. A subsequent review of the ESC Plan shall be carried out also to capture any variations to the current ESC plan. Inspections of stormwater infrastructure will be carried out post rainfall events with follow up actions captured in INX database for rectification.

Quantitative erosion monitoring will be conducted annually by surveyors utilising unmanned aerial vehicle (UAV) assessment to collect data on the presence/absence of erosion areas, including soil loss/deposition volume calculations and score on a scale from insignificant to severe.

Visual monitoring will be undertaken using the Landscape Function Analysis (LFA) Erosion assessment methodology (refer **Section 3.1**) at time of planting and annually post wet season for a total of 10 years to assess the number of gullies or rills within a 50 m transect. Revegetation assessments will be undertaken biannually (once in the wet season and once in the dry season) and include Soil stability analysis on slopes (erosivity) including an erosion assessment (noting there is a maximum erosion rate of <to be determined from landform design> t/ha/yr).

RM 8: Installation of Cover System/Capping

This milestone applies to rehabilitation areas RA2 and RA3 (NWRD, and TSF only).

A capping/cover system is to be completed on the North WRD to meet the design intent of the detailed designed, Mine Material Management Plan (RGS 2022) and Deswik.LHS model. Adequate drainage structures are to be constructed to the specified design.

Groundwater will be monitored for any contaminant seepage quarterly for the first four (4) years and then bi-annually for three (3) years. These monitoring bores have been already established within seepage zones. Surface water flows will be monitored for any presence of contaminants pre and post wet season with additional opportunistic monitoring following significant rainfall events. Any exceedance in contaminants will result in prevention of surface waters from entering the receiving environment. The capping systems will also be monitored pre and post wet season for resilience and erosivity, evidence of erosion or damage will be documented, and repair works will be commissioned.

All capping and cover systems will be verified by geotechnical assessments by a RPEQ. Capping systems are to be validated with survey/GPS data collection across multiple locations and where applicable, cross-sections provided to accompany the Landform Development ITP. All processes must comply with the engineered designs, Landform Development ITP and approval by management upon completion of the ITP. A database of constructed designs of all rehabilitated areas must be maintained.

RM 9: Surface Preparation

This milestone applies to all rehabilitation areas, RA1-RA6

Prior to the ripping of land and placement of soil, ameliorants and mulch, an erosion assessment of the rehabilitation area is to be completed. Repair work is to be commissioned in response and/or the installation of correct ESC measures before further stages of rehabilitation commence.

Soil assessments are to be taken at two (2) key periods; upon selection of the topsoil stockpiled to be utilised and within six (6) months of topsoil placement. The initial soil sampling is to determine the baseline of existing properties of the soil (pH, EC, nutrient levels etc) before placement to ascertain the required type of fertiliser and rate of the application needed to promote seed growth.

Soil is to be placed to nominated depths (100 mm minimum) and ripped to specifications (300 mm). This will be surveyed, documented and reviewed by a SQP according to the relevant ITP.

Topsoil stockpiles will be selected for use on areas that are within close proximity and contain the properties required for the vegetation type of the PMLU.

Mulch is to be placed to nominated depths where appropriate and necessary. Any mulch applied at greater depths than nominated will require respreading and levelling to ensure plant development and growth is not compromised.

The follow-up sampling is to be conducted to assist with the tracking of the rehabilitated land against the rehabilitation indicators (soil nutrient cycling).

All soil sampling is to be completed and reviewed by an SQP.

Additionally, the completion of the relevant sections of the Topsoil Works and Seeding ITP is required. This includes:

- GIS validation of surface preparation with approved design (+/- 10% design variation is acceptable);
- GIS validation and visual/manual validation of topsoil application to correct depth; and
- Details of mulch applied.

This milestone applies to all rehabilitation areas except RA1 (residual void). Application of this milestone may be limited in application to RA6 and is dependent on the advice provided by the RPEQ during design phases.

RM 10 & 11: Revegetation – Low Intensity Grazing and Open Woodland

This milestone applies to all rehabilitation areas, RA2, 3, 4 and 6.

As per RM2, an approved auditor will conduct a contaminated land investigation upon completion of contaminated land remediation to verify that land is suitable for use as low-intensity grazing. A site suitability statement from the SQP shall be obtained that formally approves the land as being free of contamination prior to topsoil placement.

In conjunction with the site suitability (contaminated land) investigation, additional sampling by a SQP will be conducted prior to seeding to establish the structure and chemical composition of the soil to determine optimal seed growth. Dependant on results, a fertiliser or soil ameliorant may be applied to topsoil stockpiles (prior to spreading) to assist with successful rehabilitation.

All seeds purchased for MRO rehabilitation will be supplied with a seed verification certificate. Any seed material waiting for use in rehabilitation should be stored in cool, dry conditions and protected from insects. Some seeds may require pre-treatment to enhance or facilitate germination. The methodology for seeding at MRO will be direct seeding. All direct seeding should take place prior to the wet season to allow for adequate rainfall during the establishment period. Establishment of seedlings should take place in approximately one month with adequate rainfall. Reseeding maybe necessary if germination fails.

Minimum seeding rates for vegetation of low intensity grazing are as follows:

- 10 kg/ha of native grass seed
- 50 kg/ha for target grass species (such as sterile Japanese millet in summer and sterile rye grass in winter)
- 2–5 kg/ha for target native tree species (listed below).

Target (Potential) Tree Species for Open Woodland PMLUs:

- kg/ha for target native tree species (listed below) as per contractor agreement.
  - *Corymbia tessellaris* - Dominant – associated with RE 12.12.5;
  - *Corymbia citriodora* subsp. *Variegate* - Dominant – associated with RE 12.12.5;
  - *Corymbia trachyphloia* - Sporadic– associated with RE 12.12.5;
  - *Eucalyptus crebra* - Dominant – associated with RE 12.12.5;
  - *Eucalyptus moluccana* - Subdom – associated with RE 12.12.5;
  - *Eucalyptus tereticornis* - Dominant – associated with RE 12.12.5; and
  - *Lophostemon confertus* - Sporadic– associated with RE 12.12.5.

Once topsoil is applied to the rehabilitation area a Topsoil Works and Seeding ITP will be completed.

To monitor land for stability (i.e. no active areas of rill or gully erosion and drainage follows appropriate drainage paths) the Landscape Function Analysis Landform (Stability Index) will be conducted at time of planting and every two (2) years following for a total of 10 years.

Monitoring vegetation for self-sustaining low intensity grazing MRO will commence as soon as land becomes available and adopt the Ecosystem Function Analysis (EFA) methodology developed by the CSIRO (Tongway and Hindley 2004). Ecosystem Function Analysis is a fast and rigorous method for monitoring landscapes using simple, visual and rapidly assessable indicators that focus on soil surface processes, focused around Landscape Function Analysis. EFA is made up of three components:

- Landscape Function Analysis (LFA) Monitoring Procedure;
- Vegetation composition and dynamics; and
- Habitat complexity.

To determine composition and dynamics at MRO, a series of permanent 20m long monitoring transects should be established in each domain when decommissioned and rehabilitated. Analogue sites should be established in nearby land that has not been subject to mining impacts and land clearing has not occurred. Vegetation within the control site should be characteristic of natural conditions. These control sites will represent suitable comparison targets for assessing rehabilitation success. In each domain, transects will exist as permanent locations to ensure accurate comparisons of the same transects over seasons and years. Transects will be placed on both slope and flat terrains.

Monitoring will be conducted within 12 months of planting and annually every year for a period of 10 years by a SQP to allow for multi-year comparison trends against reference sites. This will enable the tracking of rehabilitation against target trajectory and enable the early identification of any performance issues and adaptive management intervention if required.

Target rehabilitation for low intensity grazing are to be consistent with surrounding areas and reference sites and may include:

- A minimum 60% of target species (herbs, forb and grass) is that is comparable to the surrounding similar land uses.
- Pasture species has a pasture mass (t/ha) trending towards a sustainable grazing site.
- Shrubs and juvenile trees (with a stem diameter <5 cm) has a minimum 60% of target species established and has a percentage comparable to surrounding similar land uses.

- Total ground cover is the sum of protective ground cover components (as above) and is comparable to surrounding similar land uses
- Weeds listed under the Biosecurity Act do not exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas.
- Native fauna identified at reference sites prior to mining are present or indicators of these species have been recorded.
- Resilience to fire can be demonstrated.

Target rehabilitation criteria for open woodland are to be consistent with surrounding areas and reference sites and may include:

- Herbs, forb and grass species is comparable to the surrounding similar land uses.
- Pasture species has a pasture mass (t/ha) trending towards a sustainable grazing site.
- Shrubs and juvenile trees (with a stem diameter <5cm) has a minimum 60% of target species established and has a percentage comparable to surrounding similar land uses.
- Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation.
- Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses.
- Percentage of protective (perennial plant) ground cover (<0. 5 m in height) is comparable to surrounding similar land uses.
- Percentage of the tree population which are in healthy condition and that the percentage is comparable to surrounding similar land uses
- as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of surrounding similar land uses.
- Weeds listed under the biosecurity Act do not exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas.
- Native fauna identified at reference sites prior to mining are present or indicators of these species have been recorded.
- Resilience to fire can be demonstrated.

All soil, seeding and topsoil works will be recorded and maintained as GIS data.

Relevant guidelines that will be considered in the revegetation for low intensity grazing areas are:

- DES (2014) – Guideline for Rehabilitation requirements for mining resource activities;
- DNRM (2015) - Guideline for Agricultural Land Evaluation in Queensland; and
- Tongaway and Hindley (2004) – Landscape Function Analysis: Procedures fro Monitoring and Assessing Landscapes with Special Reference to Mine Sites and Rangelands.

RM 12: Establishment of Target Vegetation Type

Field Surveys

Field surveys are to monitor the attributes of rehabilitation areas:

- Percentage of growth of selected species from initial planting
- Ground cover establishment of grass species; and
- Percentage presence of weed species

These attributes are to be measured within a 10 m x 50 m belt transect within the defined rehabilitated areas.

Trees and shrubs, when established for measurement, are to be measured using the Bitterlich gauge. Using the 50 m transect, 360˚ sweeps at each end of the transect is to be completed, with each species of tree or shrub measured separately. From the two (2) sweeps, the basal area of each woody species will dictate the average. The proportion of the total basal area of all woody vegetation is to be used to assess the successful growth of the defined species that were originally planted.

Grasses, herbs and forbs are to be assessed along the transect, using a grid pattern (1 m wide either side of the transect) to determine the ground cover percentage. The percentage is to be estimated to the nearest 0.1% with 0.1% equivalent to 0.5 m² of total cover within the transect. Milestone species richness and weed cover can be assessed from this.

Field surveys are to be undertaken during the late wet season (February-May) however this is dependent on weather patterns. Surveys should not be conducted immediately after unprecedented weather events such as significant rainfall, as it may affect the recordings of data.

Permanent monitoring sites are to be installed after initial planting and all surveys are to be conducted within these permanent locations. Permanent monitoring locations are to be recorded using GPS coordinates to ensure consistency with monitoring. On average, a minimum of one monitoring site is required per 10 ha of rehabilitated land. Rehabilitated areas smaller than 10ha are to have at least one monitoring location. If land within a rehabilitated area varies greatly e.g. slope, direction and design, monitoring locations are to be chosen to be representative of the different landform within each 10 ha rehabilitated area. Vegetation monitoring is to be completed at the time of planting and every year following for a total of 10 years.

Monitoring for erosion assessment is to be conducted at the time of planting and annually post wet (February – May) season for a total of 10 years. Inspections will be completed of rehabilitated landforms post any major or unprecedented weather events such as significant rainfall, localised flooding, and wind storms. Significant damage to establishing rehabilitation areas can occur during such events and identifying early major damage that needs urgent remediation works will benefit landform stability long-term.

Soil Sampling

Soil sampling for chemical composition and structure is to be conducted along the same transect, with one sample per transect. Representative A-horizon samples are to be taken between 10-20 cm deep and collect approximately 1 kg of soil per sample.

Reference sites are to be used to provide baseline data for comparison against rehabilitated areas. Selected reference sites are based on representative areas of the proposed PMLUs, where possible. Monitoring of reference sites is to be conducted concurrently with the monitoring of rehabilitated areas.

In the event reference sites are damaged (e.g. unprecedented weather events) or destroyed (un-authorised clearing, etc), an alternative reference site will be required to be selected and an associated amendment of the PRCP will occur.

Monitoring of milestone 12 is based on the defined rehabilitation criteria of using Landscape Function Analysis tool. If required, additional best practice assessment tools will be used for assessing the viability and carrying capacity of pasture areas to ensure their economic stability. Specific methodologies are listed below.

RM 13 and 14: Achievement of Stable PMLU – Open Woodland, and Low-Intensity Grazing/ Open Woodland

Establishment of a stable PMLU will be assessed based on the relevant rehabilitation area.

For low-intensity grazing, open woodland and low-intensity grazing/open woodland PMLUs, the following field survey programs will be used and are described below.

- Landscape Function Analysis – patch and interpatch analysis, surface soil assessment, ground cover; and
- Pasture Productivity.

Landscape Function Analysis

The Landscape Function Analysis tool is to be used for measurement of the stability of rehabilitated land. Full details of the methodology to be used is described in the Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes (Tongway and Hindley, 2004). Monitoring is to occur in the late wet season (February-May) but is dependent on unprecedented weather patterns. Monitoring during this period will ensure that the period of maximum plant growth is captured.

Patch and Interpatch Analysis

This method involves using a 50 m transect to identify patches and interpatches to assess land stability under the Landscape Function Analysis methodology. Patches and interpatches are measured at one (1) cm above ground level to ensure the resource accumulating functionality of a patch is not confused with vegetation cover over the area. The greater the number of patches and the larger the interpatch distance between patches, the higher the risk of erosion and resource loss due to climate action.

As pasturelands establish, they may transcend the patch and interpatch analysis methodology and achieve a density where litter and sediment are not mobilised by climate interaction. In cases where this occurs, they are to be recorded as grass swards.

Surface Soil Assessment

Surface soil assessment is to be used to assess the rehabilitated lands ability to resist erosion and rainfall-runoff. The surface soil assessment will be conducted along the same 50 m transect as path and interpatch analysis. The assessment is to record the following features:

- Rain splash protection – physical surface cover of litter and woody debris;
- Litter cover – amount and origin of litter within the plot;
- Cryptogram cover – assessment of algae, fungi, lichens, mosses and liverworts;
- Crust brokenness – assessment of soil crust;
- Erosion severity – identifying the type of erosion and severity;
- Deposited material – assess the nature and amount of alluvium transportation;
- Perennial cover – density of perennial grass cover and/or density of canopy cover of trees and shrubs; and
- Surface roughness – assessment of soil surface microtopography and retention of water, topsoil and organic matter.

Qualitative indicator scores are to be allocated for each feature listed and a summarised overall score provided on datasheets. Definitions are to be included on the relevant data sheets to ensure consistent estimations by persons completing the surveys.

Pasture Productivity

Pasture productivity within rehabilitated sites is to be equivalent to nearby or surrounding unmined land uses with the same soil types. Pasture productivity is to be assessed using manual measurements of pasture mass at specific moments in time. Measurements to be used for assessing the pasture productivity are consistent with the implemented measurement tools in the prior milestones. Data from these milestones will enable an assessment of the final PMLU and its capacity for effective pasture productivity. The EverGraze Pasture Monitoring Tool (EverGraze, 2013) is a widely used tool for monitoring and assessment of perennial pastures in farming scenarios. The tool uses grids and transects for assessment of soils, the persistence of perennial species, pasture conditions (percentage of ground cover, green pasture, legumes and feed on offer).

An additional methodology within the EverGraze tool is the monitoring of livestock weight and breeding. This additional measurement tool can be introduced after 12 months of successful grazing, based on the land users approval.

It is recommended that livestock not be introduced into rehabilitated areas for a minimum of two-three (2-3) years and is dependent on a positive trend of vegetation growth to support active grazing. Active assessment of climatic conditions is also required before the introduction of livestock, e.g. grazing is not to commence during a climatic period where the land is under stress from drought or inundation.

RM 15: Achievement of Stable PMLU - Water Storage to support low-intensity grazing (Residual Void - Pit)

This milestone applies to rehabilitation area RA1 – Residual Void (Pit).

A Final Void Assessment (Attachment D: Mine Material Management Plan RGS 2022) was completed in 2022 which expanded on previous study reports and a comprehensive water quality and water balance model was developed. Monitoring requirements of the residual void will be designed to verify the findings of these previous assessments as well as geotechnical design assessments.

Assessing the success of the PMLU of water storage (in the final void) requires the monitoring of key components including:

- Geotechnical stability of the structure;
- Groundwater inflows, interactions and recharge points;
- Surface water inflows;
- Lake water quality;
- Climatic events and trends;
- Seepage points;
- Biota monitoring within the pit lake; and

As part of site wide assessments, a site suitability statement is provided by an approved auditor that the land is not contaminated and suitable for the intended use.

A geotechnical study must be completed prior to closure that the high walls are safe and the criteria of 66% for low wall and an average of 84% for highwall are sustainable over the long term. A safety assessment of slopes will also be conducted to confirm that are >57% and >5 m in height. Monitoring

will be conducted every two (2) years following initial assessment for the next 10 year including erosivity assessments of the walls.

Completion of an assessment report by a Registered Professional Engineer of Queensland (RPEQ) on the geotechnical issues and the erosivity of the proposed final landforms, including the final void, to demonstrate long-term landform stability. Reference has been made to Queensland Mining Guidelines (or subsequent reprints) during the completion of this assessment.

Hydrological modelling has been conducted of the groundwater environment in the vicinity of the final void to establish the relationship between water in the final void and the groundwater. Continued bore monitoring of groundwater quality should be within modelled predictions and shows no evidence of contamination or leachate impacting water quality. Continued monitoring to confirm that flow direction of groundwater is maintained and remains similar to pre-mining conditions. Monitoring is to be conducted quarterly for the first four (4) years and bi-annually for the next three (3) years.

A steady state groundwater model was developed by NRC in 2019 and was calibrated against water levels in 37 bores which verified that the pit is acting as a sink. This has been updated to model current conditions and predictions will be used to monitor against for completion criteria.

MODFLOW simulation has been used to show interactions between rivers, creeks and the groundwater system and will be used to monitor interactions between barriers and groundwater heads.

Surface water monitoring and leaching tests have been conducted in compliance with guidelines derived from ANZECC 2000. Long term water quality modelling of the void has been completed and will continue using Goldsim, WBM and General Lake modelling (GLM) software packages. This will be used to determine closely monitor the inflows of any surface water despite final landform design redirecting inflow. Groundwater inflows will be monitored using this model also.

Lake water quality modelling was developed using the GLM software packages and determined one-dimensional lake water balance and stratification models suitable for simulation mixing behaviours in deep stratified lake systems. The GLM model will be used to monitor seasonal stratification and salinity fluctuations.

RM 16: Achievement of Stable PMLU – Water Storage to support Low-intensity Grazing (WD1-4, West Dam, South Dam, Sed Dam 3)

Monitoring the success of rehabilitated land intended for low-intensity grazing will be done by monitoring the stability, suitability, diversity and density in which species have grown.

As discussed earlier in **Section 3.1** land stability shall be monitored using the Landscape Function Analysis (Tongway and Hindley, 2004) methodology and be done at time of planting and every two (2) years following for a total of 10 years by a SQP with accompanying report prepared.

As per RM2, a contaminated land investigation produced by a Suitably Qualified Person (SQP) will be done upon completion of contaminated land remediation to verify that land is suitable for use as low-intensity grazing. Certification from the SQP that the land is suitable as PMLU must be obtained prior to topsoil placement.

The intended final land use for water management infrastructure and dams at MRO is to remain as a water storage. Water quality sampling sites will be established in Sediment dams and WRD containment dams and commence immediately after decommissioning to ensure livestock standards have been achieved and that water is within acceptable stock drinking limits (ANZECC 2000). If surface water exceeds livestock standards, the water holding structure will be isolated until such time that parameters of concern return to acceptable levels.

Groundwater quality will be monitored at those locations set out in EA Schedule E – Table E7. Water quality targets for groundwater is to be consistent with background reference data or modelled predictions and show no evidence of contamination or leachate.

All water sampling will be conducted as per the Water Monitoring and Sampling Manual (2018) by a suitably qualified person and records of water quality will be retained in MonitorPro database. Surface water is scheduled to be sampled bi-annually (pre and post wet season) for the first five (5) years and annual for each year after that for 10 years. Ground water shall be scheduled for sampling quarterly for the first four (4) years, bi-annually between years 5-8 and reduce to annual sampling for years 9-10.

As per milestone criteria for revegetation in low-intensity grazing areas, the target pasture mass (t/ha) shall be trending towards a sustainable grazing site with sites monitored within 12 months of planting and then annually every year for 10 years. Target groundcover biomass (of desirable grass species) will comprise of a minimum of 60% of total grass cover for five (5) years during mining operations. If growth of pasture species does not perform as per performance indicators then further soil analysis, re-ripping soil, amelioration and or re-seeding in poor performing areas may be considered.

Target indicators for vegetation diversity of grasses, herbs, trees, and exotic species is that it must be comparable to surrounding land uses. Minimum Iof 60% of target species established according to species list. Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas. Weeds present no more than >5 individuals or 10 m^2. Sites are monitored within 12 months of planting and annually every year for 10 years

Vegetation Density - Herbs and Grasses. The vegetation is comprised of a range of growth forms comparable to surrounding similar land uses. The number of herb, forb and grass species is comparable to the surrounding similar land uses. Minimum of60% of target species established according to species list. Sites are monitored within 12 months of planting and annually every year for 10 years

Protective Ground Cover - Ground layer contains the protective ground cover and habitat structure comparable with surrounding similar land uses. Perennial plant cover (<0.5 m). Percentage of ground cover provided by perennial vegetation (<0.5 m) in height) is comparable to surrounding similar land uses. Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses. Sites are monitored within 12 months of planting and annually every year for 10 years.

7.2 Monitoring Report

At the completion of each monitoring period, a report is to be completed, providing a summary of all the data collected and the correlation to any previous monitoring data collected. The methodology for data collection used must clearly state its consistency with the methodology within this PRCP. The report is to be presented to demonstrate the evidence of positive or negative trends occurring within the rehabilitation areas. It will also identify any remediation works required and a prospective timeline to complete such works. Where applicable, the completion of relevant milestones is to be detailed and justified.

All monitoring reports are to be completed by 1 November in the calendar year that the relevant monitoring was completed.

7.3 Audits

In accordance with the *PRCP Guideline*, all holders of a PRCP schedule must commission a rehabilitation auditor (SQP) to complete an audit on the PRCP schedule every three (3) years. The first three (3) year period commences from the first day the schedule takes effect. Each subsequent audit period is for the three (3) years commencing on the day after the previous audit period ended.

The audit is to address the following aspects:

- Steps and processes how the PRCP holder has implemented to achieving or working towards the defined milestones.
- Whether and how the PRCP holder has complied with the conditions imposed within the PRCP schedule.
- Justification provided to the administering authority that any supplied information regarding rehabilitation is correct and true.
- Justification whether the PMLUs are likely to be achieved, with regard to pending and completed rehabilitation.

The audit report must be provided to the administering authority within four (4) months of completion of the audit period. The report must also include a declaration provided by the holder of the PRCP, stating that they have not knowingly given false or misleading information to the rehabilitation and that all relevant information has been provided to the rehabilitation auditor.

If applicable, the report may include recommendations for the PRCP holder regarding actions that may require an implementation to ensure the success of the rehabilitation and PRCP schedule.

The administering authority will provide feedback within 10 business days or request further information. From this point, the holder of the PRCP has 20 business days to provide further requested information. The administering authority reserves the right to implement the following actions upon receiving the audit report:

- Amend the PRCP schedule under section 215 of the EP Act ;
- Take appropriate compliance action if a non-compliance is identified; and
- Take no further action.

The administering authority also reserves the right to issue an audit notice, under Section 322 of the *EP Act 1994*, which requires the holder of the PRCP to commission an audit. All PRCP schedule audit reports are made public on a public register.

7.4 PRCP Amendments

The holder of the PRCP may, at any time, apply to the administering authority to amend the PRCP schedule. The application may be made to amend only the PRCP schedule, or as part of an amendment application for an EA. An amendment application must be submitted in the approved form and can be accompanied by the relevant fee and an amended rehabilitation planning part for the holder's PRCP that complies with section 126C of the EP Act. The PRCP holder should always consider whether a proposed amendment to the PRCP schedule requires a concurrent amendment to the EA to ensure consistency between both licences/instruments.

Once the PRCP has been amended, the rehabilitation planning sections of the PRCP must be reviewed to identify any required additional changes. A copy of the amended PRCP must be provided to the administering authority within 10 business days of receiving a copy of the amended PRCP schedule or receiving written notice under section 211 of the EP Act unless an extension period has been approved by the administering authority.

7.5 Annual Returns

With the relevant annual return relating to the land in which the PRCP schedule applies, the annual return must also include an evaluation of the effectiveness of the PRCP schedule, including the environmental management carried out under the schedule, for the year which the annual return relates to.

The evaluation must include:

- Whether any milestones under the PRCP schedule for the relevant year have been completed; and
- Whether the holder has complied with the conditions imposed on the PRCP schedule.

The annual return must also include the requirement for the PRCP holder to submit spatial information relating to the location of the rehabilitation or improvement.

7.6 Progressive Rehabilitation Certification

When rehabilitated areas have been rehabilitated in accordance with the completion criteria and milestones of this PRCP, in accordance with all relevant requirements of the EP Act , the relevant EA and the PRCP schedule, the holder of the EA can apply for progressive rehabilitation certification. The application must be accompanied with a progressive rehabilitation report, in accordance with the requirements listed in section 318ZD of the *EP Act 1994*.

7.7 Final Rehabilitation Report

The final rehabilitation report is to be prepared and provided when surrendering the relevant EA. The report is required to demonstrate how the conditions of the EA have been complied with and that any rehabilitation has been carried out with the requirements within the EA and PRCP. Reference to the EP Act section 262 can provide further details on the requirements of the final rehabilitation report.

7.8 Post-Mining Management Report

A post-mining management report is required to be provided with the surrender application of the EA and the final rehabilitation report. The report is required to outline the ongoing management of the rehabilitated land, including monitoring requirements. An environmental risk assessment is required to be included that identifies any potential residual risk and how this risk will be managed accordingly. Further details on the requirements of the post-mining management report can be found in section 264A of the EP Act.

8 Appendices and Attachments

8.1 PRCP Schedule

This section of the PRCP provides a schedule of land availability at MRO for rehabilitation in conjunction with the rehabilitation milestones to achieve progressive rehabilitation. The schedule has been developed in accordance with section 126D of the *EP Act 1994* and in accordance with the rehabilitation milestones that apply to each rehabilitation area. This constitutes the MRO PRCP schedule.

8.1.1 Final Site Design

Figure 66 provides a visual representation of the maximum footprint disturbance which is scheduled to occur in the Year 2023 of operations at MRO, the relevant mining lease boundaries and the proposed PMLUs.

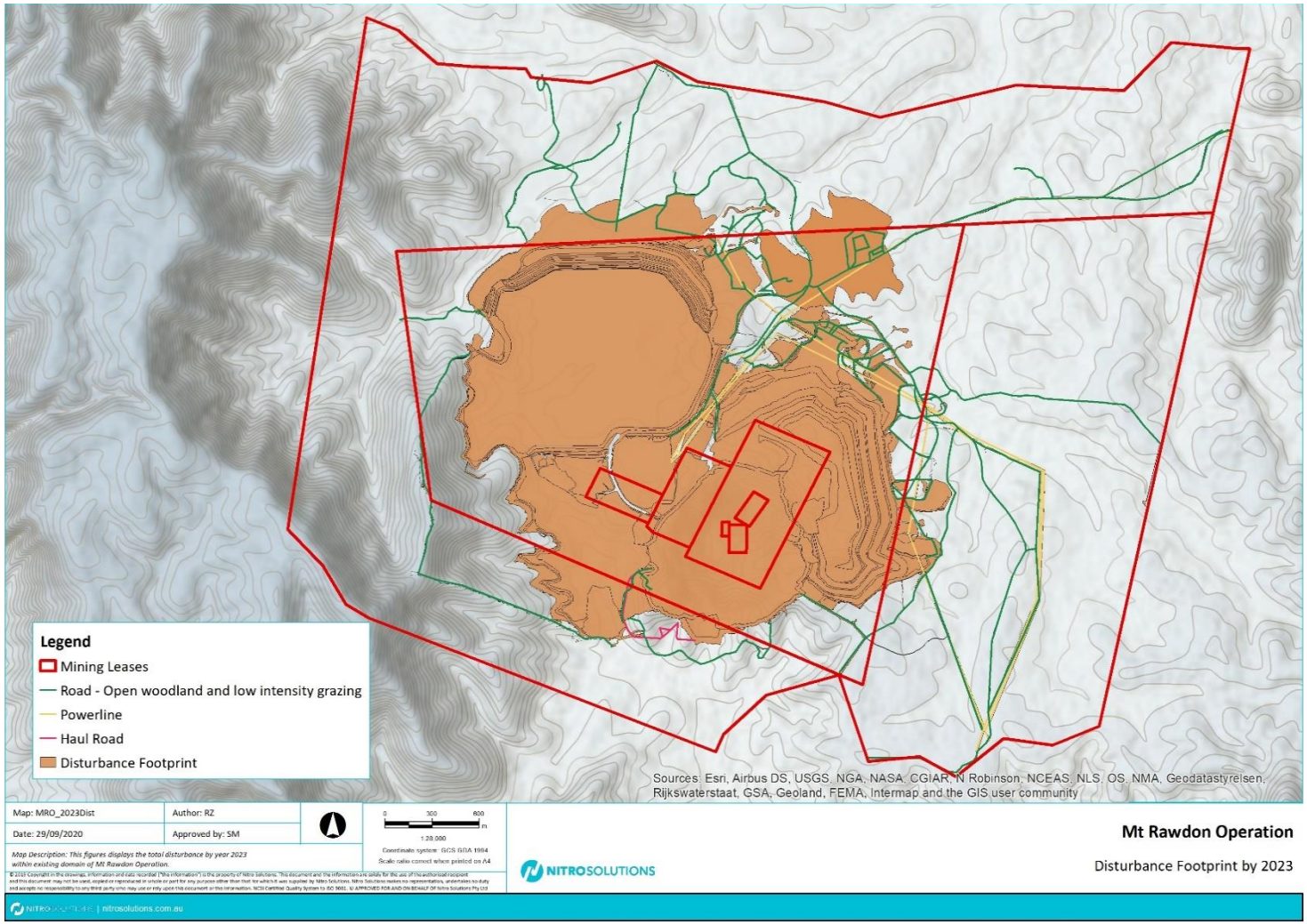


Figure 66: Maximum Footprint Disturbance at Year 2023

8.1.2 Schedule of Land Availability

The land will progressively become available as operations cease in the relevant areas, over the life of MRO. Disturbed land is considered available for rehabilitation when:

- Land is no longer being used for operational activities e.g. mining, dumping or storage of ore and waste rock;
- Area is no longer being utilised by operational equipment or infrastructure; and
- Land contains permanent infrastructure that will remain on the land for the PMLU.

The schedule of land availability for rehabilitation is shown in **Table 43**. Note that the land available per year is not a cumulative total of land available.

Table 43: Schedule of Land Availability for Rehabilitation

Land Available for rehabilitation in each rehabilitation area (ha)									
Rehabilitation areas		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
RA1	Residual Void			71 →						
RA2	NWRD and long term stockpiles					103.9→				
RA2 (2)	ROM and WWRD									41.2→
RA3	TSF					203 →				
RA4	Roads & Access Tracks					2 →				
RA5	Workshop & Infrastructure Management Areas					53 →				
RA6	Water Management Infrastructure & Dams					29 →				
Total										503 ha

8.1.3 Rehabilitation Milestones

Rehabilitation milestones relevant to MRO are listed in **Table 44**.

Table 44: Rehabilitation Milestones

Reference	Rehabilitation Milestone Criteria		Relevant Rehabilitation areas
RM1	Infrastructure decommissioning and removal	a) Disconnect and terminate services such as water and electricity that are not to remain for the landholder as part of the formal agreement; b) Itemised register of all removed infrastructure to be maintained; c) Demolish and remove buildings that will not remain; d) All infrastructure removed including concrete, steel and timber that will not remain; e) Recycling of all removed scrap metal where possible; f) Commission of Contamination Land Assessment (CLA)/Land Investigation of all areas in compliance with Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland (DoE 1998); g) All water infrastructure including groundwater bores, seepage management structures and pumping infrastructure will be inspected before remaining and TSF or mine-affected water has been transferred to the final void; h) Decommission of any boreholes not remaining for landholder or used for the purpose of monitoring; i) Stormwater infrastructure to be inspected before remaining to redirect waters to final void and/or appropriate dams and locations; j) Removal of all fencing not to remain for landholder; and k) Formalised approval of the Infrastructure Removal Register.	RA2, RA3, RA4, RA5, RA6
RM2	Remediation of contaminated land	a) Preliminary and intrusive contaminated land investigations completed; b) If possible, treat contaminated land/material on site; or c) Removal and transport for disposal of all soil or material listed under the Contaminated Lands Register (CLR) or otherwise vis regulated waste transport; d) Removal of all hazardous materials, chemicals and fuels in accordance with AS10940 to ensure it is non-polluting and safe to humans and animals;	RA2-RA6

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		e) Onsite contaminated water treated (e.g. affected by hydrocarbons, brine, metals, etc.); f) Contaminated materials (PCBs, Dioxins, Mercury, hydrocarbon contaminated soils) removed and disposed of; g) Hydrocarbon contaminated soils remediated ; h) Asbestos removed and disposed (if applicable); i) Plastic (geofabric) liners from dams, leach pads, etc. removed and disposed; j) Validation testing completed and confirms that contaminated soils have been removed/remediated; and k) Completed report provide by Suitably Qualified Persons (SQP) that land is remediated.	
RM3	North Waste Rock Dump Landform development and reshaping/reprofiling	a) Stable landform and slope angles do not exceed the angle of repose as per the final landform design; b) All major earthworks completed; c) Landform design (prior to cover system) completed as per design and Deswik.LHS d) The installation of contour or graded drains as per construction design has been certified by an appropriately qualified person; and e) Completion of the Landform Development Inspection Test Plan (ITP).	RA2
RM4	Pit Landform development and reshaping/reprofiling	a) Pit rim stabilisation activities conducted within 20 m from pit crest to counter potential landslip; b) 2m high safety bund to be constructed 20 m from the crest of residual void; c) Upper pit walls deemed geotechnically stable by suitably qualified geotechnical engineer. d) Functional safety bund should restrict accidental access to the pit; e) Access ramps should be retained to allow reasonable access in the event of accidental immersion in the water body by human or animal;	RA1

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		f) Perimeter fencing should be installed to restrict access of wildlife and livestock.	
RM5	TSF Landform development and reshaping/reprofiling	a) Final processing of ore material to pre-closure design; b) Alteration and lifts of embankments for strategic decant; c) Decanting/dewatering of TSF according to Closure Design; d) Reconstruction of embankments to final landform RL; e) Final deposition of tailings according to final landform design; f) Seepage management systems to be maintained and remain in place for monitoring purposes;	RA3
RM6	Remediation of water holding structure (water quality)	a) Floor desilting works completed (if applicable); b) Established sampling program for water quality monitoring; c) Evidence of leachate prevention through mining waste testing and management in accordance with the Mine Waste Management Plan; d) Sediment dams should be de-silted as necessary to reduce sediment loads within downstream stream environs with any sediment placed in the pit; e) Floor desilting works completed with a nominal 500 mm of sediment excavated from the floor area of each dam. Potentially contaminated material disposed of via the Tailing Storage Facility (TSF); f) Dam walls, bypass channels and clean water channels are stabilised with native vegetation or rock; g) Where appropriate, dam walls are re-profiled to allow adequate drainage; h) The slope into the dams should be assessed for integrity and ongoing stability; i) Erosion does not compromise dam wall integrity;	RA1 and RA6

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		j) In the case of a person or animal accessing the water body, egress from the dam should be managed through reasonable means; k) Water bodies to have adequate storage requirements to RPEQ design requirements; l) Appropriate diversion/ containment structures are designed to the appropriate risk event and constructed to minimise potential for site water generation and contained onsite; m) Sediment retention structures to be certified by an accredited Land Contamination assessor/ auditor to confirm the absence of any land contamination, prior to the commissioning as final clean water sediment retention structures; n) Established sampling program developed for water quality monitoring and is in place for water holding structure; o) Where applicable, water holding structure water quality characteristics meet stock drinking water quality requirements; p) Revegetation assessment occurs biannually (once in the wet season and once in the dry season) for revegetated dams walls and clean water diversions; q) Revegetation assessments should include an assessment of vegetation using Landscape Function Analysis (LFA) Methodology (Tongway and Hindley 2004) (incorporates groundcover, density, species richness, weed presence and soils nutrient analysis);	
RM7	ESC, stormwater and water infrastructure measures	a) Inspection and necessary upgrade/repair of current/remaining erosion and sediment control structures; b) Installation of erosion and sediment control structures as per rehabilitation areas design; c) Landform development of required drainage and redirection structures; d) Drainage construction is to be consistent with the approved design and based on the International Erosion Control Association best practice designs and methodologies;	All rehabilitation areas

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		e) Designs of drainage structures is validated with survey/GIS data collection across multiple locations and cross-sections provided to accompany the Drainage Construction ITP; f) A database of constructed designs of all rehabilitated areas is maintained; g) Erosion and sediment control structures are inspected regularly; h) Stormwater infrastructure remains to redirect waters to final void and/or appropriate dams and locations; i) Landscape Function Analysis (LFA) Erosion assessment – Monitoring at time of planting and annually post wet season for a total of 10 years to assess the number of gullies or rills within a 50 m transect; j) Landform development of required drainage and redirection structures; k) Revegetation assessments undertaken biannually (once in the wet season and once in the dry season) and include Soil stability analysis on slopes (erosivity) including an erosion assessment; l) No active areas of rill or gully erosion and drainage follows appropriate drainage paths; m) Maximum erosion rate of <to be determined from detailed landform design> t/ha/yr; and n) Completion of the Drainage Construction ITP.	
RM8	Installation of cover system/capping	a) Source, cart, spread, and compact required volume of impermeable material with appropriate chemical and physical properties; b) Install additional materials (capillary breaks, geofabric, etc.) as required; c) General reshaping to achieve final landform; d) Cover and capping systems including embankments is consistent with detailed design plans including the Mine Material Management Plan (RGS 2022). e) Prepare engineering and geotechnical report on completed cover; and f) Completion of the Capping & Cover System ITP.	RA2 and RA3

Reference	Rehabilitation Milestone Criteria		Relevant Rehabilitation areas
RM9	Surface preparation	a) Remediate any erosion or subsidence; b) Conduct sampling of topsoil stockpile to ascertain level and type of amelioration/fertiliser required; c) Placement of a minimum of 100 mm of topsoil; d) Mulch has been applied where required; e) Ripping of 300 mm on all sections to allow the establishment of vegetation; f) Installation of stock fencing; g) Installation of perimeter safety fencing*; h) Warning signage installed*; i) A site suitability statement, prepared by an approved auditor, is obtained that formally approves the land as being free of contamination prior to topsoil placement; j) Conduct sampling of topsoil stockpile to ascertain level and type of amelioration/fertiliser required; k) Remediate any erosion or subsidence; l) Ripping of 300 mm on relevant sections to allow the establishment of vegetation; m) Placement of a minimum of topsoil thickness as per design; n) Mulch has been applied where required; o) Insitu stockpile soil testing conducted prior to topsoil spreading to determine if fertiliser or soil ameliorants are to be applied to assist with successful rehabilitation; p) Soil structure and chemical composition sampling to be conducted to determine optimal seed growth;	All rehabilitation areas *Applies to RA1 - residual void only
RM10	Revegetation – low intensity grazing	a) Applying fertiliser; - Insitu stockpile soil testing conducted prior to topsoil spreading to determine if fertiliser or soil ameliorants are to be applied to assist with successful rehabilitation;	RA2 (2)-RA6

Reference Rehabilitation Milestone Criteria	Relevant Rehabilitation areas
- Soil structure and chemical composition sampling to be conducted to determine optimal seed growth; b) Direct seeding; - All seeds purchased have a supplied seed verification certificate; - All direct seeding to take place prior to wet season; - A minimum seeding rate of 10 kg/ha of native grass seed. Completed seeding of target grass species (such as sterile Japanese millet in summer and sterile rye grass in winter) 50kg/ha; - Herb, forb and grass species has a minimum 60% of target species established and is comparable to the surrounding similar land uses. - Pasture species has a pasture mass (t/ha) trending towards a sustainable grazing site; - Shrubs and juvenile trees (with a stem diameter <5cm) has a minimum 60% of target species established and has a percentage comparable to surrounding similar land uses; - A minimum completed seeding of target native tree species (listed below) of 2–5 kg/ha; c) Target (Potential) Tree Species for Rehabilitation (MRO FLURP, Table 6): ▪ *Corymbia tessellaris* - Dominant – associated with RE 12.12.5; ▪ *Corymbia citriodora* subsp. *Variegate* - Dominant – associated with RE 12.12.5; ▪ *Corymbia trachyphloia* - Sporadic– associated with RE 12.12.5; ▪ *Eucalyptus crebra* - Dominant – associated with RE 12.12.5; ▪ *Eucalyptus moluccana* - Subdom – associated with RE 12.12.5; ▪ *Eucalyptus tereticornis* - Dominant – associated with RE 12.12.5; ▪ *Lophostemon confertus* - Sporadic– associated with RE 12.12.5; - Total ground cover is the sum of protective ground cover components (as above) and is comparable to surrounding similar land uses; - Weeds listed under the biosecurity Act do not exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas; - Rehabilitation sites are monitored within 12 months of planting and annually every year for 10 years; d) Completion of the Topsoil Works and Seeding ITP;	

Reference Rehabilitation Milestone Criteria			Relevant Rehabilitation areas
		- Landscape Function Analysis Landform (Stability Index) to be monitored at time of planting and every two (2) years following for a total of 10 years; - A site suitability statement, prepared by an approved auditor, is obtained that formally approves the land as being free of contamination prior to topsoil placement; e) No active areas of rill or gully erosion and drainage follows appropriate drainage paths; f) Resilience to fire can be demonstrated; g) Native fauna identified at reference sites prior to mining are present or indicators of these species have been recorded; h) Completion of the Topsoil Works and Seeding ITP;	
RM11	Revegetation – open woodland	a) Landscape Function Analysis Landform (Stability Index) to be monitored at time of planting and every two (2) years following for a total of 10 years; b) Areas of active erosion are limited and stabilising (50 m transect) and are monitored at time of planting and annually post wet season for a total of 10 years; c) A site suitability statement, prepared by an approved auditor, is obtained that formally approves the land as being free of contamination prior to topsoil placement; d) Pasture species has a pasture mass (t/ha) trending towards a sustainable grazing site. Groundcover biomass of desirable grass species comprises of a minimum of 60% of total grass cover for five (5) years during mining operations and three (3) years post-cessation; e) Shrubs and juvenile trees (with a stem diameter <5cm) has a minimum 60% of target species established and has a percentage comparable to surrounding similar land uses; f) Weeds listed under the biosecurity Act are not to exceed densities typically present in unmined, grazed landscapes within MLA area and neighbouring areas, Weeds present no more than >5 individuals or 10 m^2; g) Herb, forb and grass species is comparable to the surrounding similar land uses; h) Completed seeding of target tree species (listed below) as per contractor agreement (kg/ha); Target (Potential) Tree Species for Rehabilitation (MRO FLURP, Table 6): ▪ *Corymbia tessellaris* - Dominant – associated with RE 12.12.5;	RA2 - NWRD

Reference Rehabilitation Milestone Criteria			Relevant Rehabilitation areas
		▪ *Corymbia citriodora* subsp. *Variegate* - Dominant – associated with RE 12.12.5; ▪ *Corymbia trachyphloia* - Sporadic– associated with RE 12.12.5; ▪ *Eucalyptus crebra* - Dominant – associated with RE 12.12.5; ▪ *Eucalyptus moluccana* - Subdom – associated with RE 12.12.5; ▪ *Eucalyptus tereticornis* - Dominant – associated with RE 12.12.5; and ▪ *Lophostemon confertus* - Sporadic– associated with RE 12.12.5; i) Percentage of protective (perennial plant) ground cover (<0. 5 m in height) is comparable to surrounding similar land uses; j) Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of surrounding similar land uses; k) Percentage of the tree population which are in healthy condition and that the percentage is comparable to surrounding similar land uses; l) Percentage of the tree population which are in health condition and that the percentage is comparable to surrounding similar land uses; m) Percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of surrounding similar land uses; n) Rehabilitation sites are monitored within 12 months of planting and annually every year for 10 years; o) No active areas of rill or gully erosion and drainage follows appropriate drainage paths; p) Resilience to fire can be demonstrated; q) Native fauna identified at reference sites prior to mining are present or indicators of these species have been recorded;and r) Monitoring indicators determines that vegetation meets completion criteria.	
RM12	Establishment of target vegetation type	a) Monitoring indicators determines that vegetation meets completion criteria; b) Landscape Function Analysis (LFA) Monitoring to be carried out, to determine function of the ecosystem and effectiveness of rehabilitation, using LFA (Tongway and Hindley 2004) Methodology to incorporate groundcover, density, species richness, weed presence and soils nutrient analysis.	RA2-RA6

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		c) An assessment of vegetation composition and dynamics is to be carried out: A series of permanent 20 m long monitoring transects has been established (placed on both slope and flat terrains) in each domain when decommissioned and rehabilitated; d) Habitat complexity to be determined through the use of a 50 x 50 m line transect and is scored from 0 – 4 based on per cent cover of each parameter (0 = 0%, 1 = <30%, 2 = 30-70% and 4=>70%); e) Revegetation monitoring is undertaken biannually, in the wet season and the dry season, to quantify the progress of revegetated areas and document land capability against reference sites and the rehabilitation completion criteria; f) Foliage cover in excess of 70% to meet the set values based on the regional assessment of cover requirements; and g) Ensure nutrient cycling is occurring through the presence of leaf litter to assist in limiting erosion.	
RM13	Achievement of stable PMLU (Open Woodland)	a) Revegetation uses available topsoil resources and native, tree and pasture species to meet the final land use classes and reference sites; b) Rehabilitation monitoring has determined achievement of PMLU; c) Completion of the General Landform Development Inspection Test Plan (ITP). Monitoring indicators determines that land, water, and vegetation meet completion criteria; d) Certification from an appropriately qualified person that the area has achieved stable condition; e) Maximum erosion rate of as per landform design (t/ha/yr); f) Groundcover as per revegetation plan (%); g) A contaminated land survey carried out by an appropriately qualified person indicates that no contamination unsuitable for the post-mining land use is occurring; and	RA2

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		h) Certification of no weed and pest species abundance identified in rehabilitated areas are no greater than at reference sites;	
RM14	Achievement of stable PMLU (Open Woodland/Low-Intensity Grazing)	a) Revegetation uses available topsoil resources and native, tree and pasture species to meet the final land use classes and reference sites; b) Rehabilitation monitoring has determined achievement of PMLU; c) Completion of the General Landform Development Inspection Test Plan (ITP). Monitoring indicators determines that land, water, and vegetation meet completion criteria; d) Certification from an appropriately qualified person that the area has achieved stable condition; e) Maximum erosion rate of as per landform design (t/ha/yr); f) Groundcover as per revegetation plan (%); g) A contaminated land survey carried out by an appropriately qualified person indicates that no contamination unsuitable for the post-mining land use is occurring; and h) Certification of no weed and pest species abundance identified in rehabilitated areas are no greater than at reference sites.	RA2 (2), 3, 4, 5
RM15	Achievement of stable PMLU (Water Storage) – Residual Void – Pit)	a) Rehabilitation monitoring has determined achievement of PMLU; b) Completion of the General Landform Development Inspection Test Plan (ITP). Monitoring indicators determines that land, water, and vegetation meet completion criteria; c) Certification from an appropriately qualified person that the area has achieved stable condition; d) Surface water quality within residual void complies with PMLU water quality criteria e.g. grazing / stock watering – stock water quality guidelines: • Total Suspended Solids must not exceed 1200 mg/L	RA1

Reference	Rehabilitation Milestone	Criteria	Relevant Rehabilitation areas
		• pH between 6.0 – 9.0 • Total Dissolved Solids <4000 mg/L • Sulfate 1500 mg/L • Aluminium <5 mg/L • Copper <1mg/L • Zinc <20 mg/L • Arsenic <0.5 mg/L • Boron 5 mg/L • Calcium 1000 mg/L • Chromium 1mg/L • Cadmium <0.01 mg/L • Fluoride <2mg/L • Lead <0.1 mg/L • Magnesium <2000 mg/L • Molybdenum <0.15mg/L • Nitrate as N 400mg/L • Nitrite <30mg/L • Selenium <0.02mg/L • WAD Cyanide <0.007 mg/L	
RM16	Achievement of stable PMLU (Water Storage /low intensity	a) Infrastructure is removed (unless otherwise agreed to be maintained on the land) and recoverable scrap metal is recycled; b) Rehabilitation monitoring indicates PMLU achieved	RA6

Reference	Rehabilitation Milestone Criteria		Relevant Rehabilitation areas
	grazing stock water) Includes WD1-4, West Dam, South Dam, Sed Dam3	c) Completion of the General Landform Development Inspection Test Plan (ITP). Monitoring indicators determines that land, water, and vegetation meet completion criteria; d) Certification from an appropriately qualified person that the area has achieved stable condition; e) Surface water quality (excludes residual void – pit) from the area complies with the following: • Total Suspended Solids must not exceed 1200 mg/L • pH between 6.0 – 9.0 • Total Dissolved Solids <1000 mg/L • Sulfate <250; • Copper <0.04 for mg/L • Zinc <0.15 mg/L • Arsenic <0.05 mg/L • Cadmium <0.005 mg/L • WAD Cyanide <0.007 mg/L	

8.2 Spatial Information

Data files of the following spatial information has been provided with the submission of this PRCP submission:

- The location and maximum extent of the disturbance footprint for the mine life
- The identified rehabilitation areas and associated PMLUs for the area within the MRO area
- The rehabilitation areas within the MRO area;

Polygons are within final name: *EPML00712113_PRCP_PY_28062021*

Excluded:

- The locations of any sensitive receptors – there are no nearby sensitive receptors
- The extent of the floodplain – MRO is not within a floodplain area

8.3 Supporting documents submitted with this Plan

- 2020048_MRO Geochemical Report_04122020
- 2020048_MRO Long Term Tailing Report_06012021
- MRO Waste Rock Test Pile Review RGS Environmental Pty Ltd, 2018.
- MRO Growth Media Management Procedure
- ARCHAEO 2013 Cultural Heritage Survey
- MRO TSF Closure Decommissioning and Rehab Plan Dec 2017
- 620.30185-R01-v2.0 Final void study report – *superseded by RGS Mine Material Management Plan Void Assessment.*
- 111359.83.R01_Rev1 Hydraulic Flood Assessment
- 000 MRO PRCP Scenario 2 Animation_no roads_captions_20220518 (1)
- 01_2021092_MRO Mine material management plan_FINAL A_11112022
- EVO010006 - Rev 0 - MRO PRCP Geotechnical Assessment-Open Pit_Final
- EVO010006 - Rev 0 - MRO PRCP Geotechnical Assessment-Tailings Storage Facility_Final
- EVO010006 - Rev 0 - MRO PRCP Geotechnical Assessment-Waste Dump_Final
- Rehabilitation trials_wetlands design
- Community Consultation Plan

**Please note supporting documents above may be updated following submission of the PRC Plan. Please refer to latest revision for latest information.*

8.4 References

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9 Appendices

Appendix 1 PRCP-schedule V2
Appendix 2 EPBC 2013_6886
Appendix 3 Risk Matrix
Appendix 4 Post-closure Land holder Agreement
Appendix 5 EA 20221101 Permit EPML00712113 Mt Rawdon Operations Pty Ltd

9.1.1 Appendix 1: PRC Plan Schedule

Post-mining land uses (PMLU)										
Rehabilitation area	RA 1 - Residual Void (Pit)									
Relevant activities	Pit									
Total rehabilitation area size (ha)	71.35									
Commencement of first milestone: RM4	10 Dec 2024									
PMLU	Water Storage									
Date area is available	10/12/2024	10/12/2025	10/12/26							
Cumulative area available (ha)	71.35	71.35	71.35							
Milestone completed by	10/12/2025	10/12/26	10/12/37							
Milestone Reference	**Cumulative area achieved (ha)**									
RM4	71.35									
RM6	71.35									
RM7		71.35								
RM9		71.35								
RM15			71.35							

Post-mining land uses (PMLU)											
Rehabilitation area				RA 2 - North Waste Rock Dump							
Relevant activities				Waste rock and long term ore stockpiles							
Total rehabilitation area size (ha)				103.9							
Commencement of first milestone: RM2				10 Aug 2026							
PMLU				Low-intensity Grazing / Open woodland							
Date area is available	10/08/2026	10/12/30									
Cumulative area available (ha)	103.9	103.92									
Milestone completed by	10/12/2030	10/12/2040									
Milestone Reference	**Cumulative area achieved (ha)**										
RM3	103.92										
RM7	103.92										
RM8	103.92										
RM9	103.92										
RM11		103.92									
RM12		103.92									
RM13		103.92									

Post-mining land uses (PMLU)										
Rehabilitation area	RA 2 - West Waste Rock Dump, Run of Mine (ROM)									
Relevant activities	forming waste rock stockpile (WWRD) and temporary storage location for ore prior to processi									
Total rehabilitation area size (ha)	WWRD 36ha, ROM 5.2ha = Total 41.2ha									
Commencement of first milestone: RM2	10 Dec 2030									
PMLU	Low-intensity Grazing / Open woodland									
Date area is available	10/12/2030	10/12/31								
Cumulative area available (ha)	41.2	41.2								
Milestone completed by	10/12/2031	10/12/2040								
Milestone Reference	**Cumulative area achieved (ha)**									
RM2	41.2									
RM7	41.2									
RM9	41.2									
RM10|11	41.2									
RM12		41.2								
RM14		41.2								

Post-mining land uses (PMLU)										
Rehabilitation area	RA 3 - Tailings Storage Facility									
Relevant activities	Tailings storage									
Total rehabilitation area size (ha)	203.92									
Commencement of first milestone: RM4	10 Aug 2026									
PMLU	Low-intensity Grazing / Open woodland									
Date area is available	10/08/2026	10/12/2030								
Cumulative area available (ha)	203.92	203.92								
Milestone completed by	10/12/2030	10/12/2040								
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	203.92									
RM5	203.92									
RM7	203.92									
RM8	203.92									
RM9	203.92									
RM10|11	203.92									
RM12	203.92									
RM14		203.92								

Post-mining land uses (PMLU)										
Rehabilitation area	RA 4 – Haul Roads									
Relevant activities	Haul roads									
Total rehabilitation area size (ha)	2									
Commencement of first milestone: RM1	10 Aug 2026									
PMLU	Low-intensity Grazing / Open woodland									
Date area is available	10/08/2026	10/12/2030								
Cumulative area available (ha)	2	2								
Milestone completed by	10/12/2030	10/12/2030								
Milestone Reference	**Cumulative area achieved (ha)**									
RM9	2									
RM10|11	2									
RM12	2									
RM14		2								

Post-mining land uses (PMLU)										
Rehabilitation area	RA 5 -Processing Plant, Workshops, and other Infrastructure management areas									
Relevant activities	Processing ore, heavy vehicle workshops and other infrastructure areas									
Total rehabilitation area size (ha)	53.65									
Commencement of first milestone: RM1	10 Aug 2026									
PMLU	Low-intensity Grazing / Open woodland									
Date area is available	10/08/2026	10/12/30								
Cumulative area available (ha)	53.65	53.65								
Milestone completed by	10/12/2030	10/12/2040								
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	53.65									
RM2	53.65									
RM7	53.65									
RM9	53.65									
RM10 | 11	53.65									
RM12	53.65									
RM14		53.65								

Post-mining land uses (PMLU)										
Rehabilitation area	RA 6 – Water Management Infrastructure and Dams (excluding Perry River Dam)									
Relevant activities	Mine water storage									
Total rehabilitation area size (ha)	28.8									
Commencement of first milestone: RM3	10 Aug 2026									
PMLU	Stock water									
Date area is available	10/08/2026	10/12/30								
Cumulative area available (ha)	28.8	28.8								
Milestone completed by	10/12/2030	10/12/2040								
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	28.8									
RM2	28.8									
RM6	28.8									
RM7	28.8									
RM16		28.8								

9.1.2 Appendix 2: EPBC 2013/6886

Australian Government
Department of the Environment

Notification of
REFERRAL DECISION – not controlled action if undertaken in a particular manner

Mt Rawdon Operations, Stage 4 pit cutback and western waste rock dump, 80 kilometres south west of Bundaberg, Qld (EPBC 2013/6886)

This decision is made under sections 75 and 77A of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Proposed action

person named in the referral	Mt Rawdon Operations Pty Ltd ACN: 77 152 727 663
proposed action	To construct and operate a new waste rock dump, seepage dam and pit expansion for the Mt Rawdon Goldmine, 80 kilometres south west of Bundaberg, Qld [See EPBC Act referral 2013/6886].

Referral decision: Not a controlled action if undertaken in a particular manner

status of proposed action	The proposed action is not a controlled action provided it is undertaken in the manner set out in this decision.

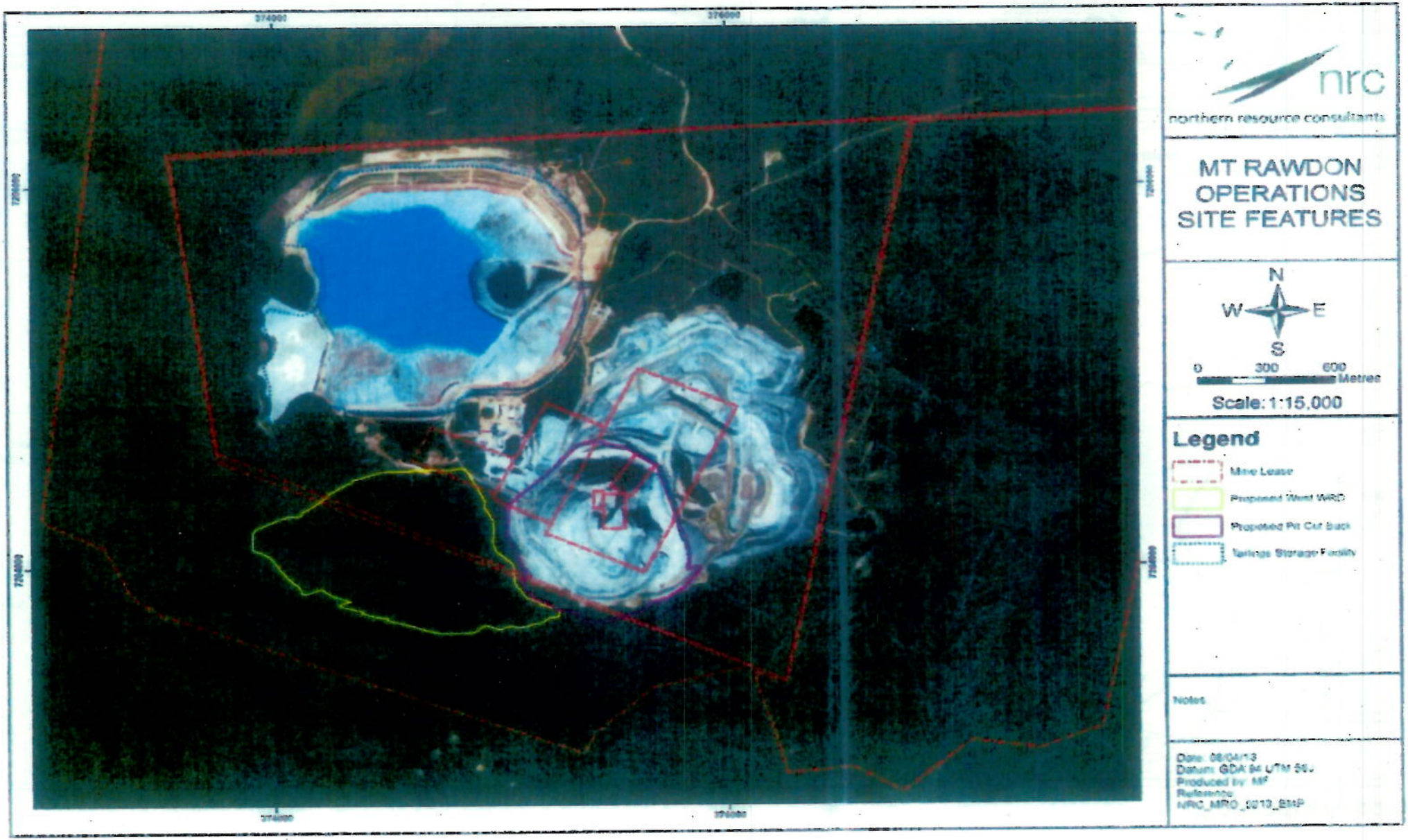
Person authorised to make decision

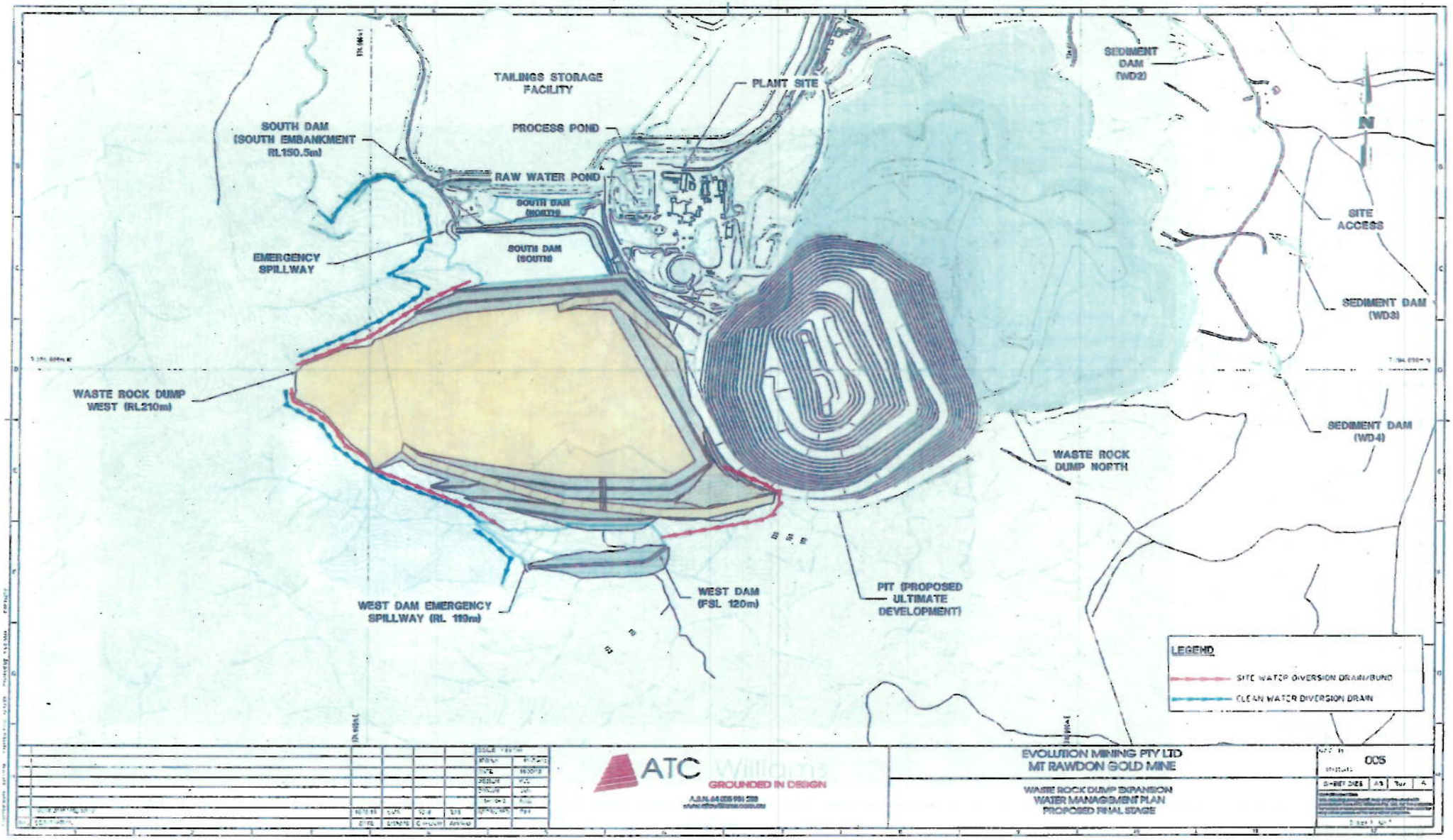
Name and position	Deb Callister Assistant Secretary Queensland and Sea Dumping Assessment Branch
signature	
date of decision	25 September 2013

manner in which proposed action must be taken	The following measures must be taken to avoid significant impacts on: • Listed threatened species and communities (sections 18 & 18A) **Project Area** 1. Disturbance from project activities must not exceed 90 hectares of vegetation, as defined in Appendix A, located in the operation area, ML1192, ML1203, ML1204, ML1206, ML1210, ML1231, ML1259, ML50119 and ML80095, as described in Appendix B. **For the Protection of the Northern Quoll (*Dasyurus hallucatus*)** 2. Implement Northern Quoll management as described in "*Northern Quoll Management Plan Mt Rawdon Operation (August 2013)*". 3. Implement feral animal management as described in "*Feral Animal Management Plan Mt Rawdon Operations Pty Ltd September 2013*" in the operation area. 4. Implement weed species management as described in "*Weed Management Plan July 2012*" in the operation area.

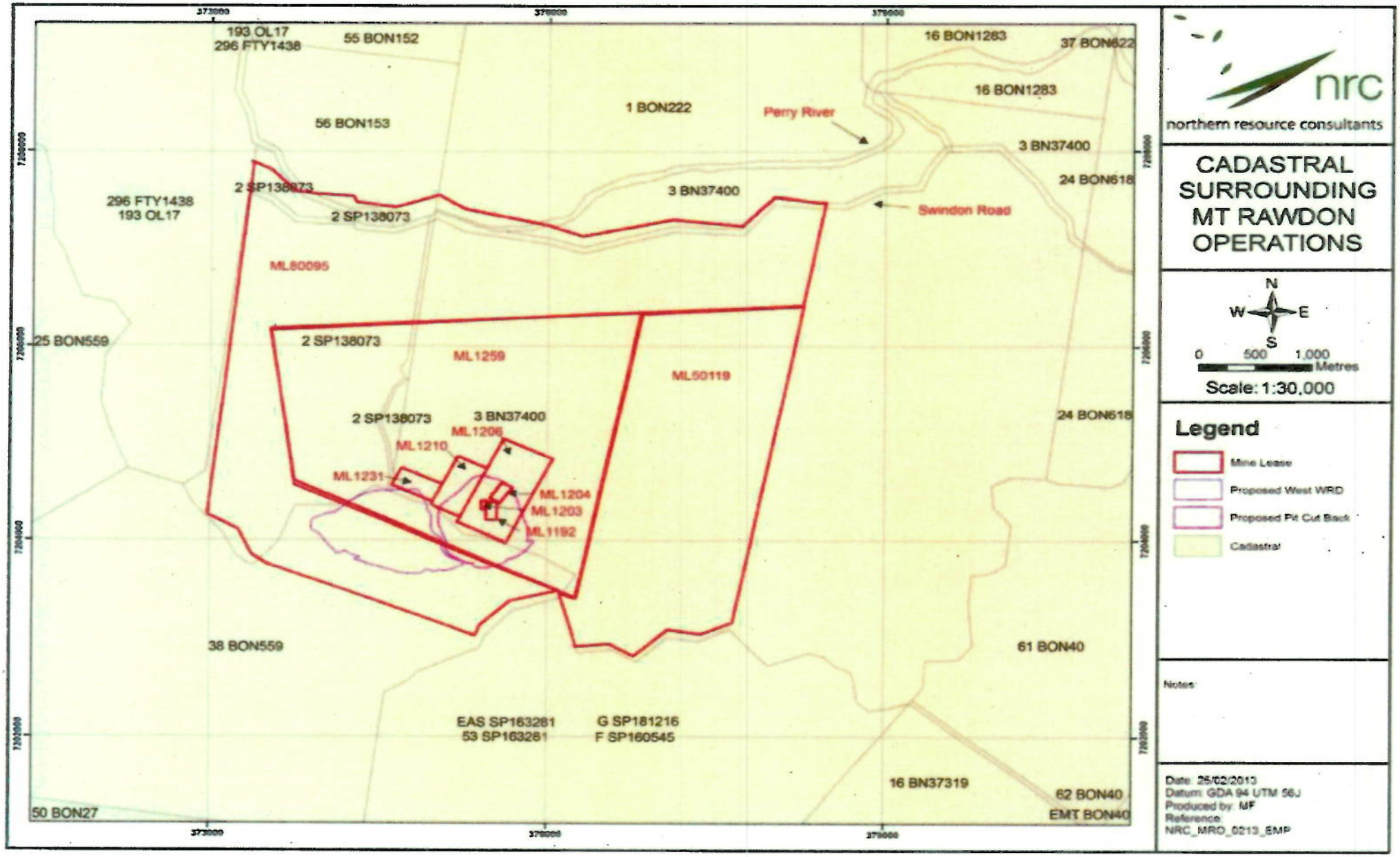
Australian Government
Department of the Environment

Appendix A




TAILINGS STORAGE FACILITY
PLANT SITE
SEDIMENT DAM (WD2)
SOUTH DAM (SOUTH EMBANKMENT RL150.5m)
PROCESS POND
RAW WATER POND
SOUTH DAM (NORTH)
SOUTH DAM (SOUTH)
EMERGENCY SPILLWAY
N
SITE ACCESS
SEDIMENT DAM (WD3)
WASTE ROCK DUMP WEST (RL210m)
SEDIMENT DAM (WD4)
WASTE ROCK DUMP NORTH
WEST DAM (FSL 120m)
PIT (PROPOSED ULTIMATE DEVELOPMENT)
WEST DAM EMERGENCY SPILLWAY (RL 119m)
LEGEND
SITE WATER DIVERSION DRAIN/BUND
CLEAN WATER DIVERSION DRAIN
ATC
GROUNDED IN DESIGN
EVOLUTION MINING PTY LTD
MT RAWDON GOLD MINE
WASTE ROCK DUMP EXPANSION
WATER MANAGEMENT PLAN
PROPOSED FINAL STAGE
005

Appendix B


193 OL17
296 FTY1438
55 BON152
16 BON1283
37 BON622
16 BON1283
1 BON222
Perry River
56 BON153
3 BN37400
24 BON618
2 SP138073
3 BN37400
296 FTY1438
193 OL17
2 SP138073
Swindon Road
ML80095
25 BON559
2 SP138073
ML1259
ML50119
2 SP138073
3 BN37400
24 BON618
ML1206
ML1210
ML1231
ML1204
ML1203
ML1192
38 BON559
61 BON40
EAS SP163281
53 SP163281
G SP181216
F SP160545
16 BN37319
62 BON40
EMT BON40
50 BON27
nrc
northern resource consultants
CADASTRAL SURROUNDING MT RAWDON OPERATIONS
N
W
E
S
0
500
1,000
Metres
Scale: 1:30,000
Legend
Mine Lease
Proposed West WRD
Proposed Pit Cut Back
Cadastral
Notes:
Date: 25/02/2013
Datum: GDA 94 UTM 56J
Produced by: MF
Reference:
NRC_MRO_0213_EMP

9.1.3 Appendix 3: Risk Matrix

Table 1: Mt Rawdon Risk Matrix

RISK MATRIX					
LIKELIHOOD	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	M	H	H	VH	VH
Likely	M	M	H	H	VH
Possible	L	M	H	H	H
Unlikely	L	L	M	M	H
Rare	L	L	M	M	H

Almost Certain	The event will occur on an annual basis	More than once per year	>95%
Likely	The event has occurred several times or more in your career	At least once per 1 year	60% – 95%
Possible	The event might occur once in your career	At least once in 3 years	30% – 60%
Unlikely	The event does occur somewhere from time to time	At least once in 10 years	5% – 30%
Rare	Heard of something like the event occurring elsewhere	Less than once in 30 years	<5%

Table 2: Mt Rawdon Consequence Matrix Table

Severity level	Consequence Types							
	Financial cost Company	Financial cost Business Unit	Human injury	Natural Environment	Social/Cultural Heritage	Community/Govt./ Reputation/Media	Legal	Variance from Business Performance (Company)
Catastrophic	>$500M	>$10M	Multiple fatalities, significant irreversible impairment to multiple persons	Very serious, long-term environmental impairment of ecosystem functions			Significant prosecution and fines Very serious litigation	>50% variance from business objectives/ KPI's
Major	$100M –$500M	$1M -$10M	Single fatality, significant irreversible impairment to a person		On-going serious social issues. Significant damage to structures/items of cultural significance	Serious public or media outcry (international coverage)	Major breach of regulation Major litigation	20% - 50% variance from business objectives/ KPI's
Moderate	$10M -$100M	$100K- $1M	Significant reversible impairment to one or more persons (LTI, DI)	Serious medium term environmental effects		Significant adverse national media/public/NGO attention	Serious breach of regulation with investigation or report to authority with prosecution and/or moderate fine possible	10% - 20% variance from business objectives/ KPI's
Minor	$1M- $10M	$10K - $100K	Reversible impairment requiring medical treatment (MTI)	Moderate, short-term effects but not affecting ecosystem functions	On-going social issues. Permanent damage to items of cultural significance	Attention from media and/or heightened concern by local community. Criticism by NGOs	Minor legal issues, non-compliances and breaches or regulations	5% - 10% variance from business objectives/ KPI's
Insignificant	<$1M	<$10K	No treatment or first aid treatment	Minor effects on biological or physical environment	Minor medium-term social impacts on local population. Mostly repairable	Minor Adverse local public or media attention or complaints		<5% variance from business objectives/ KPI's

9.1.4 Appendix 4: Post-closure Land Holder Agreement

6 April 2017

Mt Rawdon Operations Pty Ltd
ABN: 77 152 727 663
(A subsidiary of Evolution Mining Limited ABN: 74 084 669 036)

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Ingrid Fomiatti Minnesma
Director Minerals
Minerals & North Queensland Compliance
Environmental Services & Regulation
Department of Environment and Heritage Protection
PO Box 7230
CAIRNS QLD 4870

RETENTION OF INFRASTRUCTURE FOR POST-CLOSURE USE

Dear Ingrid,

Swindon Station was a cattle grazing property immediately prior to its current land use of a gold mining operation. Grazing is the current proposed post-mining land use, which is consistent with surrounding properties. Several items of infrastructure currently in place at Mt Rawdon Operation are of use to a cattle grazing property. As the current landholder of Swindon Station, Evolution Mining states that retention of the following infrastructure is consistent with the requirements of the post-closure landuse.

- Site roads and tracks
- Raw water dams and associated pipework
- Sheds
- Infrastructure to supply power to the site (powerlines, substation, switchyard)
- Groundwater bores

Regards,



Evan Elstein
Company Secretary

9.1.5 Appendix 5: EA 20221101 Permit EPML00712113 Mt Rawdon Operations Pty Ltd

Permit

Environmental Protection Act 1994

Environmental authority EPML00712113

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00712113

Environmental authority takes effect on 1 November 2022.

Environmental authority holder(s)

Name	Registered address
Mt Rawdon Operations Pty Ltd	Level 24, 175 Liverpool Street Sydney NSW 2000

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)
Schedule 3 16: Mining gold ore	ML1231, ML1259, ML50119, ML100059, ML1192, ML1203, ML1204, ML1206, ML1210
Ancillary 08 - Chemical Storage 2: Storing 50t or more of chemicals of dangerous goods class 6, division 6.1 under subsection (1)(b)	
Ancillary 63 - Sewage Treatment 1: Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of (a-ii) 21 to 100EP otherwise	
Ancillary 31 - Mineral processing 2: Processing, in a year, the following quantities of mineral products, other than coke (b) more than 100,000t	

ABN 46 640 294 485

Queensland Government

Environmentally relevant activity/activities	Location(s)
Ancillary 60 - Waste disposal 1: Operating a facility for disposing of, in a year, the following quantity of waste mentioned in subsection (1)(a) (a) less than 50,000t	

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days);
- that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term ‘duty to notify’.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority-on the nominated day; or

b) if the authority states a day or an event for it to take effect-on the stated day or when the stated event happens; or

c) otherwise-on the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Sustainable Planning Act 2009* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.

Tibbs	1 November 2022
Signature	Date

Teale Gibbs
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Minerals Business Centre
Department of Environment and Science
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Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where environmental harm or nuisance may be caused (section 443)

Other permits required

This permit only provides an approval under the Environmental Protection Act 1994. In order to lawfully operate you may also require permits / approvals from your local government authority, other business units within the department and other State Government agencies prior to commencing any activity at the site. For example, this may include permits / approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access state controlled roads), the Department of Resources (to clear vegetation), and the Department of Agriculture and Fisheries (to clear marine plants or to obtain a quarry material allocation).

Conditions of environmental authority

Schedule A - General
Schedule B - Air
Schedule C - Waste Management
Schedule D - Noise
Schedule E - Water
Schedule F - Biodiversity
Schedule G - Land and Rehabilitation
Schedule H - Regulated Structures
Schedule I - Definitions
Schedule J - Maps and Plans

Schedule A – General

A1 This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.

A2 Contaminants with the potential to cause environmental harm must not be released directly or indirectly to the receiving environment, except as permitted under the conditions of this environmental authority.

A3 The environmental authority holder must ensure that the activity is carried out in accordance with *Table A1*.

Table A1 - Authorised disturbance ('Table A1')

Mine domain[1]	Mine feature name	Sub-domain Area (ha)	Maximum disturbance area (ha)	Location (GDA94)	
				Central Peg Coordinates	
Borrow Pit	Clay Borrow	3.92	50.06	375917.3566	7205686.401
	Cleared/ Topsoil Stripped	0.69		375097.6334	7205778.725
	Combined Borrow Pit and Topsoil Stockpile Area	42.06		374905.2775	7206062.352
	NAF Rock Borrow	3.40		374946.7038	7203876.49
Infrastructure	Core Yard	0.62	58.84	376361.9136	7205364.685
	Environment Experiment Hardstand	1.21		375938.9904	7203935.688
	Explosive Magazine	0.89		374381.736	7204749.723
	Future Infrastructure Area	3.57		375266.7654	7204918.881
	Helipad	0.50		375857.7162	7205906.014
	Mining Operations	1.62		375431.4463	7205293.051
	MRT Training Area	1.60		376440.5676	7205541.877
	Orica	3.72		376230.5201	7206132.951
	Pipelines	3.23		376491.5331	7205807.7
	Pit Laydown Area	1.99		374975.2669	7204317.504
	Powerlines	13.95		376654.3306	7204939.469
	Processing Plant	14.15		374976.4789	7204691.297

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Mine domain[1]	Mine feature name	Sub-domain Area (ha)	Maximum disturbance area (ha)	Location (GDA94)	
				Central Peg Coordinates	
	Run of Mine	5.19		375191.6661	7204619.238
	South Pit Hardstand	2.35		375313.9339	7203682.747
	Landfill Area	2.65		376229	7206201
	Landfill Area	1.60		376441	7205542
North WRD	Batters	42.07	103.92	376091.7812	7204673.925
	Capping System	52.87		375870.012	7204714.79
	Cleared/ Topsoil Stripped	2.38		376434.7224	7204599.618
	Existing capping system	6.60		376236.3995	7204544.26
Pit	Pit Crest	71.35	71.35	375457.4643	7204185.751
Roads	Cleared/ Topsoil Stripped	1.43	27.90	376025.3423	7205491.726
	Roads	21.32		375301.0168	7204920.848
	Roads (Non FA)	5.16		375941.6944	7206192.787
Topsoil	Topsoil Stockpiles	13.03	13.16	375651.3175	7204954.727
	Cleared/ Topsoil Stripped	0.13		376013.885	7203870.728
TSF	Batter	45.02	203.92	374840.955	7205719.538
	Bench	22.87		374845.7628	7205731.64
	Capping System	127.72		374633.5691	7205383.006
	Cleared/ Topsoil Stripped	3.31		374285.3654	7205301.36
	PAF Dump	5		374119.470	7205140.050
Water Management	Cleared/ Topsoil Stripped	0.19	53.82	375569.1878	7206148.086
	Drains	13.56		375277.4524	7204868.76
	SD1	2.21		375280.9449	7206122.717
	SD2	0.66		375603.3949	7206359.127
	SD3	3.85		375373	7206203
	South Dam	6.20		374641.5086	7204642.337

Mine domain[1]	Mine feature name	Sub-domain Area (ha)	Maximum disturbance area (ha)	Location (GDA94)	
				Central Peg Coordinates	
	WD1	9.36		376034.6416	7205481.253
	WD2	4.85		376389.4565	7205250.938
	WD3	2.74		376650.6981	7204537.494
	WD4	3.73		376555.9628	7204223.605
	West Dam	6.29		374749.0942	7203761.15
	Effluent irrigation area	0.18		374946	7204814
West WRD	Approved, but currently undisturbed	16.72	59.14	374310.2317	7204036.078
	Batters	8.17		374630.2096	7204016.993
	Capping System	27.32		374632.1548	7204298.308
	Cleared/ Topsoil Stripped	6.94		374381.7234	7204132.821

[1] Mine domains depicted is *Schedule J, Map 1 – Location of authorised disturbance* and *Map 2A – Infrastructure locations*

A4 The holder of this environmental authority must:

a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority;

b) maintain such measures, plant and equipment in a proper and efficient condition;

c) operate such measures, plant, and equipment in a proper and efficient manner; and

d) ensure all instruments and devices used for the measurement or monitoring of any parameter under any condition of this environmental authority are properly calibrated.

Monitoring

A5 Except where specified in another condition of this environmental authority, all monitoring data, records and reports required by this environmental authority or related to environmental management of the activities must be:

a) carried out by an appropriately qualified person, periodically reviewed and updated as required to reflect operational or environmental changes;

b) kept for a period of not less than five (5) years;

c) provided to the administering authority in the specified format within 10 business days of a request; and

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d) undertaken in accordance with the most recent version of any applicable standard or guideline for the activity

A6 The following information must be recorded in relation to all monitoring required under a condition of this environmental authority:

a) the date and time when the sample was taken;

b) the location where the sample was taken; and

c) any other pertinent details of relevance to interpreting the sampling results (*i.e.* stream flow, wind conditions or any unusual observations such as odour or colouration).

A7 The environmental authority holder must implement all reasonable measures necessary to conduct monitoring required under a condition of this environmental authority.

Note: 'Reasonable measures' could include establishing and maintaining safe all-weather access to a monitoring location by upgrading roads/tracks, use of suitable automated sampling devices, developing alternative routes or utilising alternative transport.

Financial assurance

A8 Financial assurance must be lodged with the administering authority in the amount, the form and within the time required by the administering authority.

Risk management

A9 The holder of this environmental authority must develop and implement a risk management system for mining activities which mirrors the content requirement of the Standard for Risk Management (ISO31000:2009), or the latest edition of an Australian standard for risk management, to the extent relevant to environmental management, by **23 June 2017.**

Notification of emergencies, incidents, and exceptions

A10 The environmental authority holder must notify the administering authority within 24 hours of becoming aware of any emergency, incident, sample result or event which does or may contravene a condition of this environmental authority.

A11 Within 10 business days following the initial notification of an emergency, event or incident, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following:

a) results and interpretation of any samples taken and analysed;

b) outcomes of actions taken at the time to prevent or minimise unlawful environmental harm; and

c) proposed actions to prevent a recurrence of the emergency or incident.

Complaints

A12 The holder of this environmental authority must record all environmental complaints received about the mining activities including:

a) name, address and contact number of the complainant;

b) time and date of complaint;

c) reasons for the complaint;

d) investigations undertaken;

e) conclusions formed;

f) actions taken to resolve the complaint;

g) any abatement measures implemented; and

h) person responsible for resolving the complaint

A13 When requested by the administering authority, the environmental authority holder must undertake specified monitoring within the timeframe nominated by the administering authority, to investigate any complaint related to the activity.

Third-party reporting

A14 The holder of this environmental authority must:

a) by **8 January 2018**, obtain from an appropriately qualified person a report on compliance with the conditions of this environmental authority;

b) obtain further such reports at regular intervals, not exceeding three (3) yearly intervals, from the completion of the report referred to above; and

c) provide each report to the administering authority within 90 days of its completion

END OF CONDITIONS FOR SCHEDULE A

Schedule B – Air

B1 The release of noxious or offensive odour, dust or any other airborne contaminant resulting from the activities must not cause environmental nuisance or harm.

END OF CONDITIONS FOR SCHEDULE B

Schedule C - Waste Management

C1 All waste generated as part of the mining activities must be disposed of in a lawful manner at an off-site facility, with the exception of:

a) waste rock and tailings, which must be characterised, handled and disposed of in accordance with condition **C4** of this environmental authority;

b) timber pallets;

c) general waste disposed of into the waste disposal trench facility as per condition **C2**;

d) waste rock determined not to be potentially acid forming may be disposed into the West Waste Rock Dump; and

e) tyres, subject to condition **C3**.

Note: *The only waste authorised to be burnt on site is explosive boxes, so long as the burning does not cause environmental harm.*

C2 General waste must only be disposed of into the waste disposal trench facility of ML1259 and identified in *Schedule J Map 2A – Site Infrastructure.*

C3 Subject to demonstrating to the administering authority that no other use higher in the waste management hierarchy can be practicably implemented, waste tyres generated from mining activities may be disposed of on site in the North Waste Rock Dump and the West Waste Rock Dump.

C4 All waste rock and tailings must be:

a) *geochemically characterised* and disposed of in a manner that minimises the potential generation and/or release of contaminants to the receiving environment;

b) where the geochemical characteristics of waste rock is uncertain, this material must be treated as *potentially acid forming, saline mine drainage* or *neutral mine drainage* forming until demonstrated otherwise; and

c) details pertaining to meeting the requirements of this condition must be recorded and retained until this environmental authority is surrendered

Sewage Treatment

C5 Condition **C6** take effect from **23 June 2018.**

C6 The only contaminant permitted to be released to land is treated sewage effluent in compliance with the release limits stated in *Table C1*.

Table C1 – Treated sewage contaminant release limits ('Table C1')

Contaminant	Unit	Release limit	Limit type	Frequency
5 day Biochemical oxygen demand (BOD)[1]	mg/L	20	Maximum	Monthly
Total suspended solids	mg/L	30	Maximum	Monthly
Nitrogen	mg/L	30	Maximum	Monthly
Phosphorus	mg/L	15	Maximum	Monthly
E-coli	Organisms/100ml	1000	Maximum	Monthly
pH	pH units	6.0 – 9.0	Range	Monthly

C7 Treated sewage effluent may only be released to land from the following locations:

a) within the nominated irrigation area identified in *Table A1;*

b) other land for the purpose of dust suppression and/or firefighting

C8 The application of treated effluent to land must be carried out in a manner such that:

a) vegetation is not damaged

b) there is no surface ponding of effluent

c) there is no run-off or over spray of effluent

C9 All sewage effluent released to land must be monitored at the frequency and for the contaminants specified in *Table C1.*

C10 The daily volume of effluent releases must be measured and documented.

C11 When circumstances prevent the irrigation or beneficial reuse of treated sewage effluent such as during or following rain events, measures must be taken to store or lawfully dispose of effluent.

C12 Treated sewage effluent must only be supplied to another person or organisation that has a written plan detailing how the user of the treated sewage effluent will comply with their *general environmental duty* whilst using the treated sewage effluent.

END OF CONDITIONS FOR SCHEDULE C

Schedule D – Noise

Noise limits

D1 The holder of this environmental authority must ensure that noise generated by the mining activities does not cause the criteria in *Table D1* to be exceeded at a sensitive place or commercial place.

Table D1 – Noise limits ('Table D1')

Sensitive Place						
Noise level DB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7am to 6pm	6pm to 10pm	10pm to 7am	9am to 6pm	6pm to 10pm	10pm to 9am
$L_{Aeq, adj, 15 mins}$	CV = 50 AV = 5	CV = 45 AV = 5	CV = 40 AV = 0	CV = 45 AV = 5	CV = 40 AV = 5	CV = 35 AV = 0
$L_{A1, adj, 15 mins}$	CV = 55 AV = 10	CV = 50 AV = 10	CV = 45 AV = 5	CV = 50 AV = 10	CV = 45 AV = 10	CV = 40 AV = 5
Commercial Place						
Noise level DB(A) measured as:	**Monday to Saturday**			**Sundays and Public Holidays**		
	7am to 6pm	6pm to 10pm	10pm to 7am	9am to 6pm	6pm to 10pm	10pm to 9am
$L_{Aeq, adj, 15 mins}$	CV = 55 AV = 10	CV = 50 AV = 10	CV = 45 AV = 5	CV = 50 AV = 10	CV = 45 AV = 10	CV = 40 AV = 5

Table D1 – Noise limits notes:

1. CV = Critical Value

2. AV = Adjustment Value

3. To calculate noise limits in Table D1:

If bg ≤ (CV – AV):

Noise limit = bg + AV

If (CV – AV) < bg ≤ CV:

Noise limit = CV

If bg > CV:

Noise limit = bg + 0

4. In the event that measured bg ($L_{A90, adj, 15 mins}$) is less than 30 dB(A), then 30 dB(A) can be substituted for the measured background level

5. bg = background noise level ($L_{A90, adj, 15 mins}$) measured over 3-5 days at the nearest sensitive receptor

6. If the project is unable to meet the noise limits as calculated above alternative limits may be calculated using the processes outlined in the "Planning for Noise Control" guideline.

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Airblast overpressure nuisance

D2 The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in *Table D2* to be exceeded at a sensitive place or commercial place.

Table D2 – Blasting noise limits ('Table D2')

Blasting noise limits	**Sensitive or commercial blasting noise limits place limits**		
	Monday to Friday 7am to 6pm **Saturday, Sunday and Public Holidays 9am – 6pm** **Open Cut Pits and Underground Workings**	**Monday to Friday 6pm to 7am** **Saturday, Sunday and Public Holidays 6pm – 9am** **Open Cut Pits**	**Monday to Friday 6pm to 7am** **Saturday, Sunday and Public Holidays 6pm – 9am** **Underground Workings**
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	No blasting	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	No blasting	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time

Monitoring and reporting

D3 Noise monitoring and recording must include the following descriptor characteristics and matters:

a) $L_{AN,T}$ (where N equals the statistical levels of 1, 10 and 90 and T = 15 mins)

b) background noise LA90

c) the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to statistical levels

d) atmospheric conditions including temperature, relative humidity and wind speed and directions

e) effects due to any extraneous factors such as traffic noise

f) location, date, and time of monitoring

g) if the complaint concerns low frequency noise, Max LpLIN,T and one third octave band measurements in dB(LIN) for centre frequencies in the 10 – 200 Hz range.

Note: *Noise and blast monitoring as required by the administering authority in accordance with Schedule A - condition* ***A13.***

END OF CONDITIONS FOR SCHEDULE D

Schedule E – Water

E1 All determinations of the quality of contaminants released must be made in accordance with methods prescribed in the latest edition of the Environmental Protection Agency Water Quality Sampling Manual, and carried out on samples that are representative.

E2 Contaminants must not be released to any waters unless otherwise permitted by a condition of this environmental authority. For the purpose of this condition only, "waters" does not include stormwater channels from:

a) the waste rock dump area to the waste rock dump containment dams WD1, WD2, WD3, WD4; West Dam, South Dam; and

b) the Tailings Storage Facility to Sediment Dam 3 (and includes Sediment Dam 1); and

c) the Process Water Dam to South Dam.

E3 The holder of this authority must implement a Storm Water Management Plan that must include, but may not be limited to, measures to:

a) prevent incident stormwater and stormwater run-off from contacting wastes or contaminants; and

b) divert upstream run-off away from disturbed areas, or areas containing wastes or contaminants; and

c) capture and manage run-off from disturbed areas (including waste rock dump areas); and

d) manage pit water (including that resulting from inflow of groundwater).

E4 Stormwater impacted by the mining activities may only be discharged from the Containment locations listed in *Table E1* and must comply with the contaminant limits defined in *Table E2*.

E5 Stormwater released from the Containment locations listed in *Table E1* must be monitored at the locations and frequencies defined in *Table E1* for the parameters shown in *Table E2*.

E6 All reasonable and practicable erosion protection measures and sediment control measures must be implemented and maintained to minimise erosion and the release of sediment.

E7 Erosion control and sediment control structures must be maintained at all times and repaired or replaced as required after each rainfall event.

E8 In the event that a release from any dam spillway is necessary the release must be controlled or managed in such a manner that prevents erosion of any watercourse or areas affected or potentially affected by the release.

E9 Receiving waters potentially impacted by the release of stormwater impacted by mining activities, seepage from site dams or potentially impacted ground water must be monitored at the locations and frequencies defined in *Table E3*, for the water quality parameters listed in *Table E4*.

Table E1 - Containment Dams monitoring locations and frequency ('Table E1')

Impacted stormwater release location	Monitoring Frequency
Spillway of Waste Rock Dump containment dam WD1	In the event of a release from the dam spillway
Spillway of Waste Rock Dump containment dam WD2	In the event of a release from the dam spillway
Spillway of Waste Rock Dump containment dam WD3	In the event of a release from the dam spillway
Spillway of Waste Rock Dump containment dam WD4	In the event of a release from the dam spillway
Spillway of Sediment Dam 3 located in headwaters of Rawdon Creek	In the event of a release from the dam spillway
Spillway of West Waste Rock Dump containment Dam – West Dam	In the event of a release from the dam spillway

Table E2 - Containment Dams contaminant release limits ('Table E2')

Water quality parameter	Units	Release Limit for WD1, WD2, WD3, WD4, and Spillway of Sediment Dam 3.	Release Limits for West Dam
Total Suspended Solids	mg/L	Must not exceed 1200 mg/L or 10% greater than a background value[1] of the receiving waters whichever is the greater.	Within 10% greater than background value of the receiving water.
pH	pH units	6.0 – 9.0 (range)	6.0 – 9.0 (range)
Total Dissolved Solids	mg/L	<1000	<900
Sulfate	mg/L	<100	<100
Copper	mg/L	<0.04	<0.0025
Zinc	mg/L	<0.15	<0.031
Arsenic	mg/L	<0.05	<0.01
Cadmium	mg/L	<0.005	<0.0008
WAD Cyanide	mg/L	<0.007	<0.007

Note 1: A "background value" for a quality characteristic is the value of the quality characteristic measured on the same day at a background sampling and in-situ monitoring point in the receiving waters not affected by the release situated further than 20 metres up-current from the release point into Twelve Mile Creek and Swindon Creek.

E10 In the event that monitoring results, as interpreted by a suitably qualified person, indicate an impact in terms of contaminant levels in downstream monitoring sites compared to levels found in upstream monitoring sites, then the environmental authority holder must complete an investigation into the source, cause or extent of environmental harm being caused, or the extent of environmental harm likely to be caused, and provide this to the administering authority within one (1) month of receiving the analysis results.

For the purposes of this condition, a suitably qualified person is someone possessing appropriate qualifications and experience in the field of surface water monitoring program design monitoring and data analysis and who can competently make recommendations about these matters.

In assessing the monitoring results the suitably qualified person must give consideration to relevant methodology and water quality criteria specified by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand in Australian Guidelines for Water Quality Monitoring and Reporting, 2000 and Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000 or more recent editions of the documents.

Table E3 - Receiving waters monitoring locations and frequency ('Table E3')

Monitoring point	Classification	Easting (AMG)	Northing (AMG)	Monitoring frequency
Perry River Downstream	Downstream	378842	7208200	Monthly[1], in the event of flow in the receiving waters
Swindon Creek Downstream	Downstream	375038	7207001	Monthly[1], in the event of flow in the receiving waters
Rawdon Creek Downstream	Downstream	375890	7206438	Monthly[1], in the event of flow in the receiving waters
Twelve Mile Creek Downstream	Downstream	377113	7206554	Monthly[1], in the event of flow in the receiving waters
Mingham Creek Downstream	Downstream	375320	7202870	Monthly[1], in the event of flow in the receiving waters
Swindon Creek Upstream	Upstream	373410	7205443	Monthly[1], in the event of flow in the receiving waters
Twelve Mile Creek Upstream	Upstream	377298	7204777	Monthly[1], in the event of flow in the receiving waters
Perry River Upstream	Upstream	374746	7207281	Monthly[1], in the event of flow in the receiving waters

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Monitoring point	Classification	Easting (AMG)	Northing (AMG)	Monitoring frequency
Mingham Creek Upstream	Upstream	374586	7203135	Monthly[1], in the event of flow in the receiving waters

1. Where possible monitoring should coincide with groundwater monitoring

Table E4 - Receiving water monitoring requirements ('Table E4')

Water quality parameter	Units
Total Suspended Solids	mg/L
pH	pH units
Total Dissolved Solids	mg/L
Sulfate	mg/L
Copper	mg/L
Zinc	mg/L
Arsenic	mg/L
Cadmium	mg/L
Cyanide (as WAD cyanide)	mg/L
Major Ions[1]	mg/L
Electrical Conductivity	µS/cm
Nitrate	mg/L
Hardness	-

1. Major ions to be sampled include sodium, fluoride, potassium, calcium, magnesium, chloride, bicarbonate and carbonate

E11 The Tailings Storage Facility must be monitored for the water quality parameters indicated and at the frequency specified in *Table E5.*

E12 In the event that monitoring conducted in accordance with condition **E11** indicates the water quality within the Tailings Storage Facility does not comply with the contaminant limits defined in *Table E5*, implement all reasonable and practicable measures to prevent access by all livestock and minimise access by native fauna to the dam.

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Table E5 - Water quality limits for Tailings Storage Facility ('Table E5')

Water Quality Parameter	Units	Contaminant limit	Monitoring frequency
WAD Cyanide	mg/L	50	Quarterly
Arsenic	mg/L	0.5	Quarterly
Sulfate	mg/L	1000	Quarterly
Copper	mg/L	0.5	Quarterly
Zinc	mg/L	20	Quarterly
Lead	mg/L	0.1	Quarterly

E13 The design storage allowance on 1st November of each year for all regulated dams constructed or operated within the operational land must comply with *Table E6*.

Table E6 - Storage design[1] for regulated dams ('Table E6')

Dam	Design Storage Allowance[2] Critical Wet Period	Spillway Critical Design Storm[3]	Mandatory[4] Reporting Level
Tailings Storage Facility	1: 200 Year AEP 4-month wet season plus process inputs for the 4-month wet season	1: 10000 Year AEP	1: 100 Year AEP
Sediment Dam 3	1:20 Year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP
WD1	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP
WD2	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP
WD3	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP
WD4	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP
Process Water Pond	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP

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Dam	Design Storage Allowance[2] Critical Wet Period	Spillway Critical Design Storm[3]	Mandatory[4] Reporting Level
South Dam	1:20 year AEP 4-month wet season	1:100 Year AEP	1:10 Year AEP
West Dam	1:20 year AEP 4-month wet season	1:1000 Year AEP	1:10 Year AEP

NOTE: AEP means Annual Exceedance Probability – being the probability that at least one event as specified will occur in a particular year.

[1] *Calculations are to be carried out in accordance with the guideline titled Site Water Management within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995).*

[2] *The design storage allowance on 1st November of each year for any regulated dam constructed within the operational land must be sufficient to contain the run-off from the critical wet period - plus the volume of any other inputs to the storage facility during that critical wet period, as part of operations. Such inputs could be tailings, contaminated site waters, process waters, and any other materials.*

[3] *The critical storm has a duration that produces the peak discharge for the catchment.*

[4] *The level below spillway crest that can accommodate runoff from a 72-hour storm at the specified AEP, or the wave allowance at the specified AEP - whichever level is lower.*

E14 The spillway for any regulated dam, constructed or operated within the operational land must be designed and maintained to withstand the peak flow from the spillway capacity critical design storm defined in *Table E6.*

E15 In the event that a release from a Regulated Dam spillway or the Tailings Storage Facility spillway is required, environmental harm from the discharge must be avoided. This may include controlling the release to prevent erosion of sediment deposition in downstream watercourses, and ensuring that plant and infrastructure, chemical and fuel storages are not located in the flow path of any potential discharge.

E16 The holder of the environmental authority must mark the mandatory reporting level defined in *Table E6* on the spillway of all regulated dams within the operational land.

NOTE: The mandatory reporting level may also be marked and measured within the decant pond of the regulated dam. However, the mandatory reporting level within the decant pond must be compared to the mandatory reporting level on the spillway on a regular basis to ensure accuracy.

E17 The holder of the environmental authority must notify the administering authority when the pondage level of any regulated dam, reaches the mandatory reporting level defined in *Table E6*.

Receiving Environment Monitoring Program (REMP)

E18 A Receiving Environment Monitoring Program (REMP) must be implemented to meet the requirements of conditions **E18** to **E20**.

For the purposes of the REMP, the receiving environment refers to the waters of the Perry River, Burnett River, Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham Creek and connected or surrounding waterways downstream of the mining activity.

E19 The REMP must at a minimum:

a) address and comply with the latest version of the administering authority's guideline *Receiving environment monitoring program guideline (ESR/2016/2399); and*
b) encompassing the waters of Perry River, Burnett River, Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham Creek and connected or surrounding waterways within 20km downstream of the mining activities, and where possible in tributaries on-site; and
c) identify, describe and monitor any adverse impacts to surface water environmental values, quality, and flows; and
d) assess the long-term condition or state of surface waters, sediment, fine sediments, DIN (Dissolved Inorganic Nitrogen) and aquatic ecosystem health; and
e) include the locations listed in Table E3 monitoring locations; and
f) identify and describe all environmental values of the receiving environment; and
g) assess the receiving environment monitoring results against the relevant water quality guidelines for all indicators to protect all environmental values for the water as declared under an environmental protection policy or regulation; and
h) include an assessment of the potential impacts of the activity and propose appropriate mitigation measures; and
i) assess the status of and any change to aquatic ecosystem health including aquatic flora and fauna within and immediately surrounding the project area; and
j) assess the status of and any change to riparian vegetation health within and immediately surrounding the project area; and
k) apply procedures and/or guidelines from ANZG 2018 and other relevant standards and guideline documents; and
l) describe sampling and analysis methods and quality assurance and control; and
m) incorporate stream flow and hydrological information in the interpretations of water quality and biological data.

E20 A REMP Report must be prepared for any of the following and submitted to the administering authority on request:

a) annually by 1 August each year; and
b) within one (1) month following a continuous two (2) week cessation period of any release pursuant to condition **E39** or where a trigger under condition **E50** has been identified or a period otherwise agreed to by the administering authority.

E21 The REMP Report required by condition **E20** must:

a) be prepared by an appropriately qualified person; and
b) outline the findings of the REMP, including but not limited to:
   i. an assessment of current and long-term upstream water quality; and
   ii. an assessment of the current and long-term condition or state of surface waters, sediment and aquatic ecosystem health; and
   iii. recommendations for further investigation or actions; and
   iv. recommendations for changes or improvements to the monitoring program; and
   v. potential changes to management of the authorised activity to minimise impacts; and
   vi. all monitoring results; and
   vii. a description of all conclusions formed.

Groundwater

E22 Contaminants are not authorised to be released directly or indirectly to any groundwater.

E23 Groundwater must be monitored at the locations and frequencies specified in *Table E7.*

E24 Groundwater in all bores specified in *Table E7* must be monitored for the contaminants identified in *Table E8*.

E25 Groundwater measured at any compliance bore specified in *Table E7* must not exceed Limit A for any contaminant specified in *Table E8* or *Table E9* on any five (5) consecutive sampling occasions**.**

E26 Groundwater measured at any compliance bore specified in *Table E7* must not exceed Limit B for any contaminant specified in *Table E8* or *Table E9* on any three (3) consecutive sampling occasions**.**

Table E7 - Groundwater monitoring locations and frequency ('Table E7')

Monitoring Point [1]	**Location (MGA94 – Zone 56)**		**Aquifer**	**Surface RL [2] (m)**	**Depth RL [2] (m)**	**Screened interval RL [2] (m)**	**Monitoring Frequency**	
	Easting	**Northing**					**Standing Water Level RL [2] (m)**	**Ground-water Quality**
Operational Management Bores[5]								
Tailings Storage Facility								
MRMB29	375255	7206291	TBA	121.14	22	Records not available	Monthly	Quarterly
MRMB45	375060	7204704	Fractured Rock	152.60	39	33-39		

Monitoring Point [1]	Location (MGA94 – Zone 56)		Aquifer	Surface RL [2] (m)	Depth RL [2] (m)	Screened interval RL [2] (m)	Monitoring Frequency	
	Easting	Northing					Standing Water Level RL [2] (m)	Ground-water Quality
MRMB46	375348	7205133	Fractured Rock	151.34	39	26-35		
MRMB69	374430	7204749	Fractured Rock	135.50	36	29.5-36		
Twelve Mile Creek								
MRMB26	376281	7205684	Records not available	114.34	12	Records not available	Monthly	Quarterly
Waste Rock Dump								
MRMB60	376577	7204529	Fractured Rock	131.00	36	27-35	Monthly	Quarterly
MRMB27	376504	7205417	Regolith	111.62	46	Records not available		
MRMB25	376169	7205682	Regolith/ Fractured Rock	115.82	48	Records not available		
Interpretation Bore[6]								
MRMB37	377492	7204116	Fractured rock	122.74	50	25-49	Monthly	Quarterly
Compliance Bores[3]								
TSF North – Swindon Creek								
MRMB13	374164	7206247	Regolith/ Fractured rock	125.11	29.99	18-30		

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Monitoring Point [1]	Location (MGA94 – Zone 56)		Aquifer	Surface RL [2] (m)	Depth RL [2] (m)	Screened interval RL [2] (m)	Monitoring Frequency	
	Easting	Northing					Standing Water Level RL [2] (m)	Ground-water Quality
MRMB54	374473	7207154	Fractured rock	125.12	31	17.1-29.5	Monthly	Quarterly
MRMB52	375103	7207188	Fractured rock	112.51	31	17.1-29.5		
MRPB2	373568	7205655	Fractured rock	149.92	49	36-49	Monthly	Quarterly
TSF North – Unnamed Creek								
MRMB40	375135	7206605	Fractured rock	121.72	43.5	25-43	Monthly	Quarterly
MRMB55	375956	7205939	Basement	127.60	31	25-31		
MRMB53	375403	7207005	Fractured rock	111.88	25	17.7 – 23.9		
MRMB66	375834	7206885	Basement	127.34	30	27-30		
MRMB74	376301	7206896	Basement	108.6	42	36-42		
Twelve Mile Creek								
MRMB38	377096	7206635	Fractured rock	104.20	41	13-40	Monthly	Quarterly
MRMB61	376731	7204473	Fractured rock	128.00	31	25-31		
MRMB62	376572	7203977	Fractured rock	148.00	37	26-35		
MRMB77	376752	7205786	Fractured rock	107.70	15.5	9.5-15.5		
MRMB78	376952	7204828	Fractured rock	113.51	29	17-29		

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Monitoring Point [1]	Location (MGA94 – Zone 56)		Aquifer	Surface RL [2] (m)	Depth RL [2] (m)	Screened interval RL [2] (m)	Monitoring Frequency	
	Easting	Northing					Standing Water Level RL [2] (m)	Ground-water Quality
West Dam – Mingham Creek								
MRMB75	375401	7202922	Basement	98.7	30	24-30	Monthly	Quarterly
MRMB76	375155	7203435	Fractured rock	106.14	16.5	10.5-16.5		
Operational Bores[4]								
TSF North East – Rawdon Creek								
MRMB39	375856	7206535	Fractured rock	112.42	24	23-41	Monthly	Quarterly
MRMB21	375618	7206377	Regolith/ Fractured rock	116.34	34.9	23-35		
TSF North – Unnamed creek								
MRMB30	374892	7206410	Records not available	127.89	30.36	Records not available	Monthly	Quarterly
MRMB48	375466	7205964	Fractured rock	130.73	39	30-39		
Waste Rock Dump								
MRPB1	376644	7205033	Records not available	114.39	35	Records not available	Monthly	Quarterly
MRMB59	376199	7203734	Fractured rock	176.00	31	24-30		
MRMB49	375650	7205571	Basement	145.36	32	17-30		
MRMB63	376558	7205270	Fractured rock	128.00	25	19-22.5		

Monitoring Point [1]	Location (MGA94 – Zone 56)		Aquifer	Surface RL [2] (m)	Depth RL [2] (m)	Screened interval RL [2] (m)	Monitoring Frequency	
	Easting	Northing					Standing Water Level RL [2] (m)	Ground-water Quality
Twelve Mile Creek								
MRMB64	376325	7205993	Basement	125.00	43	35-41	Monthly	Quarterly
MRMB67	376399	7206366	Basement	127.10	30	27-30		
MRMB68	376140	7205997	Basement	134.90	30	27-30		
TSF North – Swindon Creek								
MRMB12	374545	7206538	Regolith	119.03	30	5-27	Monthly	Quarterly
MRMB65	374926	7206745	Basement	122.70	30	27-30		
MRMB43	373880	7205740	Fractured rock	137.70	37.5	24-37.5		
MRMB41	374809	7206896	Fractured rock	113.04	40.5	22-40		
MRMB42	374804	7206892	Fractured rock	113.06	16.8	7-16		
MRMB44	373878	7205736	Fractured rock	138.00	13	10-13		
West Dam								
MRMB36	374800	7203578	Fractured rock	108.73	49	36-49	Monthly	Quarterly
MRMB70	374482	7203728	Fractured rock	147.50	42	32.5-42		
MRMB72	374799	7203590	Basement	127.50	22	15.5-22		
MRMB71	374632	7203643	Basement	133.50	39	32.5-39		

1. Bores depicted in *Schedule J, Figure 2B– Groundwater monitoring network*.
2. RL measurement to be taken from top of bore casing to the nearest 1 centimetre.
3. Compliance bores – groundwater monitoring limits in Table E8 and Table E9 apply.

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4. Operational bores – groundwater monitoring limits in Table E8 and Table E9 do not apply, groundwater quality must be maintained or improved at these sites.
5. Operational management bores – for interpretation purposes, groundwater monitoring limits in Table E8 and Table E9 do not apply.
6. Interpretation bores – located outside of potential influence of the activity and used for comparative and interpretative purposes, groundwater monitoring limits in Table E8 and Table E9 do not apply.

Table E8 – Groundwater monitoring limits ('Table E8')

Contaminant[1] (mg/L unless specified otherwise)		Limits[10]	
		Limit A	**Limit B**
pH[5]		6.5 -7.5	-
Aluminium[2]		-	0.055
Arsenic	All bores except MRMB61, MRMB76, MRMB77 and MRMB78 [2]	-	0.013
	MRMB76 and MRMB78 [6,7]	0.05	0.08
	MRMB77 [6,7]	0.15	0.19
	MRMB61 [6,7]	0.015	0.02
Boron[2]		-	0.37
Cadmium	All bores except MRMB61, MRMB62 and MRMB78 [2]	-	0.0002
	MRMB78 [6,7]	0.0005	0.0006
	MRMB61 and MRMB62 [6,7]	0.0006	0.0009
Chromium[2]		-	0.001
Copper [6,7]	All bores except MRMB61, MRMB62 and MRMB77 [6,7]	0.001	0.004
	MRMB77 [6,7]	0.006	0.008
	MRMB61 and MRMB62 [6,7]	0.004	0.005
Lead[2]		-	0.0034
Manganese[2]		-	1.9
Selenium[2]		-	0.005
Zinc	All bores except MRMB61, MRMB62 and MRMB78 [6,7]	0.01	0.02
	MRMB78 [6,7]	0.04	0.05
	MRMB61 and MRMB62 [6,7]	0.035	0.077
Nitrate [6,7]	All bores except MRMB61 and MRMB62 [6,7]	0.02	0.04
	MRMB61 and MRMB62 [6,7]	0.04	0.06

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Contaminant[1] (mg/L unless specified otherwise)		Limits[10]	
		Limit A	Limit B
WAD Cyanide [3,4]		-	0.5
Cyanide (as un-ionised HCN, measured as [CN]) [2]		-	0.007
Iron	MRMB52 [6,7]	1.5	1.6
	MRMB13, MRMB53, MRMB54 and MRPB2 [6,7]	0.8	0.9
	MRMB75 [6,7]	4	4.9
	All other compliance bores [6,7]	0.3	0.65
Major ions[8]		For interpretation purposes	
Hardness[9]			

1. All metals and metalloids must be measured as dissolved and total, limits apply to the dissolved fraction (dissolved is from analysis of a filtered sample).
2. ANZG (2018) for 95% protection of species (freshwater).
3. WAD CN is Weak Acid Dissociable Cyanide, measured as an indicator of the bio-available cyanide.
4. The International Cyanide Management Code (2009), Section 4.5.
5. Derived from site specific values, using 20th and 80th percentile.
6. Limit A derived from site specific values (80th percentile).
7. Limit B derived from site specific values (95th percentile).
8. Major ions to be sampled include sodium, fluoride, potassium, calcium, magnesium, chloride, bicarbonate and carbonate.
9. For each sampling event, hardness adjustment for selected metals in freshwaters can be undertaken in accordance with ANZG (2018).
10. An amendment application can be made at any time under the *Environmental Protection Act 1994* to update dataset used to derive site specific limits for compliance bores, based on natural variations.

Table E9 – Bore specific Groundwater Monitoring limits ('Table E9')

Monitoring Point and Contaminant	Limits	
	Limit A[1]	Limit B[2]
Sulfate (SO_4^{2-}) mg/L		
MRMB74	390	399
MRMB75	793	846
MRMB37	503	532
MRMB62	336	376

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Monitoring Point and Contaminant	Limits	
	Limit A[1]	**Limit B[2]**
MRMB61	197	205
MRMB13	272	296
MRMB53	183	194
MRMB40	75	83
MRMB52	69	75
MRPB2	229	242
MRMB38	305	358
MRMB54	106	116
MRMB76	162	165
MRMB78	586	615
MRMB66	195	206
MRMB55	23	25
Electrical Conductivity (µS/cm)		
MRMB74	10894	11042
MRMB75	10352	10451
MRMB37	6852	6952
MRMB62	5780	5926
MRMB61	5792	5834
MRMB13	4561	4765
MRMB53	4490	4561
MRMB40	3826	3922
MRMB52	3018	3072
MRPB2	2774	2820
MRMB38	2311	2427
MRMB54	2309	2386
MRMB76	1742	1768

Monitoring Point and Contaminant	Limits	
	Limit A[1]	**Limit B[2]**
MRMB78	10840	11105
MRMB66	1396	1434
MRMB55	1552	1611

1. Limit A derived from site specific values (80th percentile).
2. Limit B derived from site specific values (95th percentile).

E27 If groundwater measured at any compliance bore specified in *Table E7* exceeds any corresponding contaminant Limit B specified in *Table E8* or *Table E9* on one (1) sampling occasion the environmental authority holder must:

a) Resample the groundwater within the compliance bore for all exceeding contaminants within 10 business days.

E28 Groundwater quality at operational bores specified in *Table E7* must be maintained or improved.

E29 A bore log must be completed for each groundwater monitoring bore constructed after **1 August 2008** which includes:

a) bore identification reference and geographic coordinate location; and

b) specific construction information including but not limited to depth of bore, depth and length of casing, depth and length of screening and bore sealing details; and

c) standing groundwater level; and

d) lithological data, stratigraphic interpretation by an appropriately qualified person to identify important features associated with groundwater monitoring; and

e) target formation of the bore.

*Note: All existing bores must have a bore drill log that meets a); and where available include information required under b), c), d) and e) of condition **E29.***

E30 The construction, maintenance and decommissioning of groundwater monitoring bores must be undertaken in a manner that:

a) prevents contaminants entering the groundwater; and
b) ensures the integrity of the bores to obtain representative groundwater samples from the target aquifer; and
c) maintains the hydrogeological environment within the aquifer.

Note: Decommissioning of groundwater monitoring bores must meet a) and c) of condition **E30.*

E31 Monitoring and sampling must be carried out in accordance with the requirements of the latest version of the following documents unless otherwise approved by the administering authority:

a) for waters and aquatic environments, the Queensland Government's Monitoring and Sampling Manual 2009 – *Environmental Protection (Water) Policy 2009*
b) for groundwater, *Groundwater Sampling and Analysis – A Field Guide* (2009:27 GeoCat#6890.1);
c) for subterranean aquatic fauna, the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna*.

E32 A Seepage Management Plan must be developed and implemented by **24 September 2018**.

E33 The Seepage Management Plan required under condition **E32** must be developed by a suitably qualified person.

E34 The Seepage Management Plan required under condition **E32** must at a minimum include control measures to:

a) prevent the release of seepage to groundwater in the receiving environment; and

b) prevent seepage migration into surface waters.

E35 By **22 March 2018**, a Groundwater Monitoring and Management Program must be developed by an appropriately qualified person.

E36 By **22 June 2018**, the Groundwater Monitoring and Management Program required under condition **E35** must be implemented.

E37 The Groundwater Monitoring and Management Program required by condition **E35** must:

a) identify potential sources, causes and extent of contaminant seepage and disturbance to groundwater from the activity; and

b) ensure that all potential groundwater impacts due to the activity are identified, mitigated, and monitored in accordance with the conditions of the environmental authority; and
c) ensure that adequate groundwater monitoring and data analysis is undertaken to achieve the following objectives:
    i. detect any impacts to groundwater levels due to the activity; and
    ii. detect any impacts to groundwater quality due to the activity; and
    iii. detect any impacts caused by contaminant seepage on surface water quality; and
    iv. detect and analyse short- and long-term trends in groundwater quality at operational bores at an annual frequency; and
    v. determine compliance with conditions **E22**, **E23, E24, E25, E26** and **E28**; and
d) include a review process to identify improvements to the program; and
e) include an appropriate quality assurance and quality control program; and
f) assess the success of the seepage management system required under conditions **E32** and **E34** and determine if any additional mitigation measures are required for the adequate management of seepage; and

g) include a groundwater model which includes an assessment of current seepage rates and predicted post-mining seepage rates; and
h) have consideration for any comments provided by the administering authority.

E38 The Groundwater Monitoring and Management Program must be reviewed by **24 June 2019**, then every 2 years by an appropriately qualified person. The review must include:

a) an assessment that the Groundwater Monitoring and Management Program continues to meet the requirements stated in condition **E37**; and
b) a review of all the historical groundwater data against the limits specified in *Table E8 and Table E9*; and
c) a review of the ionic balance of all on site water storages including tailings storage and comparison against historical groundwater data; and
d) a review of the conceptual groundwater model and details of any adjustment made.

High flow releases

E39 Water may be released via WD1 into the Perry River Dam, upstream of the weir, where the flows measured at the Perry River Weir are equal to or greater than $1m^3$/sec as measured through an operational flow gauging station.

E40 Water released pursuant to condition **E39** must be:

a) released in a controlled manner to prevent erosion of the bed or banks of the Perry River; and
b) released in a controlled manner to ensure sufficient mixing and dispersion in the Perry River.

E41 The following information must be recorded daily for the duration of releases pursuant to condition **E39** and provided to the administering authority upon request:

a) the water level in WD1, WD2, WD3 and WD4; and
b) contaminant monitoring results required by condition **E48**; and
c) the volume of the release to the Perry River; and
d) the background flow rate in the Perry River.

E42 Water released pursuant to condition **E39** must be monitored for and comply with the contaminant limits and monitoring frequency specified in *Table E10*.

Table E10 - High flow contaminant release limits ('Table E10')

Contaminant parameters	Contaminant Limits	Monitoring frequency
Flow	Interpretation purposes only	Continuous
Electrical Conductivity (EC)	4000 uS/cm (maximum)	Continuous

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pH (pH units)	6.0-9.0	Daily (within 2 hours of the release starting) and every 24hrs thereafter during the release.
Total Suspended Solids	Interpretation purposes only	
Total Dissolved Solids (TDS)	Interpretation purposes only	
Sulfate	Interpretation purposes only	
Copper[1]	Interpretation purposes only	
Zinc[1]	Interpretation purposes only	
Arsenic[1]	Interpretation purposes only	
Cadmium[1]	Interpretation purposes only	
WAD Cyanide	Interpretation purposes only	
Dissolved Inorganic Nitrogen (DIN)	Interpretation purposes only	
Ammonia	Interpretation purposes only	
Total nitrogen (Nitrite and Nitrate)	Interpretation purposes only	

1. Total and dissolved metals must be monitored

E43 Monitoring for the contaminants listed in *Table E12* must be conducted when water is being released pursuant to condition **E39** at the monitoring locations and frequencies specified in *Table E11*.

Table E11 - Monitoring locations and frequencies ('Table E11')

Monitoring location	Coordinates	Monitoring frequency
WD1	376002; 7205529	For Electrical Conductivity and pH (pH units) live monitoring for Perry River (within 1 km of the weir) and for all other locations and parameters daily (within 2 hours of the release starting) and every 24hrs thereafter during the release. Daily for 14 days following the cessation of the release (excluding WD1).
Upstream Perry River	374746; 7207281	
Downstream Perry River (as close as reasonably practical to the weir)	378842; 7208200	
Downstream Perry River (within 1 km of the weir)	*Within 1km of the weir*	

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E44 Water released pursuant to condition **E39** must immediately cease after becoming aware of any release not in accordance with, or reasonably expected to not be in accordance with, the conditions of this environmental authority.

E45 Stock access to the area immediately downstream of the discharge point, specified in condition **E39,** must be restricted until water quality objectives (total) as specified in *Table E12* are complied with.

E46 While water is released pursuant to condition **E39**, visual monitoring must occur twice every day to verify that discharges in the Perry River comply with the requirements of this environmental authority and records of this visual monitoring must be recorded and maintained onsite.

E47 Water released pursuant to condition **E39** must cease when flows in the Perry River falls below 1m^3/s at the Perry River Weir.

E48 The quality of receiving waters must be monitored at the locations and frequency in *Table E11*, for the contaminants specified in *Table E12*.

Table E12 - Receiving waters quality objectives ('Table E12')

Contaminant[1]	**Water quality (mg/L unless specified otherwise)**	
	Water quality objectives (totals) for Perry River	**Water quality objectives (dissolved) for Perry River**
pH (pH units)[9]	6.5 (minimum) or 5th percentile[2] of reference sites[3], whichever is higher 8.5 (maximum) or 95th percentile[2] of reference sites[3], whichever is lower	
Electrical Conductivity	1,000[6] µS/cm or 95th percentile[2] of reference sites[3], whichever is higher	
Total dissolved solids	600[15] or 95th percentile[2] of reference sites[3], whichever is higher	*Refer to water quality objectives (totals)*
Sulfate (SO_4^{2-})	250[6] or 95th percentile[2] of reference sites[3], whichever is higher	*Refer to water quality objectives (totals)*
Arsenic	0.05[4]	0.013[5] or 95th percentile[2] of reference sites[3] whichever is higher
Cadmium	0.005[4]	0.0002[5] or 95th percentile[2] of reference sites[3] whichever is higher

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Copper	0.04[4]	0.0014[5] or 95th percentile[2] of reference sites[3], whichever is higher
Zinc	0.15[4]	0.008[5] or 95th percentile[2] of reference sites[3] whichever is higher
Cyanide[8]	Not applicable	0.007[5]
Dissolved Inorganic Nitrogen (DIN)	No net increase from background.	
Ammonia	No net increase from background.	
Total nitrogen (Nitrite and Nitrate)	No net increase from background.	

1. For water quality, all metals and metalloids must be measured as both 'total' (from analysis of an unfiltered sample) and 'dissolved' (from analysis of a field filtered sample).
2. Percentiles (5th, 80th and 95th) of reference site contaminant concentration applied as trigger levels/water quality objectives must be calculated in accordance with QWQG (2009) and ANZECC (2000) methodology. The environmental authority holder must maintain a database documenting all relevant water quality monitoring data and calculation of percentiles adopted as trigger levels/water quality objectives.
3. The relevant reference site for Perry River is specified in Schedule E – *Table 3* of the environmental authority
4. ANZECC (2000) stock limits.
5. ANZECC (2000) 95% species protection, Table 3.4.1.
6. Dunlop et al 2016 "Ecosystem protection trigger values for sulfate in hard waters of the Fitzroy River basin"
7. Analysis for metals/metalloids concentrations in sediment must be conducted on the <2mm fraction of the sample and measured as a dilute acid extractable concentration in a manner consistent with the Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines, CSIRO (May 2013).
8. Cyanide is to be measured with pH and temperature in accordance with ANZECC (2000) methodology
9. pH limits from ANZECC (2000) Table 4.4.2

E49 The contaminant concentrations measured at *Table E11* "Downstream Perry River (within 1 km of the weir)" in receiving waters must not be outside the pH range or exceed the Electrical Conductivity or any total water quality objective specified in *Table E12*.

E50 Should any contaminant measured at *Table E11* "Downstream Perry River (within 1 km of the weir)" in receiving waters be outside the pH range or exceed the Electrical Conductivity or dissolved water quality objective specified in *Table E12*, the environmental authority holder must immediately cease releasing and notify the administering authority under condition **E51** and additionally provide the following information in writing:

a) release cessation date/time; and

b) natural flow volume in receiving water; and

c) volume of water released; and

d) details regarding the compliance of the release with the conditions of this environmental authority

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(i.e., contamination limits, natural flow, discharge volume); and

e) all in-situ water quality monitoring results; and

f) any other matters pertinent to the water release event.

E51 At the commencement and cessation of releasing water pursuant to condition **E39,** the holder of the environmental authority must notify the administering authority by written notification (via email to the pollution hotline at: pollutionhotline@des.qld.gov.au) within twenty-four (24) hours and must at minimum, include:

a) the stream flow measured at the Perry River Weir; and
b) live monitoring of Electrical Conductivity (EC) and pH (pH units) at the Downstream Perry River (within 1 km of the weir).

E52 The holder of the environmental authority must notify the administering authority by phone call within six (6) hours, followed by written notification (via email to the pollution hotline at: pollutionhotline@des.qld.gov.au) within twenty-four (24) hours, after becoming aware of any release not in accordance, or reasonably expected to not be in accordance with, the conditions **E39** to **E51**.

END OF CONDITIONS FOR SCHEDULE E

Schedule F – Biodiversity

Biodiversity offsets

F1 Significant residual impacts to prescribed environmental matters, are not authorised under this environmental authority or the *Environmental Offsets Act 2014.*

F2 The offset area identified in the document *Biodiversity Offsets Strategy – Mt Rawdon Operations* (NRC, May 2013) must be managed in accordance with the approved *Offset Area Management Plan* (MRO ENV PRO 0243 Offset Area Management Plan, February 2016), so that:

a) the proposed management continues to benefit the offset area; and

b) where the intended management strategies are required to change, the Offset Area Management Plan is updated to reflect the required management changes and submitted for endorsement to the administering authority.

F3 Reporting of the offset area's progress to the administering authority must occur in accordance with the reporting framework outlined in the *Biodiversity Offsets Strategy – Mt Rawdon Operations* (NRC, May 2013) and must ensure that it:

a) reports progress of offsetting requirements.

b) demonstrates whether or not the offsetting requirements are being met.

c) identifies any changes to offset delivery during the reporting period; and

d) is available for auditing by a third party to identify where investigation and/or compliance action is required by the department.

F4 Impacts on State Significant Biodiversity Values, in accordance with the *Biodiversity Offsets Strategy – Mt Rawdon Operations* (NRC, May 2013) must not occur before the following is provided to the administering authority:

a) the bank guarantee details (financial institution, account number and account name) for the holding of offset area management funds; and

b) evidence that adequate management costs are held by the nominated bank guarantee, within 4 months of the environmental authority being issued.

Livestock or native fauna mortalities

F5 Livestock or native fauna mortalities in or around areas containing cyanide must be reported to the administering authority within 24 hours of observation. The report must state the probable cause of death and include actions that will be taken to prevent the likelihood of livestock or native fauna deaths in future. WAD cyanide levels at the nearest monitoring point to the deceased animal must be reported to the administering authority.

*Note: The intent of condition **F5** is for the reporting of native fauna deaths only as a result of cyanide exposure.*

END OF CONDITIONS FOR SCHEDULE F

Schedule G – Land and Rehabilitation

G1 The environmental authority holder must rehabilitate all land disturbed by the mining activities in a manner that ensures rehabilitated areas achieve the following rehabilitation objectives:

a) safe for humans and wildlife;

b) non-polluting;

c) stable;

d) able to sustain an agreed post-mining land-use;

e) revegetated with species endemic to the area with no declared pest species; and

f) compliant with all conditions of this environmental authority

G2 A Final Land Use Rehabilitation Plan ('FLURP') that describes how the rehabilitation objectives in condition **G1** will be achieved must be developed, documented and implemented for all stages of the mining activity by **8 January 2018** The FLURP must at minimum include:

a) schematic representation of the proposed final land form inclusive of site drainage features;

b) details of proposed slope design and erosion and sediment controls;

c) proposed cover designs for encapsulation of waste material, including performance criteria;

d) proposed re-vegetation methods inclusive of plant species selection, propagation methods and establishment of suitable plant growth medium (*i.e.* top soil);

e) materials balance for all rehabilitation requirements including available top soil and material suitable for encapsulating waste in accordance with the proposed encapsulation methodology;

f) geotechnical, geochemical and hydrological studies necessary to demonstrate likely success of proposed rehabilitation methodology to achieve the required rehabilitation outcomes;

g) an investigation of proposed residual voids including potential for generation/mobilisation of contaminants, potential pathways for release of contaminants to waters (including groundwater) and a long-term void water balance model; and

h) a rehabilitation monitoring program sufficient to identify if required rehabilitation outcomes have been achieved.

G3 Rehabilitation in accordance with condition **G2** must commence progressively in accordance with the plan of operations.

G4 Residual voids (including open pits and underground workings) must not cause any serious or material environmental harm, other than the environmental harm constituted by the existence of the residual void itself, subject to any other condition within this environmental authority.

G5 All explosives, flammable or corrosive substances, hazardous chemicals, toxic substances, gases and dangerous goods must be stored and handled in accordance with:

a) the current Australian Standard where applicable; or

b) where no relevant Australian Standard exists, store such materials within an on-site containment system sufficient to prevent release to the receiving environment.

G6 Minimise the potential for contamination of land by hazardous contaminants.

G7 All previous disturbance on mining lease ML80095, as depicted in *Schedule J – Map 3* must be rehabilitated in accordance with conditions **G1** and **G2** of this environmental authority.

END OF CONDITIONS FOR SCHEDULE G

Schedule H – Regulated Structures

H1 The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* at the following times:

a) prior to the construction of the structure, if it is not an existing structure; or

b) if it is an existing structure, by **23 June 2017**; or

c) prior to any change in its purpose or the nature of its stored contents.

H2 A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.

H3 Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*.

Design and construction of a regulated structure

H4 Conditions **H5** to **H9** inclusive do not apply to existing structures.

H5 All regulated structures must be designed by, and constructed under the supervision of, a suitably qualified and experienced person in accordance with the requirements of the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*.

H6 Construction of a regulated structure is prohibited unless the environmental authority holder has submitted to the administering authority and 28 days have elapsed, the following:

a) a consequence category assessment report, as required by condition **H2**, and

b) the suitably qualified and experienced person certified design and design plan; and

c) the associated suitably qualified and experienced person certified operating procedures.

H7 Certification must be provided by the suitably qualified and experienced person who oversees the preparation of the design plan in the form set out in the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*, and must be recorded in the Regulated Structures register.

H8 Regulated structures must:

a) be designed and constructed in accordance with and conform to the requirements of the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933).*

b) be designed and constructed with due consideration given to ensuring that the design integrity would not be compromised on account of:

i) floodwaters from entering the regulated structure from any watercourse or drainage line; and

ii) wall failure due to erosion by floodwaters arising from any watercourse or drainage line.

H9 Certification by the suitably qualified and experienced person who supervises the construction must be submitted to the administering authority within 10 days of the completion of construction of the regulated structure, and state that:

a) the 'as constructed' drawings and specifications meet the original intent of the design plan for that regulated structure.

b) construction of the regulated structure is in accordance with the design plan.

Operation of a regulated structure

H10 Operation of a regulated structure, except for an existing structure, must not commence unless the environmental authority holder has submitted to the administering authority:

a) One paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition **H7**, and

b) A set of 'as constructed' drawings and specifications, and

c) Certification of those 'as constructed drawings and specifications' in accordance with condition **H9**, and

d) Where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the design storage allowance (DSA) volume across the system, a copy of the certified system design plan;

e) A statement that confirms:

i. The requirements of this authority relating to the construction of the regulated structure have been met;

ii. The details required under this authority, have been entered into a Register of Regulated Structures; and

iii. There is a current operational plan for the regulated structures.

H11 For existing structures that are regulated structures:

a) where the existing structure that is a regulated structure is managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the environmental authority holder must submit to the administering authority within three (3) months of the commencement of this condition a copy of the certified system design plan including that structure; and

b) There must be a current operational plan for the existing structures.

H12 Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in a manner that is consistent with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings.

Mandatory reporting level

H13 Conditions **H14** to **H17** inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.

H14 The Mandatory Reporting Level (the MRL) specified in *Table H1* must be marked on a regulated structure in such a way that during routine inspections of that structure, it is clearly observable.

Note: *The mandatory reporting level may also be marked and measured within the decant pond of the regulated dam. However, the mandatory reporting level within the decant pond must be compared to the mandatory reporting level on the spillway on a regular basis to ensure accuracy.*

H15 The environmental authority holder must, as soon as practical and within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated structure reaches the MRL.

H16 The environmental authority holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated structure.

H17 The environmental authority holder must record any changes to the MRL in *Table H1* and in the Register of Regulated Structures.

Design storage allowance

H18 The environmental authority holder must assess the performance of each regulated structure or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated structure or linked containment system taken prior to 1 July of each year.

H19 By 1 November of each year, storage capacity must be available in each regulated structure (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the structure (or network of linked containment systems), as specified in *Table H1*.

H20 The environmental authority holder must, as soon as possible and within forty-eight (48) hours of becoming aware that the regulated structure (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, notify the administering authority.

H21 The environmental authority holder must, immediately on becoming aware that a regulated structure (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated structure or linked containment systems.

Annual inspection report

H22 Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

H23 At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include recommended actions, if applicable, to ensure the integrity of the regulated structure.

H24 The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*.

H25 The environmental authority holder must within 20 business days of receipt of the annual inspection report, provide to the administering authority:

a) The recommendations section of the annual inspection report; and

b) If applicable, any details of any actions being taken in response to those recommendations.

Transfer arrangements

H26 The environmental authority holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.

Decommissioning and rehabilitation

H27 Regulated structures and structures must not be abandoned but must be decommissioned and rehabilitated to achieve compliance with conditions **G1** and **G2** of this environmental authority.

Transitional Arrangements

H28 All existing structures that have not been assessed in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* must be assessed and certified in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* by **23 June 2017.**

Hydraulic performance of regulated structures

H29 Each regulated structure authorised by this environmental authority as specified in *Table A1 Authorised Disturbance*, must meet the hydraulic performance criteria listed in *Table H1* for that structure.

Table H1 – Hydraulic performance criteria ('Table H1')

Name of Regulated Structure	Consequence Category	Spillway Critical Design Storm Capacity		Design Storage Allowance[2] (DSA)		Mandatory Reporting Level[4] (MRL)		Purpose of structure
		Design Criteria	mAHD	Design Criteria	mAHD	Design Criteria	mAHD	
Tailings Storage Facility[6]	High	1:10000 year AEP	174.0	1: 200 Year AEP 4 month wet season plus process inputs for the 4 month wet season	172.0	1: 100 year AEP	173.5	Tailings Storage and PAF waste storage
Sediment Dam 3	Significant	1:1000 year AEP	118.5	1:20 Year AEP 4 month wet season	116.6	1:10 Year AEP	116.6	TSF Seepage Collection
WD1	Significant	1:1000 year AEP	126.0m	1:20 year AEP 4 month wet season	123.5	1:10 Year AEP	124.5	North WRD Runoff Containment
WD2	Significant	1:1000 year AEP	119.2m	1:20 year AEP 4 month wet season	118.3	1:10 Year AEP	118.8	North WRD Runoff Containment
WD3	Significant	1:1000 year AEP	125.0m	1:20 year AEP 4 month wet season	124.2	1:10 Year AEP	124.7	North WRD Runoff Containment
WD4	Significant	1:1000 year AEP	133.5m	1:20 year AEP 4 month wet season	132.3	1:10 Year AEP	133.0	North WRD Runoff Containment
Process Water Pond	Significant	1:1000 year AEP	154.7m	1:20 year AEP 4 month wet season	N/A	1:10 Year AEP	N/A	Process Water Buffer Storage
South Dam	Significant	1:100 year AEP	146.5m	1:20 year AEP 4 month wet season	145.7	1:10 Year AEP	145.9	Process Plant Runoff, Containment of Pit Dewatering, and TSF Seepage

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Name of Regulated Structure	Consequence Category	Spillway Critical Design Storm Capacity		Design Storage Allowance[2] (DSA)		Mandatory Reporting Level[4] (MRL)		Purpose of structure
		Design Criteria	mAHD	Design Criteria	mAHD	Design Criteria	mAHD	
West Dam	Significant	1:1000 year AEP	122.5m	1:20 year AEP 4 month wet season	120.3	1:10 Year AEP	121.5	West WRD Runoff Containment, Containment of Pit Dewatering

NOTE: AEP means Annual Exceedance Probability – being the probability that at least one event as specified will occur in a particular year.

[1] *Calculations are to be carried out in accordance with the guideline titled Site Water Management within the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland (DME 1995).*

[2] *The design storage allowance on 1st November of each year for any regulated dam constructed within the operational land must be sufficient to contain the run-off from the critical wet period - plus the volume of any other inputs to the storage facility during that critical wet period, as part of operations. Such inputs could be tailings, contaminated site waters, process waters, and any other materials.*

[3] *The critical storm has a duration that produces the peak discharge for the catchment.*

[4] *The level below spillway crest that can accommodate runoff from a 72 hour storm at the specified AEP, or the wave allowance at the specified AEP - whichever level is lower*

[5] *TSF is approved for Stage 5 Life of Mine lifts, Stages 5A to 5F, with a final lift approval to RL193.0m*

H30 The hydraulic performance criteria specified in *Table H1* are the minimum mandatory performance requirements; regulated structures must be managed in a manner that ensures compliance with all conditions of this environmental authority.

END OF CONDITIONS FOR SCHEDULE H

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Schedule I - Definitions

Key terms and/or phrases used in this document are defined in this section and bolded throughout this document. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

Word / Phrase	Definition
Acceptance criteria	Means the measures by which actions implemented are deemed to be complete. The acceptance criteria indicate the success of the decommissioning and rehabilitation outcomes or remediation of areas which have been significantly disturbed by the mining activities. Acceptance criteria may include information regarding: a) Stability of final land forms in terms of settlement, erosion, weathering, pondage and drainage; b) Control of geochemical and contaminant transport processes; c) Quality of runoff waters and potential impact on receiving environment; d) Vegetation establishment, survival and succession; e) Vegetation productivity, sustained growth and structure development; f) Fauna colonisation and habitat development; g) Ecosystem processes such as soil development and nutrient cycling, and the recolonisation of specific fauna groups such as collembola, mites and termites which are involved in these processes; h) Microbiological studies including recolonisation by mycorrhizal fungi, microbial biomass and respiration; i) Effects of various establishment treatments such as deep ripping, topsoil handling, seeding and fertiliser application on vegetation growth and development; j) Resilience of vegetation to disease, insect attack, drought and fire; k) Vegetation water use and effects on ground water levels and catchment yields.
Acid rock drainage	Means any contaminated discharge emanating from a mining activity formed through a series of chemical and/or biological reactions.

Word / Phrase	Definition
Administering authority	Is the agency that administers the environmental authority provisions under the *Environmental Protection Act 1994*.
Airblast overpressure	Means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dB).
Annual exceedance probability or AEP	The probability that at least one event in excess of a particular magnitude will occur in any given year.
Annual inspection report	means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan): a) Against recommendations contained in previous annual inspections reports; b) Against recognised dam safety deficiency indicators; c) For changes in circumstances potentially leading to a change in consequence category; d) For conformance with the conditions of this authority; e) For conformance with the 'as constructed' drawings; f) For the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year, of accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems); g) For evidence of conformance with the current operational plan.
Appropriately qualified person	Means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods or literature.
Assessed or assessment	By a suitably qualified and experienced person in relation to a consequence assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit of the assessment:

Word / Phrase	Definition
	(a) exactly what has been assessed and the precise nature of that determination; (b) the relevant legislative, regulatory and technical criteria on which the assessment has been based; (c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and (d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.
Associated works	In relation to a dam, means: a) Operations of any kind and all things constructed, erected or installed for that dam; and b) Any land used for those operations.
Authority	Means an environmental authority or a development approval.
Background noise level	means either: • $L_{A90,\,T}$ being the A-weighted sound pressure level exceeded for 90 percent of the time period not less than 15 minutes, using Fast response, or • $L_{abg,\,T}$ being the arithmetic average of the minimum readings measured in the absence of the noise under investigation during a representative time period of not less than 15 minutes, using Fast response.
Blasting	Means the use of explosive materials to fracture: • Rock, coal and other minerals for later recovery; or • Structural components or other items to facilitate removal from a site or for reuse.
Certification	Means assessment and approval must be undertaken by a suitably qualified and experienced person in relation to any assessment or documentation required by this Manual, including design plans, 'as constructed' drawings and specifications, construction, operation or an annual report regarding regulated structures, undertaken in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQs (ID: 1.4 (2A)).

Word / Phrase	Definition
Certifying, certify or certified	By an appropriately qualified and experienced person in relation to a design plan or an annual report regarding dams/structures, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit at any time: a) exactly what is being certified and the precise nature of that certification b) the relevant legislative, regulatory and technical criteria on which the certification has been based c) the relevant data and facts on which the certification has been based, the source of that material, and the efforts made to obtain all relevant data and facts d) the reasoning on which the certification has been based using the relevant data and facts, and the relevant criteria.
Chemical	Means: a) An agricultural chemical product or veterinary chemical product within the meaning of the *Agricultural and Veterinary Chemicals Code Act 1994* (Commonwealth); or b) A dangerous good under the dangerous goods code; or c) A lead hazardous substance within the meaning of the *Workplace Health and Safety Regulation 1997*; or d) A drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or e) Any substance used as, or intended for use as – i. A pesticide, insecticide, fungicide, herbicide, rodenticide, nematicide, miticide, fumigant or related product; or ii. A surface active agent, including, for example, soap or related detergent; or iii. A paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide; or iv. A fertiliser for agricultural, horticultural or garden use; or

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Word / Phrase	Definition
	f) A substance used for, or intended for use for – i. Mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater; or ii. Manufacture of plastic or synthetic rubber.
Commercial place	Means a workplace used as an office or for business or commercial purposes, which is not part of the mining activity and does not include employees' accommodation or public roads.
Construction or constructed	In relation to a regulated structure includes building a new regulated structure and lifting or otherwise modifying an existing regulated structure, but does not include investigations and testing necessary for the purpose of preparing a design plan.
Consequence	In relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.
Consequence category	Means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*.
Dam	Means a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and **associated works**.
Design plan	Is a document setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.
Design storage allowance or DSA	Means an available volume, estimated in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.
Designer	For the purposes of a regulated dam, means the certifier of the design plan for the regulated dam.

Word / Phrase	Definition
EM Plan	Means the environmental management plan report titled Mt Rawdon Gold Project: Environmental Management Plan and dated February 2006. Although legally the environmental authority is the enforceable document, not the EM Plan, if there was any need for interpretation of the conditions, then the interpretation should be in the context of the EM Plan.
Environmental authority holder	Means the holder of this environmental authority or any other works conducted by another entity on the approved leases.
Environmental offset	Has the meaning in section 7 of the *Environmental offsets Act 2014*.
Existing structure	Means a structure that was in existence prior to the adoption of this schedule of conditions under the authority.
Flowable substance	Means matter or a mixture of materials which can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids fluids or solids, or a mixture that includes water and any other liquids fluids or solids either in solution or suspension.
Foreseeable future	Is the period used for assessing the total risk of an event occurring. Permanent structures and ecological sustainability should be expected to still exist at the end of a 150 year foreseeable future with an acceptable risk of failure before that time.
Hazard category	Means a category, either low significant or high, into which a dam is assessed as a result of the application of tables and other criteria in *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)*.
Hazardous waste	Means any substance, whether liquid, solid or gaseous, that tends to destroy life or impair or endanger health.
Holder	Means: a) Where this document is an environmental authority, any person who is the holder of, or is acting under, that environmental authority; or b) Where this document is a development approval, any person who is the registered operator for that development approval.

Word / Phrase	Definition
Hydraulic performance	Means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933).*
Infrastructure	Means water storage dams, roads and tracks, buildings and other structures built for the purpose of mining activities.
$L_{A\ 10,\ adj,\ 15\ mins}$	Means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 10% of any 15 minute measurement period, using Fast response.
$L_{A\ 1,\ adj,\ 15\ mins}$	Means the A-weighted sound pressure level, (adjusted for tonal character and impulsiveness of the sound) exceeded for 1% of any 15 minute measurement period, using Fast response.
$L_{A,\ max\ adj,\ 15\ mins}$	Means the average maximum A-weighted sound pressure level, adjusted for noise character and measured over any 15 minute period, using Fast response.
Land	In the 'land schedule' of this document means land excluding waters and the atmosphere.
Land capability	As defined in the *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (DME 1995)*.
Land use	Term to describe the selected post mining use of the land, which is planned to occur after the cessation of mining operations.
Leachate	Means a liquid that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed or disposed of at the operational land which contains soluble, suspended or miscible contaminants likely to have been derived from the said material.
Levee	Means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times.

Word / Phrase	Definition
Maintained	With regards to groundwater quality, means no trending increase measured over three (3) consecutive sampling events in accordance with condition **E25**, or five (5) consecutive sampling events in accordance with condition **E26** in the concentration of any contaminant specified in *Table E10.*
Mandatory reporting level or MRL	Means a warning and reporting level determined in accordance with the criteria in the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* published by the administering authority.
Manual	Means the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* published by the administering authority.
Metalliferous mine drainage	Means any waters, contaminated with metals / metalloids or other contaminants as a result of the mining activities.
Modification or modifying	See definition of 'construction'.
N/A	Means not applicable.
Natural Flow	Natural flow is defined as a flow event caused as a result of a local rainfall event, within a defined catchment area, and measured within the same receiving waters.
Non-acid producing (NAP)	Rock that when exposed to an oxidising environment will not produce acid solutions. Compare with "ore or waste rock characterised as having acid forming potential.
Neutral mine drainage	Has the same meaning as metalliferous mine drainage.
Operational management bore	Means a bore located within the operational seepage management footprint, as shown in *Schedule J, Figure 2B– Groundwater monitoring network*.
Operational seepage management footprint	Means the area depicted by bores specified as operational management bores in *Table E7* and depicted in *Schedule J, Figure 2B– Groundwater monitoring network*.
Ore or waste rock characterised as having acid forming potential	Means any rock with either a Net Acid Producing Potential of greater than 5 kg of H_2SO_4/tonne or a Net Acid Generation oxidation pH of less than 4.5 (pH unit).

Word / Phrase	Definition
Peak particle velocity (ppv)	Means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mms).
Percent slope	Means: $\frac{\text{Height difference (metres)}}{\text{Horizontal difference (metres)}}$ X100
Prescribed environmental matters	Has the meaning in section 10 of the *Environmental Offsets Act 2014*, limited to the matters of state environmental significant listed in Schedule 2 of the *Environmental Offsets Regulation 2014*.
Protected area	Means: • A protected area under the *Nature Conservation Act 1992*; or • A marine park under the *Marine Parks Act 1992*; or • A World Heritage Area.
Progressive rehabilitation	Means rehabilitation (defined below) undertaken progressively OR a staged approach to rehabilitation as mining operations are ongoing.
Receiving environment	in relation to an activity that causes or may cause environmental harm, means the part of the environment to which the harm is, or may be, caused. The receiving environment includes (but is not limited to): a) a watercourse or surface waters b) groundwater
Receiving waters	Has the same meaning as receiving environment.
Reference site (or analogue site)	May reflect the original location, adjacent area or another area where rehabilitation success has been completed for a similar biodiversity. Details of the reference site may be as photographs, computer generated images and vegetation models etc.
Regional groundwater	Means the groundwater potentially impacted by mining activities on or around the site beyond the seepage capture systems implemented for the Tailings Storage Facility.

Word / Phrase	Definition
Register of Regulated Dams	Includes: a) Date of entry in the register; b) Name of the dam, its purpose and intended/actual contents; c) The consequence category of the dam as assessed using the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (EM635)*; d) Dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam; e) Name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings; f) For the regulated dam, other than in relation to any levees – i. The dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam; ii. Coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area iii. Dam crest volume (megalitres); iv. Spillway crest level (metres AHD). v. Maximum operating level (metres AHD); vi. Storage rating table of stored volume versus level (metres AHD); vii. Design storage allowance (megalitres) and associated level of the dam (metres AHD); viii. Mandatory reporting level (metres AHD); g) The design plan title and reference relevant to the dam; h) The date construction was certified as compliant with the design plan; i) The name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan; j) Details of the composition and construction of any liner; k) The system for the detection of any leakage through the floor and sides of the dam;

Word / Phrase	Definition
	l) Dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year; m) Dates when recommendations and actions arising from the annual inspection were provided to the administering authority; Dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.
Regulated dam	Means any dam in the significant or high consequence category as assessed using the *Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933)* published by the administering authority.
Regulated structure	Includes land-based containment structures, levees, bunds and voids, but not a tank or container designed and constructed to an Australian Standard that deals with strength and structural integrity.
Rehabilitation	Means the process of reshaping and revegetating land to restore it to a stable landform and in accordance with the acceptance criteria set out in this environmental authority and, where relevant, includes remediation of contaminated land.
Representative	Means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activities.
Residual void	Means an open pit resulting from the removal of ore and/or waste rock which will remain following the cessation of all mining activities and completion of rehabilitation processes.
Saline mine drainage	Means the movement of waters, contaminated with salt(s), as a result of the mining activity.
Sediment dam	Means a structure for the capture and treatment of stormwater runoff contaminated only by sediments from disturbed areas and which discharge off-site once full.
Self-sustaining	Means an area of land which has been rehabilitated and has maintained the required acceptance criteria without human intervention for a period nominated by the administering authority.

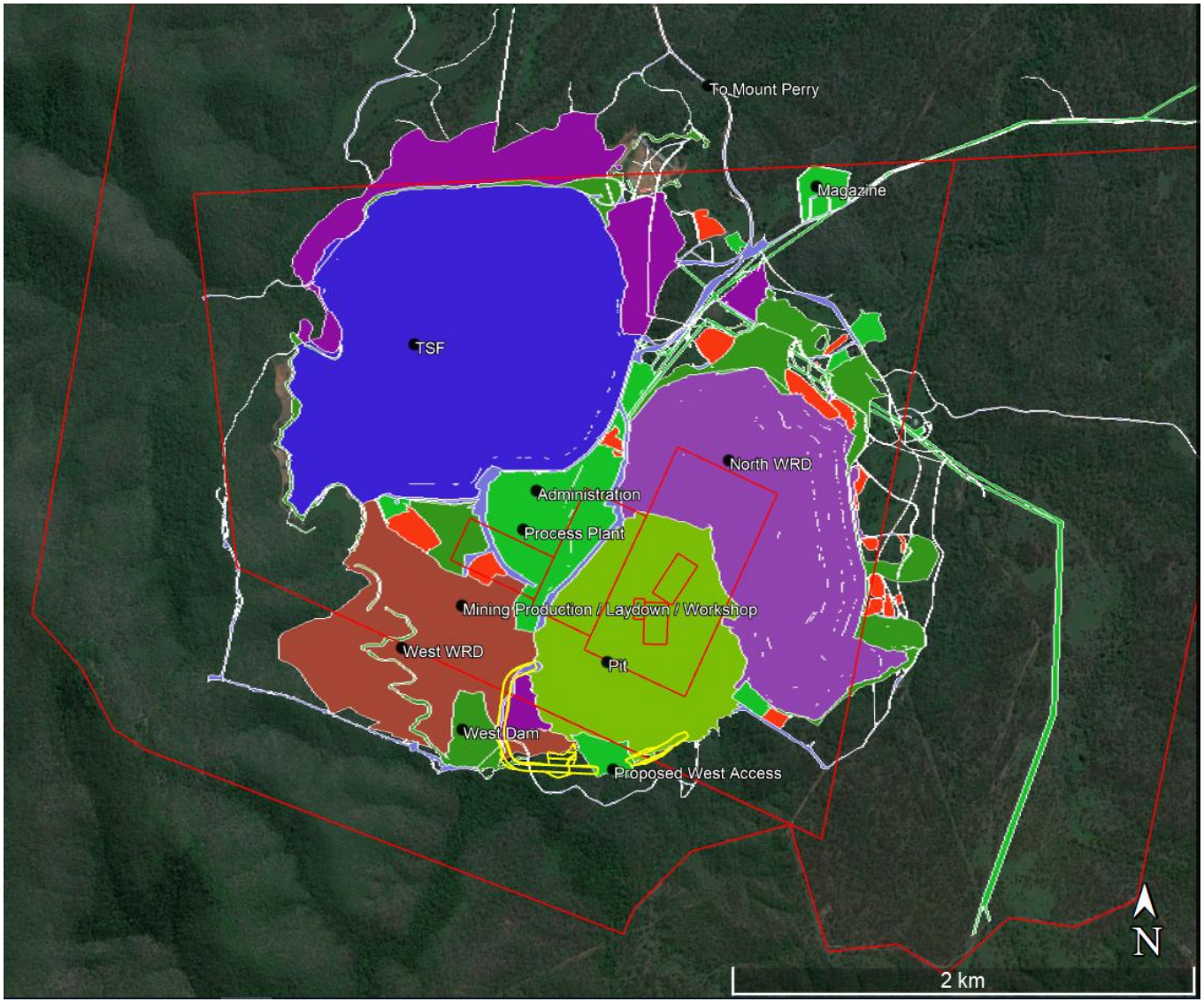
Word / Phrase	Definition
Sensitive place	Means: a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises, or b) a motel, hotel or hostel, or c) an educational institution, or d) a medical centre or hospital, or e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 1992* or a World Heritage Area, or f) a public park or gardens.
Spillway	Means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges form the dam, normally under flood conditions or in anticipation of flood conditions.
Stable	Means land form dimensions are or will be stable within tolerable limits now and in the foreseeable future. Stability includes consideration of geotechnical stability, settlement and consolidation allowances, bearing capacity (trafficability), erosion resistance and geochemical stability with respect to seepage, leachate and related contaminant generation.
Standing water level (potentiometric level)	means the level (m AHD) to which groundwater would rise (due to the static pressure in the system) from a partially or totally confined aquifer if allowed to equilibrate with atmospheric pressure (e.g., the level groundwater would rise to if the aquifer were penetrated by a bore).
Structure	Means any dam or levee
Suitably qualified and experienced person	in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience: a) For regulated dams, an RPEQ who is a civil engineer with the required qualifications in dam safety and dam design. b) For regulated levees, an RPEQ who is a civil engineer with the required qualifications in the design of flood protection embankments.

Word / Phrase	Definition
	Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology.
System design plan	Means a plan that manages an integrated containment system that shares the required DSA and/or ESS volume across the integrated containment system.
Tolerable limits	Means that a range of values could be accepted to achieve an overall environmental management objective (e.g. A range of settlement of a tailing capping could still meet the objective of draining the cap quickly, preventing pondage and limiting infiltration and percolation). Tolerable limits may be specified: a) By agreement between the proponent and the chief executive as an interim arrangement, b) By insertion of conditions as agreed above into this Environmental Authority, or c) By direction by the chief executive and insertion in this Environmental Authority as necessary.
Void	Means any constructed, open excavation in the ground.
Watercourse	Has the same meaning given in the *Water Act 2000*.
Waters	Includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater or any part-thereof.
Wet season	Means the time of year, covering one or more months, when most of the average annual rainfall in a region occurs. For the purposes of DSA determination this time of year is deemed to extend from 1 November in one year to 31 May in the following year inclusive.

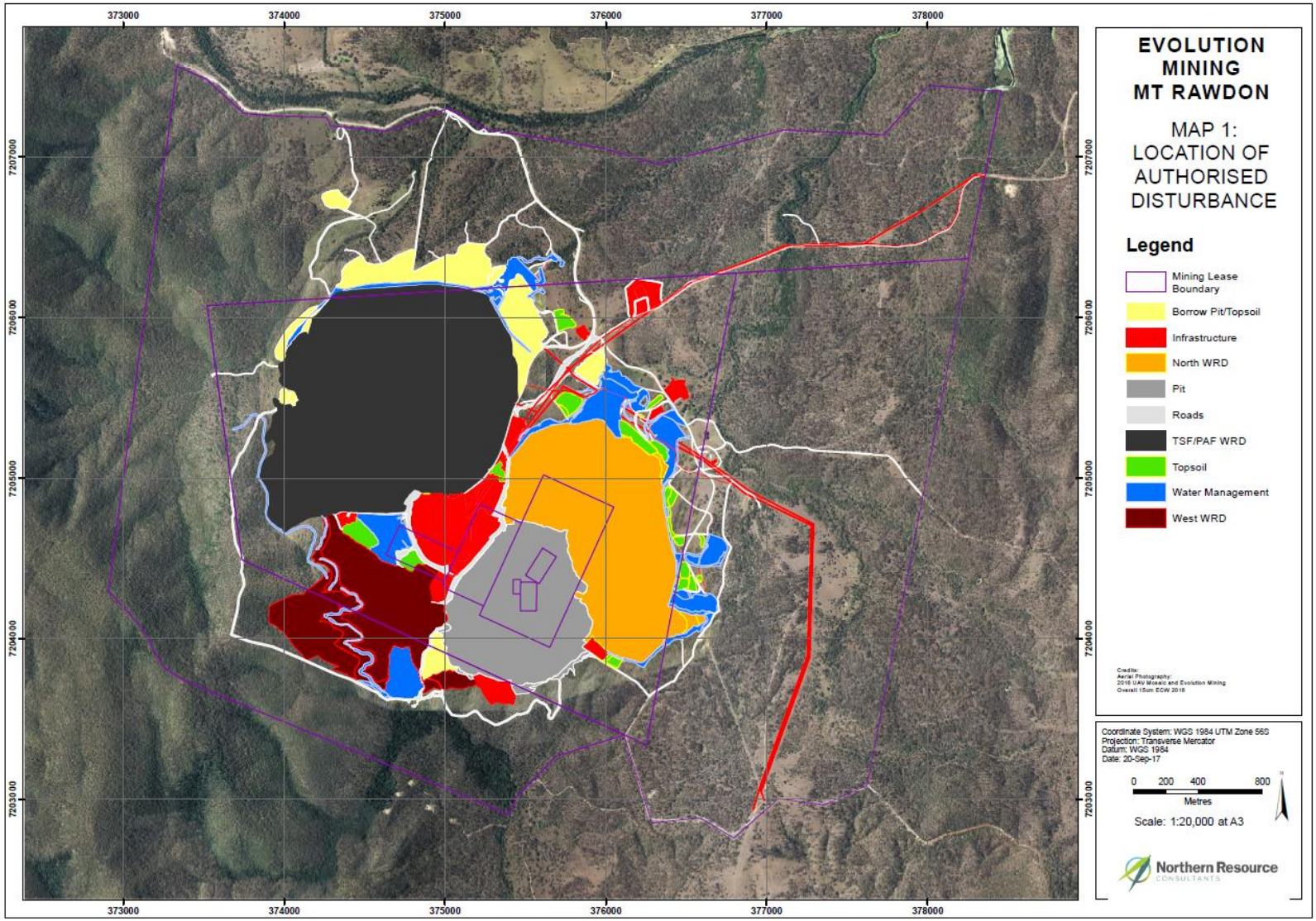
END OF SCHEDULE I

Schedule J – Maps and Plans

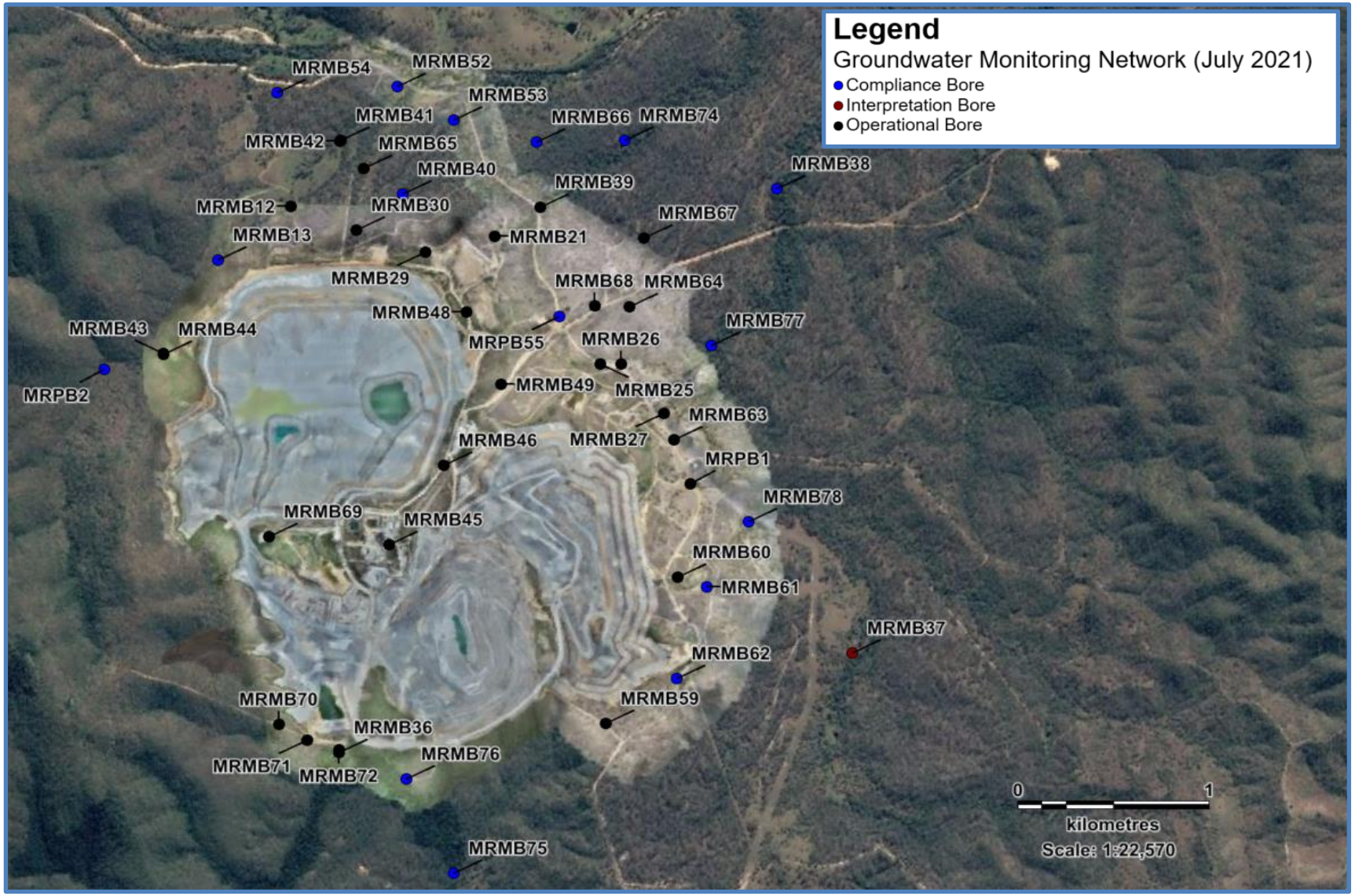
Map 1 – Location of authorised disturbance.



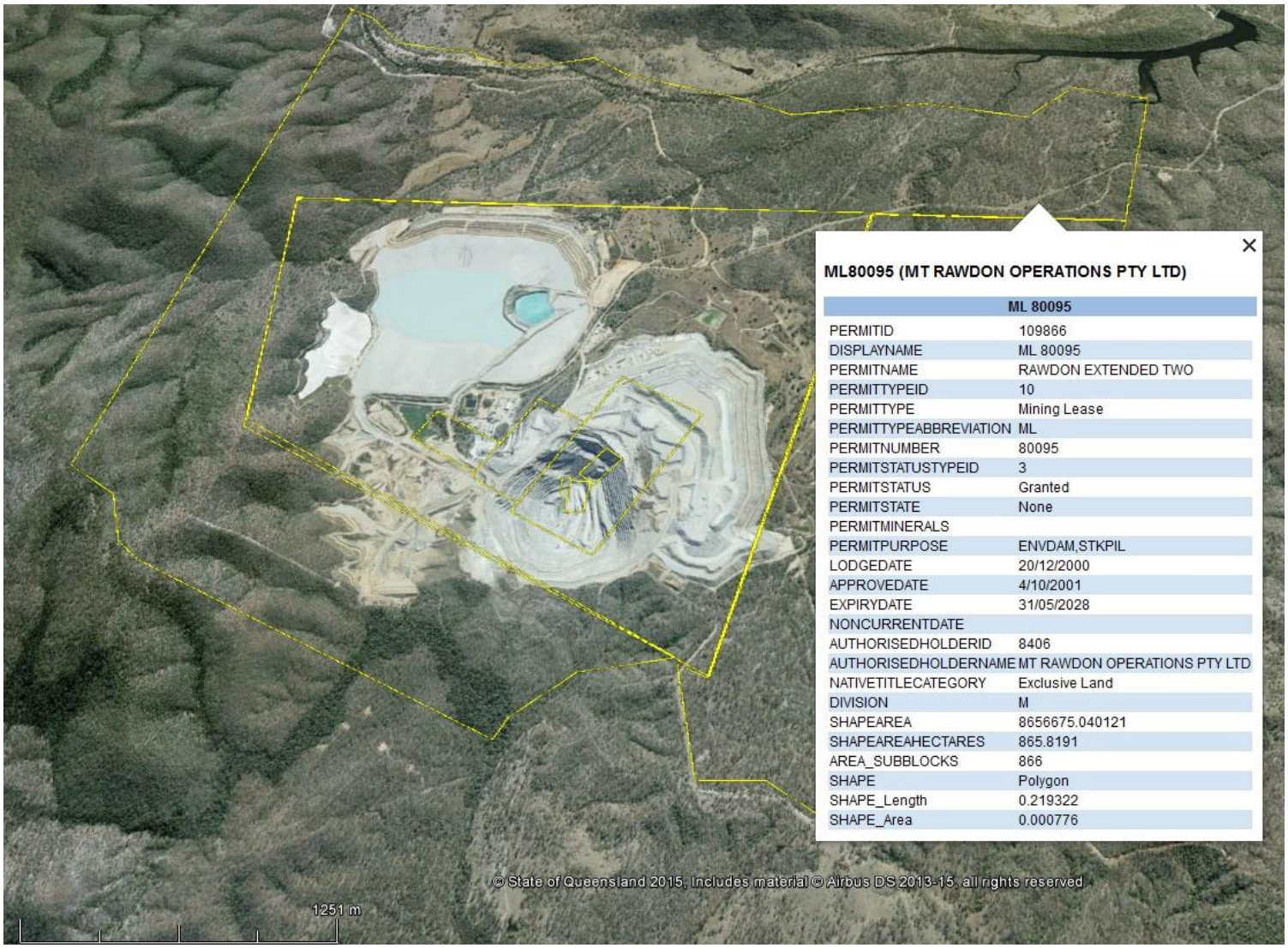
Map 2A – Infrastructure locations.



Map 2B – Groundwater monitoring network.



Map 3 - Mining disturbance on mining lease ML80095 (replaced with ML100059).



End of Schedule J

END OF PERMIT

9.1.6 Appendix 6: Post Closure Landholder Agreement

6 April 2017

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RETENTION OF INFRASTRUCTURE FOR POST-CLOSURE USE

Dear Ingrid,

Swindon Station was a cattle grazing property immediately prior to its current land use of a gold mining operation. Grazing is the current proposed post-mining land use, which is consistent with surrounding properties. Several items of infrastructure currently in place at Mt Rawdon Operation are of use to a cattle grazing property. As the current landholder of Swindon Station, Evolution Mining states that retention of the following infrastructure is consistent with the requirements of the post-closure landuse.

- Site roads and tracks
- Raw water dams and associated pipework
- Sheds
- Infrastructure to supply power to the site (powerlines, substation, switchyard)
- Groundwater bores

Regards,



Evan Elstein
Company Secretary

Conceptual Closure, Decommissioning and Rehabilitation Plan

Mount Rawdon Tailings Storage Facility

Mount Rawdon Operations

***Prepared for**: Evolution Mining*

LEADERS IN MINING GEOCHEMISTRY

Conceptual Closure, Decommissioning and Rehabilitation Plan

Mount Rawdon Tailings Storage Facility

Mount Rawdon Operations

Prepared for: Evolution Mining Pty Ltd

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Limitations and disclaimer:

This report documents the work undertaken by RGS Environmental Pty Ltd (RGS).

This report should be read in full. While the findings presented in this report are based on information that RGS considers reliable unless stated otherwise, the accuracy and completeness of source information cannot be guaranteed, although RGS has taken reasonable steps to verify the accuracy of such source data. RGS has made no independent verification of this information beyond the agreed scope of works and RGS assumes no responsibility for any inaccuracies or omissions outside of RGS's direct control. Furthermore, the information compiled in this report addresses the specific needs of the Client, so may not address the needs of third parties using this report for their own purposes. Thus, RGS and their employees accept no liability for any losses or damage for any action taken or not taken on the basis of any part of the contents of this report. Those acting on information provided in this report do so entirely at their own risk.

This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

EXECUTIVE SUMMARY

Mount Rawdon Operations (MRO) operates the Mt Rawdon gold mine, which incorporates a cyanide in leach (CIL) process circuit, that deposits tailings into a valley fill/turkey nest tailings storage facility (TSF). An economic evaluation of the deposit by MRO indicates the cessation of mining is likely to be in late 2026 and cessation of processing is likely to be in late 2027. RGS Environmental Pty Ltd (RGS) has developed a concept level decommissioning and rehabilitation plan for the TSF based on these closure dates. MRO commissioned RGS and their sub-consultants to evaluate conceptual options for closure, decommissioning and rehabilitation of the MRO TSF.

The tailings have a static non-acid forming (NAF) classification with an Acid Neutralising Capacity: Maximum Potential Acidity ratio ANC:MPA ratio) of 1 to 2. The sulfide sulfur content in the tailings is approximately 1% and the sulfide minerals consist of Pyrite with minor Sphalerite, Galena and Chalcopyrite. The sulfide minerals oxidise at the surface of the TSF and are subsequently neutralised by residual acid neutralising minerals producing neutral pH drainage in the TSF. In the western TSF cell surface tailings have been exposed for seven years. Tailings samples collected from this cell were subjected to kinetic leach testing under laboratory conditions. The leachate data from the kinetic tests show that the tailings had initially high concentrations of salts and metals due to evapo-concentration of supernatant and runoff in the (isolated) cell over several years. Leach testing of the tailings verified (1) that the soluble major ions that had accumulated in the surface profile of the TSF would be leached from the tailings under a closure scenario whereby surface runoff was directed from the surface of the TSF and (2) that subsequent leachate from the tailings would remain pH neutral: static analyses and the ANC:MPA ratio suggest the drainage will always be neutral but will leach salts and metals over time as the tailings oxdise and weather.

The geochemical properties of the tailings verify there is no requirement for an engineered cover system that would include a single or double capillary break because the tailings are likely to remain NAF and are not enriched in metals or metalloids: a tailings sample collected from the TSF in July 2016 had Geochemical Abundance Index (GAI) values of two to three for As (134 mg/kg), Cd (8.6 mg/kg), Cu (358 mg/kg) and Zn (1,490 mg/kg).

The NAF classification and low level of metalliferous enrichment indicates there is very low potential for acid, salts or metals to have an adverse effect on vegetation. The rehabilitation plan for the TSF will be to place an **analogue low permeability soil cover system** on the tailings that would be designed to limit the rate of infiltration into the tailings and the subsequent release of solutes from the tailings and the TSF so that the potential for environmental harm is minimised.

If the seepage from the TSF does not meet environmental objectives it will be intercepted and pumped back to the open pit until the seepage is of appropriate quality to be returned to the hydrological system in the receiving environment. The concept closure, decommissioning and rehabilitation plan (CDaR Plan) in this report includes the following key components.

- Continued placement of High PAF waste rock into the decant structure within the TSF to fully encapsulate this material within fine grained NAF low permeability tailings to essentially eliminate oxygen entry into bulk High PAF waste rock materials and shut down the sulfide oxidation process.
- Placement of Moderate PAF waste rock into a series of low profile benches on the western TSF cell that will be encapsulated progressively within NAF tailings. The key design criteria for this are that Moderate PAF waste rock will not be placed within 25 m horizontal of the natural ground to the west of the TSF, 50 m of the external final TSF landform and top of the waste rock will be covered with at least 3 m of NAF tailings. Consideration will be given to increasing the acid neutralising capacity of the tailings stream to maintain an ANC:MPA ratio of > 2 within the TSF from the existing to final elevation of the tailings beach.
- Sourcing, crushing and stockpiling of NAF rock from the western NAF waste rock dump (WRD) from 2017 to 2026 for the rehabilitation phase of the TSF

- Utilising NAF rock crusher dust (from above) to increase the ANC of the tailings stream from 2017 to 2027.
- Increased rate of mining through 2025 to stockpile ore.
- Cessation of mining and closure of the open pit in late 2026.
- Development of infrastructure from late 2026 to early 2027 to enable ponded water in the TSF to be discharged into the open pit
- Processing of stockpiled ore throughout 2027 and cessation of processing in late 2027.
- Revised operations plan for the TSF to move from perimeter deposition of tailings creating a concave TSF and a lateral tailings beach that will drain tailings from the north to the south. This requires staged progression of the new decant structure from north to south.
- Retention of the TSF decant pond and design storage allowance in the TSF from 2017 to early 2027
- Lowering the southern TSF embankment to the final spillway elevation so all retained supernatant and ponded water can drain the open pit from late 2026 to early 2027.
- Transferring the TSF Design Storage Allowance (DSA) to the open pit once the final elevation in the TSF is attained.
- Placing and then pushing stockpiled NAF waste rock into the tailings to provide a competent profile to construct the soil cover on.
- Sourcing, hauling and placing material from Borrow Area 1 on the tailings to create an **analogue low permeability soil cover system** with some store and release functionality to support moderate vegetation growth.
    - Test pit and diamond core drilling at six locations at MRO gold mine in mid-2016 verified the presence of approximately 2.5 million bulk cubic metres (BCM) of soil and weathered granitoid/schist/gneiss and gneiss/meta sediment within a borrow area to the east of the TSF. Chemical and physical analyses of the rehabilitation units verify they are suitable for construction of a 2.5 m deep soil cover system over the tailings. Analysis of the drill core using Hylogger^{TM} has identified kaolinite, mica and chlorite group minerals: montmorillonite was identified, but is considered to be an artefact of the drilling fluid.
    - The field permeability testing of the in-situ soil in Borrow Area 1 verify that it has low permeability under field conditions: under saturated conditions the tailings also have very low permeability. Laboratory testing of the soil and weathered overburden samples and geochemical analyses verify the materials are susceptible to compaction and very low rates of permeability. This gives MRO the flexibility of constructing a soil cover with low permeability, or higher rates of infiltration if the materials are placed in a way that compaction is minimised.
- Installing monitoring equipment within the tailings and soil cover system.
- Seeding the soil cover to initiate a vegetative cover on the TSF.
- Undertaking post construction monitoring to determine if the cover system meets design specifications.

One of the key assumptions for this conceptual CDaR Plan is that all mine impacted water from the TSF will drain or be pumped to the open pit after the cessation of open pit mining. A range of other options were considered in this study and although the 2.5 m analogue soil cover system was identified as the preferred soil cover system, the other options cannot be excluded until a PFS level first principles cost estimate is derived for all viable options to allow MRO to make an informed decision that addresses all aspects in the risk and opportunity register appended to this report. RGS recommends the following work to reduce the degree of risk and/or uncertainty to MRO and Evolution Mining associated with potential environmental harm or financial liability.

- A first principles cost estimate should be developed for viable options to remove uncertainty pertaining to the cost of rehabilitation of the TSF eg. actual cost to crush and screen NAF waste rock for drainage material, actual cost to source, haul and place overburden onto the TSF to meet soil cover system design criteria.

- PFS evaluation of the other options in this study should be completed including, for example, evaluation of the site for conversion to a hydro-pump back and solar power farm as a future land use option.
- Soil cover system field trials should be established to determine how the soil and weathered overburden from Borrow Area 1 will perform when they are placed with various types of equipment with defined design criteria (eg. compacted versus non-compacted scenarios).
- A final void (pit lake) hydro-geochemical model should be completed to determine if the TSF runoff and seepage (combined with other site water) can be directed to the open pit, and that the subsequent volume and quality of water in the open pit meets appropriate (yet to be defined) future land use criteria.

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GLOSSARY of TERMS and ACRONYMS

AC	Acid consuming mine waste that has the potential to consume substantial acidity
AF	Acid forming mine waste typified as having an existing pH < 5
bgl	Below ground level
Acid Base Account	Evaluation of the balance between acid generation and acid neutralisation processes. Generally determines the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below.
AMD	Acid and metalliferous drainage from mine waste materials characterised by low pH, elevated metal concentrations, high sulfate concentrations and high salinity. See also “NMD”.
ANC	Acid Neutralising Capacity, expressed as kg H_2SO_4 per tonne of sample. A measure of a sample’s maximum potential ability to neutralise acid.
ANC: MPA Ratio	The ratio of the acid neutralising capacity to the maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
EC	Electrical Conductivity, expressed as µS/cm.
eCEC	Effective cation exchange capacity provides a measure of the amount of exchangeable cations (Ca, Mg, Na and K) in a sample.
ESP	Exchangeable sodium percentage provides a measure of the sodicity of a materials and propensity to erode.
IOR	Intrinsic oxidation rate
Kinetic Test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
KLC test	Kinetic leach column tests are procedures used to measure the geochemical/ weathering behaviour of a sample of mine material over time.
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity. Calculated by multiplying the total sulfur or sulfide-sulfur (Scr) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acid conditions.

NMD	Neutral and metalliferous drainage typically caused by exposure of sulfide minerals in mine waste materials to oxygen and water and then neutralisation by gangue minerals. Typically characterised by neutral pH and elevated concentrations of salts, sulfate and metals.
NAPP	Net Acid Producing Potential, expressed as kg H_2SO_4 per tonne. Calculated by subtracting the ANC from the MPA.
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
pH	A measure of hydrogen ion (H^+) concentration; generally expressed as pH.
pH_{Ox}	Hydrogen ion concentration of the oxidised NAG solution.
ROM	Run-of-Mine. Ore as it comes from the mine prior to screening or processing.
S	Sulfur
SS	Sulfide sulfur
Scr	Chromium reducible sulfur. Analytical procedure to determine the sulfide sulfur concentration in a sample.
S_{PYR}	Sulfur as Pyrite.
S_{SO4}	Sulfur as Sulfate.
SO_4^{2-}	Sulfate.
Static test	Procedure for characterising the geochemical nature of a sample at a single point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
Tailings	Fine-grained mineral waste materials produced from the processing of coal or ore.
TS	Total sulfur content of a sample generally measured using a 'LECO' analyser expressed as TS%.
TSS	Total suspended solids is a measurement of the suspended solids concentration in a water sample.

1 Introduction

Evolution Mining Ltd (EML) operates Mount Rawdon Gold Mine Operation (MRO), which is located approximately 16 km southeast of Mount Perry and approximately 38 km northwest of Biggenden in Queensland. RGS Environmental Pty Ltd (RGS) was commissioned by MRO to undertake a conceptual level closure, decommissioning, rehabilitation plan (CDaR Plan) for the tailings storage facility (TSF). RGS commissioned ATC Williams (ATCW) and See Built Earth (SBE) as sub-consultants to work on this project. MRO commenced production in January 2001 with an initial process throughput of 2.25 million dry tonnes of ore per annum (Mtpa). The cyanide and carbon in leach (CIL) plant was upgraded in 2003 to a throughput of 3.7 Mtpa. A total of 50 Mt of ore has been processed up to January 2016, with the remaining ore reserves at Mt Rawdon being some 39 Mt, providing a remaining mine life of around 11 years (ATCW, 2016). The tailings from the CIL plant are deposited in the TSF using sub aerial deposition via perimeter spigots that direct supernatant to a central decant structure that is mainly constructed from potentially acid forming (PAF) waste rock.

MRO commissioned RGS to develop this CDaR Plan to evaluate viable closure options for the TSF and then recommend a preferred option for closure at the end of mine life (EoML).

1.1 Requirement for this plan

There are four distinct components of a “closure plan” that include:

- Defining the date of cessation of operations or the “closure date”, which is defined by the economic viability of the mine;
- Ascertaining how the plant and equipment and infrastructure will be decommissioned;
- Defining the way the landforms will be constructed and rehabilitated[1]; and
- Providing a pathway to relinquishment of the site (that could include perpetual management of the site if it cannot be relinquished to a third party).

The scope of work for MRO excludes the relinquishment pathway. The need for the CDaR Plan includes the following.

- Evolution requires a conceptual CDaR Plan for the TSF to understand the risks and opportunities associated with the TSF and to therefore reduce site and corporate risk.
- The TSF is a regulated structure that must be maintained and operated for the duration of its operational life until decommissioned and rehabilitated in a manner that is consistent with the current operational plan (refer to Environmental Authority (EA) EPML00712113 (Schedule H, H-12, (DEHP, 2017).
- The dam must not be abandoned, but must be decommissioned and rehabilitated to achieve compliance with Conditions G1 and G2 of the EA (Schedule H, H-27) (DEHP, 2017).
- Condition G1 of the EA requires all land disturbed by mining activities to be rehabilitated to achieve a number of rehabilitation objectives including:
  - safe to humans and wildlife;
  - non-polluting;
  - stable; and
  - able to sustain an agreed post-mining land use.

[1] There are three phases of **rehabilitation** that include reclamation, remediation, and restoration.
- **Remediation** is a legally and technically specific term for treating hazardous material to reduce or eliminate harm to human or environmental health.
- **Reclamation** returning a disturbed site to some useful purpose
- **Restoration** is a legally and technically specific term for returning a disturbed site to a more-or-less natural condition.

- Any seepage from the northern part of the TSF is intercepted by the sub-surface north drain and directed to Sediment Dam 1, prior to being pumped back to the TSF. Towards the south, any TSF seepage is collected in the underground Stan's Well and then pumped back to the TSF.
- The pH of the water in the TSF pond is generally mildly alkaline and brackish to mildly saline and static and kinetic data suggest low rates of sulfide oxidation and little, if any, potential to produce acidic drainage during operation of the TSF.

1.2 Purpose

This study has two components that include (1) a geo-environmental evaluation and (2) a conceptual closure decommissioning and rehabilitation plan (CDaR Plan).

The **purpose** of the **geo-environmental** evaluation is to:

- ascertain the type of cover that may be required on the TSF to reduce the risk of adverse environmental impacts; and,
- verify the type of soil cover that could be constructed on the TFS using readily available materials and document the cover system that would be required to meet the TSF basis of design.

The **purpose** of the TSF **CDaR Plan** is to document:

- the goals and objectives of the CDaR Plan; and,
- how the TSF is proposed to be closed, decommissioned and rehabilitated.

1.2.1 Objectives

The **objectives** or the TSF geo-engineering study package were to:

- identify potential borrow areas to source cover materials;
- ascertain the types of materials that are available within the borrow areas;
- develop an indicative material balance for each of the available materials;
- characterise the chemical and physical properties of each cover material and the tailings that are to be covered; and
- develop a material balance from viable borrow areas.

The **objectives** or the TSF CDaR Plan were in two parts.

Part 1 had the objective of:

- identifying potential and viable rehabilitation / soil cover options; and
- selecting a preferred rehabilitation / soil cover option.

Part 2 had the following objectives:

- use the material balance for each material type to produce potential configurations for the cover;
- document and verify cover design objectives and performance criteria;
- use numerical modelling methods (VadoseW) to evaluate the likely performance of viable cover configurations;
- evaluate the likely performance of the covers and their ability to meet the design objectives;
- produce a schedule of work to execute the construction of the cover options;
- evaluate the need for using other materials in the cover design if the cover design objectives cannot be met;
- document the findings in a risk and opportunity assessment considering environmental, technical and financial aspects;
- identify a preferred cover option and develop conceptual design drawings and material specifications for the components of the cover as won and as placed; and
- develop a sampling and monitoring program to evaluate the performance of the cover design after construction.

2 Design considerations for soil covers

In discussions with mining regulators on various mining projects, RGS has determined that the regulators typically suggest that mines should consider the application of impermeable or low permeability water shedding cover systems or cover systems that incorporate single or double capillary breaks. The DEHP financial assurance calculator includes single or double capillary break components for low risk and high risk materials. The intent of the proposed cover systems "preferred by mining regulators" is to decrease the potential for rain to percolate through mined materials into groundwater or to seep from the mine waste into surface water. In general terms RGS has inferred that mining regulators are opposed to store and release cover systems due to the perception that these cover systems may not have met performance objectives at some sites (eg. Kidston gold mine).

2.1 The context of success and failure

The discussion relating to mine waste management and the ability to close and rehabilitate mined landforms typically comes down to the need for the rehabilitated landforms to meet the goals of DEHP ie. be stable, safe to humans and wildlife, non-polluting and able to sustain an agreed post mining land use (DEHP, 2015a). In EM1122 ESR/2016/1875 (the Guideline for rehabilitation requirements for mining resource activities (DEHP, 2015a), the process of setting rehabilitation objectives, indicators for success and completion criteria that will lead to the rehabilitated area being surrendered is outlined (relinquished by the Department of Natural Resources and Mines (DNRM) and DEHP). Success is attained when the rehabilitation objectives have been met through completion criteria.

It is therefore imperative the design criteria that are established for a mine waste storage facility such as a TSF are attainable and do not lead to environmental harm in the receiving environment. Without clear and measurable completion criteria that have been agreed with DEHP, and that suitably qualified persons (SQPs) designated with the task of signing off on the rehabilitation can verify have been met, relinquishment of the mine (or specific domain within the mine footprint) is unlikely to be obtained and perpetual management of, and liability for, the site could result.

2.2 The need for containment of tailings and waste rock

The processed and mined materials in TSFs and waste rock storage facilities (WRSF) can range from being geochemically inert, having the potential for minimal adverse eco-toxicological or human health impacts, to potentially toxic. The physical properties of the materials also vary from clay sized fractions through to boulders. From the time that they are mined, the materials are subject to chemical, physical and biological weathering processes affect the stability and reactivity of the material. The mined landforms are not immune to the forces of nature and have the potential to weather and erode over time.

The methods that are applied to **close**, **decommission** and **rehabilitate** mine landforms are dependent on the **environmental risk** posed by contained materials as well as regulation and legislation. The most common approach applied to closure of these landforms is to **contain the material** to stop it being moved from the landforms into the receiving environment by wind and water.

Containment systems for mine landforms were developed from (or tended to align with) domestic, dangerous and hazardous waste landfill design principles that typically comprise a cover and a liner. There are a wide range of cover systems for landfills and the evolution of their design, that is relevant to the application of cover systems in the mining context, is discussed in the following sub-sections of this report section. This discussion is required, because the concepts and construction methods developed for landfills typically cannot be directly applied directly to mine landforms especially **if** large mining scale plant and equipment is used for cover systems: and this may be the typical assumption in closure planning at a mine site.

Cover systems for mine landforms can include **water cover** or **dry cover** systems and their use is governed principally by the **climatic variables** of the site. When the climatic variables are favourable, and rainfall is equal to or exceeds evaporation, water covers on a TSF can be achieved by permanent inundation (eg. Mount Kasi in Fiji) or variable levels of inundation (eg. wetland systems Henty Gold Mine on the West Coast

of Tasmania). Climatic considerations mean that a water cover is not a viable and sustainable closure option for the Mount Rawdon TSF and will not be discussed further.

2.3 Clay landfill liners

Liners under landfill waste were the first application of compacted clay “barriers”. Clay liners in landfills are successful because they tend to remain wet and are under constant compacting pressure (Hauser, 2009). Because of this, these types of clay liners are not prone to dry out, desiccate and crack.

2.4 Landfill dry cover system dynamics

Soil cover systems function at the interface between the atmosphere, biosphere and the geosphere (Wilson, 2003). The soil/atmosphere boundary is responsible for the partitioning of all incoming energy (ie. short-wave and long-wave solar radiation) together with meteoric water (Wilson, 2003). Fluctuations in temperature, soil water potential, and heat and mass transfer rates are the most extreme at this position within the soil–atmosphere profile (Wilson, 2003). Soil cover systems are essentially designed to control these variables (Wilson, 2003). Examples of dry systems include:

- geotechnical methods such as encapsulation with HDPE that provide an impermeable cover;
- chemically inert and geotechnically competent rock covers; and
- soil cover systems that range from monolithic analogue soil covers through to highly engineered multi-layer soil cover systems.

2.5 Performance of conventional landfill covers

The ITRC series of landfill document provide substantial information on the alternative landfill cover program (ITRC, 2003a, 2003b, 2006a and 2006b). Most landfill covers in place today in the USA are conventional cover systems. The conventional style of cover systems are **soil barrier covers** because both state and federal regulatory officials have readily accepted them in the past (Hauser, 2009); this style of cover system is also the conventional landfill cover system used in Australia (Salt et al., 2010). They include one or more barrier layers within the cover and they meet the presumptive requirements for containment. The intention is that the barrier should oppose the forces of nature and prevent water from moving downward in response to the force of gravity. A common misconception is that the barrier layers are “impermeable”; this is seldom, if ever, true (Hauser, 2009).

Barrier covers include shallow soil covers underlain by compacted soil or compacted clay and some barrier systems also have permeable drainage layers (Hauser, 2009). Landfill cover systems are regulated and have specified engineering criteria applied to their design and construction (Hauser, 2009). In the USA two styles of soil barrier covers include the RCRA Subtitle C and Subtitle D covers.

The **RCRA Subtitle D Compacted Soil Barrier Cover** is a modified compacted soil barrier typically comprising:

- soil to support grass and reduce erosion;
- compacted soil (or clay) to reduce infiltration; and
- the foundation layer sourced from local borrow material.

Subtitle D covers are widely accepted for use as final landfill covers in arid and semiarid locations (Hauser, 2009) and have specified design criteria. The RCRA Subtitle D has a specified maximum hydraulic conductivity of 1×10^{-5} cm/sec that would allow 315 mm/yr of deep percolation of water through the upper soil profile if the barrier layer were continuously wetted with a hydraulic gradient of 1.

Despite their wide use and acceptance soil barrier cover systems have variable performance. Hauser (2009) presents data from four compacted soil barrier trials in the US conducted from 1996 to 2004. While there was some success of some covers the general findings by Hauser (2009) were that the compacted soil barrier cover system has the following deficiencies.

- The thin topsoil layer has limited water holding capacity.
- There is no drainage layer.
- Roots find it difficult to penetrate the compacted layer.
- Physical weathering (freezing and wetting and drying) increase the k value up to 10,000 times its as-built value due to development of cracks in the compacted layer.
- Roots will enter the cracks increasing the rate of physical weathering.

The **Compacted Clay Layer (CCL) Barrier Cover** is a **variation of the Subtitle D** Compacted Soil Barrier Cover that incorporates a drainage layer. The use of compacted clay in the cover systems stemmed from the success of using clay liners in the base of landfills, the use of compacted clay to form a low permeability barrier in a soil cover profile was an obvious first choice for landfill cover design (Wilson, 2003). Unfortunately, the physical environment and associated stresses for compacted clay liners situated deep within the soil profile are radically different from those at the soil surface (Wilson, 2003, Hauser, 2009). The compacted clay layer (CCL) of a RCRA Subtitle C barrier cover is typically 0.6 m deep and USA federal regulation require a saturated hydraulic conductivity (K) of ≤ 1 x 10^{-7} cm/sec that allow 32 mm/yr of deep percolation if the barrier layer were continuously wetted with a hydraulic gradient of 1. Even though these cover systems are widely accepted, they are prone to leak and can be expected to fail. The general findings by authors in Hauser (2009) who evaluated six sites were that the compacted clay layer barriers have the following deficiencies.

- Suter et al, 1993 reported that clay barriers in covers on landfills were likely to fail in the long term due to natural physical and biological processes
- Warren et al 1996 reported trace leakage in a semi-arid climate after 3.8 years
- Melchior 1997 reported that in cool wet climate clay barriers leaked 8 or 9% and that after 8 years leakage rates were increasing
- Albright et al 2006a concluded that in a wet sub-tropical site numerous cracks and roots appeared in the clay barrier as a result of a drought and this led to an increase in the hydraulic conductivity
- Albright et al 2006b concluded that large increases in the hydraulic conductivity of clay barriers in cover systems with time are not uncommon

With respect to the application of clay barriers covers in Australian mines, the most commonly known and studied barrier cover was placed on waste rock at the Rum Jungle uranium mine in Northern Territory. In 2003, an Australian government survey of the tailings piles at Rum Jungle found that covering with a 625 mm multilayered cover system, which was supposed to help contain radioactive waste for at least 100 years, had failed in less than 20 years (Taylor et al., 2003). The deterioration in cover performance with respect to water infiltration appeared to be due to increased permeability related to the formation of shrinkage crack in the clay rich layer combined with illuviation of coarse materials into the cracks and to the effects of root penetration and formation of termite galleries (Taylor et al., 2003), specifically:

- Physical weathering (freezing and wetting and drying) increased the hydraulic conductivity by up to 10,000 times its as-built value due to development of cracks in the compacted layer.
- Roots entered the cracks increasing the rate of physical weathering.

Geomembrane Barriers were found to leak and most of the causes of failure were due to holes in membrane produced during construction (seven sites were evaluated in 1995 by Crozier and Walker in Hauser, 2009).

Composite Barriers that can include a clay barrier covered by a geomembrane are accepted as the best conventional barrier system (Hauser, 2009). Evaluation of 13 composite barrier covers from 1997 to 2004 found that sites with more than 240 mm of annual precipitation leaked and the test sites allowed from 2 % to 7 % of annual precipitation. As the limitations of conventional soil and clay barrier covers became apparent through vigorous cover system trials in the USA from 1996 to 2006 there was a move to evaluate alternative landfill cover options.

2.6 Performance of alternative landfill covers

Alternative barrier covers investigated in the USA between 1997 and 2004 (Albright et al, 2010) include:

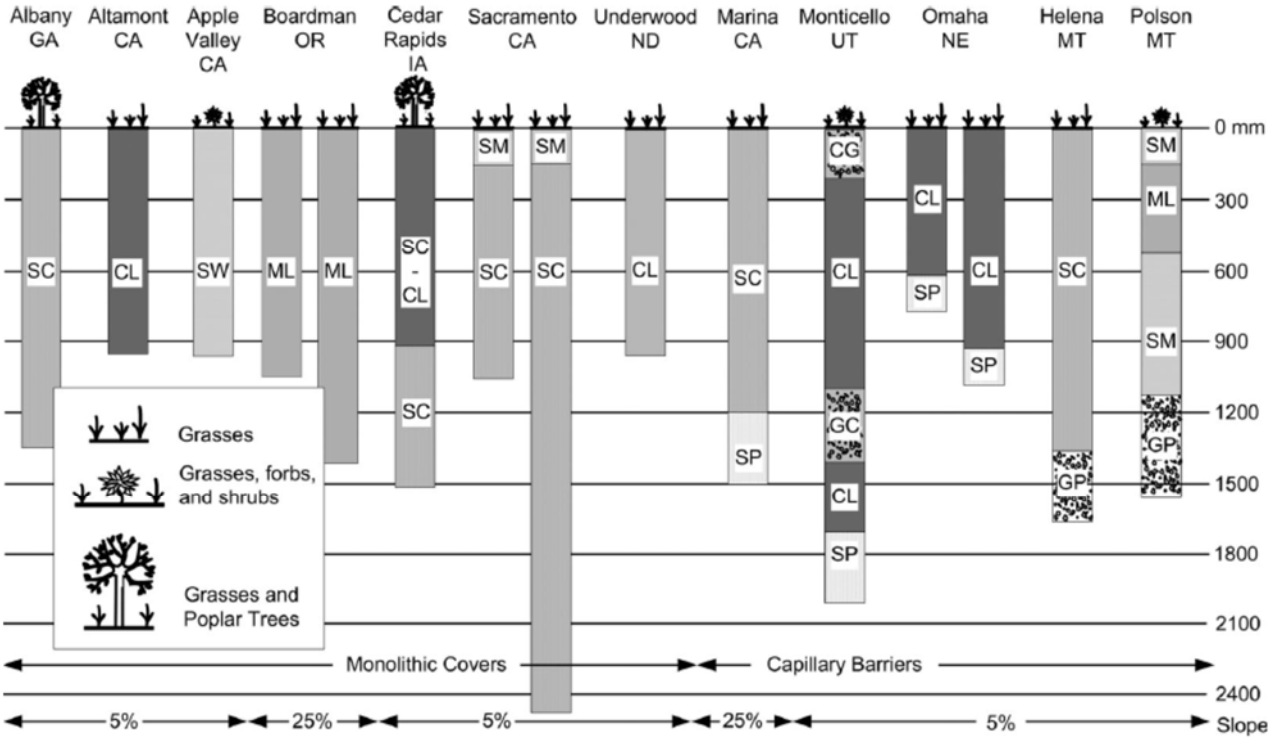
- capillary barriers utilising a layer of fine grain soil over a coarse material such as sand or gravel that may include;
  - surfaces with vegetation (15 trial sites)
  - surfaces without vegetation (rock covers) (4 trial sites);
- dry barriers to allow ingress of air to expel gas;
- asphalt barriers;
- modified surface runoff covers; and
- vegetative covers (9 sites) using a monolithic cover design.

The capillary barrier is an alternative to conventional barrier layers. The capillary barrier utilizes two layers: a layer of fine soil over a layer of coarser material (eg, sand or gravel sized material). A geotextile over the coarse layer is required to control intrusion of fines into the coarse layer. The barrier is the discontinuity in soil pore size found at the interface between the coarse and fine soil. Capillary force causes the layer of fine soil overlying the coarser material to hold more water than if there were no change in the pore size of the layers. Lateral drainage, evaporation, and plant transpiration remove water stored in the soil above the barrier. A plant cover to remove water stored in the fine soil is part of a capillary-barrier cover. A capillary barrier is effective if the combined effect of evapotranspiration, soil water storage, and lateral diversion exceeds the infiltration from precipitation, thereby keeping the system sufficiently dry so that breakthrough does not occur. This barrier can fail if too much water accumulates in the fine-soil layer or if the desired large change in pore size is missing in spots. It can also fail through differential settlement effects in both the covered and cover system materials, which are common at mining operations.

The **RCRA Subtitle C Capillary Barrier Cover** may have five or more layers comprising:

- soil to support grass and reduce erosion;
- a drainage layer constructed of sand or gravel to remove water via lateral drainage;
- a barrier layer of either compacted clay, geosynthetic clay liner (GCL), geo-membrane (GM), high density polyethylene (HDPE), linear low-density polyethylene (LLDPE), polypropylene (PP), polyvinyl chloride (PVC) or a combination of these material;
- gas collection layer constructed of sand or gravel to remove water via lateral drainage; and
- foundation layer sourced from local borrow material.

The capillary-barrier system may perform better than conventional clay hydraulic barriers, because it is not subject to desiccation and cracking. It may be preferred where soils with high water-holding capacity are unavailable or expensive and in dry climates. A summary of the cover configuration of the 15 trials comprising vegetated capillary cover systems is in **Figure 2-1** (Albright et al, 2010).



United Soil Classification symbols are shown eg. SC, SM, CL

Figure 2-1: Vegetated Capillary Barrier Landfill Covers (source Albright et al., 2010)

The 15 measurements of the performance of vegetated capillary barriers in **Figure 2:1** show that they frequently leaked (Hauser, 2009 and (Albright et al, 2010). Covers with a thin soil cover produced more leakage than those with thick soil covers. The likely cause of leakage in many cases appears to be soil compaction that may have restricted root growth. The single test with adequate soil density and a thick soil cover allowed no leakage. For vegetated covers, even though success was expected, many vegetated covers failed to meet expectations for a landfill cover by allowing a significant amount of precipitation to infiltrate through the cover.

Experience from landfill sites indicates that a drainage layer on top of a clay layer increases the risks of desiccation and cracking of the clay barrier (Kistinger *et al*.,2002). On the other hand, a drainage layer can improve the geo- mechanical stability (slope stability) of the system and can act as a capillary barrier against moisture flow from the clay into the upper layers of the cover system during dry periods (Kistinger *et al*.,2002). The discussion concerning the benefits and drawbacks of a drainage layer in a cover system was ongoing as of 2002 (Kistinger *et al*.,2002).

Anderson (1997) (in Hauser, 2009) stated that "*failures of earthen barriers as final caps on landfills in arid or semiarid regions likely result from insufficient depths of soil to store precipitation and support healthy stands of perennial plants*." Both the Los Alamos and the Sacramento plots support Anderson's (1997) statement that inadequate soil water-holding capacity is likely to cause failure for vegetated covers. All test had vegetated covers whose purpose was to remove water stored in a soil profile. Table 3.3 in Hauser 2009 contains performance measurements for seven experimental, alternative covers stated to have compacted soil in the cover or soil density equal to or greater than 1.7 Mg/m^3; none were successful. The data presented in Table 3.3 in Hauser (2009) show that high soil density is likely to produce failure for vegetated covers.

2.7 Current industry practice

Because of the limitations of conventional impermeable or low permeability soil and clay cover and alternative capillary barrier cover systems (Albright et al., 2010; Yuen., et al., 2011; Salt et al., (2011); and Hauser, 2009), the next phase of landfill cover designs moved towards work devoted to (i) evapotranspiration

covers or water balance covers as they are known in the USA landfill sector (Albright et al., 2010), (ii) phyotcaps as they are referred to in Australia in the landfill sector or (iii) store and release covers as they are referred to in the mining sector.

In 2003 in a review of the integrity of cover systems by leading practitioners in cover system design it was determined that despite the construction of hundreds of covers there was only limited documentation describing the success or failure of these systems: Rum Jungle, Kidston and Equity Silver (Wilson et al., 2003). A technology for the analysis, design, instrumentation and monitoring of barrier-type (oxygen limiting) and store/release type covers developed through the mid 1990's to early 2000's and the number of covers under construction had grown extensively (Wilson et al, 2003). In 2003 mine operators began investing in store and release approaches with the expectation that these covers would reduce long-term liability with respect to acid generation, drainage and treatment costs (Wilson et al, 2003). It was anticipated that while the design life for cover systems could extend into hundreds of years, in 2003 there was less than ten years of construction experience and proven performance (Wilson et al, 2003). In 2003 some cover designs appeared to be functioning well; however, the performance of many more was being called into question (Wilson et al, 2003).

In 2014 the body of knowledge relating to store and release covers was limited to field trials at Kidston, Century, Mt Whaleback and Cadia where the final land use was a return to habitat. In 2016 there is very little additional publicly available information given the huge amount of work that had been completed globally.

Anecdotally (as discussed earlier) store and release cover systems are, considered to be, inadequate by DEHP if the intention of the cover is to stop the occurrence of AMD as seepage from a landform. However, decades of data from well-designed, constructed, monitored and maintained landfill cover trials in the USA and Australia has verified that earthen covers leak, and they leak for a myriad of reasons. Soil and clay barriers and even capillary break covers (with vegetation) have not met the design objectives and led to regulators in Australia and the USA evaluating the capacity of store and release covers to meet the needs of landfills. In Australia, there are clear guidelines for the siting, design, operation and rehabilitation of landfills (DEHP, 2013a) ie.:

"*A key element of the rehabilitation is the capping of the landfill. The design objectives listed in the DEHP guideline (DEHP, 2013a) for the final landfill surface or capping are to:*

- *isolate the deposited waste from the immediate environment*
- *reduce leachate generation by limiting water infiltration*
- *reduce surface emissions of landfill gas and assist in odour management*
- *improve the efficiency and effectiveness of any gas collection or management system*
- *provide a stable and sustainable land form fit for its intended future purpose.*

The performance of the capping system will be based on the outcomes from the risk assessments for the site. Alternative landfill caps, such as evapotranspiration caps (also referred to as 'ET caps') or phytocaps are increasingly being proposed in Australia and used internationally. Ultimately, any proposed site capping system must undergo a robust design, assessment and construction process to ensure an acceptable level of environmental performance, proportional to the environmental risk from the site. Where satisfactory evidence of a conventional or alternative systems performance is demonstrated its use will not be unreasonably withheld (DEHP, 2013a)".

It is clear from the wide body of research that a zero approach to seepage cannot be obtained in landfill covers, and will not be obtained at mine sites using geological materials and current TSF and WRSF construction methods. It must be accepted that seepage will occur when the capacity of the cover system to store water is exceeded: this may only occur during extreme climatic events that may occur on decadal cycles.

The performance of the cover system is dependent on the materials that are available, the degree of consistency within each material type, the type of machinery that is used, and the level of engineering control applied during construction.

Soil cover systems are civil engineered structures and will have a finite design life. For comparative purposes paved roads that have rigorous design criteria, low tolerances (variations for design specifications) for the types of materials that are used and controls in place to ensure the materials are placed in accordance with the design specifications are likely to have a design life of little as 25 years.

2.8 Re-evaluating design considerations

Dedicated research over 30 years in the landfill sector has verified that the engineered earthen cover systems (excluding synthetic materials) can reduce but will not stop seepage from landfills. This fact applies to soil covers through to engineered multi-layer and barrier covers.

The construction of a soil cover system on mineralised material will:

- not reduce the overall AMD potential of the mineralised waste
- stop, erosion by wind or water, and the mobilisation of contaminated dust, suspended and bedload sediment into the receiving environment ie. the solid phase materials will be contained;
- delay and lengthen the contaminant release rate from the contained material.

Thus, the contaminant load in the seepage per unit of time (ie. the contaminant release rate) is reduced, so that lower contaminant loads are discharged over a longer time span. Ideally, a cover system should reduce the contaminant loads discharged with the seepage to levels that – even without seepage treatment – contaminant concentrations in the receiving water bodies do not exceed acceptable levels: this is a fundamental principle of geochemical engineering. Even if some water treatment is still required after cover construction, the long-term costs may be lower than for a simple collect-and treat option, due to financial discounting of future expenditures and potential improvements in water treatment technologies (eg. passive or microbiological treatment (Kistinger et al., 2002)).

Some of the key points that need to be addressed when developing soil cover systems are summarised below.

- **Define the next land use**. The configuration of the cover system and the intended purpose of the cover and the landform after it is relinquished by the mine should up front ie. what is the purpose of building the cover and what is the rehabilitated land going to be used for? At this stage RGS envisages that the next land use of the TSF will be to support vegetation and provide habitat for fauna.
- **Construct a cover to meet the defined land use**. A cover that will meet the goals of being stable, safe and non-polluting requires construction of a soil cover that will partition rain as surface runoff, store it within the soil cover for transpiration and allow sufficient percolation to the tailings to maintain them under saturated conditions to limit oxidation of sulfide minerals without creating a positive hydraulic head that would result in excess seepage from the TSF to groundwater or surface water as a resurgent seep. Some of the key design considerations required to meet these goals and design criteria are provided below.
    - Suitable soil physical properties are required to minimise adverse effects on plant growth and root development: these properties include particle size distribution, bulk density, hydraulic conductivity, moisture retention, dispersion and shrinkage. Similarly, appropriate chemical properties, such as pH, EC, exchangeable cations (Na, K, Ca, Mg), macronutrients (N, P, K, Ca, Mg, S), micronutrients (B, Cu, Fe, Cl, Mn, Mo, Zn) and organic carbon are required to be achieved that are conducive to the vegetation that will colonise the site over time.
    - Without suitable chemical and physical properties, vegetation is likely to be impacted and the rate of evapotranspiration will be reduced, thereby increasing infiltration, percolation to groundwater and resurgent seepage to surface water.
    - A primary mechanism for limited success in store and release systems is lack of water storage capacity. Storage capacity is controlled by the soil water characteristic curve of the cover profile in the active root zone. In the same way that environmental stressing due to wetting and drying, freezing and thawing degrades hydraulic conductivity for barrier soils, these mechanisms also tend to reduce water storage capacity.

- The primary objective of placing a store and release layer is to use the material with a high porosity and a gently sloping soil water characteristic curve (Wilson, 2003). Thus, the material is placed in a loose non-compacted state. Wetting and drying may cause the soil structure to consolidate and/or become aggregated with the formation of soil peds (particularly in the case where the soil contains clay). A significant reduction in porosity as well as an increase in density can be observed. In some cases, a reduction in storage capacity of up to 50 per cent may occur.
- Clay-rich soils are sensitive to volume change. While highly plastic clay materials have proven to be successful in the construction of liners, they are not suitable for the construction of cover systems. Highly plastic clay, commonly referred to as expansive soil, is widely regarded as a problematic soil when used to construct highway pavements. Road builders have known this for decades. The design of pavement structures shares the same physical environment and climatic extremes as those for soil cover systems. In some ways, the approaches used in pavement/road design may have formed a better starting point for the development of cover design when compared to liner technology. The design of pavement structures is rooted in material science. Clays and silts are problematic soils for road construction. The same can be said for the construction of cover systems. While highly plastic clay materials provide the lowest values of saturated hydraulic conductivity when compacted, they degrade rapidly in the active zone (ie. the upper 0 - 3 m of the soil profile with seasonal variation in temperature and water content). Silt-rich soils are somewhat less susceptible to volume change, but are most susceptible to erosion. Sand and gravel soils offer high strength and are relatively incompressible compared to clay. However, granular materials have higher permeability with poor moisture retaining capacity and offer no benefit with respect to barrier or store and release covers. Well-graded materials have proven to be the best performers for the construction of the base and sub-grade layers in pavement structures. In general, this rule can be applied to cover systems.
- Store and release covers require material to be placed at a density that will not impede root growth, particularly in the early stages of development. This is key consideration for construction as most mines will try to utilise large mining plant and equipment to reduce construction cost. The typical approach is to rip along contour, sometimes with winged tynes to break the soil up after it is placed to overcome compaction issues.
- The availability of appropriate material can be a major constraint. The ‘ideal’ soil for a phytocap is a well-structured loam soil with slightly acidic to slightly alkaline pH, low or no salinity, moderate to high organic matter content (2–5%), low to moderate saturated hydraulic conductivity and large available water storage ((Salt et al., 2011) The good structure and loam texture tend to result in large available water content; low to moderate saturated hydraulic conductivity tends to result in occasional runoff while limiting drainage; very low saturated hydraulic conductivity tends to result in increased runoff, while higher saturated hydraulic conductivity tends to result in excessive drainage (Salt et al., 2011).

- **Consider the probable performance of the store and release cover system** in terms of its ability to develop and sustain vegetation, and determine how the performance of the vegetation will change over time. Actual evaporation from a bare or non-vegetated soil cover will generally only be about ten per cent of the potential rate of evaporation available. High evapotranspiration can only be obtained with a fully developed plant canopy.
  - At Kidston Mine, the **decline in water transpiration rates** over the first few years was due to a lack of nutrients that reduced vegetation growth and vitality. While this reduction in performance was easily corrected with the addition of fertiliser, the need to monitor ongoing performance was demonstrated (Durham, Wilson and Currey, 2000 in Wilson et al., 2003). Furthermore, there is a lack of data to describe root water uptake as a function of nutrients or to predict the progression and natural succession of plant communities. Natural ecosystems in semi-arid or arid environments are nutrient deficient and the vigour of the vegetation ebbs and flows with cyclic rainfall patterns.
  - The **variability in rainfall over annual, decadal or multi-decadal cycles** has a major effect on the performance of a soil cover system and the vegetation on it. Soil cover systems should be

designed to manage a defined percentage of rainfall. To design a soil cover that will accommodate the maximum rainfall event likely at a site would be unreasonable and even if a deep soil cover was placed on the mined landform to provide the theoretical water storage requirement, during extreme rainfall events preferential flow would become the controlling hydraulic process and ultimately lead to percolation and seepage.

  - Despite the large scientific body of data there is very **little quantitative information relating to the root depth** of grass, shrubs and trees that will almost certainly migrate through a store and release cover into the underlying mine waste unless it is deep enough to preclude the potential for this to occur. Plant roots living, and more so dead, provide preferential pathways into the underlying material. Grass, shrub and tree root depth can be in the order of 0.3 to 1 m, 1 to 3 m and 1 to 40 m respectively (Salt et al., 2011). If deep plant roots are to be excluded from underlying mine waste this could require ongoing maintenance and clearing.
  - In general, the primary mechanism for **failure of barrier-type cover systems** is that the active biogeochemical zone penetrates the barrier layer. Repeated cycles of wetting and drying produce environmental fatigue in the barrier layer. Highly plastic clays have the highest sensitivity to these stresses and develop a nuggety, fractured structure in the active layer resulting in values of in situ hydraulic conductivity three and sometimes four orders of magnitude greater than the value measured in a compacted state in the laboratory.

- **Topography and landform placement** also has a major effect on the hydraulic performance of a mined landform. If the landform is prone to flooding the rising water can seep into the landform through its base mobilising years or decades of weathering products that can subsequently drain from the landform as the flood water recedes. The lag effect from post flood events is a notable risk because the seepage from the base of the landform can occur for days or weeks after the flood water has receded resulting in a plume of poor quality water impacting the land (and potentially) the water resources in the receiving environment.
- **Erosion is a failure mechanism** that may destroy the integrity of any cover, and is almost certain on steep, long slopes (Wilson et al., 2003). This may be attributed to three key factors. Firstly, store and release covers are placed as loose, low-density materials. Secondly, the vegetative canopy is often stressed due to lack of rainfall and thus the surface of the cover becomes exposed and susceptible to erosion. Finally, the nature of semi-arid climate systems generally produces high intensity storms. The concepts and mechanisms for failure or loss of cover integrity described above are largely subjective. For example, there are no theories available to describe or quantify the influence of weathering on the reduction in storage capacity for store/release covers, or to describe the change in saturated hydraulic conductivity due to wet/dry/freeze/thaw cycles.
- **Fire is a natural hazard** and will lead to a temporary or prolonged absence of vegetation and ground cover increasing the risk of erosion. Fire can move vertically into the root systems of some trees providing increased pathways for the percolation of water.

2.9 Range of costs

2.9.1 Landfill cover systems

There are few documented examples of the cost associated with the construction of landfill cover systems and even less relating to the cost of construction of cover systems for mine landforms. Some available data **Table 2-1)** indicates that the cost of landfill covers is substantially higher then cover costs for mine landforms. There are clear reasons for this, which include the following.

- Cover systems constructed on landfills are subject to regulated performance criteria that must be met.
- Cover systems constructed on landfills are constructed with civil design plant and equipment, not mine site plant and equipment, thus the unit cost to move and place dirt and rock on landfills is much higher.

Table 2-1: Landfill cover system costs

1998 (Dywer) (Sandia 1988)	**Cost/ha ($US)**
2 layer soil cover	$ 51,400
2 layer evapotranspiration cover	$ 73,890
4 layer anisotropic layer	$ 75,260
2 layer GCL soil / sand drainage layer	$ 89,990
5 layer capillary break cover	$ 92,640
3 layer compacted clay soil / sand drainage layer	$ 157,540
2003 (Wilson et al)	**Cost/ha ($US)**
Simple vegetative cover	$ 10,000
Monolithic barrier cover	$ 35,000
Two layer store and release cover	$ 50,000
Multi-layer barrier cover	$ 100,000
Highway base	$ 150,000
Composite cover for landfill	$ 400,000
2006 (Rykaart et al)	**Cost/ha ($US)**
Reclamation covers	$ 2,000
	$ 20,000
Simple covers	$ 20,000
	$ 100,000
Complex covers	$ 100,000
	$ 800,000
2014 (NJDEP)	**Cost/ha ($US)**
5 layer asphalt pavement	$ 83,054
5 layer clay cover	$ 545,884
5 layer geomembrane cover	$ 395,039
6 layer geo-membrane soil cover	$ 814,565
2 layer 60 cm soil cover	$ 106,480
2 layer evapotranspiration cover	$ 485,544
2014 (Smith and Athanassopoulos)	**Cost/ha ($US)**
Composite MSW cover - lower cost	$ 300,000
3 layer GCL soil / sand drainage layer	$ 365,000
Evapotranspiration cover	$ 365,000
Composite MSW cover - upper cost	$ 470,000
Geomembrane/CCL - lower cost	$ 788,000
CCL cover	$ 1,235,000
Geomembrane/CCL - upper cost	$ 1,410,000
2011 (A-ACAP) Salt et al., 2011	**Cost/ha ($AU)**
1.5 m store and release cover	$250,000
2016 March*	**Cost/ha ($US)**
Hypothetical multi-layer clay / geomembrane cover	$660,000 to $1,760,000

* http://foresternetwork.com/daily/waste/landfill-management/landfill-economics-part-ii-getting-down-to-business-part-i/

2.9.2 Landfill liner unit rates

As installed unit costs in $US from 2006 are provided for a range of cover / liner materials (Kadlec and Wallace, 2008) for reference in **Table 2-2**.

Table 2-2: Landfill liner unit costs (as of 2006)

Material	**Thickness**	**Installed Cost $/m^2**	**Installed Cost $/ha**
Bentonite	10 kg/m^2	7.96	$ 79,600
Native clay (short haul)	30 cm	7.50	$ 75,000
Clay geotextile	NS	4.84	$ 48,400
PVC	0.76 mm	4.09	$ 40,900
HDPE	1.5 mm	4.73	$ 47,300
Polypropylene	1.02 mm	5.92	$ 59,200
Reinforced Polypropylene	1.14	6.89	$ 68,900
Hypalon	0.76 mm	6.89	$ 68,900
Hypalon	1.52 mm	8.07	$ 80,700
XR-5	NS	11.19	$ 111,900

3 Project description

3.1 Existing basis of design and financial assurance

3.2 Proposed basis of design

- Ramping down of open cut mining in 2026 and cessation of tailings deposition in 2027
- The current landform of the TSF is concave in shape, and directs supernatant and runoff towards the decant structure
- The final landform of the TSF will slope from north to south resulting in the last stage of operations placing the final decant pond up against the western haul road, which runs from the pit to the TSF
- Final planned southern TSF embankment elevation will be some RL 193 m
- The final planned north, east and western TSF embankment elevations will be at RL 193 m plus some 10 m to achieve a 1:100 gradient from the north to south, and additional 2 m for the cover layers. This would result in an estimated final TSF elevation of RL 205 m.
- High capacity (PAF-HC) waste rock placed within the TSF will be covered with tailings shortly after placement. Whereas, the moderate capacity (PAF-MC) material will be placed as a dump and finally covered with tailings towards the end of 2026. The dump batters will be progressively covered with tailings as the tailings level in the TSF increases, and the final tailings cover will be minimum 3 m of tailings.
- After placement of final tailings in 2027 the surface will be progressively covered in NAF rock to provide a stable foundation for construction of the soil cover. This placement of rock may take in the order of three years to allow for consolidation of the tailings and to reduce the potential for lateral displacement of tailings.
- Drainage of the TSF surface will be required to assist with creating a stable foundation and manage stormwater during the placement of NAF rock and the construction of the soil layers. Stormwater will be discharged via the haul road and into South Dam and eventually into the Pit, once South Dam has been rehabilitated.

3.3 Catchment Area

The TSF cover project is limited to the catchment area that has the potential to report to the surface of the TSF. RGS notes that the CDaR Plan will need to consider the broader aspects of the site. For example, if surface runoff from the TSF cover is directed to the final void the impact of this on the rate the void fills with water and the evolving quality of water will need to be evaluated.

Erosion and rehabilitation of borrow areas is excluded from the TSF design ie. this will not be quantified or modelled, but will be considered in the risk and opportunity assessment (RaOA) and qualified in the report.

3.4 Tailings Storage Facility

The TSF cover project is limited to the surface of the existing TSF and excludes the embankment(s) and drains around the TSF.

Impacts to the embankment walls (eg. geotechnical stability) or perimeter drains (eg. erosion, sedimentation) are excluded from the RGS scope of work ie. this will not be quantified or modelled, but will be identified in the RaOA and qualified in the report.

Geotechnical and dam safety aspects of the TSF are excluded from the RGS scope of work and are being addressed separately by MRO.

3.5 Hydrogeological Impacts

In the scope of work SBE will provide input to the risk and opportunity assessment (RaOA) and address aspects such as existing seepage from the TSF and projected changes to the TSF seepage if the proposed cover system is constructed on the TSF.

3.6 Ecology

Ecological data gathering, species identification and vegetation mapping were excluded from the RGS scope.

3.7 No go Areas

MRO has provided no-go areas for the TSF study area (see **Figure 3-1)**.

3.8 Rehabilitation of Borrow Areas

MRO has verified that the potential borrow areas will be rehabilitated per standard site rehabilitation procedures and that RGS is not required to consider this in the study package.



Figure 3-1: TSF Major Features

4 Tailings storage facility

4.1 As Designed TSF

The existing TSF (comprising the Stage 4A and 4B development) is described by ATCW as comprising a valley-type storage, formed by a primary embankment at the northern (downstream) end of the site, an upstream embankment at the southern end and a saddle back embankment at the western end of the site (ATCW, 2016). The major stages of development of the TSF from pre-development to 2016 are described in **Figure 4-1**.

An internal wall has been constructed for isolating an internal cell towards the western edge of the TSF to allow for rehabilitation trials on the tailings surface. The configuration of the existing TSF comprises the following:

- Current embankment crest level RL 172.0 m
- Proposed 4C embankment crest level RL 175.0 m
- Potential 5F Maximum embankment crest level RL 193.0 m
- Current spillway invert level RL 171.0 m
- Spillway width 10 m
- Embankment lengths
  - Northern Embankment 1,700 m
  - Southern Embankment 1,500 m
  - Western Embankment 80 m
- Maximum embankment heights
  - Northern Embankment 60 m
  - Southern Embankment 41 m
  - Western Embankment 6 m
- Embankments crest width
  - Northern Embankment 7 m
  - Southern Embankment 7 m
  - Western Embankment 7 m
- Current Storage Area (at full supply level) 119 ha
- Maximum Storage Area (at full supply level) 112 ha
- Current Storage Capacity (solids and water) 34,100 ML
- Maximum Storage Capacity (solids and water) 45,600 ML

4.2 Tailings Physical Properties

ATCW (2016) characterise the tailings as

- Sandy Silt / Silty Sand (SM-ML), Non-Plastic
- Particle Density 2.6 t/m^3
- Particle Size Distribution P80 106um
- Atterberg Limits Non-Plastic
- Laboratory Permeability 10^{-6} to 10^{-8} m/s
- Undrained Settled Density 1.2 t/m^3
- Drained Settled Density 1.6 t/m^3

In-situ permeability testing using double ring infiltrometer by RGS and ATC during the site visit for this study verified that the tailings have a very low permeability (1.04E-06 m/s).

4.2.1 Tailings Deposition

Beaching/deposition of tailings within the TSF has occurred by sub aerial peripheral discharge techniques. This approach has been encouraged to maximise decant water recovery, forming a significant objective of the surface water management strategy for the TSF. The decant pond extent is therefore minimised, which exposes beach areas to air-drying and consolidation and contributes to development of a geotechnically competent tailings beach.

4.3 Tailings Stability

Exposed tailings beaches within the existing TSF area are variable in terms of strength/geotechnical integrity depending on the age of the beach surface. It is considered that access (by foot or plant) is not available if the tailings surface less than six weeks old. The anticipated (minimum) beach strength beyond six weeks is inferred to be as follows:

- 3 months 10 to 25 kPa
- 6 months 25 to 50 kPa
- 12 months, greater than 50 kPa not more than 100 kPa, due to material and beach variability the strength could range typically between 50 and 100 kPa

Based on these conditions, access to and construction on a dried tailings surface beyond an age of three months is considered feasible: note that a D6 Swamp Dozer exerts 35 kPa. Detail evaluation of the consolidated surfaces will be required prior to commencing with construction activities. During the site visit heavy machinery was working on the tailings within the perimeter of the TSF embankment. Nominal risk ratings pertaining to accessibility on the TSF could include the following:

- Very High Risk - very low bearing capacity < 25 kPa
- High Risk - low bearing capacity > 25 and < 35 kPa
- Moderate risk - bearing capacity > 35 and < 55 kPa
- Low risk - high bearing capacity > 55 kPa: note that the soil profile below a topsoil horizon is generally of moderate strength and may have an inferred undrained shear strength of 100 kPa (ATCW, 2016).

4.4 Tailings Geochemistry

The total sulfur (TS) and sulfide sulfur (CRS) concentrations in the tailings have remained consistent between 2011 and 2016. Analysis of the historic TS data from the geology model and data from site geology database could be evaluated in more detail by MRO to ascertain if the TS and ANC ratio observed historically is likely to continue over the projected LoM. Indications are that the tailings stream will not differ in terms of TS, CRS or ANC over the remainder of the LoM. Additional information on the tailings and waste rock is provided in **Section 8.1.**

Table 4-1: Tailings TS, CRS and ANC Data (Averages)

Dec-11	TS%	CRS %	% Sulfide	MPA	ANC (kg H_2SO_4/t)	NAPP	ANC:MPA
TSF West Cell							
Surface (n=6)	1.3	0.89	68.8	27.2	51.0	-23.8	1.9
50 cm (n=6)	1.4	1.06	74.2	32.5	43.7	-11.2	1.3
100 cm (n=6)	1.2	1.03	88.9	31.4	46.7	-15.3	1.5
Nov-15	TS%	CRS %	% Sulfide	MPA	ANC (kg H_2SO_4/t)	NAPP	ANC:MPA
TSF West Cell							
Surface (n=4)	1.1	0.8	71.4	24.6	36.6	-11.9	1.5
Sep-16	TS%	CRS %	% Sulfide	MPA	ANC (kg H_2SO_4/t)	NAPP	ANC:MPA
Main TSF Cell							
Spigot (n=4)	1.5	1.2	80.0	36.7	35.4	-1.3	1.0

4.5 Tailing Supernatant

Monthly supernatant (tailings pond) water quality data from Jun 2009 to Nov 2016 provides the following information.

- pH (n=277) Min. (7.1), Num. Av. (8.2) and Max. (9.1)
- EC (µS/cm) (n=277) Min. (1,460), Av. (2,985) and Max. (4,510)
- Sulfate (mg/L) (n=276) Min. (517), Av. (1,113) and Max. (1,690)
- As (mg/L) (n=276) Min. (0.001), Av. (0.387) and Max. (2.14)
- Cu (mg/L) (n=276) Min. (0.192), Av. (11.751) and Max. (111.0)
- Zn (mg/L) (n=277) Min. (0.006), Av. (0.289) and Max. (9.05)
- WAD CN (mg/L) (n=276) Min. (0.015), Av. (7.99) and Max. (103)

Monthly supernatant (tailings pond) water quality data from Nov 2013 to Nov 2016 provides the following information.

- WAD CN (mg/L) (n=87) Min. (0.05), Av. (1.62) and Max. (10.5)

4.6 Tailings Seepage

Seepage monitoring and management is detailed in Sections 2.3 and 3.2 of the ATCW 2016 report (ATCW, 2016). Seepage from the TSF is not through any core zone, but is limited to contact zones. Management of seepage includes the following:

- Construction of groundwater cut-off keys providing interception of subsurface seepage were formed as part of the Stages 1, 2, 3A, 3B, 3C, 3D, 3E, 4A and 4B TSF construction works to a level of RL 172m. Foundation works will be required on all embankment extension areas to be formed over residual sequences.
- Seepage collection drain beneath the downstream rock fill zone, which drains to a collection sump, and surface seepage flow into TSF Sed Dam 1.
- Collection trench along the base of the northern TSF embankment toe that drains to TSF Sed Dam 1, which was constructed 2008 and reporting approximately 2 L/sec.
- Southern embankment seepage collection system that comprises a seepage collection trench with subsurface drainage pipe, located beneath the Southern Embankment along the eastern perimeter adjacent to the plant site that drains to Stans' Well. This automated pumping system was installed in 2014 and reports approximately 34 L/sec, of which the portioning between TSF seepage, groundwater and surface runoff has not been ascertained.
- Dewatering bore located on the Stage 2C (RL150.0m) crest of the Northern Embankment, was constructed in 2013 and reporting approximately 2.4 L/sec.

Seepage management during and post cover construction will need to be defined to determine if there is the potential for adverse environmental impacts. In order to minimise seepage potential from the TSF and to maintain effective containment, the following attributes should be adopted:

- Embankment geometry should be formed such that a low permeability zone of tailings will be located on the upstream internal embankment face.
- Construction of a deepened cut-off key into the basement foundations along the embankment perimeter, with localised deepening appropriate at existing drainage lines.
- Perimeter seepage interception trench with associated pumping.
- Downgradient monitoring and seepage recovery bores.

Control of seepage as it relates to, or impacts on, lift embankment stability is of significance, ensuring that seepage does not cause internal erosion or piping through the embankment. The potential for piping to occur

would be subject to the permeability and depressiveness/erodibility of the embankment fill. In this respect, careful selection of embankment fill materials to inhibit piping potential is required.

Available monthly seepage water quality data from Stan's Well to Nov 2016 provides the following information.

- pH (n=190) Min. (5.96), Num. Av. (7.93) and Max. (8.67)
- EC (µS/cm) (n=191) Min. (1,905), Av. (3,181) and Max. (4,120)
- Sulfate (mg/L) (n=190) Min. (736), Av. (1,229) and Max. (1,910)
- As (mg/L) (n=191) Min. (0.065), Av. (0.458) and Max. (0.788)
- Cu (mg/L) (n=190) Min. (0.001), Av. (0.057) and Max. (2.32)
- Zn (mg/L) (n=189) Min. (0.005), Av. (0.34) and Max. (0.781)
- WAD CN (mg/L) (n=190) Min. (0.004), Av. (0.099) and Max. (1.53)

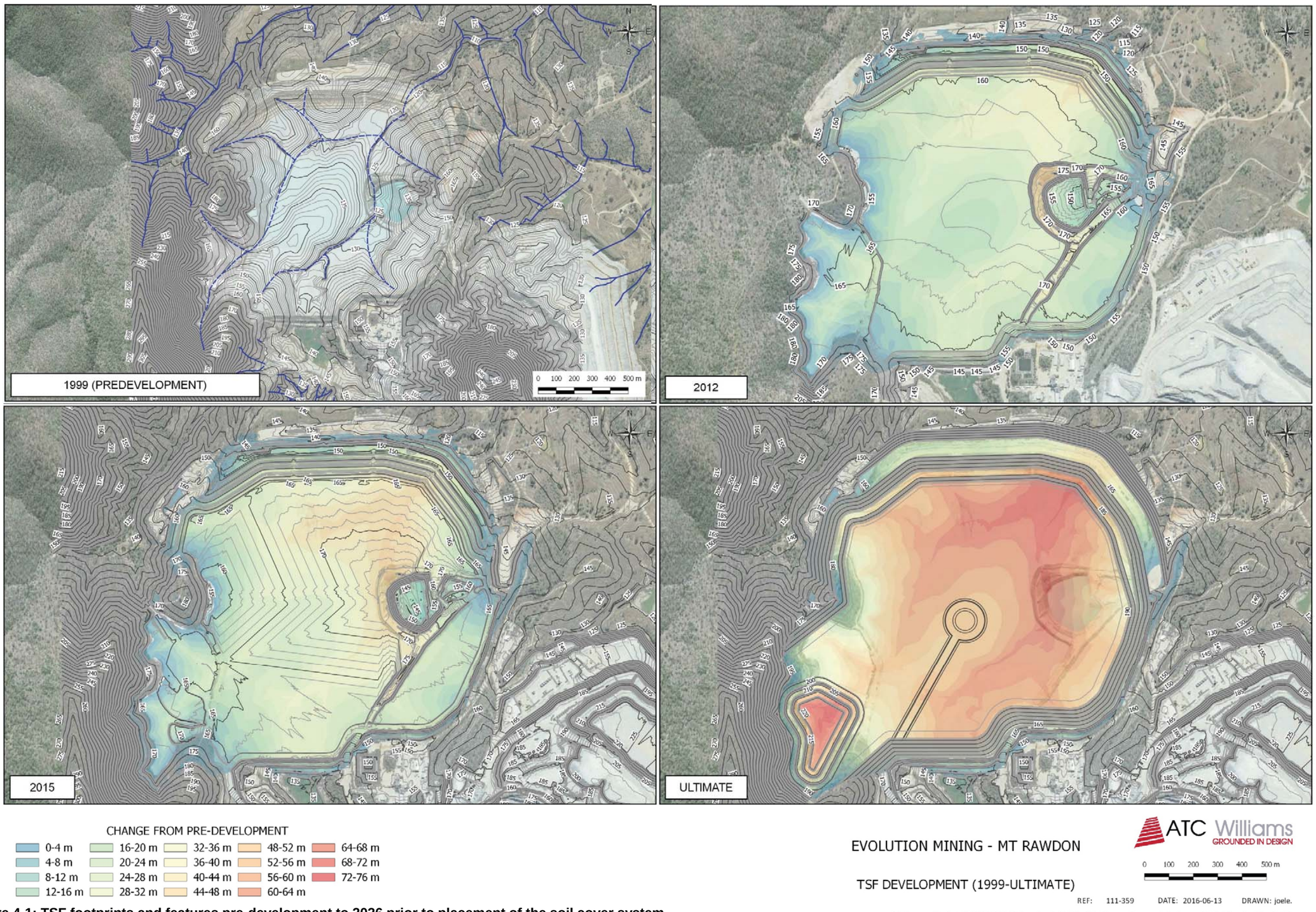


Figure 4-1: TSF footprints and features pre-development to 2026 prior to placement of the soil cover system

5 Potential borrow areas

5.1 2016 drilling and test pit program

RGS and ATCW defined four potential borrow areas prior to the field program to define test pit and drilling locations (**Figure 5-1**). Tailings and borrow material samples were obtained from test pits, and a drilling program that was arranged and managed by MRO. The duplication of work from previous test pit sampling for TSF2 was required because there were no samples from these pits available for chemical and physical analyses.

The test pits and drill holes were used to select a preferred borrow location(s) that were in turn used to identify the samples from the program that would be submitted for geochemical and physical analyses.

5.2 Preferred borrow area

Based on the following data RGS has allocated **Borrow Area 1** near DH001 and DH002 as the preferred Borrow Area to source material for the TSF soil cover option for the following reasons.

- The location of the borrow area is off to the side of the TSF and would not incur removing material from below the TSF embankment that may have geotechnical or hydrogeological implications
- The borrow area has the shortest haul to TSF
- The material appears to able to be mined without blasting and has favourable chemical and physical properties
- 2.5 M m^3 of material could be obtained from elevation 137 m ASL to 121 m ASL
- The volume of material from the borrow area would be sufficient for approximately 2 m of soil cover over TSF.

Other borrow areas have the following limitations:

- DH003 has less than 2 m of weathered material
- DH004 is removed from the TSF and has a long haul distance
- DH005 (Borrow Area 2) and DH006 (Borrow Area 3) could be secondary borrow areas. Volumes will need to be defined for these borrow areas.

5.3 Stockpiled material inventory

MRO currently has 1.24 M bcm of stockpiled soil and 0.5 M bcm of stockpiled oxide overburden, as per the MRO Nov 2015 inventory provided to RGS in August 2016.

5.4 Stockpiled NAF overburden inventory

There is approximately 6.9 M bcm of NAF waste rock in the western NAF WRD.

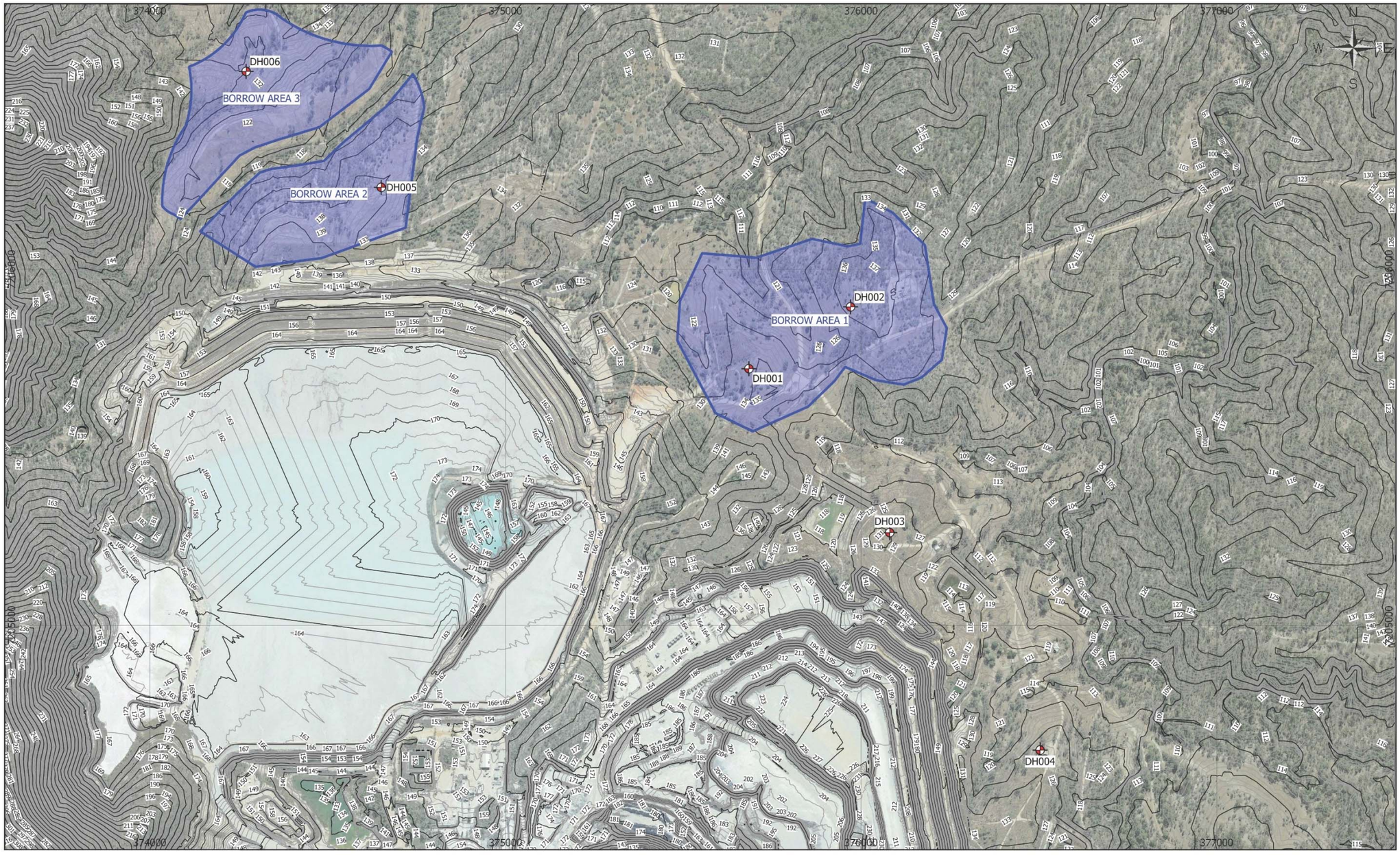


Figure 5-1: Drill hole and test pit locations and potential borrow areas to the east and north of the TSF

6 Geology

6.1 Test pits

Test pit photographs in **Figure 7-1** and **Figure 7-2** show all sites and surface soils were consistent: notwithstanding the very shallow depth to rock at DH003 (< 2 m) and shallow depth rock at DH006 (< 11 m).

The Australian Soil Classification (ASC) classifies the dominant soils across the site as brown sodosols (refer to the map included in the appendices of this document). The ASC defines sodosols as:

- Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2m thick) is sodic and not strongly acid. Hydrosols and soils with strongly sub-plastic upper B2 horizons are excluded.
- Sodosol surface soils are characterised by a shallow sandy loam and sandy clay loam that is poorly structured with slight to moderate alkalinity, low salinity and non-sodic. However, the subsoil is typically poorly structured (sodic) medium to heavy clay, strongly alkaline with increasing salinity with depth. A typical description of brown sodosols is as follows:
  - Poorly structured allowing for erosion, waterlogging and poor plant emergence
  - Increased surface water runoff impact potential (dispersive, sodic)
  - Increased soil erosion potential.

The Atlas of Australian Soils further breaks down the soil classification into two distinctive soils groups comprising:

- Tb88 - Steep hilly to mountainous country on metasediments: chief soils are hard acidic yellow mottled soils (Dy3.41) with hard acidic red soils (Dr3.41) and (Dr2.41), all often stony. Associated are shallow loams (Um1.42) and (Um2.12) on the steeper slopes; (Dr2.21), (Dy2.21), and (Dy2.23) soils with smaller areas of (Uc1.21 and Uc1.23) on included granites; and (Uf6.41) and (Gn3.11) soils on included basic rocks. As mapped, small areas of units Tb90, Tb92, and Tb96 are included.
- Tb103 - Low to moderately hilly lands on phyllites and schists; a close pattern of hills with short to moderate slopes: chief soils are gravelly hard acidic yellow mottled soils (Dy3.41) and (Dy2.41) with shallow gravelly loamy soils (Um2.12) and (Um4.1) on crests and upper slopes. Associated are gravelly (Dr3.41) soils. Minor soil occurrences include (Gn3.42).

6.2 Drill holes

Drill hole logs (**Table 6-1**) verify that the underlying geology is dominated with metamorphics (schist and gneiss) near DH001 and metasandstone and schist / gneiss near DH002. Photographic mosaics of the drill holes are in **Table 7-1** to **Table 7-9** and a photograph of the samples selected from DH001 and DH002 for geochemical and physical analyses are in **Table 7-10**.

6.3 Major rehabilitation material units (MRM_{UNITS})

The major rehabilitation material units (MRM_{UNITS}) within the local soil zones and borrow areas were identified from test pit and diamond core drilling holes.

The MRM_{UNITS} have been defined for potential soil cover design and include the following broad material types.

- **Soil** that includes;
  - Topsoil (nominally 0 to 50 cm depth bgl) - top layer of the native soil profile recognised by higher organic carbon content, some development of soil structure, the presence of plant roots, and typically containing the soil seed bank. A valuable resource suitable for use during the rehabilitation program.
  - Subsoil (nominally 50 to 100 cm depth bgl) - soil layer underlying the native topsoil, typically identified by a decrease in organic carbon content and fewer (and finer) roots. The characteristics of subsoil materials vary markedly depending on the soil type.
- **Overburden** that includes oxide and transition material.
  - Oxide overburden - typically highly weathered materials with minor partially-weathered rock
  - Transition overburden - weathered materials with minor partially-weathered rock and some competent fresh rock
- **Fresh competent rock** that may be suitable for armouring drains or being used as rock mulch in the soil cover eg. NAF waste rock from the western WRD.

Table 6-1: Geological logs of drill holes

Hole ID	Meter From	Meter To	Classification	Lithology	Alteration Mineral 1	Alteration Mineral 2	Alteration Mineral 3	Weathering	Oxidation	Oxidation Intensity	Colour	Comments
MRORGS-001	0	0.1	Curtis Island Group Basement	Soil	Clay			Strong	Yes	Strong	Dark Brown	
	0.1	2.2		Granitoid	Limonite	Clay	Hematite	Strong	Yes	Medium	Brown	Traces of Kaolin
	2.2	4.4		Schist / Gneiss	Limonite	Clay	Hematite	Strong	Yes	Medium	Grey Brown	Gneiss texture/fabric visible
	4.4	4.7		Granitoid	Limonite	Clay		Medium	Yes	Weak	Pink Brown	
	4.7	5.3		Schist / Gneiss	Limonite	Clay		Medium	Yes	Weak	Grey Brown	Oxidation along fracture margins
	5.3	9.1		Schist / Gneiss	Clay	Limonite		Weak	Yes	Weak	Grey Brown	Structural brecciated pug
	9.1	11.7		Schist / Gneiss	Silica						Grey	Strong visible carbonate stockwork veining
	11.7	17.2		Schist / Gneiss	Clay	Limonite		Weak	Yes	Weak	Grey Brown	Structural brecciated pug
	17.2	21.4		Schist / Gneiss	Silica						Grey	Visible carbonate stockwork veining
	21.4	25		Granitoid	Feldspar	Quartz					Pink Grey	
MRORGS-002	0	3.7	Curtis Island Group Basement	Meta-Sandstone	Clay	Limonite	Hematite	Strong	Yes	Strong	Brown	Traces of Kaolin/Smectite
	3.7	13.8		Meta-Sandstone	Limonite	Hematite		Medium	Yes	Medium	Brown	More oxidised (hematite) along fractured planes
	13.8	15.4		Schist / Gneiss	Limonite	Kaolin	Silica	Weak	Yes	Weak	Light Brown	Foliated
	15.4	18.7		Meta-Sandstone	Limonite				Yes	Weak	Grey Brown	
	18.7	24.6		Meta-Sandstone	Silica						Grey	Weak Limonite staining along fracture planes_ carbonate stockwork veining visible
MRORGS-003	0	0.2	Curtis Island Group Basement	Soil	Hematite	Clay		Strong	Yes	Strong	Dark Brown	
	0.2	1.4		Trachyte	Feldspar						Khaki	Minor oxidation along fracture planes
MRORGS-004	0	0.2	Curtis Island Group Basement	Soil	Hematite	Clay		Strong	Yes	Strong	Dark Brown	
	0.2	6.8		Schist / Gneiss	Illite	Limonite		Medium	Yes	Medium	Light Brown	
	6.8	8.2		Schist / Gneiss	Silica						Grey	Quartz+ Carbonate veining - High Foliation
MRORGS-005	0	0.2	Curtis Island Group Basement	Soil	Clay	Hematite	Limonite	Strong	Yes	Strong	Dark Brown	
	0.2	7.2		Schist / Gneiss	Clay	Limonite	Hematite	Strong	Yes	Medium	Brown	Traces of Kaolin/Smectite
	7.2	10.9		Schist / Gneiss	Limonite	Limonite	Hematite		Yes	Weak	Light Brown	Strong Limonite and Clay
	10.9	13.6		Schist / Gneiss	Limonite	Limonite	Hematite		Yes	Weak	Light Brown	
	13.6	18.7		Schist / Gneiss	Silica	Silica					Grey	Strong quartz + carbonate veining
MRORGS-006	0	0.1	Aranbanga Volcanics	Soil	Clay	Hematite	Limonite	Strong	Yes	Strong	Dark Brown	
	0.1	6.8		Volcaniclastic/conglomerate, 'GRIT' clasts <4mm dominant	Illite	Illite		Weak	Yes	Weak	Grey Brown	
	6.8	10.8		Volcaniclastic/conglomerate, 'GRIT' clasts <4mm dominant	Silica	Clay	Limonite		Yes	Weak	Grey	Oxidation + Clay along fracture planes

7 Sampling and analytical program

Samples for geochemical and physical testing were collected as part of the July 2016 drilling and test pitting program (**Section 5.1**).

7.1 Test pit

Test pits to approximately 1.5 m depth were excavated at each drill hole site to obtain 20 L samples of topsoil and subsoil for geochemical and physical analyses (**Table 7-1** and **Table 7-2**). RGS collected 12 bulk samples from the six test pits, including one sample scraped from the face of the test pit profile from 0 to 50 cm depth and another sample scraped from the side of the test pit from 50 cm to the base of the test pit (approximately 1.75 m depth). Of the samples collected, six samples from DH001, DH002 and DH006 (**Table 7-1**) were submitted to ALS Laboratories (Brisbane) for geochemical analyses and Trilab (Brisbane) for physical testing (see Attachment A and B for full analysis results).

Table 7-1 Test Pit Samples Selected for Geochemical and Physical Testing

Test Pit ID	Soil Horizon	Depth Interval (m)	Trilab Sample Number	RGS Sample ID
DH001	O	0.0 to 0.5	16080081	MRORGS001-1
DH001	A	0.5 to 1.0	16080086	MRORGS001-2
DH002	O	0.0 to 0.5	16080082	MRORGS002-1
DH002	A	0.5 to 1.0	16080087	MRORGS002-2
DH006	O	0.0 to 0.5	16080083	MRORGS003-1
DH006	A	0.5 to 1.0	16080088	MRORGS003-2

ALS laboratory analysed:

- 6 samples for soil moisture;
- 6 samples for net acid producing potential (NAPP; for total ANC and TS);
- 6 samples for 1:5 (soil:water) pH and EC;
- 6 samples for exchangeable cations using the pre-treatment to remove soluble ions method;
- 6 samples for total major, minor and trace elements;
- 6 samples for total and organic carbon; and,
- 6 samples for TN, TP and N species, and Collwell extractable P.

Trilab laboratory analysed:

- 6 samples for Atterburg limits;
- 6 samples for Emerson Class;
- 6 samples for permeability by falling head test method;
- 6 samples for particle size distribution by hydrometer method; and
- 6 samples for moisture/density testing.

7.2 Drill core

For this study diamond core drilling was undertaken at DH001 to DH006 (**Table 7-2**) using HQ diameter core to allow underlying geology to be logged, verify depth to fresh rock and provide intact core samples for geochemical and physical analyses.

All drill holes were photographed and logged by Department of Natural Resources and Mines (DNRM) using a HyLogger^{TM} to identify mineralogical assemblages within the drill core. The drill core was cleaned (wiped with wet cloth) prior to scanning. The drillers used a bentonite based drilling mud during drilling and this should be considered in interpretation of the data as bentonite does contain montmorillonite.

The HyLogger^{TM} is a cost-effective means of obtaining quantitative mineralogy at 10 mm continual increments along the entire length of drill core. The HyLogger^{TM} is capable of quantitating clay minerals

which are an important component of rehabilitation media; however, is unable to identify or discern sulfide minerals.

Four bulk core samples from DH001 and DH002 (**Table 7-2**) were submitted to ALS Laboratories (Brisbane) for geochemical analyses and Trilab (Brisbane) for physical testing. The need for additional samples to characterise the soil profile was not considered necessary due to the similar characteristics of the soil at all sites. The contiguous nature of the soil was further verified by visual observation of the scraped access road (fire break) to DH005.

Table 7-2 Drill Core Samples Selected for Geochemical and Physical Testing

Borehole ID	Depth Interval (m)	Trilab Sample Number	RGS Sample ID
DH001_A	3.5 to 6.3	16090340	MRORGSDH001_A
DH001_B	6.3 to 15.4	16090341	MRORGSDH001_B
DH002_A	3.2 to 9.1	16090342	MRORGSDH002_A
DH002_B	9.1 to 15.1	16090343	MRORGSDH002_B

ALS laboratory analysed:

- 4 samples for soil moisture;
- 4 samples for net acid producing potential (NAPP; for total ANC and TS);
- 4 samples for 1:5 (soil:water) pH and EC;
- 4 samples for exchangeable cations using the pre-treatment to remove soluble ions method;
- 4 samples for total major, minor and trace elements;
- 4 samples for total and organic carbon; and,
- 4 samples for TN, TP and N species, and Collwell extractable P.

Trilab laboratory analysed:

- 4 samples for Emerson Class;
- 4 samples for particle size distribution by hydrometer method;
- 2 samples for point load testing; and,
- 2 samples for permeability by falling head test method.

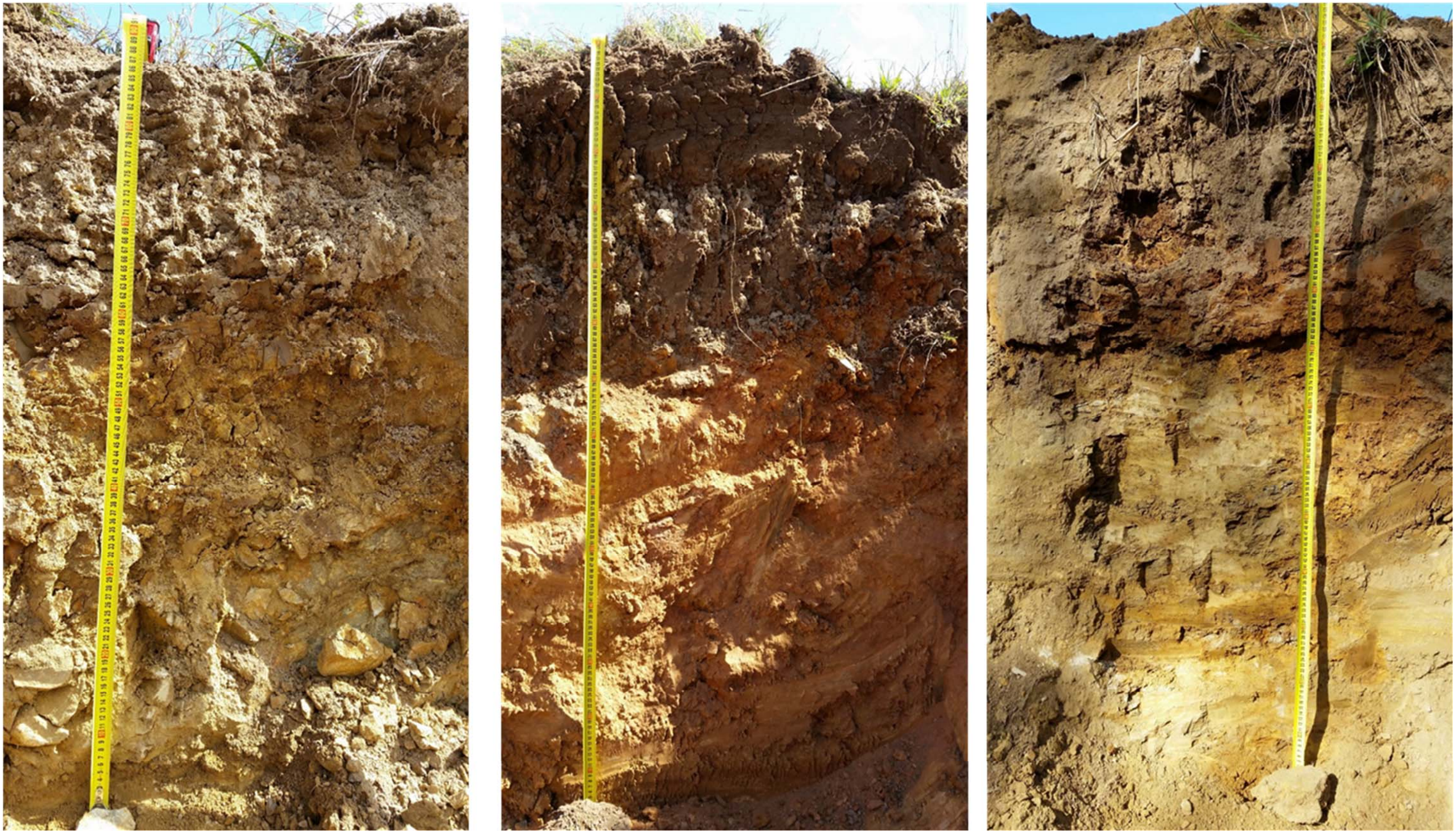


Figure 7-1: Test Pits DH001, 002 and 003

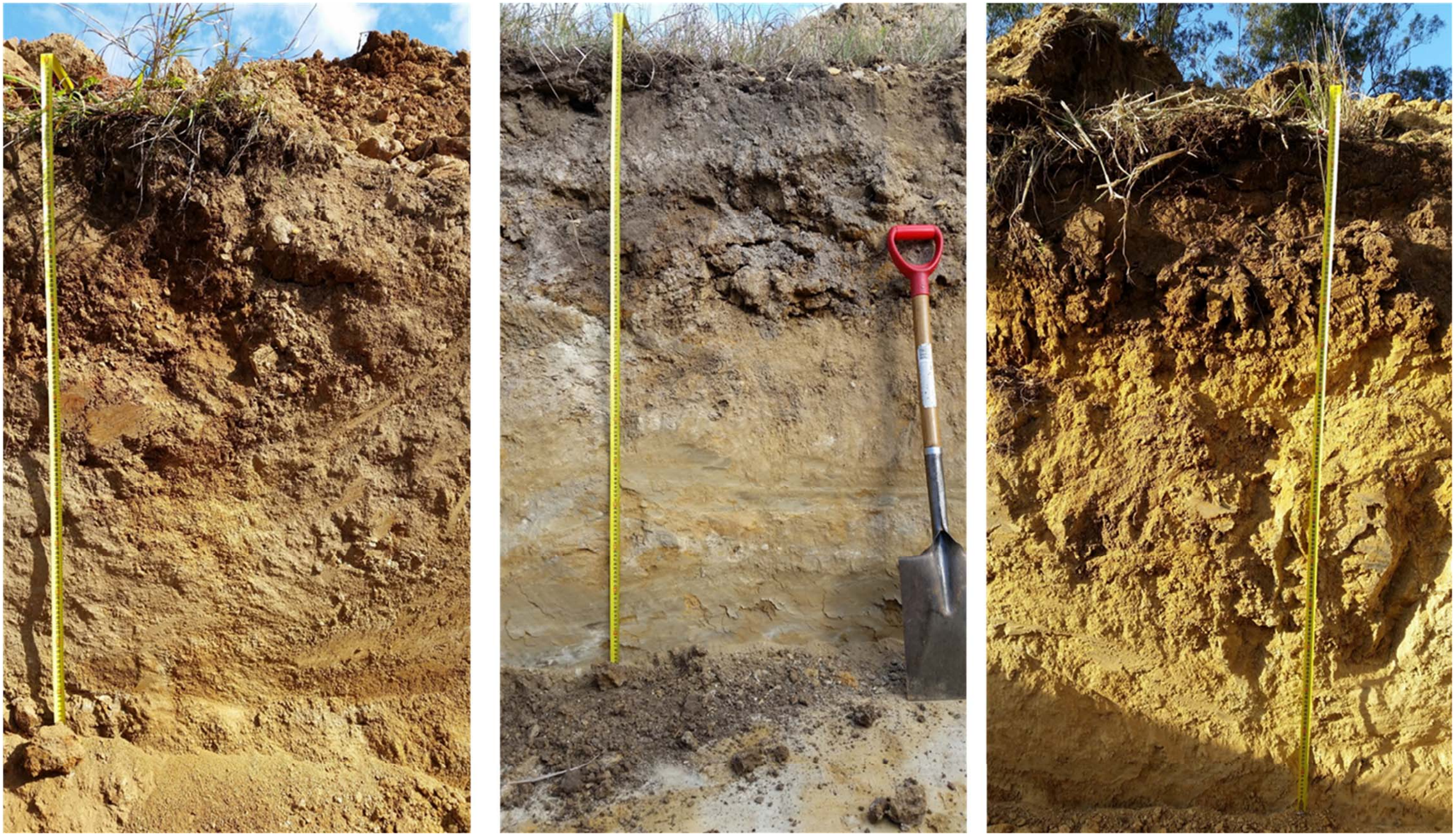


Figure 7-2: Test Pits DH004, 005 and 006



Figure 7-3: Drill hole photographic mosaic DH001



Figure 7-4: Drill hole photographic mosaic DH002

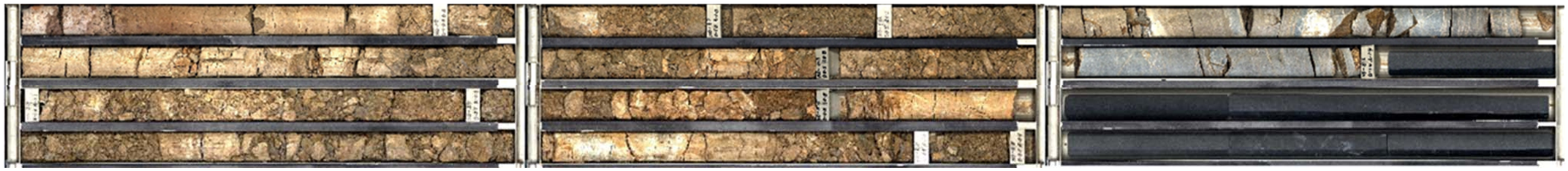


Figure 7-5: Drill hole photographic mosaic DH004



Figure 7-6: Drill hole photographic mosaic DH005



Figure 7-7: Drill hole photographic mosaic DH006









Figure 7-8: Drill hole bulk samples from DH001 and DH002

8 Geochemical analytical results

8.1 Geochemical properties – waste rock and tailings[2]

8.1.1 Waste Rock

Initial geochemical investigations into the nature of MRO waste rock and ore formed an integral part of the approved 1999 Environmental Management Overview Strategy (EMOS) (EGi, 1996). These investigations concluded that most the MRO materials were Non-Acid Forming (NAF) and that sulfide minerals contained in any Potentially Acid Forming (PAF) materials were relatively slow to react and a long period (10-20 years) was predicted before acid conditions could occur. The main potential impact to seepage quality from waste rock and ore was predicted to be elevated sulfate concentration as trace metals were sparingly soluble under ambient pH conditions. Mineralogical assessment of MRO waste rock and ore involved petrological, mineragraphic, scanning electron microscope, microprobe and trace element analyses on selected core samples (Ewington, 1996). Pyrite, sphalerite, chalcopyrite and covellite mineralogy were identified in the core samples and pyrite crystal morphologies ranged from cubic to octahedral. Samples from PAF-HC acid categories contained unevenly distributed carbonates and high levels of sphalerite in contact with pyrites. Samples for lower risk acid categories contained carbonates as rims around the pyrite grains and generally less sphalerite in contact with pyrite.

The geochemical results and trends obtained for KLC tests conducted in composite waste rock samples by RGS in 2009 to 2011 (RGS, 2009 and RGS, 2011) indicated that:

- Initial surface runoff and leachate from waste rock and low-grade ore materials is likely to be alkaline and non-saline.
- There is some uncertainty associated with the geochemical classification of waste rock and low-grade ore materials caused by material heterogeneity.
- In PAF-HC materials, a larger proportion of carbonate minerals, compared to reactive sulfides, may be contained within the rock matrix and therefore less available for acid buffering. However, KNAG results suggest that some of the sulfides may be present on rock surfaces in a less reactive mineralogical form.
- There is significant localised variability (heterogeneity) in the geochemical nature of the waste rock and low-grade ore materials at MRO. This variability and the resulting uncertainty regarding material classification and geochemical characteristics in the field (including water quality at interception dams WD1 and WD2 downstream of the North Waste Rock Dump (NWRD), prohibited any recommendation at that time to significantly change to the encapsulation management strategy for PAF-MC waste rock within NAF waste rock at the NWRD.
- Total metal concentrations in waste rock and low-grade ore materials are unlikely to present any concerns related to mine operation and final rehabilitation. The NAF MRO waste rock materials appear to be amenable for use as the final surface and batters of the WRD and as part of a final cover system over tailings at the TSF.
- Initial surface runoff and leachate from stored waste rock and low-grade ore materials is likely to be moderately alkaline, have low salinity, and contain relatively low concentrations of trace metals and sulfate, predominantly below the analytical detection limit and well within applied water quality guideline criteria. Hence, initial surface runoff and leachate from waste rock and low-grade ore materials is unlikely to impact upon the quality of surface and groundwater resources at relevant storage facilities.
- KLC test results suggest that surface runoff and seepage from waste rock and low-grade ore materials will remain slightly alkaline to pH neutral and contain a low concentration of salts and trace metals for a significant period (> 20 years).
- The rate of sulfide oxidation in the KLC test samples is low and synonymous with materials that are unlikely to generate acid leachate for a significant period (> 20 years).

[2] The geochemical test work and properties of waste rock and tailings described in this section were formulated with due recognition of relevant government and industry guidelines (AMIRA, 2002; DME, 1995; DEHP, 2013b; Commonwealth of Australia (2016 a, b, c, d).

- The mineralogical assessment completed by Levay and Co. (contained in RGS, 2011) indicates that the geochemical behaviour of the mine materials is complex and depends on the relative amounts of each size fraction present. For waste rock and low-grade ore, an excess of alkalinity appears to be present, although much of this is encapsulated in composite particles and therefore the outcome of weathering reactions will depend on which mineral phases (sulphide or carbonate) are more exposed, making prediction of the likely AMD behaviour of these materials difficult to define in the context of a WRD.

To supplement work done in 2009-2011, waste rock samples from MRO are being subjected to additional KLC tests by RGS over a period of two years (RGS, 2017a). The 20 kg samples being used in the KLC tests were obtained from > 200 kg samples collected by MRO geologists from the 50-tonne waste rock dump field trials established by MRO on site in 2016. Some of these tests are investigating the interaction of waste rock and tailings materials. RGS is also assisting MRO to review the waste rock characterisation and acid waste model criteria currently being used at the site (RGS, 2016) as well as studying the geochemical characteristics of tailings generated from the processing plant in real time and ongoing weathering behaviour under idealised oxidising conditions.

The elemental concentrations of the representative samples in **Table 8-1** show the tailings can be enriched with some metals (eg. As, Ba, Bi, Cd, Cu, Th, U and Zn) when compared to NAF, PAF-MC and PAF-HC waste rock, although the enrichment of Th and U is simply an artefact of the laboratory Limit of Reporting. The elemental data also includes total sulfur (TS) and sulfide sulfur (CRS) data for the materials. The low geochemical reactivity of the waste rock and the tailings is a key component of the design process.

Table 8-1 Waste rock and tailings elemental enrichment

	Unit	NAF Waste Rock	Moderate PAF Waste Rock	High PAF Waste Rock	Tailings
Aluminium	mg/kg	22700	12200	8000	11300
Antimony	mg/kg	0.6	3.5	1.3	0.5
Arsenic	mg/kg	8	26	26	134
Barium	mg/kg	29	40	20	69
Beryllium	mg/kg	0.6	0.6	0.4	0.5
Bismuth	mg/kg	0.2	1.1	12	22
Boron	mg/kg	<50	<50	<50	<50
Cadmium	mg/kg	<0.1	0.2	4	9
Chromium	mg/kg	35	83	30	26
Cobalt	mg/kg	15	9	10	7
Copper	mg/kg	9	27	140	358
Iron	mg/kg	39200	24200	39700	28500
Lead	mg/kg	4	8	160	53
Lithium	mg/kg	50	31	18	11
Manganese	mg/kg	2260	1940	1950	1180
Molybdenum	mg/kg	0.6	1.9	1.0	1.9
Nickel	mg/kg	10	29	12	12
Selenium	mg/kg	<1	<1	<1	<1
Sulfur	%	0.5	1.5	4.3	1.5
Sulfide (CRS)	%	0.4	1.3	3.6	1.2
% Sulfide	%	65	90	84	81
Silver	mg/kg	<0.1	0.2	3	1.3
Strontium	mg/kg	109	70	43	68
Thallium	mg/kg	<0.1	<0.1	<0.1	0.1
Thorium	mg/kg	1.4	2.4	1.7	4.2
Tin	mg/kg	1.2	0.9	0.6	0.7
Uranium	mg/kg	<1	<1	<1	0.6
Vanadium	mg/kg	72	25	11	17
Zinc	mg/kg	141	126	748	1490

The blue bars show the relative proportion of each element within the four samples. The red boxes show where the tailings are elevated in concentration compared to the waste rock.

8.1.2 Tailings

In November 2009, RGS obtained representative tailings samples from MRO and subjected these to KLC tests. The geochemical results and trends obtained for KLC tests conducted on these tailings were reported in 2011 (RGS, 2011) and indicate that:

- Initial surface runoff and leachate from tailing materials is likely to be alkaline and non-saline.
- There is some uncertainty associated with the geochemical classification of tailing materials, caused by a low ANC/MPA ratio (generally between 1 and 2), which suggests a lower factor of safety than indicated by traditional static NAPP and NAG test geochemical classification criteria.
- The coarse tailing fraction contains a greater proportion of sulfide and smaller proportion of ANC than the fine tailing fraction.
- There appears to be some variability (heterogeneity) in the geochemical nature of the ore feed generating the tailing resulting in a variable geochemical nature for tailing materials reporting to the TSF.
- The concentration of total metals in tailing samples ("as received", fine and coarse) indicates that these materials have relatively low total metal concentrations in solids are unlikely to present any concerns related to mine operation and final rehabilitation.
- The results of the chemical tests on the tailings supernatant sample indicate that MRO should continue to monitor pH, EC, soluble arsenic, copper, molybdenum and sulfate in TSF decant water and in groundwater monitoring bores downstream of the TSF.
- Total and WAD cyanide concentrations in the supernatant sample are elevated as would be expected for a sample taken directly from the process plant.
- KLC test results suggest that surface runoff and seepage from tailing materials will remain slightly alkaline to pH neutral and contain a low concentration of salts and trace metals for significant period (> 20 years).
- The rate of sulfide oxidation in the KLC test samples is currently low and synonymous with materials that are unlikely to generate acid leachate for a significant period (> 20 years).
- Surface water quality down gradient of the TSF (Sediment Dam 1) may contain elevated concentrations of Cu and occasionally total cyanide and WAD cyanide, compared to EA limits and is managed by pumping back to the TSF. For groundwater, some monitoring bores located close to the northern TSF wall can have elevated sulfate concentrations, which marginally exceed the regional groundwater limit for this parameter set out in the EA. In addition, one bore at the southern end of the TSF near the Plant Area can have elevated concentrations of some trace metals and sulfate, compared to the relevant regional groundwater limit for these parameters.
- The mineralogical assessment completed by Levay and Co. (RGS, 2011) indicates that the geochemical behaviour of the tailing materials is complex and depends on the relative amounts of each size fraction present. The coarse tailing fraction (>75 µm) contains more sulfides than the fine fraction and the former may have limited potential to produce some acidity during oxidation, however this outcome is not reflected in KLC test results to date.

In November 2014 four near-surface tailing samples were collected from the isolated western cell at the TSF and sent directly to ALS Environmental laboratory in Brisbane for initial static geochemical testing. Following receipt and interpretation of the static geochemical test results, four KLC tests were set up at the RGS laboratory using the bulk composite tailing sample. The KLC tests comprised:

- Two duplicate KLC columns under permanently saturated (anoxic) conditions - analogous to the conditions experienced by bulk tailings materials in the TSF with a cover system in place.
- Two duplicate free draining KLC columns under unsaturated (oxic) conditions - analogous to freely oxidising surface tailings at the TSF with no cover system).

The KLC tests commenced in December 2014 and results are scheduled to be completed in December 2018. The results of the KLC testing and previous studies to date (RGS, 2017b) indicate that:

- The tailings samples have relatively consistent static geochemical characteristics and are classified as NAF. Whilst some uncertainty remains over the long term geochemical characteristics of tailings, based on KLC test and field monitoring data, the risk of any acid generation now and into the future is low.

- The first leachate from the samples was highly saline (Avg. 8,622 µS/cm) and was elevated in salts including SO_4^{2-} > Ca^{2+} > Na^+ > Cl^- > K^+ > Mg^{2+}. The high salinity was due to the retention of all rain within the TSF cell (there was no drainage from the TSF cell), the subsequent effects of evapotranspiration and concentration and the accumulation of NaCl and other soluble salts on the surface of the tailings that accumulated over the five years that the tailings had been exposed in the TSF under atmospheric conditions. Subsequent leach events were dominated by SO_4^{2-} > Na^+ > Cl^- > Ca^{2+} > K^+ > Mg^{2+} after six leach cycles the EC is 1,378 µS/cm.
- Contact water and leachate from tailing materials are likely to be pH neutral (in the range pH 7 to 8) and contain excess alkalinity.
- The quality of the tailings pore water and any TSF seepage is likely to gradually improve when supernatant/fresh tailings (and waste rock materials) are no longer added to the TSF following closure of this facility.
- Whilst tailings solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to be relatively immobile and sparingly soluble at neutral pH.
- The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring programs at the site.
- It is expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure of the TSF.

8.2 Geochemical properties – borrow materials

In this study soil is determined to be present from surface to a nominal depth of 1 m bgl. Topsoil is limited to the top 10 to 50 cm of the soil profile (O Horizon) and subsoil includes material from 50 to 100 cm (B and C Horizons). Overburden includes the weathered material from 1 m to the end of the drill hole.

Analytical results for TP1, TP2 and TP6 and DH001 and DH002 are in **Table 8-2** and **Table 8-3** and summarised for Borrow Area 1 in **Table 8-4**. The ALS raw data files are in **Attachment A – ALS Raw Data.**

8.2.1 Mineralogical properties

Mineralogical analysis was undertaken on the entire length of the six drill core holes using a HyLogger™ that identifies the minerals present in a sample in 10 mm increments and therefore provides a substantial amount of data to identify the minerals present within the potential borrow areas. The HyLogger™ is particularly effective at discerning clay minerals which have important characteristics for rehabilitation.

HyLogging™ is an advanced technique that helps geologists to non-destructively assess the mineralogical distribution of an entire drill core, with minimal sample preparation or removing from its original tray. The virtual online library offers geologists the chance to examine detailed mineralogical results remotely from their desks, thus avoiding physical inspection and a visit to the core library. HyLogging™ systems incorporate a suite of hardware and software tools for Hyperspectrally Logging voluminous drilled materials, thus enabling geologists to non-destructively log an entire drill core without removing the core from its original trays. HyLogger™ works on the principle of reflectance spectroscopy, rapidly measuring the reflectance spectra for contiguous 10 mm pixels in the visible and near infrared (VNIR; 400-1000 nm), shortwave infrared (SWIR; 1000-2500 nm) and Thermal infrared (TIR; 8000-12000 nm) regions, relevant to geological mineral identification. Currently Hylogger targets the following minerals in the VNIR-SWIR regions:

- Iron oxides — hematite, goethite, magnetite
- Al(OH) — paragonite, muscovite, phengite, illite, pyrophyllite, kaolinite, halloysite, dickite, smectite varieties, gibbsites, etc.
- Sulphates — alunite, jarosite, gypsum
- Si(OH) — opaline silica, hydrothermal quartz with fluid inclusions
- Ammonium bearing minerals — NH-alunite, buddingtonite, etc.
- Fe(OH) group — saponite, nontronite

- Mg(OH) — chlorites, biotite, phlogopite, tremolite, actinolite, talc, hornblende, etc.
- Carbonates — calcite, dolomite, magnesite, ankerite, siderite, malachites, Cu-carbonates, etc.
- Selected OH-bearing silicates — epidote, prehnite, tourmaline, topaz,etc.
- Selected Zn silicates / phosphates — sauconite, tarbuttite
- Selected Zeolites — laumontite
- Selected REE-bearing minerals — neodymium, praseodymium

The results of the HyLogger™ scanning summarised in **Figure 8-1** and **Figure 8-2** include the following.

- DH001 and DH002 are within a very deep weathered profile that extend to at least 25 m depth and are comprised of silica, smectite group minerals (montmorillonite, nontronite and biotite), plagioclase and k feldspar and kaolinite, mixed interlayered clay minerals potentially comprising illite and muscovite, chlorite and muscovite[3].
- DH003 and DH004 are within very shallow weathered profiles (1.3 m and 8 m depth) and lack mica and chlorite minerals groups
- DH005 and DH006 are on deep weathered profiles (19 and 11 m depth) and are comprised of silica, smectite group minerals (montmorillonite, nontronite and biotite), mica, plagioclase and kaolinite

Clay properties, including the hydraulic characteristics of clays, can be influenced by the interaction between clay minerals and contact water of different qualities. Common phenomena affecting the engineering properties of clay are slaking and dispersion because of contact between clay and different water qualities and the potential for clay to shrink and swell.

Clay slaking refers to the fragmentation of large particle aggregates (> 2-5 cm) which may disintegrate to become microaggregates (> 0.025 cm). Clay slaking is generally caused by clay swelling and the consequent expulsion of trapped air when pure water is added, while clay dispersion is the disintegration of individual clay particles. This may occur when two different water types are mixed (mine affected water and clay porewater) in the presence of clays, particularly when saline/sodic water is mixed with non-saline water. Clay dispersion results from net negatively charged clay particles attracting cations, which consequently attracts non-saline water molecules. The non-saline water molecules move between the clay particles (inter layers) and consequently push the clay particles apart, reducing their attractive forces. Soils with a high content of expansive minerals can form deep cracks in drier seasons or years; such soils are called vertisols. Soils with smectite clay minerals, including montmorillonite / bentonite, have the most dramatic shrink-swell capacity. Kaolinite has a low shrink–swell capacity and a low cation-exchange capacity (1–15 meq/100 g).

The cations that are partitioned within the clay structure/ near the minerals surface, may exchange with other cations from the soil solution (this process is known as ion exchange, or cation exchange when referring to positively charged ions). The ion exchange reaction is restricted by the number of exchange sites on the clay and by the strength of the bonding of the exchangeable cations to the clay surface. The capacity for ion exchange varies for each clay mineral due to differences in structure and in chemical composition. Typical ranges of cation exchange capacity in clay minerals is variable, with ranges (in milliequivalents per 100 grams) including kaolinite (3–15); halloysite (40–50); montmorillonite (70–100); illite (10–40); vermiculite (100–150); glauconite (11–20); attapulgite (20–30); and, allophane (~70).

The Hylogger™ analysis identified Kaolinte and Montmorillonite down to 6 m depth. The presence of Kaolinite and Illite minerals is probable but the presence of Montmorillonite is questionable because the drillers used Bentonite (also known as Montmorillonite) that will have been entrained in porous core within the overburden. Montmorillonite is a plastic clay. The Atterburg Limit testing on verifies the TP01 test pit

[3] Chlorite minerals are ubiquitous minerals within low and medium temperature metamorphic rocks, some igneous rocks, hydrothermal rocks and deeply buried sediments. Chlorite is the group name for about 10 related minerals. However, the term Chlorite can be used both to describe the group in general, or as a specific term to describe any green member of the Chlorite group whose exact identity is not practical to be determined. Although Chlorite is not recognized as an individual mineral species by the IMA, mineral collectors still refer to it by its traditional name, except when specifically referring to the individual member minerals such as Clinochlore, Chamosite, and Cookeite. Muscovite is the most common mica, found in granites, pegmatites, gneisses, and schists, and as a contact metamorphic rock or as a secondary mineral resulting from the alteration of topaz, feldspar, kyanite, etc. Muscovite is not especially resistant to chemical weathering. It is quickly transformed into clay minerals.

samples are non-plastic and samples from TP02 have very low plasticity (**Table 9-4**): it is therefore probable the overburden samples are not prone to the effects of shrinking and swelling that would make them less amenable to use within a soil cover system. The CEC of the samples from DH001 and DH002 have a CEC of 10 to 19.4 putting them in the range of Kaolinite and Illite providing additional evidence the Montmorillonite is an effect of the drilling fluids and the bulk of the clay minerals are non-expanding have low plasticity and not likely to be prone to shrinking or swelling.



Figure 8-1: Summary of Hylogger™ SWIR Data DH001, DH002, DH003, DH004, DH005 and DH006

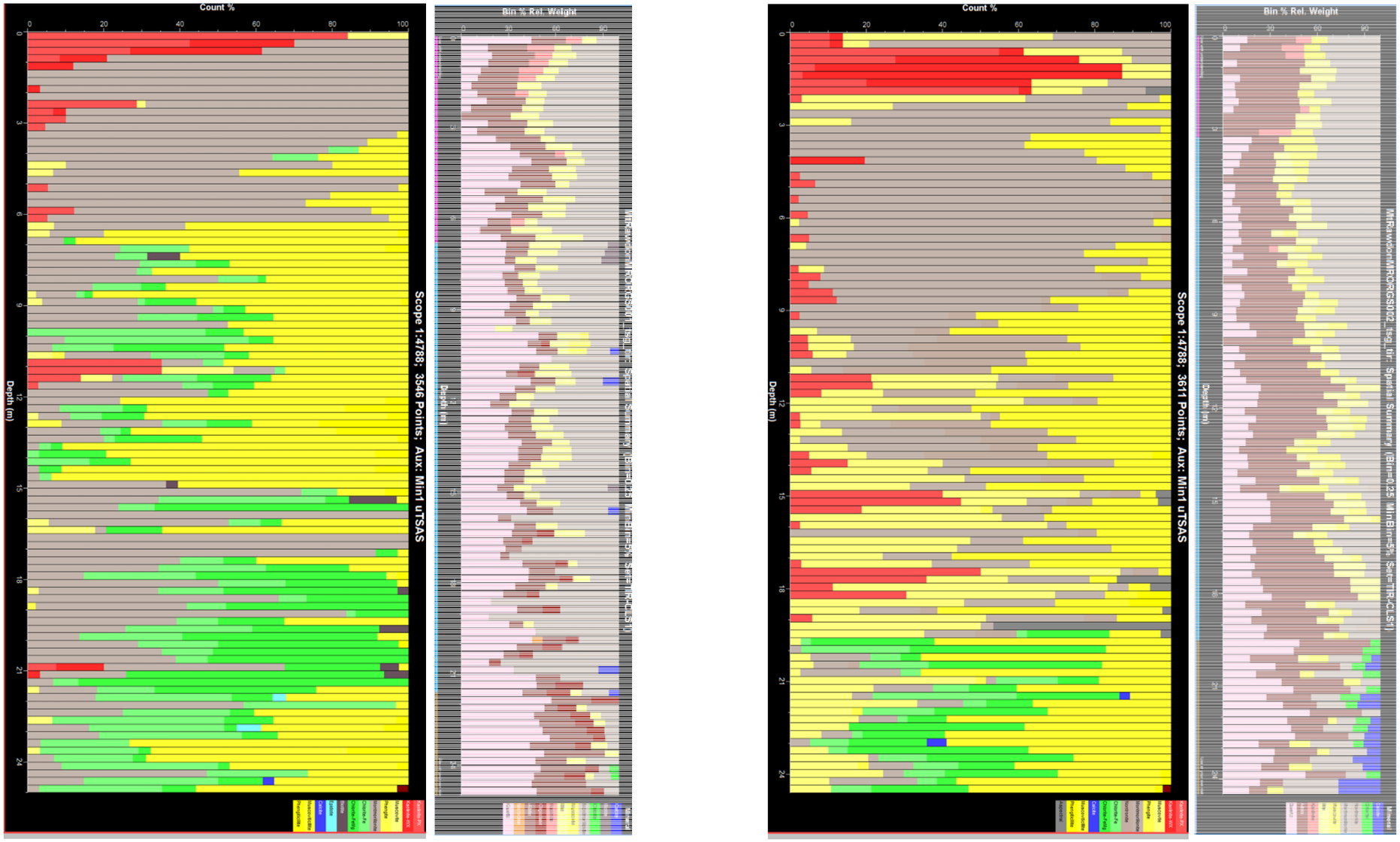


Figure 8-2: Summary of Hylogger™ SWIR (left) and TIR (right) Data in DH001 (left images) and DH002 (right images)

8.2.2 Acid base account and pH

8.2.2.1 Test pits

In general terms soil in the eastern borrow from TP1 and TP2 area has neutral to mildly alkaline pH of 6.8 to 9.0 whereas soil from TP6 in the northern borrow area has slightly acidic pH of 4.8 to 5.7 verifying the geological controls on soil development (**Table 6-1**) and consistency with regional soil mapping. Soil from Borrow Area 1 (including TP1 and TP2 and DH001 and DH002) is likely to have mildly acidic to neutral pH of 5.7 to 5.8 (NAPP <0.5 kg H_2SO_4/t) and sub-soil (including DH001 and DH002) is likely to have neutral to mildly alkaline pH of 6.7 to 8.3 (NAPP range from -1.4 to -2.9 kg H_2SO_4/t)

8.2.2.2 Drill holes

Bulk diamond core samples were collected from the Schist/ Gneiss and Meta-Sandstone overburden units from DH001 and DH002 in the eastern borrow area and analysed for their chemical properties. The pH of the four overburden samples was 6.0 to 9.7. The acid base account results verify the core material has no potential to produce acidic drainage through sulfide oxidation and has very low ANC, except for DH001_B which has moderate ANC (30.9 kg H_2SO_4/t). The core log and HyLogger™ results (**Figure 8-1** and **Figure 8-2**) show the presence of some calcite present as stockwork veining.

8.2.3 Cation exchange capacity, salinity and sodicity

8.2.3.1 Test pits

The low effective Cation Exchange Capacity (CEC) of the soils (Avg. 2 meq/100g) and sub-soil (Avg. 11 meq/100g) is consistent with their classification. Soil from Borrow Area 1 has very low salinity (27 to 31 µS/cm) and very low sodic potential with Exchangeable Sodium Percentage (ESP) of <1 to 2.1 %. The sub-soil in Borrow Area 1 also has low salinity (226 to 260 µS/cm) but moderate to high sodic potential (ESP of 27.4 (minimum), 34 % (average) and 40.5 % (maximum)).

8.2.3.2 Drill holes

The CEC of the samples ranges from 10 to 19.4 meq/100g, which is low to moderate and compares with typical CEC fine sandy loams through to clay loams (5 to 30 meq/100g) and much lower than the CEC for pure clays: eg. montmorillonite has a CEC of 60 – 100 meq/100g. This verifies that despite the high relative abundance of smectite clay minerals (montmorillonite and nontronite) identified in the Hylogger™ anlaysis they are not the dominant clay minerals in the matrix and the overburden should not be prone to high levels of shrinkage and swelling leading to cracking. The salinity of the overburden samples is low with average values of 201 and 131 µS/cm at 3.5 to 6 m and 6 to 15 m depth. The exchangeable sodium percentage (ESP) ranged from 12.8 to 47.7%. Generally, samples with an ESP values less than 6 are considered non-sodic, greater than 6 are considered sodic and greater than 14 are considered strongly sodic and may be susceptible to dispersion and erosion (Isbell, 2002; and Northcote and Skene, 1972). Hence, most materials represented by the four samples are likely to be strongly sodic and have a high risk of being susceptible to dispersion and erosion, unless the soil materials are amended with gypsum.

8.2.4 Elemental enrichment

The soil and weathered overburden does not contain sulfide minerals and the total sulfur content was < 0.02% in the six soil and overburden samples from Borrow Area 1 and Borrow Area 3 and four samples from the drill core in DH001 and DH002. The concentrations of elements in the soil and overburden are at or near average soil concentrations and geochemical abundance indices for all samples are < 1: the overburden materials are therefore unlikely to have adverse environmental impacts.

Table 8-2: Test Pit Geochemistry and Fertility Data

		Data Analysed	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
		Test Pit Hole ID	TP01	TP02	TP06	TP01	TP02	TP06
		Sample ID	MRORGS001-1 0.0-0.5m <5mm	MRORGS002-1 0.0-0.5m <5mm	MRORGS003-1 0.0-0.5m <5mm	MRORGS001-2 0.5-1.0m <5mm	MRORGS002-2 0.5-1.0m <5mm	MRORGS003-2 0.5-1.0m <5mm
		Soil Horizon	O Horizon	O Horizon	O Horizon	A horizon	A horizon	A horizon
Chemical Parameter	**Units**	**Limit of reporting**	Tb103	Tb103	Tb88	Tb103	Tb103	Tb88
pH Value	pH Unit	0.1	5.8	5.7	6.3	8.3	6.7	8.7
Net Acid Production Potential	kg H_2SO_4/t	0.5	<0.5	<0.5	0.6	-2.9	-1.4	-2.1
Electrical Conductivity @ 25°C	µS/cm	1	27	31	62	260	226	349
ANC as H_2SO_4	kg H_2SO_4 equiv./t	0.5	0.6	<0.5	<0.5	2.9	2	2.7
ANC as $CaCO_3$	% $CaCO_3$	0.1	<0.1	<0.1	<0.1	0.3	0.2	0.3
Fizz Rating	Fizz Unit	0	0	0	0	0	0	0
Moisture Content (dried @ 103°C)	%	1	<1.0	<1.0	1.2	1.4	1.7	1.5
Exchangeable Calcium	meq/100g	0.1	0.6	0.8	0.3	0.2	0.1	0.2
Exchangeable Magnesium	meq/100g	0.1	0.6	0.8	3.4	8.6	5.8	5.4
Exchangeable Potassium	meq/100g	0.1	<0.1	0.1	0.2	0.1	<0.1	<0.1
Exchangeable Sodium	meq/100g	0.1	<0.1	<0.1	0.6	3.4	4.1	4.9
Exchangeable Sodium Percent	%	0.1	<0.1	2.1	12.7	27.4	40.5	45.7
Cation Exchange Capacity	meq/100g	0.1	1.4	1.8	4.5	12.5	10.1	10.7
Sulfur - Total as S (LECO)	%	0.01	0.02	<0.01	0.02	<0.01	0.02	0.02
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	0.5	0.7	0.1	0.3	0.2	0.3
Total Kjeldahl Nitrogen as N	mg/kg	20	390	510	520	130	120	140
Total Nitrogen as N	mg/kg	20	390	510	520	130	120	140
Total Phosphorus as P	mg/kg	2	64	82	122	111	90	150
Bicarbonate Ext. P (Colwell)	mg/kg	5	8	10	10	9	8	8
Total Organic Carbon	%	0.02	0.5	0.52	0.77	0.16	0.14	0.15
Total Carbon	%	0.02	0.61	0.68	1.12	0.24	0.21	0.18

Table 8-3: Drill Core Geochemistry and Fertility Data

		Sample ID	DH001_A	DH001_B	DH002_A	DH002_B
		Drill Hole ID	DH001	DH001	DH002	DH002
		Sample ID	16090340	16090341	16090342	16090343
		Depth Interval	3.5 to 6.3	6.3 to 15.4	3.2 to 9.1	9.1 to 15.1
Chemical Parameter	**Units**	Limit of reporting	Schist/ Gneiss	Schist/ Gneiss	Meta-Sandstone	Meta-Sandstone
pH Value	pH Unit	0.1	7.7	9.7	6.0	7.2
Net Acid Production Potential	kg H_2SO_4/t	0.5	-5.9	-30.9	-0.8	-1.7
Electrical Conductivity @ 25°C	µS/cm	1	134	286	162	99
ANC as H_2SO_4	kg H_2SO_4 equiv./t	0.5	5.9	30.9	0.8	1.7
ANC as $CaCO_3$	% $CaCO_3$	0.1	0.6	3.2	<0.1	0.2
Fizz Rating	Fizz Unit	0	0	2	0	0
Moisture Content (dried @ 103°C)	%	1	2.1	2.0	2.2	1.8
Exchangeable Calcium	meq/100g	0.1	0.4	10.0	0.3	0.4
Exchangeable Magnesium	meq/100g	0.1	7.2	6.6	6.0	6.2
Exchangeable Potassium	meq/100g	0.1	<0.1	0.2	<0.1	<0.1
Exchangeable Sodium	meq/100g	0.1	4.5	2.5	3.7	6.2
Exchangeable Sodium Percent	%	0.1	37.1	12.8	36.5	47.7
Cation Exchange Capacity	meq/100g	0.1	12.2	19.4	10.0	12.9
Sulfur - Total as S (LECO)	%	0.01	<0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1	0.8	0.4	0.8	0.3
Total Kjeldahl Nitrogen as N	mg/kg	20	40	70	40	40
Total Nitrogen as N	mg/kg	20	40	70	40	40
Total Phosphorus as P	mg/kg	2	274	281	151	319
Bicarbonate Ext. P (Colwell)	mg/kg	5	9	<5	<5	15
Total Organic Carbon	%	0.02	0.04	0.06	0.05	0.04
Total Carbon	%	0.02	0.08	0.21	0.07	0.06

Table 8-4: Borrow Area 1 Summary

	Soil	Sub-soil	Overburden	Overburden
	0-50 cm	50-150 cm	3.5 to 6 m	6 to 15 m
pH Value	5.75	7.50	8.70	6.60
Net Acid Production Potential	0.25	-2.15	-18.40	-1.25
Electrical Conductivity @ 25°C	29.00	243.00	210.00	130.50
ANC as H_2SO_4	0.60	2.45	18.40	1.25
ANC as $CaCO_3$		0.25	1.90	0.13
Fizz Rating			1.00	
Moisture Content (dried @ 103°C)	0.05	1.55	2.05	2.00
Exchangeable Calcium	0.70	0.15	5.20	0.35
Exchangeable Magnesium	0.70	7.20	6.90	6.10
Exchangeable Potassium	0.08	0.08	0.13	0.05
Exchangeable Sodium	0.08	3.75	3.50	4.95
Exchangeable Sodium Percent	1.08	33.95	24.95	42.10
Cation Exchange Capacity	1.60	11.30	15.80	11.45
Sulfur - Total as S (LECO)	0.01	0.01	0.01	0.01
Nitrite + Nitrate as N (Sol.)	0.60	0.25	0.60	0.55
Total Nitrogen as N	450.00	125.00	55.00	40.00
Total Phosphorus as P	73.00	100.50	277.50	235.00
Bicarbonate Ext. P (Colwell)	9.00	8.50	5.75	8.75
Total Organic Carbon	0.51	0.15	0.05	0.05
Total Carbon	0.65	0.23	0.15	0.07
Total Organic Carbon	5100.00	1500.00	500.00	450.00
Total Carbon	6450.00	2250.00	1450.00	650.00
OC:C ratio	0.79	0.67	0.39	0.69
C:N ratio	11.51	11.99	9.29	11.25
Ca:Mg ratio	1.00	0.02	0.75	0.06

The calcium/magnesium ratio is found by dividing the quantity of calcium (meq/100 g) by the quantity of magnesium (meq/100 g). If the figure is below 2, it is more difficult for plants to take up potassium, and there can be problems with soil structure breaking down due to dispersion. The soil, subsoil and OB are deficient in Ca. increasing the Ca with addition of gypsum will reduce potential for dispersion and correct the Ca:Mg ratio imbalance.

OB at 3.5 to 6 m due to presence of carbonate minerals (calcite) in in-filled fractures of rock identified in Hylogger results.

OC and N are both critical to soil microbiota. A C:N ratio of 12 is the baseline value for the soils in this area. Agricultural soils should have > 2% OC. The OC% in the soils is 0.5% and OC decreases with depth. If sub-soil is used in the upper profile of the soil cover system the OC:N ratio must be amneded to increase it to at least 0.5% OC. The increase in OC must be balnaced with an increase in N to maintain the OC:N ratio of at least 12.

Table 8-5: Western TSF KLC Data (Average data from KLC testing on tailings)

Analyte grouping/Analyte	CAS Number	Units	LOR	Dec-14	Mar-15	Jun-15	Sep-15	Dec-15	Jun-16
pH Value		pH Unit	0.01	7.0	7.4	7.5	7.5	7.5	7.6
Electrical Conductivity @ 25°C		µS/cm	1	8622.5	4015.0	3065.0	2055.0	1710.0	1378.5
Hydroxide Alkalinity as CaCO3	DMO-210-001	mg/L	1	0.5	0.5	0.5	0.5	0.5	0.5
Carbonate Alkalinity as CaCO3	3812-32-6	mg/L	1	0.5	0.5	0.5	0.5	0.5	0.5
Bicarbonate Alkalinity as CaCO3	71-52-3	mg/L	1	134.3	93.3	75.5	66.3	61.3	75.0
Total Alkalinity as CaCO3		mg/L	1	134.3	93.3	75.5	66.3	61.3	75.0
Acidity as CaCO3		mg/L	1	13.8	12.5	6.3	3.8	7.3	2.5
Silicon	7440-21-3	mg/L	0.05	3.2	4.5	9.1	7.3	8.0	8.0
Sulfate as SO4 - Turbidimetric	14808-79-8	mg/L	1	3265.0	1965.0	1712.5	1137.8	851.0	677.3
Chloride	16887-00-6	mg/L	1	626.8	155.3	69.3	21.0	10.0	7.8
Calcium	7440-70-2	mg/L	1	512.8	500.5	416.3	363.3	279.5	245.8
Magnesium	7439-95-4	mg/L	1	72.5	28.3	18.3	14.5	10.5	9.8
Sodium	7440-23-5	mg/L	1	1445.0	408.5	213.0	99.8	46.8	37.0
Potassium	7440-09-7	mg/L	1	386.5	143.3	85.5	61.0	48.5	38.8
Aluminium	7429-90-5	mg/L	0.01	0.009	0.005	0.005	0.005	0.005	0.005
Antimony	7440-36-0	mg/L	0.001	0.003	0.003	0.003	0.003	0.002	0.001
Arsenic	7440-38-2	mg/L	0.001	0.003	0.003	0.002	0.001	0.002	0.002
Boron	7440-42-8	mg/L	0.05	0.108	0.125	0.100	0.061	0.088	0.025
Cadmium	7440-43-9	mg/L	0.0001	0.039	0.019	0.018	0.015	0.011	0.007
Chromium	7440-47-3	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Cobalt	7440-48-4	mg/L	0.001	0.010	0.004	0.003	0.001	0.002	0.002
Copper	7440-50-8	mg/L	0.001	0.023	0.016	0.014	0.012	0.012	0.012
Iron	7439-89-6	mg/L	0.05	0.025	0.025	0.025	0.025	0.104	0.051
Lead	7439-92-1	mg/L	0.001	0.003	0.001	0.001	0.001	0.001	0.001
Manganese	7439-96-5	mg/L	0.001	1.110	1.918	0.714	0.150	0.712	0.862
Molybdenum	7439-98-7	mg/L	0.001	0.157	0.082	0.055	0.026	0.035	0.031
Nickel	7440-02-0	mg/L	0.001	0.002	0.002	0.001	0.001	0.001	0.001
Selenium	7782-49-2	mg/L	0.01	0.005	0.005	0.005	0.005	0.005	0.005
Zinc	7440-66-6	mg/L	0.005	1.321	2.138	1.965	1.435	0.850	0.581

9 Physical analytical results

Laboratory reports for physical analyses provided by Trilab (Brisbane) are included in **Attachment B – Trilab Raw Data**. Photographs of the samples supplied to Trilab for testing are in **Figure 7-2** to **Figure 7-8** and the results of the test pit and drill core physical testing are summarised in **Table 9-4** and **Table 9-5**, respectively.

9.1 Atterberg limits

Atterberg limits is a series of tests used to define the properties of cohesive soils at a range of moisture contents. The liquid limit (LL) is the minimum moisture content at which the soil can flow under its own weight (ie. when soil behaves like a liquid). The plastic limit (PL) is the minimum moisture content at which the soil can be rolled into a 3 mm diameter thread without breaking (ie. when soil behaves plastically). The numerical difference between the LL and PI is the plasticity Index (PI = LL - PL). The PI represents the range of water contents across which a soil is in a plastic state. Linear Shrinkage is the percentage decrease in a single dimension of a specimen of soil when moisture is reduced from LL due to heating of the material in an oven. **Table 9-1** to **Table 9-3** indicates the ratings relevant to describing the soil properties.

Table 9-1 Liquid Limit Ratings for Compressibility and Shrink-Swell Potential

Rating	Liquid Limit (%)
Low	<45
Medium	45 – 55
High	55 – 75
Very High	>75

Table 9-2 Plasticity Index Ratings for Compressibility and Shrink-Swell Potential

Rating	Plasticity Index (%)
Low	<25
Medium	25 – 35
High	35 – 45
Very High	>45

Table 9-3 Categories of Linear Shrinkage

Rating	Plasticity Index (%)	Expansive Rating
Low	0-12	Non-critical
Medium	12-17	Marginal
High	17-22	Critical
Very High	>22	Very Critical

The results from Atterberg tests for the six test pit samples are summarised in the following points:

- The LL, PL and linear shrinkage was not obtainable for samples collected from test pit 001, due to the non-plastic nature of the sample; the soil contains a relatively high proportion of gravel size material and the finer fractions are silty with a low clay content.
- The LL for the O horizon samples ranged from 23-27% and 33-35% for the A horizon. This corresponds to a low compressibility and shrink-swell potential for both soil horizons (Error! Reference source not found.).
- The PI for the O horizon samples ranged from 6-8% and 11-18% for the A horizon, which corresponds to low compressibility and shrink-swell potential for both soil horizons (**Table 9-4).**

- The Plasticity Chart (Error! Reference source not found.) is used to determine the nature of soil based on its PI and LL. According to the Unified Soil Classification System (USCS), the samples groups include: CL-ML (1 sample), CL or OL (2 samples) and ML or OL (1 sample) which corresponds to lean clay to silt, lean clay or organic clay and silt or organic clay, respectively.
- The linear shrinkage of all samples tested were classified as “non-critical” (Error! Reference source not found.). This indicates that there is a low potential for the soil mass to shrink upon drying.

Figure 9-1 indicates the plotting potions for the four samples using the USCS classification system.

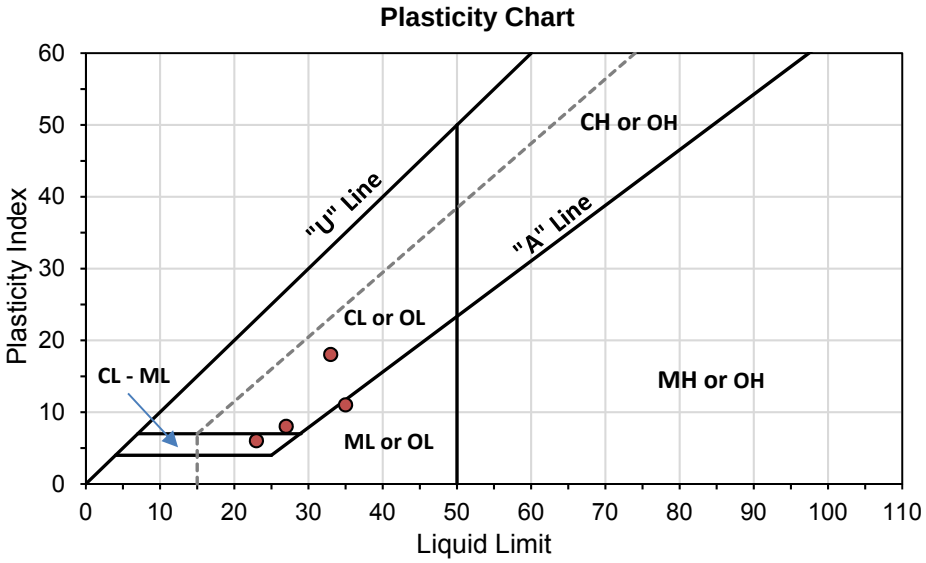


Figure 9-1: **Unified Soil Classification System (USCS) Plasticity Chart for classification of samples**

9.2 Rock strength

The drill core samples from DH001 and DH002 were submitted for diametral point load testing to quantify the strength of the core (**Table 9-5**). The test results verify the material in Borrow Area 1 has low to moderate strength and it should be possible to free dig the material without blasting. The analysis suggests that the material may be susceptible to physical degradation during the mining, haulage and placement onto the soil cover.

9.3 Emerson aggregate

The soil and sub-soil samples from DH001, 002 and 006 and drill core samples from DH001 and DH002 had Emerson Class Numbers of 3 and 2 that makes them potentially dispersive soils that disperse after the application of mechanical stress by raindrop impact, irrigation or tillage (**Table 9-4** and **Table 9-5**). Type 3 soil (MRORGS001-1 0.0-0.5 m <5 mm) may also flocculate and remain in suspension. The Emmerson results are consistent with the ESP analyses and suggest that these materials may require amendment with gypsum to reduce the ESP.

9.4 Particle size distribution

Particle size distribution results for the borrow materials and core samples are shown in **Figure 9-2** and **Figure 9-3.** Note that the core samples were crushed prior to PSD testing; the results are expected to replicate the PSD of crushed rock due to excavation and transportation by haul truck. The key results are summarised in the following points:

- The results for all the samples are generally quite variable with the bulk of particles sand or gravel sized. The test pit samples typically have a greater sand content than the crushed core samples which have a greater gravel content.
- The test pit samples (TP01 – TP06) typically show a larger sand and silt content (~20%), particularly for the 0.5 – 1m samples.
- The gravel content of the test pit samples range from ~1-55%; sample TP02 and TP06 0.5-1m samples have < 5% gravel and are composed mostly of sand (~80%).
- Typically, the gravel content of the crushed core samples is very high (~40-80%), particularly for the deeper samples. The exception is sample DH001_A (~10%).
- The sand content of the crushed core samples range from ~15-80%, with < 10% clay or silt.

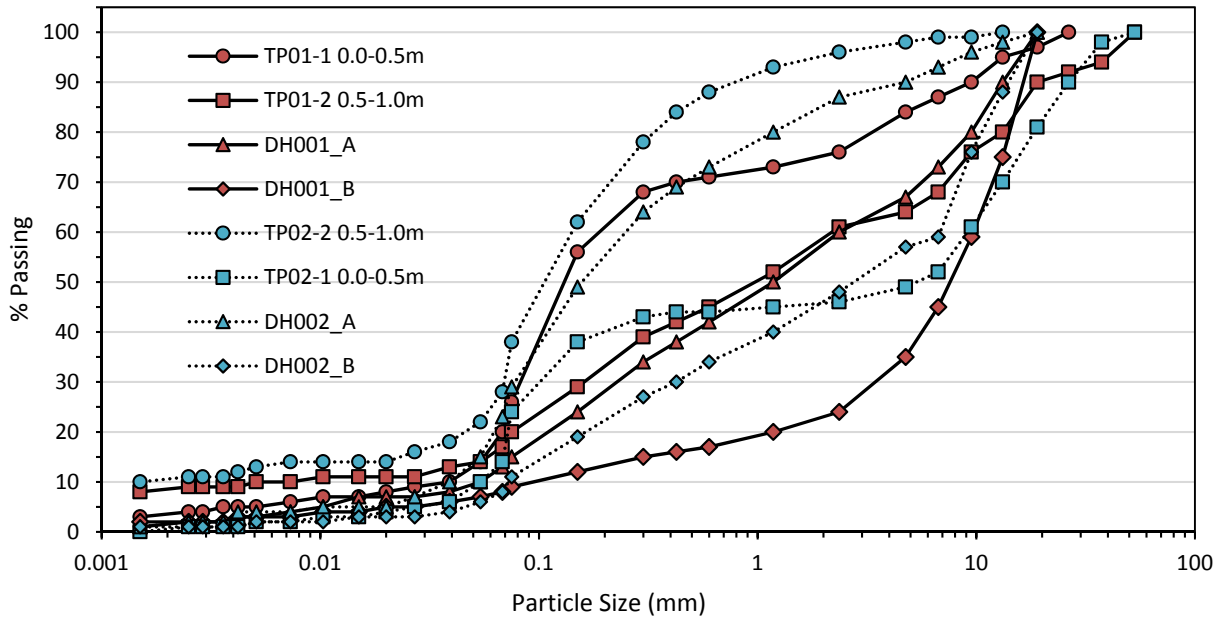


Figure 9-2: Particle Size Distribution (PSD) for test pit and drill core samples

9.5 Field permeability

The hydraulic conductivity of the tailings and topsoil was completed at one site on the TSF and at TP01 and TP02 using a double ring infiltrometer (**Table 9-4** and **Table 9-5**). The field permeability of the soils was very low and in the order of 5 to 9 mm/hr and 2 mm/hr for tailings (**Figure 9-3**).

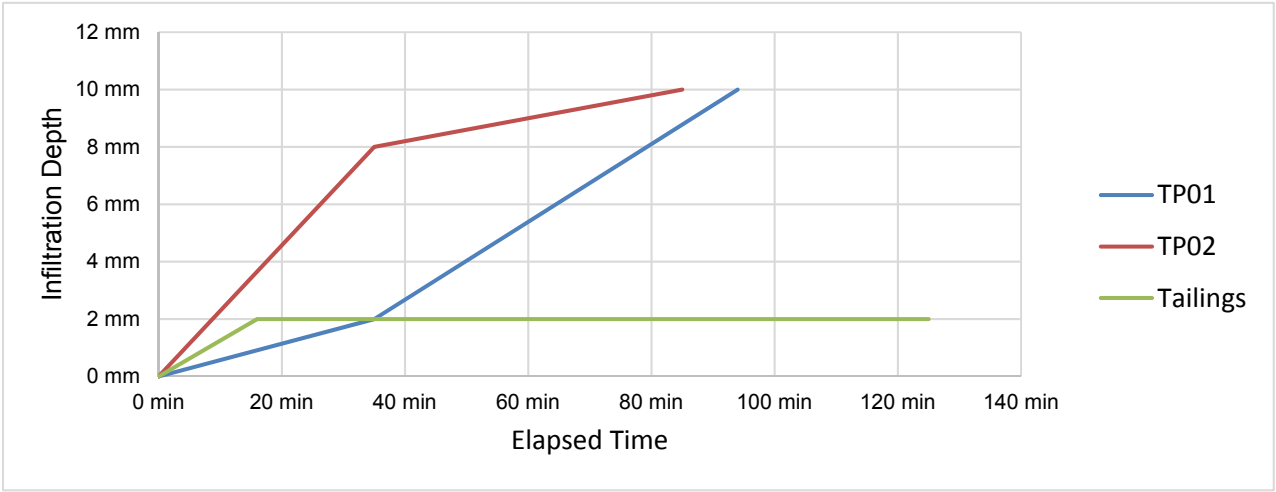


Figure 9-3: Field permeability results

9.6 Hydraulic conductivity - falling head test

Falling head tests were done on samples from TP01, TP02, DH001 and DH002 at 100 % standard compaction (**Table 9-4** and **Table 9-5**) that represent optimum compaction that might be achieved under field conditions (if compaction is required).

The data verify that the soil and overburden is susceptible to compaction and a substantial loss of permeability if the soil cover is compressed during construction.

Table 9-4: Test Pit Physical Testing Data

Data Analysed		22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016	22/08/2016
Test Pit ID		TP01	TP02	TP06	TP01	TP02	TP06
Sample ID		MRORGS001-1 0.0-0.5m <5mm	MRORGS002-1 0.0-0.5m <5mm	MRORGS003-1 0.0-0.5m <5mm	MRORGS001-2 0.5-1.0m <5mm	MRORGS002-2 0.5-1.0m <5mm	MRORGS003-2 0.5-1.0m <5mm
Soil Horizon		O Horizon	O Horizon	O Horizon	A horizon	A horizon	A horizon
Atlas of Australian Soils – Description - Soil Type		Tb103	Tb103	Tb88	Tb103	Tb103	Tb88
Atterberg Limits	Units						
Liquid Limit	%	Not Obtainable	Not Obtainable	23	33	27	35
Plastic Limit	%	Not Obtainable	Not Obtainable	17	15	19	24
Plasticity Index	%	Non-Plastic	Non-Plastic	6	18	8	11
Linear Shrinkage	%	Not Obtainable	Not Obtainable	2.5	8.5	4+	4
Moisture Content	%	11.3	12.2	12.2	8.4	7.2	8.9
Emerson Class		3	2	2	2	2	2
Maximum dry density (t/m^3)	t/m^3	1.86	1.97	1.81	1.96	1.91	1.76
Optimum moisture content (%)	%	9.9	9.4	12.9	10.1	9.7	11.7
Placement moisture content (%)	%	9.7	9.1	13.1	10.0	9.5	11.5
Moisture ratio (%)	%	98.5	97.1	101.9	98.7	97.6	98.12
Placement wet density (t/m^3)	t/m^3	2.04	2.16	2.04	2.16	2.09	1.96
Density ratio (%)	%	100.1	100.3	99.8	100.2	100.0	100.0
Hydraulic gradient		9.4	9.4	9.4	9.4	9.6	9.4
Surcharge (kPa)	kPa	3.7	3.6	3.7	3.7	0.0	2.9
Head pressure applied (kPa)	kPa	10.79	10.79	10.79	10.79	10.79	10.79
Water type (deionised)	Deionised	Deionised	Deionised	Deionised	Deionised	Deionised	Deionised
Percentage material retained on a 19 mm sieve	%	3%	19%	5%	10%	1%	0%
Permeability (Falling head test)	m/sec	4.50E-09	9.70E-09	6.10E-10	8.90E-10	9.80E-10	2.70E-09
Permeability (Falling head test)	mm/hr	0.016	0.035				
Field Permeability	m/sec	1.61E-06	2.24E-06				
Field Permeability	mm/hr	5.8	8.1				

Table 9-5: Drill Core Physical Testing Data

	Sample ID	MRORGSDH 001_A	MRORGSDH 001_B	MRORGSDH 002_A	MRORGSDH 002_B
	Soil depth	3.5 to 6.3 m	6.3 to 15 m	3.2 to 9.1 m	9.1 to 15 m
	Soil description	Silty, sandy gravel – yellow brown	Silty, sandy gravel – grey	Silty, sandy gravel – yellow brown	Silty, sandy gravel – yellow brown
Emerson class	**Units**	3	2	2	3
Maximum dry density	t/m^3	1.99	2.05	1.94	1.97
Optimum moisture content	%	8	9.1	10.1	11.1
Placement moisture content	%	8	9	9.9	10.7
Moisture ratio	%	100.2	99.3	97.7	96.1
Placement wet density	t/m^3	2.15	2.24	2.13	2.19
Density ratio	%	99.9	100.0	100.1	100.4
Hydraulic gradient		9.4	9.4	9.4	9.4
Surcharge	kPa	3.6	3.7	3.7	3.7
Head pressure applied	kPa	10.79	10.79	10.79	10.79
Water type	Deionised	Deionised	Deionised	Deionised	Deionised
Percentage material retained / sieve size	mm	0 % / 19 mm	0 % / 19 mm	0 % / 19 mm	0 % / 19 mm
Permeability (Falling head test)	m/sec	5.8E-09	7.40E-07	3.8E-09	6.40E-07
Permeability (Falling head test)	mm/hr	0.02	2.6	0.01	2.3
Point Load Test					
Is	Mpa	0.1	0.13	0.12	0.69
Is (50)	Mpa	0.11	14	0.14	0.76
Load Direction		Diametral	Diametral	Diametral	Diametral
Descriptive Term*		L	L	L	M

10 Discussion of geochemical and physical results

10.1 Geochemical findings of tailings, waste rock, soil and overburden

10.1.1 Tailings

The sulfide minerals in the tailings that include Pyrite > Chalcopyrite > Sphalerite > Galena can oxidise and undergo chemical weathering when exposed to atmospheric conditions. The static classification of the tailings is NAF, but with an ANC:MPA ratio of between 1 and 2. PAF waste rock is added to the TSF. The addition of PAF waste rock to NAF tailings could be viewed as changing the overall classification of the tailings from net NAF to PAF, particularly in areas of the TSF where the proportion of PAF waste rock to tailings is higher and the ANC:MPA ratio decrease from between 1 and 2 to < 1: this would occur around the edge of the decant structure and near the Western TSF WRD Cell.

KLC testing in 2009 to 2011 and 2014 to 2016 verifies the tailing materials have a very low rate of geochemical reactivity and continue producing neutral pH leachate (**Section 8.1.2**): for at least 7 years in the case of the ongoing KLC testing program. After six leach cycles on the four tailings samples collected in November 2014 (**Section 8.1.2**) that are being subjected to saturated and unsaturated leach cycles conducted over 24 months the concentrations of the dissolved metals in the leachate in June 2016 are typically very low (Al (0.005 mg/L), As (0.005 mg/L), Cd (0.007 mg/L), Co (0.002), Cu (0.012 mg/L), Fe (0.051 mg/L), Mn (0.862 mg/L), Mo (0.031), Ni (0.001 mg/L), Pb (0.001 mg/L) and Zn (0.581 mg/L)). The KLC leach testing data has consistently verified the low rate of reactivity of the tailings and the probability that the tailings will not contribute to elevated concentrations in the tailings pore water during operations or after the placement of the soil cover system.

The fine-grained nature of the tailings and their low rate of geochemical reactivity combined with their static classification as NAF with an ANC:MPA ratio of 1 to 2 means the tailings do not need to be covered immediately following the cessation of tailings deposition to limit any potential for the tailings to produce acidic drainage. Nevertheless, once the deposition of tailings stops, the tailings will be much drier and the potential for loss of tailings via erosion by wind will increase. It is therefore necessary to implement a rehabilitation strategy that will cover the tailings as soon as practicable. The rate of cover placement and depth that the material can be placed will be dependent on the strength the tailings.

In real terms, it is the management strategy applied to the waste and the kinetics of the mine waste that determines whether it is likely to produce, and leach, acid, salts or metals, not the static classification. The addition of supplementary ANC to the tailings may be a valid contingency to ensure that the zones around the PAF waste remain NAF and additional lines of defence exist.

10.1.2 Waste rock

Representative samples of NAF, PAF-MC and PAF-HC waste rock collected for KLC tests verify the low, moderate and high sulfide content of the waste rock types and low rates of geochemical reactivity (**Section 8.1.1**). The reactivity of the waste rock under unsaturated conditions will be lower than the tailings (i) because the tailings have a much higher surface area per volume than the waste rock (the surface area of the tailings is orders of magnitude higher than the waste rock) and (ii) in most of the waste rock the sulfide minerals are contained within the matrix of the rock thereby reducing their exposure to oxygen (iii) the morphology of the sulfide minerals present in fracture surfaces is dominated by coarse grained crystals that will have considerable lower rates of oxidation than sulfide minerals in the tailings. KLC testing of NAF, PAF-MC and PAF-HC waste rock from laboratory and field test pads will provide the data over the next 2 to 5 years to support these assumptions.

PAF-HC waste rock will be encapsulated within 12 months of its deposition in the decant structure within the tailings in the TSF. The PAF-MC material placed into the western TSF cell will be placed in low lifts and the entirety of the waste rock will be covered with tailings. Where practicable, tailings will be deposited onto or within benches of waste rock to seal the waste rock and fill voids. The top of the waste rock will be > 3 m

below the final height of the tailings beach and > 10 m from the edge of the natural ground on the western embankment of the TSF or external embankments to the north and south (**Attachment C – MRO Western TSF PAF Cell Design**).

10.1.3 Soil and overburden

The soil, sub-soil and overburden is not mineralised, does not contain acid producing minerals, has low acid neutralising potential but does have elevated exchangeable sodium percentage (ESP) in sub-soil and overburden below 50 cm depth (**Table 8-4**). The high ESP may induce dispersion resulting in a lower rate of infiltration.

There is unlikely to be a deficit of soil as there is a surplus of stockpiled soil at the mine so there will not be a requirement to utilise sub-soil or overburden in the upper soil profile of the soil cover system. This is turn suggests that there should be no requirement to add fertiliser to the soil after it is placed on the soil cover.

There is also a surplus of NAF waste rock in the West WRD (6.9 Mt as of November 2016) that could be used as a screening layer if a drainage layer is considered in the design or if NAF rock is required for armouring drains or steep slopes.

10.2 Physical findings of tailings, waste rock, soil and overburden

10.2.1 Tailings

The worked tailings are fine grained, non-plastic and have very low permeability (**Section 4.2** and **Figure 9-3**) that are likely to result in low rates of recharge into the tailings once the decant pond is decommissioned and consolidation of the tailings is achieved (nominally within 6 to 12 months along the embankment perimeter (**Section 4.3**), but potentially 12 to 24 months within or adjacent to the decant pond where the slimes content is higher.

The decant structure to the north of the TSF was not keyed in and is likely to be a pathway for tailings water seepage. It is probable that when this decant structure is decommissioned and covered with tailings the flow rate to Stans' Well will decrease. The new decant structure will be keyed in and this structure will not have the same potential to act as a conduit for tailings water. The central decant structures contribute to the recharge of tailings water to groundwater and changing the location and geotechnical configuration of the structures will affect the localised seepage form the TSF to the receiving environment. There is some seepage modelling work required to verify and then quantify these assumptions.

The tailings are prone to vertical and lateral deformation if they are loaded with waste rock inappropriately. This began to occur on the northern part of the western TSF cell during placement of the first bench of waste rock. This flags a requirement for a progressive and well planned program to place waste rock on the tailings, particularly as this TSF Cell is relatively shallow compared to the main TSF and has been inactive for at least seven years.

The final embankment height of the TSF is 193 m ASL. The proposed TSF soil cover may be up to 10 m above this elevation. Stability analyses are required to be completed to ensure that the additional loading on the embankment and the TSF will not lead to geotechnical failure. Regulatory approval will also be required to increase the overall height of the embankment and soil cover system.

10.2.2 Waste rock

The NAF waste rock at MRO is structurally competent and could be quarried, crushed and screened to provide graded material for specific use within the cover system. The NAF waste rock used within the soil cover system should have < 1% TS so that it does not have the potential to significantly contribute acidity and saline drainage, and should have the potential to contribute some alkalinity due to the presence of carbonate minerals (calcite).

Capillary breaks within final soil cover system typically require well graded material in the range of 5 to 15 mm PSD in some applications with a limited proportion of fines that yield a hydraulic conductivity of $1x10^{-3}$ to 1 cm/sec (Daniel and Koerner, 1993, and Neng, 1997). Material in drainage layers in landfill covers is required to be 20 to 40 mm PSD with < 10 % of the material having a PSD of < 20 mm and no more than 3% of the material being < 0.075 mm (EPA, 2015). The cost of producing graded and screened material in this size range could be in the order of $20 to $40 per m^3 (MRO, 2015).

There is considerable cost and energy associated with the crushing and screening of aggregate for use in drainage layers (which will increase greenhouse gas emissions). Indicative costs to produce +5 to -15 mm aggregate on site could be in the order of $10 to $20 / m^3. Crushing a large volume of aggregate would produce a large amount of dust, and this would also need to managed. The potential for re-purposing the process plant crushing equipment at the end of production to produce aggregate for the drainage layer will be investigated by MRO.

10.2.3 Soil and overburden

The in-situ soil has very low field permeability in the range of 5.8 to 8.1 mm/hr that will lead to low rates of infiltration and a high proportion of surface runoff during slight to moderate rainfall events. While this is favourable for reducing recharge into the tailings, it could lead to surface erosion. The low permeability of the soil may also lead to a low degree of soil moisture within the soil cover, thereby reducing the establishment and persistence of vegetation and a reduced rate of evapotranspiration.

Because of the low permeability of the soil and potential for erosion it could be necessary to incorporate some competent rock into the soil cover to provide some resistance to erosion until the vegetation has become established, and provide residual protection to the soil if the vegetation is damaged or lost from fire, for example. The inclusion of rock armour in the soil profile is also likely to lead to a higher rate of infiltration than the soil on its own.

The soil and overburden in Borrow Area 1 has low to moderate rock strength down to 15 m that is the likely base of the borrow pit. The material should be able to be mined without blasting and will form a structurally favourable soil cover. The permeability data verify that the soil and overburden in susceptible to compaction that would decrease plant growth and in-situ permeability. The use of suitable construction equipment and methodology will therefore be a key requirement for the construction of a soil cover.

10.2.4 Water

Water associated with the TSF domain includes the following:

- rainfall directly onto the tailings facility;
- supernatant - mix of rain and process water within the decant pond affected by dilution and evapotranspiration;
- entrained tailings porewater - water contained within the tailings matrix in the TSF;
- tailings decant seepage - water that seeps from the TSF to surface water from the toe of the TSF embankment or as seepage to Stan's Well;
- tailings percolate - porewater that percolates from the TSF to the groundwater system;
- groundwater - non-impacted water from up-gradient gradient sources that may mix with the tailings percolate; and
- surface runoff (during and after completion of rehabilitation).

Behaviour of the tailings water system to date suggests there is leakage occurring from the facility as both seepage under the embankment, captured by Stans Well and northern interception drains, and also leakage to groundwater. The tailings facility rises above the landscape and with a permanent decant and pressure water head, with groundwater flow likely to occur via fractures and faults underneath the facility itself. Whilst this has not resulted in compliance concerns at measurement locations, it presents a dynamic of the tailings system requiring management and consideration at closure. Current and water entering the system until

closure will continue to drain, and closure options will prioritise minimising the potential for water entering the tailings storage at and beyond closure as a primary control.

For closure, it is currently assumed that:

- seepage and impacted groundwater from the TSF will be pumped back to the open pit after the cessation of mining in the pit); and
- surface runoff from the TSF will flow to the open pit.

11 Cover design options analysis

11.1 Generic rehabilitation goals

The four general rehabilitation goals in the DEHP rehabilitation guidelines require rehabilitation of areas disturbed by mining to result in sites that are:

- safe to humans and wildlife;
- non-polluting;
- stable; and,
- able to sustain an agreed post-mining land use.

Generic examples of the rehabilitation goals from the guidelines that are relevant to a TSF are in **Table 11-1**.

Table 11-1: Possible strategies to achieve rehabilitation goals for a TSF (DEHP, 2015a)

<table>
<tr><th></th><th>SAFE</th><th>NON-POLLUTING</th><th>STABLE LANDFORM</th><th>SUSTAINS AGREED LAND</th></tr>
<tr><td rowspan="5">Generally acceptable</td><td>Structurally safe (appropriate certification against relevant code) - no hazardous materials</td><td rowspan="5">Runoff and seepage will be good quality water that is unlikely to affect known environmental values</td><td>Stored in redundant pit below natural surface level with appropriate erosion control</td><td>Reinstate original ecosystem</td></tr>
<tr><td rowspan="4">Structurally safe - treated hazardous material</td><td>Outer walls designed for long term stability</td><td>Create a different use with enhanced environmental, economic or social values acceptable to stakeholders</td></tr>
<tr><td rowspan="2">Vegetation cover established and preventing erosion</td><td>Return to previous use/ condition</td></tr>
<tr><td>Site management plan in place and effective</td></tr>
<tr><td rowspan="5">May be acceptable</td><td rowspan="5">Containment of hazardous material but limited strengthening of walls or capping</td><td>Eliminate inflow</td><td rowspan="5">Appropriate maintenance program proposed</td><td rowspan="5">Return to previous use, or a different use with reduced environmental, economic or social values (evidence that use is acceptable to stakeholders would be essential).</td></tr>
<tr><td>Breach wall to prevent ponding</td></tr>
<tr><td>Armoured impervious capping with capillary break if needed</td></tr>
<tr><td>Store and release capping</td></tr>
<tr><td>Collect and treat seepage</td></tr>
</table>

11.2 Cover goals, risks and actions

RGS was required to provide conceptual cover design options and a preferred conceptual cover design for the TSF. The RGS work program addressed geochemical and hydrological aspects of conceptual cover design for the TSF. The work did not address consultation with stakeholders or technical aspects related to safety or stability of the TSF or hydrogeological aspects relating to the interaction of tailings pore water with surrounding groundwater or vice versa.

Dedicated research over 30 years in the landfill sector has verified that the engineered earthen cover systems (excluding synthetic materials) can reduce, but will not stop, seepage from landfills. This fact applies to soil covers through to engineered multi-layer and barrier covers.

The construction of a soil cover system on mineralised material will:

- not reduce the overall AMD potential of the mineralised waste;
- stop, erosion by wind or water, and the mobilisation of contaminated dust, suspended and bedload sediment into the receiving environment ie. the solid phase materials will be contained; and
- delay and lengthen the contaminant release rate from the contained material.

Thus, the contaminant load in the seepage per unit of time (ie. the contaminant release rate) is reduced, so that lower contaminant loads are discharged over a longer time span. Ideally, a cover system should reduce the contaminant loads discharged with the seepage to levels that – even without seepage treatment – contaminant concentrations in the receiving water bodies do not exceed acceptable levels: this is a fundamental principle of geochemical engineering. Even if some water treatment is still required after cover construction, the long-term costs may be lower than for a simple collect-and treat option, due to financial discounting of future expenditures and potential improvements in water treatment technologies (eg. passive or microbiological treatment (Kistinger et al., 2002)).

The cover options for the TSF were developed using the basis of design in **Section 3.2** and the primary goals, risks and actions or objectives identified by RGS and MRO in **Table 11-2**.

The primary objectives to evaluate and select a suitable conceptual cover design included:

- physical containment of tailings within the TSF
- physical containment of mineralised waste rock present on the TSF embankment (inclusive of suspended and bedload sediment)
- reducing the potential for acidic, metalliferous or saline drainage to be released from the TSF as surface water or resurgent seepage from the TSF or to groundwater;
- providing a surface cover on the TSF beach and TSF embankment that can sustain vegetation;
- having a surface that is susceptible to low rates of erosion; and,
- having a free draining surface that will not contain water in the TSF.

The risks and opportunities associated with the options for the conceptual cover design are listed in **Table 21-1**.

Table 11-2: Goals, risks and action for evaluation of the cover design

COVER DESIGN GOAL	RISK	ACTION / OBJECTIVE
Regulatory Requirements		
The EA requires a certified closure, decommissioning and rehabilitation plan (CDaR Plan) for the TSF.	The cover design scope of work undertaken by RGS is one component of the final CDaR Plan. Other aspects may be required to be addressed by MRO.	Present risk and opportunity assessment and options to DEHP and outline the proposed cover design option. Request information from DEHP to identify other required scope of work that must be completed to satisfy their requirements for a certified plan.
DEHP Guidelines for rehabilitation require a defined end land use and acceptance by stakeholder(s)	Lack of consultation with stakeholders prior to development of CDaR Plan may lead to incorrect end land use being proposed by MRO.	MRO to consult with relevant stakeholders to determine next land use. The EA stipulates that the end land use is bushland. It is assumed that this land use has been verified with the relevant stakeholders
		Decision-making should involve (will involve) stakeholders who have been provided relevant information about possible future impacts developed through a thoroughly documented risk assessment process which considers the likelihood and consequence of hazards being realised.
The result of rehabilitation must, to the maximum extent possible, be maintenance free and require no future management intervention beyond the normal land management practices for the post mining land use.	Differences in implementation of the end land use (eg. over grazing, or failure of rehabilitation design) may lead to future maintenance requirement.	Demonstrate that end land use implementation is agreed with end land holder and provide documentation to demonstrate the CDaR Plan will be effective for an agreed period and conditions.
		The CDaR Plan must clearly identify the intended land use and other rehabilitation objectives for the TSF and cover the relevant rehabilitation goals listed in this table.
The TSF has a defined final elevation for the embankment height of 193 m ASL.	The final soil cover system on the TSF will most likely exceed the nominated final elevation.	MRO to engage with DEHP and seek a final height above 193 m ASL to allow construction of the soil cover system.
The TSF is a regulated structure and is therefore required to be managed until there is certified plan for the decommissioning and rehabilitation of the regulated structure at the end of its operational life (refer to EA EPML00732613_J10-F, J32-1, D11, D22, G16)	MRO has some uncertainty about the DEHP requirements for this TSF.	MRO has undertaken consultation with DEHP to address this risk.
The EA requires that the TSF must not contain flowable substances.	If the tailings cannot be flowable then sufficient dewatering and consolidation may need to be completed so these criteria can be met.	The basis of design is to alter the TSF landform to be free-draining so that water does not pond in the TSF footprint i.e. lower or remove the spillway, so there is no (or a much smaller) permanent pond.
		The definition of flowable substances is to be addressed by MRO with DEHP.
MRO Objectives		
No future non-compliance events with the TSF to avoid mandatory remedial action from the regulator	Extreme climatic variables or diffuse seepage from the TSF may trigger a regulatory response i.e. Environmental Investigation	Evaluate cover options and develop a preferred cover option to present to DEHP.
If relinquishment of the TSF is a primary objective, then a pathway to achieve this goal must be established with DEHP so there is agreement on the process that will meet the needs of MRO.	There are no specific criteria in the EA stipulating how **relinquishment** of the TSF is to be obtained following completion of the rehabilitation program for the TSF.	When a preferred final option is selected MRO will develop an agreed pathway forward with DEHP to attain reduction in FA or relinquishment of the TSF.
		The proposed content of the preferred cover design option being developed by RGS and the list of technical (or other) work to be commissioned and completed by MRO will be presented to DEHP to identify current gaps.
		Indicators and criteria for the preferred option will be discussed with DEHP prior to actioning the work program for the preferred cover option. To ensure that the indicators are relevant, it is recommended that monitoring of the indicators start as soon as possible and continue until the application to surrender the area has been approved by the administering authority.
		Presentation of a long-time series of monitoring data is potentially the most credible way to demonstrate that the risk of rehabilitation failure is low and/or quantifiable. RGS will include monitoring equipment within or on the cover and include cost estimates on an annual basis and over a timeframe of 30 years.
		Completion criteria must be developed and provide a clear definition of successful rehabilitation in the form of a set of measurable benchmarks against which the rehabilitation indicators can be compared to determine whether the objectives are being met. Completion criteria for the preferred option will be discussed with DEHP prior to actioning the work program for the preferred cover option.
		At least one completion criterion will be developed for each indicator. Completion criteria should specifically relate to the environmental, social and economic context of the mine site.
Safe to Animals and Humans		
The EA requires the TSF to be **safe** to animals and humans.	Animals and humans could get stuck in unconsolidated tailings.	Dewater the tailings and remove / reduce the maximum area and volume of the supernatant pond. If wet tailings cannot be sufficiently dewatered the construction works will segregate these areas from the cover design until they are trafficable.
		The site will be manned by a decommissioning team for 12 months following closure of the site. During the decommissioning phase the risk of people or animals getting stuck in tailings will therefore be very low. The TSF will be trafficable to humans and animals within 3 to 6 months of final tailings deposition. During this time NAF rock will be progressively placed over the tailings to create a stable surface profile. Following placement of NAF rock on the tailings the risk of people or animals getting stuck in tailings will therefore be improbable.
	The presence of contaminated water may affect animals if the water is consumed.	Post closure the supernatant pond will be kept as low as possible to dewater the TSF. Staff

COVER DESIGN GOAL	RISK	ACTION / OBJECTIVE
		will be on site daily to pump water down. Animals would only have access to the pond on an opportunistic basis.
		Acute or chronic ecotoxicity to animals is unlikely and is demonstrated by long term supernatant water quality data. Weak acid dissociable (WAD) cyanide (CN) concentrations are < 5 mg/L
	The tailings should not present a combustion risk.	MRO could ascertain the actual risk of tailings combustion by a SQP. The risk is understood to be very low or inconsequential.
Non-Polluting		
Tailings – the tailings have sulfide content of approximately 1% and an ANC:MPA ratio in the range of 1 to 2 i.e. the tailings do not have abundant excess acid neutralising capacity.	The addition of PAF waste rock to the NAF tailings will change the net acid producing potential (NAPP) of the contained material in the TSF.	The inclusion of PAF waste rock in the decant structure and the placement of PAF waste rock in the western cell of the TSF will be managed through encapsulation of the rock within NAF tailings. To ensure that the TSF remains net NAF, finely ground ag-lime will be added to the PAF waste rock to maintain a ANC:MPA ratio > 2.
Surface water	Surface water during operations is managed through EA conditions. After completion of a soil cover constructed from local borrow material surface runoff from the TSF could be directed to the receiving environment and comply with surface water quality conditions in the EA. Seepage from the TSF (e.g. from the embankment toe) that reports to surface water is unlikely to meet surface water quality conditions in the EA. If the seepage cannot be stopped, it will need to be contained within the TSF through construction of an impermeable or low permeability cover or if this cannot be achieved, water will need to be contained within the extent of the ML i.e. pumped to the final void.	A whole of mine (TSF+WRD) water quantity and water quality model is required to be developed to evaluate options for surface, seepage and groundwater management. The intent of the model is to ascertain whether surface runoff from the soil cover on the TSF will report to the receiving environment or to the final void.
Groundwater	Localised groundwater impacts from the TSF are occurring and will be quantified through 3D groundwater modelling after the final cover system for the TSF has been agreed with DEHP. Cyanide is present in monitoring bores and is inferred to be from TSF seepage (NRC, 2015). Sulfate concentrations in groundwater monitoring bores continue to increase (NRC, 2015) and this is inferred to be from sulfide oxidation of tailings and or waste rock.	
Seepage is occurring from the TSF.) The hydraulic characteristics of the TSF and the underlying hydrogeology below and surrounding the TSF and its interconnectivity with the open pit are described conceptually in this report.	There is a high seepage flow into Stan's Well and lower rates of seepage in other areas of the TSF (refer to **Section 4.6**). The primary source of seepage at Stans Well is inferred to be water draining from the eastern decant pond through the eastern decant access road within the TSF. The effect that the soil cover may have on decreasing seepage rates from the TSF after placement of the soil cover and the subsequent effect that this would have on the alluvial groundwater system will need to be quantified to provide assurance to DEHP and stakeholders that the rehabilitation plan for the TSF is fit for purpose.	
Suspended sediment	DEHP are unlikely to accept an unstable tailings surface or cover design that is susceptible to erosion and movement of tailings or sediment from the soil cover to the receiving environment.	Retention of a smaller TSF pond could serve as a sediment control structure during the establishment of vegetation so that bedload and suspended sediment can be retained within the TSF. The sediment dam within the TSF would be lowered to provide a free draining facility when water quality monitoring verifies this is appropriate.
		Tailings must not leave the TSF footprint and the concentration and load of suspended sediment and soil from a TSF cover should not result in turbidity higher than upstream quality, or agreed TSS release criteria.

11.3 Cover Options

The cover options evaluated in this study include the following.

1. Do nothing
2. Reprocess the tailings (Au, Ag, Cu, Pb or Zn are unlikely to be economic value)
3. Direct vegetation of tailings and maintaining a partial wetland cover or a free draining cover
4. Cover with NAF waste rock
5. Covering tailings with HDPE, NAF waste rock and using the area for a local Solar Farm (a 20-ha area can produce 10 MW therefore 100 ha of TSF could provide 50 MW)
6. Construct an analogue soil cover over the tailings
7. Construct an engineered soil cover over the tailings with a capillary break.

The outcome of this evaluation is that Option 6 is the preferred option from a conceptual perspective because it is line with industry practice. Options 3, 4 and 7 are also viable. Option 5 is also viable but requires a major change in direction from the current thought process around closure, rehabilitation and the next land use for the site.

A summary of the key design objectives and risks associated with the options is provided below. The risk and opportunity assessment in **Table 21-1** should be read to understand the broader risks of the TSF cover project. Conceptual diagrams showing the key aspects relating to water management and the TSF are included in **Figure 11-1**.

11.3.1 Option 1 Do Nothing

Doing nothing is not an acceptable option by MRO, Evolution Mining, or DEHP.

11.3.2 Option 2 Reprocessing Tailings

In some instances, there can be economic value in tailings. The tailings in the MRO TSF do not currently have economic grades of Ag, Au, Cu, Pb or Zn.

11.3.3 Option 3 Direct Vegetation

The basis of this option is that the current design approach using perimeter spigots and a central decant pond in the TSF will be maintained and any water (surface or groundwater) not meeting environmental criteria would be pumped back to the open pit.

Design objectives of this option could include the following.

- The current design philosophy of the TSF remains unchanged ie. central decant structure and a concave final landform that will store rainfall.
- Towards the end of the operation of the TSF organic amendments could be added to the tailings stream (eg. soil or biosolids) to provide organic carbon and nutrients.
- The concave profile of the final tailings beach would create a dam that would store water during the wet season and that would evaporate over the dry season resulting in a fluctuating water level on the tailings beach in the TSF. The periphery of the tailings beach could support vegetation such as reeds and rushes (Mt Kasi (Fiji), Mt Carrington (NSW), Henty (Tasmania)). Areas of the tailings beach that may be exposed could be covered in NAF waste rock (Option 2).
- The static NAF chemistry of the tailings and very low rates of oxidation and acid production, and the low/moderate saline and metalliferous content of the tailings, are likely to make them amenable to direct revegetation.
- Older tailings exposed for five years collected for KLC testing from the West TSF Cell verify high salinity for the first leach event (**Section 8.1.2**) and the salts were dominated by sulfate and calcium not sodium. With subsequent leach events salinity decreases rapidly and after six leach events the EC was

1,378 µS/cm. At this EC, there would not be any substantial adverse effects on vegetation (Hazleton and Murphy, 2007).
- The TSF would be fenced to stop access to cattle that may eat the vegetation (although it is unlikely that the vegetation would have adverse eco-toxic effects). Any fence would require ongoing maintenance.
- A spillway would need to be maintained to allow supplemental surface water to be directed from the TSF to the open pit.

Potential risks of this option include:

- Low rates of establishment (or persistence) of vegetation on tailings than on a soil cover system.
- Potential loss of tailings from the TSF via wind or surface runoff over the spillway (unlikely if there is waste rock cover included).
- Loss of vegetation from fire exposing tailings as there is no soil cover over the tailings (unlikely if there is waste rock cover included).
- Ongoing infiltration into, through and from the tailings to groundwater (not an issue if there will be ongoing water management of impacted TSF water until environmental release limits can be attained in seepage from the TSF).

11.3.4 Option 4 NAF Waste Rock Cover

This would require a major change in TSF design from perimeter deposition of tailings with central decant, to deposition of tailings from two to three sides of the TSF towards a decant structure against the southern side of the TSF embankment.

Design objectives of this option could include the following.

- Profiling the tailings to be externally draining to the TSF via a spillway to the open pit
- The final profile of the final tailings beach would be changed from a concave bowl to a linear slope (1:100) to facilitate surface runoff from the low permeability tailings to the open pit.
- Pushing up to 1 m of NAF waste rock into the tailings to:
  - provide a solid structurally competent base with low permeability
  - increase the ANC in the upper profile to ensure the tailings remain NAF
  - ensure tailings would not be susceptible to erosion by wind or water
- The NAF chemistry of the tailings and the low/moderate saline and metalliferous content of the tailings are likely to make them amenable to direct revegetation (Option 3).
- Placement of 0.5 to 1 m of NAF waste rock drainage layer (nominal PSD ranging from 300 to 30 mm PSD) over the NAF rock and tailings basal layer that would ensure the tailings are not eroded by wind and transferred to the receiving environment.
- The NAF waste rock layer would act as rock mulch and would protect the tailings from drying out and oxidising. Soluble weathering products pulled to the tailings surface through capillary action would be washed from the TSF through the drainage layer to the open pit.
- The NAF rock cover would be covered with 0.5 m soil that would fill the surficial voids in the NAF rock. The cover would be vegetated providing some opportunistic vegetative establishment and some evapotranspiration functionality.

Potential risks of this option include:

- Limited soil volume to facilitate dense vegetation growth (considered low risk as the local vegetation is not dense).
- Limited removal of water from evaporation or transpiration (compared to Option 6 and 7).
- No (or limited) reduction in seepage to the tailings (compared to Option 6 and 7), however as the primary water management control is to pump water the open pit this risk is negligible.
- No beneficial reuse as grazing, but likely to be a suitable habitat for ground dwelling fauna.
- DEHP and community acceptance.

11.3.5 Option 5 HDPE Cover and Power Generation

Option 3 (direct vegetation and an intermittent water cover on TSF) and Option 4 (waste rock and soil cover) provide cover systems to support vegetation and manage impacted water by directing it to the open pit. The current closure plan is to return the TSF to a cover that supports vegetation.

There is alternative approach to obtain substantial post closure benefit from the MRO that would most likely lead to successful post closure relinquishment. This approach includes using the TSF, Open Pit and WRDs to supply power to local communities from a combined solar and hydro-pump back system.

Design objectives of this option could include the following.

- Profiling the tailings to be externally draining and covering the tailings with HDPE and a protective layer of gravel (NAF waste rock) would provide a very low cover system that could be used as a solar farm to produce power. This would essentially provide an impermeable cover over the tailings and cut-off seepage from the TSF.
- Supplementing the solar farm with a hydro – pump back system utilising the open pit and WRD(s). This may include building a header dam from waste rock and lining the header dam with HDPE thereby providing an impermeable cover over the waste rock.
- No requirement to remove existing power supply infrastructure as the infrastructure may be able to be used to supply power into the grid.

This approach is being proposed for Kidston gold mine in north Queensland[4].

Potential risks of this option include:

- Defined need for local solar farm to provide power to the grid.
- Ability of existing infrastructure to carry power to the grid.
- Ability of the configuration of the open pit, TSF and WRDs to support the approach.
- Change in the mine design to facilitate a transition to the proposed next land use.
- Ongoing integrity of HDPE over time with natural changes.
- DEHP and community acceptance.

11.3.6 Option 6 Analogue Soil Cover

This would require a major change in TSF design from perimeter deposition of tailings with central decant to deposition of tailings from two to three sides of the TSF towards a decant structure against the southern side of the TSF embankment.

Design objectives of this option could include the following.

- Profiling the tailings to be externally draining and pushing up to 1 m of NAF waste rock into the tailings to:
  - provide a solid structurally competent base with low permeability.
  - increase the ANC in the upper profile to ensure the tailings remain NAF.
  - ensure tailings would not be susceptible to erosion by wind or water.
- The NAF waste rock would be overlain by an analogue soil cover comprising placement of soil (0.5 m) and weathered overburden (2 m) on top of the profiled tailings:
  - reduce the movement of excess water into the tailings.
  - store water during rain events.
  - establish and maintain vegetation for opportunistic native fauna habitat.
  - release water through evapotranspiration.

[4] http://www.entura.com.au/news/entura-completes-kidston-pumped-storage-hydro-project-technical-feasibility-study/

Potential risks of this option include:

- some seepage may still enter tailings.
- a perception that because there is no inclusion of a capillary break in the cover weathering products in the tailings (eg. salts and metals) may enter soil cover and have an adverse effect on vegetation.
- gaining DEHP and community acceptance.

11.3.7 Option 7 Engineered Soil Cover

This would require a major change in TSF design from perimeter deposition of tailings with central decant to deposition of tailings from two to three sides of the TSF towards a decant structure against the southern side of the TSF embankment.

Design objectives of this option could include the following.

- Profiling the tailings to be externally draining and pushing up to 1 m of NAF waste rock rock into the tailings to:
  - provide a solid structurally competent basal layer with low permeability.
  - increase the ANC in the upper profile to ensure the tailings remain NAF.
  - ensure tailings would not be susceptible to erosion by wind or water.
- The basal layer would be covered with an average of 0.5 m depth crushed and screened NAF or acid consuming waste rock (nominal PSD of 20 to 50 mm) to provide a drainage layer that would:
  - reduce the movement of water into the tailings by providing a compacted low permeability base for the soil cover.
  - allow seepage to drain out of the cover through the capillary break.
  - stop potential contaminants in the tailings moving up into the soil cover through capillary action.
  - store water during rain events.
- Drainage layer outlets are required to allow water within the drainage layer to be discharged to a drain and then into the open pit.
- The NAF rock basal layer would be covered with geofabric and this would be overlain by an analogue soil cover comprising placement of soil (0.5 m) and weathered overburden (2 m) on top of the profiled tailings:
  - reduce the movement of excess water into the tailings.
  - store water during rain events.
  - establish and maintain vegetation for opportunistic native fauna habitat.
  - release water through evapotranspiration.

Potential risks of this option include:

- Some seepage may still enter tailings
- The drainage layer / capillary break layer needs to be designed so that it allows contained water to drain freely into a sump or drain. The outlets from the drainage layer are open conduits for water and air. As such the actual inclusion of a capillary break / drainage layer would provide a mechanism for air to make direct contact with the tailings. This is also likely to lead to increased rates of drying at the interface of the tailings and drainage layer.
- The soil cover needs to be deep enough to limit vegetation roots entering the capillary break.
- Availability of material for the capillary break (typically graded material with a PSD of 10 to 30 mm).
- Constructability of the drainage layer / capillary break layer (typically 0.3 to 0.5 m of graded material placed at a defined gradient).
- Failure of the geofabric on top of the capillary break leading to ingress of overlying soil rendering the break ineffective.
- Ingress of tree roots through the geofabric into the capillary break rendering the capillary break ineffective.

- Cost assumption in the DEHP financial assurance calculator if costs that are $108,000 / ha for a single capillary break or $136,000 / ha for a double capillary break.
- Actual costs of an engineered single or double capillary break may be > $300,000 / ha and in some cases cited in the USA, upwards of $1,000,000 / ha (refer to **Section 2.9.1**).

11.4 Cover Ranking

The ranking of the options has been undertaken using the semi- quantitative scoring matrix developed and completed by RGS, ATCW, SBE and MRO **(Table 11-3**).

It was agreed by the above parties that:

- **Option 1 Doing nothing is not an acceptable position**
- **Option 2 Tailings reprocessing is not an option**

The outcome of the options evaluation was that:

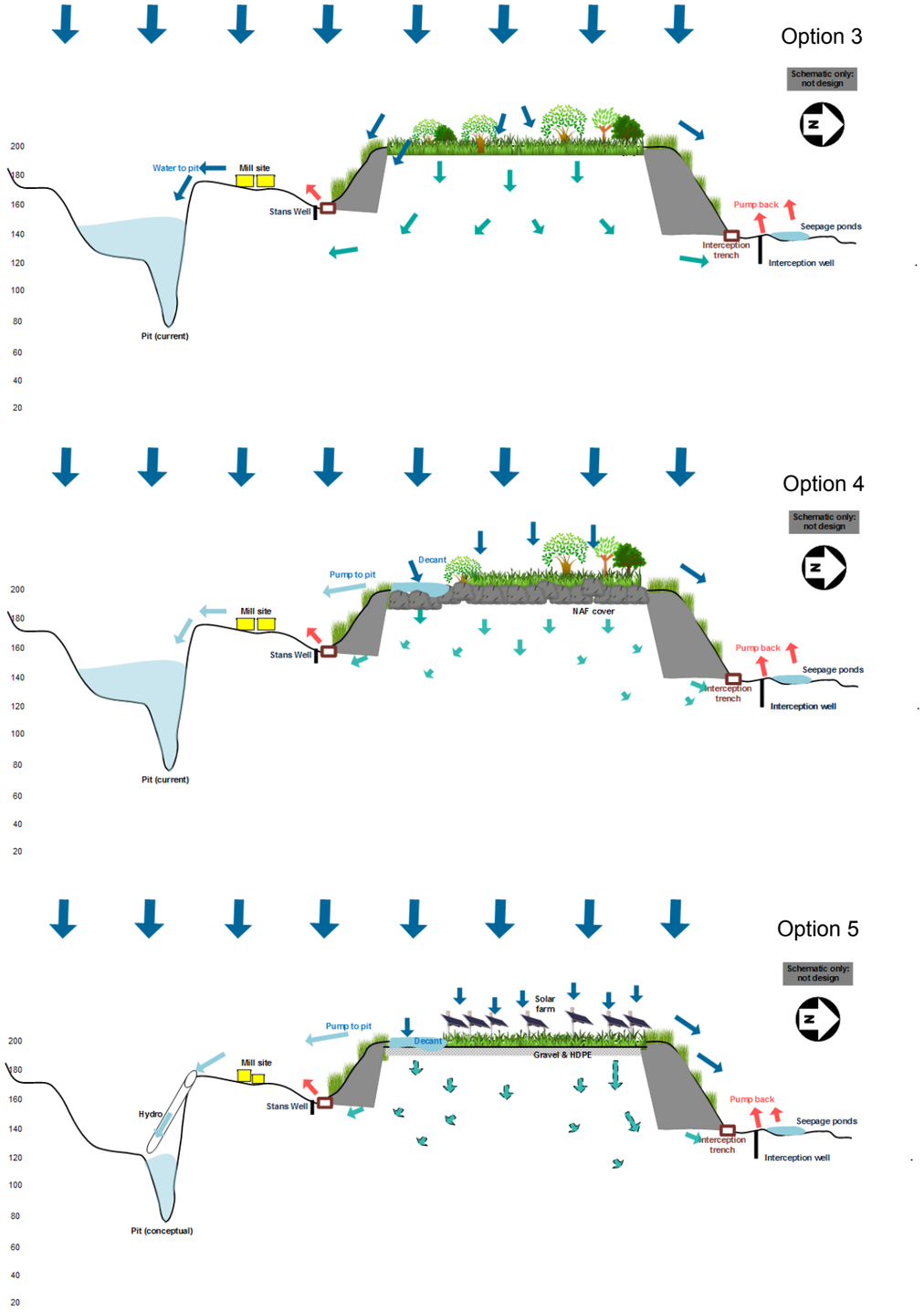
Option 3: Direct vegetation of tailings: is a viable strategy that contains tailings within the TSF and does not require major changes of the TSF design and operation of the decant structures. Seepage from the TSF is likely to be higher than the options described below.

Option 4: Cover with NAF waste rock: is a viable strategy and contains waste. This strategy could be pursued depending on the overall water management strategy for the TSF ie. if surface runoff and seepage is to be directed to the open pit this option becomes viable, but if surface runoff is to report to the receiving environment it may not be viable.

Option 5: Post closure use of the site for solar and hydro power supply: may be viable but requires a major change in the development of the mine and overall closure strategy.

Option 6: Analogue soil cover: is current industry practice and should be developed further as the preferred option that would be taken to pre-feasibility stage.

Option 7: Engineered soil cover: could be developed and taken to pre-feasibility stage. There are potential technical benefits to the inclusion of drainage / capillary breaks in soil covers, but the cost of the additional components of the cover need to be balanced against the risks of failure.



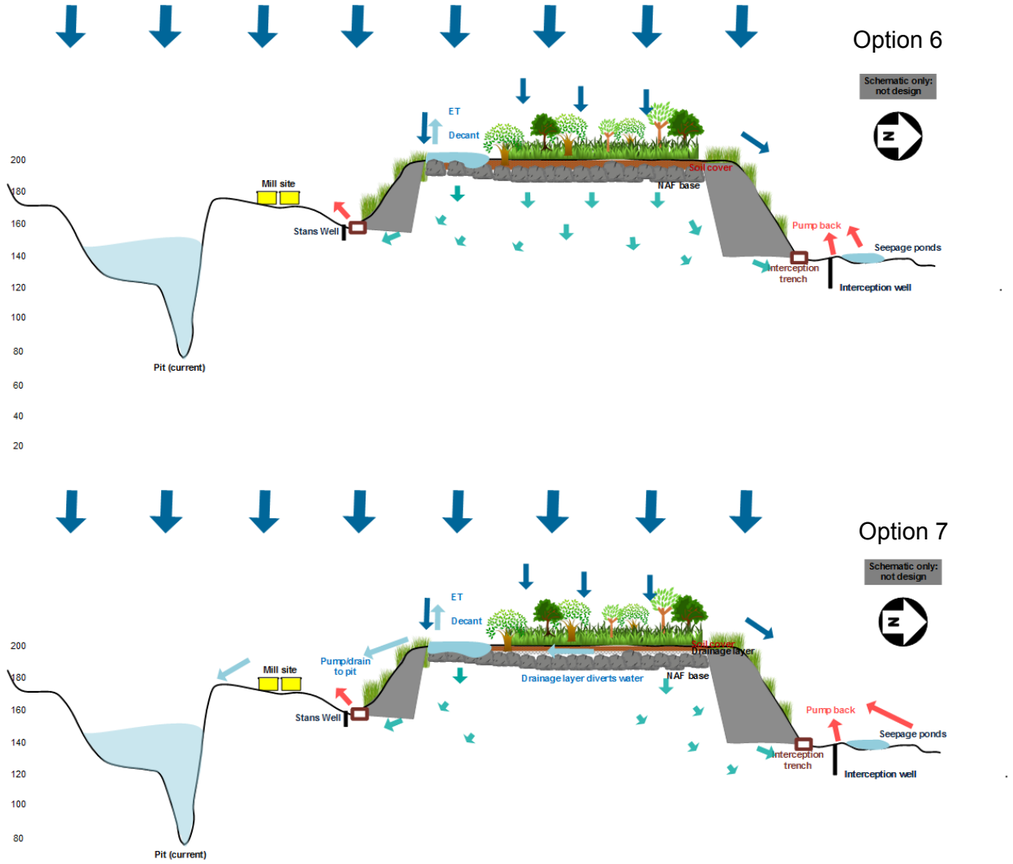


Figure 21-1: Conceptual water flow diagrams for Option 3 to Option 7

Table 11-3: Scoring Outcome of the Options Evaluation

	Aspect / risk																												
	Stakeholder Consultation	Change required to current tailings deposition and embankment design	Dam Saefty Requirements	Relinquishmnet	Cover complexity	Cover sequencing	Settlement	Dewatering of wet tailings	Equipment practicality	Acid Water in TSF	Saline Water in TSF	TSF Seepage Acid	TSF Seepage Salinity	Erosion from TSF	Surface flow	Groundwater	Fire	Borrow Area Land Disturbance	Borrow Area Erosion	Cover Material Balance	Material Balance Unit Cover Cost	Cover Cost	Regulation	Total Score	Ranking		Score	
Weighting	1	5	5	2	1	2	3	1	2	5	3	5	3	5	2	2	1	2	3	3	4	5	2		5	Most favourable	25	Most favourable
Option 3-Direct vegetation / rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0		4		10	
Option 4-NAF rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0		3		0	
Option 5-HPDE power generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4	2		-10	
Option 6-Analogue soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1	1		-25	Least favourable
Option 7-Engineered soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5	-1			
																									-2			
Score																									-3			
Option 3-Direct vegetation / rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	25	-4			
Option 4-NAF rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-10	0	-10	-5	Least favourable		
Option 5-HPDE power generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	20				
Option 6-Analogue soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5				
Option 7-Engineered soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-25	0	-25				

12 Conceptual closure, decommissioning & rehabilitation strategy

The timeframes and concepts presented in this section of the report are provided to MRO to support CDaR planning and concept development.

12.1 Closure

Mine closure refers to the date the mine will cease mining and processing. The closure plan for a mine requires an economic evaluation of the financial viability of the deposit that is controlled by ore grade and commodity prices.

For this concept CDaR Plan it is anticipated by RGS that:

- throughout 2026 ore will be mined, and excess ore stockpiled to allow processing to continue through to end of 2027
- the last ore will be moved from the pit in October 2026 before the wet season begins
- processing of stockpiled ore will continue until October 2027

12.2 Decommissioning

12.2.1 Tailings Deposition Process

A revised TSF design and tailings deposition schedule will need to be developed. The tailings are currently deposited into the TSF by perimeter spigots. Supernatant is pumped from the inside of a permeable central decant structure, constructed of PAF-HC waste rock, to the process plant, stored in process dams or lost through water cannons and evaporation. The deposition of tailings in this way will result in a concave tailings beach that will drain towards the centre of the TSF. A concave tailings beach is not a conducive landform for rehabilitation if the objective is to limit seepage and have a landform that will shed most of the water to the receiving environment.

For the CDaR Plan the preferred cover system requires amendments to the TSF design that will require MRO to progressively move the new decant structure from the centre of the TSF to the south to create a spooned landform that will direct surface runoff from the east, north and west TSF embankments to towards a final decant pond in the approximate location above the southern sediment dam.

12.2.2 Embankment height

The final planned embankment height of the north-west, north and north-east TSF embankment is likely to be RL 193 m. The proposed TSF embankment elevations on the north, east and west will need to change to RL 199 m to achieve a 1:100 gradient on the final tailings beach from the north to south. The increase in elevation allows for 2.5 m of analogue soil cover. Conversely the final embankment height on the southern side may be 6 m lower than it is currently planned to be. Revised TSF designs, plans and EA amendments are required for this to occur.

12.2.3 PAF waste rock placement and use

PAF-HC waste rock placed within the TSF will be covered with tailings shortly after placement whereas, the PAF-MR material will be placed as a dump on the western TSF cell, progressively covered with tailings and finally covered with at least 3 m of tailings towards the end of 2027. The dump batters will be covered progressively as the tailings level in the TSF increases, and the final tailings cover over the top of the waste rock will be a minimum 3 m of tailings and at least 10 m from the edge of the WRD cell and the final edge of the tailings.

12.2.4 NAF waste rock placement and use

NAF waste rock is placed into the Western NAF WRD. The NAF waste rock can contain some sulfide minerals but the concentrations of acid neutralising minerals and overall alkalinity significantly exceed the acid producing potential of the rock. Nevertheless, exposed sulfide minerals in NAF rock can oxidise and weather and produce neutral to alkaline pH drainage containing major ions such as sulfate and calcium. RGS has completed a review of the waste rock characterisation methodology and acid waste model used at MRO (RGS, 2016). This work demonstrates that NAF waste rock generated at MRO is likely to have an average ANC:MPA ratio greater than 6, if a simple sulfur cut-off value of < 1 %S is used to delineate NAF waste rock materials and these materials are therefore suitable for use as part of the TSF soil cover system.

12.2.5 Spillway TSF drainage and DSA

From November 2026, through to October 2027 civil engineering work will be required to convert the haul road from the pit to the TSF to a spillway and drainage channel to direct water from the TSF to the open pit. During this time the DSA would be retained in the TSF.

From November 2026, through to October 2027 DSA would be retained in the TSF and stockpiled ore would continue to be processed.

From November 2027, prior to the onset of the wet season, the southern TSF embankment would be progressively removed under controlled conditions. During this transitional period as the spillway in the TSF is lowered the storage capacity in the TSF would progressively be reduced to the point that the TSF becomes free draining with all contained supernatant and surface water being able to flow directly to the open pit via the final spillway.

From this point the TSF DSA will be provided by the open pit.

12.2.6 Water management

Developing and evaluating a full site water balance quantity and quality model is a critical subcomponent of an effective tailings and overall closure solution for the Mount Rawdon site, with a focus to the tailings drainage/interception and pit dynamics. Factors such as decant capacity, pit fill rates, level variance and water quality over time are central to estimating performance, including the potential for thermocline and haloclines development if forming a permanent body of water. Additionally, most closure options identified in this study require a level of decant or drainage water to be pumped to the pit. Estimation of pumping costs over the closure period need to be included as a core output of a site water balance in the next stages of closure assessments.

With the current water system processes in place, seepage from the tailings to surface water or groundwater is likely to continue from the TSF after the soil cover system is constructed on the TSF, although an appropriate cover solution will reduce seepage rates over time. Residence times, velocity and overall water budgets of groundwater from the facility drive the period until reduced impacted occurs. A site wide numerical groundwater model is required evaluate how seepage and groundwater flow and quality are likely to behave at and following rehabilitation.

Practical planning is also required for how the DSA within the TSF will be managed through the transition of the TSF from operations, through to decommissioning and rehabilitation.

For water at closure, the key strategic need is determination and agreement of closure criteria and location of compliance. A review of the tailings water system behaviour, boundaries, environment profiles, regulatory acceptance and points of measurement is recommended as a priority as guidance to further work moving forward.

A closure focussed monitoring programs and controls is required to assess potential and actual performance of the tailings and pit domain, particularly mine impacted seepage and groundwater from the TSF is intercepted and can be pumped back to the open pit to ensure that the potential for environmental harm is minimised.

12.3 Rehabilitation

After placement of final tailings in October 2027 the surface of the tailings beach will be progressively covered in up to 1 m of NAF rock (nominal PSD of 100 to 500 mm) to provide a stable **NAF basal layer** for construction of the **analogue low permeability soil cover**. Experience in the western TSF cell has shown that tailings in a relatively shallow offset cell of the TSF can be prone to overloading and deformation if waste rock is placed too fast or too close to the embankment. The placement of rock would most likely occur by end tipping and pushing rock form the west-north-east embankments in towards the southern embankment. Equipment selection will be a key consideration to reduce deformation of the tailings and ensure the as designed gradient of the final tailings plus NAF waste rock landform is maintained. It may take in the order of three years to complete this phase of the rehabilitation process.

After the final tailings profile is achieved the external 1:4 **external ridge caps** on the west-north-east embankments will be constructed using compacted NAF waste rock (nominal PSD of 30 to 300 mm) to provide a competent water shedding surface that will minimise seepage into the tailings. Surface flow from the rock armoured embankments will be preferentially drained to the receiving environment over the TSF embankment face or to the toe of the TSF embankment using contour drains and drop structures. Where the drainage allows the surface runoff from the external ridge caps will be directed to the open pit.

The **analogue low permeability soil** will comprise from top to bottom:

- **organic profile** (0.5 m soil) from the borrow area containing seed, nutrients and organic carbon with an as placed dry density of < 1.4 t/m^3
- **upper inorganic profile** comprising approximately 1 m of transition overburden (nominally the fractured basement material from 6 to 15 m depth bgl in Borrow Area 1) with an as placed dry density of < 1.4 to 1.6 t/m^3
- **lower inorganic profile** comprising approximately 1 m of weathered overburden (nominally the heavily weathered material from 0.5 m to 6 m bgl in Borrow Area 1) with an as placed dry density of < 1.6 to 1.8 t/m^3

One of the key engineering design considerations will be maintaining low compaction in all cover units during placement of the cover components as the laboratory testing verifies the materials have the potential for substantial compression and subsequent very low rates of permeability (**Table 9-4** and **Table 9-5**).

The concept behind the cover configuration is to lightly rip the placed soil into the top of the upper inorganic profile. This will pull some coarser rock to the surface and allow rain to more readily infiltrate into the 1.5 m soil and upper inorganic profile: this layer will provide a ready storage compartment for rain, promoting the establishment of vegetation. The residual water in this storage layer water will then percolate slowly into the lower inorganic profile comprised of fine grained weathered overburden.

The probable performance of the cover system was modelled using VadoseW and this is described in the **Section 13** of this report.

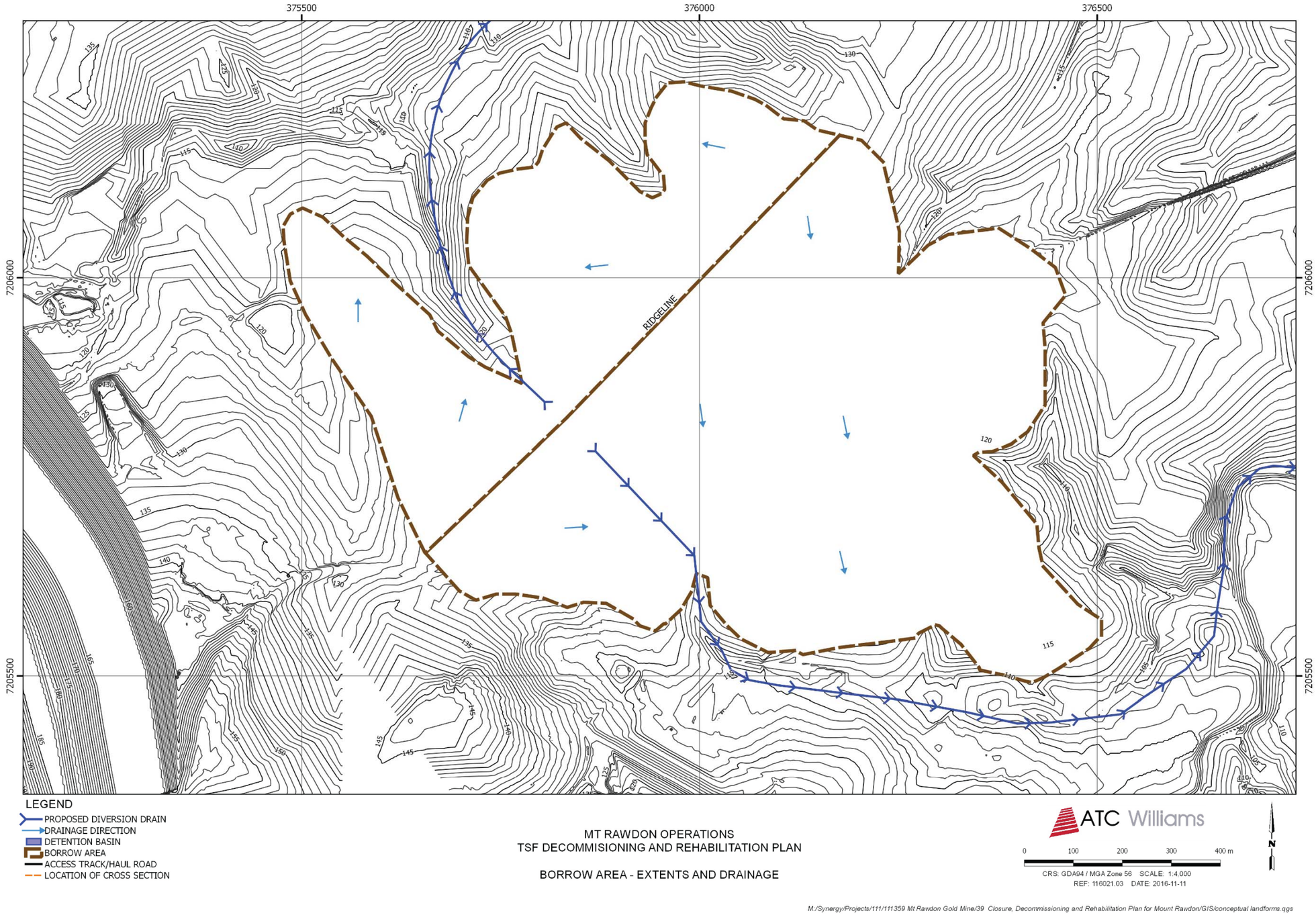


Figure 12-1: Proposed Borrow Pit

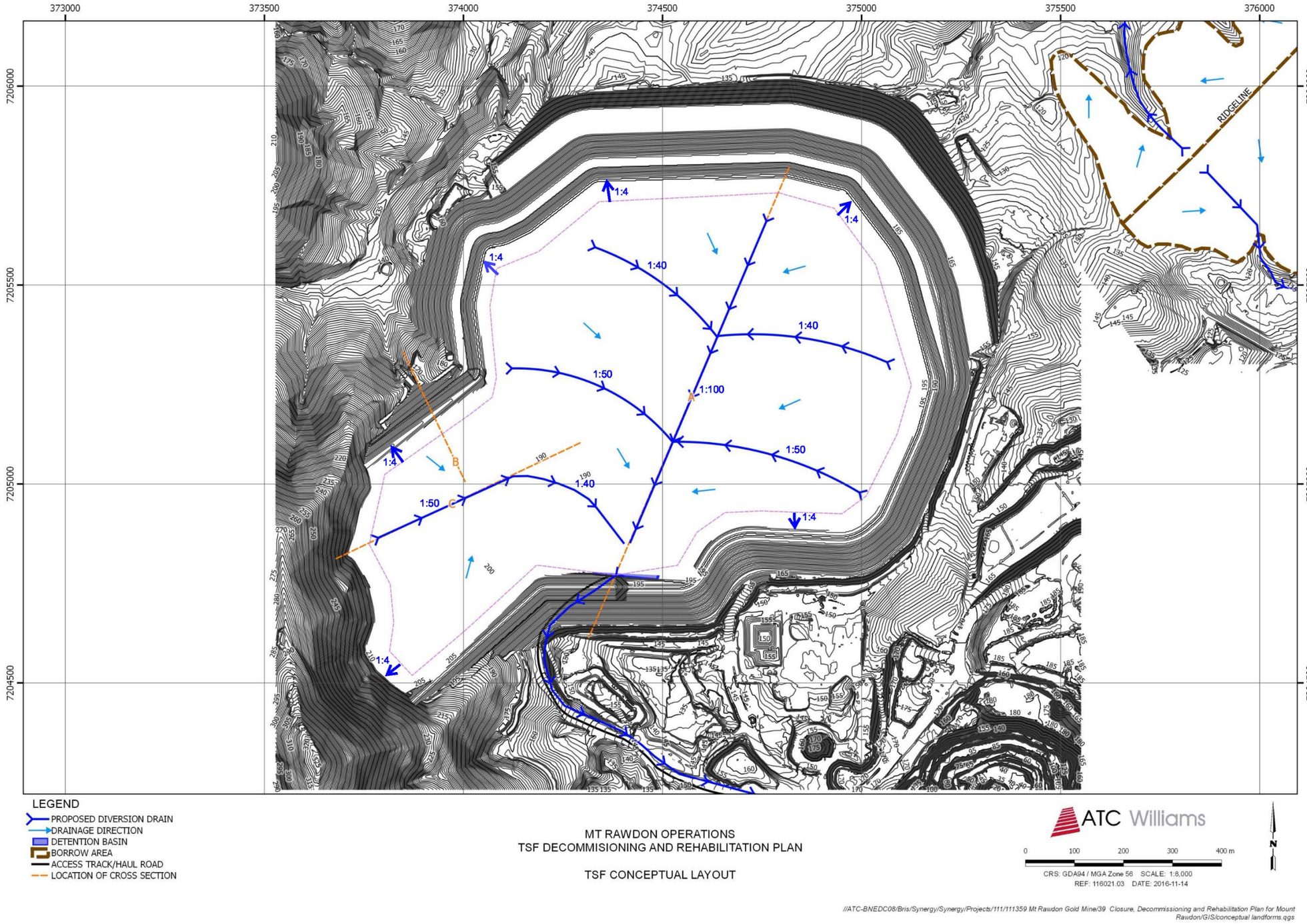


Figure 12-2: Proposed TSF Final Landform

13 Soil cover system modelling

13.1 Basis of the modelling

Concept level numerical modelling was done to assess the one-dimensional hydrological performance of the TSF **analogue low permeability soil cover systems**. The purpose of this modelling is to assess the movement and potential fate of moisture within the proposed cover systems and inform decisions relating to the preferred soil cover systems evaluated in this report.

Modelling was undertaken with VadoseW a computer-based, finite element package used for numerical modelling of saturated and unsaturated flow within materials exposed to climatic inputs and losses. VadoseW is a powerful tool for the analyses of saturated and unsaturated flow within soils near the ground surface, through the vadose (unsaturated) zone and into the saturated or groundwater regime.

The modelled results assist to assess the ground surface (surface cover) profile with inward fluxes associated with infiltration from rainfall and outward fluxes from plant transpiration and evaporation. In addition, the model quantifies the quantity of water runoff, which represents the proportion of rainfall that does not infiltrate the model surface.

Modelling was undertaken using a one-dimensional slice taken through the proposed cover profile extending some 12 metres into the tailings material below. This modelling approach supports an assumed one-dimensional (upward or downward) movement of moisture, with no significant rates of lateral drainage occurring. It is acknowledged that this modelling approach has limitations when the effect of a drainage layer with substantial lateral flow in the soil cover system is included. The limitations of the modelling would be resolved by undertaking 2D or 3 D modelling of the soil cover and TSF in a PFS scope of work.

Analogue low permeability store and release soil cover options modelled included **Options 6 and 7** described in **Section 11.3.** The profiles of these options are shown in **Figure 13-1.**

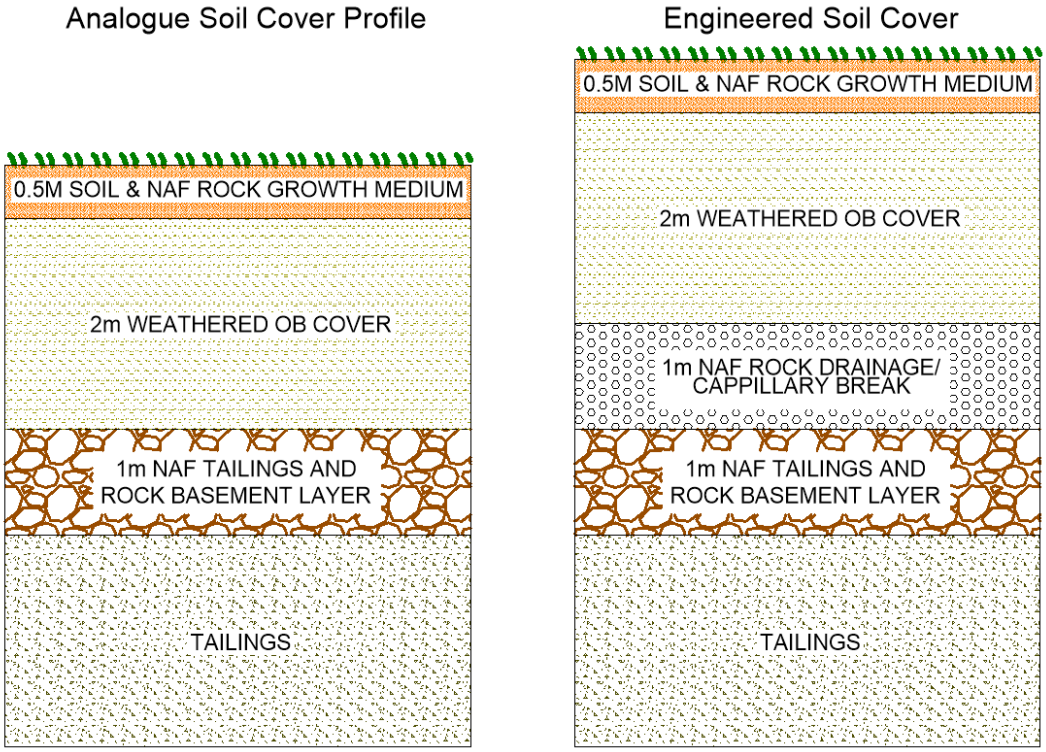


Figure 13-1: Analogue low permeability soil cover profiles

Modelling assumptions include the following.

- Models were developed based on the assumed cover thickness layers and proposed cover materials;
- Cover systems were modelled as columns with moisture movement limited in the vertical direction. The capillary break option does not allow for free lateral draining of the moisture entering this layer, and hence is assumed to be limited to vertical losses;
- Vegetation is mature throughout the modelling period and assumed to be grass species with roots penetrating some 0.3 meters;
- Runoff occurs when rainfall intensity exceeds infiltration rates and is lost to the system, i.e. no ponding was modelled; and
- To allow for drainage, soil depth will vary over the tailings surface, the modelled results indicate the minimum cover thickness applied over the TSF.

13.2 Input Parameters

The duration of the model was set as 7,300 days (approximately 20 years) and with a daily time step, which is the same as the daily climatic data.

Input parameters required for the VadoseW modelling include the following:

- Soil Parameters
  - Saturated moisture content
  - Saturated permeability
- Material Thermal Functions
  - Thermal conductivity
  - Mass specification heat capacity
- Vegetation Parameters
  - Leaf area index
  - Vegetation moisture limiting factor
  - Root depth function
- Climate Data
  - Rainfall
  - Maximum and minimum temperatures
  - Maximum and minimum humidity
  - Average wind velocity

Sources and values of these parameters are discussed in the sections below. It must be noted that VadoseW model results are very sensitive to these input parameters.

Soil parameters for the cover system were derived from laboratory test results on soil samples taken August 2016. Tailings parameters were adopted based on laboratory test data from previous testing (ATCW 2016 and 2016a). Geotechnical descriptions for cover materials were also used for inference of relevant geotechnical properties, using appropriate literature sources. The soil parameters adopted for the purpose of modelling, based on the above sources are summarised in Table 3.

The soil water characteristic curves (SWCC) were calculated using the Van Genuchten Formula (1980) in conjunction with Mualem equation (1976) to define the water content at defined matric potential and unsaturated conductivity respectively.

The Van Genuchten and Mualem equations are defined in equation 1 and equation 2 respectively.

$$\theta_w = \theta_r + \frac{(\theta_s - \theta_r)}{[1+(\frac{\varphi}{a})^n]^m}$$ **Equation 1**

Where:

$\Theta_w\ (m^3/m^3)$	=	volumetric water content/matric potential
$\Theta_s\ (m^3/m^3)$	=	effective water content
$\Theta_r\ (m^3/m^3)$	=	residual water content
Ψ (kPa)	=	matric potential
A (1/cm), n (unitless), m (unitless)	=	curve fitting parameters

Table 13-1: Van Genuchten Parameters

Parameter	Soil & NAF Rock Growth Medium	Weathered OB Cover	NAF Rock Drainage Capillary Break	NAF Tailings & Rock Basement Layer	Tailings
$\Theta s\ (m^3/m^3)$	0.450	0.460	0.290	0.036	0.480
$\Theta r\ (m^3/m^3)$	0.080	0.050	0.010	0.053	0.058
n	2.761	2.171	2.440	2.036	1.991
A (1/cm)	0.012	0.059	0.574	0.070	0.014
m	0.638	0.539	0.590	0.507	0.498

$$K_\varphi = K_S \cdot S_e^l \cdot [1 - \left(1 - S_e^{\frac{1}{m}}\right)^m]^2$$ **Equation 2**

Where:

K_ψ (cm/s)	=	Hydraulic Conductivity at Matric Potential symbol
K_s (cm/s)	=	Saturated hydraulic conductivity
S_e (m³/m³)	=	effective water content
I (unitless)	=	pore structure of material (default value of 0.5 used)
M (unitless)	=	curve fitting parameter estimated using Van Genuchten Formula

Table 13-2: Mualem Parameters

Parameter	Soil & NAF Rock Growth Medium	Weathered OB Cover	NAF Rock Drainage/Capillary Break	NAF Tailings & Rock Basement Layer	Tailings
Ks (m/day)	2.12E-09	4.62E-07	1.00E-02	1.00E-06	1.00E-07
S_e (m³/m³)	0.450	0.460	0.290	0.036	0.480
I	0.5	0.5	0.5	0.5	0.5
m	0.638	0.539	0.590	0.507	0.498

Curves generated for the soil water characteristic are shown in **Figure 13-2**.

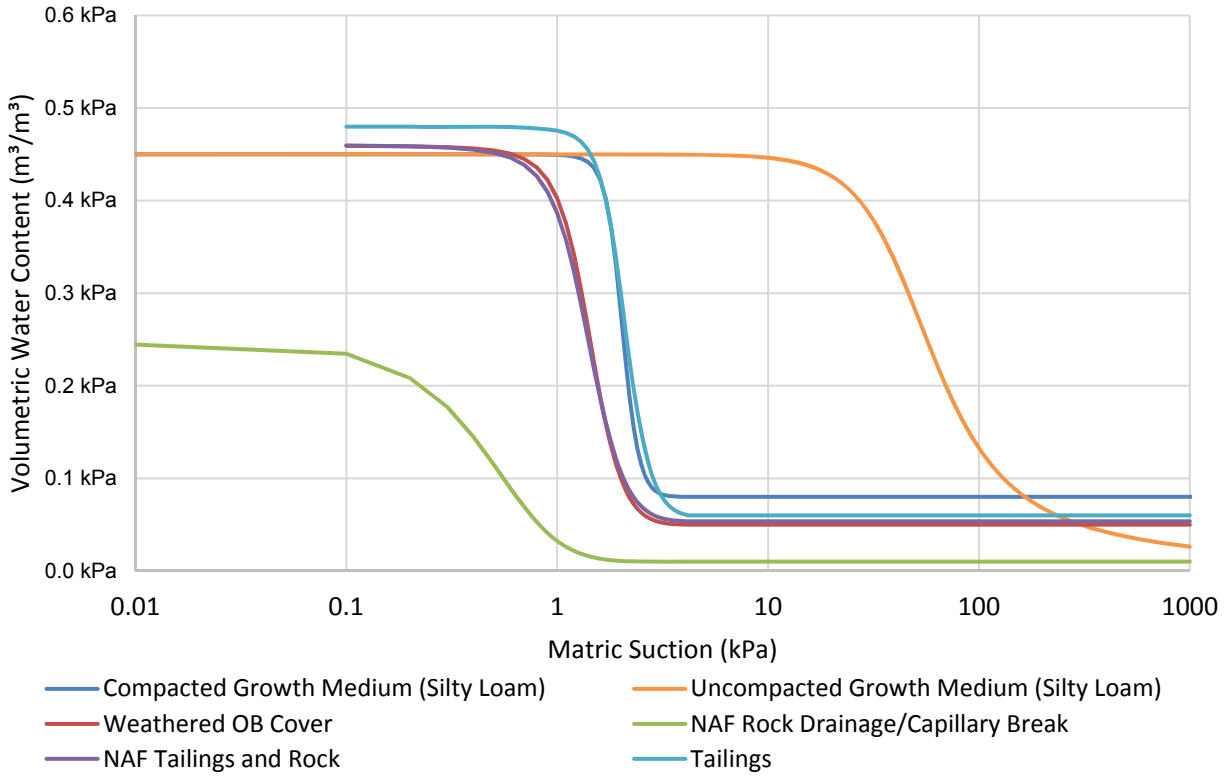


Figure 13-2: Volumetric Water Content of Cover Materials and Tailings

Climate data used in the modelling was primarily sourced from a SILO data drill generated for the site location with the exception of wind speed which was obtained from Bureau of Meteorology (BOM). The details of climatic data used for modelling is presented in **Table 13-3**.

Table 13-3: Climatic Data

Model Parameter	Data Source	Comments
Rainfall (mm/day)	Rainfall data obtained from the SILO data drill program for the Mt Rawdon Site Location (1889 - 2016)	Applied as direct rainfall to surface layer
Evapotranspiration (mm/day)	Evaporation data from SILO Data Drill obtained formed by conjoining CLIMARC estimates (typically 1889 – 1957) and Class A evaporation pan data interpolated from weather stations within the region.	Applied to surface layers of model
Maximum and minimum air temperatures (°C)	Maximum and minimum daily temperatures.	Temperature effects evaporation and evapotranspiration
Relative humidity (max and Min) (%)	Adopted from SILO data drill	Relative humidity is estimated using maximum and minimum temperatures. Humidity influences evaporation and evapotranspiration
Wind speed (m/s)	Wind speed from Bundaberg aero station (number 039128)	Influences evaporation and evapotranspiration

13.3 Interpretation

For each of the soil cover options (**Figure 13-1**) two scenarios were assessed.

- **Option A1:** Compacted analogue low permeability store and release soil cover system
- **Option A2:** Compacted analogue low permeability store and release soil cover system with capillary break
- **Option B1:** Uncompacted analogue store and release soil cover system
- **Option B2:** Uncompacted analogue store and release soil cover system with capillary break

The modelling results for Option A1 and B1 are summarised below.

Option A1: Laboratory defined data (e.g. *k* values from 100% Std. compaction falling head permeability analysis **Table 9-4** and **Table 9-5** and measured SWCC data in **Figure 13-2**) were used to simulate potential performance of the cover system if the borrow materials are placed with heavy ground bearing pressure equipment and subsequently subjected to high levels of compaction. The measured values were applied to the organic layer comprising borrow soil and coarse rock (0 to 0.5 m depth) and the inorganic layer comprising oxide overburden from 0.5 to 2.5 m depth. These soil layers were placed over the basal layer of the tailings beach that includes approximately 1 m of NAF rock pushed into the surface of the tailings to create a geotechnically competent and low permeability base for the soil cover (**Figure 13-1**).

The effect of the placement and compaction of the borrow materials would be the development of a low permeability soil cover system that is likely to shed a significant proportion of rainfall to the open pit. The shedding of water from the surface layer would be beneficial for reducing infiltration into the tailings and seepage from the tailings in the TSF to groundwater: the modelling suggests there may be some small recharge into the tailings. Conversely the low permeability of the soil cover will reduce the moisture content of the soil limiting vegetation growth and reducing the potential for transpiration. Results indicate that the surface layer may not have moisture content suitable for vigorous and sustained grass growth and it is more likely that perennial grasses and woody shrubs may establish at certain times of the year when precipitation and soil moisture content is high: this is envisaged to be consistent with the less disturbed type of vegetation cover near the TSF. The low permeability of the soil cover system would also increase the potential for erosion and the surface of the soil cover would need to be designed to limit slope length and slope angle and include sufficient competent rock to resist erosion.

Option B1: In this scenario inferred data, based on the laboratory *k* values, were applied to increase the permeability of the materials in the upper organic and lower inorganic layers to determine how the properties of the cover system may change if low bearing pressure equipment was used to place the soil cover materials to limit compaction. The results show that there is runoff, but less so than in A1.

Option A2: The inclusion of a capillary break in A1 was not determined to have any substantial effect on the performance of the soil cover system because there was very little downward flux of water into the soil cover system.

Option B2: In this scenario inferred data, based on the laboratory *k* values, were applied to increase the permeability of the materials in the upper organic and lower inorganic layers to determine how the properties of the cover system may change if low bearing pressure equipment was used to place the soil cover materials to limit compaction. The results show that there is substantially less runoff from the soil cover (i) because the water is moving through the soil profile than in A1 and (ii) the water entering the soil cover is subsequently stored within the voids in the capillary break (the void storage in 1 m^3 could be in the order of 200 to 300 L that would be equivalent to 200 to 300 ml of rain or percolate). The 1D modelling showed movement of water into the tailings (although this was negligible), and a substantial flux from the capillary break up into the soil cover through evaporation. The inclusion of the capillary break requires a 2D modelling approach to allow lateral flow from the drainage layer.

14 Risk assessment – preferred cover option

The main risks from the risk and opportunity assessment included in **Attachment D – Risk Assessment** are summarised below.

- DEHP (mining department) is not favourable towards store and release cover systems: partially due to the **perception** these covers have not been successful at some mining operations in Queensland (eg. Kidston gold mine).
- DEHP (landfill department) are favourable towards store and release cover systems: 30 yrs of research in the USA and Australia verifies they can perform better than clay barrier or capillary break cover systems.
- The findings in this report verify that a store and release cover system with low permeability features is a viable management strategy for this TSF.
- PFS and FS work will need to be completed to prove up the concept described in this report.
- Water quality and containment risk for performance, closure period and costing as leakage is currently occurring from the tailings impoundment:
    - Updated assessment of water system behaviour and character around the tailings impoundment is required in next stages, at two likely scales:
        - Analytical and relationship assessment of water levels and quality;
        - Investigations to assess leakage time frames from the tailings impoundment for current water;
        - PFS and FS work (including 2D or 3D numerical modelling) will need to be done to verify how the long-term seepage from the TSF will evolve over time if the concept cover system is developed on the TSF; and
        - A level of modelling to assess:
            - Groundwater leakage rates from current water, potential interaction with proposed decant system and PAF storage, and responses to concept soil system(s).
            - Nature, volumes and design needs of surface water draining from the landform as clean discharge to the environment and for contained volumes, including significant storm events.
    - Install pipeline from Stan's Well to the open pit as post closure wall seepage management.
    - Viability of pit void as a water storage for closure containment waters.
    - A key working assumption of water handling for TSF closure design is diversion and reporting of all TSF waters to the pit as a destination, which is currently untested for closure management: water fill/loss rates, expected water quality, influences on the pit void stability. A water balance and quality assessment with model will be required to inform possible scenarios and behaviour in the next stages.
        - The assumption is that surface runoff from the TSF will report to the open pit after the pit is closed. A whole of mine water quantity and quality final void numerical model will be required to verify the effect that directing surface runoff from the TSF will have on the evolution of the final void.
    - Nature of closure criteria and closure maintenance period.
- To attain a suitable slope angle and slope length on the TSF, the final elevation of the TSF exterior soil cover slopes may be 10 m higher along the north, east and western sides of the TSF than the elevation currently being discussed with DEHP. ATCW advise there are no fatal geotechnical / civil construction flaws with this concept: PFS level work is required to verify these design assumptions.
- Cost estimation typically based on mining fleet for cover construction. To construct a viable store and release cover system, small plant and equipment will be required (large mining fleet could displace tailings and will compact soil cover system reducing design criteria of the cover). Impact of using small plant and equipment on haulage and placement costs to be considered in subsequent stages with a dig and dump schedule (RGS suggests this be done by a mine planning/scheduling firm such as Deswik).

15 Conclusions

Closure Plan

An economic evaluation of the resource that is dependent on grades and commodity prices (ie. a closure plan) will be developed by MRO and Evolution Mining to verify the probable dates for cessation of mining and cessation of processing. Processing could end sometime after mining ceases in the open pit (**Section 12.1**).

Decommissioning Plan

The concept TSF decommissioning plan for the TSF in this report includes a substantial change to the TSF design: providing a final free draining landform directing surface runoff from north to south as opposed to the concave beach slope being developed through perimeter deposition methods. The decommissioning plan for the TSF will need to be developed further. Specifically, the aspects relating to the retention of the DSA in the TSF and transferring the DSA to the open pit when mining ceases needs to be considered and discussed with DEHP. A key assumption of the concept CDaR Plan is that all mine impacted water can be directed to the open pit when mining ceases and this assumption needs to be tested through development of a site wide water quantity and quality model.

This CDaR Plan has addressed the TSF. The outcome of the report has identified that the TSF cannot be evaluated in isolation and an integrated CDaR Plan is required to determine how the mining and cessation of mining in the open pit, potential stockpiling of ore, processing of ore, production of tailings, and management of water from the TSF, may need to be integrated and managed.

Tailings

Tailings have a static NAF classification with an ANC:MPA ratio between 1 and 2 (**Section 4.4 to 4.6 and Section 8.1**). Kinetic testing and field evaluation verifies the tailings have a long lag before any acidity could be produced: at least 7 years in the Western TSF Cell from field observations (**Section 8.1.2**). The addition of PAF rock into the TSF may change the “overall” net static classification of the contents of the TSF from NAF to PAF. In areas around the decant structure and Western PAF Cell in the TSF the “overall” net classification of the contents of the TSF in these areas will most likely become PAF.

The TSF supernatant water quality data verifies neutral pH mildly alkaline water with elevated parameters including As, Cu and Zn (**Section 4.5**). When the TSF is decommissioned and mining stops in the open pit it is assumed the residual process water in the TSF will be directed to the open pit.

The low rate of chemical reactivity and weathering of the tailings will not contribute to an increase in the soluble fraction in the runoff from the tailings. During the rehabilitation process surface runoff from rain will leach the soluble ions from the tailings beach into the open pit. Under these concurrent conditions that may occur for two to three years the surface tailings will be leached and the runoff will have water quality data that is consistent with steady state (24 month) tailings leached under laboratory conditions ie. relatively clean water.

NAF Rock

There is an ample supply of NAF rock in the western NAF WRD (**Section 5**). If NAF rock is used on the TSF for rehabilitation work it will have an ANC:MPA ratio of greater than 6 if a total sulfur cut off value of <1 %S is used in the MRO waste rock characterisation methodology and acid waste model to delineate NAF waste rock. It is preferable to select and utilise NAF rock with < 1 % TS to ensure seepage from this material is likely to remain chemically inert.

Soil

There is an ample supply of stockpiled soil for rehabilitation of the TSF 1.2 M BCM (**Section 5**) (MRO, 2016). The soil has very low permeability under field conditions and much lower permeability if it is over compacted. The inclusion of NAF rock into the soil is proposed to increase the permeability and percolation of water into the upper profile of the soil cover during the establishment phase to sustain vigorous growth of vegetation. Over time as the soil cover repacks the permeability will decrease. The inclusion of rock will also provide some additional resistance to erosion.

Borrow Materials

Test pits and drill holes developed at six locations in four potential borrow areas (**Table 6-1**) verify that Borrow Area 1 is the most favourable location for a borrow area as it has at least 15 m depth of weathered material that can be utilised for a soil cover and could yield 2.5 M BCM: there is alos 0.5 M BCM of stockpiled oxide overburden (MRO, 2016) The test pit and drill holes east of the main WRD verify there is limited potential to obtain material in this area (< 3 to bedrock): the borrow areas to the north of the TSF may provide supplementary material.

The chemical properties of the soil and overburden in Borrow Area 1 (**Figure 5-1**) are favourable for a soil cover system (**Table 8-2**, **Table 8-3**). The borrow materials are likely to be dominated by non-expansive clays including Illite and Kaolinite (**Figure 8-2**), and the fines content will provide adequate water storage within the soil cover (**Table 9-4** and **Table 9-5**).

There is sufficient volume of material to place 2 to 3 m of soil cover over the tailings. The permeability testing in the field and in the laboratory confirm the materials could have very low rates of infiltration if they are over compacted (**Table 9-4** and **Table 9-5**). Over compaction of material in a soil cover system may lead to failure of the design objectives if the intention is to create a vigorous vegetative cover.

The numerical modelling verifies that the soil cover system on the TSF could be constructed to provide a low permeability cover system that preferentially has a higher rate of runoff and maintains very low rates of recharge to the tailings. The downside to the development of a cover system with these characteristics is that the high rate of runoff could lead to erosion and lower rates of vegetation cover that would lower transpiration.

Risk and Opportunities

There are a range of potential options for the closure, decommissioning and rehabilitation of the MRO TSF (**Section 11.3**). The current and actual cost of a soil cover system has inherent uncertainty and will need to be defined by MRO. The concept level risks and opportunities table developed by RGS, ATCW and SBE in this report should be reviewed and updated by MRO and Evolution Mining when there is a sound economic basis to evaluate the full range of options (refer to **Table 21-1**).

Capillary Breaks or Drainage Layers

Capillary breaks and drainage layers are designed to (i) stop oxidation products (salts, acid and metals) moving up into the overlying soil profile through capillary action and (ii) provide adequate water storage within the drainage layer so that any seepage can drain from within the cover system to the external drains thereby limiting movement of water into the cover system. This requires the drainage layer below the cover system to be in contact with the external drain providing a pathway for water to seep from the cover system in preference to the water seeping into the underlying material. This pathway and connectivity between the external drains and the interior of the soil cover system conversely provide a pathway for air to move in and out of the cover system through the process of convection and advection.

If the material under the cover system contains sulfide minerals and is being encapsulated to stop sulfide oxidation the inclusion of a capillary break or drainage layer contradicts the design requirement. The inclusion of a drainage layer / capillary break within the soil cover system therefore needs careful consideration. Differential settlement often occurs to some extent in final landforms and can lead to failure of the core function of a capillary break layer over time.

Preferred Option

A 0.5 m soil cover underlain by 2 m of oxide overburden from Borrow Area 1 is the preferred soil cover system as this aligns with current industry practice and provides an outcome that would meet DEHP rehabilitation goals. The NAF waste rock may be a suitable material for a capillary break or drainage layers in a soil cover system. However, the geochemical characteristics of the tailings do not warrant the need for a capillary break system (i) because the tailings have a static NAF classification (albeit with an ANC: MPA ratio of between 1 and 2) (ii) the tailings will have a very long lag time prior to any potential for acidic conditions to become apparent due to low oxidation and weathering rates (iii) under neutral drainage conditions the concentrations of salts and metals in the tailings would not cause adverse ecotoxicological effects on vegetation in the soil cover.

Pre-Feasibility Studies

There is a substantial amount of work associated with stakeholder consultation to define potential CDaR options, and to identify an outcome that will most likely / almost certainly be accepted by the relevant post mine landowners. The impact of the social license to operate and close a mining operation is becoming increasingly onerous and this aspect of closure cannot be underestimated.

Pre-Construction Activities

If NAF waste rock is to be used on the cover system, processing and stockpiling of the best material could commence in the near term. Crusher dust produced by this process could be added to the tailings to increase the ANC of the tailings over the remainder of the LoM.

Performance Monitoring

A performance monitoring program is a key component of demonstrating the cover system is performing as it was designed to. This can require collection and analysis of data over long periods of time eg. > 5 years.

16 Recommendations

Tailings

Ongoing sampling and analysis of tailings being placed into the TSF is proposed to occur over the remainder of the LoM. Ongoing (at least monthly) sampling and pH, EC, acidity, alkalinity total sulfur and carbon analysis of the tailings will provide quantitative evidence on the geochemical properties of the tailings over time. Ongoing sampling and analysis will demonstrate whether the NAF classification of the tailings changes as the quality of ore changes. If the geochemistry of the tailings decreases supplemental addition of ANC could be required to ensure the tailings remain NAF.

NAF Rock

There is approximately 6.9 Mt of NAF waste rock in the western NAF WRD. Crushed NAF will be required for the TSF cover system for internal drains and surface sheeting of internal and external TSF embankments. Crushing and screening NAF waste rock should be done over the LoM to spread costs and to make it is available for use at the end of the life of mine. Supplementary ANC could be provided from rock dust as NAF and acid consuming waste rock is crushed over the LoM. The rock dust could be added to the tailings stream to increase the ANC.

Borrow Materials

The chemical and physical properties of the soil and overburden in Borrow Area 1 are favourable for a soil cover system. There is sufficient material to place 2 to 3 m of soil cover over the tailings. However, the permeability testing in the field and in the laboratory, confirm the materials could have very low rates of infiltration if they are over compacted.

Pre-Feasibility Studies

A first principles cost assessment of the viable CDaR options is required to be done in the first stage of the PFS phase to thoroughly evaluate the financial aspects of the CDaR Plan. This would include deriving accurate construction costs for site based construction activities eg. cost to source, haul, crush screen and place 20-40 mm PSD NAF rock for a capillary break. The outcome of the financial assessment would verify actual construction costs and short list CDaR Planning options to be evaluated in the PFS works program.

Pre-Construction Activities

Evaluation of soil cover materials using proposed plant and equipment should be done to quantify how the borrow materials will behave under field conditions in a soil cover construction program. This could be achieved by excavating a small borrow pit (slot) in Borrow Area 1, then mining and placing the materials using proposed plant and equipment and construction methods onto an area of the TSF (the existing decant structure would be a good choice).

Whereas the field scale PAF waste rock pads are providing long term geochemical data for the waste rock, the purpose of the field scale soil cover test pads would be to provide actual field measurements including measuring surface runoff, seepage through the cover (lysimeters), oxygen and temperature through the installation of in-situ probes within the cover and sampling and analysis of the as placed materials. The field data would verify the concept level analyses from test pits and drill core and verify the design objectives and criteria for full scale implementation of the final soil cover system.

Risk and Opportunities

The risks and opportunities table in this report should be used by MRO to produce an internal risk register that would be provided as a supporting document in tender documentation or TSF rehabilitation work programs to site personnel or contractors.

Performance Monitoring

A performance monitoring program is required to be developed when the preferred cover system is finalised.

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18 Attachment A – ALS Raw Data

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1620758**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	:
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 MRO WR	Date Samples Received	: 22-Aug-2016 16:05
Order number	: ----	Date Analysis Commenced	: 24-Aug-2016
C-O-C number	: ----	Issue Date	: 02-Sep-2016 14:17
Sampler	: MINGRUI YUAN		
Site	: ----		
Quote number	: ----		
No. of samples received	: 6		
No. of samples analysed	: 6		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils, Stafford, QLD
Satishkumar Trivedi	Acid Sulfate Soils Supervisor	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: **SOLID** (Matrix: **SOIL**)

Compound	CAS Number	LOR	Unit	Client sample ID	16080081 MRORGS001-1 0.0-0.5m <5mm	16080082 MRORGS002-1 0.0-0.5m <5mm	16080083 MRORGS003-1 0.0-0.5m <5mm	16080086 MRORGS001-2 0.5-1.0m <5mm	16080087 MRORGS002-2 0.5-1.0m <5mm
				Client sampling date / time	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]
					EB1620758-001	EB1620758-002	EB1620758-003	EB1620758-004	EB1620758-005
					Result	Result	Result	Result	Result
EA002 : pH (Soils)									
pH Value	----	0.1	pH Unit		**5.8**	**5.7**	**6.3**	**8.3**	**6.7**
EA009: Nett Acid Production Potential									
Net Acid Production Potential	----	0.5	kg H2SO4/t		<0.5	<0.5	**0.6**	**-2.9**	**-1.4**
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		**27**	**31**	**62**	**260**	**226**
EA013: Acid Neutralising Capacity									
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t		**0.6**	<0.5	<0.5	**2.9**	**2.0**
ANC as CaCO3	----	0.1	% CaCO3		<0.1	<0.1	<0.1	**0.3**	**0.2**
Fizz Rating	----	0	Fizz Unit		**0**	**0**	**0**	**0**	**0**
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		<1.0	<1.0	**1.2**	**1.4**	**1.7**
ED008: Exchangeable Cations									
Exchangeable Calcium	----	0.1	meq/100g		**0.6**	**0.8**	**0.3**	**0.2**	**0.1**
Exchangeable Magnesium	----	0.1	meq/100g		**0.6**	**0.8**	**3.4**	**8.6**	**5.8**
Exchangeable Potassium	----	0.1	meq/100g		<0.1	**0.1**	**0.2**	**0.1**	<0.1
Exchangeable Sodium	----	0.1	meq/100g		<0.1	<0.1	**0.6**	**3.4**	**4.1**
Cation Exchange Capacity	----	0.1	meq/100g		**1.4**	**1.8**	**4.5**	**12.5**	**10.1**
Exchangeable Sodium Percent	----	0.1	%		<0.1	**2.1**	**12.7**	**27.4**	**40.5**
ED042T: Total Sulfur by LECO									
Sulfur - Total as S (LECO)	----	0.01	%		**0.02**	<0.01	**0.02**	<0.01	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg		**0.5**	**0.7**	**0.1**	**0.3**	**0.2**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	20	mg/kg		**390**	**510**	**520**	**130**	**120**
EK062: Total Nitrogen as N (TKN + NOx)									
^ Total Nitrogen as N	----	20	mg/kg		**390**	**510**	**520**	**130**	**120**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	2	mg/kg		**64**	**82**	**122**	**111**	**90**
EK080: Bicarbonate Extractable Phosphorus (Colwell)									
Bicarbonate Ext. P (Colwell)	----	5	mg/kg		**8**	**10**	**10**	**9**	**8**
EP003: Total Organic Carbon (TOC) in Soil									

Analytical Results

Sub-Matrix: SOLID (Matrix: SOIL)				Client sample ID	16080081 MRORGS001-1 0.0-0.5m <5mm	16080082 MRORGS002-1 0.0-0.5m <5mm	16080083 MRORGS003-1 0.0-0.5m <5mm	16080086 MRORGS001-2 0.5-1.0m <5mm	16080087 MRORGS002-2 0.5-1.0m <5mm
				Client sampling date / time	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]	[22-Aug-2016]
Compound	CAS Number	LOR	Unit		EB1620758-001	EB1620758-002	EB1620758-003	EB1620758-004	EB1620758-005
					Result	Result	Result	Result	Result
EP003: Total Organic Carbon (TOC) in Soil - Continued									
Total Organic Carbon	----	0.02	%		**0.50**	**0.52**	**0.77**	**0.16**	**0.14**
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		**0.61**	**0.68**	**1.12**	**0.24**	**0.21**

Analytical Results

Sub-Matrix: SOLID (Matrix: SOIL)			Client sample ID	16080088 MRORGS003-2 0.5-1.0m <5mm	----	----	----	----
			Client sampling date / time	[22-Aug-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1620758-006	--------	--------	--------	--------
				Result	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.7**	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-2.1**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**349**	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**2.7**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**0.3**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**0**	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**1.5**	----	----	----	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**0.2**	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	**5.4**	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	----	----	----	----
Exchangeable Sodium	----	0.1	meq/100g	**4.9**	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	**10.7**	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	**45.7**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.02**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.3**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**140**	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**140**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**150**	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**8**	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil								

Analytical Results

Sub-Matrix: **SOLID** (Matrix: **SOIL**)				Client sample ID	**16080088 MRORGS003-2 0.5-1.0m <5mm**	**----**	**----**	**----**	**----**
				Client sampling date / time	[22-Aug-2016]	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**EB1620758-006**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
EP003: Total Organic Carbon (TOC) in Soil - Continued									
Total Organic Carbon	----	0.02	%		**0.15**	**----**	**----**	**----**	**----**
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		**0.18**	**----**	**----**	**----**	**----**

Australian Laboratory Services Pty. Ltd.

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CERTIFICATE BR16140243

Project: EB1620758

P.O. No.: MS61 + Hg

This report is for 6 Pulp samples submitted to our lab in Brisbane, QLD, Australia on 24- AUG- 2016.

The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LOG- 22	Sample login - Rcd w/o BarCode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
F- ELE81a	F by Specific Ion Electrode	TITRATOR
ME- MS61	48 element four acid ICP- MS	
ME- ICP81x	Peroxide Fusion - 51 Elements by ICP- AES	ICP- AES
Hg- MS42	Trace Hg by ICPMS	ICP- MS

To: ALS ENVIRONMENTAL
ATTN: SUB RESULTS
32 SHAND STREET
STAFFORD QLD 4053

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager

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Project: EB1620758

CERTIFICATE OF ANALYSIS BR16140243

Sample Description	Method Analyte Units LOR	ME- MS61 Ag ppm 0.01	ME- MS61 Al % 0.01	ME- MS61 As ppm 0.2	ME- MS61 Ba ppm 10	ME- MS61 Be ppm 0.05	ME- MS61 Bi ppm 0.01	ME- MS61 Ca % 0.01	ME- MS61 Cd ppm 0.02	ME- MS61 Ce ppm 0.01	ME- MS61 Co ppm 0.1	ME- MS61 Cr ppm 1	ME- MS61 Cs ppm 0.05	ME- MS61 Cu ppm 0.2	ME- MS61 Fe % 0.01	ME- MS61 Ga ppm 0.05
16080081		0.02	3.01	5.0	440	0.87	0.15	0.11	<0.02	32.6	2.5	69	2.25	6.6	1.86	6.56
16080082		0.02	4.34	10.6	440	0.94	0.12	0.21	0.02	23.0	2.5	59	2.16	6.3	1.81	8.58
16080083		0.05	5.24	22.9	420	1.51	0.24	0.47	0.03	42.6	4.1	58	7.40	10.5	3.30	12.40
16080086		0.04	7.60	4.0	660	4.17	0.22	0.09	0.02	101.0	10.5	65	7.87	21.8	3.57	19.75
16080087		0.02	7.71	13.0	860	2.64	0.16	0.18	0.02	88.1	7.6	48	6.84	9.1	3.11	17.65
16080088		0.02	7.70	27.9	540	2.37	0.33	0.81	0.03	75.5	9.7	53	16.00	26.7	4.61	20.4

***** See Appendix Page for comments regarding this certificate *****

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Project: EB1620758

CERTIFICATE OF ANALYSIS BR16140243

Sample Description	Method Analyte Units LOR	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	Hg- MS42 Hg ppm 0.005	ME- MS61 In ppm 0.005	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10	ME- MS61 Pb ppm 0.5
16080081		0.10	1.2	0.010	0.023	1.57	15.7	8.6	0.09	79	1.65	0.41	3.5	5.4	200	16.9
16080082		0.08	1.6	0.010	0.025	1.15	11.5	8.3	0.09	53	0.57	1.44	4.4	5.1	160	13.6
16080083		0.13	1.0	0.009	0.045	1.19	19.9	14.4	0.28	102	0.84	0.99	4.7	9.3	250	20.7
16080086		0.19	2.6	0.008	0.071	3.05	42.4	26.7	0.75	213	0.61	0.95	10.7	20.9	190	20.2
16080087		0.17	1.5	<0.005	0.055	1.80	32.4	18.5	0.54	147	0.42	2.55	5.6	8.2	120	15.6
16080088		0.16	1.2	0.005	0.080	2.03	37.1	24.4	0.91	305	0.50	1.67	8.7	18.9	250	22.4

***** See Appendix Page for comments regarding this certificate *****

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Finalized Date: 2- SEP- 2016
Account: ALSENV

Project: EB1620758

CERTIFICATE OF ANALYSIS BR16140243

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1
16080081		68.3	<0.002	0.01	0.40	4.0	1	0.9	62.2	0.26	0.08	7.74	0.133	0.32	1.3	49
16080082		44.9	<0.002	0.01	0.90	4.6	1	1.1	130.0	0.33	<0.05	5.60	0.177	0.20	1.2	61
16080083		68.3	<0.002	0.01	0.74	9.9	2	1.5	100.0	0.36	0.09	8.56	0.226	0.32	1.5	84
16080086		223	<0.002	0.01	0.48	19.4	1	2.4	110.5	0.86	0.06	15.25	0.333	0.91	2.3	86
16080087		120.0	<0.002	0.02	0.78	20.1	1	2.1	181.5	0.48	<0.05	12.80	0.277	0.50	2.0	95
16080088		156.5	<0.002	0.01	0.73	21.6	1	2.7	154.0	0.66	0.07	10.80	0.421	0.60	1.8	116

***** See Appendix Page for comments regarding this certificate *****

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Project: EB1620758

CERTIFICATE OF ANALYSIS BR16140243

Sample Description	Method Analyte Units LOR	ME- MS61 W ppm 0.1	ME- MS61 Y ppm 0.1	ME- MS61 Zn ppm 2	ME- MS61 Zr ppm 0.5	F- ELE81a F ppm 20	ME- ICP81x SiO2 % 0.2
16080081		0.7	7.0	21	46.7	130	89.4
16080082		0.8	7.2	24	57.0	90	84.8
16080083		1.0	7.3	37	32.9	190	78.0
16080086		1.4	38.0	90	92.3	370	70.6
16080087		1.1	28.8	65	49.8	280	71.2
16080088		1.7	14.1	93	45.1	460	68.0

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Project: EB1620758

CERTIFICATE OF ANALYSIS BR16140243

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.
Applies to Method: ME- MS61

ACCREDITATION COMMENTS

NATA Accredited. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist.
Applies to Method: ME- MS61

NATA Accredited. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is Samantha Profke, ICPAES Supervising Chemist
Applies to Method: ME- ICP81x

LABORATORY ADDRESSES

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. NATA Accreditation does not cover the performance of ALS Brisbane Sample Preparation which is processed at 116 Delta Street, Geebung, QLD 4034, Australia
Applies to Method: F- ELE81a Hg- MS42 LOG- 22 ME- ICP81x
ME- MS61

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1622359**	Page	: 1 of 4
Amendment	: **1**		
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016015 - MRO WR	Date Samples Received	: 13-Sep-2016 14:35
Order number	: ----	Date Analysis Commenced	: 14-Sep-2016
C-O-C number	: ----	Issue Date	: 11-Nov-2016 12:08
Sampler	: MINGRUI YUAN		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	16090340	16090341	16090342	16090343	----
			Client sampling date / time	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	----
Compound	CAS Number	LOR	Unit	EB1622359-001	EB1622359-002	EB1622359-003	EB1622359-004	--------
				Result	Result	Result	Result	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**7.7**	**9.7**	**6.0**	**7.2**	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-5.9**	**-30.9**	**-0.8**	**-1.7**	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**134**	**286**	**162**	**99**	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**5.9**	**30.9**	**0.8**	**1.7**	----
ANC as CaCO3	----	0.1	% CaCO3	**0.6**	**3.2**	<0.1	**0.2**	----
Fizz Rating	----	0	Fizz Unit	**0**	**2**	**0**	**0**	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**2.1**	**2.0**	**2.2**	**1.8**	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	**0.4**	**10.0**	**0.3**	**0.4**	----
Exchangeable Magnesium	----	0.1	meq/100g	**7.2**	**6.6**	**6.0**	**6.2**	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	**0.2**	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	**4.5**	**2.5**	**3.7**	**6.2**	----
Cation Exchange Capacity	----	0.1	meq/100g	**12.2**	**19.4**	**10.0**	**12.9**	----
Exchangeable Sodium Percent	----	0.1	%	**37.1**	**12.8**	**36.5**	**47.7**	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**0.8**	**0.4**	**0.8**	**0.3**	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**40**	**70**	**40**	**40**	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**40**	**70**	**40**	**40**	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**274**	**281**	**151**	**319**	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	**9**	<5	<5	**15**	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	**0.04**	**0.06**	**0.05**	**0.04**	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	16090340	16090341	16090342	16090343	----
				Client sampling date / time	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	----
Compound	CAS Number	LOR	Unit		EB1622359-001	EB1622359-002	EB1622359-003	EB1622359-004	--------
					Result	Result	Result	Result	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		**0.08**	**0.21**	**0.07**	**0.06**	**----**

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Finalized Date: 19- SEP- 2016
Account: ALSENV

CERTIFICATE BR16154309

Project: EB1622359

This report is for 4 Pulp samples submitted to our lab in Brisbane, QLD, Australia on 14- SEP- 2016.

The following have access to data associated with this certificate:

SUB RESULTS		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
LOG- 22	Sample login - Rcd w/o BarCode

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
F- ELE81a	F by Specific Ion Electrode	TITRATOR
ME- MS61	48 element four acid ICP- MS	
Hg- MS42	Trace Hg by ICPMS	ICP- MS

To: ALS ENVIRONMENTAL
ATTN: SUB RESULTS
32 SHAND STREET
STAFFORD QLD 4053

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager

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Project: EB1622359

CERTIFICATE OF ANALYSIS BR16154309

Sample Description	Method Analyte Units LOR	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05
16090340		0.03	6.69	4.2	600	2.06	0.19	0.26	0.02	105.0	8.3	68	10.95	15.4	2.92	18.30
16090341		0.04	7.74	3.1	420	2.79	0.41	0.69	0.08	101.5	12.9	73	15.75	22.8	3.83	22.6
16090342		0.05	7.73	19.2	740	1.76	0.19	0.28	0.02	62.9	4.6	51	6.89	14.7	2.97	18.95
16090343		0.06	7.23	16.9	560	1.68	0.47	0.26	0.10	59.5	13.9	47	4.09	11.8	3.01	17.85

***** See Appendix Page for comments regarding this certificate *****

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Project: EB1622359

CERTIFICATE OF ANALYSIS BR16154309

Sample Description	Method Analyte Units LOR	ME- MS61 Ge ppm 0.05	ME- MS61 Hf ppm 0.1	Hg- MS42 Hg ppm 0.005	ME- MS61 In ppm 0.005	ME- MS61 K % 0.01	ME- MS61 La ppm 0.5	ME- MS61 Li ppm 0.2	ME- MS61 Mg % 0.01	ME- MS61 Mn ppm 5	ME- MS61 Mo ppm 0.05	ME- MS61 Na % 0.01	ME- MS61 Nb ppm 0.1	ME- MS61 Ni ppm 0.2	ME- MS61 P ppm 10	ME- MS61 Pb ppm 0.5
16090340		0.17	1.4	<0.005	0.054	2.70	42.5	27.8	0.59	321	1.10	1.54	11.1	10.7	300	20.9
16090341		0.21	2.3	<0.005	0.072	3.56	43.5	50.2	1.14	652	1.06	0.77	13.0	21.0	500	25.7
16090342		0.15	2.2	<0.005	0.054	2.67	30.3	11.7	0.53	157	0.42	2.51	7.6	8.3	240	19.1
16090343		0.15	1.9	0.005	0.052	2.04	27.9	18.3	0.58	889	0.57	2.95	6.8	14.5	460	21.1

***** See Appendix Page for comments regarding this certificate *****

Australian Laboratory Services Pty. Ltd.

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ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation No: 825, Corporate Site No: 818.

Finalized Date: 19- SEP- 2016
Account: ALSENV

Project: EB1622359

CERTIFICATE OF ANALYSIS BR16154309

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61	ME- MS61
	Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOR	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1
16090340		141.5	0.002	0.01	0.34	12.5	1	2.2	145.5	0.72	0.05	13.80	0.299	0.63	1.7	58
16090341		215	0.002	0.01	0.37	15.9	1	3.0	81.0	0.88	0.06	18.85	0.352	0.98	2.7	90
16090342		120.0	<0.002	0.01	1.23	14.5	1	2.7	240	0.58	<0.05	11.70	0.298	0.56	1.8	101
16090343		95.1	<0.002	<0.01	0.94	12.9	1	2.4	178.5	0.53	0.05	10.40	0.278	0.46	1.6	100

***** See Appendix Page for comments regarding this certificate *****

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Project: EB1622359

CERTIFICATE OF ANALYSIS BR16154309

Sample Description	Method	ME- MS61	ME- MS61	ME- MS61	ME- MS61	F- ELE81a
	Analyte	W	Y	Zn	Zr	F
	Units	ppm	ppm	ppm	ppm	ppm
	LOR	0.1	0.1	2	0.5	20
16090340		1.7	32.0	75	56.7	290
16090341		2.8	27.4	102	90.2	700
16090342		1.4	17.4	69	79.6	290
16090343		1.3	22.5	82	67.6	370

***** See Appendix Page for comments regarding this certificate *****

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Project: EB1622359

CERTIFICATE OF ANALYSIS BR16154309

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REE's may not be totally soluble in this method.

Applies to Method: ME- MS61

ACCREDITATION COMMENTS

NATA Accredited. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones, ICPMS Supervising Chemist.

Applies to Method: ME- MS61

LABORATORY ADDRESSES

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. NATA Accreditation does not cover the performance of ALS Brisbane Sample Preparation which is processed at 116 Delta Street, Geebung, QLD 4034, Australia

Applies to Method: F- ELE81a Hg- MS42 LOG- 22 ME- MS61

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1622359**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	:
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016015 - MRO WR	Date Samples Received	: 13-Sep-2016 14:35
Order number	: ----	Date Analysis Commenced	: 14-Sep-2016
C-O-C number	: ----	Issue Date	: 20-Sep-2016 13:50
Sampler	: MINGRUI YUAN		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	16090340	16090341	16090342	16090343	----
			Client sampling date / time	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	----
Compound	CAS Number	LOR	Unit	EB1622359-001	EB1622359-002	EB1622359-003	EB1622359-004	--------
				Result	Result	Result	Result	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	7.7	9.7	6.0	7.2	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-5.9	-30.9	-0.8	-1.7	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	134	286	162	99	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	5.9	30.9	0.8	1.7	----
ANC as CaCO3	----	0.1	% CaCO3	0.6	3.2	<0.1	0.2	----
Fizz Rating	----	0	Fizz Unit	0	2	0	0	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	2.1	2.0	2.2	1.8	----
ED008: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.4	10.0	0.3	0.4	----
Exchangeable Magnesium	----	0.1	meq/100g	7.2	6.6	6.0	6.2	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	0.2	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	4.5	2.5	3.7	6.2	----
Cation Exchange Capacity	----	0.1	meq/100g	12.2	19.4	10.0	12.9	----
Exchangeable Sodium Percent	----	0.1	%	37.1	12.8	36.5	47.7	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	<0.01	<0.01	<0.01	<0.01	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.8	0.4	0.8	0.3	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	40	70	40	40	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	40	70	40	40	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	274	281	151	319	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	9	<5	<5	15	----
EP003: Total Organic Carbon (TOC) in Soil								
Total Organic Carbon	----	0.02	%	0.04	0.06	0.05	0.04	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Client sample ID	16090340	16090341	16090342	16090343	----
				Client sampling date / time	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	[13-Sep-2016]	----
Compound	CAS Number	LOR	Unit		EB1622359-001	EB1622359-002	EB1622359-003	EB1622359-004	--------
					Result	Result	Result	Result	----
EP003TC: Total Carbon (TC) in Soil									
Total Carbon	TC	0.02	%		**0.08**	**0.21**	**0.07**	**0.06**	**----**

19 Attachment B – Trilab Raw Data

Trilab
Soil Rock Calibration

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EMERSON CLASS NUMBER TEST REPORT

Test Method: AS 1289 3.8.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090340-EM
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	24/09/2016
		Report Date	30/09/2016
Project	RGS_2016027_MRO		

Sample No.	16090340	16090341	16090342	16090343	-	-	-
Client ID	MRORGSDH 001_A	MRORGSDH 001_B	MRORGSDH 002_A	MRORGSDH 002_B	-	-	-
Depth (m)	Not Supplied	Not Supplied	Not Supplied	Not Supplied	-	-	-
Description	GRAVEL - yellow/brown	GRAVEL - grey	GRAVEL - yellow/brown	GRAVEL - yellow/brown	-	-	-
Emerson Class Number	**3**	**2**	**2**	**3**	**-**	**-**	**-**

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	**-**	**-**	**-**	**-**	**-**	**-**	**-**

NOTES/REMARKS:

Sample/s supplied by the client

Tested with Distilled water at 22°C

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

J. Russell

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Laboratory No. 9926

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Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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PERMEABILITY BY FALLING HEAD TEST REPORT

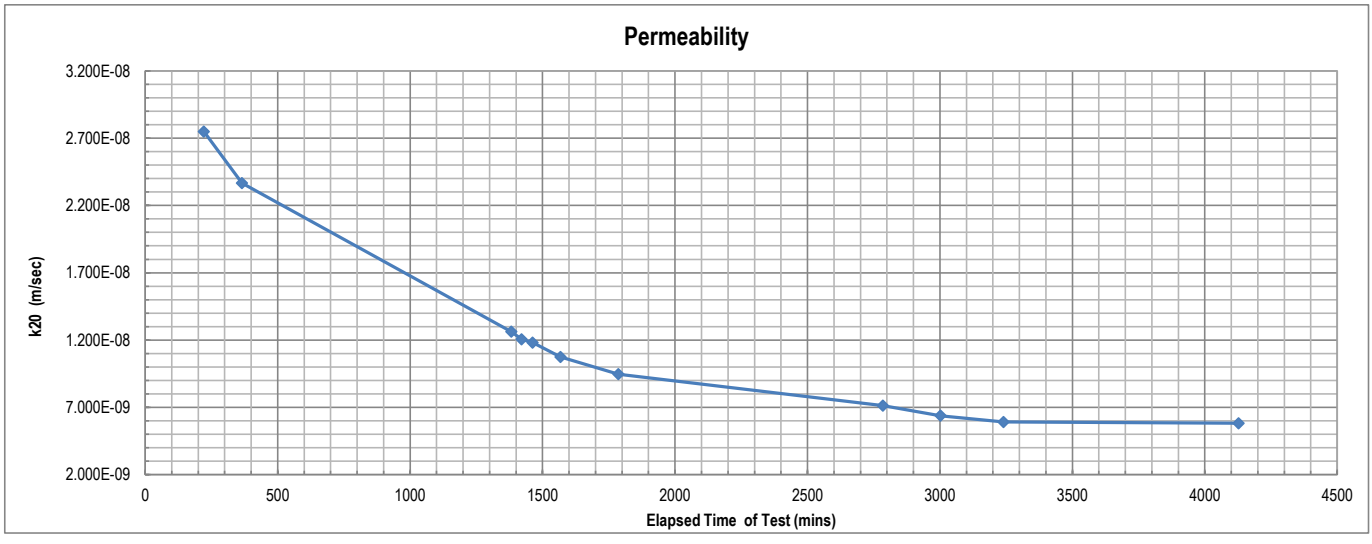
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16090340-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	11/10/16-17/10/16
		Report Date	17/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH001_A	**Depth (m)**	Not Supplied
Description	SILTY SANDY GRAVEL-yellow/brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.99**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**8.0**	Surcharge (kPa)	**3.6**
Placement Moisture Content (%)	**8.0**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**100.2**	Water Type	**De-ionized**
Placement Wet Density (t/m^3)	**2.15**	Percentage Material Retained/Sieve Size (mm)	**0 % /19 mm**
Density Ratio (%)	**99.9**		

PERMEABILITY $k_{(20)}$ = 5.8 x 10^{-09} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client

 REP06301

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The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Park

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Soil Rock Calibration

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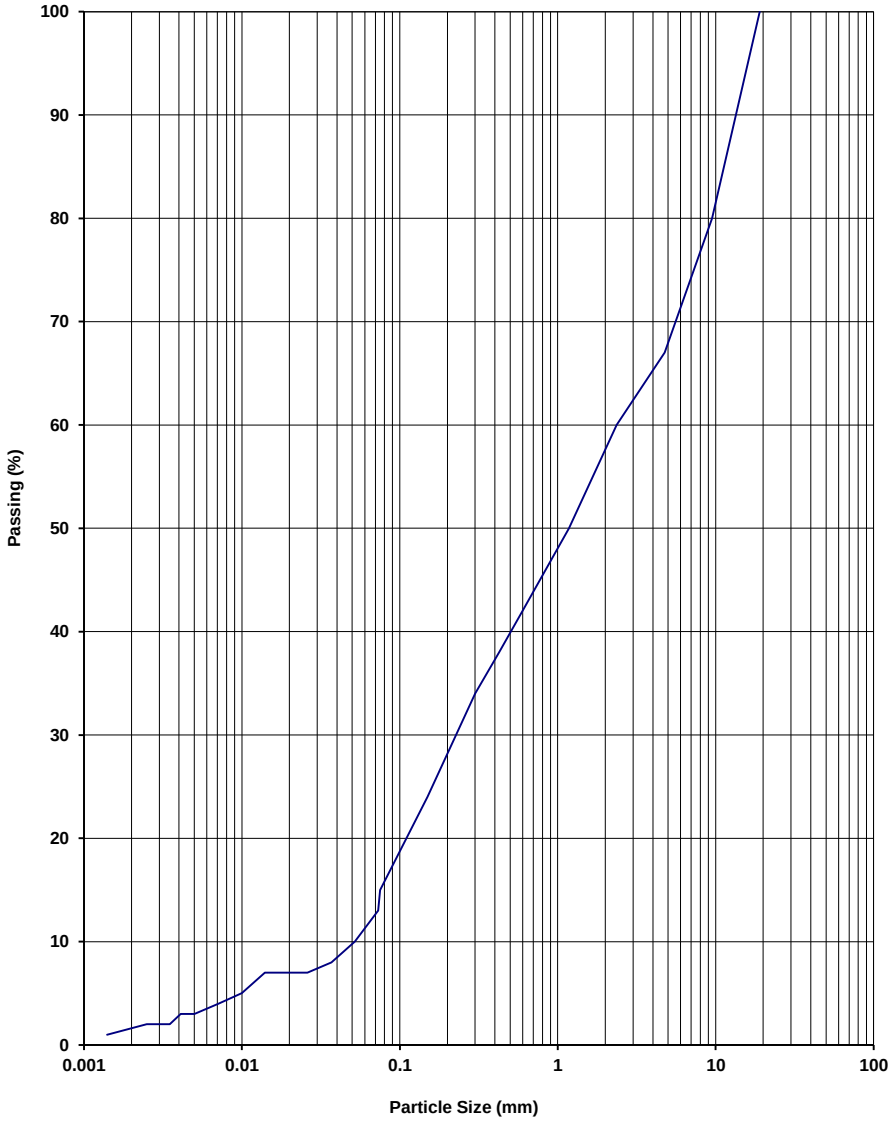
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090340-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	27/9/16-5/10/16
		Report Date	5/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH001_A	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	100
13.2	90
9.5	80
6.7	73
4.75	67
2.36	60
1.18	50
0.600	42
0.425	38
0.300	34
0.150	24
0.075	15
0.073	13
0.052	10
0.037	8
0.026	7
0.019	7
0.014	7
0.01	5
0.0071	4
0.005	3
0.0041	3
0.0035	2
0.0028	2
0.0025	2
0.0014	1



NOTES/REMARKS: -

Moisture Content 1.5% -2.36mm Soil Particle Density(t/m^3) 2.61

Sample/s supplied by the client

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory
J. Russell

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Laboratory No. 9926

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POINT LOAD TEST REPORT

Test Method: AS 4133.4.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090340-PL
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	16/09/2016
		Report Date	16/09/2016
Project	RGS_2016027_MRO		

Sample No.	16090340	16090341	16090342	16090343			
Client ID	MRORGSDH 001_A	MRORGSDH 001_B	MRORGSDH 002_A	MRORGSDH 002_B			
Depth (m)	Not Supplied	Not Supplied	Not Supplied	Not Supplied			
I_S (MPa)	0.10	0.13	0.12	0.69			
$I_{S(50)}$ (MPa)	0.11	0.14	0.14	0.76			
Load Direction	Diametral	Diametral	Diametral	Diametral			
***Descriptive Term**	L	L	L	M			

Sample No.							
Client ID							
Depth (m)							
I_S (MPa)							
$I_{S(50)}$ (MPa)							
Load Direction							
***Descriptive Term**							

NOTES/REMARKS: Tested as received + Irregular Lump * AS 1726: Table A8

EL: Extremely Low, VL: Very Low, L: Low, M: Medium, H: High, VH: Very High, EH: Extremely High

Sample/s supplied by the client

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Authorised Signatory

C. Purvis

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Laboratory No. 9926

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PERMEABILITY BY FALLING HEAD TEST REPORT

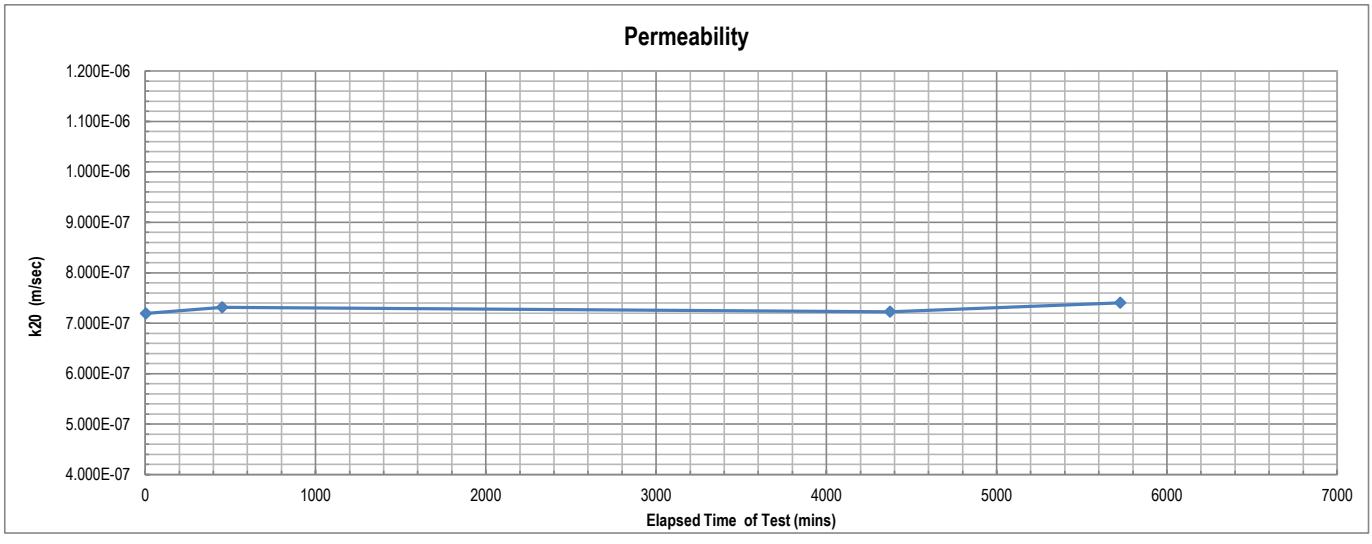
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16090341-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	29/9/16-5/10/16
		Report Date	6/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH001_B	**Depth (m)**	Not Supplied
Description	SILTY SANDY GRAVEL - grey	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**2.05**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**9.1**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**9.0**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**99.3**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.24**	Percentage Material Retained/Sieve Size (mm)	**0 % /19 mm**
Density Ratio (%)	**100.0**		

PERMEABILITY $k_{(20)} =$ **7.4×10^{-07} (m/sec)**



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Park

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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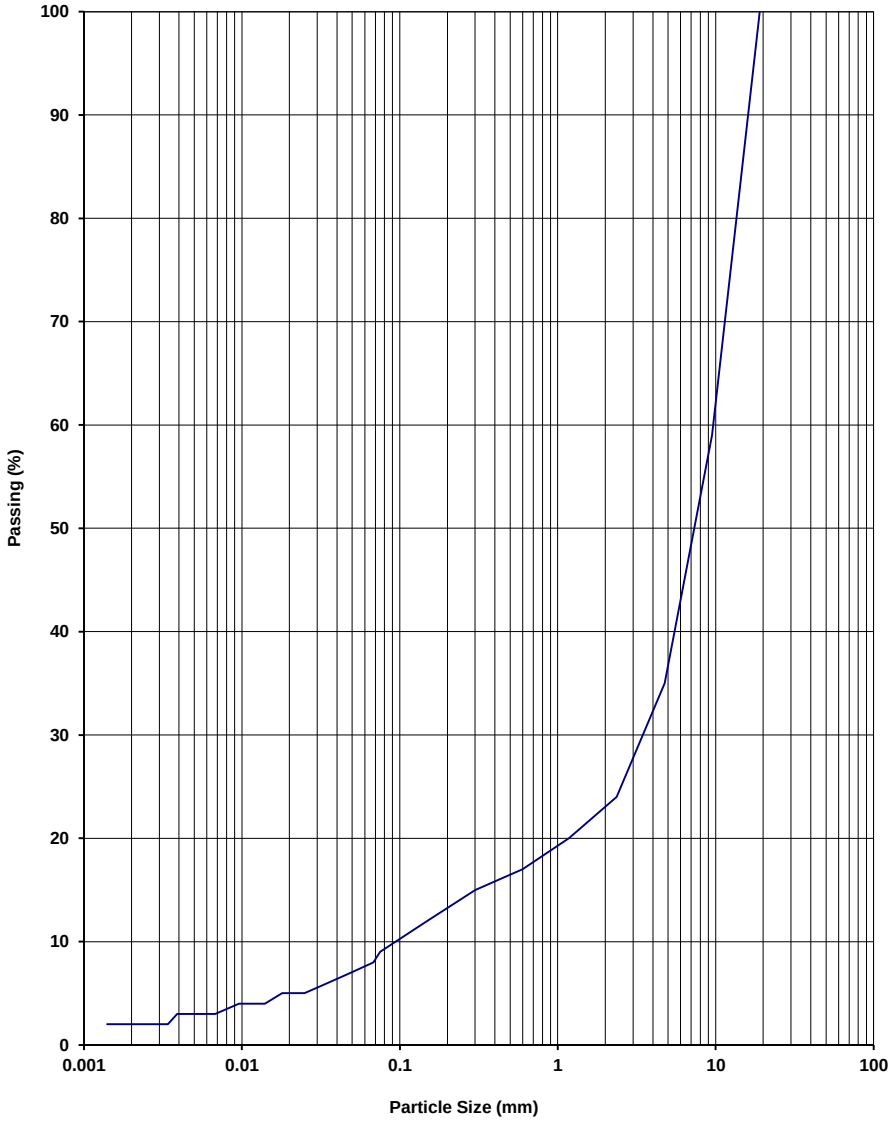
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090341-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	27/9/16-5/10/16
		Report Date	5/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH001_B	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	100
13.2	75
9.5	59
6.7	45
4.75	35
2.36	24
1.18	20
0.600	17
0.425	16
0.300	15
0.150	12
0.075	9
0.068	8
0.049	7
0.035	6
0.025	5
0.018	5
0.014	4
0.0096	4
0.0068	3
0.0048	3
0.0039	3
0.0034	2
0.0027	2
0.0024	2
0.0014	2



NOTES/REMARKS: Percentage of material passsing the 0.075mm is less than allowable by AS1289.3.6.3
Moisture Content 1.2% -2.36mm Soil Particle Density(t/m^3) 2.65
Sample/s supplied by the client

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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PERMEABILITY BY FALLING HEAD TEST REPORT

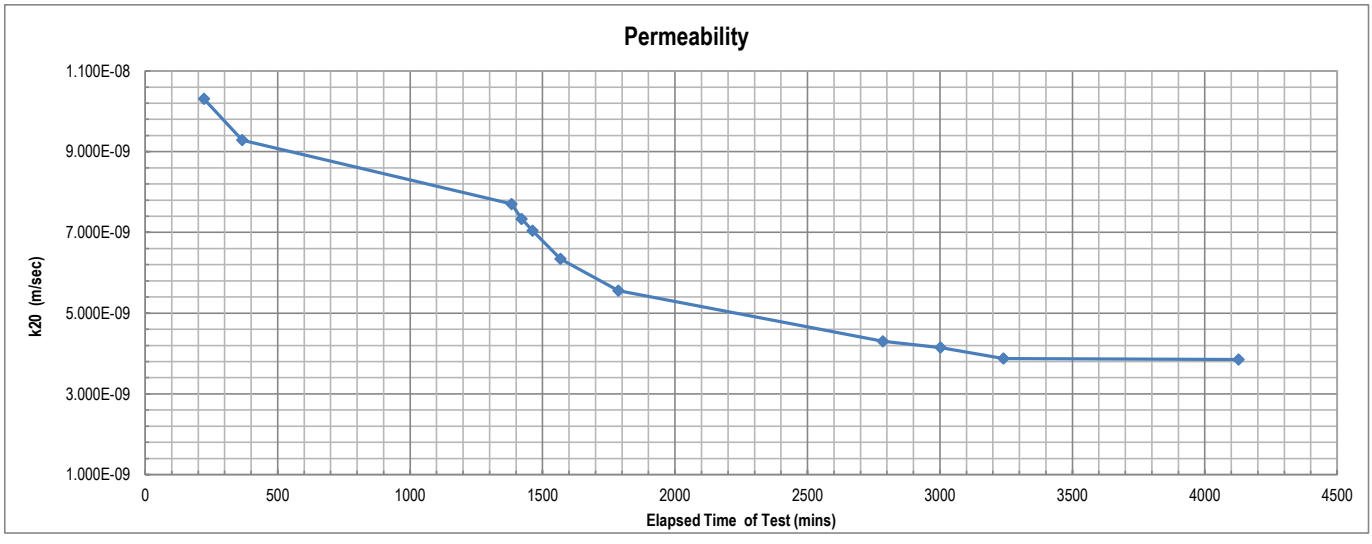
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16090342-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	11/10/16-17/10/16
		Report Date	17/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH002_A	**Depth (m)**	Not Supplied
Description	SILTY SANDY GRAVEL- yellow/brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.94**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**10.1**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**9.9**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**97.7**	Water Type	**De-ionized**
Placement Wet Density (t/m^3)	**2.13**	Percentage Material Retained/Sieve Size (mm)	**0 % /19 mm**
Density Ratio (%)	**100.1**		

PERMEABILITY $k_{(20)}$ = 3.8×10^{-09} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Park

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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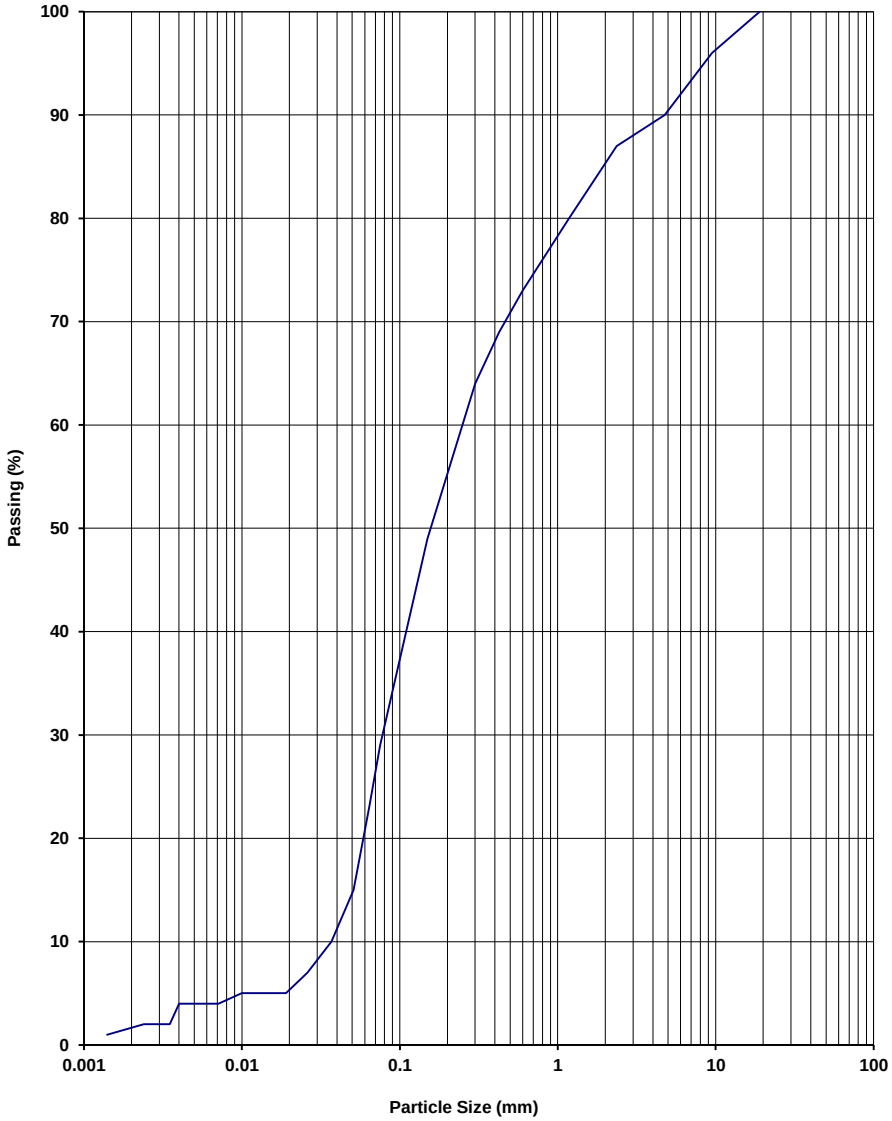
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090342-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	23/9/16-5/10/16
		Report Date	5/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH002_A	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	100
13.2	98
9.5	96
6.7	93
4.75	90
2.36	87
1.18	80
0.600	73
0.425	69
0.300	64
0.150	49
0.075	29
0.064	23
0.051	15
0.037	10
0.026	7
0.019	5
0.014	5
0.01	5
0.0071	4
0.0049	4
0.004	4
0.0035	2
0.0028	2
0.0024	2
0.0014	1



NOTES/REMARKS: -

Moisture Content 2% -2.36mm Soil Particle Density(t/m^3) 2.62

Sample/s supplied by the client

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PERMEABILITY BY FALLING HEAD TEST REPORT

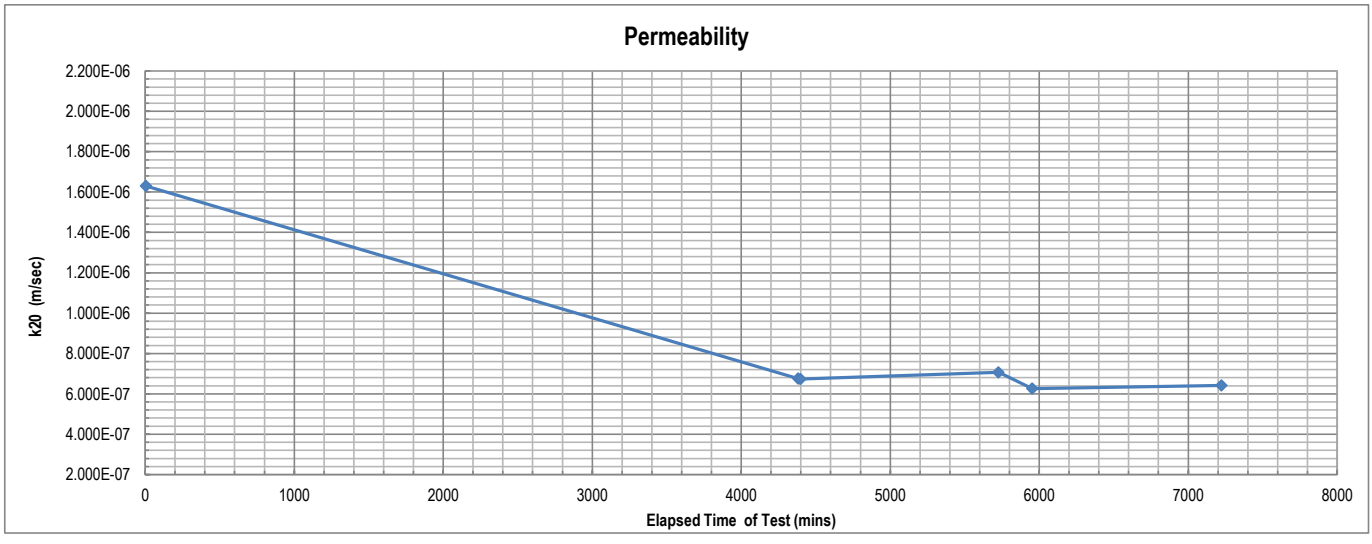
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16090343-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/10/16-6/10/16
		Report Date	6/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH002_B	**Depth (m)**	Not Supplied
Description	SILTY SANDY GRAVEL - yellow brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.97**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**11.1**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**10.7**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**96.1**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.19**	Percentage Material Retained/Sieve Size (mm)	**0 % /19 mm**
Density Ratio (%)	**100.4**		

PERMEABILITY $k_{(20)} =$ **6.4×10^{-07} (m/sec)**



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

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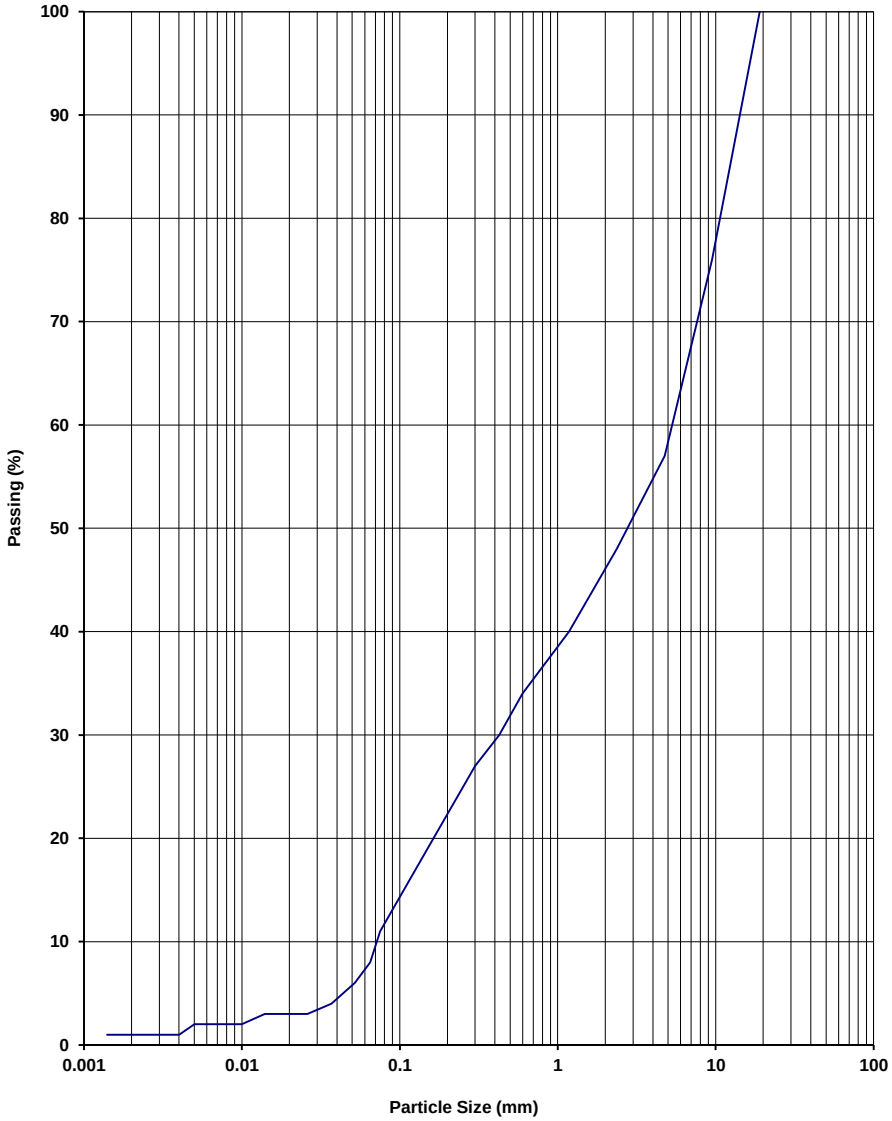
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090343-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	23/9/16-5/10/16
		Report Date	5/10/2016
Project	RGS_2016027_MRO		
Client ID	MRORGSDH002_B	**Depth (m)**	Not Supplied

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	100
13.2	88
9.5	76
6.7	59
4.75	57
2.36	48
1.18	40
0.600	34
0.425	30
0.300	27
0.150	19
0.075	11
0.065	8
0.052	6
0.037	4
0.026	3
0.019	3
0.014	3
0.01	2
0.007	2
0.005	2
0.004	1
0.0035	1
0.0028	1
0.0024	1
0.0014	1



NOTES/REMARKS: -

Moisture Content 1.8% -2.36mm Soil Particle Density(t/m^3) 2.63

Sample/s supplied by the client

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory
J. Russell

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

Department of Industry
Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO16/147R2
REPORT TO:	Chris Channon Trilab Pty Ltd 346A Bilsen Rd Geebung QLD 4034
REPORT ON:	Six soil samples Ref: MRORGS_2016015
PRELIMINARY RESULTS ISSUED:	12 October 2016
REPORT STATUS:	Final
DATE REPORTED:	25 October 2016
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

L Dunn
Scone Laboratory

SOIL CONSERVATION SERVICE
Scone Research Centre

Report No: SCO16/147R2
Client Reference: Chris Channon
Trilab Pty Ltd
346A Bilsen Rd
Geebung QLD 4034

Lab No	Method	P18A/3 (%)*										
	Sample Id	Saturation	0.05 bar	0.1 bar	0.3 bar (Field Capacity)	1.0 bar	3.0 bar	5.0 bar	8 bar	10 bar	12 bar	15 bar (Wilting Point)	Available Water Capacity
1	16080081/MRORGS001/O HORIZON E:375789 N:7205907 Elevation 134/0-50m	37	14	12	9	6	5	4	4	3	3	3	6
2	16080082/MRORGS002/O HORIZON E:376075 N:7206081 Elevation 140/0-50m	41	22	20	14	7	6	5	5	4	4	4	10
3	16080083/MRORGS003/O HORIZON E:376608 N:7204836 Elevation 136/0-50m	44	27	23	14	10	8	7	7	6	6	6	8
4	16080086/MRORGS001/A HORIZON E:375789 N:7205907 Elevation 134/50-100m	47	26	25	20	16	12	10	10	9	9	9	11
5	16080087/MRORGS002/A HORIZON E:376075 N:7206081 Elevation 140/50-100m	41	23	21	17	13	10	9	8	8	8	7	10
6	16080088/MRORGS003/A HORIZON E:376608 N:7204836 Elevation 136/50-100m	49	32	29	20	14	10	9	8	7	7	7	13

*moisture content (%) by weight

END OF TEST REPORT

Trilab
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ATTERBERG LIMITS TEST REPORT

Test Method: AS 1289 2.1.1, 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080081-AL
Address	PO Box 3091, Sunnybank South QLD 4109	**Report Date**	27/07/2016
Project	MRORGS_2016015		

Sample No.	16080081	16080082	16080083	16080086	16080087	16080088
Test Date	23/09/2016	23/09/2016				
Client ID	MRORGS001-1 O Horizon E: 375789 N: 7205907 Elevation 134	MRORGS002-1 O Horizon E: 376075 N: 7206081 Elevation 140	MRORGS003-1 O Horizon E: 376608 N: 7204836 Elevation 136	MRORGS001-2 A Horizon E: 375789 N:7205907 Elevation 134	MRORGS002-2 A Horizon E: 376075 N: 7206081 Elevation 140	MRORGS003-2 A Horizon E: 376608 N:7204836 Elevation 136
Depth (m)	0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00	0.50-1.00
Liquid Limit (%)	Not Obtainable	Not Obtainable	23	33	27	35
Plastic Limit (%)	Not Obtainable	Not Obtainable	17	15	19	24
Plasticity Index (%)	Non Plastic	Non Plastic	6	18	8	11
Linear Shrinkage (%)	Not Obtainable	Not Obtainable	2.5 *	8.5	4.0 +	4.0 *
Moisture Content (%)	11.3	12.2	12.2	8.4	7.2	8.9

NOTES/REMARKS: The samples were tested oven dried, dry sieved and in a 125-250mm mould.

Sample/s supplied by the client * Cracking occurred + Curling occurred

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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EMERSON CLASS NUMBER TEST REPORT

Test Method: AS 1289 3.8.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080081-EM
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	19/8/16-24/8/16
		Report Date	24/08/2016
Project	MRORGS_2016015		

Sample No.	16080081	16080082	16080083	16080086	16080087	16080088	-
Client ID	MRORGS001-1 O Horizon E: 375789 N: 7205907 Elevation 134	MRORGS002-1 O Horizon E: 376075 N: 7206081 Elevation 140	MRORGS003-1 O Horizon E: 376608 N: 7204836 Elevation 136	MRORGS001-2 A Horizon E: 375789 N:7205907 Elevation 134	MRORGS002-2 A Horizon E: 376075 N: 7206081 Elevation 140	MRORGS003-2 A Horizon E: 376608 N:7204836 Elevation 136	-
Depth (m)	0.00-0.50	0.00-0.50	0.00-0.50	0.50-1.00	0.50-1.00	0.50-1.00	-
Description	Gravelly SAND - brown	Gravelly SAND - brown	Clayey Gravelly SAND - brown	Gravelly SAND - pale brown	Clayey SAND - red/brown	Clayey SAND - brown	-
Emerson Class Number	**3**	**2**	**2**	**2**	**2**	**2**	**-**

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Sample No.	-	-	-	-	-	-	-
Client ID	-	-	-	-	-	-	-
Depth (m)	-	-	-	-	-	-	-
Description	-	-	-	-	-	-	-
Emerson Class Number	**-**	**-**	**-**	**-**	**-**	**-**	**-**

NOTES/REMARKS:

Sample/s supplied by the client

Tested with Distilled water at 21.9°C

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Authorised Signatory

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PERMEABILITY BY FALLING HEAD TEST REPORT

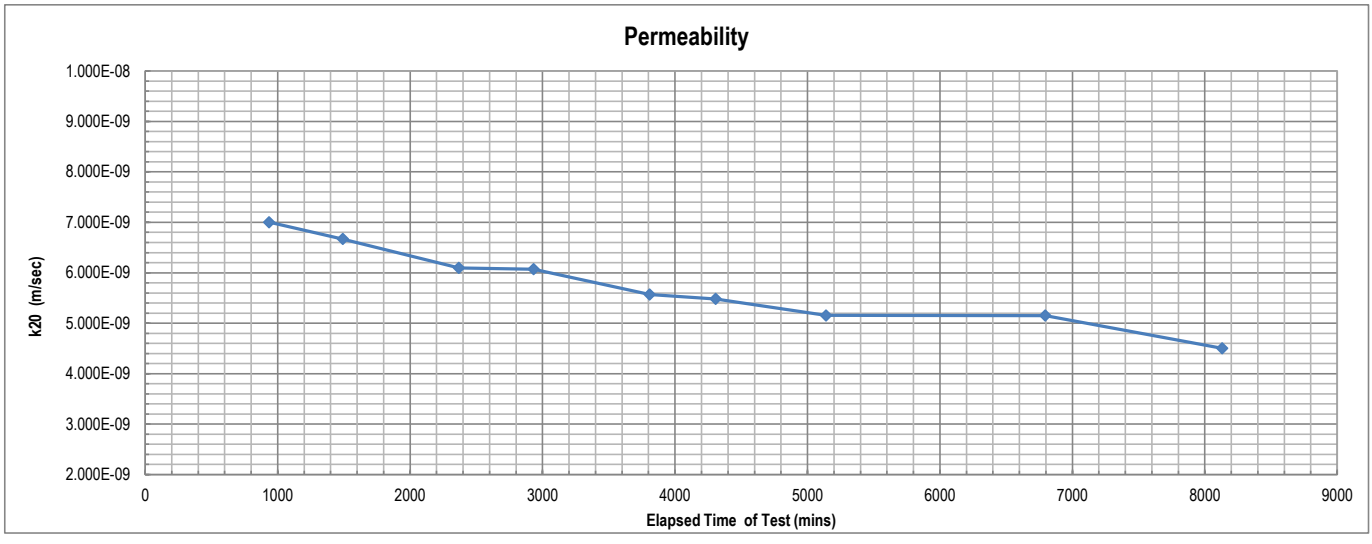
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080081-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/09/2016
		Report Date	13/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-1 O Horizon E: 375789 N: 7205907 Elevation 134	**Depth (m)**	0.00-0.50
Description	CLAYEY SAND - brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.86**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**9.9**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**9.7**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**98.5**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.04**	Percentage Material Retained/Sieve Size (mm)	**3 % /19 mm**
Density Ratio (%)	**100.1**		

PERMEABILITY $k_{(20)}$ = 4.5×10^{-09} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client **The maximum particle size exceeds the minimum cylinder diameter requirements** **Page: 1 of 1** REP06301

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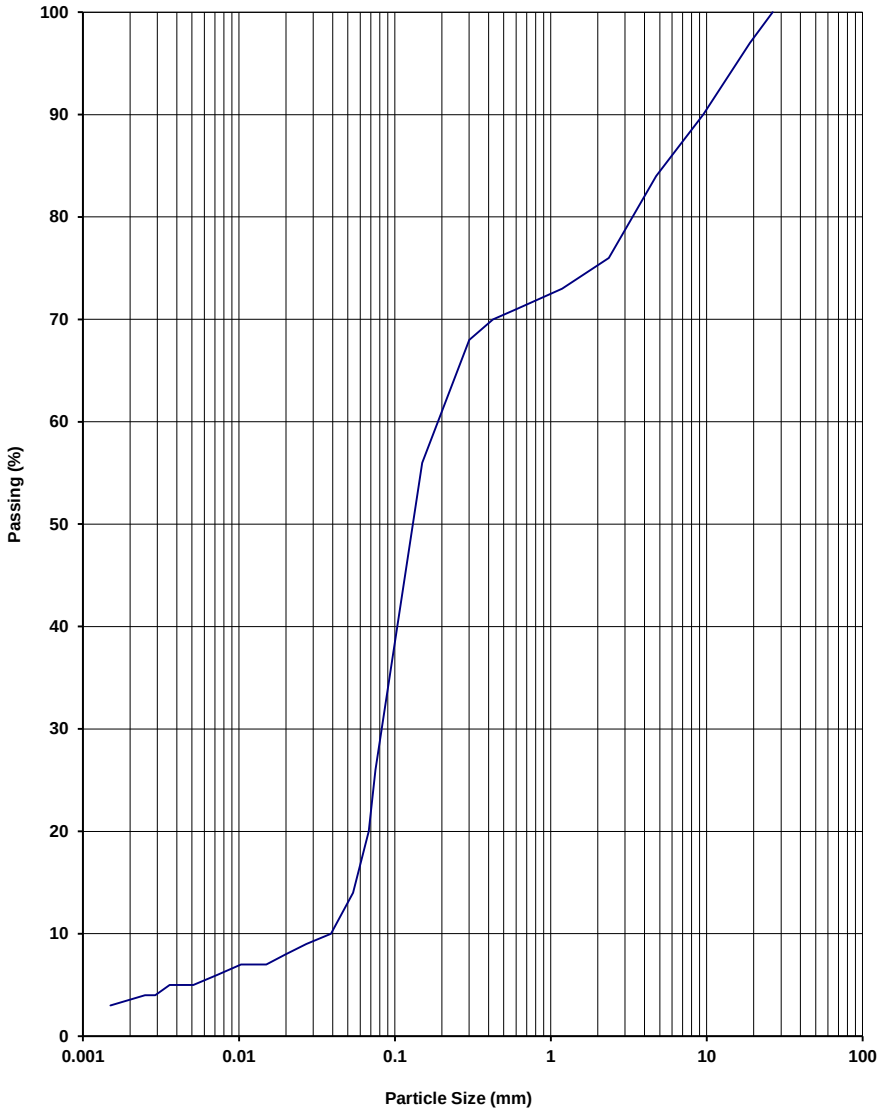
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080081-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	9/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-1 O Horizon E: 375789 N: 7205907 Elevation 134	**Depth (m)**	0.00-0.50

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	100
19.0	97
13.2	95
9.5	90
6.7	87
4.75	84
2.36	76
1.18	73
0.600	71
0.425	70
0.300	68
0.150	56
0.075	26
0.068	20
0.054	14
0.039	10
0.027	9
0.02	8
0.015	7
0.0103	7
0.0073	6
0.0051	5
0.0042	5
0.0036	5
0.0029	4
0.0025	4
0.0015	3



NOTES/REMARKS: -

Moisture Content 11.3% -2.36mm Soil Particle Density(t/m^3) 2.59

Sample/s supplied by the client

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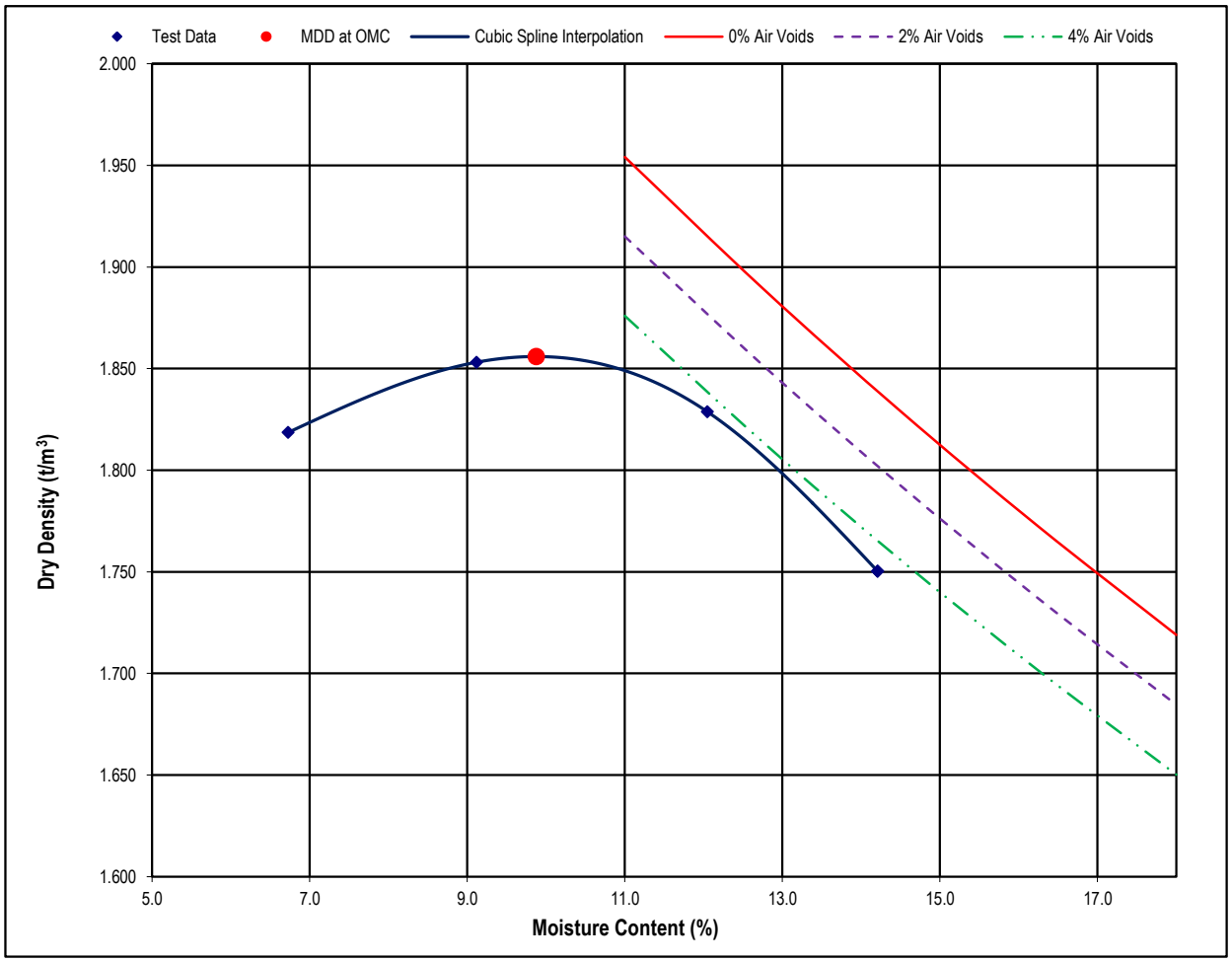
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080081-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	19/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-1 O Horizon E: 375789 N: 7205907 Elevation 134	**Depth (m)**	0.00-0.50



Maximum Dry Density (t/m^3)	1.86	**Optimum Moisture Content (%)**	9.9
Moisture Content (%)	11.3	**Percentage of Oversize/Sieve Size (mm)**	3 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.49

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

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PERMEABILITY BY FALLING HEAD TEST REPORT

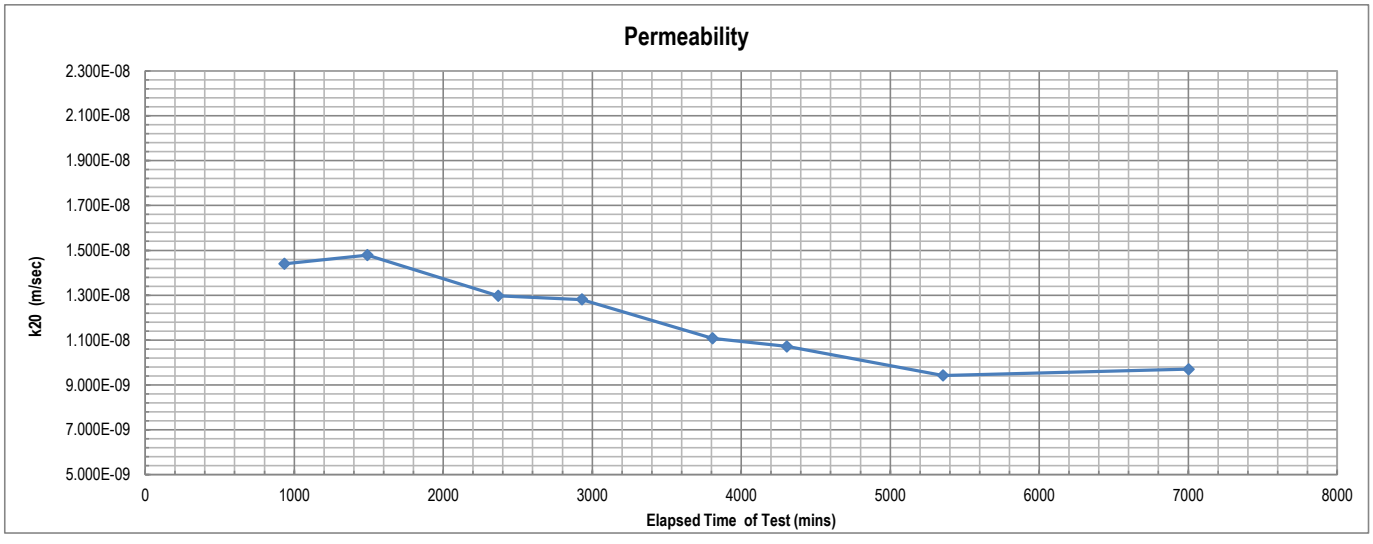
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080082-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/09/2016
		Report Date	13/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-1 O Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.00-0.50
Description	SILTY SANDY GRAVEL - dark brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.97**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**9.4**	Surcharge (kPa)	**3.6**
Placement Moisture Content (%)	**9.1**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**97.1**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.16**	Percentage Material Retained/Sieve Size (mm)	**19 % /19 mm**
Density Ratio (%)	**100.3**		

PERMEABILITY $k_{(20)}$ = 9.7×10^{-09} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client **The maximum particle size exceeds the minimum cylinder diameter requirements** **Page: 1 of 1** REP06301

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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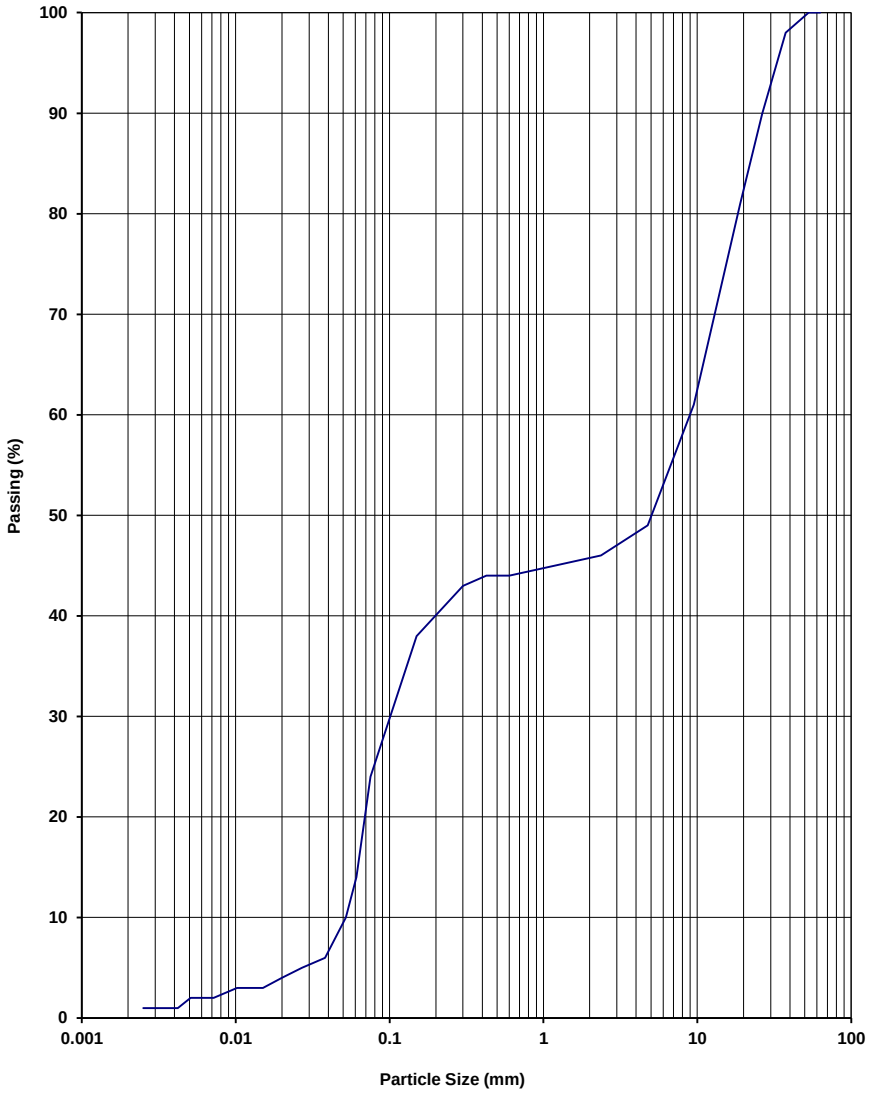
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Queens Park
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Ph: +61 8 9258 8323

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080082-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	9/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-1 O Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.00-0.50

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	100
37.5	98
26.5	90
19.0	81
13.2	70
9.5	61
6.7	52
4.75	49
2.36	46
1.18	45
0.600	44
0.425	44
0.300	43
0.150	38
0.075	24
0.061	14
0.052	10
0.038	6
0.027	5
0.02	4
0.015	3
0.0102	3
0.0072	2
0.0051	2
0.0042	1
0.0036	1
0.0029	1
0.0025	1
0.0015	0



NOTES/REMARKS: -

Moisture Content 12.2% -2.36mm Soil Particle Density(t/m^3) 2.62

Sample/s supplied by the client

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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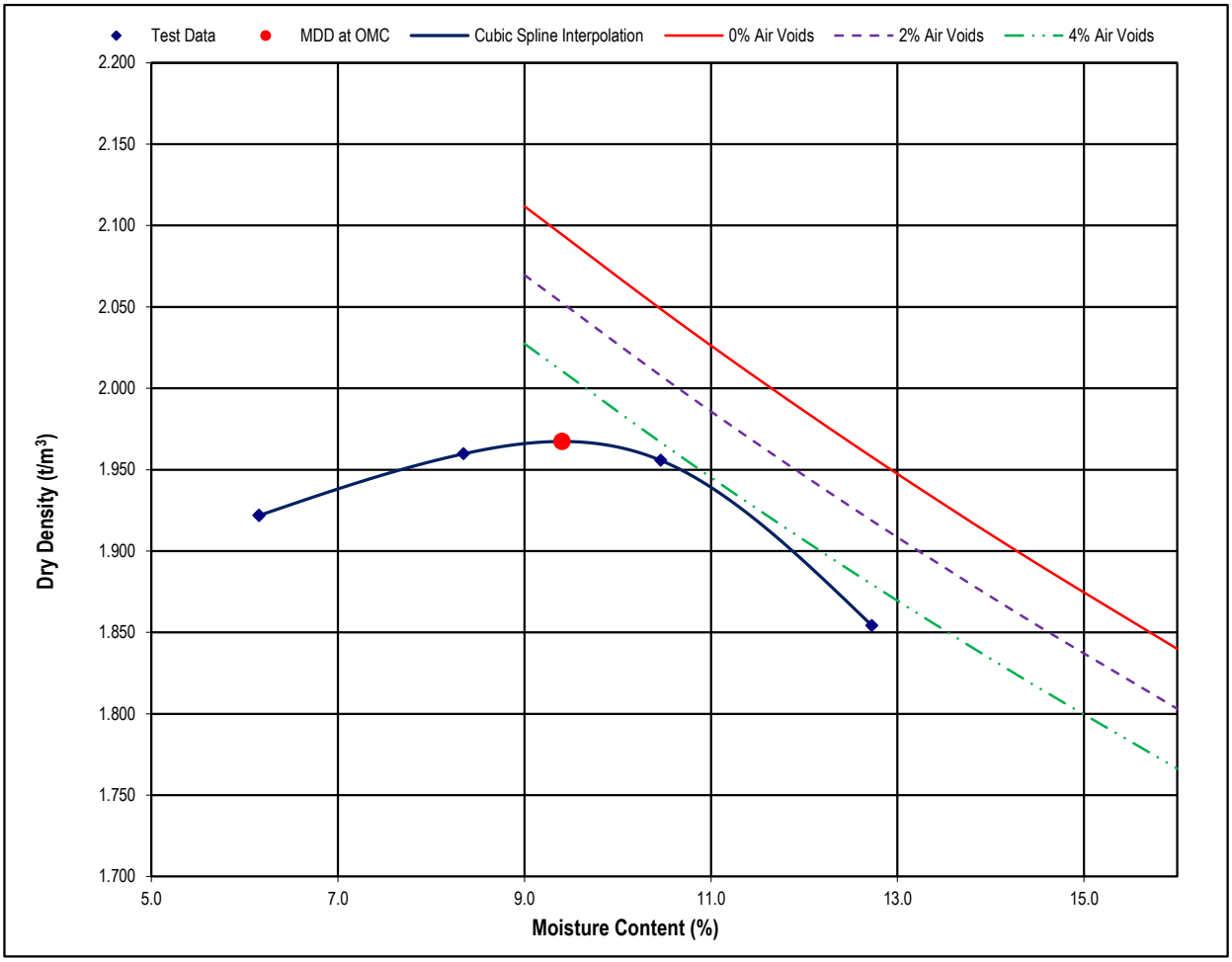
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080082-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	11/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-1 O Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.00-0.50



Maximum Dry Density (t/m^3)	1.97	**Optimum Moisture Content (%)**	9.4
Moisture Content (%)	12.2	**Percentage of Oversize/Sieve Size (mm)**	19 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.61

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PERMEABILITY BY FALLING HEAD TEST REPORT

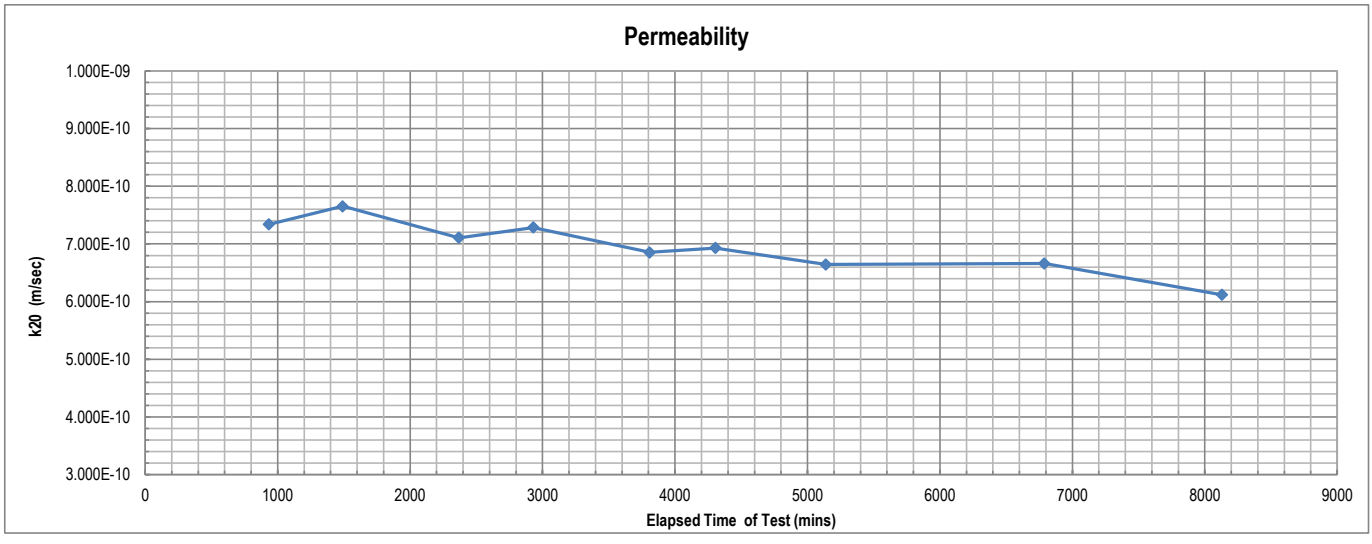
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080083-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/09/2016
		Report Date	13/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-1 O Horizon E: 376608 N: 7204836 Elevation 136	**Depth (m)**	0.00-0.50
Description	CLAYEY SANDY SILT - brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.81**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**12.9**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**13.1**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**101.9**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.04**	Percentage Material Retained/Sieve Size (mm)	**5 % /19 mm**
Density Ratio (%)	**99.8**		

PERMEABILITY $k_{(20)}$ = 6.1×10^{-10} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client **The maximum particle size exceeds the minimum cylinder diameter requirements** **Page: 1 of 1** REP06301

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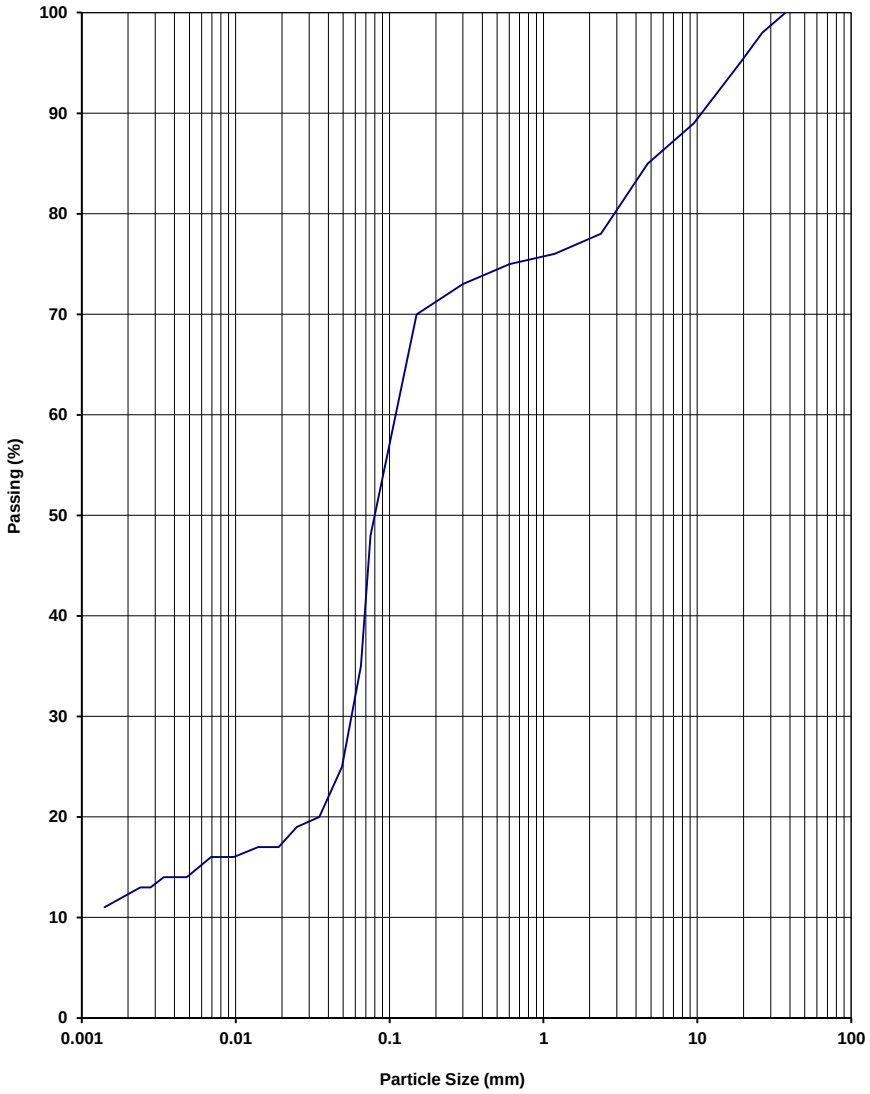
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2 Kimmer Place,
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Ph: +61 8 9258 8323

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080083-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	9/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-1 O Horizon E: 376608 N: 7204836 Elevation 136	**Depth (m)**	0.00-0.50

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	100
26.5	98
19.0	95
13.2	91
9.5	89
6.7	87
4.75	85
2.36	78
1.18	76
0.600	75
0.425	74
0.300	73
0.150	70
0.075	48
0.065	35
0.049	25
0.035	20
0.025	19
0.019	17
0.014	17
0.0097	16
0.0069	16
0.0048	14
0.0039	14
0.0034	14
0.0028	13
0.0024	13
0.0014	11



NOTES/REMARKS: -

Moisture Content 12.2% -2.36mm Soil Particle Density(t/m^3) 2.62

Sample/s supplied by the client

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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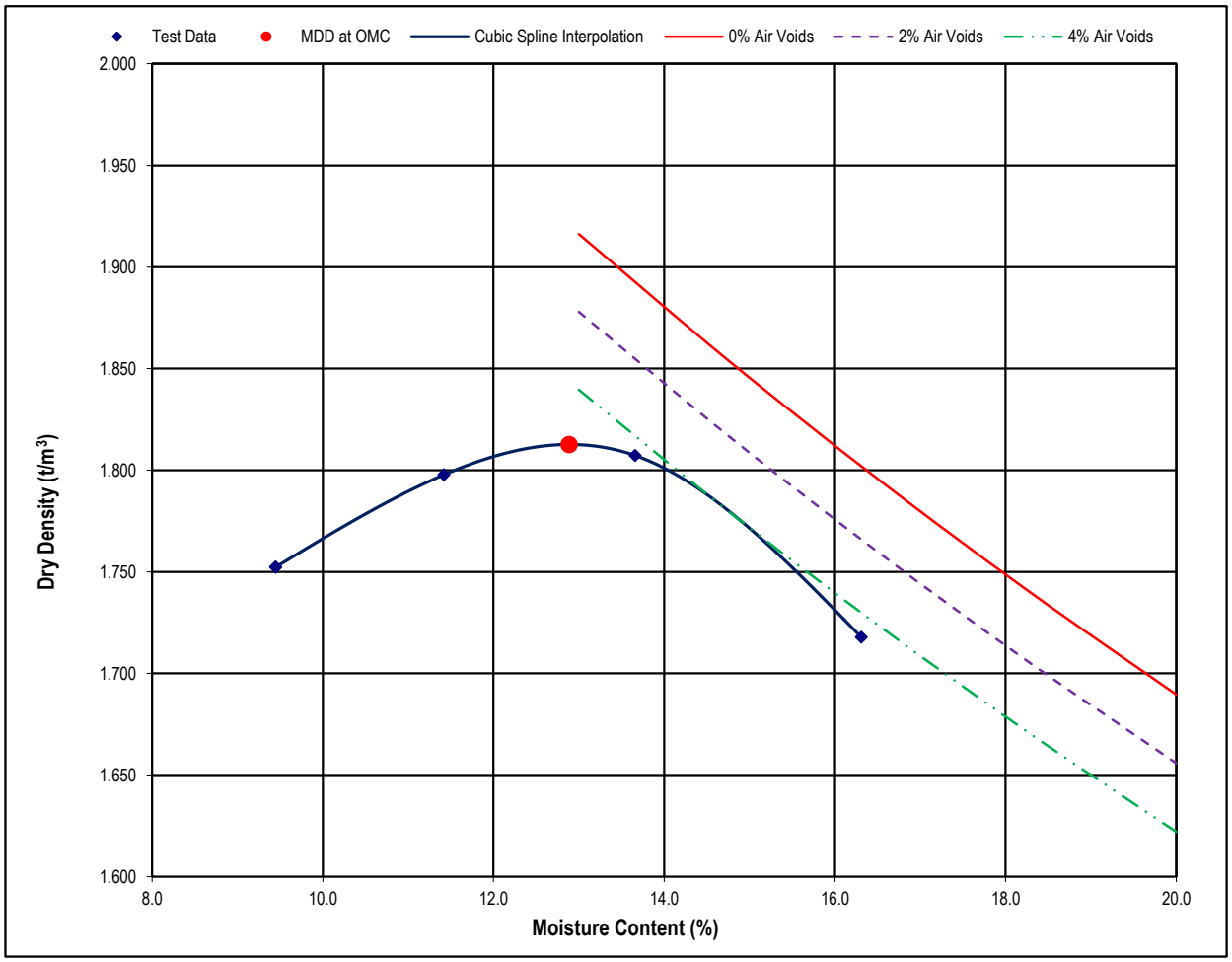
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Ph: +61 7 3265 5656

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Queens Park
WA 6107
Ph: +61 8 9258 8323

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080083-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	11/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-1 O Horizon E: 376608 N: 7204836 Elevation 136	**Depth (m)**	0.00-0.50



Maximum Dry Density (t/m^3)	1.81	**Optimum Moisture Content (%)**	12.9
Moisture Content (%)	12.2	**Percentage of Oversize/Sieve Size (mm)**	5 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.55

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PERMEABILITY BY FALLING HEAD TEST REPORT

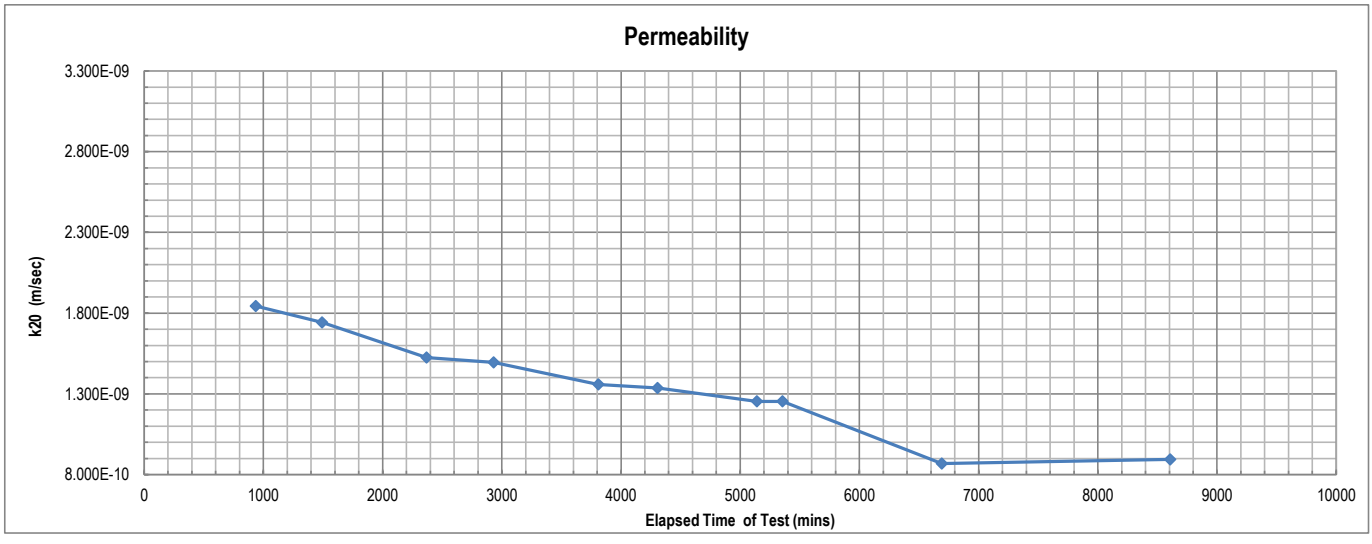
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080086-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/09/2016
		Report Date	13/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-2 A Horizon E: 375789 N:7205907 Elevation 134	**Depth (m)**	0.50-1.00
Description	SILTY SANDY GRAVEL - pale brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.96**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**10.1**	Surcharge (kPa)	**3.7**
Placement Moisture Content (%)	**10.0**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**98.7**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.16**	Percentage Material Retained/Sieve Size (mm)	**10 % /19 mm**
Density Ratio (%)	**100.2**		

PERMEABILITY $k_{(20)}$ = 8.9×10^{-10} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client **The maximum particle size exceeds the minimum cylinder diameter requirements** **Page: 1 of 1** REP06301

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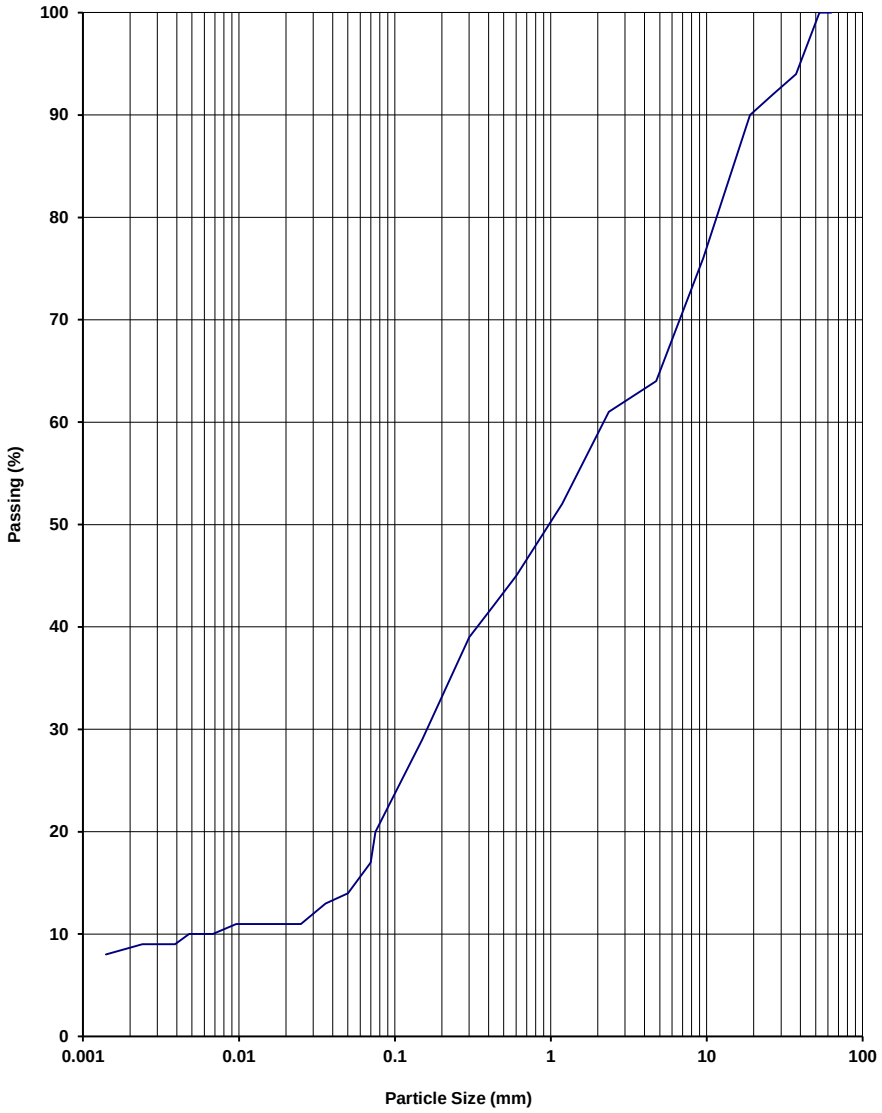
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Ph: +61 8 9258 8323

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080086-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	12/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-2 A Horizon E: 375789 N:7205907 Elevation 134	**Depth (m)**	0.50-1.00

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	100
37.5	94
26.5	92
19.0	90
13.2	80
9.5	76
6.7	68
4.75	64
2.36	61
1.18	52
0.600	45
0.425	42
0.300	39
0.150	29
0.075	20
0.07	17
0.05	14
0.036	13
0.025	11
0.019	11
0.014	11
0.0096	11
0.0068	10
0.0048	10
0.0039	9
0.0034	9
0.0027	9
0.0024	9
0.0014	8



NOTES/REMARKS: -

Moisture Content 8.4% -2.36mm Soil Particle Density(t/m^3) 2.70

Sample/s supplied by the client

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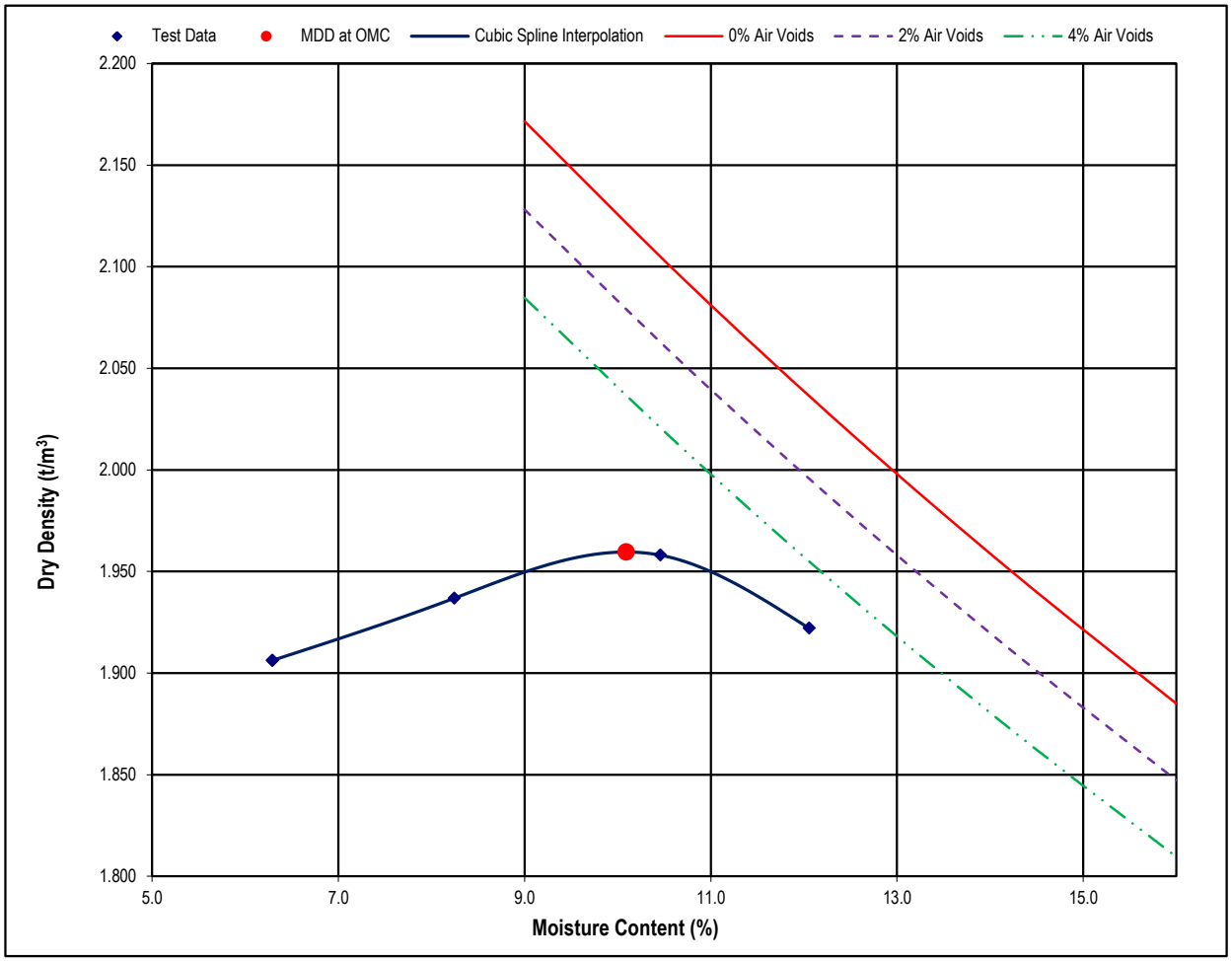
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Ph: +61 8 9258 8323

MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080086-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	17/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS001-2 A Horizon E: 375789 N:7205907 Elevation 134	**Depth (m)**	0.50-1.00



Maximum Dry Density (t/m³)	1.96	**Optimum Moisture Content (%)**	10.1
Moisture Content (%)	8.4	**Percentage of Oversize/Sieve Size (mm)**	10 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.7

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PERMEABILITY BY FALLING HEAD TEST REPORT

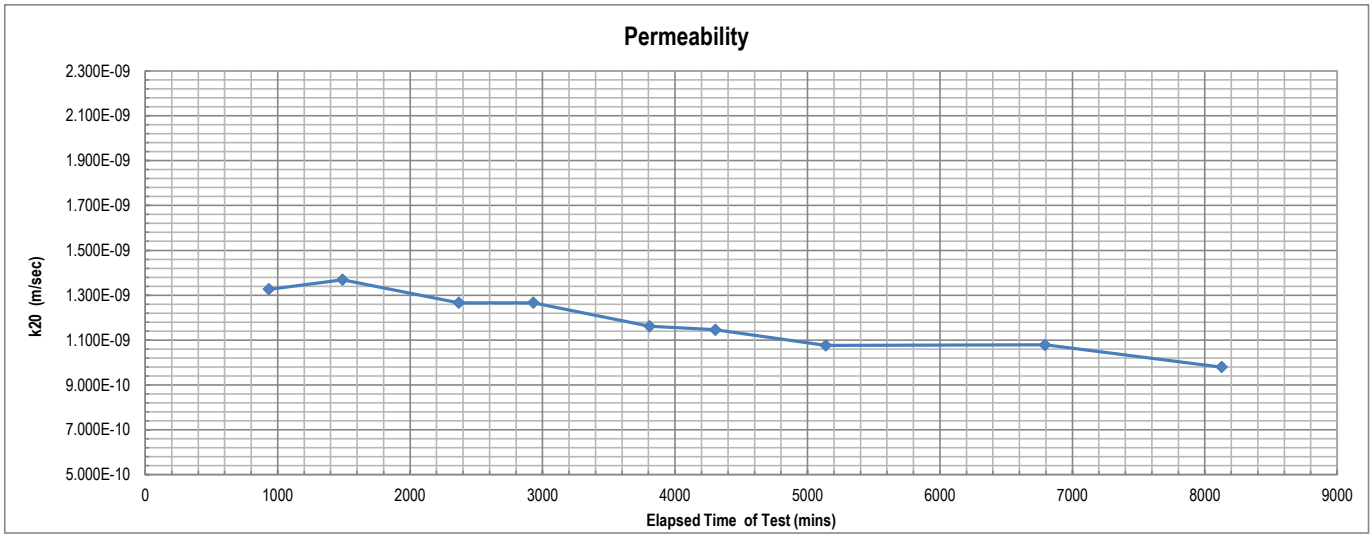
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080087-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	31/08/2016
		Report Date	14/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-2 A Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.50-1.00
Description	SILTY SAND - brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.91**	Hydraulic Gradient	**9.6**
Optimum Moisture Content (%)	**9.7**	Surcharge (kPa)	**0.0**
Placement Moisture Content (%)	**9.5**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**97.6**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**2.09**	Percentage Material Retained/Sieve Size (mm)	**1 % /9.5 mm**
Density Ratio (%)	**100.0**		

PERMEABILITY $k_{(20)}$ = 9.8×10^{-10} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client

Accredited for compliance with ISO/IEC 17025.
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Tested at Trilab Brisbane Laboratory.

Authorised Signatory

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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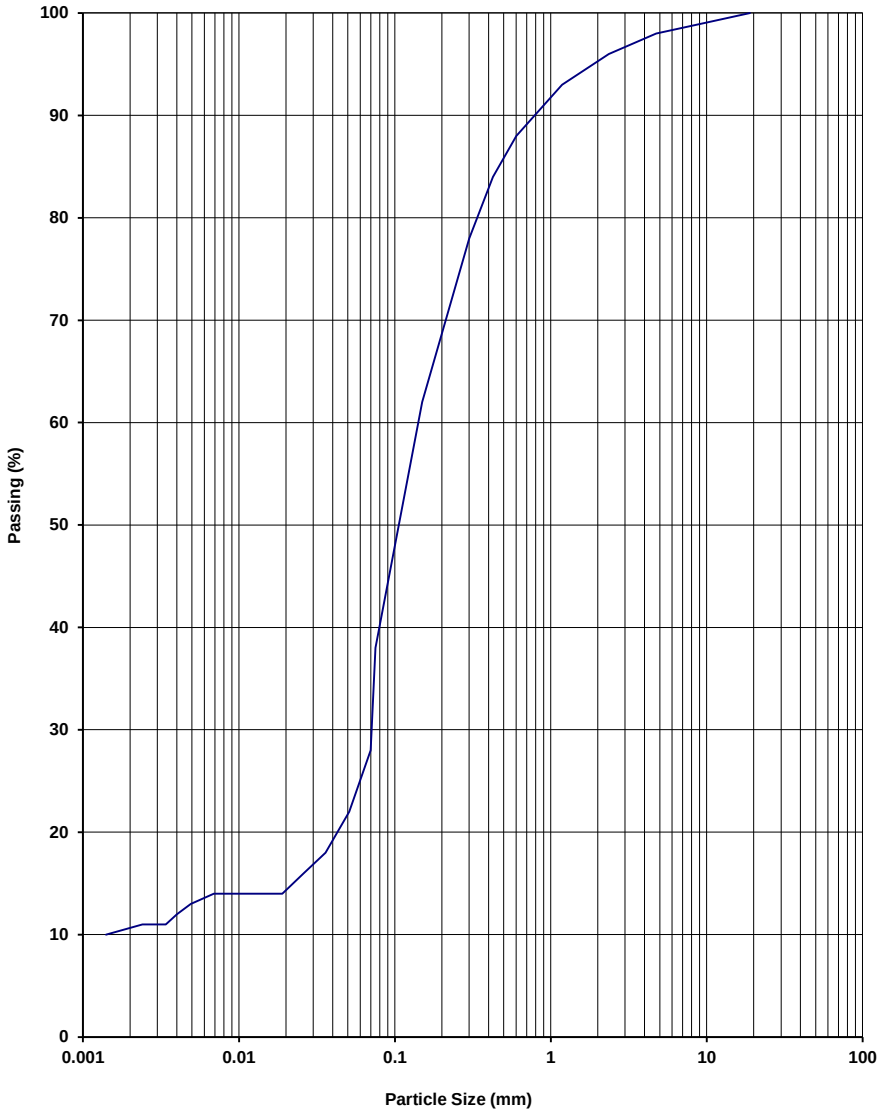
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WA 6107
Ph: +61 8 9258 8323

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080087-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	12/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-2 A Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.50-1.00

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	
13.2	100
9.5	99
6.7	99
4.75	98
2.36	96
1.18	93
0.600	88
0.425	84
0.300	78
0.150	62
0.075	38
0.07	28
0.051	22
0.036	18
0.026	16
0.019	14
0.014	14
0.0098	14
0.0069	14
0.0049	13
0.004	12
0.0034	11
0.0028	11
0.0024	11
0.0014	10



NOTES/REMARKS: -

Moisture Content 7.2% -2.36mm Soil Particle Density(t/m^3) 2.68

Sample/s supplied by the client

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Park

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ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

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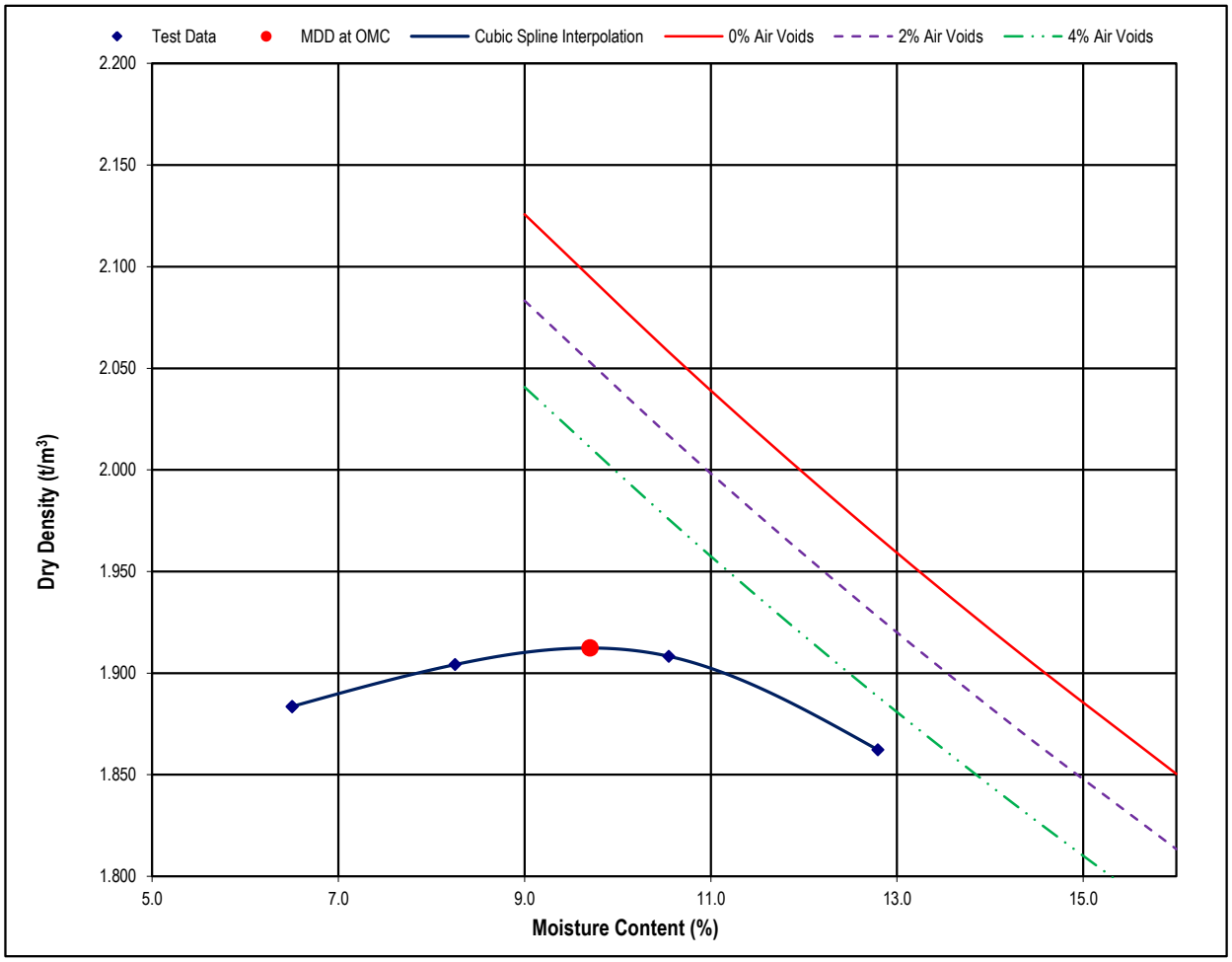
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080087-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	17/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS002-2 A Horizon E: 376075 N: 7206081 Elevation 140	**Depth (m)**	0.50-1.00



Maximum Dry Density (t/m^3)	1.91	**Optimum Moisture Content (%)**	9.7
Moisture Content (%)	7.2	**Percentage of Oversize/Sieve Size (mm)**	0 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.63

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PERMEABILITY BY FALLING HEAD TEST REPORT

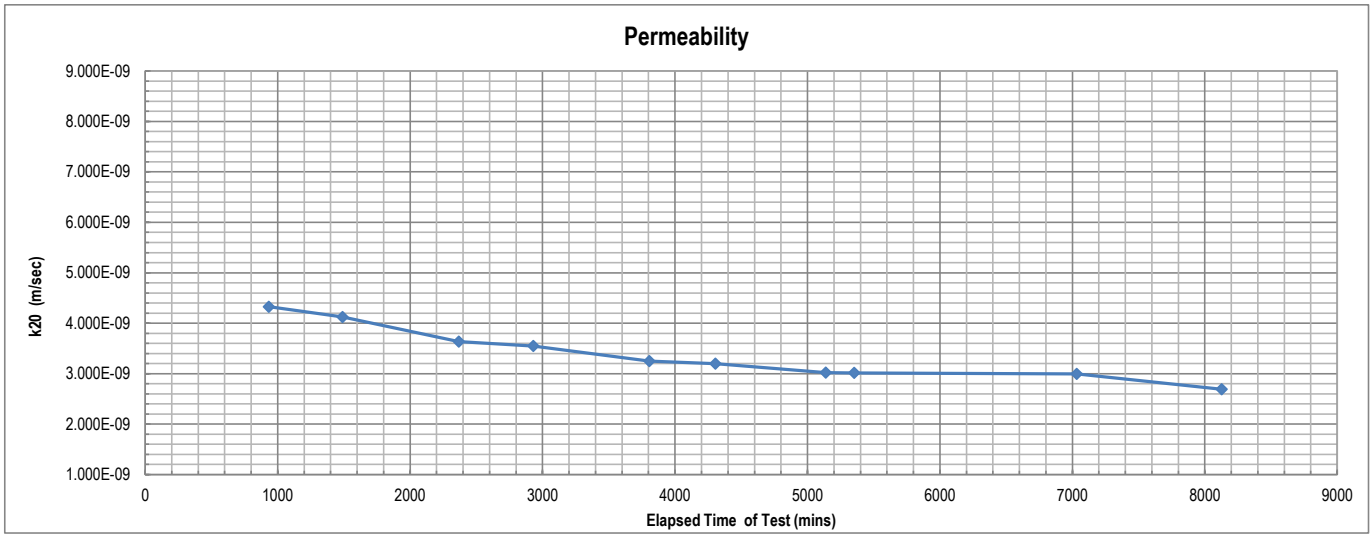
Test Method AS 1289 6.7.2, 5.1.1 , KH2 (Based on K H Head (1988) Manual of Laboratory Testing,10.7)

Client	RGS Environmental Pty Ltd	**Report No.**	16080088-FHPT
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	1/09/2016
		Report Date	14/09/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-2 A Horizon E: 376608 N:7204836 Elevation 136	**Depth (m)**	0.50-1.00
Description	SANDY SILT- brown	**Sample Type**	Remoulded Soil Specimen

RESULTS OF TESTING

Compaction Method	**AS1289.5.1.1 - Standard Compaction**		
Maximum Dry Density (t/m^3)	**1.76**	Hydraulic Gradient	**9.4**
Optimum Moisture Content (%)	**11.7**	Surcharge (kPa)	**2.9**
Placement Moisture Content (%)	**11.5**	Head Pressure Applied (kPa)	**10.79**
Moisture Ratio (%)	**98.2**	Water Type	**De-Ionized**
Placement Wet Density (t/m^3)	**1.96**	Percentage Material Retained/Sieve Size (mm)	**0 % /9.5 mm**
Density Ratio (%)	**100.0**		

PERMEABILITY $k_{(20)}$ = 2.7×10^{-09} (m/sec)



Remarks: The above specimen was remoulded to a target of 100% of Standard Dry Density and at 100% of Optimum Moisture Content.

Sample/s supplied by client The compaction data was supplied by the client.

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

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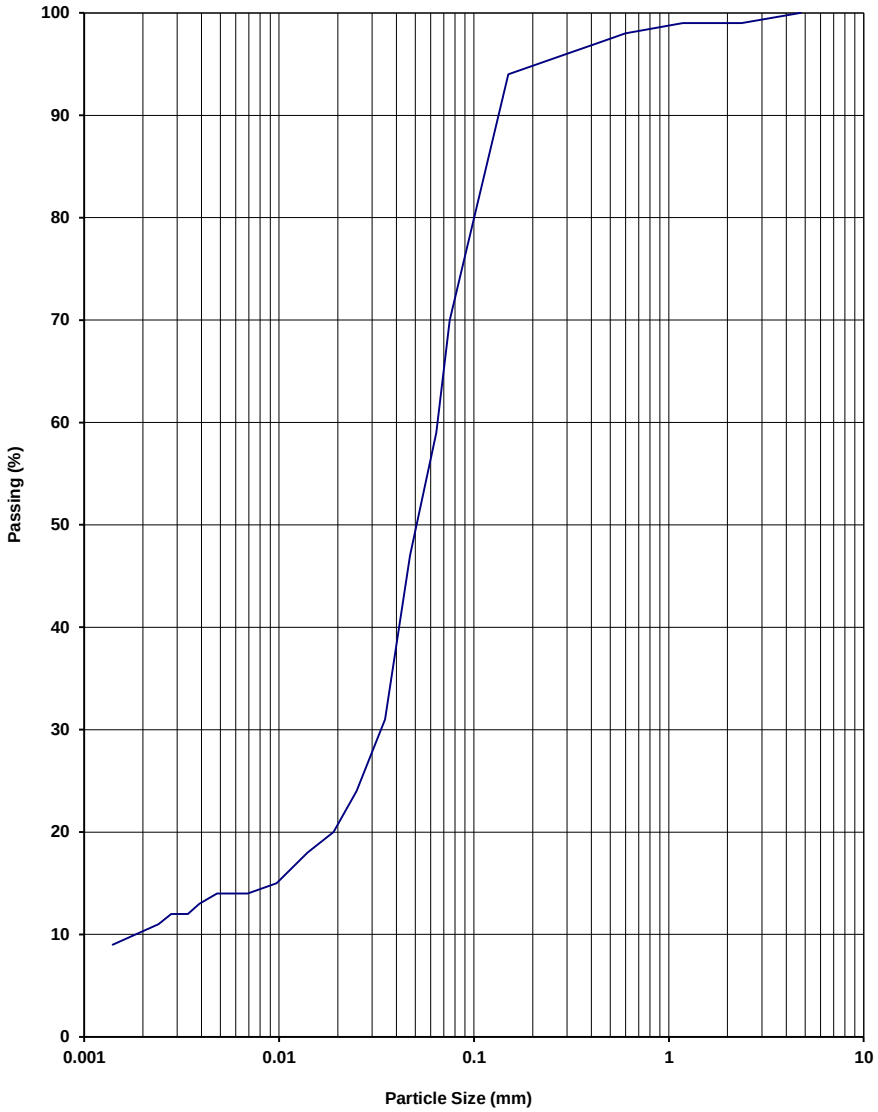
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.3, 3.5.1 & 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080088-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	12/8/16-22/8/16
		Report Date	24/8/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-2 A Horizon E: 376608 N:7204836 Elevation 136	**Depth (m)**	0.50-1.00

Sieve Size (mm)	Passing %
150.0	
75.0	
63.0	
53.0	
37.5	
26.5	
19.0	
13.2	
9.5	
6.7	
4.75	100
2.36	99
1.18	99
0.600	98
0.425	97
0.300	96
0.150	94
0.075	70
0.064	59
0.047	47
0.035	31
0.025	24
0.019	20
0.014	18
0.0097	15
0.0069	14
0.0048	14
0.0039	13
0.0034	12
0.0028	12
0.0024	11
0.0014	9



NOTES/REMARKS: -

Moisture Content 8.9% -2.36mm Soil Particle Density(t/m^3) 2.71

Sample/s supplied by the client

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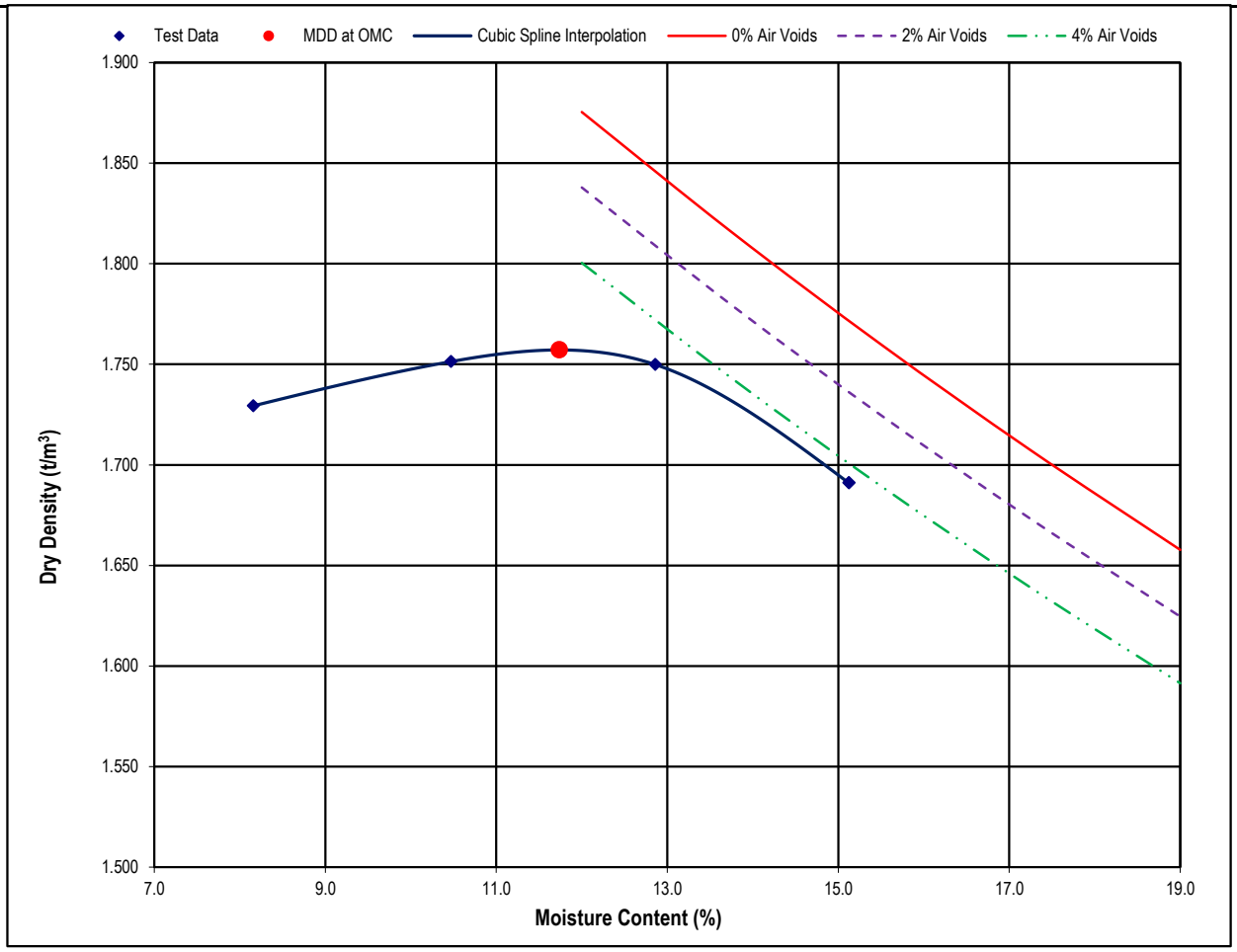
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MOISTURE/DENSITY RELATIONSHIP TEST REPORT

Test Method: AS 1289 5.1.1 & AS 1289.2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16080088-MDD
Address	PO Box 3091, Sunnybank South QLD 4109	**Test Date**	17/08/2016
		Report Date	22/08/2016
Project	MRORGS_2016015		
Client ID	MRORGS003-2 A Horizon E: 376608 N:7204836 Elevation 136	**Depth (m)**	0.50-1.00



Maximum Dry Density (t/m^3)	1.76	**Optimum Moisture Content (%)**	11.7
Moisture Content (%)	8.9	**Percentage of Oversize/Sieve Size (mm)**	0 / 19

NOTES/REMARKS:

Sample/s supplied by the client

% Voids based on assumed SG of 2.42

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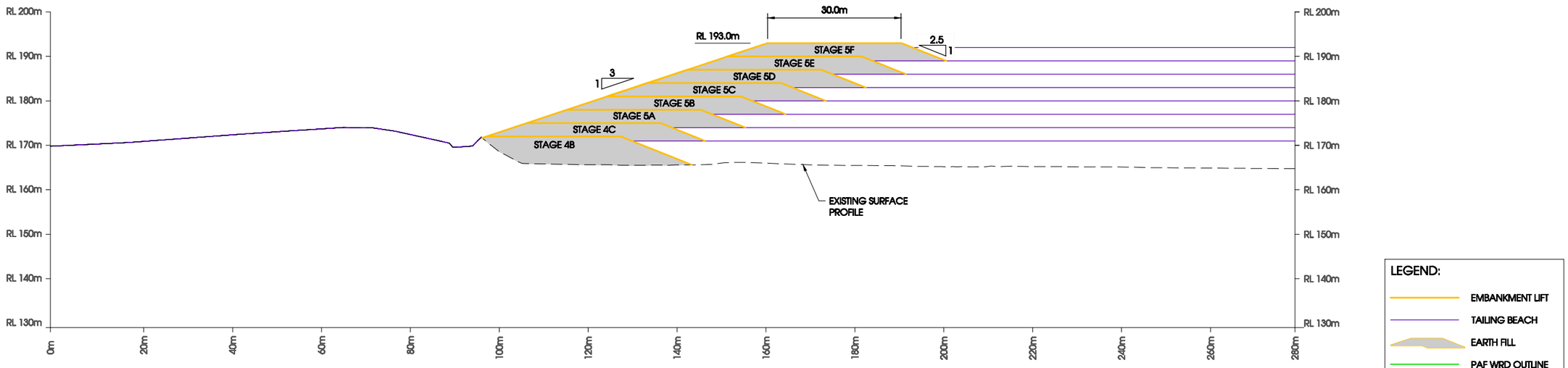
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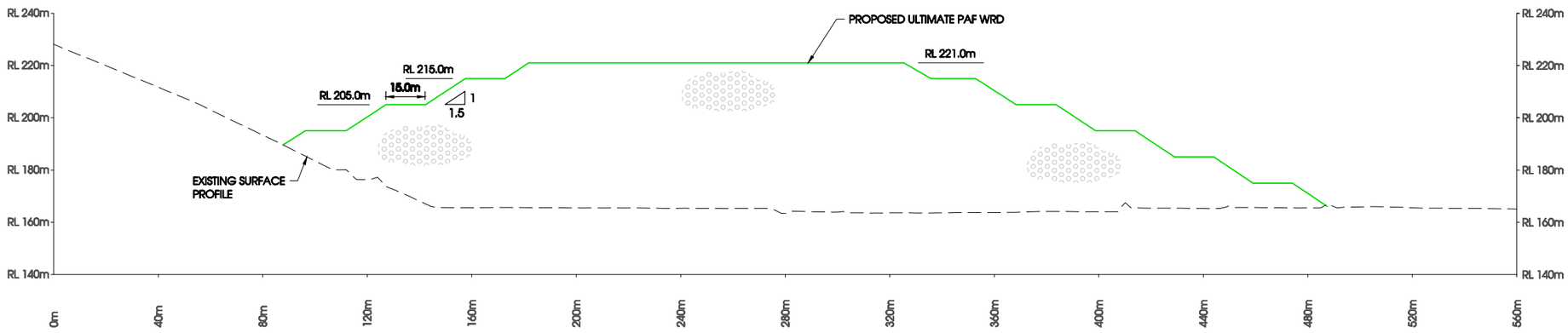
20 Attachment C – MRO Western TSF PAF Cell Design

BASE DATA SUPPLIED BY: EVOLUTION MINING
FILE REF: TOTALSITE201502.STR DATED: FEB. 2015

HORIZONTAL DATUM: AGD84-56
HEIGHT DATUM: AHD



TYPICAL DETAIL C WESTERN EMBANKMENT
SCALE: 1:1000
002 003



TYPICAL DETAIL D PAF WRD
SCALE: 1:2000
002 003

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No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
A	ISSUED FOR REVIEW	15/04/16	SIT	MM	RJH

SCALE:	1:1000
JOB No.	111359.31
DATE	APR. 2016
DESIGN	SIT
DRAWN	SIT
CHECKED	MM
APPROVED	RJH

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EVOLUTION MINING LIMITED
MOUNT RAWDON GOLD MINE

TAILINGS STORAGE FACILITY
LIFE OF MINE DEVELOPMENT
TYPICAL CROSS SECTIONS

005

SHEET SIZE A3 Rev. A

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SHEET 1 OF 1

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Plotted Date: 15/04/16

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BASE DATA SUPPLIED BY: EVOLUTION MINING
FILE REF: TOTALSITE201502.STR DATED: FEB. 2015

HORIZONTAL DATUM: AGD84-56
HEIGHT DATUM: AHD

LEGEND:

- TSF SED DAM 1 CATCHMENT
- CLEANWATER DIVERSION DRAIN
- SEEPAGE COLLECTION TRENCH
- SEEPAGE RECOVERY SUMP
- TSF DRAINS

B 007 SEEPAGE COLLECTION TRENCH

A 007 SEEPAGE RECOVERY SUMP NORTHERN EMBANKMENT

WESTERN CLEAN WATER DIVERSION DRAIN

TSF SED DAM 1 (NEW EMBANKMENT)

EMERGENCY SPILLWAY

TSD SED DAM 1 STORAGE EXTENT

ROCK FILL EXTENT

SWINDON CREEK

EASTERN CLEAN WATER DIVERSION DRAIN

SECONDARY DRAIN

TAILINGS STORAGE FACILITY

FALL

PRIMARY DRAIN

B 007 SEEPAGE COLLECTION TRENCH

WD1

WD2

PAF WRD EXTENTS

PAF DUMP

TSF WESTERN CLEAN WATER DIVERSION DRAIN

SETTLING POND (INDICATIVE)

PLANT SITE

NORTHERN WASTE ROCK DUMP

SOUTH DAM

DISCHARGE CHANNEL (INDICATIVE)

PIT

WD3

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DATE	APR. 2016
DESIGN	SIT
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21 Attachment D – Risk Assessment

Table 21-1: Options Analysis and Risk and Opportunities

Risk Type
Project Specific
Stage Specific
Standard to All Projects

Aspect
Operations
Technical
Health & Safety
Environmental
Government Regulations
Reputation
Legal
Human Resources
Estimated cost
Risk
Relinquishment
Vegetation
Surface Hydrology
Tailings Bearing Capacity
Dewatering
Acid Neutralisation
Borrow Material
Erosion
Fire
Maintenance
Surface Hydrology-Discharge Points
Schedule Impact
Tailings Geochemistry
Tailings physical properties
Economic
Equipment
Regulation/Legislation
Corporate

		3	4	5	6	7	8	9
		Insignificant	Low	Minor	Moderate	Major	Extreme	Catastrophic
9	Almost certain	27	36	45	54	63	72	81
8	Likely	24	32	40	48	56	64	72
7	Probable	21	28	35	42	49	56	63
6	Possible	18	24	30	36	42	48	54
5	Unlikely	15	20	25	30	35	40	45
4	Very unlikely	12	16	20	24	28	32	36
3	Improbable	9	12	15	18	21	24	27

Consequence	
Insignificant	3
Low	4
Minor	5
Moderate	6
Major	7
Severe	8
Extreme	9

Likelihood	
Almost certain	9
Likely	8
Probable	7
Possible	6
Unlikely	5
Very unlikely	4
Improbable	3

	Descriptor	Operations	Technical	Health & Safety	Environmental	Government Regulations	Reputation	Legal	Human Resources	Estimated Cost ($US)
1	**Insignificant**	Easily addressed or rectified	Minimal or no consequence	Heightened Stress levels	No or very low environmental impact. Impact confined to small area	Non-compliance to guidelines	Public concern restricted to local complaints	Minor technical / legal compliance issue, unlikely to attract regulatory response.	Complaint / dissatisfaction amongst the workforce	1 to 10 K
2	**Low**	Minor / superficial damage to equipment. No loss of production	Technical performance compromised but rectifiable	First Aid Injury, Nuisance value	Low environmental impact. Rapid cleanup by site staff and/or contractors. Impact contained to area currently impacted by operations	Non-compliance to regulations	Minor adverse local/public/media attention and complaints	Possible fraud implications. Minor technical / legal compliance issue which may attract regulatory response. Incident requires reporting in routine reports (e.g.. Monthly)	Grievances	10 to 100 K
3	**Minor**	Moderate damage to equipment and / or facility. Loss of < 1 week	Some reduction in technical performance (Cost Δ5-15)	Medical Treatment Injury, Restricted Work Injury	Moderate environmental impact. Cleanup by site staff and/or contractors. Impact confined within lease boundary	Negative tension which may result in relations breakdown	Adverse local attention from media/NGO/public	Breach of regulation with prosecution and penalties. Continuing occurrences of minor breaches. Incident requires immediate (≤ 48 hours) notification	Disputes / marches / organised stay always	100 K to 1 M
4	**Moderate**	Major damage to facility. Loss of production < 6 months	Technical goals compromised. (Cost Δ15-30)	Disabling Injury	Serious but reversible short term impact. Impact may extend beyond the lease boundary.	Breakdown in relations at a local government level	Adverse national media/public attention	Major breach of regulation resulting in investigation by regulator. Severe prosecution, penalties or other action likely.	Strike at one facility	1 to 10 M
5	**Major**	Future operations at site seriously affected. Loss of production > 6 months	Technical goals significantly compromised. (Cost Δ30-50)	Fatality / Permanent Disability	Major environmental impact. Considerable cleanup effort required using site and external resources. Impact may extend beyond the lease boundary	Breakdown in relations with key people in government departments (provincial and central)	Serious negative national criticism. Risk to corporate image.	Serious breach of regulation resulting in investigation by regulator. Operation/licenses may be revoked	Strikes at several facilities	10 to 100 M
6	**Severe**	Future loss of production untenable	Technical goals materially compromised. (Cost Δ >50)	Multiple Fatalities	Severe environmental impact. Local species destruction and likely long recovery period. Extensive cleanup involving external resources. Impact on a regional scale	Breakdown in relations with State/Provincial Premier/Ministers	International and national criticism. High risk to corporate image	Serious breach of regulation resulting in investigation by regulator. Operation/licenses will be revoked	National strike action	100 to 250 M
7	**Extreme**	Total loss of production	Technical goals cannot be achieved	Disaster/ >3 Fatalities	Irreversible impact on a pristine environment	Breakdown in relations with President/Premier/National Minister/s	Prolonged international and national criticism. Loss of corporate image	Serious breach of regulation resulting in significant business interruption. Operation/licenses will be revoked	International strike action	> 250 M

RISK AND OPPORTUNITY REGISTER										
ASSUMED RISK AND OPPORTUNITIES AHEAD OF THE COMPLETION OF THE TECHNICAL STUDIES										
Assumed Risk - Initial risk in the absence of any controls										
Primary Mitigation Option	**Aspect**	**Activity**	**Impact**	**Potential Risk**	**Potential Opportunity**	**Comment**	**Risk Aspect**	**Conseq.**	**Likelihood**	**Risk Level**
Issues related to all options.	Equipment	The correct equipment must be used to construct a cover with tight engineering tolerances e.g. 1 m layers with 50% of material comprising rock with a PSD of > 50 mm and < 200 mm diameter	Inappropriate equipment use results in the as constructed cover system not meeting as designed cover criteria	Cover system required to be re-done or MRO retain perpetual site management			Estimated cost	Extreme	Almost certain	81
Issues related to all options.	Tailings physical properties	Tailings have low bearing capacity in some areas, specifically near decant structures.	Small equipment with low bearing pressure must be used for cover construction	Increase in construction cost compared to current DEHP calculation of FA for TSF due to smaller equipment and increased level of engineering control	Review past CPTU testing and undertake testing to establish zones of low bearing capacity.	Difference in cost between current FA for TSF and potential actual cost for fully engineered cover that will attain relinquishment	Estimated cost	Extreme	Almost certain	81
Issues related to all options.	Economic	Tailings do not have sufficient bearing capacity for heavy construction equipment	Small plant and equipment required to be used	Additional construction cost compared to current FA estimate	Requirement for first principles cost estimate		Estimated cost	Extreme	Almost certain	81
Option 7: Engineered soil cover system	Economic	Engineered cover requires capillary break	Current cost per ha for TSF is $85k	Actual cost to construct engineered soil cover with capillary break likely to be significantly higher than $85k/ha- may be order of magnitude higher.			Estimated cost	Extreme	Almost certain	81
Issues related to all options.	Equipment	Large equipment with 80psi bearing pressure used to haul and place soil cover	Bearing pressure greater than tailings strength	Slumping and failure of tailings profile	Install a NAF rock layer using low ground bearing pressure equipment to improve bearing capacity.	Placement of rock would include dozing and spreading.	Technical	Severe	Almost certain	72
Issues related to all options.	Tailings Bearing Capacity	Loading of tailings with waste rock	Bearing pressure of tailings exceeded	Slumping and failure of tailings profile	Reduced and controlled rate of loading is required to limit potential of tailings deformation e.g. note movement in Western TSF Cell		Technical	Extreme	Likely	72
Option 1: Do nothing	Corporate	No action taken on TSF	Rehabilitation targets not met	May not comply with Corporate requirements			Reputation	Severe	Almost certain	72
Option 1: Do nothing	Economic	No action taken on TSF	Perpetual management required	No relinquishment or transfer of TSF due to no implementation of rehabilitation			Reputation	Severe	Almost certain	72
Option 2: Reprocess tailings	Economic	No economic grades of metals	Tailings have no economic value and TSF requires CDaR	DEHP might require an engineered soil cover system with double capillary break		No current viable grades for reprocessing.	Estimated cost	Severe	Almost certain	72
Option 5: Cover with NAF rock	Regulation/Legislation	NAF rock cover used on tailings as preferred cover option	DEHP rejects this option, and require more justification or trials to show potential outcomes.	DEHP might require an engineered soil cover system with double capillary break	Use of field trials and laboratory KLC testing may provide some data to support this.	Blending of NAF waste rock and soils to create a cover.	Estimated cost	Severe	Almost certain	72
Option 7: Engineered soil cover system	Equipment	Engineered cover requires high degree of QA/QC on all aspects of construction and design	Substantial increase in construction of cover system.	Requirement for engineered soil cover may increase FA.			Financial	Severe	Almost certain	72

Assumed Risk - Initial risk in the absence of any controls										
Primary Mitigation Option	**Aspect**	**Activity**	**Impact**	**Potential Risk**	**Potential Opportunity**	**Comment**	**Risk Aspect**	**Conseq.**	**Likelihood**	**Risk Level**
Issues related to all options.	Economic	Cost of construction for budgeting	Highly variable and dependent on design criteria and specification of construction and contractor rates and degree of post placement QA/QC	Uncertainty related to cover construction costs.	Refine cover system design and develop a final tailings surface model based on what can be achieved with beach slopes. Model cover system on tailings and improve on the estimates.	Unit rates to win, haul and place material within a designed cover system could be in the order of $20-25 / BCM- based on actual costs provided by a TSF construction manager for winning, hauling and placing material on internal areins in	Estimated cost	Severe	Likely	64
Issues related to all options.	Economic	Cost of construction	Contractors may underestimate degree of engineering control required to construct the cover	Uncertainty relating to cover construction costs, as contractors do not fully appreciate degree of engineering and quality control required to construct an engineered cover	Develop cover construction information and include in tender documents.	Construction of a complex soil cover requires a high degree of engineering control, and quality control to ensure material is placed according to design specification	Estimated cost	Major	Almost certain	63
Option 2: Reprocess tailings	Relinquishment	All tailings is used for beneficial reuse	TSF is removed from site infrastructure	Requires rehabilitation of TSF catchment after TSF removed	TSF removed from ML		Estimated cost	Major	Almost certain	63
Option 3: Direct vegetation of tailings	Borrow Material	No soil cover proposed	No borrow material required	DEHP might require an engineered soil cover system.	No disturbance of 50 to 70 ha of Borrow Area	Significant environment benefit if no borrow area developed	Estimated cost	Major	Almost certain	63
Option 7: Engineered soil cover system	Surface Hydrology-Discharge Points	Capillary breaks / drainage layers are permeable gravel that contain water	Water from drainage layer must be able to drain out to perimeter drain.	Drainage layer with external connectivity to perimeter drain will provide direct conduit for air to make contact with tailings.			Technical	Major	Almost certain	63
Option 7: Engineered soil cover system	Surface Hydrology-Discharge Points	Water from drainage layer must be able to drain out to perimeter drain.	Drainage layer with external connectivity to perimeter drain will provide direct conduit for air to make contact with tailings.	Air dries out tailings and increase oxidation rate of sulfide bearing tailings increasing AMD risk.			Technical	Extreme	Probable	63
Issues related to all options.	Regulation/Legislation	Final TSF elevation increases from 193 to 199 m ASL with addition of soil cover to create free draining landform	Additional height exceeds TSF design constraints	Changes to embankment or cover depth required	Assess if additional height and cover system would exceed TSF design constraints.		Estimated cost	Major	Likely	56
Issues related to all options.	Groundwater-Economic	Groundwater leakage from tailings facility to groundwater ongoing	Impact to meeting closure criteria or closure period	Ongoing pumping required to contain tailings impacted water	Update water system assessment of tailings domain - current & at closure.		Estimated cost	Major	Likely	56
Issues related to all options.	Equipment	Large equipment with 80 psi bearing pressure used to haul and place soil cover	Bearing pressure over compacts soil cover reducing store and release function of the cover	Cover system required to be re-done or MRO retain perpetual site management		Implementation of additional monitoring of constructed surfaces during construction.	Legal	Moderate	Almost certain	54
Issues related to all options.	Borrow Material	Development of borrow areas for soil, clay and rock for soil cover creates large area requiring rehabilitation	Loss of land use	Disturbance and rehabilitation of borrow areas may pose an unacceptable environment risk. The borrow area will remove 60 ha of cleared grazing land.	Reshaping of landscape to improve drainage and development of grazing land.	Talk to stakeholders early to ensure CDaR plan is accepted. Allow adequate time for this to occur.	Estimated cost	Moderate	Almost certain	54
Issues related to all options.	Surface Hydrology-Discharge Points	Concept CDaR Plan is to use final void to contain mine impacted water from TSF	Requires discussion with stakeholders to see if there is general agreement in the concept	A water quantity / quality final void hydro-geochemical model of the pit is required to inform stakeholder discussion		Commission integrated hydro-geochemical model of the site inclusive of TSF, WRDs and Final Void	Estimated cost	Moderate	Almost certain	54

Assumed Risk - Initial risk in the absence of any controls										
Primary Mitigation Option	**Aspect**	**Activity**	**Impact**	**Potential Risk**	**Potential Opportunity**	**Comment**	**Risk Aspect**	**Conseq.**	**Likelihood**	**Risk Level**
Issues related to all options.	Tailings Geochemistry	TSF has PAF zones	Acid will be neutralised but saline drainage may persist. Salts likely to be from sulfate from sulfide oxidation.	Saline drainage cannot be readily managed and may require changes to EC release criteria and flow weighted release conditions			Regulation	Moderate	Almost certain	54
Issues related to all options.	Relinquishment	TSF retains storage capacity after rehabilitation	Retention of TSF embankment as a closure design requires detailed geotechnical evaluation	Safety factor for TSF embankment may not be sufficient for closure requirements			Estimated cost	Extreme	Possible	54
Issues related to all options.	Dewatering	Dewatering of the tailings slimes may take 2 to 3 years or longer than higher beach areas	Longer periods of dewatering may affect construction program	Uncertainty related to final dewatering program must be verified			Technical	Moderate	Almost certain	54
Issues related to all options.	Relinquishment	Unplanned consolidation of tailings occurs during placement of waste rock or cover	Integrity and functionality of cover is compromised	Design objectives cannot be met			Technical	Extreme	Possible	54
Issues related to all options.	Regulation/Legislation	Residual risk legislation enacted in Qld	Potential for increased FA beyond current estimates	Changes in project FA lead to force majeure	Regular review of legislation changes, and discuss interpretation with regulator		Estimated cost	Extreme	Possible	54
Option 1: Do nothing	Regulation/Legislation	No action taken on TSF	Environmental degradation may increase over time	Increased potential for non-compliance and fines associated with the TSF		Loss of license to operate and damage to reputation leading to share price decline	Reputation	Moderate	Almost certain	54
Option 2: Reprocess tailings	Relinquishment	TSF removed from ML through relinquishment	TSF is removed from site infrastructure and domain relinquished reducing FA	WRDs and Open Pit remain as residual risks	Reduction in financial assurance costs.		Estimated cost	Moderate	Almost certain	54
Issues related to all options.	Economic	Capillary break system required by regulator	NAF waste rock would need to be sourced, crushed and screened	Capillary material has economic impact	NAF waste rock can be used for this purpose	Need to determine if graded capillary is required, through PFS studies.	Estimated cost	Major	Probable	49
Issues related to all options.	Schedule Impact	Tailings dewatering required over at least 3 years	Probability of large rainfall event during dewatering phase of TSF increases	Construct the NAF rock/Tailings layer to assist in dewatering of the tailings.			Estimated cost	Major	Probable	49
Issues related to all options.	Borrow Material	Capillary break system may be required	NAF waste rock would need to be sourced, crushed and screened	Provide details to regulators that low rate of reactivity of the tailings is inferred to not require a capillary break.	The low rate of reactivity of the tailings is inferred to not require a capillary break		Estimated cost	Major	Probable	49
Issues related to all options.	Tailings Bearing Capacity	DSA in TSF must be maintained and rehabilitation work must be completed in 12 month period.	To meet TSF 12 month DSA constraints physical stabilisation of tailings required e.g. use of geo-grids or geo-fabric	Apply for EA amendment. Obtain approval to use South Dam and/or Pit for DSA storage.		Talk to stakeholders early to ensure CDaR plan is accepted. Allow adequate time for this to occur.	Estimated cost	Severe	Possible	48
Issues related to all options.	Corporate	SLTO aspects are becoming increasingly problematic	MRO must engage with stakeholders from the concept stage of the CDaR Plan through to completion of the construction and through to engagement with local landowners during the post rehabilitation monitoring program	Requires active input and engagement from MRO and Evolution			Estimated cost	Moderate	Likely	48
Issues related to all options.	Tailings Geochemistry	Last years of mining change quality of ore feed as less carbonate is mined	Tailings become PAF instead of NAF	Additional effort required to manage TSF through addition of ANC	Utilise geology model and waste rock model to quantify future ore feed quality and potential tailings chemistry		Estimated cost	Moderate	Likely	48
Issues related to all options.	Tailings Geochemistry	Tailings are NAF with low reactivity, and NPR of 1 to 2. High PAF waste rock is added to the TSF for the decant structure and Moderate PAF waste rock is to be placed into the Western TSF Cell	High PAF and Moderate PAF waste rock to TSF may change overall static classification of NAF TSF	NAF TSF may become or be considered as a PAF TSF requiring increased level of engineering to the TSF cover	Utilise AC waste rock at site for additional ANC in waste rock and tailings to retain NAF classification		Technical	Severe	Possible	48
Issues related to all options.	Surface Hydrology-Discharge Points	Concept CDaR Plan is to use final void to contain mine impacted water from TSF	Requires discussion with stakeholders and reliable data from a numerical model on how water quantity and quality in the final void will change over time	Time to reach agreement on concept CDaR Plan may increase planning schedule for completion of PFS	Talk to stakeholders early to ensure CDaR plan is accepted. Allow adequate time for this to occur.	Talk to stakeholders early to ensure CDaR plan is accepted. Allow adequate time for this to occur.	Estimated cost	Minor	Almost certain	45

Assumed Risk - Initial risk in the absence of any controls										
Primary Mitigation Option	**Aspect**	**Activity**	**Impact**	**Potential Risk**	**Potential Opportunity**	**Comment**	**Risk Aspect**	**Conseq.**	**Likelihood**	**Risk Level**
Issues related to all options.	Borrow Material	Development of borrow areas for rehabilitation increases disturbed land	Cover extent may be 40-60 ha	Potentially large borrow area required			Environmental	Minor	Almost certain	45
Issues related to all options.	Relinquishment	Cover design proposed does not include graded capillary break	Capillary break system may be a mandatory requirement of regulator	Substantial discussion and modelling in PFS to prove the concepts			Estimated cost	Minor	Almost certain	45
Issues related to all options.	Borrow Material	Development of borrow areas for soil, clay and rock for soil cover creates large area requiring rehabilitation	Loss of sediment from borrow area could be substantial	Impacts from sediment loss require ongoing maintenance		Talk to stakeholders	Estimated cost	Minor	Almost certain	45
Issues related to all options.	Borrow Material	Borrow materials have moderate to high exchangeable sodium	Soil and clay from borrow areas likely to have strong sodic potential	Sodic soil needs to be amended with exchangeable Ca and Mg	Amend with exchangeable Ca and Mg - this may be able to be sourced from crusher dust from crushing NAF rock if capillary break is required in soil cover system		Estimated cost	Minor	Almost certain	45
Option 5: Cover with NAF rock	Regulation/Legislation	Use of NAF rock cover on tailings	MRO need to do PFS work to demonstrate this is a viable outcome	Outcome of PFS required ASAP to inform options analysis to include / exclude it as a viable option.			Estimated cost	Minor	Almost certain	45
Option 6: Analogue soil cover	Regulation/Legislation	DEHP oppose analogue store and release soil cover - on principal	MRO need to do PFS work to demonstrate this is a viable outcome	Outcome of PFS required ASAP to inform options analysis to include / exclude it as a viable option.			Estimated cost	Minor	Almost certain	45
Issues related to all options.	Relinquishment	MRO require relinquishment of the mine lease	Some domains may not be able to be relinquished	Site remains under perpetual management by Evolution			Reputation	Major	Possible	42
Issues related to all options.	Tailings Geochemistry	Cyanide is present in tailings supernatant pond and tailings porewater as free, WAD and SAD species	Cyanide is present in tailings supernatant pond and tailings porewater as free, WAD and SAD species	Leaching of cyanide species to groundwater causes environment harm in the receiving environment	Investigate hydrogen peroxide dosing to reduce the risk of cyanide.	Under preferred cover option impacted water form TSf is pumped to open pit at end of mine life	Environmental	Major	Possible	42
Issues related to all options.	Surface Hydrology-Discharge Points	Consolidation of tailings occur after cover is constructed	Cover landform design / geomorphology changes	Surface drainage design may be compromised	Construct to account for settlement in TSF		Technical	Severe	Unlikely	40
Option 3: Direct vegetation of tailings	Fire	Fire damages / destroys vegetation	Tailings are no longer covered / contained	Tailings could be blown from TSF to receiving environment	Use of native species with lower burn temperatures. Use of soil NAF rock mixture on surface layer to reduce the potential of erosion.		Regulation	Severe	Unlikely	40
Issues related to all options.	Tailings Geochemistry	Fresh tailings have low to moderate EC and sulfate from the tailings exceeds environmental release criteria	Saline water may not be fit for environmental release, and water is assumed to be directed to the final open pit.	Perpetual water storage in the pit results in overtopping of open pit the receiving environment	Model a final closure scenario and assess the potential pit long term water level.		Environmental	Extreme	Very unlikely	36
Issues related to all options.	Relinquishment	No agreed land use with end land owner	Inability to specify vegetation species and required cover criteria	If constructed end land use does not meet end land owner requirements transfer of land may not be achieved.	Use of native species with lower burn temperatures. Use of soil NAF rock mixture on surface layer to reduce the potential of erosion.		Legal	Moderate	Possible	36
Issues related to all options.	Equipment	Large equipment with 80psi bearing pressure used to haul and place soil cover	Equipment sinks in soft tailings	Loss of equipment in soft tailings / fatality	Review past CPTU testing and undertake testing to establish zones of low bearing capacity.		Health & Safety	Extreme	Very unlikely	36
Issues related to all options.	Surface Hydrology-Discharge Points	'Internal drains fail or are eroded through high velocity/abrasive flow.	Erosion of soil cover	Ongoing moderate level of maintenance			Estimated cost	Moderate	Possible	36
Option 1: Do nothing	Surface Hydrology-Discharge Points	TSF retains current storage capacity with spillway	Large rainfall event results in failure of embankment and release of contaminated water or PAF tailings to environment	Embankment failure and tailings water / tailings flow into receiving environment. Ongoing storage of water in TSF leads to ongoing leakage into subsurface. Degradation of water quality of water storage in TSF.			Estimated cost	Extreme	Very unlikely	36

Assumed Risk - Initial risk in the absence of any controls										
Primary Mitigation Option	**Aspect**	**Activity**	**Impact**	**Potential Risk**	**Potential Opportunity**	**Comment**	**Risk Aspect**	**Conseq.**	**Likelihood**	**Risk Level**
Option 2: Reprocess tailings	Maintenance	An alternative use for tailings e.g. component in bricks is considered requiring remining of TSF	Remining of TSF affects structural integrity of TSF	Removal of tailings may increase risk to geotechnical integrity of TSF			Technical	Moderate	Possible	36
Issues related to all options.	Borrow Material	Sourcing borrow material for soil cover	Up to 60 ha of land may be disturbed to obtain soil materials for cover	Large area of land with poor vegetation cover			Environmental	Minor	Probable	35
Issues related to all options.	Acid Neutralisation	NAF waste rock used for TSF rehabilitation	NAF waste rock should contain < 1% TS	NAF rock may produce neutral / saline drainage	Use waste rock block model to identify and store NAF waste rock with ANC:MPA ratio > 2 and < 1% TS		Environmental	Minor	Probable	35
Option 4: Cover with HDPE and rock and use for hydro-solar power supply	Corporate	Consideration of this CDaR outcome requires major change in planning	Requires preliminary discussion with DEHP. Requires corporate and site to undertake scoping report into viability of the closure approach.	Outcome of scoping study on power viability required ASAP to inform options analysis to include / exclude it as a viable option.	Could provide a very real ability to transfer ownership.		Estimated cost	Minor	Probable	35
Issues related to all options.	Economic	Dewatering of TSF required during final LoM while pit is operating	Supernatant cannot be stored or used in process circuit	Saline water from TSF requires desalination water treatment using mobile package plant to allow release of excess water to environment during dewatering if water cannot go the operating pit	Pit could be used to contain surface runoff and seepage from TSF after mining ceases	May need to consider fast mining and storing LGO and Ore to obtain access to the pit for TSF dewatering	Estimated cost	Minor	Possible	30
Issues related to all options.	Surface Hydrology-Discharge Points	TSF elevation goes from 193 to 199 m ASL with addition of soil cover to create free draining landform	Change to EA	DEHP may not agree to amendment requiring review of concept CDaR Plan			Estimated cost	Minor	Possible	30
Issues related to all options.	Tailings physical properties	Consolidation of cover tailings will occur during placement of cover system	Geomorphology of the cover will change as the cover and underlying material consolidates	Designed drainage within TSF cover system fails requiring maintenance			Estimated cost	Moderate	Unlikely	30

	Aspect / risk																							
	Stakeholder Consultation	Change required to current tailings deposition and embankment design	Dam Saefty Requirements	Relinquishmnet	Cover complexity	Cover sequencing	Settlement	Dewatering of wet tailings	Equipment practicality	Acid Water in TSF	Saline Water in TSF	TSF Seepage Acid	TSF Seepage Salinity	Erosion from TSF	Surface flow	Groundwater	Fire	Borrow Area Land Disturbance	Borrow Area Erosion	Cover Material Balance	Material Balance Unit Cover Cost	Cover Cost	Regulation	Total Score
Weighting	1	5	5	2	1	2	3	1	2	5	3	5	3	5	2	2	1	2	3	3	4	5	2	
Option 3-Direct vegetation / rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	
Option 4-NAF rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	0	
Option 5-HPDE power generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4
Option 6-Analogue soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-1
Option 7-Engineered soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5
Score																								
Option 3-Direct vegetation / rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	25
Option 4-NAF rock cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-10	0	-10
Option 5-HPDE power generation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	20
Option 6-Analogue soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5	0	-5
Option 7-Engineered soil cover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-25	0	-25

Ranking	
5	Most favourable
4	
3	
2	
1	
-1	
-2	
-3	
-4	
-5	Least favourable

Score	
25	Most favourable
10	
0	
-10	
-25	Least favourable

PROMPTS - Actions to be addressed

Stakeholder consultation
Landowners
DEHP

Schedule
A construction schedule is required to be developed and should consider aspects such as:
- stakeholder consultation
- develop detailed enginerrign designs to alter TSF embankment if surface runoff is to report over the northern area of the existing embankment
- time to clear vegetation on TSF - requirement of low ground bearing pressure equipment
- time to grid sample TSF for pH and DCP testing after clearnace of vegetation
- time to add lime - requirement of low ground bearing pressure equipment
- time to place cover - requirement of low ground bearing pressure equipment
- time to dewater wet tailings - requirement of low ground bearing pressure equipment

Surface hydrology (ATC)
Will the TSF embankment need to be altered (re-aligned) to provide sufficent room for a drain between the TSF and railway line- if so what is required
What is the schedule impact of this

Hydrogeology (RGS/SBE)
What direction is groundwater flow outside of the TSF
Would development of the borrow areas affect the groundwater levels outside the TSF
Is the TSF connected hydraulically to the groundwater outside the TSF
Does seepage from the TSF report to the groundwater or vice versa
Where should piezometers outside of the TSF be installed for longer term performance monitoring
What is the likely scope required to quantify hydrogeology

Regulation
What level of detail do DEHP require for a Certified Decommissioning and Rehabilitation Plan, how does this differ from the RGS/ATC deliverable
Is DSA required to be met after placement of a cover
Is a geotechnical evaluation required of the TSF
Would changes to the TSF embankment be required to ensure it meets closure criteria
What additional DCP testing is required to apply a risk/hazard rating to the surface strength of the tailings e.g. grid based DCP testing over the TSF
ATC to provide a work program to undertake the above tasks
Who is required to supervise construction of the cover, what is this likely to entail
What documentation is required to ensure the cover is constructed as per design specifiaction

TSF Seepage
Site assessment required by RGS/ATC/SBE
Water quality samples and flow required to be monitored: may requires excavation of a small sump in the vicinity of the embankment toe
Downstream piezometers to monitor groundwater level and quality below seepage areas required.

Sensitivity Analysis of Construction Cost
Contractors providing quotes must be made aware of all aspects related to the cover construction e.g. clearance of vegetation, application of lime, strict control on placement of waste, QA/QC to verify material is placed as specified and strict survey control, soft tailings

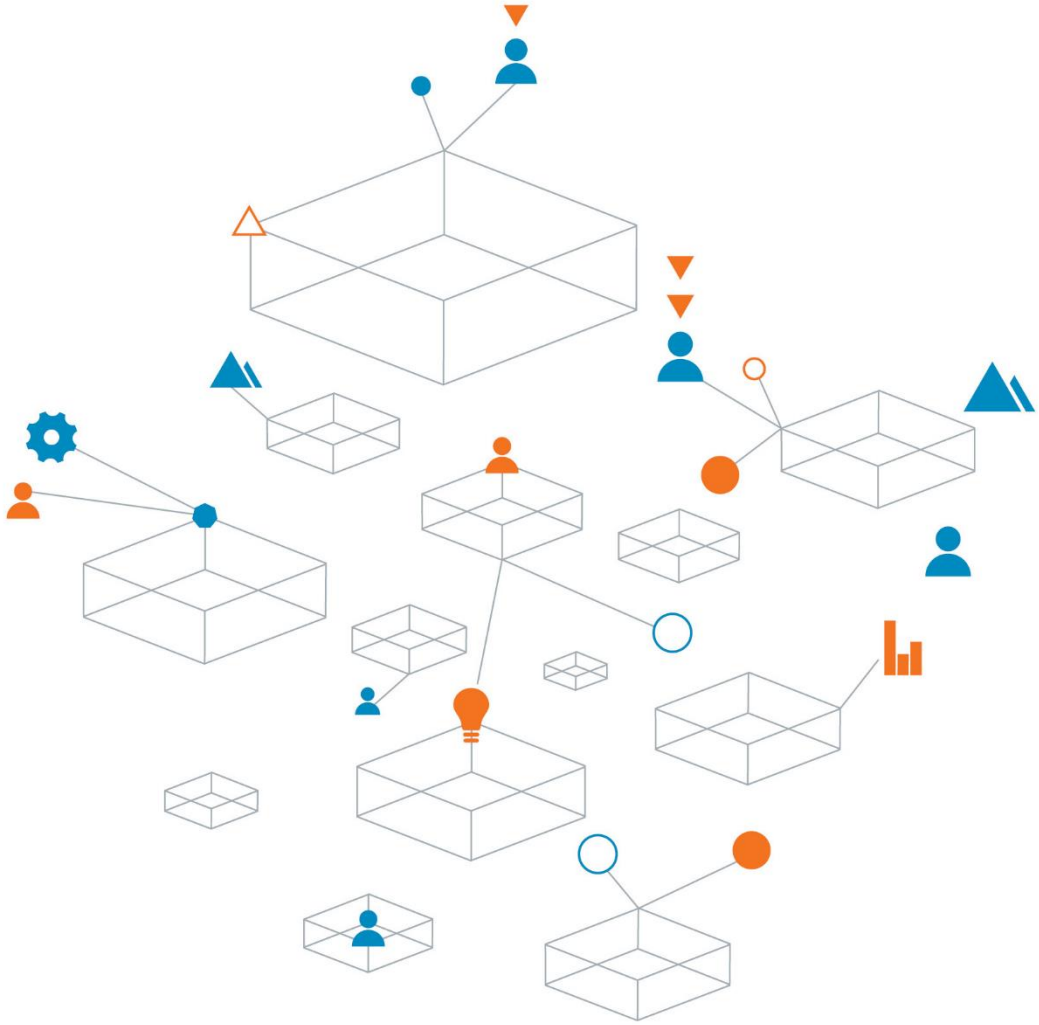


LEADERS IN MINING
GEOCHEMISTRY

Evolution Mining
Mt Rawdon Gold Operations
Community Consultation Plan 2020

754-MELEN279449_1_v2

10 December 2020



Trust is the cornerstone of all our projects

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Mt Rawdon Gold Operations - Community Consultation Plan 2020

Prepared for
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Quality information

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Attachments

Attachment A – Community consultation register

1. Introduction

Coffey Services Australia Pty Ltd (Coffey) has been engaged by Evolution Mining Limited (Evolution Mining) to prepare a community consultation plan for Mt Rawdon Gold Operations. This community consultation plan will form part of the progressive rehabilitation and closure plan (PRC plan) required under the *Environmental Protection Act 1994* (Qld). A draft PRC plan is currently being prepared for the Mt Rawdon Mine in accordance with the act and the Queensland Department of Environment and Science Guideline – Progressive Rehabilitation and Closure Plans (DES, 2019).

Mt Rawdon Mine is an existing open pit gold mine located near the township of Mount Perry in the North Burnett Regional Council area. The mine is situated on nine mining leases: ML1192, ML1203, ML1204, ML1206, ML1210, ML1231, ML1259, ML50119 and ML100059. Onsite facilities include a single open pit, processing plant, overburden and waste rock dumps (WRD), tailings storage facility (TSF), water management dams, and associated supporting infrastructure.

The Mt Rawdon Mine has been in operation since 2001 and Evolution Mining have owned and operated the mine since November 2011. The current mine life is estimated to be a further eight years, with pit mining to be completed by 2023 and processing operations completed by the end of 2028, followed by rehabilitation and mine closure.

The key objectives of this community consultation plan are to:

- Describe key stakeholders for mine closure.
- Summarise stakeholder consultation during the mine closure engagement process to date.
- Provide an overview of the closure engagement approach.
- Provide an informative program outlining stakeholder engagement activities to be undertaken during closure planning.
- Describe the mechanisms to be implemented to ensure that all stakeholder inputs are recorded, considered and addressed, including a grievance and commitment management process.

1.1. Rehabilitation and closure overview

Prior to the commencement of mining at the Mt Rawdon Mine, the primary land use was cattle grazing on native and improved pastures (Nitro Solutions, 2020). Surrounding properties, including the underlying Swindon Station lot, were extensively grazed by sheep and cattle from the 1850s and 1880s.

Following the cessation of mining activities, the mine area is proposed to be returned to grazing land, and where possible, open woodland to restore native ecosystems. Six domains and potential post-mining land uses, presented in Table 1.1 and Figure 1.1, have been identified by Evolution Mining.

Table 1.1 Proposed post-mining land uses for Mt Rawdon domains

Domain	Current domain use	Proposed post-mining land use
Residual pit	Single, open cut pit with a total surface area of approximately 70 ha.	Water storage facility.
Overburden and waste dumps (Northern WRD, Western WRD, run-of-mine and stockpiles)	The Northern WRD is used for the storage of both non-acid forming and potential acid forming material. The WRD covers an area of approximately 105 ha and is predicted to remain in active use until February 2023. The Western WRD is used for the storage of non-acid forming material and has a current disturbance footprint of approximately 37 ha.	Open woodland. Low-intensity grazing.

Domain	Current domain use	Proposed post-mining land use
	However, the NAF material will be used for rehabilitation of other domains.	
TSF	The TSF covers an area of approximately 165.5 ha and is predicted to remain in active use until 2027. A second TSF is proposed, however, has not been approved.	Open woodland. Low-intensity grazing.
Roads and access tracks	Haul roads, access roads and tracks and powerline corridors cover a total area of approximately 25.7 ha across the project area.	Open woodland. Low-intensity grazing.
Infrastructure management areas, including workshops	Approximately 17.9 ha of land across the project area is allocated to infrastructure management areas and workshops. Most of the site infrastructure is centralised to operations.	Open woodland.
Water management areas	Water management dams (excluding Perry River Dam) cover approximately 28.8 ha of the project area.	Stock water storage. Low-intensity grazing.

Source: Nitro Solutions, 2020.

1.2. Legislative context and guidelines

The primary piece of legislation relevant to the development of this community consultation plan is the *Environmental Protection Act 1994* (Qld). Specifically, Section 126C which outlines the requirements for PRC plans, including:

- Details of the consultation undertaken by the applicant in developing the proposed PRC plan.
- Details of how the applicant will undertake ongoing consultation in relation to the rehabilitation to be carried out under the plan.

The following guidelines and advisory documents are also relevant to this community consultation plan:

- Progressive Rehabilitation and Closure Plans (PRC plans) Guideline (DES, 2019). This guideline outlines the considerations for developing a PRC plan in accordance with the Environmental Protection Act. In particular, the guideline outlines the requirements of community consultation for inclusion in the PRC plan.
- Public participation concepts developed by the International Association for Public Participation (IAP2, 2018).
- AA1000 Stakeholder Engagement Standard 2015 (AccountAbility, 2015). This standard outlines a framework for the assessment, design, implementation and communication of quality stakeholder engagement.
- International Council on Mining and Metals Closure Maturity Framework (ICMM, 2020). This document provides a framework for determining how stakeholder engagement should evolve as mine closure planning progresses, in particular closure maturity levels three and four.
- International Council on Mining and Metals Integrated Mine Closure: good practice guide (ICMM, 2019). This document provides guidance with the intent of promoting a disciplined approach to integrated closure planning, including engagement with stakeholders for closure plan development.

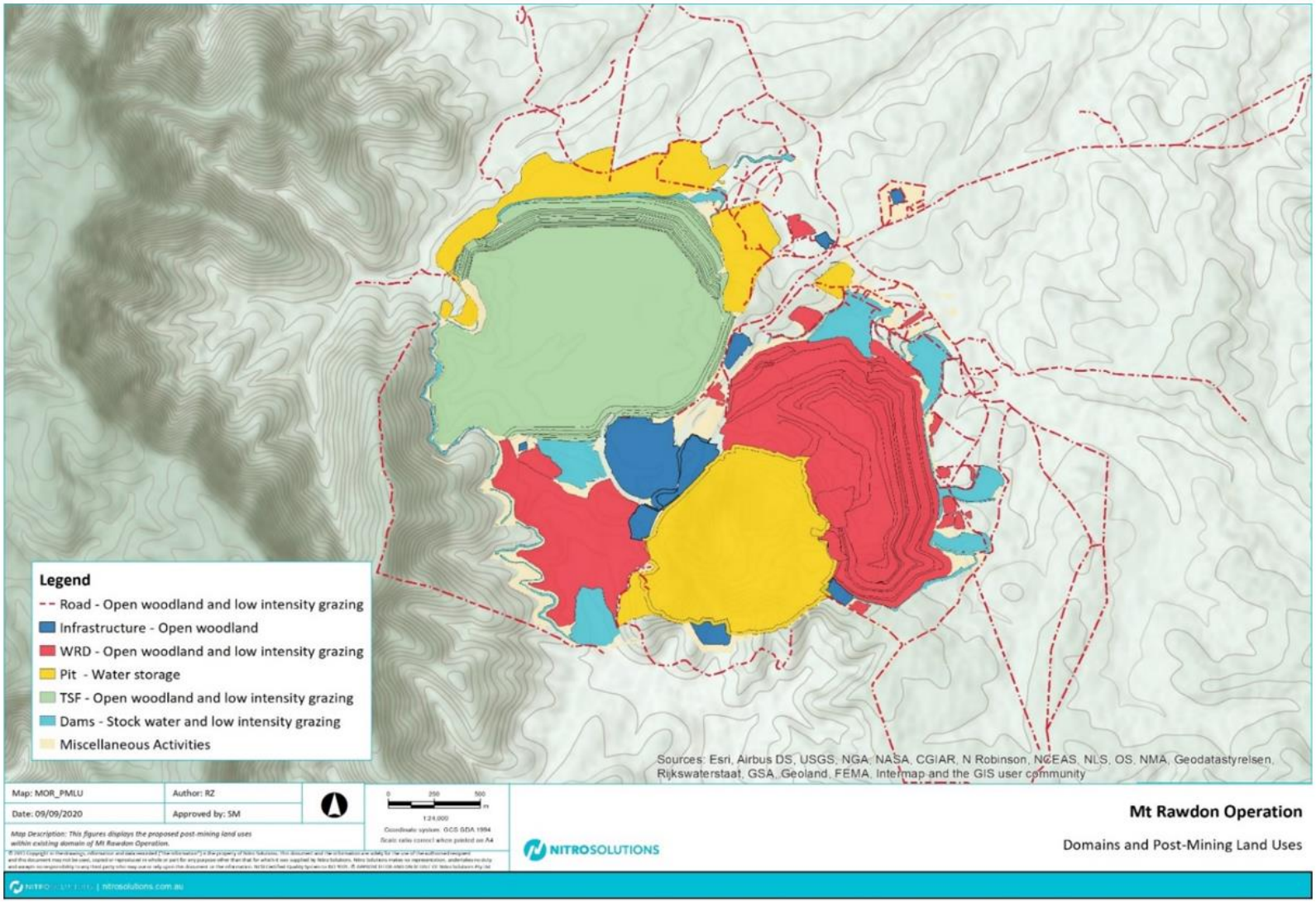


Figure 1.1 Mt Rawdon Operations domains and post-mining land uses

1.3. Evolution Mining policies and standards

Evolution Mining's Community Relations Policy provides a commitment to working with communities to achieve their future aspirations through:

- Identifying opportunities for partnerships that create shared value, both for Evolution and the community stakeholders.
- Investing in community development projects that will continue to benefit the community long beyond the life of the mine, including projects that deliver long-term outcomes that are aimed at supporting communities to be resilient, to thrive and to be sustainable long-term.
- Sharing the economic benefit with local communities where possible by maximising local procurement and local employment and training opportunities, particularly for local Indigenous communities.

Additionally, Evolution Mining's Social Responsibility Performance Standards outline the minimum requirements to manage issues associated with the project, and to identify opportunities for both Evolution Mining and the community. In particular, the Stakeholder Engagement Standard defines the minimum requirements for engaging with stakeholders and community groups.

1.4. Closure stakeholder engagement objectives

The objectives of the stakeholder engagement approach adopted as part of this community consultation plan are to:

- Ensure affected stakeholders and interested parties are informed of and given opportunities to be further involved in mine closure planning.
- Encourage participation and input to the mine closure process, so that local expectations, knowledge and priorities can inform the outcomes stated in the PRC plan.
- Ensure that timely, consistent and open engagement with stakeholders occurs throughout the mine closure process.

1.5. Community consultation plan

This plan is designed to be a working document to guide stakeholder engagement as the project progresses through the mine closure process. The plan should be reviewed and revised (as necessary) on an annual basis to capture any updates as mine closure planning is further developed. Additional amendments to the plan may also be required in response to a grievance or complaint.

It will be the responsibility of the Mt Rawdon Sustainability Manager and the Environment and Community Relations Superintendent to ensure this plan, including the community consultation register, is maintained and the information is kept up to date.

2. Stakeholder environment

Stakeholders are groups or individuals that have an interest in the project, may be affected in some way by the project, or can potentially influence (or be influenced by) closure of the mine.

The following section provides a description of the different stakeholder groups relevant to mine closure, their interests and previous engagement events.

2.1. Stakeholder groups

A number of primary and secondary stakeholders relevant to the project were identified through the development of the social impact assessment (SIA) (Coffey, 2020). Primary stakeholders include people who are directly affected by the project, such as individuals with land or businesses within the immediate surrounding areas that are likely to be impacted by mine closure. Secondary stakeholders include people who are indirectly affected by the project, such as members of state Parliament, local government councillors, representative bodies, service providers and the broader regional community.

Table 2.1 lists these groups along with a brief description of each. Within these groups there are several sub-groups which are described in Section 2.3.

Table 2.1 Stakeholder groups

Stakeholder group	Description
Primary stakeholders	
Landowners and communities	Comprises landowners with property adjoining the current mining lease, and other communities in the vicinity of the mine, such as Mount Perry and Gin Gin.
Employees, contractors and suppliers	Includes employees and contractors currently employed by Mt Rawdon Gold Operations and local businesses and service providers located in surrounding communities and townships.
Traditional Owners	Includes Traditional Owner groups in the area, including the Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people.
Secondary stakeholders	
State and local government representatives	Representatives from the Queensland government and the North Burnett and Bundaberg regional councils.
Representative bodies	Individuals elected to local representative bodies, such as industry groups (e.g., AgForce), business groups (e.g., local Chambers of Commerce) and development organisations (e.g., Regional Development Australia Wide Bay Burnett).
Interest groups	Local groups in the surrounding area with a special interest, such as sports and community clubs and environmental groups (e.g., Burnett Mary Regional Group).
Service providers	Emergency services (e.g., Rural Fire Service) and healthcare and education providers.
Regional community	Residents and local organisations present in the broader regional community, such as Gayndah.

Within these stakeholder groups, underrepresented and vulnerable sub-groups may exist, including women, youth (persons aged between 15 and 24 years old), vulnerable groups (such as persons with a disability) and other minorities (such as Indigenous persons).

As part of Evolution Mining's overall stakeholder engagement program, it would be beneficial to engage with relevant representatives of these groups and determine whether any additional engagement methods are required.

2.2. Summary of previous engagement relating to closure

A stakeholder consultation program relating to mine closure commenced in 2020, with the intent of continuing this program until planned mine closure in 2030. To date, stakeholder engagement has involved briefings of key community personnel, town-hall style meetings, site tours and the distribution of fact sheets.

A summary of stakeholder engagement relating to closure undertaken to date is provided in Table 2.2.

Table 2.2 Summary of mine closure stakeholder engagement (as of December 2020)

Date / occurrence	Location	Details
13 November 2020	Mount Perry Town Hall, (approximately 20 attendees)	Town-hall style meeting to present updates on current operations and life of mine planning. A question and answer session was held following the presentation and key themes raised by the community included, post-mining use of plant and equipment; potential mine life extension projects; and current ore production.
13 November 2020	North Burnett Regional Council Office, Gayndah	Discussion regarding council opinion on the most effective consultation mechanisms, and potential mine closure issues relating to the Mt Rawdon Mine.
12 November 2020	Bundaberg Regional Council Office, Bundaberg	Discussion regarding Bundaberg Regional Council Economic Development Division's opinion on the most effective consultation mechanisms, and potential mine closure issues relating to the Mt Rawdon Mine.
28 October 2020	North Burnett Regional Council Office, Gayndah	Meeting by Mt Rawdon General Manager with North Burnett Regional Council to present project updates and discuss regional considerations for closure.
30 November 2020	Bundaberg Regional Council Office, Bundaberg	Meeting by Mt Rawdon General Manager with Bundaberg Regional Council to present project updates and discuss regional considerations for closure.
16 September 2020	Mt Rawdon Gold Mine	Meeting with Gidarjil Development Corporation onsite to discuss current mine life and potential for pumped hydro project, including cultural heritage clearances.
27 November 2020	Burnett Mary Regional Group Office, Bargara	Meeting with Burnett Mary Regional Group to discuss funding for future rehabilitation and revegetation programs.
14 September 2020	Telephone conversation*	Discussion with North Burnett Regional Council undertaken as part of SIA to seek feedback on potential mine closure issues relating to the Mt Rawdon Mine.
16 July 2020	Telephone conversation*	Discussion with Gin Gin and Mount Perry School Chaplain undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.

Date / occurrence	Location	Details
15 July 2020	Telephone conversation*	Discussion with North Burnett Regional Council undertaken as part of SIA to seek feedback on potential mine closure issues relating to the Mt Rawdon Mine.
15 July 2020	Telephone conversation*	Discussion with Wide Bay Burnett Regional Development Association undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
13 July 2020	Telephone conversation*	Discussion with Mount Perry landowner undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
9 July 2020	Telephone conversation*	Discussion with Gidarjil, Employment & Training Management undertaken as part of SIA to identify any potentially relevant concerns and opportunities relating to the closure of the Mt Rawdon Mine. Discussions also focussed on potential opportunities for participation during closure and rehabilitation activities.
9 July 2020	Telephone conversation*	Discussion with a local real estate agent in Gin Gin undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
9 July 2020	Telephone conversation*	Discussion with Mount Perry Tourist and Historical Society undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
8 July 2020	Telephone conversation*	Discussion with local business owners in Mount Perry undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
7 July 2020	Telephone conversation*	Discussion with local business owners in Mount Perry undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
7 July 2020	Telephone conversation*	Discussion with Mount Perry Community Development Board undertaken as part of SIA to identify any potentially relevant issues or concerns relating to the closure of the Mt Rawdon Mine.
Quarterly	Mt Rawdon Gold Mine	Quarterly presentations delivered to all Mt Rawdon Gold Mine employees to provide an update on current operations and life of mine planning.
Quarterly	Telephone conversation	Quarterly telephone conversations by Mt Rawdon General Manager with Mayor Chambers to provide an update on closure planning and discuss regional considerations for closure.

Note: * Telephone conversations were held with stakeholders as an alternative to in person engagement methods due to travel restrictions imposed by the COVID-19 pandemic.

2.3. Stakeholder groups, interests and potential issues

Further to the broad stakeholder groups outlined in Section 2.1, Table 2.3 provides detail on key identified stakeholders (including sub-groups); their interests in mine closure; and potential issues of relevance to those interests.

The information presented in this section is based on discussions with Evolution Mining during a workshop held on 24 September 2020; discussions with stakeholders held on 12 November and 13 November 2020; and findings of the SIA completed in September 2020.

Table 2.3 Summary of stakeholder groups, interests and potential issues or concerns

Stakeholder group	Interests	Potentially relevant issues or concerns
Landowners and communities		
Adjoining landowners	• Management of invasive species. • Effective closure and site rehabilitation. • Compliance with state environmental legislation and regulations. • Post-closure end land uses (e.g., access to additional grazing land if possible).	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Disruptions to stock or farming operations during decommissioning and post-closure. • Impacts on land values.
Local community, i.e., Mount Perry	• Mount Perry town viability, including access to services, property values, population. • Compliance with state environmental legislation and regulations. • Post-closure end land uses.	• Loss of employment and procurement opportunities. • Population decline in Mount Perry and reduced liveability. • Loss of community financial support. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure.
Employees, contractors and suppliers		
Current Mt Rawdon employees and contractors	• Employment and business impacts. • Mine closure timelines. • Closure and site rehabilitation approaches and standards.	• Loss of employment and procurement opportunities. • Opportunity for participation in site rehabilitation.
Local businesses and suppliers	• Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain. • Employment and business impacts. • Mine closure timelines. • Closure and site rehabilitation approaches and standards.	• Loss of employment and procurement opportunities. • Population decline in local area. • Opportunity for participation in site rehabilitation.

Stakeholder group	Interests	Potentially relevant issues or concerns
Traditional Owners		
Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people	• Maximising support from Mt Rawdon in the period leading to closure. • Native title and cultural heritage. • Effective closure and site rehabilitation. • Post-closure end land uses.	• Opportunity for participation in site rehabilitation. • Loss of community financial support. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure.
State and local government representatives		
• Minister for Environment and the Great Barrier Reef • Minister for Resources	• Closure and site rehabilitation approaches and standards. • State liabilities. • Industry environmental performance, reputation and support.	• Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of royalties.
• Department of Environment and Science • Department of Natural Resources, Mines and Energy • Department of State Development, Tourism and Innovation • Department of Communities, Disability Services and Seniors	• Closure and site rehabilitation approaches and standards. • Local stakeholder satisfaction with the closure and rehabilitation process. • Compliance with state environmental legislation and regulations. • Industry and regional development.	• Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of royalties.
• Member for Callide • Member for Bundaberg • Member for Burnett	• Impact on local jobs and businesses. • Closure and site rehabilitation approaches and standards. • Local stakeholder satisfaction with the closure and rehabilitation process.	• Adequacy of regional infrastructure to support local development (agriculture and tourism) post-closure. • Local stakeholder support for closure approach. • Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of community financial support.

Stakeholder group	Interests	Potentially relevant issues or concerns
North Burnett Regional Council	• Mount Perry town viability, including access to services, property values, population. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain, such as Gayndah and Eidsvold. • Post-closure end land uses. • Local stakeholder satisfaction with the closure and rehabilitation process.	• Loss of employment and procurement opportunities. • Population decline in Mount Perry and reduced liveability. • Loss of community financial support. • Local stakeholder support for closure approach.
Bundaberg Regional Council	• Viability of Gin Gin and other regional towns that form part of the Mt Rawdon supply chain.	• Loss of employment and procurement opportunities.
Representative bodies		
• AgForce • Queensland Resources Council • Regional Development Australia Wide Bay Burnett • Regional Organisation of Councils • Gin Gin and District Chamber of Commerce • Bundaberg and District Chamber of Commerce • Gayndah Chamber of Commerce Inc.	• Closure and site rehabilitation approaches and standards. • Management of invasive species. • Industry environmental performance, reputation and support. • Industry and regional development. • Post-closure end land uses.	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Loss of employment and procurement opportunities. • Disruptions to stock or farming operations during decommissioning and post-closure.
Interest groups		
• Burnett Mary Regional Group • Burnett Catchment Care Association	• Post-closure end land uses. • Effective closure and site rehabilitation. • Closure and site rehabilitation approaches and standards. • Compliance with state environmental legislation and regulations.	• Legacy environmental issues due to unsuccessful rehabilitation following mine closure. • Opportunity for participation in site rehabilitation. • Membership decline due to population decline.
• Mount Perry Community Development Board • Mount Perry Tourist and Historical Society	• Post-closure end land uses. • Industry and regional development.	• Loss of community financial support. • Volunteer decline due to population decline. • Opportunity for use of decommissioned machinery.

Stakeholder group	Interests	Potentially relevant issues or concerns
Service providers		
Service providers	• Mount Perry town viability, including access to services, property values, population. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain.	• Loss of community financial support. • Volunteer decline due to population decline. • Reduced demand for services.
Regional community		
Regional communities, i.e., Gin Gin, Biggenden, Eidsvold and Monto	• Impact on local jobs and businesses. • Viability of other regional towns and businesses that form part of the Mt Rawdon supply chain.	• Loss of employment and procurement opportunities.

3. Engagement approach

This section outlines the typical methods that may be used with different stakeholder groups to consult relating to mine closure issues. The approach is guided by the International Association of Public Participation (IAP2) Public Participation Spectrum and the principles and practices contained in the AA1000 Stakeholder Engagement Standard (AccountAbility, 2015).

The proposed closure engagement approach should be undertaken to coincide with existing Evolution Mining's engagement process and events. The overall stakeholder engagement approach during the mine closure process should be adapted as closure progresses, for example as closure activities increase the frequency of engagement activities will increase. Further detail is provided in Section 3.3.

3.1. Methods, information and communication material

To successfully achieve closure stakeholder engagement objectives, Evolution Mining will:

- Tailor language, format materials and activities to specific stakeholders.
- Interact in a location that maximises the sharing of information and opportunities for broad participation in the discussion of mine closure issues.
- Provide support for stakeholders to understand technical concepts and provide sufficient time for stakeholders to discuss mine closure issues and develop responses to particular issues.

Selection of the most appropriate method for an engagement will depend on the purpose of the engagement and the characteristics of the stakeholder or stakeholder group being consulted. Sometimes this may involve using of a mix of methods, with the selection considered presented in this plan. The purpose of engagement will typically be to either impart information to assist understanding, or to discern a stakeholder's aspirations, expectations or opinions on an issue.

Stakeholder consultation will include engagement activities detailed in Table 3.1.

Table 3.1 Description of engagement activities

Engagement activity	Engagement purpose			Description
	Distributing information	Seeking information	Incorporating feedback	
One-on-one meetings	✓	✓	✓	Personal meetings will continue to be held between Evolution Mining and key stakeholders to discuss closure planning. This method is used to establish and maintain close communication with key stakeholders, such as landowners, Traditional Owners and local government.
Community updates	✓	✓		Flyers and local community newsletters will be used to communicate upcoming engagement opportunities with local communities. These updates will be aimed at local community members and individuals who may not have access to online engagement methods, such as online websites.

Engagement activity	Engagement purpose			Description
	Distributing information	Seeking information	Incorporating feedback	
Local media update	✓			Advertisements and articles will be placed in local media outlets, including local newspapers and radio stations, to communicate key closure milestones and details of upcoming engagement events and activities. This method is used to engage a broad range of stakeholders including, local communities, businesses and interest groups.
E-mail distribution	✓		✓	Evolution Mining will maintain an e-mail distribution list to effectively communicate updates and information to stakeholders. This list will be compiled from community meetings, one-on-one meetings and online enquiries.
Direct communications	✓	✓	✓	Written correspondence, such as letters, emails, online enquiries, and verbal correspondence, such as phone calls, face-to-face meetings and informal discussions that require actions or follow-up will be conducted with all stakeholders.
Website	✓		✓	A website will be established as an online resource for communities to access information about the project at any time. The website will include frequently asked questions, information sheets and government approval documentation.
Community information sessions (i.e., town hall meeting)	✓		✓	Community information sessions will be continued to be held at least annually or as required to convey important information to the wider community and provide a community update.
Focus group workshops	✓	✓	✓	Workshops may be held at frequent intervals closer to mine closure. The workshops will include key representatives from the local community and businesses. The intent of the focus group workshops is to provide a forum for the local community to participate in the mine closure process to generate ideas and seek feedback on post mine land uses and opportunities.

3.2. Responsibilities for engagement

The Mt Rawdon General Manager will hold overall responsibility for mine closure engagement and will be assisted by the Sustainability Manager and the Environment and Community Relations Superintendent.

Responsibilities for implementing and updating this plan will be the Mt Rawdon Sustainability Manager and Environment and Community Relations Superintendent and will be supported by the Community Relations Officer.

The Mt Rawdon Environment and Community Relations Superintendent and Community Relations Officer will be ultimately responsible for maintaining the community consultation register.

Responsibilities for engagement facilitation with key stakeholders will be as follows:

- **Landowners and communities:** Sustainability Manager; the Environment and Community Relations Superintendent; and Community Relations Officer.
- **Employees, contractors and suppliers:** Sustainability Manager; and the Environment and Community Relations Superintendent.
- **Traditional Owners:** Sustainability Manager; the Environment and Community Relations Superintendent; and Community Relations Officer.
- **State and local government representatives:** Evolution Mining Chief Executive Officer; and Mt Rawdon General Manager.
- **Representative bodies:** Mt Rawdon General Manager; and the Sustainability Manager.
- **Interest groups:** Sustainability Manager; the Environment and Community Relations Superintendent; and Community Relations Officer.
- **Service providers:** Sustainability Manager; the Environment and Community Relations Superintendent; and Community Relations Officer.
- **Regional community:** Sustainability Manager; the Environment and Community Relations Superintendent; and Community Relations Officer.

3.3. Proposed engagement activity by closure planning stage

Evolution Mining will engage with local communities and other stakeholders at all stages throughout the mine closure process. The intensity of engagement activity will be aligned with the mine closure schedule, with the frequency of engagement increasing as closure planning progresses or as issue resolution demands.

A summary of proposed engagement activity by closure planning stage is presented in Table 3.2.

Table 3.2 Summary of engagement activity by closure planning stage

Planning stage	Engagement activity*	Engagement tools
Operations (5 to 3 years until closure)	• Stakeholders engaged on post-mining land uses, including government representatives, landowners and local community. • Landowners and government representatives are engaged on the development of closure success criteria with documented agreement in place. • Community consultation plan updated annually to identify key affected people for engagement throughout closure process. • Scheduled periodic engagements (at least annual). • Grievances, comments and questions are recorded, managed and actioned as required.	• One-on-one meetings • Community information sessions • Focus group workshops

Planning stage	Engagement activity*	Engagement tools
Pre-closure (Less than 3 years until closure)	• Final post-mining land uses are agreed with stakeholders and related rehabilitation methods align with the post-closure land use. • All employees and contractors have been engaged at the appropriate level of influence. • Key stakeholders (i.e., landowners, Traditional Owners, interest groups) are engaged and involved in the development of post-mining monitoring program. • Where interest exists, partnerships with stakeholders to assist monitoring activity required to achieve the closure objectives. • Scheduled periodic engagements (at least annual). • Grievances, comments and questions are recorded, managed and actioned as required.	• One-on-one meetings • Focus group workshops • Community information sessions • Community updates • E-mail distribution • Online website updates
Closure execution and post-closure monitoring	• Where interest exists, partnerships with stakeholders for successful delivery of closure plan outcomes. • Agreed engagement process with stakeholders to provide details on progress on closure outcomes and achieving closure criteria. • Grievances, comments and questions are recorded, managed and actioned as required.	• Community information sessions • Focus group workshops • One-on-one meetings • Direct communication

Note: * Adapted from ICMM, 2020.

3.4. Proposed engagement approach by stakeholder group

The proposed engagement approach should be tailored to specific stakeholder groups to ensure all affected stakeholders and interested parties are informed of and given opportunities to be further involved in mine closure planning.

A summary of the proposed engagement approach by stakeholder group for the current stage of operations is presented in Table 3.3.

Table 3.3 Proposed engagement approach by stakeholder group

Stakeholder group	Proposed engagement approach
Landowners and communities	
Adjoining landowners	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach.

Stakeholder group	Proposed engagement approach
	• Routine meetings (6 monthly or more frequently if required). • Continued town-hall meetings (12 monthly or more frequently if required).
Local community, i.e., Mount Perry	• Continued town-hall meetings (12 monthly or more frequently if required). • Keep informed of key milestones through email updates, phone conversations or local media updates.
Employees, contractors and suppliers	
Current Mt Rawdon employees and contractors	• Quarterly presentations delivered to all employees and contractors. • Keep informed of key milestones through email updates, phone conversations or local media updates.
Local businesses and suppliers	• Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
Traditional Owners	
Bailai, Gurang, Gooreng Gooreng, Taribelang Bunda people	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or more frequently if required).
State and local government representatives	
• Minister for Environment and the Great Barrier Reef • Minister for Resources	• Routine meetings (12 monthly or more frequently if required).
• Department of Environment and Science • Department of Natural Resources, Mines and Energy • Department of State Development, Tourism and Innovation • Department of Communities, Disability Services and Seniors	• Routine meetings (12 monthly or more frequently if required).
• Member for Callide • Member for Bundaberg • Member for Burnett	• Routine meetings (12 monthly or more frequently if required).
North Burnett Regional Council	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or more frequently if required).

Stakeholder group	Proposed engagement approach
Bundaberg Regional Council	• Inception meeting to present and get feedback on PRC plan, including current closure plans and proposed closure approach. • Add closure as agenda item to regular meetings (12 monthly or more frequently if required).
Representative bodies	
• AgForce • Queensland Resources Council • Regional Development Australia Wide Bay Burnett • Regional Organisation of Councils • Gin Gin and District Chamber of Commerce • Bundaberg and District Chamber of Commerce • Gayndah Chamber of Commerce Inc.	• Keep informed of key milestones through email updates, phone conversations or local media updates. • Routine meetings (12 monthly or more frequently if required).
Interest groups	
• Burnett Mary Regional Group • Burnett Catchment Care Association	• Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
• Mount Perry Community Development Board • Mount Perry Tourist and Historical Society	• Routine meetings (12 monthly or more frequently if required). • Keep informed of key milestones through email updates, phone conversations or local media updates. • Respond to issues as they arise.
Service providers	
Service providers	• Continued town-hall meetings (12 monthly or more frequently if required). • Keep informed of key milestones through email updates, phone conversations or local media updates.
Regional community	
Regional communities, i.e., Gin Gin, Biggenden, Eidsvold and Monto	• Routine meetings (12 monthly or more frequently if required).

4. Stakeholder information management

The closure stakeholder engagement process will be planned and documented as a component of the Progressive Rehabilitation and Closure Plan. The following section outlines the stakeholder information management requirements.

4.1. Community consultation register

In accordance with Section 126C(1)(c)(iii) of the Environmental Protection Act, a community consultation register has been developed to identify the consultation carried out in developing the PRC plan and maintain a record of mine closure consultation. Attachment A provides a copy of the community consultation registered developed for the project.

The community consultation register includes:

- Consultation date.
- Identification of each community member.
- Description of consultation type, e.g., community meeting, annual meeting.
- Information provided during engagement.
- Issues raised/discussed by the community.
- How issues raised by the community have been considered.
- Decisions/outcomes of engagement.
- Commitments made by Evolution Mining.

4.2. Grievance and commitments management

Evolution Mining will aim to respond to all comments and complaints received in a timely and effective manner. All comments, complaints and commitments relating to mine closure will be captured in the community consultation register and managed in accordance with existing Evolution Mining procedures.

Evaluation of the effectiveness of grievance and commitment management will be undertaken by Evolution Mining as required based on feedback received from stakeholder participating in the process.

In the event a complaint is received, the following steps will be implemented:

1. Collect and record all details from complainant, including specific timing, locations and concerns.
2. Schedule a follow-up meeting with complainant (if required).
3. If related to closure activities, cease works immediately (if required) and implement appropriate controls to mitigate the situation.
4. Provide a response to complainant, within 24 hours, outlining corrective actions undertaken.
5. Record the event as an incident and log required actions and outcomes within INX InControl and Inform.

5. References

AccountAbility. 2015. AA1000 Stakeholder Engagement Standard 2015.

Coffey. 2020. Mt Rawdon Gold Operations Social Impact Assessment 2020. A reported prepared by Coffey Services Australia for Evolution Mining. Brisbane, Queensland.

DES. 2019. Progressive Rehabilitation and Closure Plans (PRC plans) Guideline. Queensland Department of Environment and Science, November 2019.

IAP2. 2018. IAP2 Spectrum of Public Participation. International Association for Public Participation.

ICMM. 2019. Integrated Mine Closure: good practice guide. International Council on Mining & Metals, Second edition.

ICMM. 2020. Closure Maturity Framework. International Council on Mining & Metals.

Nitro Solutions. 2020. Mount Rawdon Progressive Rehabilitation Closure Plan. Report prepared by Nitro Solution Pty Ltd for Evolution Mining. Brisbane, Queensland.

Attachment A – Community consultation register

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Mt Rawdon Gold Operations
Community Consultation Register 2020
* Complete from drop-down items

Consultation date	Stakeholder group*	Stakeholder sub-group	Consultation type*	Information provided during engagement	Key issue/concern theme*	Issues or concerns raised during engagement	How issues or concerns have been considered	Actions	Commitments	Responsibility	Other comments
12/11/2020	State and local government	Bundaberg Regional Council, Economic development	One-on-one meeting	Indicative closure timeline; post-mining land uses; current procurement and employment data at MRO.	Economic impact of closure	· Loss of procurement and employment opportunities for Gin Gin. · Desire annual meetings with MRO as closure progresses and provision of annual employment and procurement data.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	
13/11/2020	Adjoining landowners and local communities	Mt Perry local community	Community information sessions	Presentation providing update on current operations and closure planning	Post-mining land use	· Post-mining use of plant and equipment. · Potential mine life extension projects.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	
13/11/2020	State and local government	North Burnett Regional Council	One-on-one meeting	Indicative closure timeline; post-mining land uses; current procurement and employment data at MRO.	Economic impact of closure	· Loss of procurement and employment opportunities for Mount Perry. · Satisfied with the current level of engagement undertaken by MRO.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	
14/09/2020	State and local government	North Burnett Regional Council	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Loss of procurement and employment opportunities for the North Burnett region. · Interested in tracking current employment and procurement to understand where potential closure impacts may be experienced.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
16/07/2020	Service providers	Gin Gin and Mount Perry School Chaplain	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Social impact of closure	· Further social impacts to already disadvantaged families. · Loss of traineeship opportunities for Mount Perry and Gin Gin students. · Loss of financial support for community events and organisations.	Annual donation and support	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
15/07/2020	State and local government	North Burnett Regional Council, Office Manager	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Loss of procurement and employment opportunities for the North Burnett region.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
15/07/2020	Representative bodies	Wide Bay Burnett Regional Development Association	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Positive about future of Mount Perry and broader region. · Other resource developments proposed for the broader region which would maintain economy of area.	Annual meeting addresses key areas which may be impacted by the stakeholder.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
13/07/2020	Adjoining landowners and local communities	Mount Perry landowner	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Social impact of closure	· Loss of procurement and employment opportunities for Mount Perry. · Loss of financial support for community events and organisations. · Identified the upgrade of unpaved segments of the Gayndah Mount Perry Road as an opportunity to boost tourist visitation to Mount Perry.	Alternative post mine land uses always being considered to generate future economic support local community and region. E.g pumped-hydro feasibility study.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
09/07/2020	Traditional Owners	Gidarjil, Employment & Training Management	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Business and employment supply	· Loss of training and employment opportunities for local Traditional Owner groups. · Opportunity for partnership to undertake rehabilitation and closure activities. · Limited concern regarding funding as the organisation is well-funded from across the region.	Ongoing support through sponsorships and donations, as well as Shared Value Projects.	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
09/07/2020	Local businesses	Gin Gin real estate agent	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Social impact of closure	· Concerns relating to decline in housing market. · Positive about housing market in Mount Perry and broader region as sales have been increasing (especially during COVID).	Issues raised e.g. housing, were discussed with NBRC at annual meetings	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
09/07/2020	Interest groups	Mount Perry Tourist and Historical Society	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Social impact of closure	· Loss of financial support for community events and organisations. · Interest in opportunity for use of decommissioned machinery etc. · Interest in opportunity for tourism industry in Mount Perry (e.g., Summit walk). · Identified the upgrade of unpaved segments of the Gayndah Mount Perry Road as an opportunity to boost tourist visitation to Mount Perry.	Ongoing support through sponsorships and donations, as well as Shared Value Projects. Support to MPCDB to establish plans to make Mt Perry economically sustainable e.g. tourism attractions (Summit walk, Tram).	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
08/07/2020	Local businesses	Federal Inn; Mount Perry General Store	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Population decline. · Loss of procurement opportunities for local businesses in Mount Perry. · Concerns that following Mt Rawdon Mine closure a number of businesses in Mount Perry will close. · Loss of financial support for community events.	Ongoing support through sponsorships and donations, as well as Shared Value Projects. Support to MPCDB to establish plans to make Mt Perry economically sustainable e.g. tourism attractions (Summit walk, Tram).	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
07/07/2020	Local businesses	Mount Perry Golf Club	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Population decline. · Loss of procurement opportunities for local businesses in Mount Perry. · Loss of financial support for community events.	Ongoing support through sponsorships and donations, as well as Shared Value Projects. Support to MPCDB to establish plans to make Mt Perry economically sustainable e.g. tourism attractions (Summit walk, Tram).	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.
07/07/2020	Representative bodies	Mount Perry Community Development Board	Direct communications	Engagement undertaken as part of SIA; indicative closure timeline; current employment numbers.	Economic impact of closure	· Loss of financial support for community events and organisations. · Interest in opportunity for tourism industry in Mount Perry (e.g., Summit walk). · Identified the upgrade of unpaved segments of the Gayndah Mount Perry Road as an opportunity to boost tourist visitation to Mount Perry.	Ongoing support through sponsorships and donations, as well as Shared Value Projects. Support to MPCDB to establish plans to make Mt Perry economically sustainable e.g. tourism attractions (Summit walk, Tram).	Provide updates as per Stakeholder engagement schedule	Meetings scheduled/agreed as part of stakeholder engagement plan.	Sustainability Superintendent Sustainability Manager	Engagement conducted during COVID-19 health and travel restrictions.

ARCHAEO
CULTURAL HERITAGE SERVICES

CULTURAL HERITAGE SURVEY

Mount Rawdon Gold Mine
Evolution Mining
Mount Perry, Queensland



March 2013

Report prepared for the PCCC by ARCHAEO Cultural Heritage Services

ARCHAEO Cultural Heritage Services undertook this survey and assessment in association with the PCCC Native Title Claimants.

Contact details are:

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1 Introduction

1.1 Project Description and Scope of Study

Evolution Mining (the Proponent) operates the Mount Rawdon Gold Mine near Mount Perry, Queensland (Figure 1). The location of the Mount Rawdon Gold Mine is within the external boundaries of the Port Curtis Coral Coast Native Title Claim. Evolution Mining are proposing to develop an area of 55 hectares west of the current mine pit and south of the tailings storage facility (the study area) as a waste rock storage area (Figure 2).

The scope of the present study was to undertake a systematic cultural heritage survey and assessment of the expansion area and to develop appropriate strategies to manage any potential impacts on Aboriginal cultural heritage. Specifically, the scope of the project was to:

- Determine the presence of any cultural heritage objects, significant Aboriginal areas and significant Aboriginal values within the study area; and
- Identify management and mitigation options in consultation with PCCC representatives.

ARCHAEO Cultural Heritage Services (ARCHAEO) was nominated by the Port Curtis Coral Coast Native Title Claimants (PCCC) to act as technical advisors on cultural heritage matters relating to the project, including accompanying PCCC representatives on the cultural heritage survey.



Figure 1: Mt Rawdon mine (red arrow) within the external boundaries (blue) of the Port Curtis Coral Coast Native Title Claim (Image adapted from Google Earth Pro 2012).

1.2 Dates and Duration of the Work

The field survey for the proposed expansion area was undertaken on 13th to14th March 2013. During the assessment the PCCC were represented by William Little, Elijah Blackman, Tyrelle Collins and Peter Williams, Dr Phil Habgood was the ARCHAEO technical advisor and Evolution Mining was represented by Andrew Harwood.

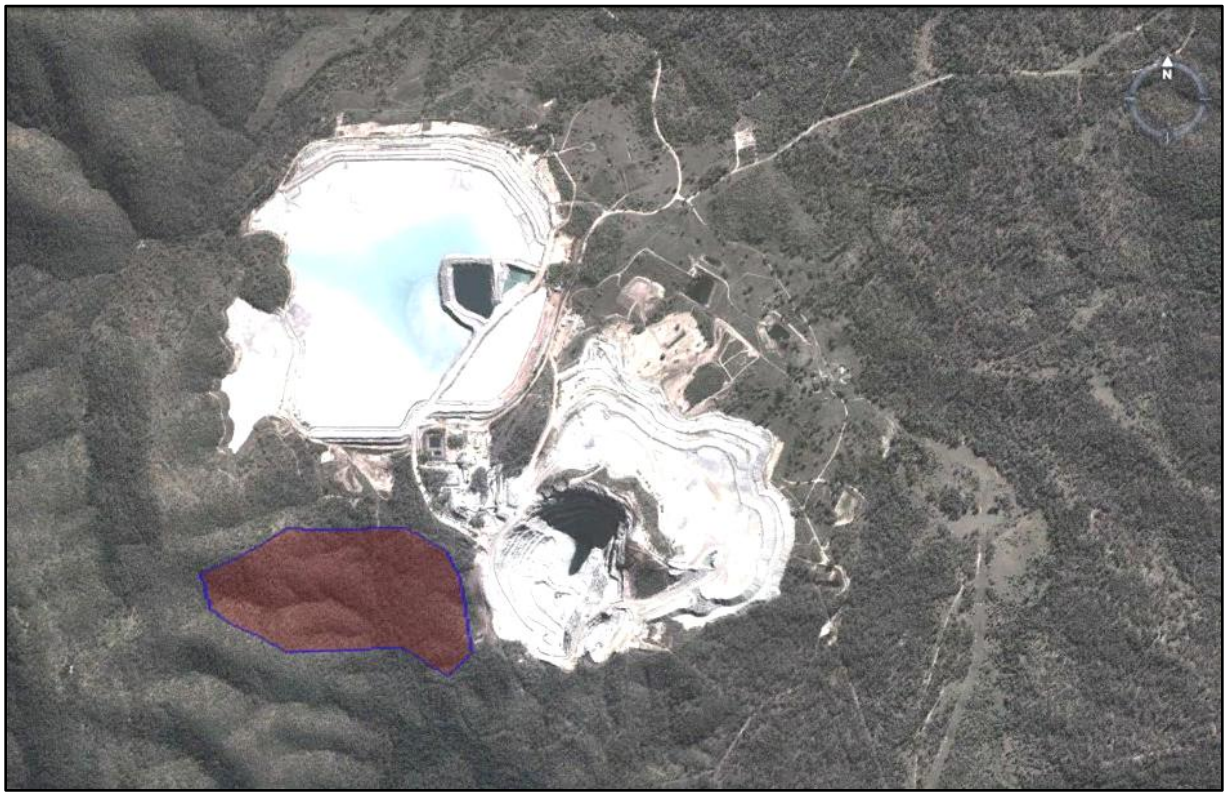


Figure 2: The proposed waste storage extension area (red) adjacent to the Mt Rawdon mine pit (Base image adapted from Google Earth Pro 2012).

2 Fieldwork

2.1 Methodology



Figure 3: The field team undertaking the survey.

Archaeologists use various forms of assessment to carry out cultural heritage surveys and these surveys occur in a series of clearly defined steps including sampling, surveying, site evaluation, recording, impact assessment, and management recommendations. All artefacts are manifestations of Aboriginal cultural heritage and are, therefore, of cultural significance and as such all finds would be recorded. For the purposes of this report the following definitions apply:

- **Site** refers to all physical traces of Aboriginal occupation, including isolated artefacts.
- **Isolate** refers to a find-spot of a single artefact separated by more than 5m from other artefacts and/or associated archaeological features.
- **Artefact scatter** refers to a group of 2 or more artefacts (especially stone tools) located on the ground surface, with a distance of no greater than 5m between each. Low density artefact scatters have ≤5 artefacts/m², medium density artefact scatters have between 5-10 artefacts/m², high density artefact scatters have ≥10 artefacts/m².
- **Culturally modified trees**, commonly called scarred or carved trees, if present, were assessed according to a detailed list of selection criteria developed by ARCHAEO that allow for some degree of scientific rigour to be applied to the identification process;

Where relevant, reference was made to the principles of the Burra Charter (see Appendix B) as a basis for attributing levels of significance to areas or objects noted during the survey. However, the attribution of significant Aboriginal area status to cultural places or localities of significance on the basis of cultural grounds was left entirely to the Traditional Owner members of the survey team.

Areas of interest were photographed using a digital camera with 12.1 mega-pixels, and locations were recorded using a hand-held global positioning system (GPS) accurate to approximately 5 metres, and all field data was recorded in a field notebook. Upon completion of the report these photographs are stored on disk (CD) in the ARCHAEO office.

Ground Surface Integrity (GI) and **Ground Surface Visibility (GSV)** were both recorded across the study area in order to provide insight into the levels to which the landscape had been modified, and how much of the ground surface could actually be seen during the survey. GI and GSV levels were both determined using a percentage range between 0-100% i.e. **Zero - 0%; Poor - 1-25%; Moderate- 26-50%; Fair - 51-75%; Good - 76-85%; Excellent 86-100%** (e.g. GSV of 0% indicates that the ground surface is completely covered, while 100% indicates that the ground surface is completely bare).

2.2 Bio-geographical Background

In this report, Sattler and Williams (1999) is used as the basis for descriptions of geo-morphological and bio-geographical context. Using the environmental framework set out in Sattler and Williams (1999) landscapes can be described in terms of 'bioregions' based on the dominant geological features found within a region. These bioregions are subdivided into 'provinces' that display characteristic patterns of landforms and associated vegetation. An understanding of both geology and flora habitats provides important information about the resources available to Aboriginal people in the present and in the immediate 'historical' past.

According to Sattler and Williams (1999:12/6), the study area is situated within the Burnett-Curtis Hills and Ranges Province of the Southeast Queensland Bioregion and is geologically diverse with granite ranges and sedimentary deposits. Predominant vegetation includes narrow-leafed ironbark (*Eucalyptus crebra*) and lemon-scented gum (*Eucalyptus citriodora*) woodlands and eucalypt mixed open forest (Sattler and Williams 1999).

The study area consists of steep ridge lines bisected by ephemeral creeks and drainage gullies (Appendix D). There are indications of hand clearing of the native woodlands with the presence of sawn tree trunks and fallen trees. Currently the area is covered by thick eucalypt regrowth scrub and some remnant vegetation often associated with the ridge tops and creek lines and areas of thick native and introduced grasses and lantana.

2.3 Field Survey Methodology

The general methodology applied to the cultural heritage survey was as follows:

- The cultural heritage survey was conducted on 13th to 14th March 2013;
- The survey team consisted of four PCCC representatives (William Little, Elijah Blackman, Tyrelle Collins and Peter Williams), an ARCHAEO technical advisor (Dr Phil Habgood) and an Evolution Mining representative (Andrew Harwood);
- The survey was carried out on foot and targeted the major ridges and creek lines; and
- The focus of the survey was to assess the presence of, or potential for Aboriginal cultural heritage.

2.4 Constraints - Ground Integrity (GI) and Ground Surface Visibility (GSV)

The study area was within a landscape that had been cleared in the past and now had thick eucalypt regrowth scrub and areas of thick native and introduced grasses and lantana. Limited remnant vegetation was present on ridge lines and more commonly associated with ephemeral creeks. Grass trees (*Xanthorrhoea*) were present along the eastern ridge line. Consequently, GI was good across the majority of the study area, whereas the area exhibited consistently low levels of GSV, with higher levels primarily restricted to vehicular tracks, creek or gully beds and areas where grass cover had been eroded or removed (see Figure 5). Poor GSV and the very steep nature of the ridges were the major constraints for the survey.

2.5 Field Survey Outcomes - Aboriginal Cultural Heritage

The body of consultancy work undertaken by ARCHAEO within the external boundaries of the Port Curtis Coral Coast Native Title Claim has demonstrated a rich history of Aboriginal occupation (see ARCHAEO 2012).

A cultural heritage survey was undertaken as part of the feasibility study for the Mt. Rawdon mine and a single flaked stone artefact was identified at the northern edge of the tailings dam (information provided by the Proponent). The tailings dam is to the north of the present study area (Figure 2).

Based on archaeological research and consultancy work the following predictive model can be put forth regarding the most common site types expected to be encountered in and around the study area:

- Occupation sites/campsites incorporating stone artefacts as isolates and in low to medium density scatters, particularly in proximity to fresh, permanent or semi-permanent water sources;
- Sources of raw lithic materials such as silcrete, siltstone and chert and associated artefacts relating to utilisation of these resources; and

- Scarred trees and other culturally significant trees (e.g. medicinal/food resources) in areas of remnant vegetation, particularly within riparian corridors;

In relation to the study area it is predicted that the site types listed above are the most likely site types that could be located during the survey, especially artefacts as isolates and scatters of varying densities associated with ridge tops and creeks. Sites such as these reflect the general use of the area by Aboriginal people over time, and may represent both transitory and more permanent camp sites and activity areas.

A search of the State Aboriginal Cultural Heritage Database and Register did not reveal any recorded sites within the study area (Appendix C). The search results stated that it is probable that the absence of recorded Aboriginal cultural heritage places reflects a lack of previous cultural heritage surveys of the area.

The field survey was not a systematic survey of the entire study area. Rather, due to the very steep nature of the topography and the poor GSV throughout the study area, the survey targeted the major ridges and the creek lines across the study area as these areas would have high potential for Aboriginal cultural heritage (Figure 4).

2.6 Conclusions

Whilst cultural heritage was not identified during the survey, the fact that the majority of the study area exhibited poor GSV limited the ability of the survey team to locate artefactual material if it was present. When also considering that GI was fair, there is potential that undetected cultural heritage remains within the study area. However, due to the nature of the landscape (steep ridge lines with shallow soil profiles bisected by ephemeral creeks and drainage gullies), this potential is assessed being very low.

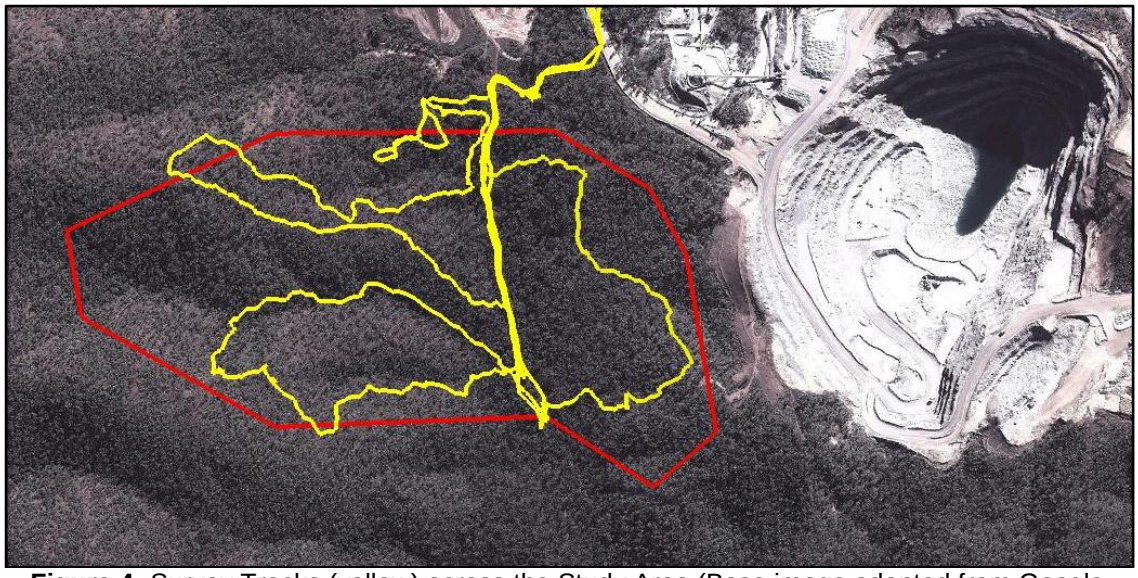
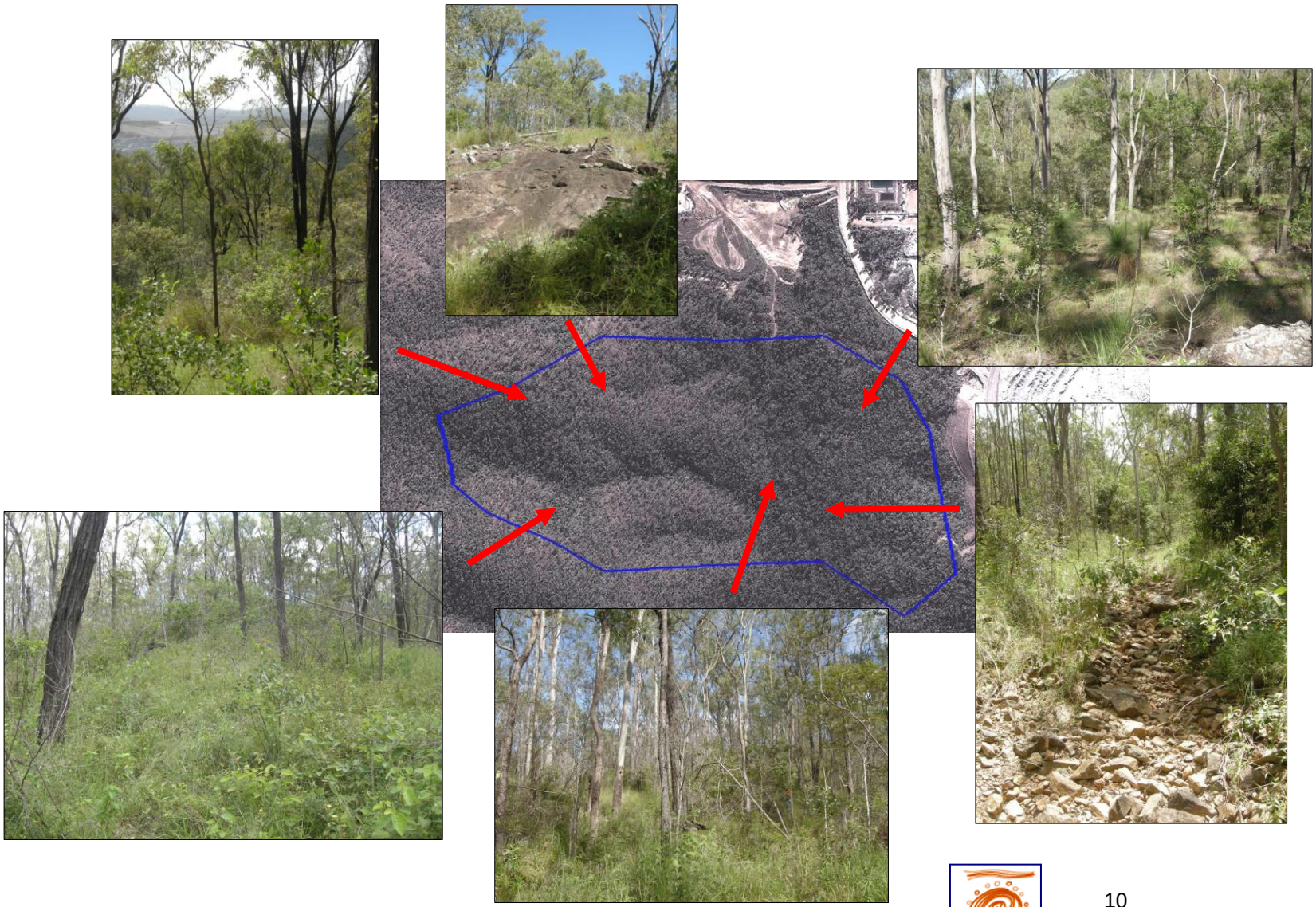


Figure 4: Survey Tracks (yellow) across the Study Area (Base image adapted from Google Earth Pro 2012).

Figure 5: GSV and GI across the Study Area (Base image adapted from Google Earth Pro 2012).



3 Cultural Heritage Management

When protecting cultural heritage values, a number of management options are available. These include:

1. **Avoidance**.
   This option is favoured by the Traditional Owners as it allows for their cultural heritage to remain 'on country'. Sites remaining 'on country' may require the development of site specific management protocols including the establishment of activity exclusion zones.

2. **Mitigation**
   In areas where impact cannot be avoided an appropriate mitigation program utilising recognised archaeological methods will need to be developed. Mitigation processes may vary according to site or feature types and may include but not be restricted to processes such as detailed site recording and mapping, manual and machine excavation and/or controlled collection of artefacts and features.

3. **Monitoring**
   A program of site monitoring by representatives of the Aboriginal Party during activities causing ground disturbance (i.e. vegetation clearance, earthworks) can be developed as a management option for recognised areas of higher potential for the presence of unidentified cultural heritage.

3.1 Recommendations

The PCCC have indicated that in all cases the number one option for management of their cultural heritage should be avoidance and leaving cultural material *in situ*, in context and 'on country'. As there remains potential, albeit low, for undocumented cultural material to be present within the study area, the Proponent should ensure that appropriate management strategies are implemented during vegetation clearance, ground disturbance and other project activities.

Recommendation 1: On-going Consultation

Ultimately, the most important factor within the successful management of the cultural heritage process remains ongoing consultation between the proponent and the Aboriginal Parties. Evolution Mining should therefore ensure that they continue to consult with the PCCC on the management of cultural heritage.

Recommendation 2: New Find Measures and Cultural Heritage Inductions

As there remains potential for undocumented cultural material to be present within the study area, Evolution Mining should institute a procedure for incidental finds. As part of this process, Evolution Mining should, before works begin, use all reasonable endeavours to

arrange for all persons (staff and/or contractors) who will be engaged in works and who are likely to have contact with cultural heritage to participate in a cultural heritage induction session. Among other things these inductions should inform workers what archaeological material may look like and give them clear instructions on what to do if they find anything that could be cultural heritage. These inductions should be jointly presented by Evolution Mining, a suitably qualified cultural heritage practitioner and a representative(s) from the PCCC.

If potential cultural heritage material is identified during the project works, all activities at that location should stop immediately and an exclusion zone of at least 10m radius be established. The PCCC should be notified as soon as practicable after the identification of potential Aboriginal cultural heritage. Any potential Aboriginal cultural heritage material identified should be recorded and assessed *in situ* by an appropriately qualified cultural heritage practitioner and management strategies developed in consultation with the PCCC. Work at that particular location should not recommence until written approval has been provided by the PCCC.

4 References

ARCHAEO Cultural Heritage Services. 2012. Cultural Heritage Survey, Curtis Island Plant Site, Gladstone, Central Queensland. Unpublished report prepared for Arrow Energy.

Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 1999.

Sattler, P and R. Williams (eds)
1999 *The conservational status of Queensland's bioregional ecosystems*. Environmental Protection Agency: Brisbane.

Appendix A – Relevant Legislation

Knowledge of cultural heritage legislation is essential when assessing sites, places or items of cultural heritage significance. The following section discusses both National and State Legislation relevant to cultural heritage.

Commonwealth

At the national level, the *Environment Protection and Biodiversity Conservation Act 1999* is now the key national heritage legislation, and is administered by the Commonwealth Department of the Environment, Water, Heritage and the Arts. In addition to this Act, the following pieces of legislation are relevant to heritage:

⇒ The *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* provides Aboriginal people with the right to request the federal Minister for Aboriginal Affairs to intervene through an injunction in cases where they consider that their cultural heritage is at risk. The Act does not determine significance, or limit the type and place for which protection is being sought.

⇒ The *Australian Heritage Council Act 2003* provides for the establishment of the Australian Heritage Council, which is the principal advisory group to the Australian Government on heritage issues. The AHC Act also provides for registration of places considered of national significance on the Register of the National Estate (RNE) or the Australian Heritage Places Inventory (AHPI).

State (Queensland)

The paramount legislation in Queensland, with regard to Indigenous cultural heritage issues, is the *Aboriginal Cultural Heritage Act 2003*, which states that a person who carries out an activity must take all reasonable and practicable measures to ensure the activity does not harm Aboriginal cultural heritage (the "cultural heritage duty of care") (Section 23[1]). The Act defines cultural heritage as (S8):

⇒ A significant Aboriginal area or Aboriginal object.

⇒ Evidence, of archaeological or historic significance, of Aboriginal occupation of an area.

A significant Aboriginal area is "an area of particular significance to Aboriginal people" because of either or both of the following:

⇒ Aboriginal tradition.

⇒ The history, including contemporary history, of any Aboriginal party for the area (S9).

The Act states that it is an offence for a person to harm, remove or possess cultural heritage if the person "knows or ought reasonably to know that the object is Aboriginal cultural heritage" (S26). The ACH Act also states:

Without limiting the matters that may be considered by a court required to decide whether a person has complied with the cultural heritage duty of care in carrying out an activity, the court may consider the following:

(a) the nature of the activity, and the likelihood of its causing harm to Aboriginal cultural heritage;
(b) the nature of the Aboriginal cultural heritage likely to be harmed by the activity;
(c) the extent to which the person consulted with Aboriginal parties about the carrying out of the activity, and the results of the consultation;
(d) whether the person carried out a study or survey, of any type, of the area affected by the activity to find out the location and extent of Aboriginal cultural heritage, and the extent of the study or survey;
(e) whether the person searched the database and register for information about the area affected by the activity;
(f) the extent to which the person has complied with cultural heritage duty of care guidelines (Section 23(2), pp. 19-20).

In the case where cultural heritage issues exist, a proponent can move ahead with a mitigation program on the following basis.

A person who carries out an activity is taken to have complied with the cultural heritage care of duty if the person is acting:

i. under the authority of another provision of this Act; or
ii. under an approved cultural heritage management plan; or
iii. under a native title agreement or another agreement with an Aboriginal party, unless Aboriginal cultural heritage is expressly excluded from being subject to the agreement; or
iv. in compliance with cultural heritage duty of care guidelines (Section 23(4)(a), p. 20).

An approved Cultural Heritage Management Plan (CHMP) is required when an Environmental Impact Study (EIS) is initiated for a project, but also may be developed voluntarily. Another appropriate way in which compliance with the cultural heritage duty of care can be achieved is through the development of an agreement between at least one Aboriginal Party and the party intending to undertake a project. If agreement is not reached between parties, then mediation, and finally involvement of the Land Court, a specialised judicial tribunal established under the *Land Court Act 2000,* may follow.

Appendix B – The Burra Charter

Although not codified in law, the *Australia ICOMOS Burra Charter, 1999* (*Burra Charter*) is the foundational document upon which cultural heritage management practice is based, and this document continues to guide cultural heritage management in Australia. It was first adopted in 1979 by Australia ICOMOS (International Council on Monuments and Sites) and was initially designed for the conservation of and management of historical heritage. However, after the addition of further guidelines that defined cultural significance and conservation policy, use of the charter was extended to Aboriginal studies.

The *Burra Charter* defines conservation as 'the processes of looking after a place so as to retain its cultural significance' (Article 1.4). A place is considered culturally significant if it possesses aesthetic, historic, scientific, social or spiritual value for past, present or future generations (Article 1.2). The *Guidelines to the Burra Charter: Cultural Significance* provides the following definitions (Section 2):

Aesthetic value includes aspects of sensory perception for which criteria can and should be stated. Such criteria may include consideration of the form, scale, colour, texture and material of the fabric; the smells and sounds associated with the place and its use.

Historic value encompasses the history of aesthetics, science and society, and therefore to a large extent underlies all of the terms set out in this section. A place may have historic value because it has influenced, or has been influenced by, an historic figure, event, phase or activity. It may also have historic value as the site of an important event. For any given place the significance will be greater where evidence of the association or event survives *in situ*, or where the settings are substantially intact, than where it has been changed or evidence does not survive. However, some events or associations may be so important that the place retains significance regardless of subsequent treatment.

Scientific (archaeological) research value of a place will depend upon the importance of the data involved, on its rarity, quality or 'representativeness', and on the degree to which the place may contribute further substantial information.

Social value embraces the qualities for which a place has become a focus of spiritual, political, national or other cultural sentiment to a majority or minority group.

Article 5 of the *Burra Charter* states that:

> *Conservation of a place should identify and take into consideration all aspects of its cultural and natural significance without unwarranted emphasis on any one value at the expense of others.*

Appendix C – Register Search Results

From: Christy A Anderson [mailto:Christy.Anderson@datsima.qld.gov.au]
Sent: Wednesday, 27 March 2013 11:33 AM
To: Frances Dawson
Subject: Cultural Heritage Search: 1201469

I refer to your application in which you requested advice on Aboriginal cultural heritage places recorded on the above location.

I wish to advise that no Aboriginal cultural heritage is recorded on the Cultural Heritage Database and Register in your specific search area, from the data provided by you. However, it is probable that the absence of recorded Aboriginal cultural heritage places reflects a lack of previous cultural heritage surveys of the area. Therefore, our records are not likely to reflect a true picture of the Aboriginal cultural heritage values of the area.

All significant Aboriginal cultural heritage in Queensland is protected under the Aboriginal Cultural Heritage Act 2003, and penalty provisions apply for any unauthorized harm. Under the legislation a person carrying out an activity must take all reasonable and practical measures to ensure the activity does not harm Aboriginal Cultural Heritage. This applies whether or not such places are recorded in an official register and whether or not they are located in, on or under private land.
Aboriginal cultural heritage, which may occur on the subject property, is protected under the terms of the Aboriginal Cultural Heritage Act 2003 even if the Department of Environment & Resource Management has no records relating to it.

Please refer to our website www.derm.qld.gov.au/cultural_heritage/index.html for a copy of the gazetted Cultural Heritage duty of care guidelines, which set out reasonable and practical measures for meeting the duty of care.

The Cultural Heritage body for the Mt Rawdon.zip area is:
Gidarjil Cultural Heritage Corporation
PO Box 2773, Bundaberg Qld 4670
53 Walker Street Bundaberg Qld 4670
Ph: 07 4130 7700 Fax: 07 4130 7777
Authorised Contact: Mr Kerry Blackman (Manager) Mob. 0412 760 501

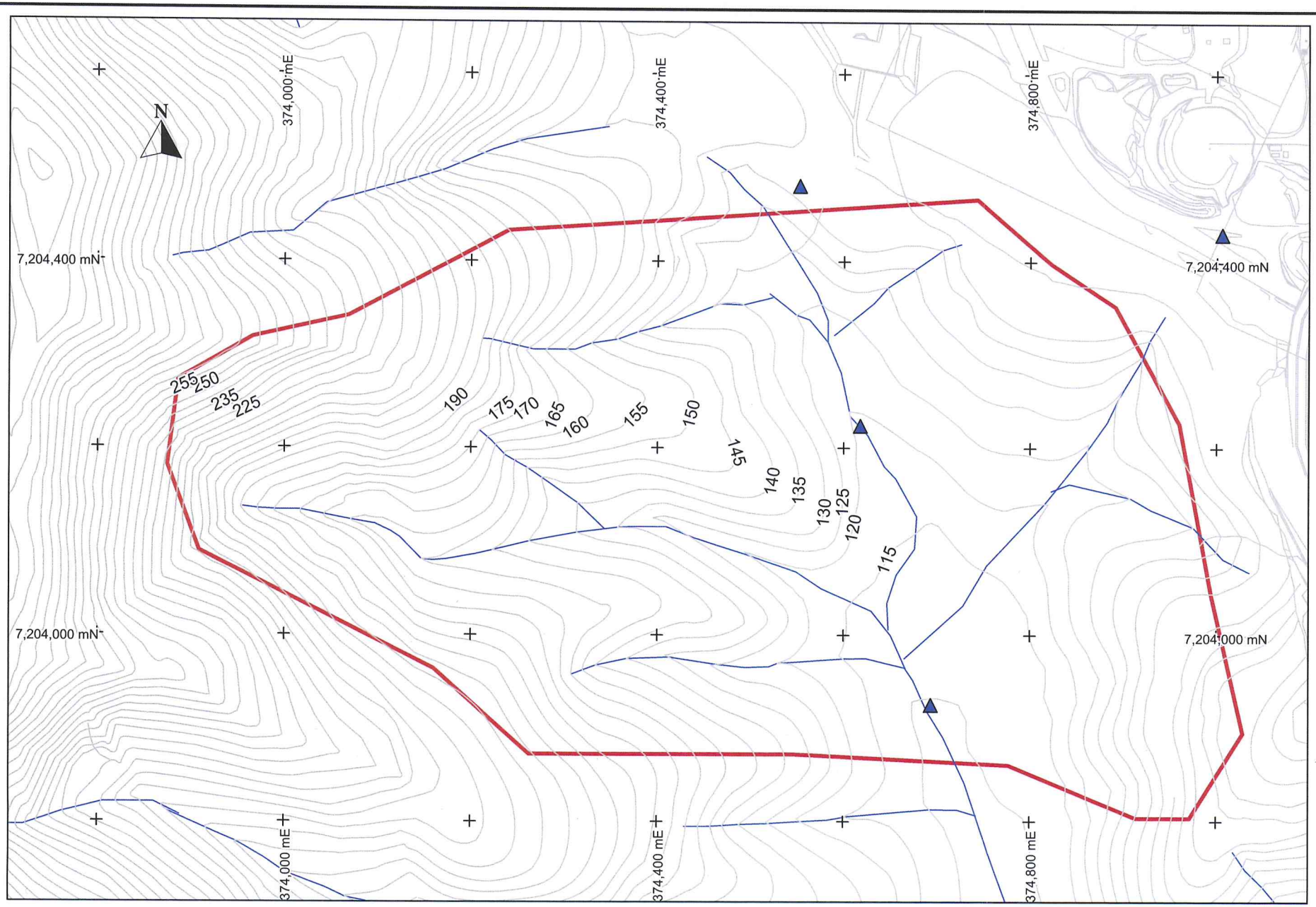
The Aboriginal party for the Mt Rawdon.zip area is:
QC01/29 - QUD6026/01
Port Curtis Coral Coast Claim
Queensland South Native Title Services
Level 4, 370 Queens Street (PO Box 10832, Adelaide Street)
BRISBANE QLD 4000
Ph (07) 3224 1200 Fax (07) 3229 9880

Should you have any further queries, please do not hesitate to contact me on (07) 3239 3648.

Christy Anderson
Policy Officer | Cultural Heritage |
Aboriginal and Torres Strait Islander Employment, Culture and Programs |
Department of Aboriginal and Torres Strait Islander and Multicultural Affairs |

6B Neville Bonner Building, 75 Williams Street, BRISBANE QLD 4001 |**T**: 07 3247 6212

Appendix D – Contour Map of Study Area



Evolution MINING

Western Waste Dump

Date: 27.02.2013 GDA94 Zn56



Mt Rawdon Gold Mine treatment wetland project

Feasibility Assessment

Client	: Evolution Mining
Prepared by	: Australian Wetlands Consulting Pty Ltd
Project #	: 1-181017
Date	: June 2019

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Mt Rawdon Gold Mine treatment wetland project

Feasibility Assessment

Project control

Project name: **Mt Rawdon Gold Mine treatment wetland project**
Feasibility Assessment

Job number: 1-181017
Client: Evolution Mining
Contact: Graeme Esslemont

Prepared by: Australian Wetlands Consulting Pty Ltd

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Date:	Revision:	Prepared by:	Reviewed by:	Distributed to:
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16 June 2019	B	Dr. Mark Bayley		Graeme Esslemont
5 July 2019	C	Dr. Mark Bayley		Graeme Esslemont

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AWC's management system has been certified to ISO 9001

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1 Introduction and Background

Evolution Mining runs an open pit gold mine (Mt Rawdon Operations - MRO) amongst a landscape largely dominated by bushland and grazing. The mine is located approximately 80km southwest of Bundaberg and 15km northwest of Mt Perry, QLD, mining approximately 100,000 ounces of gold per year. Historically, Mt Rawdon Mine has produced 1.5 million ounces of gold (since 2001), with current projections estimated at a further 32.69Mt @ 0.83g/t of gold.

The processing of excavated earth within the mine involves the leaching of mined material with cyanide, storage of tailings and the onsite storage of waste rock. Tailings reserves within the mine site have a finely balanced acid generating potential (1.5% sulfur, with 1.2% potentially acid generating) / acid neutralizing capacity and thus the tailings have a low chance of generating acid mine drainage. The management of acid mine drainage across the site is facilitated using the Waste Rock Management Plan. This management plan is based on a Net Acid Generation and Acid Base Accounting of total S and C, along with a block model that identifies the different rock types across the mine to inform selective handling and placement of unearthed material. Based on the rock type, waste rock or sub-economic ore is placed in one of two rock dumps:

1. Northern Waste Rock Dump (NWRD) that contains acid forming rock encapsulated by non-acid forming rock, which is contained by a series of interception dams (WD1, WD2, WD3 and WD4), and
2. Western Waste Rock Dump (WWRD) that contains non acid forming rock, which is contained by an interception dam (West Dam)

The NWRD has been designed to produce neutral drainage via encapsulating an inner core of acid producing rock with an outer core of neutralizing rock, thereby acid runoff formed within the center of the dump is neutralized as it passes through the outer ring of neutralising rocks. As stormwater exits the NWDR and enters the four inception dams, it has been shown to be elevated in:

- sulfur - generated from pyrite oxidation,
- nitrate – from explosive residues, and
- heavy metals.

The interception dams WD1, WD2, WD3 and WD4 have been designed to hold a 1:20 year AEP 4 month wet season storm event, and a 72hr 1:1000 year AEP critical design storm event. The management of water within the interception dams involves transferring water from WD2, WD3 and WD4 to WD1. When water is within WD1 it becomes available for use within the process water circuit. Key attributes of each of the dams intercepting the NWRD are outlined in Table 1-1.

Under the operation approval from the QLD government (refer to Section 2), water exiting the interception dams (off site) must comply with a strict set of water quality discharge limits. In order to meet these discharge limits to allow controlled discharge of water to the downstream environment, some degree of treatment and/or shandying is often required.

Table 1-1: Water storage capacities within the NWRD drainage basin

Dam	Capacity, ML	Dam operations data @ 1/8/18			
		Volume, ML	% full	Depth below spillway, m	Space to fill, ML
WD1	209.8	28.2	13.4	5.44	181.6
WD2	113.9	4.6	4.5	5.3	95.6
WD3	119.5	0.1	0.3	5.35	35.7
WD4	126.5	1.7	2.4	7	70.5

1.1 Project aims and objectives

The primary aim of this report is to assess the feasibility of natural, passive based treatment systems at reducing sulphate concentrations from mine stormwater runoff within WD2 and thus allow for the controlled discharge of water to the environment.

Key project objectives will be:

- Review and report on relevant literature on sulphate removal using natural based treatment systems,
- Complete site visits to assess the potential incorporation of a natural based treatment system within the mine area,
- Assess the potential feasibility of natural based treatment systems to reduce sulphate (and other contaminants) to license discharge requirements,
- Develop a pilot project to evaluate the most suitable technology/method to employ to reduce sulphate levels, while also providing sufficient data to allow upscale design to a full treatment system.

2 Legislative requirements

Mt Rawden Mine operates with approval from the QLD Department of Environment and Heritage Protection, under Section 5 of the Environmental Protection Act 1994, Environmentally Relevant Activity (ERA) Permit number EPML00712113. Schedule E of this permits details all water related conditions, stating that:

> ***E2:*** *contaminants must not be released to any waters or the bed and banks of any waters other than releases of stormwater in compliance with Condition E4.*
>
> ***E4:*** *Stormwater impacted by the mining activities may only be discharged from the catchment location listed in Schedule E -Table 1 and must comply with the contaminant limits defines in Schedule E -Table 2.*

Table 2-1 presents relevant water quality release limits as set forth within ERA Permit number EPML00712113. These release limits will be used to guide the development of this feasibility project.

Table 2-1: Water quality release limits

Parameter	Units	Release limits	
	mg/L	WD1, WD2, WD3, WD4 and Spillway of SD 3	Groundwater Seepage Operational Target concentrations
Total Suspended Solids		< 1200 Note 1	N.A.
Total Dissolved Solids	mg/L	<1000	N.A.
pH		6.0 – 9.0	6.0 – 7.5
Aluminium	mg/L	N.A.	0.055
Arsenic	mg/L	<0.05	0.013 (as As V)
Boron	mg/L	N.A.	0.37
Cadmium	mg/L	<0.005	0.0002
Chromium	mg/L	N.A.	0.001
Copper	mg/L	<0.04	0.002
Cyanide (an un- ionised HCN, measured as [CN])	mg/L	N.A.	0.007
Lead	mg/L	N.A.	0.0034
WAD Cyanide	mg/L	<0.007	0.5
Manganese	mg/L	N.A.	1.9
Nitrate	mg/L	N.A.	2.1
Selenium	mg/L	N.A.	0.011
Sulphate	mg/L	<100	N.A.
Zinc	mg/L	<0.15	0.0142
Note 1: ...or 10 % greater than a background value of receiving waters, whichever is greater			

3 Basis of design

In order to adequately assess the feasibility of the constructed wetland/bioreactor technology to reduce sulphate concentrations from the waste storage dams, an accurate understanding of the quality and quantity of the water to be treated needs to be defined.

3.1 Current dam water quality and release limits

Water quality data from Waste Rock Dam 2 (WD2) has been provided to AWC for analysis. This data set spans 15 years, from December 2003 through to December 2018 and is summarized in Table 3-1. Comparing this data to the Environmental Authority EPML00712133, water quality within WD2 is:

- significantly elevated in Sulphate and Nitrate,
- moderately elevated in Zinc and TDS, and
- sporadically and marginally elevated in Copper and Cadmium.

In order the assess the feasibility of the proposed constructed wetland/bioreactors the following pollutant (75^{th}%ile) concentrations will be used:

- Total Dissolved Salts (TDS): 1409.25 mg/L,
- Sulfate: 1205 mg/L,
- Zinc: 1.23 mg/L, and
- Nitrate: 29.7 mg/L.

Given the strong positive correlation between TDS and Sulfate (r^2= 0.824), a reduction in the concentration of TDS may be achieved within the wetland/bioreactor systems through the removal of sulphate. This will be dependent upon the specific form of salt/s within the water and the behavior of these salts following sulphate reduction.

Table 3-1: Water quality data from WD2. Grey cells refer to non compliant water quality parameters.

Parameter	Unit	WD2 water quality univariate statistics			
	mg/L	25th%ile	50th%ile	75%ile	Max
Total Suspended Solids	mg/L	5.5	10	15.5	91
Total Dissolved Solids	mg/L	804.75	1023.5	1409.25	3697
pH		7.15	7.53	7.99	9.44
Aluminium	mg/L	0.01	0.01	0.01	0.4
Arsenic	mg/L	0	0	0	0.02
Boron	mg/L	0.05			0.05
Cadmium	mg/L	0.01	0.01	0.02	0.05
Chromium	mg/L	0			
Copper	mg/L	0	0	0.01	0.04
Cyanide (an un- ionised HCN, measured as [CN])	mg/L				
Lead	mg/L	0	0	0	0.1
WAD Cyanide	mg/L	0	0	0	0.05
Manganese	mg/L	0.09	0.24	0.46	3.25
Nitrate*	mg/L	19.08	26.7	29.7	44.4
Selenium	mg/L	0.01	0.01	0.01	0.01
Sulfate	mg/L	738	974	1205	2220
Zinc	mg/L	0.44	0.95	1.23	3.17

3.2 Wastewater flow

The ability of any water treatment system or device to meet the design intent is inherently governed by the volume of water traveling through it. The volume of water entering and leaving the treatment system will govern two important factors:

1. The total mass of 'pollutants' to be removed, and
2. The time in which the water interreacts with the treatment system.

3.2.1 Pump flow measurements

Flow from WD2 to WD1 is measured via a pump flow meter (FM03). Data spans seven years, from Feb 2012 through to Feb 2019, which is summarized in Table 3-2 and Figure 3-1. The flow data from WD2 to WD1 clearly shows a seasonal trend, matching the areas summer rainfall / winter dry climatic pattern. Flow seems to be greatest during February and March (median 1801 and 1940 kL/day respectively) and lowest during August (169 kL/day). Total monthly flow can exceed 20,000 kL during the Summer/Autumn period, with the highest monthly flow recorded at 38,574 kL (Feb 2016).

Given the variable nature of the rainfall at the site, it is recommended that the proposed wetland/bioreactor ultimately be built downstream of a buffer storage facility. Such a facility will store water in high rainfall times and slowly feed the proposed wetland/bioreactor treatment system. The ultimate size of the buffer storage dam will influence the size of the proposed wetland/bioreactor, however sizing this system for the ultimate solution is beyond the scope of this project.

This project will focus around the feasibility of the wetland/bioreactor technology rather than full scale application. As such, the flow rate of water through the wetland/bioreactor trail will be proportionally smaller than that theoretically required for a full scale system. Assuming that we require a system that has the ability to treat a range of differing flow rates in accordance with Table 3-2, a range of differing hydraulic loading rates will be proposed for the application of this feasibility assessment.

Table 3-2: Monthly flow statistics from flow meter attached to FM3 – WD2 to WD1

Month	N	Median	Minimum	Maximum	Std. Deviation
Jan	20	1168	62	2261	684
Feb	40	1801	34	4602	1303
Mar	34	1940	49	4279	1205
Apr	35	1693	0	2970	813
May	24	1220	1	4047	1371
Jun	14	850	3	2861	930
Jul	14	902	27	2199	697
Aug	10	169	0	2434	768
Sep	9	1136	93	1987	742
Oct	12	1696	166	3061	1099
Nov	31	1279	0	2393	878
Dec	33	929	0	3202	1140

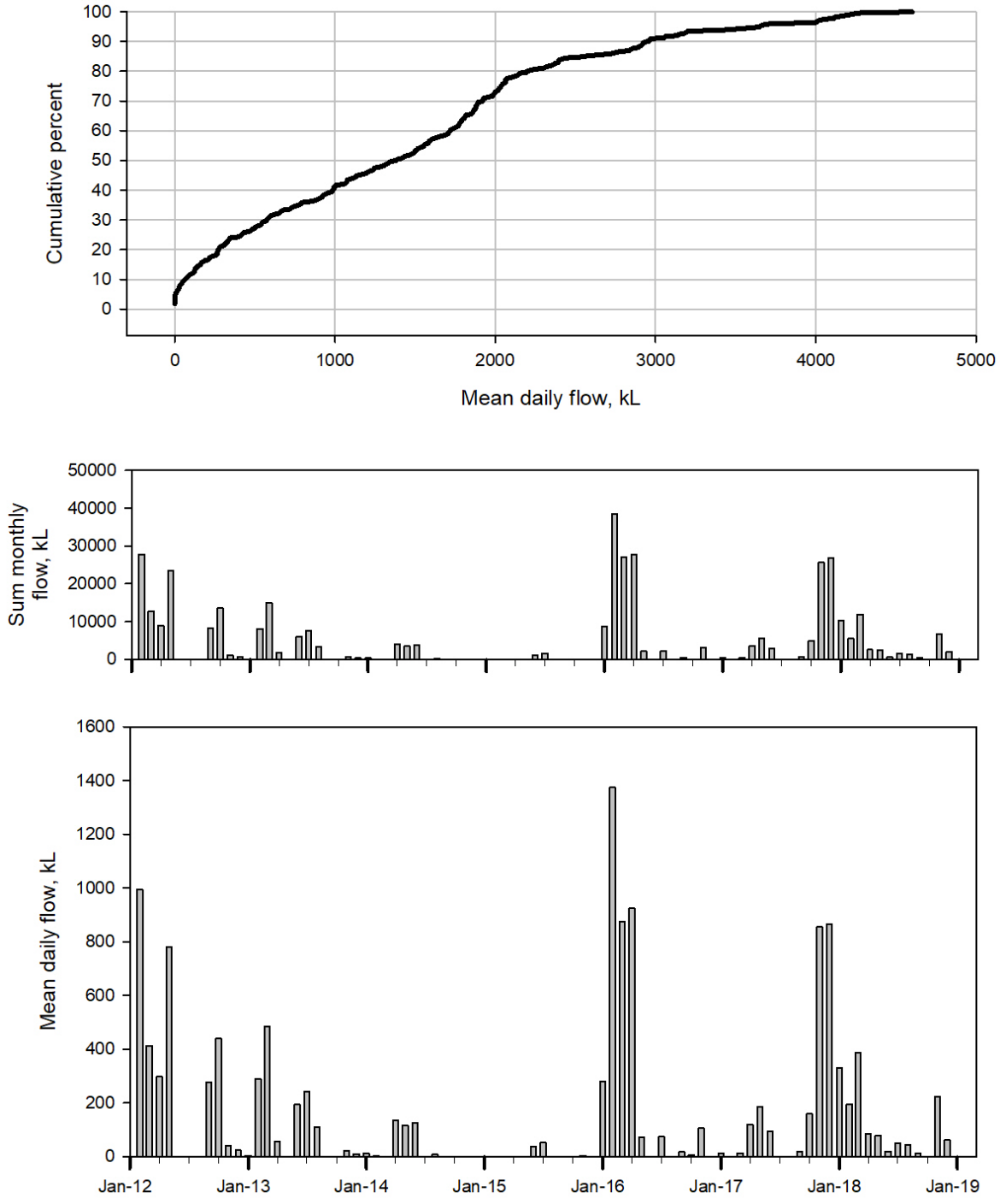


Figure 3-1. Flow data

3.2.2 Modelled flow measurements

While the pump flow measurements presented in the above section provide some degree of flow estimation, its unsure if this volume of water is indicative of the actual treatment volume required if the proposed wetland/bioreactor is to treat water under a continuous flow scenario. Based on modelling conducted by ATC Williams using GoldSim, water flow from pond WD2 during a 50th%ile rainfall year equals 45ML/year, with a median daily flow rate of 7.4m^3. This daily flow rate peaks at 45m^3 during the summer wet period, reducing to zero flow in the winter dry climatic conditions (Figure 3-2).

Using this information, it is appropriate to adopt a daily treatment volume of 7.5 m^3/day for wetland feasibility study. However, as presented in Figure 3-2, actual daily flow volumes from the mine site will, at times, be significantly greater and less than that 7.5 m^3/day.

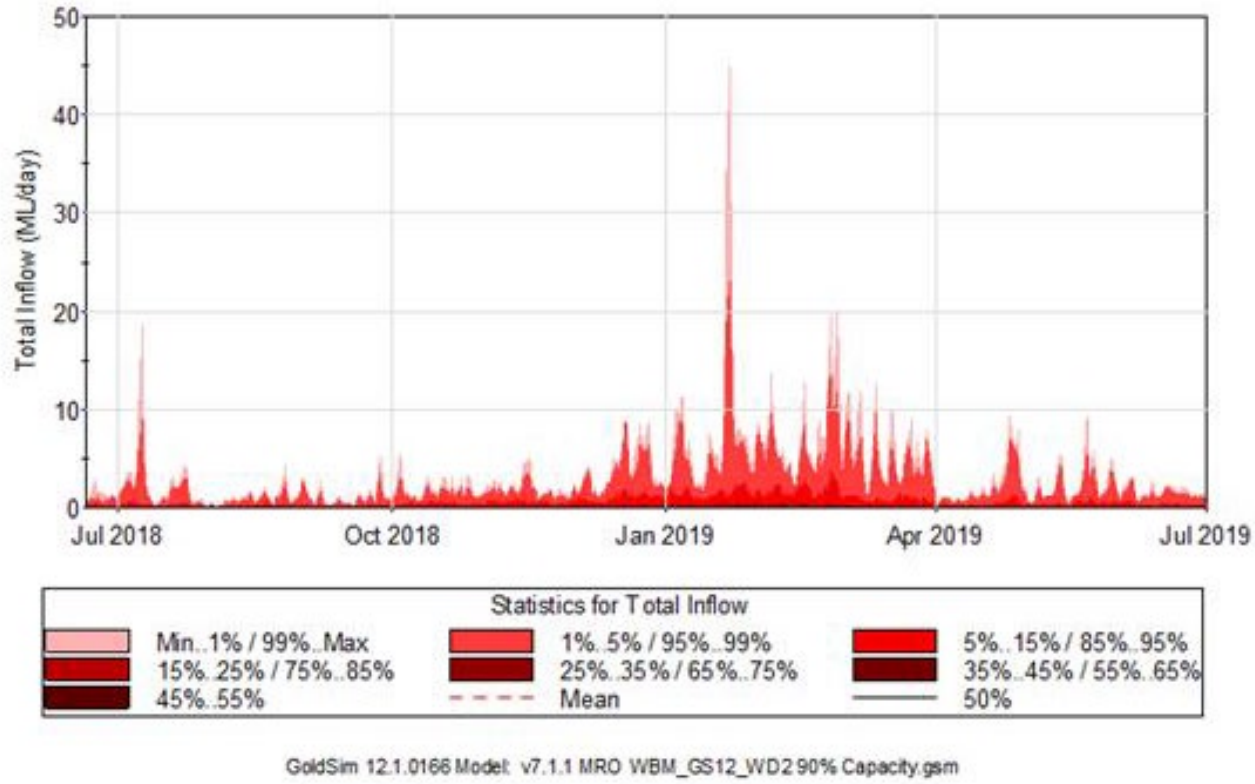


Figure 3-2: Modelled daily inflow to WD2

4 Overview of sulphate reduction wetland/bioreactors

Natural based treatment technologies for sulphate reduction rely predominantly on dissimilatory sulphate reduction. Dissimilatory sulphate reduction is a microbial mediated anaerobic reaction that involves the conversion of sulphate (and other oxidized forms of Sulphur) to hydrogen sulfide (by bacteria) under anaerobic conditions and with the readily supply of electron donors (basic organic compounds). Figure 4-1 displays sulphate processing within the various pelagic and benthic zones of wetlands. As shown in this figure, the conversion of sulphate to hydrogen sulfide occurs within the anaerobic soil layer.

In order to construct a natural based treatment system that uses bacteria to reduce inorganic sulphate to sulfide, there a number of key factors that need to be considered:

- What is the best and most appropriate organic carbon source in which to 'fuel' the sulphate reduction process?
- Which bacteria are the most efficient, available and robust?
- At what rate do these bacteria metobolise sulphate?
- What influences, both in a good and bad way, the rate of sulphate reduction?

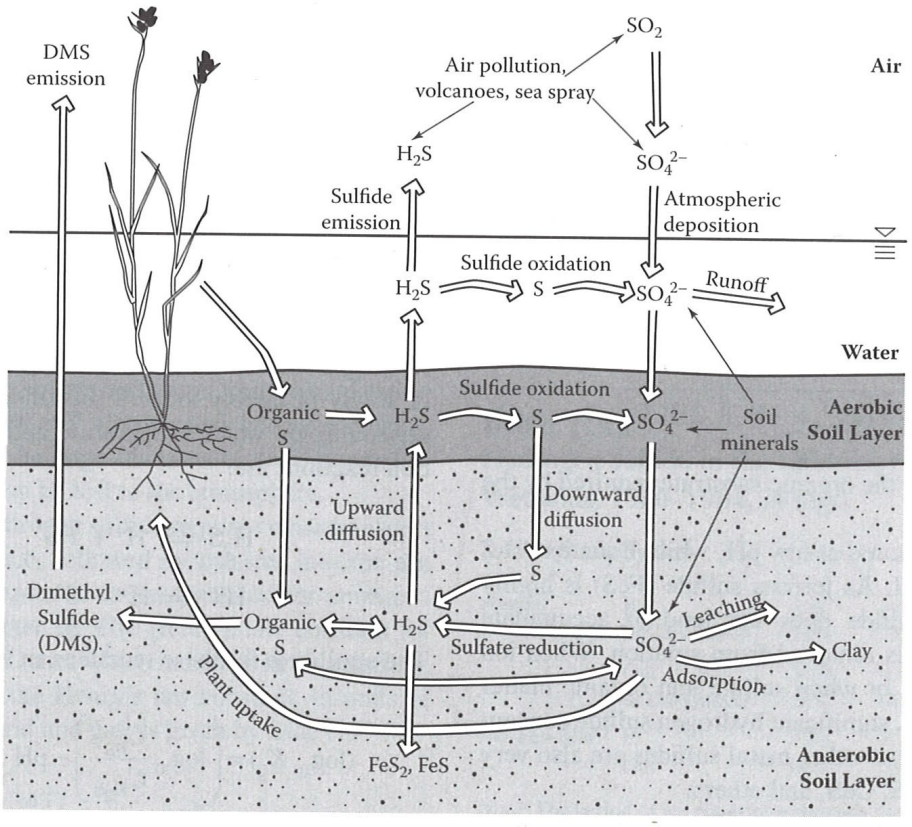


Figure 4-1: Sulphur cycle within wetland systems (Kadlec and Wallace, 2009)

4.1 Carbon source

In order to initiate microbial sulphate reduction, carbon must be supplied either passively or actively. The passive supply of carbon generally refers to the internal supply of carbon from a substrate or media within the treatment system (wood chips, straw, compost), whereas an active supply of carbon refers to the external supply of carbon (i.e. ethanol dosing). The system/s proposed within the MRO for treatment of water from the NWRD is proposed to be predominantly a passive based system, as such a ready supply of decaying organic matter (to supply carbon) is required to fuel the dissimilatory sulphate reduction process.

Many carbon sources are available for use within the passive sulphate reduction systems, ranging from biosolids/manure/compost, to hard/soft wood chip. The correct choice of the carbon source is likely to be largely dependent upon:

- hydraulic characteristics (can water move freely through the media?),
- longevity (how long does the media last?), and
- availability (can we get it?).

Sulphate reduction rates appear to be higher in more labile sources of carbon (compost, activated sludge wastes) than when compared to less labile sources of carbon (wood chip/saw dust). As such there in an initial tendency to favor carbon sources from materials that are more labile. However, these sources of carbon tend to be fine textured and thus offer some constraint to the interaction of the target high sulphate waters. While less labile carbon sources have a lower sulphate reduction potential, they are likely to provide a more suitable substrate by which water can travel through and thus sulphate exposure to an anaerobic environment rich in carbon – which will subsequently result in the loss of sulphate from the water column.

The most suitable engineered/created carbon source/media to employ for this feasibility assessment will likely be a blend of woodchip, soil/gravel and compost/sewage plant waste (biosolids). This blend of materials will provide a range of carbon sources while also providing a permeable matrix by which water can infiltrate, interact with the carbon and leave the treatment system. Blends of a range of materials have been found to report higher sulphate reduction rates when compared to using a single media type.

4.2 Sulphate reduction rates

As stated above, sulphate reduction rates within treatment wetlands/bioreactors reported within the literature seem to be linked to the type of carbon media used in the experiment/study. Table 4-1 presents sulphate reduction rates (g/m^3/day) from CSIRO's recent study using site material/water. As shown in this table, the more labile Typha biomass (oven dried, ground) reduced sulphate at significantly higher rates (66.9-75.8 g/m^3/day) than that of hardwood Eucalyptus sawdust (5.6-7.4 g/m^2/day. Many research papers mirror this finding, with manure/activated sludge substrate reporting sulphate reduction rates ranging from 122-415 g/m^3/day, compared to rates ranging from 3.2-25 g/m^3/day from systems comprising of yard waste/wood chip/straw/peat/mussel shell.

Table 4-1: Sulphate reduction rates as measured by CSIRO, 2019

Treatment	g/m3/d	Period considered (d)
TB-HTW	75.8	0-44
TB-DW-Nut	72	0-44
TB-HTW-Nut	68.5	0-44
TB-DW	66.9	0-44
EtOH-DW-Nut	64.4	0-44
Lac-HTW-Nut	59.6	0-44
Lac-DW-Nut	57.4	0-44
EtOH-HTW-Nut	57.1	0-44
EW-DW-Nut		0-60
EW-HTW	7.4	0-60
EW-HTW-Nut	5.8	0-60
EW-DW	5.6	0-60

EW= Eucalyptus sawdust; TB= Typha biomass; DW= WD2 water; HTW= VCL-treated WD2 water; Ctrl= control; Lac= lactate; EtOH= ethanol; Nut= nutrients (nitrogen and phosphorus).

4.3 Abiotic factors governing the rate of sulphate reduction

There are numerous factors that will govern the rate of sulphate reduction with the proposed wetlands/bioreactors. Key factors worth considering for this project include:

- Temperature,
- Oxygen, and
- Iron.

Being a microbial mediated reaction, sulphate reduction increases with increased microbial production/respiration. As such, sulphate reduction is higher in higher temperatures and lower in lower temperature. However, in winter oxygen tends to penetrate deeper into waters/soils, thus affecting sulphate reduction via oxygen inhibition.

The presence of oxygen, either within its free gas (O_2) form or forms associated with nitrogen, iron or manganese results in other bacteria out competing sulphate reducing bacteria within the soil/water, and thus can significantly inhibit sulphate reduction.

If waters have high concentrations of iron, iron reducing bacteria can out compete sulphate reducing bacteria for organic carbon. However, soluble iron can be microbially converted into insoluble ferrous sulfide using dissolved sulphates formed during sulphate reduction. This process essentially removes iron from the water stream by the formation of pyrite with sulphur. As discussed and detailed further in Section 5.3, a ferrosol soil treatment is proposed following the wetland/bioreactor treatments.

4.4 Zinc reduction and removal in wetlands/bioreactors

Zinc removal with biological systems is dominated by chemical precipitation and associated physical settlement and filtration. Relevant to this project, zinc forms a very insoluble compound with sulfide providing pH levels are high (>8), as such this removal pathway is unlikely to occur within the proposed treatment systems. Zinc removal within the proposed treatment systems is most likely to occur via chemical sorption of the metal onto organic sediments. Zinc removal in treatment wetlands can be modeled, using a decay rate constant of between 20-28 m/y.

4.5 Cadmium reduction and removal in wetlands/bioreactors

The behavior of cadmium within the biological treatment system is similar to that of Zinc, with precipitation occurring with both sulfide and carbonate and co-precipitation occurring with iron, manganese and aluminum. Cadmium reduction within wetlands/bioreactors can also occur via the sorption with organic substrates, with many mine wastewater treatment systems reporting cadmium removal percentages in excess of 90%.

5 Proposed wetland/bioreactor feasibility assessment

There are many worldwide examples of the use of bioreactor technologies for sulphate reduction, using a wide range of organic based material. Numerous studies, including that undertaken by CSIRO for this investigation (refer to Section 4, have reported sulphate reduction rates for a range of substrates within bioreactors. Key information on sulphate reduction rates are outlined below:

- CSIRO reported a mean sulphate reduction rates of 65 g/m^3/day using vegetative biomass from the wetland plant species Typha spp., however only a mean of 6.2 g/m^3/day using Eucalyptus saw dust.
- Muhammad et al. (2017) reported a reduction of sulphate levels from 1600 mg/L to 80 mg/L using a bioreactorwith a substrate of spent mushroom compost, activated sludge and woodchips,
- Burnes et al (2012) reported a reduction of sulphate levels from 3538 mg/L to 1153 mg/L using a bioreactor with a substrate of woodchip, straw and seasoned municipal yard waste,
- Van Den Berg et al (2016) concluded that their bioreactor had a sulphate reduction rate of up to 120g/m^3/day using Synthetic domestic wastewater sludge.

In order to assess the appropriateness of using constructed wetland/bioreactor technology at Mt Rawdon Mine, it is recommended that a trial be conducted that investigates the use of this technology for the specific application on site. Based on the site inspection undertaken with AWC, client consultation and literature research, the feasibility of the wetland/bioreactor system at removing sulphate needs confirmation prior to full scale design, construction, commissioning and operation.

As discussed in the previous section, sulphate reduction within natural based treatment systems occurs in an oxygen poor, high carbon environment (electron donors) in the presence of sulphur compounds and microbial groups capable of utilizing inorganic sulfur compounds (electron acceptors).

Specifically, the rate of sulphate reduction achieved within the field, the application of the technology and its influence on other key water contaminants all needs further investigation. It is recommended that three broad technologies be investigated:

1. High carbon bioreactor bed,
2. Typha spp. wetland trial, and
3. Horizontal bioreactor column (in pipe).

Figure 5-1 displays a schematic of the proposed pilot scale treatment experiment, showing the above three treatment options, wastewater source and broad arrangement of the experiment. In additional to the above three treatments, a post ferrosol soil treatment will be trialed to immobilise sulphate with iron via the formation of pyrite.

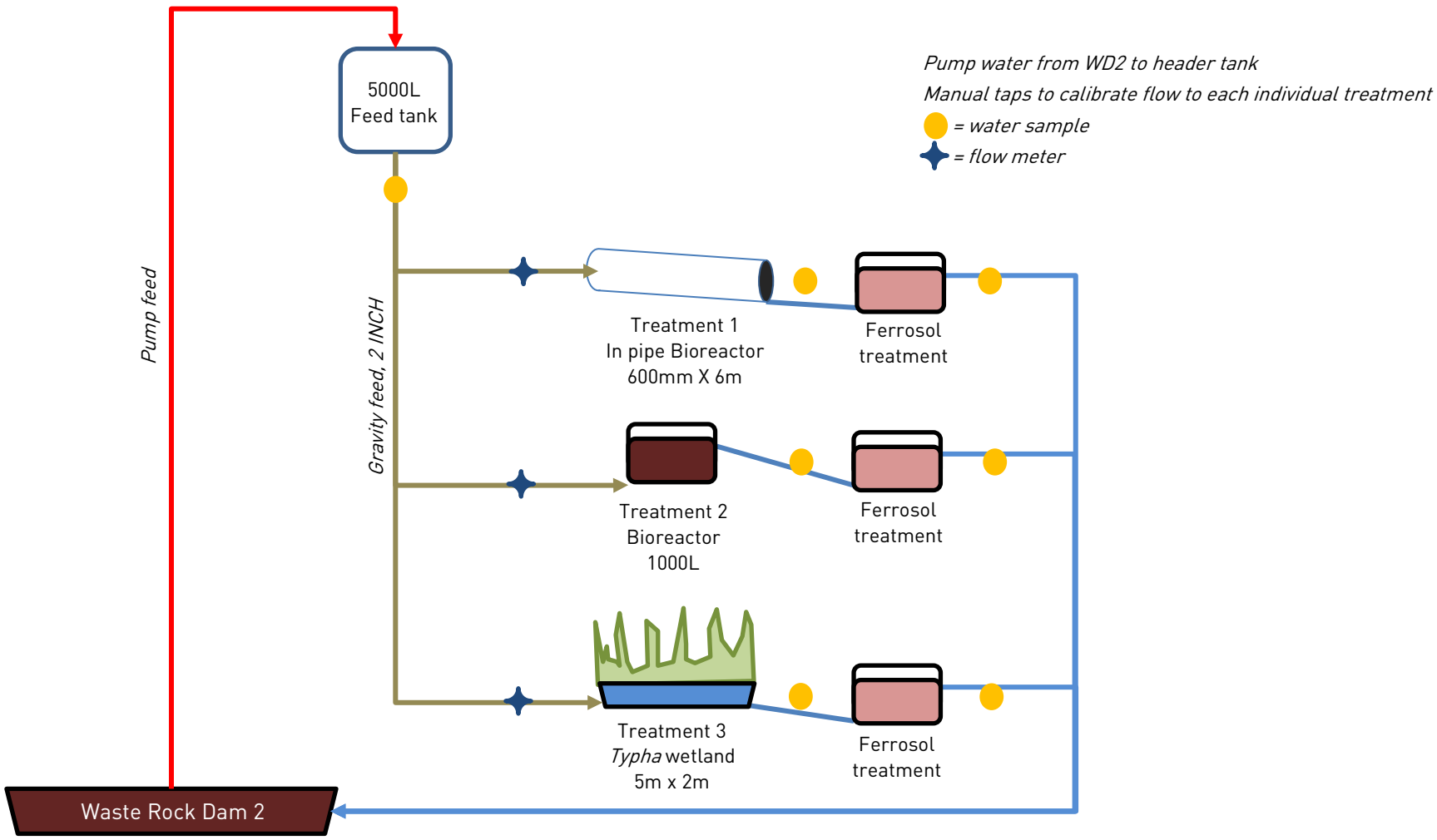


Figure 5-1: Proposed wetland / bioreactor pilot scale treatment experiment

5.1 Bioreactor trial

Across much of the literature, passive sulphate reduction treatment systems occur via "bioreactor" technology. This basically refers to the passage of the sulphate rich water through a porous medium rich in organic carbon. As indicated by work undertaken by CSIRO, sulphate within water sourced from WD2 can be reduced via dissimilatory sulphate reduction using two carbon sources:

1. Typha biomass – mean 65.65 g sulphate reduction per m^3/day, and
2. Hardwood chip – mean 5.8 g sulphate reduction per m^3/day

The method employed by CSIRO to calculate sulphate reduction rates involved the oven drying and grinding of plant material before adding WD2 water and WD2 inocula to measure sulphate reduction rates. While this method yielded accurate sulphate reduction rates, the results are difficult to upscale in this feasibility assessment due to the practicalities of oven drying and grinding large amounts of wood chip/Typha biomass, and the ability of water to flow through a fine grained material at rates whereby significant volumes of water can be treated. Across the literature, media used within sulphate reduction bioreactors generally consists of a mixture of materials ranging from compost, activated sludge, woodchips, sawdust, straw, mulch, peat, and/or manure. Based on the use of this material, sulphate reduction has been reported at rates of approximately 120 g sulphate reduction per m^3/day under hydraulic retention times (HRT) ranging from 24-120 hrs. Most importantly, several studies have reduced sulphate concentration in waters from 1600 mg/L to 80 mg/L under a 120 hr HRT (media = spent mushroom compost, wood chips and activated sludge).

The bioreactor trial will involve two components; 1) a horizontal flow bioreactor bed (see Figure 5-2); and 2) a 'in pipe' horizontal flow bioreactor column (see Figure 5-3). The media used in both bioreactor treatments will consist of a blended material under specifications listed in Table 5-1. Table 5-1 also stipulates other key bioreactor operational specifications.

Table 5-1: Key bioreactor specifications

	Bioreactor bed	Bioreactor 'In pipe'
Size	1 m^3	0.95m^3
Vessel	1000L IBC / pallet tank	450mm stormwater pipe, 6m in length
Flow direction	Horizontal	
Media		
Woodchip	40%	
Compost	30%	
Sewage sludge	20%	
Aggregate (10-200mm)	10%	
Sum	**100%**	

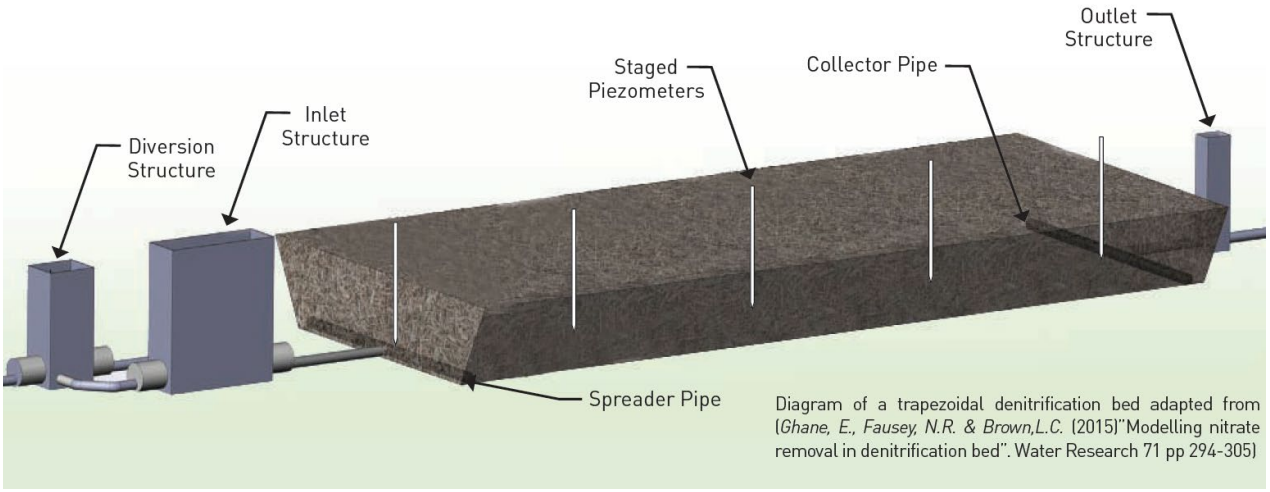


Figure 5-2: Schematic of bioreactor bed

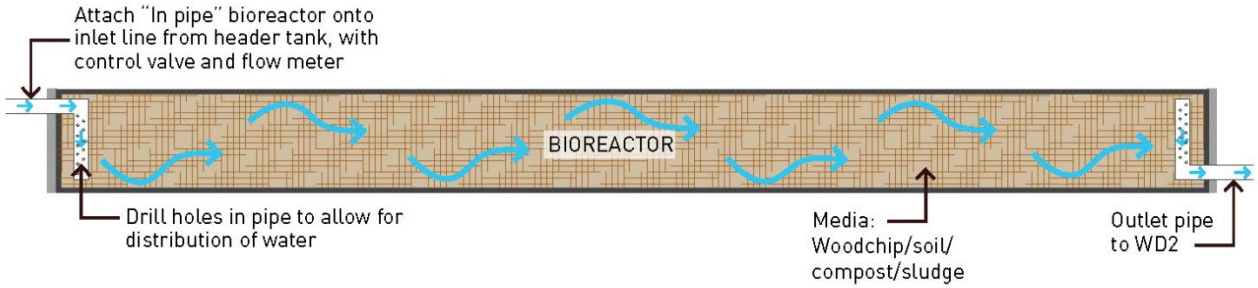


Figure 5-3: Side view of 'in pipe' bioreactor column.

5.2 Typha spp. Wetland trial

Based on the presence of Typha within the WD2 and the sulphate reduction rates of Typha biomass reported by CSIRO, the use of a Typha wetland to remove sulphate will be assessed as part of this feasibility assessment. While the sulphate reduction rate is anticipated to be less than that within the bioreactor trials, the potential ease of operation and large area available may provide a feasible option for the reduction of sulphate from WD2 and the broader water management system within the mine.

To emulate the potential upscaling of the treatment wetland, a Surface Flow (SF) constructed wetland type is recommended. This type of wetland allows water to flow through a plant community at about 10-50cm deep, which is planted within a topsoil matrix – generally 20-30cm deep, as shown in Figure 5-4.

Given that sulphate reduction occurs in a low oxygen environment in the presence of organic matter, it may take some time for the treatment wetland to reach its optional sulphate reduction potential. This is due to the growth of the Typha and the production of organic matter that will reduce dissolved oxygen concentrations within wetland to levels where sulphate reduction to occur. This process is often called wetland maturation and can take upwards of 12 months. To reduce this maturation phase, it is recommended that large Typha root balls be harvested from WD2 and planted within the proposed treatment wetland and that a high carbon based media be used.

Key treatment wetland specifications are provided in Table 5-2, which are subject to alterations based on the final location of the trial.

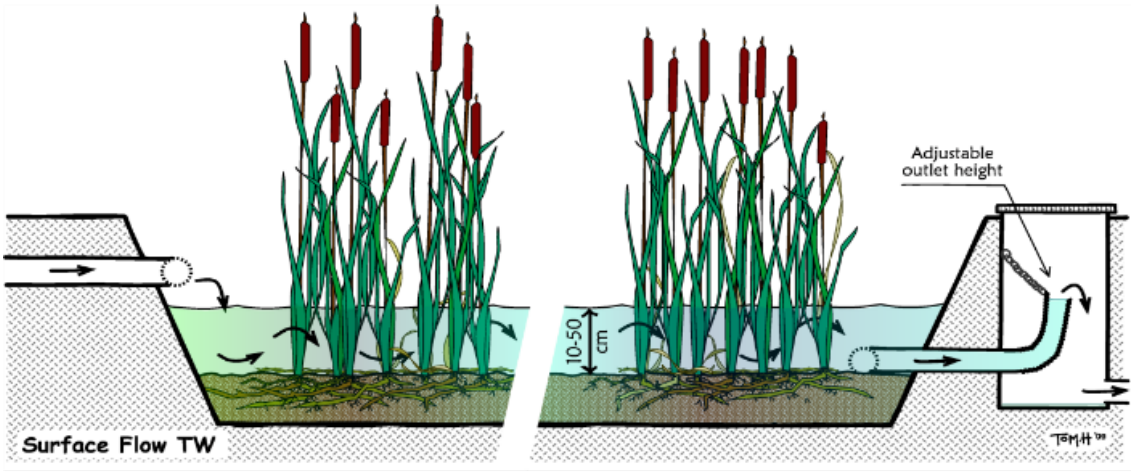


Figure 5-4: Example of Surface Flow Treatment Wetland

Table 5-2: Key treatment wetland specifications

Wetland dimensions			Wetland component	
Length	12m		Plant type / planting density	Typha spp. harvested from WD2 using excavator. Plant at 10 stems or clumps per m^2
Width	4m			
Depth (topsoil)	0.3m			
Depth (water)	0.5m		Soil volume / mix	7.2m^3; blend of: 50% soil 30% hardwood chip 20% sewage sludge
Depth (total, including freeboard)	1.0m			

5.3 Ferrosol soil treatment

As shown in Figure 5-1, a ferrosol soil treatment cell will be proposed following each of the bioreactor/wetland treatments. This ferrosol soil treatment cell will run under anaerobic conditions with the aim to bind free sulphur produced from dissimilatory sulphate reduction with iron – forming pyrite. There is little guidance within the literature to size such a treatment cell, however oxygen diffusion (via atmosphere or plants root aeration) needs to be eliminated or minimised to ensure formed pyrite does not oxidise and thus release sulphate to the water column.

Each ferrosol soil treatment cell will consist of upward flow filter contained within a 1000L IBC / pallet tank, as shown diagrammatically in Figure 5-5.

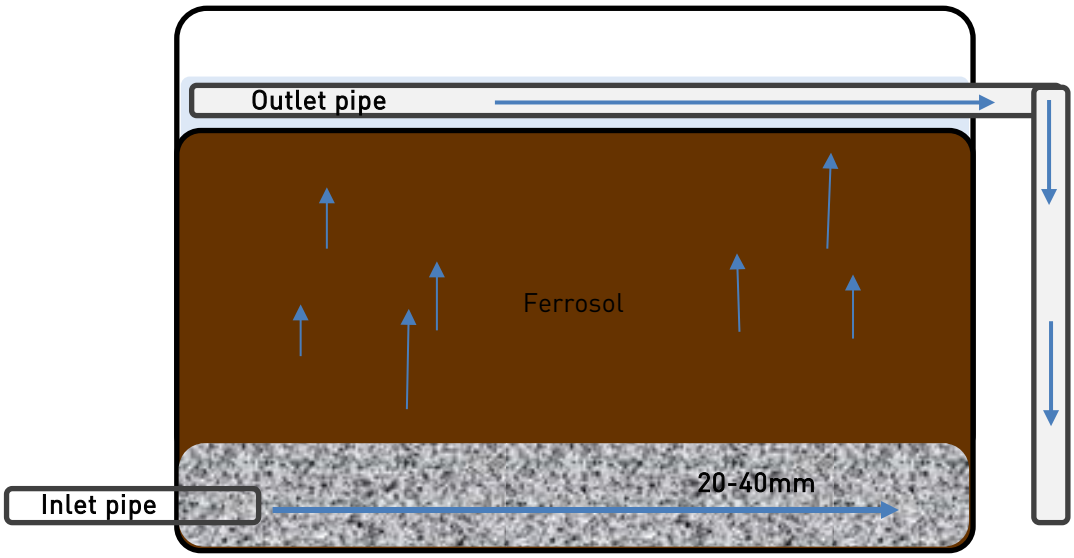


Figure 5-5: Downward flow ferrosol filter

5.4 Key hydraulic parameters for trial

In order to assess the ability of the constructed wetland and bioreactors at removing sulphate from the mine waters, several separate investigations will be required. These investigations will commence with the uniform application of water to the various treatment elements with the objective of achieving the desired level of sulphate reduction. Based on the review of the literature and investigations undertaken by the CSIRO, sulphate reduction rates of between 65-120 g/m^3/day could be achieved. Using this information and the key treatment system details outlined in the preceding section, a guiding hydraulic regime can be established.

Table 5-3 presents the key hydraulic design parameters for the proposed trial, stating that for a hydraulic load rate of 0.1, 0.1 and 1.5 m^3/day for the in tank bioreactor, in pipe bioreactor and treatment wetland is required to achieve a predicted sulphate outlet concentration of 750-850 mg/L respectively. This outlet concentration is based on an assumed inlet sulphate concentration of 1400 mg/L and a 'Low rate' sulphate reduction rate of 65g m^3/day.

Sampling of the three bioreactor / wetland treatments will commence in mid January 2020, following a 6-12 week commissioning period (refer to Table 5-4). Sampling is suggested to occur three times per week, on the morning of the Monday. Tuesday and Friday. Each sample should be collected, transported and analysed in accordance with Mt Rawdon Mines current water sampling QA/QC protocol. Parameters for analysis should include:

- Nitrate + Nitrite
- Sulphate
- Cadmium
- Copper
- Zinc
- Iron
- Total Dissolved Solids (insitu)
- Electrical Conductivity (insitu)
- pH (insitu)
- Temperature (insitu)
- Dissolved Oxygen (insitu)
- Redox Potential (insitu)

As shown in the conceptual layout plans (Appendix A), flow meters are positioned at the inlet to each treatment. At the time of water sample collection, these flow meters should be read and the data recorded. It is imperative that accurate flow data be recorded to calculate sulphate reduction rates per treatment element. This information will be key to the upscaling of the system should this trial be successful.

Appendix A provides a conceptual layout, include cross sections of the proposed trial.

Table 5-3: Key hydraulic design parameters for the proposed sulphate reduction trial

		Unit	Bioreactor		Constructed Wetland
			1000L tank	In pipe	
Length		m	1	6.00	12.00
Width		m	1		4.00
Depth / diameter		m	1	0.45	0.60
Volume		m^3	1	0.95	28.8
Surface area		m^2	1	0.64	48.00
Predicted sulphate removal rates					
Low rate Note 1	SO4 removed	g/m^3/day	65	65	5
High rate Note 2			120	120	10
Hydraulics and predicted outlet sulphate concentrations					
Low rate Note 1	Flow delivered	m^3/day	0.1	0.1	0.1
	Sulphate load delivered Note 3	g/day	140	140	140
	Predicted sulphate removal	g/day	65	62.01	144
	Effluent sulphate load	g/day	75	77.98	1206.98
	Predicted concentration	**mg/L**	**750**	**779.85**	**804.65**
High rate Note 2	Flow delivered	m^3/day	0.2	0.2	0.2
	Sulphate load delivered Note 3	g/day	280	280.00	4200.00
	Predicted sulphate removal	g/day	120	114.4	288
	Effluent sulphate load	g/day	160	165.51	2551.35
	Predicted concentration	**mg/L**	**800**	**827.55**	**850.45**

Note 1:	All bioreactor calculations based on an assumed sulphate removal rate of 65 g/m^3/day; wetland calculation based on 5 g/m^3/day
Note 2:	All bioreactor calculations based on an assumed sulphate removal rate of 120 g/m^3/day; wetland calculation based on 10 g/m^3/day
Note 3:	Assumed inlet sulphate concentration of 1400 mg/L

Table 5-4: Propose sampling regime

Monitoring year	Month	Week	Sampling regime	Sample frequency	# samples per regime	Hydraulic inflow rate, m^3/day		
						In tank bioreactor	In pipe bioreactor	Constructed wetland
2019	Nov – Dec	all	See Note 1			0.1	0.1	1.5
2020	Jan	1	n/a	n/a	n/a	0.1	0.1	1.5
		2	n/a	n/a	n/a	0.1	0.1	1.5
		3	1	3 samples / week	12	0.1	0.1	1.5
		4	1			0.1	0.1	1.5
	Feb	1	1			0.1	0.1	1.5
		2	1			0.1	0.1	1.5
		3	See Note 2			0.2	0.2	3.0
		4				0.2	0.2	3.0
	Mar	1	1	3 samples / week	12	0.2	0.2	3.0
		2	1			0.2	0.2	3.0
		3	1			0.2	0.2	3.0
		4	1			0.2	0.2	3.0
	Apr	1	Note 2			Note 3		
		2						
		3	1	3 samples / week	12			
		4	1					
	May	1	1					
		2	1					
		3						
		4						
Note 1	Provide respective flow rates for system commissioning							
Note 2	Provide 2 weeks flow at new hydraulic inflow rates to re-calibrate systems							
Note 3	To be determined as a result from preceding investigations							

6 Conclusion and recommendations

The use of constructed wetland and / or bioreactor technology for the reduction of sulphate within the wastewater from the Mt Rawdon Mining Operations potentially poses a cost effective, robust and long term solution to the management of sulphate, zinc, and cadmium concentrations. While there are good examples worldwide of where this technology has been used to manage water quality compliance issues within mining operations, their application, design of technology and operation are varied. As such, a pilot scale feasibility assessment is recommended prior to the full scale construction and operation of a treatment system for the Mt Rawdon Mining Operations site. Preliminary costs to implement the above trial are presented in Appendix B,

This feasibility assessment aims to assess the use of bioreactors and wetlands to primarily reduce sulphate concentrations, but also provide zinc and cadmium removal. The pilot scale assessment will investigate the performance of these systems under a scaled down application, treating 0.1m^3 of water per day. Based on a literature review of sulphate reduction rates, this hydraulic loading rate should result in a sulphate outlet concentration of >100mg/L, assuming an inlet concentration of ~ 1400mg/L.

As the sulphate reduction rates reported within the literature are similar to that recorded during this investigation, the size a of full scale system (to treat 7.5m^3/day water) would be:

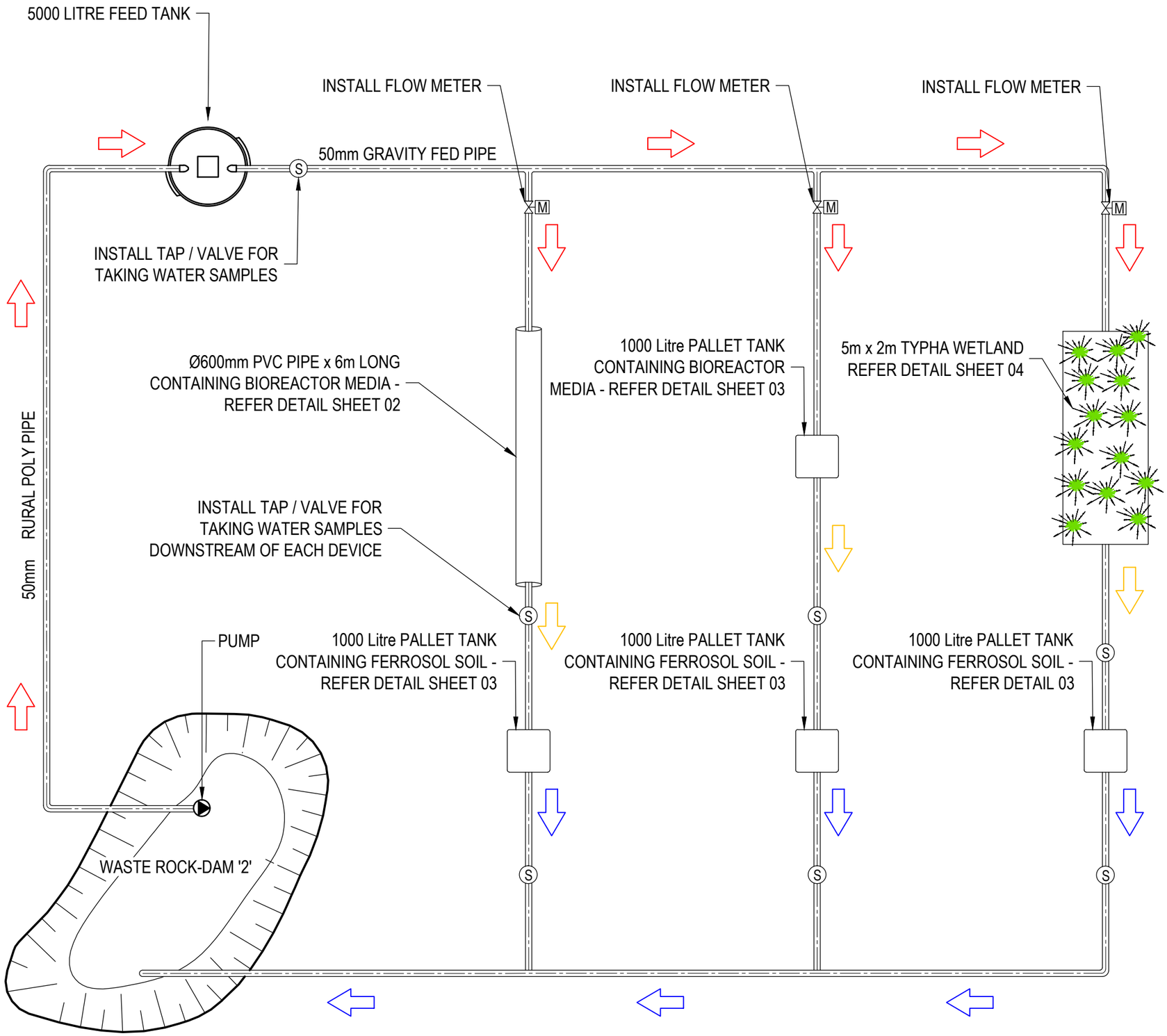
- 160m^3 bioreactor bed,
- 1000m bioreactor pipe (0.45m diameter), or
- 3,500m^2 wetland.

Results from this assessment will report sulphate reduction rates for each of the treatment units. This will enable the upscaling of the most applicable design with a degree of confidence around its performance.

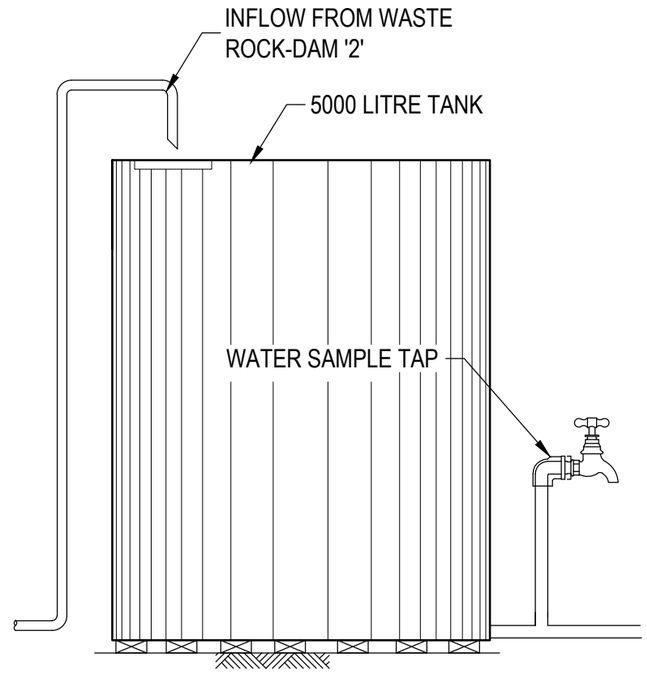
7 References

To do.....

Appendix A – Trial design



SCHEMATIC PLAN - NOT TO SCALE



FEED TANK ELEVATION

PROJECT

BIOREACTOR TREATMENT EXPERIMENT

DRAWING

PLAN VIEW SCHEMATIC

CLIENT

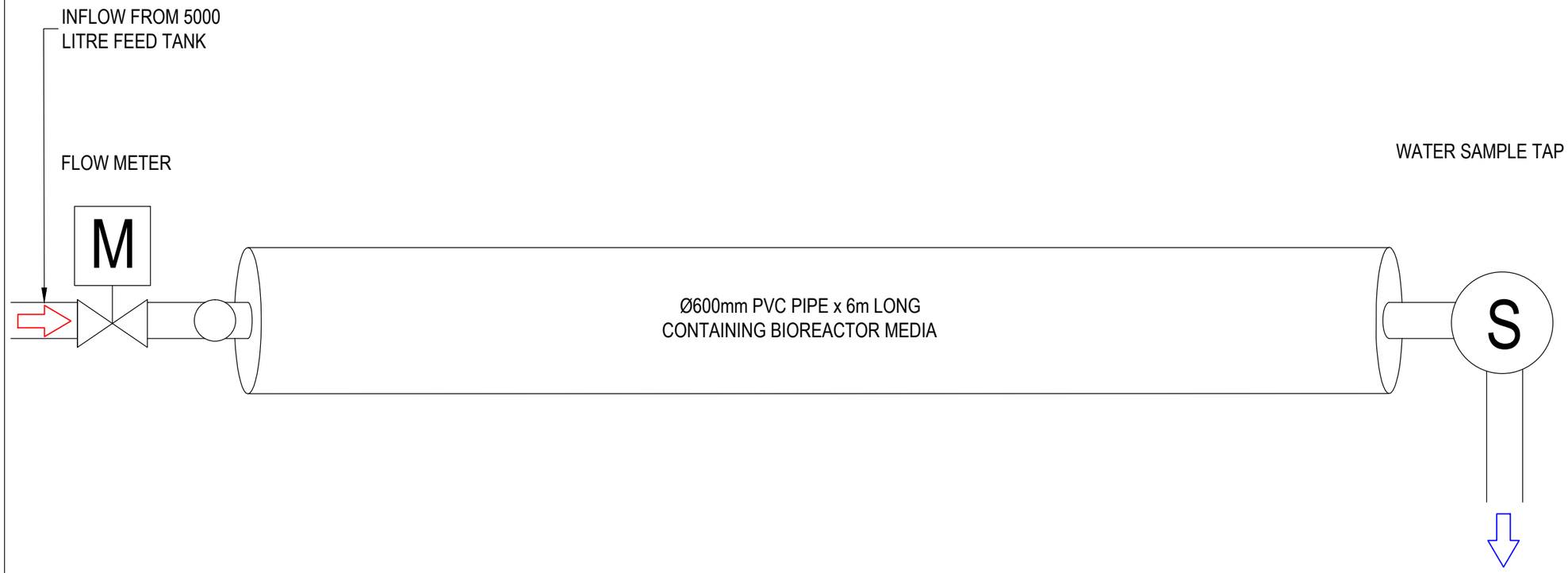
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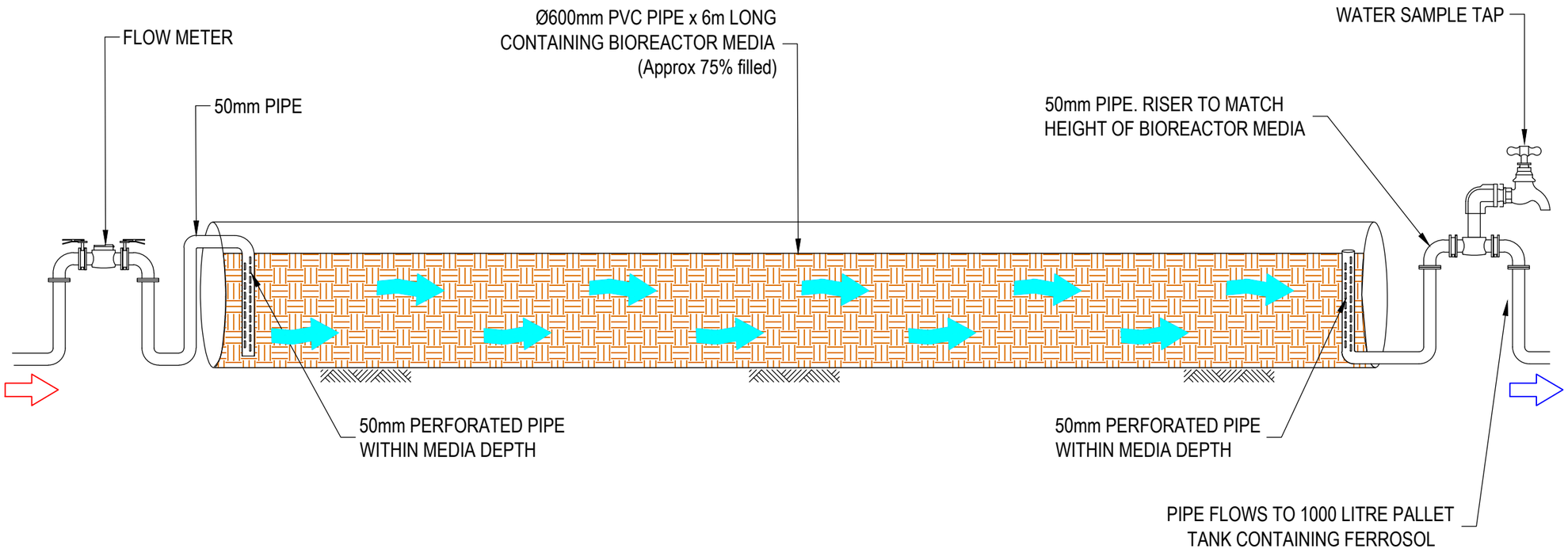
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PLAN VIEW



ELEVATION VIEW

PROJECT

BIOREACTOR TREATMENT EXPERIMENT

DRAWING

PLAN SCHEMATIC & SECTION
OF TREATMENT 1

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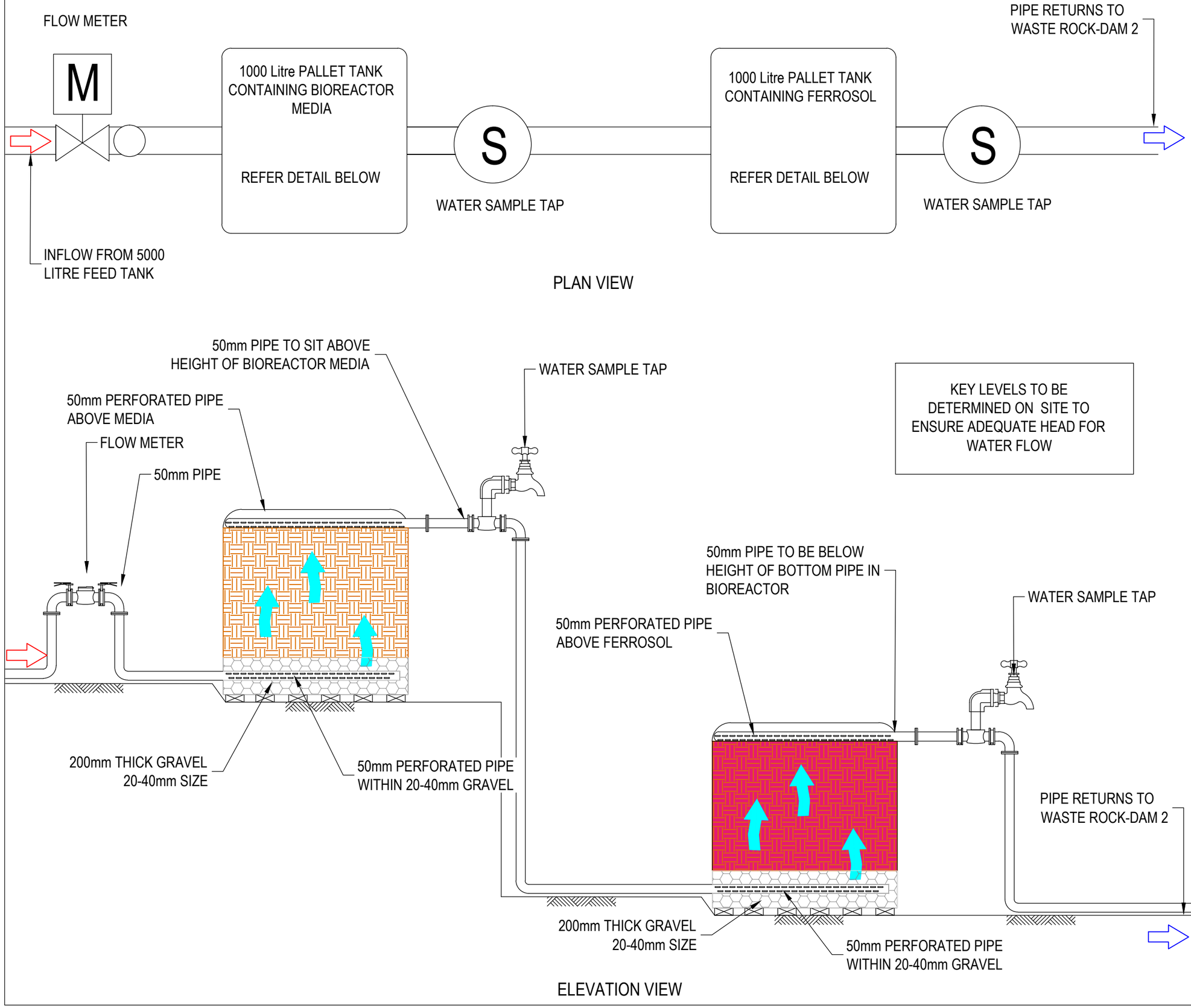
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KEY LEVELS TO BE DETERMINED ON SITE TO ENSURE ADEQUATE HEAD FOR WATER FLOW

PROJECT

BIOREACTOR TREATMENT EXPERIMENT

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PLAN SCHEMATIC & SECTION OF TREATMENT 2

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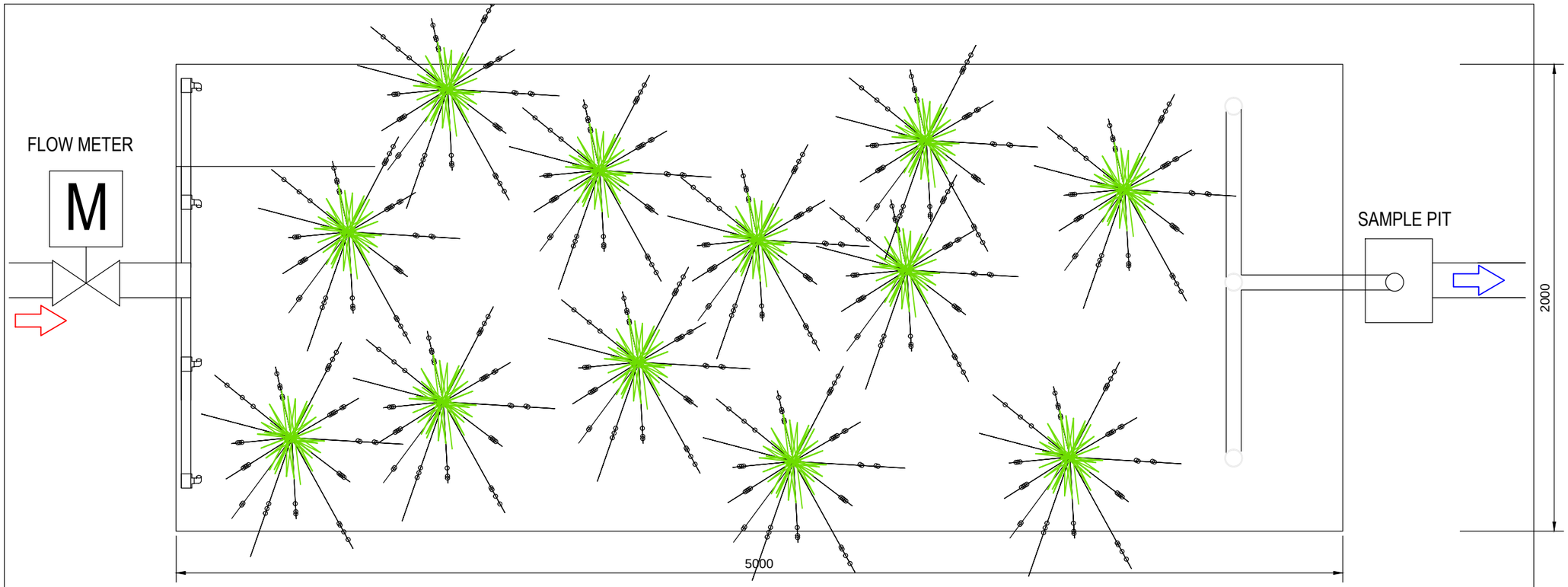
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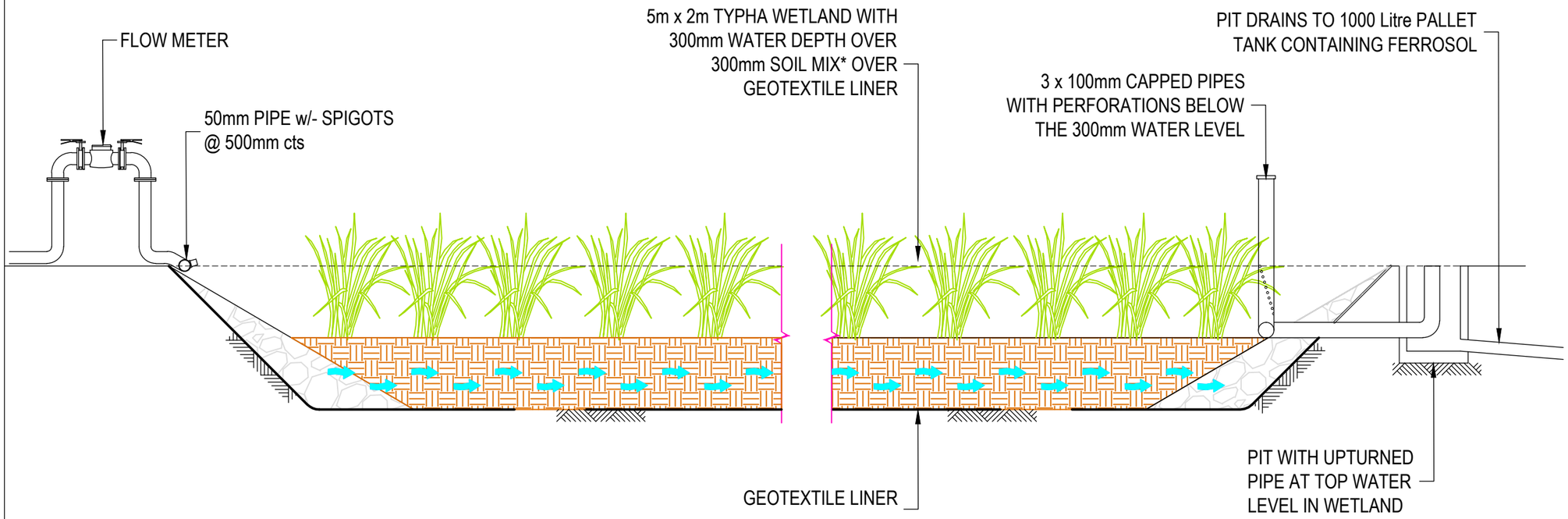
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PLAN VIEW



ELEVATION VIEW

* SOIL MIX COMPRISES
50% BIOREACTOR MEDIA
50% FERROSOL

PROJECT

BIOREACTOR TREATMENT EXPERIMENT

DRAWING

PLAN SCHEMATIC & SECTION
OF TREATMENT 3

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Appendix B – Preliminary costing



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MOUNT RAWDON OPERATION

Final Void Study Report

Prepared for:

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SLR Ref: 620.30185-R01
Version No: -v2.0
December 2020

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Mount Rawdon Operations Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
620.30185-R01-v2.0	1 December 2020	Louis Bouchet	Brian Rask	Brian Rask
620.30185-R01-v1.0	11 November 2020	Louis Bouchet, Lilia Criste	Fiona Stark, Brian Rask	Brian Rask

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Appendix A Post-Closure Groundwater Level Cross Sections

1 Introduction

1.1 Study Objectives

As part of its Mine Closure Planning, Mount Rawdon Operation (MRO) is looking to update its existing steady state groundwater model to predict post-closure groundwater levels and assess potential risks to environmental receptors.

1.2 Scope of Work

The scope of work includes the development of a recovery groundwater model and a surface water final void model. An iterative modelling process is required between the groundwater numerical model and the final void model to develop a groundwater inflow relationship for the final void. The final void model then provides long-term estimate of water level and salt concentration for the void stored water while the groundwater recovery model allows estimating post-closure (equilibrium) groundwater levels, potential areas of seepage and discharge to creeks.

2 Background Information

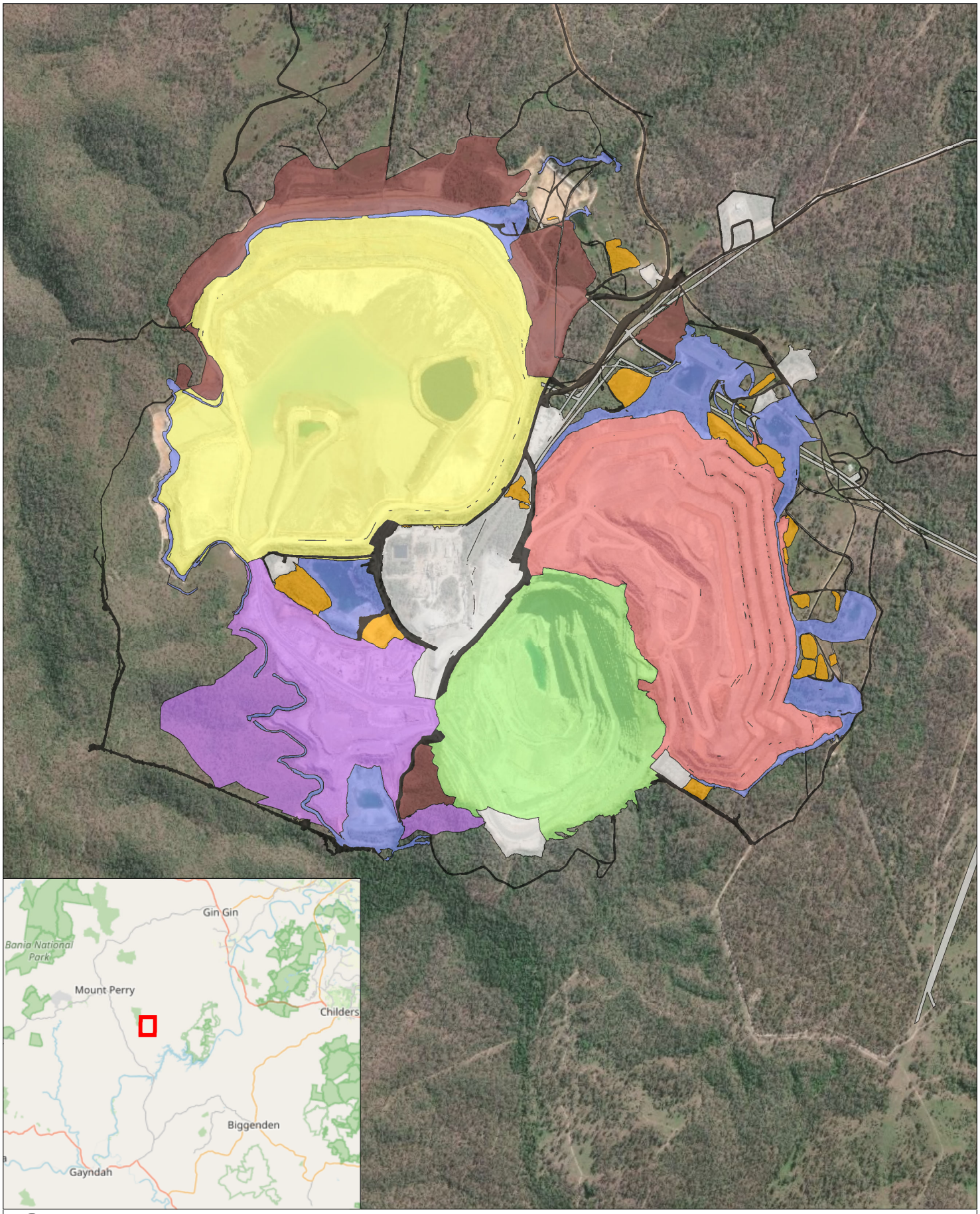
2.1 Site Overview

MRO is located 75km southwest of Bundaberg. The mine production is from a single open pit, utilising conventional drill and blast, load and haul methodologies. Mining operation started in 2001 under Equigold NL ownership. Since 2011, Evolution Mining has owned and operated the Mt Rawdon mine. The current life of mine extends to 2027.

The site main infrastructures includes the Pit, the Tailing Storage Facility (TSF), the North Waste Rock Dump (NWRD), The West Waste Rock Dump (WWRD), several storage and sediment dams as well as roads and offices (**Figure 1**).

2.2 Post Closure Topography and Hydrology

The topography of MRO originally fell away steeply from the top of Mount Rawdon to the northeast of the site, leading to undulating hills at the base of the mountain. Following the commencement of mining, most of Mt Rawdon has been dug out and is now a pit. The land slopes gently over a distance of 3km to alluvial flats along the Perry River. Estimated post closure topography includes the North Waste Rock Dump (NWRD) with a maximum height of 251mAHD, the West Waste Rock Dump with a maximum height of 195mAHD, the Tailing Storage Facility (TSF) with a capped maximum elevation of 193mAHD and the final void (pit) with a maximum depth of -250mAHD (**Figure 2**).



0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:20,000 at A4
Project Number:	620.30185
Date:	20-Oct-2020
Drawn by:	JG

TSF
North WRD
West WRD
Borrow Pit
Pit
Roads
Topsoil
Water Management
Other Infrastructure

MT RAWDON POST-CLOSURE GROUNDWATER MODEL

Site Overview

FIGURE 1

H:\Projects-SLR\620-BNE\620.30185.00000 Mt Rawdon Post Closure Groundwater model\06 SLR Data\01 CADGIS\GIS\62030185 F01 Site Overview.mxd



0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:30,000 at A4
Project Number:	620.30185
Date:	21-Oct-2020
Drawn by:	JG

Watercourses

Elevation (m)

- -245 to -200
- -200 to -100
- -100 to -50
- -50 to 0
- 0 to 50
- 50 to 100
- 100 to 200
- 200 to 300
- 300 to 400
- >400

MT RAWDON POST-CLOSURE GROUNDWATER MODEL

Final Landform Contours and Hydrology

FIGURE 2

H:\Projects-SLR\620-BNE\620.30185.00000 Mt Rawdon Post Closure Groundwater model\06 SLR Data\01 CADGIS\GIS\62030185 F02 Final Landform contours and hydrology.mxd

MRO is situated in the Lower Burnett sub-catchment of the Burnett Basin catchment. Surface runoff from MRO drains into the Burnett River towards the south and into the Perry River towards the north. Swindon Creek, Rawdon Creek and Twelve Mile Creek are ephemeral creeks that course to the northeast and discharge into the Perry River. The Perry River flows in an easterly direction and merges with the Burnett River near Morganville, approximately 35km downstream of MRO and 25km directly to the northeast of the site. The southern boundary of the pit is adjacent to the crest of a hill called Mount Rawdon. The southern area of the mine site drains to the southeast via Mingham Creek into the Burnett River (**Figure 2**).

Runoff from the mining lease travels overland rapidly, and surface flow in ephemeral creeks is only sustained for a few hours following a rainfall event. For most of the year there is no flow in the Perry River, water pools in a series of low volume waterholes (Angus and Lewis, 1996). A network of drainage lines within site feed Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham Creek after rainfall. The northern area of the site drains into the Perry River via Twelve Mile Creek, Rawdon Creek, Swindon Creek and an un-named creek. The southern area of the site drains via drainage lines into Mingham Creek, an ephemeral system that during heavy rainfall will flow into the Burnett River approximately 8km south of the site. The primary source of surface water at MRO is runoff subsequent to a rainfall event which is stored in the impoundment of Perry River Weir. Within MRO, a network of diversion drains channel clean water runoff away from operational areas and prohibits mixing of potentially mine affected runoff with clean stormwater.

2.3 Climate

2.3.1 Past and Current Climate

The average monthly rainfall based on the data collected onsite at MRO from January 2001 to 2019 and the patched point data from Mount Perry the Pines Bureau of Meteorology (BOM) weather station (039070) for the same period are shown in **Figure 3**. It is evident from this figure that the wet season rainfall at MRO is slightly higher than Mount Perry the Pines BOM station. While overall, the rainfall at both locations is similar, MRO appears to be prone to more intense, local rainfall events relative to Mount Perry the Pines, most likely due to the local topography surrounding Mount Rawdon.

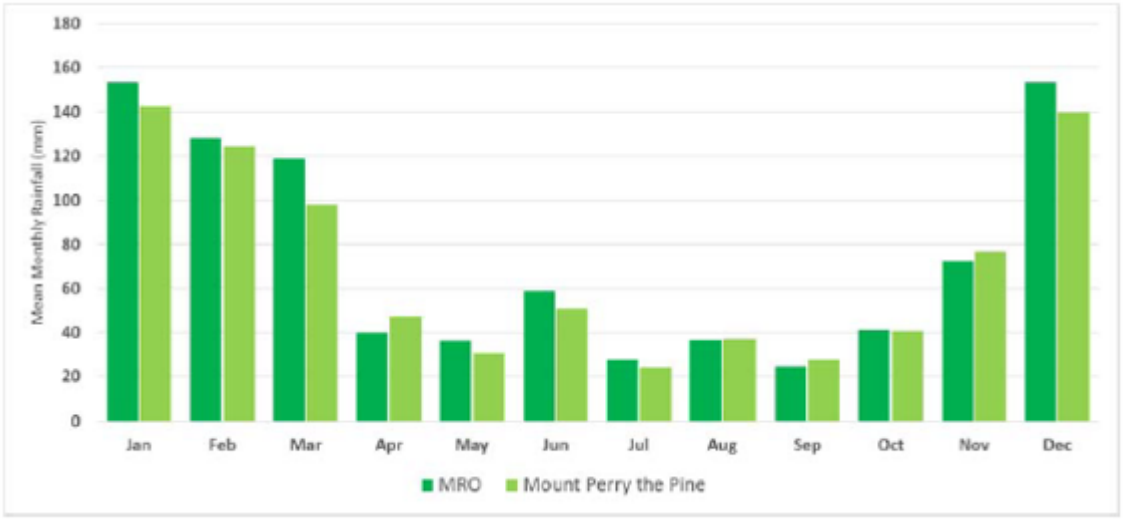


Figure 3 Comparison of long-term average rainfall at MRO and Mount Perry the Pines

Pan evaporation data available from Mount Perry the Pines weather station shows that evaporation is on average two to three time greater than rainfall (**Figure 4**).

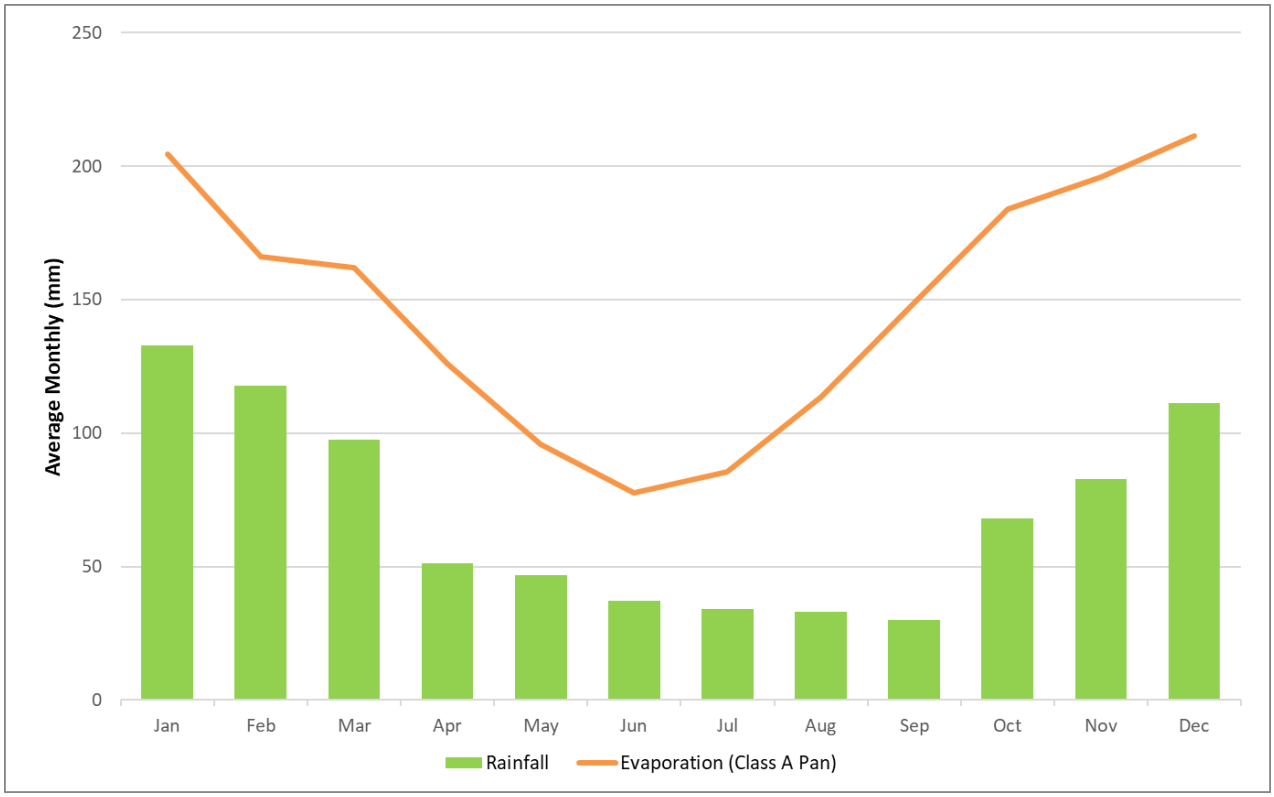


Figure 4 Average monthly rainfall and class A Pan evaporation from January 1970 to September 2020 at BOM station 39070 Mount Perry the Pines

2.3.2 Future Climate

Future climate prediction has been investigated using the Australian Climate Future (ACF) tool. The ACF tool *is a flexible, multi-purpose decision-support tool to assist understanding and application of climate change projections for impact assessment and adaptation planning* (CSIRO 2020).

The climate futures tool shows the percentage change in rainfall, evaporation and evapotranspiration for the predicted years. The tool allows the user to view climate change scenarios for a region of interest. The MRO site is located in the East Coast area of Australia (as defined by the ACF tool). There are four Representative Concentration scenarios (RCPs) which represent different greenhouse gas concentration scenarios. The percentage value for each RCP indicates the percentage of models (n) which had the corresponding outcome of percent rainfall, evaporation or evapotranspiration. For example, in 2050 for RCP 2.6, 38% (11 of 29) models predicted -5 to -15 percent rainfall.

2.3.2.1 Future Rainfall

Based on the annual rainfall comparison tables (**Table 1, Table 2** and **Table 3**), most scenarios show that rainfall is likely to vary from 5 to -15% in the next 70 years, indicating little change in annual rainfall or a shift to a lower annual rainfall. However, it should be noted that climate change predictions indicate that individual events may increase in intensity even as annual rainfall totals decrease.

Table 1 Predicted scenarios for 30 years time – Rainfall 2050

% Annual Rainfall Comparison	RCP 2.6 (n=29)	RCP 4.5 (n=68)	RCP 6.0 (n=22)	RCP 8.5 (n=70)	Average
>15% (much wetter)	-	1%	-	3%	2%
5 to 15% (wetter)	24%	15%	14%	16%	17%
-5 to 5 (little change)	31%	54%	50%	31%	45%
-15 to -5 (drier)	38%	22%	32%	33%	29%
> -15% (much drier)	7%	7%	5%	17%	9%

Table 2 Predicted scenarios for 50 years time – Rainfall 2070

% Annual Rainfall Comparison	RCP 2.6 (n=29)	RCP 4.5 (n=68)	RCP 6.0 (n=22)	RCP 8.5 (n=70)	Average
>15% (much wetter)	-	-	5%	1%	3%
5 to 15% (wetter)	14%	15%	18%	19%	17%
-5 to 5 (little change)	38%	47%	41%	24%	37%
-15 to -5 (drier)	34%	24%	27%	30%	27%
> -15% (much drier)	14%	15%	9%	26%	16%

Table 3 Predicted scenarios for 70 years time – Rainfall 2090

% Annual Rainfall Comparison	RCP 2.6 (n=29)	RCP 4.5 (n=68)	RCP 6.0 (n=22)	RCP 8.5 (n=70)	Average
>15% (much wetter)	-	-	9%	6%	8%
5 to 15% (wetter)	14%	15%	23%	13%	16%
-5 to 5 (little change)	34%	29%	27%	21%	26%
-15 to -5 (drier)	24%	40%	23%	23%	29%
> -15% (much drier)	28%	16%	18%	37%	25%

2.3.2.2 Future Evaporation and Evapotranspiration

All scenarios showed that evaporation and evapotranspiration was most likely to increase by >4.59%. **Table 7** presents three emission scenarios B1 (low emissions), A1B (medium emissions) and A2 (high emissions) for 2070 (data was not available for other timeframes) all scenarios showed that evaporation was most likely to increase by >4.59%.

Table 4 Predicted scenarios for 30 years time – Evapotranspiration 2050

% Annual Evapotranspiration	RCP 2.6	RCP 4.5 (n=28)	RCP 6.0	RCP 8.5 (n=29)	Average
>4.59 (Large increase)	-	39%	-	90%	64.5%
1.00 to 4.59 (Small increase)	-	61%	-	10%	35.5%
-1.00 to 1.00 (No change)	-	-	-	-	-

% Annual Evapotranspiration	RCP 2.6	RCP 4.5 (n=28)	RCP 6.0	RCP 8.5 (n=29)	Average
-4.59 to -1.00 (Small decrease)	-	-	-	-	-
<-4.59 (Large decrease)	-	-	-	-	-

Table 5 Predicted scenarios for 50 years time – Evapotranspiration 2070

% Annual Evapotranspiration	RCP 2.6	RCP 4.5 (n=28)	RCP 6.0	RCP 8.5	Average
>4.59 (Large increase)	-	75%	-	100%	87.5%
1.00 to 4.59 (Small increase)	-	25%	-	-	25%
-1.00 to 1.00 (No change)	-	-	-	-	-
-4.59 to -1.00 (Small decrease)	-	-	-	-	-
<-4.59 (Large decrease)	-	-	-	-	-

Table 6 Predicted scenarios for 70 years time – Evapotranspiration 2090

% Annual Evapotranspiration	RCP 2.6	RCP 4.5 (n=28)	RCP 6.0	RCP 8.5	Average
>4.59 (Large increase)	-	82%	-	100%	91%
1.00 to 4.59 (Small increase)	-	18%	-	-	18%
-1.00 to 1.00 (No change)	-	-	-	-	-
-4.59 to -1.00 (Small decrease)	-	-	-	-	-
<-4.59 (Large decrease)	-	-	-	-	-

Table 7 Predicted scenarios for 70 years time – Evaporation 2090

% Annual Evaporation	B1 Low emissions (n=10)	A1B medium emissions (n=11)	A2 High emissions (n=9)	Average
>4.59 (Large increase)	70%	91%	67%	76%
1.00 to 4.59 (Small increase)	30%	9%	11%	16.7%
-1.00 to 1.00 (No change)	-	-	-	-
-4.59 to -1.00 (Small decrease)	-	-	11%	11%
<-4.59 (Large decrease)	-	-	11%	11%

2.4 Geology

2.4.1 Regional Geology

The Mount Rawdon gold deposit is hosted within the Late Triassic Aranbanga Volcanics which consists of predominantly rhyolitic to dacitic volcanic and volcaniclastic rocks, with minor basalt at the base of these formations. Underlying the Aranbanga Volcanics are Carboniferous metasediments of the Curtis Island Group which are the oldest rocks in the area. Granitoid intrusions into the Curtis Island Group belong to the Briggs granodiorite formation that has a Triassic to Permian age. These geological formations have been intruded by numerous dykes and sills (Horton et al., 1980).

Two major fault systems occur in the area: an east-northeast trending Swindon Fault, and north-northwest trending Mount Perry Fault. These faults have likely influenced the directional trends of dykes, sills and volcanic flows. Mount Rawdon is situated to the north of the Swindon Fault and east of the Mount Perry Fault.

2.4.2 Site Geology

The Mount Rawdon gold deposit is enclosed within volcanoclastic rocks. The volcanoclastic rocks are bound by faults mainly on the western, eastern and southern sides. A north-south trending band of dacite and rhyodacite rocks (Curtis Island Group) separates andesitic rock (Aranbanga Volcanic Group) to the west from the volcanoclastic rocks in the east associated with the gold deposit and Mount Rawdon pit. To the north, east, south, and southwest of the pit lies an expanse of metasedimentary outcrops. Within these metasediments, minor pockets of phyllite outcrop occur adjacent to the northern embankment of the TSF and further northeast of that area around Perry River. Phyllite is more prominent in a large wedge-shaped area about 2km east of the TSF. Gneiss is the predominant metasedimentary rock at the surface in the areas to the east, south and southwest of the pit. A patch of gneiss also occurs north of the TSF. Small outcrops of Briggs Granodiorite occur about 1km north of the TSF, with outcropping patches becoming larger in area about 2km north of the TSF north embankment.

Numerous local faults cut across the site which includes steep to moderate dipping N-S, NW-SE, and NE-SW faults (Howard, n.d.). Multiple N-S and SW-NE faults are prominent around the pit area, running northwards past the south-eastern extent of the TSF. Three other SW-NE fault structures exist to the north of the TSF and were the target of investigative bores drilled in a past hydrogeological investigation. Two of the main dykes outcropping at the ground surface traverse east to west across the pit (Dugdale, 2014).

2.5 Hydrogeology

Groundwater storages are compartmentalised, with variable transmissivity in different parts of the mine lease. Interconnectivity of the compartments is weak except, potentially, after major storm events when the soil and saprolite recharge and become saturated (Klohn Crippen Berger, 2010). Angus and Lewis (1996) reported that aquifers at MRO have limited areal occurrence and groundwater flow is fracture-controlled with yields of up to 0.8L/s.

The main water bearing zones at MRO are the fractures in hard rock belonging to the Aranbanga Volcanic Group (AVG) or the Curtis Island Group (CIG). Aquifers are underlain by basement rocks with very low permeability due to reduced fracture intensity. Drilling records of monitoring bores at MRO also show that some of the water bearing fracture zones are overlain by localised clayey layers of decomposed rocks.

2.5.1 Hydrogeological Units

Drilling records for monitoring bores (KCB, 2012; NRC, 2014a) indicate the presence of three main hydrogeological units: The regolith, the fractured rock aquifer and the basement rock.

2.5.1.1 Regolith

The regolith consists of an organic-rich topsoil layer less than a metre thick. This is underlain by gravel, sand or a clay layer of thickness varying from 1 to 4m and highly decomposed/ weathered igneous rocks up to a thickness of 15m. Groundwater levels from the monitoring bores suggest that the regolith is usually permanently saturated near mine water storages such as the TSF and runoff containment dams. Elsewhere, the regolith contains water predominantly in the form of soil moisture and is generally unsaturated. Nearly all recharge occurs due to rainfall infiltrating through the regolith within the catchment. The weathering zone becomes saturated during rainfall events and is expected to be a significant source of groundwater recharge. No continuous aquifer system is present up to the depth of 20m below ground surface (Allan Watson Associates, 2012).

2.5.1.2 Fractured Rock Aquifer

Groundwater monitoring bores at MRO are less than 50m deep. Saturated zones in these bores lie either in the mudstone, chert, minor mafic volcanics or metasediments of the CIG and dacite or dacite-rich volcanics of the AVG. The upper beds of the AVG and CIG form the fractured rock aquifer. Most groundwater bores in rock fractures intercept groundwater in joints and isolated fractures (low volume aquifer compartments), with these “aquifers” having low storativity. Groundwater bearing zones in fractured rock at MRO are mainly aquicludes, with possibly bimodal porosity, and isolated or semi-isolated compartments of fractured rock surrounded by competent rock.

2.5.1.3 Basement Unit

Basement consists of fresh granite, dacite, rhyolite or granodiorite occurring generally at depths of more than 30m below ground level but very close to surface in some areas. Fracturing intensity in this unit is very low and therefore it accounts for little groundwater flow.

2.5.2 Groundwater flow

2.5.2.1 Water Levels

There is large variation in standing water level (SWL) observed at MRO. Saturated thickness of aquifers is also highly variable. Drilling records suggest that most of the monitoring bores encountered water bearing zones of very low supply capacity, possibly at the intersection of the weathered top layer with the less permeable basement. Aquifer yields have also been reported to be lower than 0.5L/s for more than two thirds of all groundwater monitoring bores at site (NRC, 2014b).

2.5.2.2 Recharge and discharge

Rainfall is the major source of recharge at MRO. Changes to the ponded water level in the TSF (i.e. decant level) are also regulated largely by rainfall rather than process water inputs. This is due to the water content in the tailings being small in comparison to rainfall. Major groundwater recharge areas at MRO are expected to be the weathered outcropping hills located on the western side of the mining lease. Alluvial deposits underlying or in vicinity of streams can also be minor sources of recharge during very short periods of flow. RPS (2015) identified that, since the commencement of mining, the TSF the NWRD and runoff containment dams downstream of the NWRD have become sources of groundwater recharge.

The open pit is the main discharge area for groundwater owing to a steep hydraulic gradient towards the open pit. Apart from this, there are no known perennial discharge areas for groundwater. Flow in all watercourses at MRO ceases within hours of cessation of a rainfall event. Base flow contribution to these streams is negligible both in volume as well as duration (up to two weeks) which is a further affirmation of low storativity (aquifer potential) of aquifers at MRO.

2.5.2.3 Flow Direction

The RPS (2015) seepage memorandum identified a prominent set of northeast to southwest trending faults reported in several hydrogeological studies, with local drainages tending to follow these broad fault lines (RPS, 2015).

Data from groundwater monitoring indicates that the northeast-southwest trending fault located between the TSF and the pit forms a hydraulic barrier to groundwater flow across the fault (i.e. preventing northwest to southeast flow; RPS, 2015). RPS concludes that other than local influences on groundwater flow already identified here, overall groundwater flow in the area remains similar to pre-mining conditions.

The RPS memorandum identified that pre-mining groundwater flows were largely controlled by topography and drainage, with groundwater flowing from elevated areas toward the major creek lines and then following the major drainage systems (through alluvium and underlying weathered and fractured basement rocks). The memorandum states that there will have been some groundwater baseflow to the local creeks (springs) at topographic breakaways. Most of the pre-mining groundwater flow was to the northeast, parallel with Swindon, Rawdon and Twelve Mile Creeks, towards the Perry River with some minor groundwater flows to the south toward Mingham Creek (RPS, 2015). Since the commencement of mining, local groundwater flow patterns have been influenced by site activities, with RPS identifying that the TSF, NWRD and runoff containment dams downstream of the NWRD have become sources of groundwater recharge, while the pit has become a groundwater sink (RPS, 2015).

2.5.3 Hydraulic Conductivity

A series of slug tests and pump tests have been conducted by NRC and MRO from 2015 to 2018. Most of the bores tested were located within the fractured rock aquifer while a few bores monitor the regolith and the basement rock. Available bore logs indicate that several bores are screened both in the regolith (or weathered zone) and fractured rock. Also, several bore logs were not available. For consistency purposes, statistics were performed on the bore based on screen depth: Bores partially screened within 5 to 15m between the surface were grouped as part of the regolith and bores partially screened within 16 to 50m below surface were grouped as part of the fractured rock aquifer. Statistics are provided in **Table 8**.

Table 8 Statistics of horizontal hydraulic conductivity in the weathered and fractured rock zones

Kx	Min (m/d)	Max (m/d)	Average (m/d)	Median (m/d)
Weathered rock	5.90E-02	4.60	1.08	3.15E-01
Fractured rock	3.53E-04	6.10	5.31E-01	4.36E-02

3 Numerical Groundwater Modelling

A steady state groundwater numerical model was developed by NRC (2019) to identify flow directions, flow rates and preferential groundwater pathway around the mine site. This model was updated for this assessment. Model specifications and updates are presented in this section.

3.1 Model Verification

The Steady State model was developed in 2018, reflecting 2018 site development conditions (i.e. Waste rock dumps location and height; Pit extent; TSF extent and height). The model was calibrated against water level in 37 boreholes, measured in December 2017.

The calibration was satisfactory with a Scaled Root Mean Square Error (SRMSE) of 7.8%. However, the simulated inflows to the pit were not compared with measured inflows to the pit.

To verify that the simulated inflows are comparable with measured data, the average flow rate of water pumped out of the pit is compared to the rate of groundwater inflows to the pit simulated in the model. The flow rate from the pit sump is an estimation of maximum groundwater inflows, as it also includes water from rainfall over the open pit and run-off.

The average pumping rate (2007 – 2019) is 1.47ML/day. However, 2017 was a particularly wet year with yearly pumping rate 10x time higher than average (likely due to higher rainfall and run-off). The average pumping rate for the period 2007-2016 and 2018-2019 (i.e. omitting 2017) is 0.70ML/day which is very close to the measured groundwater inflow to the pit in the model (0.72ML/d). The model is thus considered fit for purpose (**Figure 5**).

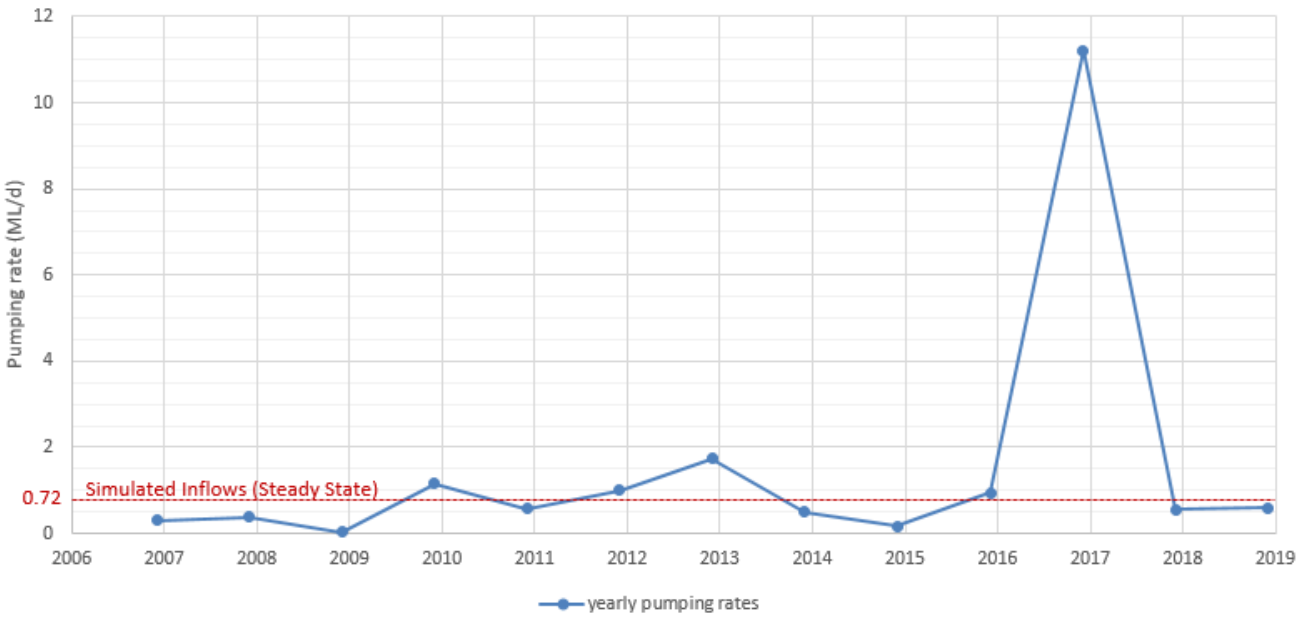


Figure 5 Simulated inflows and yearly pumping rates for the Mt Rawdon pit

3.2 Model Updates Summary

The existing steady state model, which was developed to simulate condition as in 2018, was modified as follows for the post closure modelling:

- The top elevation of layer 1 (surface elevation) was modified to match the final landform (as discussed in **Section 2.2** for the following site infrastructures:
  - TSF (RL 193);
  - NWRD; and
  - WWRD.
- The bottom elevation of the basement rock layer (layer 7) was "pushed down" by 200m to capture the full depth of the final void;
- The drains set up to represent the 2018 pit shell and seepage interception trenches were removed;
- The hydraulic conductivity of the hydrogeological units intercepted by the full extent of the final void were changed to represent a void (or "Air" hydraulic conductivity). A nominal high conductivity value of 10 m/d was selected and checked as appropriate;
- The Constant Head Boundary (CHD) cells set up to represent the TSF dam level were removed; and
- The groundwater recharge to the TSF was set as 0.01% of rainfall (2.5 $x10^{-07}$ m/d).

3.3 Model Specifications

3.3.1 Model Grid

The model grid has a fine discretisation (10x10m) around the mine's infrastructure to allow more detailed representation of groundwater flow around the TSF and the pit. Further away from the site, the grid progressively increases to a coarser discretisation (50x50m). The model is discretised into 449 columns and 406 rows **Figure 6**.

3.3.2 Model Layers

The model was discretised vertically through 7 layers of variable thickness, using AHD as a reference datum for elevation (**Figure 7** and **Table 9**). The ground surface elevation was assigned to the top of the first layer by importing a DEM provided by Evolution in 2018. The top elevation of layer 1 was updated to include final landform infrastructures as detailed in **Section 3.2.** The vertical discretisation is designed to capture the features that control or impact groundwater flow. This includes both the modified landscape (i.e. mining infrastructure) and the natural hydrology and geology. The first layer allows representation of mining infrastructure that is above the natural (i.e. pre mining) elevation. The second layer represents the top soil and allows modelling of shallow seepage and recharge infiltration. The third and fourth layers represent the regolith. All layers above and including the regolith are initially unsaturated. They allow modelling of the infiltration from rainfall and mining infrastructure such as the TSF that recharge the aquifer in variable amounts. The fifth and sixth layers represent the fractured rock aquifer. As discussed in the conceptualisation Section, this zone is modelled as a saturated porous medium aquifer. Finally, the seventh layer represent the basement unit (country rock).

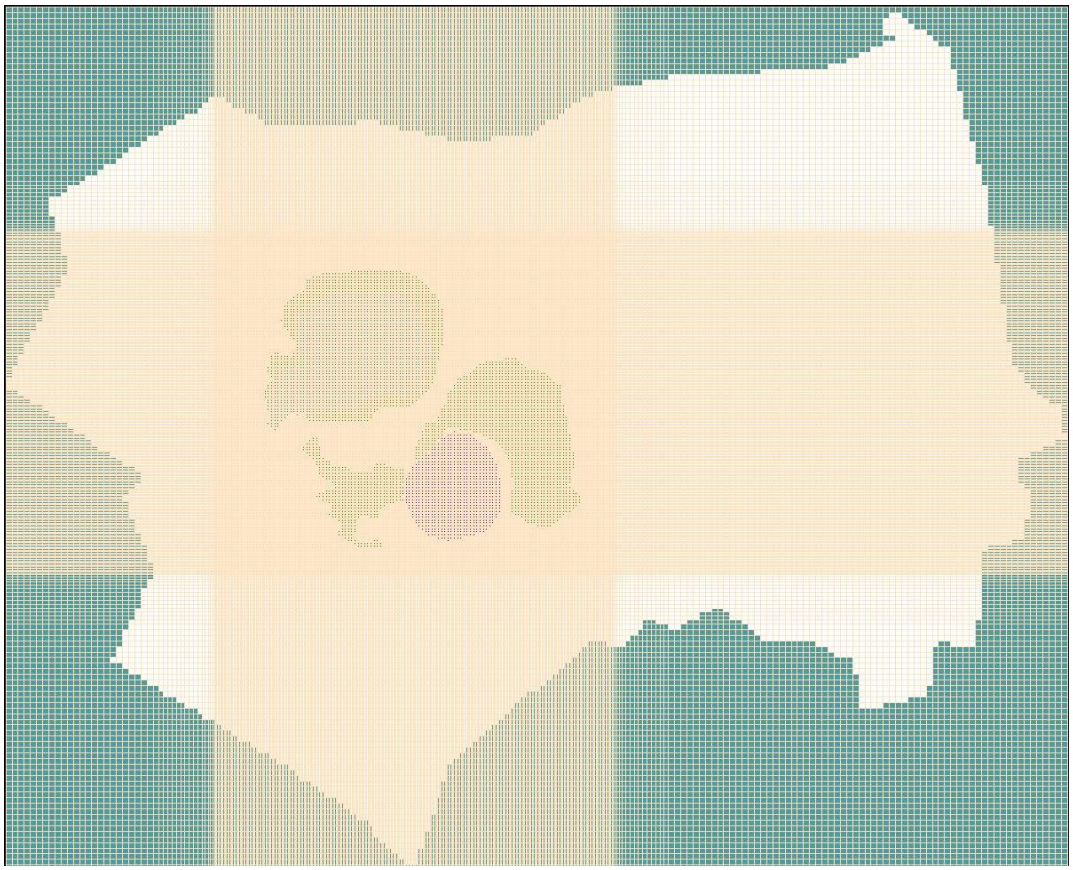


Figure 6 Model grid. Mine infrastructure zones can be seen within the fine discretisation area.

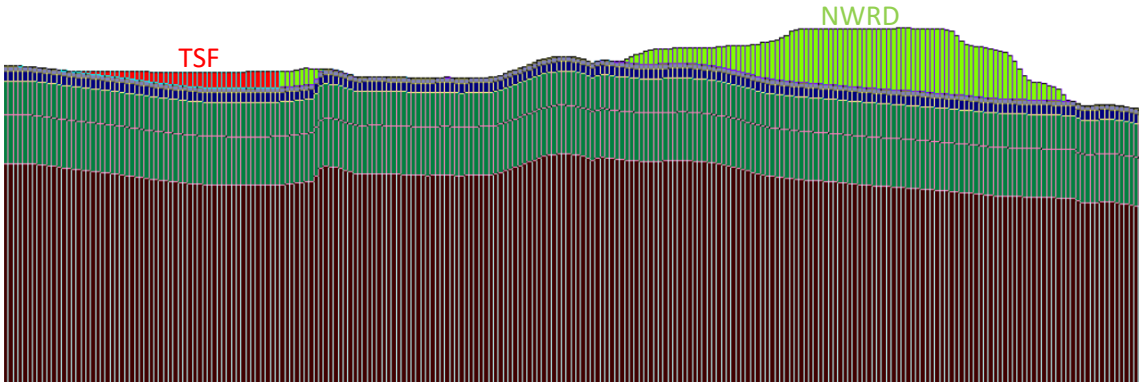


Figure 7 Row view (zoomed) showing the 7 layers in the model.

Table 9 Model Layers

layer	Extent	Description
1	**Top:** Final Landform **Bottom:** Natural elevation	MRO infrastructure above pre-mining elevation
2	0.5m thick below Layer 1	Top soil under infrastructure
3	4.5m thick below Layer 2	Subsoil clay and sand material
4	10m thick below layer 3	Highly weathered zone (regolith)
5	35m thick below layer 4	Upper fractured rock aquifer. Assumed as one zone porous medium
6	50m below layer 5	Lower fractured rock aquifer. Assumed as one zone porous medium
7	450m below layer 6	Non-fractured basement

3.3.3 Boundary Conditions

Boundary conditions are constraints imposed on the model grid to represent the interface between the model calculation domain and the surrounding environment (Aquaterra Consulting, 2000). MODFLOW allows use of several types of boundary conditions (also called boundary packages) to best represent the conditions at the interface between the model domain and its surrounding environment. The boundary conditions used in this model are described below.

3.3.3.1 Recharge

Recharge is a special condition of the specified flux boundary condition, in which a linear recharge rate (length/time) is applied to the top cell of the model to simulate flux from rainfall recharge or a similar external areal flux. The recharge is applied to the topmost layer of the model. Although the recharge rates are unknown, areas with similar infiltration capacity are grouped together in recharge zones. The recharge value for each of these zones was calculated during the 2018 model calibration.

3.3.3.2 No-Flow Boundary

This is a specified flux boundary condition (with zero flux) that ideally represents an impermeable boundary. As discussed earlier, groundwater flow at MRO most likely occurs due to intra-catchment recharge and is controlled by the topography. Therefore, the catchment boundary is assumed to be a no-flow boundary. No-flow boundaries are located at least 1.8 km away from the TSF footprint.

3.3.3.3 Constant Head Boundary

In this type of boundary condition, the head is specified in a group of cells that represent physical features such as lakes, rivers and coastlines. It theoretically allows an inexhaustible amount of water flow into or out of the model. The impoundment created by the Perry River dam is represented as specified head (or constant head) boundary conditions. The Perry River dam constant head has been set at 98mAHD.

In each of the predictive models, constant head boundary cells are used to simulate the water level in the pit. CHD set up for each model are detailed respectively in **Section 3.4.1.1** and **Section 3.4.2.1**.

3.3.3.4 River

The river package in MODFLOW simulates head-dependant flow conditions. It allows representation of the interaction between a river and the groundwater system. Creeks at MRO can be sinks for groundwater if the surrounding groundwater head is above the bottom elevation of creeks. This phenomenon is simulated by the river (RIV) package. If the head in the river cell is above the head in the surrounding cells, the river cell acts as a source of recharge for the model. If the head in the river cell is below the head of the surrounding cells, the river cell acts as a drain. If the head in the river cell falls below a certain threshold, which is still above the head in the surrounding cells, the flux from the river to the model cell is set to a specified lower bound (i.e. no flow).

The bottom elevations of the creeks were obtained from the elevations in the DEM. The head in the river cell was initially given the same value to simulate no flow (dry creek) conditions.

3.3.3.5 General Head Boundary

The general head boundary (GHB) package also simulates head-dependant flow conditions. The GHB is used to estimate the flux between a model cell and a body of water at a certain distance. Using this boundary allows modellers to reduce the size of the model if the exact estimation of flow at a given point between the model boundary and the body of water is not needed. The flux (recharge or discharge) across the model boundary (Q_B) is proportional to the difference in head $(h_B - h)$ between the surrounding cells and the boundary: $Q_B = C_B \times (h_B - h)$

The conductance term (C_B), expressed in m^2/day is a function of the hydraulic conductivity (K) of the assumed uniform media, the distance (D) between the model and the boundary and the model cell geometry (Width (W) and length (L)): $C_B = K \times W \times \frac{L}{D}$

In the model, there are no bores available between the model boundary and Paradise dam. Since the geology is mapped as relatively uniform over the area, aquifer parameters are thus estimated as uniform over the area. For that reason, a GHB is used at the southwestern boundary.

3.3.3.6 Horizontal Flow Barrier

Unlike other boundary conditions, the horizontal flow barrier package does not simulate a boundary between the model domain and the surrounding environment but represents a flow barrier within the model. This is why this condition is listed under a groundwater flow package in the MODFLOW nomenclature.

All dykes and faults have been represented using this package. Dykes have fault were calibrated during the 2018 model calibration (**Table 10**). Dykes extend from Layer 2 (natural surface) to layer 8 (model base) while faults extend from layer 5 (fractured rock) to layer 8.

This package was also used to represent the low permeability TSF embankment made of consolidated tailings, compacted clay and a geomembrane. The permeability of the embankment is estimated at 5.00E-09m/s (NRC, 2016). The barrier thickness was set at 5m (embankment width) and the extent from Layer 1 (top of the TSF) to the bottom of layer 3.

3.3.4 Calibrated Hydraulic Parameters and Boundary Conditions

Values for each input parameter of the calibrated model are reported in **Table 10**.

Table 10 Calibrated models parameters

Parameter	Model reference and unit	Calibrated model
Kx NWRD, WWRD and TSF rock armouring	Kx1 (m/d)	6.36E-03
Kx settled tailings	Kx2 (m/d)	6.43E-05
Kx soil/subsoil (high ranges)	Kx3 (m/d)	3.27E-02
Kx soil/subsoil (Valley)	Kx4 (m/d)	9.62E-01
Kx alluvium	Kx5 (m/d)	1.82
Kx weathered rock	Kx6 (m/d)	1.21E-01
Kx fractured rock	Kx7 (m/d)	1.79E-03
Kx basement	Kx8 (m/d)	4.15E-03
Kz NWRD, WWRD and TSF rock armouring	Kz1 (m/d)	4.03E-04
Kz settled tailings	Kz2 (m/d)	3.94E-06
Kz soil/subsoil (high ranges)	Kz3 (m/d)	1.32E-02
Kz soil/subsoil (Valley)	Kz4 (m/d)	4.62E-02
Kz alluvium	Kz5 (m/d)	1.22E-01
Kz weathered rock	Kz6 (m/d)	5.37E-02
Kz fractured rock	Kz7 (m/d)	1.79E-03
Kz basement	Kz8 (m/d)	2.17E-03
Recharge WWRD and TSF rock armouring	r1 (m/d)	2.47E-05
Recharge high ranges	r3 (m/d)	1.48E-04
Recharge valley	r4 (m/d)	4.12E-06
Recharge alluvium	r5 (m/d)	1.34E-05
Recharge NWRD	r6 (m/d)	2.78E-03
Evapotranspiration	et1 (m/d)	1.65E-03
Evapotranspiration depth	ed1 (m)	4
River bed Kz	(m/d)	3.13E-03
Horizontal Flow Boundary Kx – TSF Embankment	hfb20 (m/d)	8.64E-05
Horizontal Flow Boundary Kx – Dykes	hfb21 (m/d)	1.48E-03
Horizontal Flow Boundary Kx – Faults	hfb22 (m/d)	1.48E-03
General Head Boundary – Kx L6	(m/d)	1.00E-02
General Head Boundary – Kx L7	(m/d)	4.32E-04

3.4 Predictive Modelling

3.4.1 Predictive Model 1: Stage – discharge curve

3.4.1.1 Model Setup

A steady state model was set up with the CHD package set at specific pit lake elevations for the final void in order to extract the stage discharge curve. CHD were set up in the model for 75 steady-state stress periods, each period representing a void elevation. Final void elevation was simulated from -245mAHD to 125mAHD, using 5m increments between stress periods.

3.4.1.2 Model Results

The stage discharge curve was processed from the groundwater model to inform the Water Balance Model (WBM). Groundwater inflows ranges from 2.3ML/d for a void lake elevation of -245mAHD to 0.02ML/d for a void lake elevation of 125mAHD (**Figure 8**).

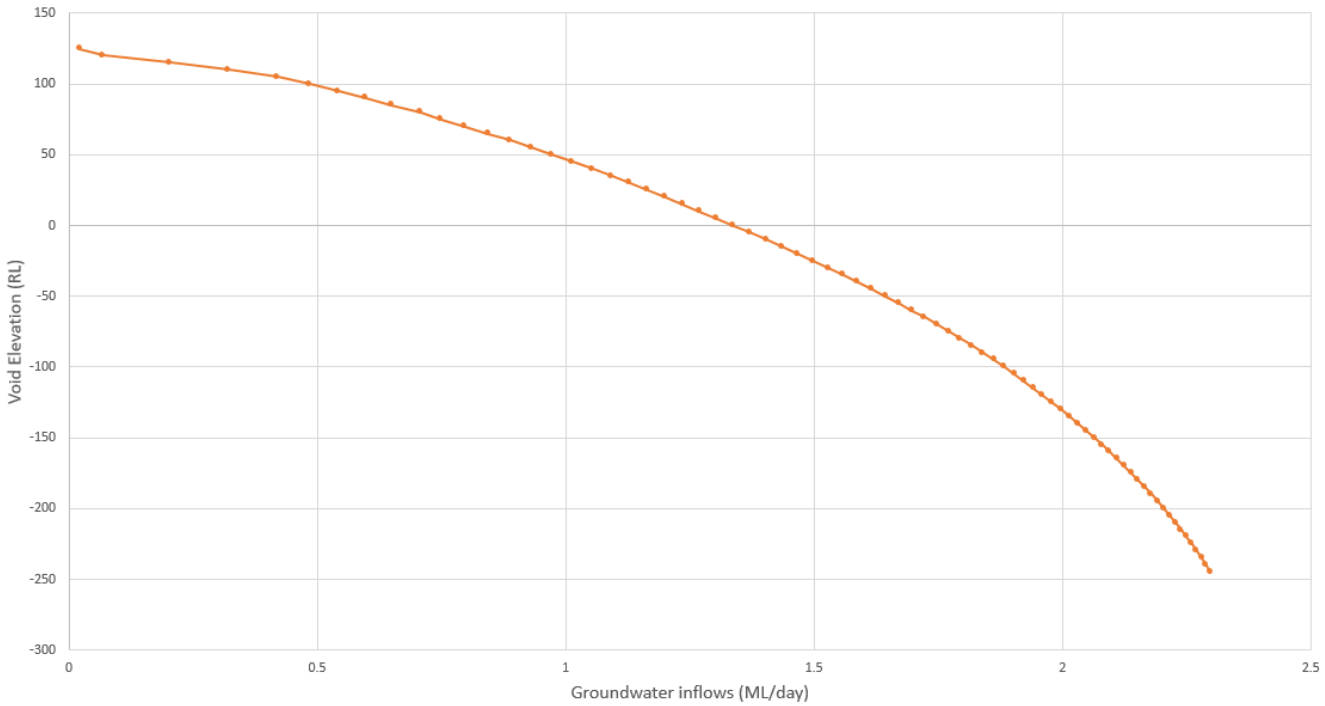


Figure 8 Groundwater inflow to the void VS Void lake elevation

3.4.2 Predictive Model 2: Post Closure Groundwater Model

3.4.2.1 Model Setup

A second steady-state model was set up with the CHD package set at the equilibrium pit lake elevations for the final void, as estimated by the final void model (**Section 4.1**). CHD were set up in the model for a single steady-state stress period representing the post mining, recovery pit lake and groundwater levels.

An additional model was run to include likely climate change scenarios (see **Section 2.3.2**).

For the Climate Change scenario, the equilibrium pit water elevation was set at 107mAHD as estimated by the surface water modelling (refer to **Section 4.1.8**). For consistency with the surface water study input, the recharge was kept the same (i.e. no change in rainfall) and the evapotranspiration was increased by 4.6% (**Table 11**).

Table 11 Parameter variation between prediction model run 2 and model run 3

	Model run – Average conditions	Model run – Climate change likely scenario
Final pit lake elevation (mAHD)	110	107
Average daily Evapotranspiration (m/d)	0.00165	0.00173

3.4.2.2 Model Results

Predicted groundwater levels are presented in **Section 5.** The water balance for each model run is presented in **Section 3.4.2.2.1** below.

3.4.2.2.1 Water balance

The water balance for the steady state model is provided in **Table 12**. Rainfall recharge comprises the majority of total inflows, with the Perry River Weir contributing to about 10% of inflows. ET comprises the majority of total outflows. Differences between the base model and the Climate Change likely scenarios are:

- Groundwater inflows (reflected in the constant head out) are slightly greater given the lower pit stage for the climate change scenario
- The water coming out of the model through Evapotranspiration and the creek beds (River) is slightly lower in the climate change model, due to the lower groundwater table connected to the pit stage.

The Australian Groundwater Modelling Guidelines (Barnett et al, 2012) recommends for mass balance closure error criteria that "[a] value less than 1% should be achieved and reported at all times and cumulatively over the whole simulation." The water balance discrepancy between calculated inflows and outflows is < 0.1%, which meet the Australian Groundwater Modelling Guidelines criterion stated above.

Table 12 Water Balance for the Predictive Models

	Model run – Average conditions		Model run – Climate change likely scenario	
	In (KL/d)	Out (KL/d)	In (KL/d)	Out (KL/d)
Constant Head (Pit Lake)	8.2	429.3	2.0	461.9
Constant Head (Perry River Weir)	429.7	6.3	451.8	6.8
Recharge	3927.1	0	3927.1	0
ET	0	3917.6	0	3901.6
River (Creeks)	0	11.6	0	10.4
GHB	0	0.3	0	0.3
Total	4365.0	4365.1	4380.9	4381.0

	Model run – Average conditions		Model run – Climate change likely scenario	
	In (KL/d)	Out (KL/d)	In (KL/d)	Out (KL/d)
In- Out	-0.1		-0.1	
% Discrepancy	<-0.1%		<-0.1%	

3.5 Sensitivity Analysis

Groundwater models represent complex environmental systems and processes in a simplified manner. This means that predictions from models are inherently uncertain. National modelling guidelines encourage the acknowledgement of uncertainty and suggest methods to formulate predictions in which uncertainties are minimised.

To reduce the uncertainty, it is first necessary to identify which parameters in the model are having the greatest influence on the model outputs (i.e. how sensitive the outputs are to changes in model parameters). Following the sensitivity analysis, a review of the quality and quantity of available data for the most critical parameters is done. Additional data collection can then be focussed on critical parameters which are not well understood.

The Murray Darling Basin Modelling Guidelines (MDBC, 2001) provide a classification based on how model parameters change model calibration and predictions. According to this process, models can be classified as one of four main types:

- Type I: Insignificant changes to calibration (low identifiability) and prediction (low identifiability);
- Type II: Significant changes to calibration (high identifiability) – insignificant changes to predictions (low identifiability);
- Type III: Significant changes to calibration (high identifiability) – significant changes to predictions (high identifiability); and
- Type IV: Insignificant changes to calibration (low identifiability) – significant changes to predictions (high identifiability).

Types I and II are of no concern, as these model types have an insignificant impact on model predictions. Type III has a significant impact on predictions, but calibration process can constrain the range of likely outcomes. Type IV is classed as 'a cause for concern' as different combinations of model input values can generate equally valid model calibrations that produce significantly different predictive results.

3.5.1 Sensitivity Analysis Set-up

A sensitivity analysis was conducted on the calibration and the prediction models. The identifiability of each parameter for each model was computed using the PEST automated calibration software (Doherty, 2010). Put simply, identifiability refers to the visibility of changes (i.e. impact) in model outputs in response to using different parameter values. A parameter with a low identifiability (i.e. close to 0) may be changed in the model without affecting model results. A parameter with a high identifiability (i.e. close to 1) will have a greater effect on model results as input value is changed.

Model results are specific to each model and associated objective(s). For the calibration model, results are groundwater levels in specific locations (site bores) and groundwater inflow to the pit (see **Section 3.1**). For the first prediction model, which is used to predict inflow for each pit stage, results are solely inflow to the pit. For the second prediction model, which is used to predict groundwater levels across the model domain, results are groundwater levels in the fractured rock unit (layer 5), homogeneously distributed across the model domain.

3.5.2 Sensitivity Analysis Results

Figure 9 shows the identifiability of model parameters for the calibration model and the two predictive models. As per the MDBC nomenclature presented in **Section 3.5**, model parameters have been divided into four types. The cut off value for parameters with high identifiability was set as 0.2. Thus, all parameters with an identifiability between 0 and 0.2 were classed as “low identifiability” and all parameters with an identifiability between 0.2 and 1 were classed as “high identifiability”.

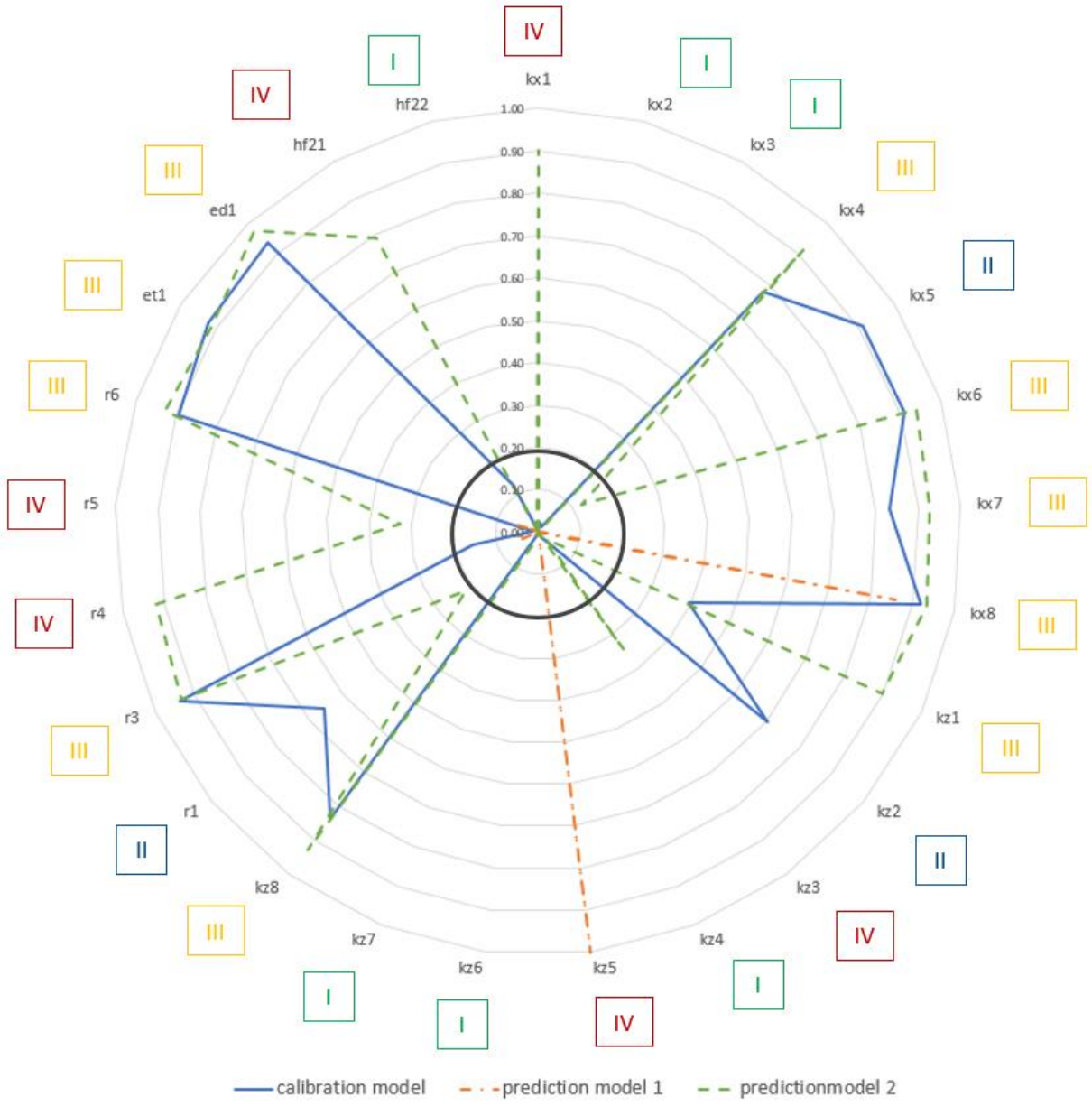


Figure 9 Radar Diagram showing the identifiability and types of model parameters

The Type IV parameter that pose the greatest uncertainty to the void inflow recovery predictions (predictive model 1) is the vertical hydraulic conductivity of the alluvium (Kz5).

Type IV parameters that pose the greatest uncertainty to the potentiometric heads in the fractured rock predictions (predictive model 2) are:

- Horizontal conductivity of the waste rock (Kx1);
- Vertical hydraulic conductivity of the soil/subsoil (High ranges);
- Recharge to the valley (r4);
- Recharge to the alluvium (r5); and

- Horizontal hydraulic conductivity of dykes (hf21).

3.5.3 Confidence in Type IV parameter values

The confidence on Type IV parameter values is based on the quality and quantity of available data to define each parameter. This can be increased by gathering statistically sufficient data.

3.5.3.1 Vertical hydraulic conductivity of the alluvium (Kz5) and Hydraulic conductivity of the waste rock (Kx1)

There is limited data available for these parameter and thus low confidence on each parameter value. The only available data consists of measurements (number of measurements unknown) from permeability tests conducted by AWA in 1999 and presented in AWA (2012) around the TSF area. Models results would benefit from additional field data for both the alluvium and the waste rock units.

3.5.3.2 Horizontal conductivity of dykes (hf21)

There is limited data available for this parameter. However, basalt-andesite and rhyolite dykes are generally dense with minimal weathering, as can be observed in several outcropping dykes around the site. In the model, dykes have been set up as hydraulic barriers (low hydraulic conductivity) and thus, there a relatively good confidence in this parameter as defined in the model.

3.5.3.3 Recharge to the valley (r4) and the alluvium (r5)

There is limited data available for these parameters and SLR is not aware of any groundwater recharge study previously conducted at MRO. There is low confidence in this parameter and model results would benefit from a groundwater recharge study for MRO.

4 Surface Water Void Modelling

The long-term water quality of the final void was modelled using the Goldsim WBM and General Lake Model (GLM) software packages. This section details the assumptions, methodology and findings of the WBM and GLM modelling.

4.1 Water Balance Modelling

4.1.1 Catchment Area

The catchment configuration was provided by MRO as an input to the WBM. This included an external catchment of 192.3 ha (rehabilitated area) draining to the void. The void will have a footprint of 68.8 ha. It is noted that because a detailed surface model of the final landform was unavailable, it was not possible to verify the catchment areas.

An initial WBM assessment showed that due to the size of the external catchment, the void was predicted to be unable to contain the volume of runoff and groundwater inflows within the first 100 years post closure. It was therefore agreed with MRO, that the final landform be modified to exclude the external catchment and it is assumed this will be diverted away from the void.

4.1.2 Stage-Storage Relationship

The stage storage surface area curves were derived from the final landform contours. The void has a depth of approximately 370 m with an invert of -240 m AHD and would overflow at a level of 130 m AHD. **Figure 10** shows the stage-storage-surface area relationship for the final void.

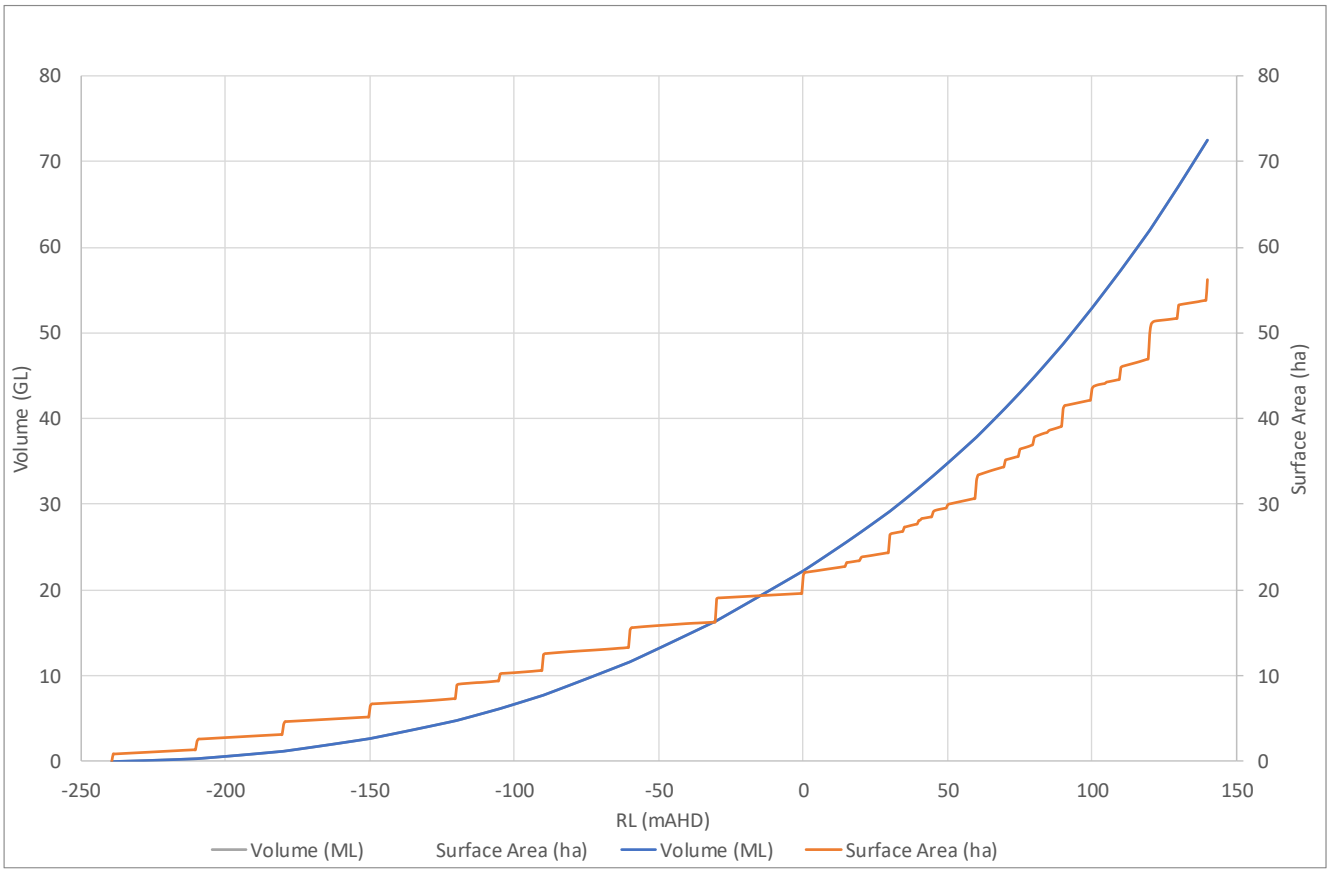


Figure 10 Final void level-volume-surface area curves

4.1.3 Long Term Historical Rainfall

Section 2.3 discusses the climate data for the site from 2001 to 2019. In order to produce a statistically valid probabilistic rainfall dataset, historical rainfall records of at least 50 years are required. As such, SILO which is a database of Australian climate data from 1889 to present, was used for the site. SILO data utilises BoM rainfall and evaporation gauges for several locations in the vicinity of the Project site and provides a continuous long term data set. The long term historical rainfall and evaporation records were analysed to determine the climate at the Project site. Where the MRO rainfall site records had gaps, the SILO data were also used to infill the gaps. A sensitivity assessment was also completed where pure SILO rainfall data was used, which showed negligible difference in the final void level.

The gauges are summarised in **Table 13**.

Table 13 Rainfall and Evaporation Gauge Data

Gauge Number	BoM Name	Open – Closed	Number of Years of data & completeness	Location (Lat/ Long)
039096	Wateranga	1912-2018	106 years (85 % complete)	-25.356, 151.817
039256	Dingle dell	1973- Open	47 years (93 % complete)	-25.148, 151.629
039045	Goodnight scrub res 169	1935-1990	55 years (97 % complete)	-25.283, 151.913
039099	Girvan vale	1911-1953	42 years (88 % complete)	-25.317, 151.750
039331	Mingo crossing	1994-2000	6 years (10 % complete)	-25.400, 151.783
039340	Mingo creek alert	2000- Open	20 years (94 % complete)	-25.321, 151.721
039342	Mt yeatman tm	2001-2015	14 years (89 % complete)	-25.391, 151.760
039300	Mount yeatman	1979-2000	21 years (77 % complete)	-25.390, 151.761
039070	Mt perry the pines	1986- Open	34 years (99 % complete)	-25.169, 151.638
039184	Paradise dam	2010-2013	3 years (39 % complete)	-25.351, 151.919
039280	Rockleigh	1947-1972	25 years (100 % complete)	-25.167, 151.617

4.1.4 Probabilistic Rainfall

Probabilistic rainfall data was generated for the WBM. The purpose of the probabilistic rainfall generation is to develop a range of climate sequences for the life of the Project and after closure based on the recorded historical rainfall data of the Project area.

The probabilistic data still maintains the climate statistics of the historical rainfall record but also examines the robustness of the system. This is achieved by modelling the potential for events that are statistically likely to or have the possibility of occurring (based on the historical series). But that may be less than, greater than or occur in a different sequence to the historical record. The 500 sequences of probabilistic data are summarised as exceedance probabilities.

The probabilistic rainfall data was generated from recorded historical data using the eWater CRC Stochastic Climate Library (SCL). Data was initially generated from 500 replicates of 108 years (from 1912 to 2020 as consistent with the available historical data record) of daily rainfall data in accordance with the SCL Manual. The generated data was found to be representative of the historical record within acceptable tolerances for key statistics.

Figure 11 illustrates how the probabilistic data compares to the historical rainfall record for annual rainfall totals. The graph indicates that the model is simulating a range greater than that provided by the historical record but that the median or 50th percentile of the results are aligned with the historical record.

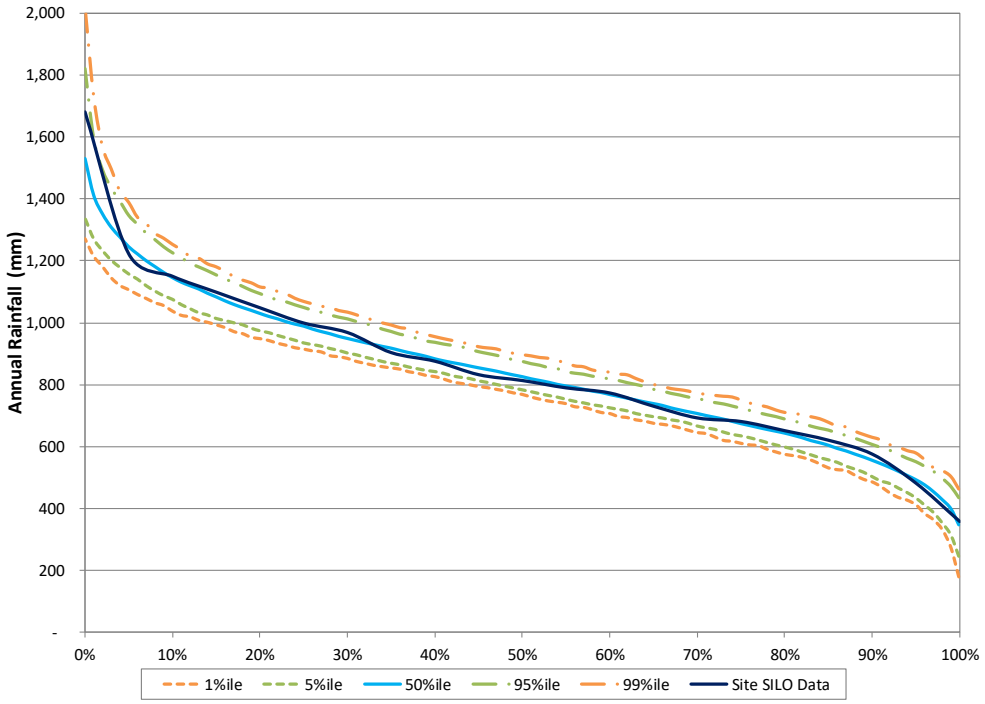


Figure 11 Comparison of Historical and Probabilistic Data

Initial assessments showed that it takes at least 300 years to reach the final void levels, as such, 100 sequences of probabilistic rainfall at 500 years in length were generated. It is noted that the number of sequences were less than the standard probabilistic assessment practice, this was due to GoldSim memory limitations. Because the focus of the final void assessment is the median levels, 100 sequences was deemed acceptable.

4.1.5 Evaporation

Evaporation from the site were determined as discussed in **Section 2.3.1**.

For the WBM, monthly averages were used as the evaporation data for the area is limited. The extended evaporation record available in SILO was reviewed but the infilled data consisted of monthly averages (rather than daily records from other gauges) for the period prior to gauge readings. This is most likely due to the limited available data for infilling. Due to the short evaporation record and missing data the error bounds on the generation of stochastic evaporation records would be significant. As such monthly evaporation data was adopted rather than daily data for use in the WBM simulations.

4.1.6 Runoff modelling

The rainfall is converted to runoff using the Australian Water Balance Model (AWBM). This runoff can be split into two forms:

1. Surface runoff which travels overland to the destination; or
2. Sub-surface which travels through the ground to reach the destination.

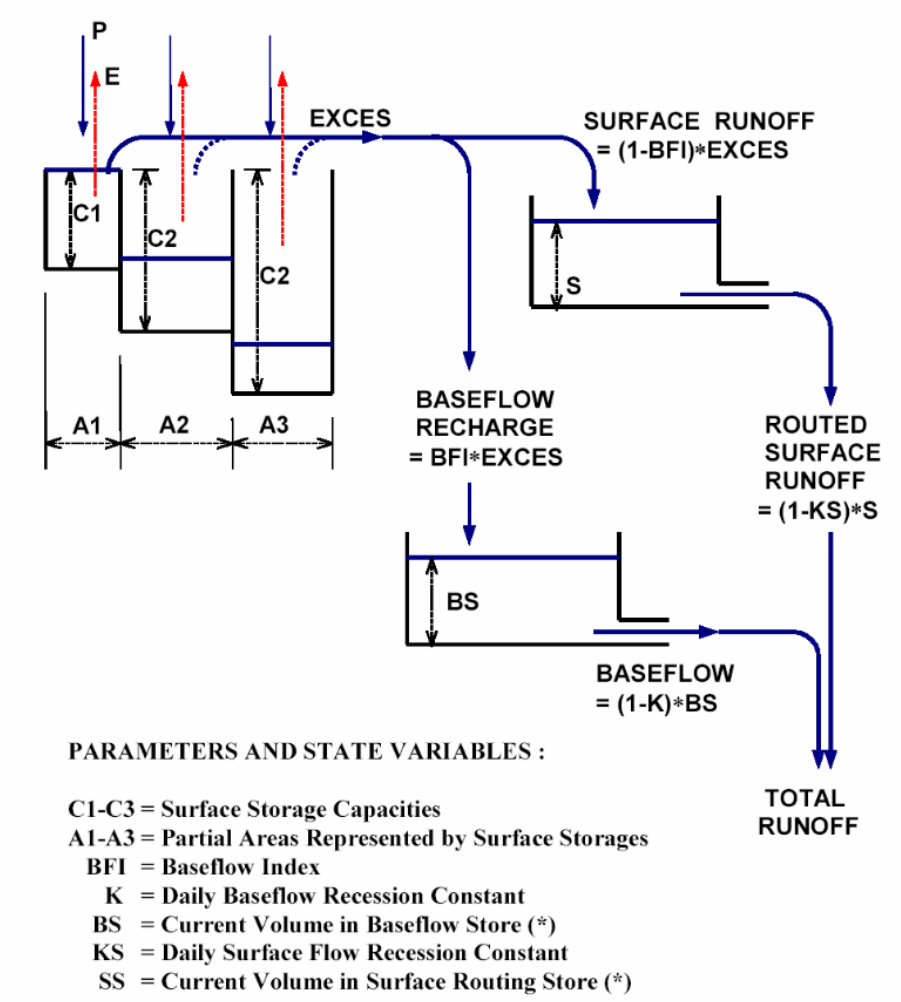


Figure 12 AWBM Rainfall Runoff Model

The AWBM parameters were adopted from the supplied exiting site's water balance model (v7.1.2 MRO WBM_GS12_West Dam.gsp). A summary of the AWBM parameters adopted is presented in **Table 14.** The final void modelling only had one land use type which is for the void surface.

Table 14 AWBM Parameters

Parameter	Void
Small storage capacity (mm)	5
Medium Storage Capacity (mm)	20
Large storage capacity (mm)	20
Small storage Initial Depth (%)	25
Medium Storage Initial Depth (%)	25
Large storage Initial Depth (%)	25
Small partial area portion	0.1

Parameter	Void
Medium partial area portion	0.9
Large partial area portion	0
Baseflow index	10
Baseflow recession	1
Daily streamflow recession	0

4.1.7 Groundwater Inflow

Groundwater inflows to the GoldSim void water balance model were derived from the groundwater model and provided as a relationship between water level and inflow (discussed in **Section 3.4.1.2**). This was modelled as an inflow in the WBM and were calculated daily based on the current water level in the void as predicted by the WBM.

4.1.8 Results

The water balance model was predicted to stabilise after 275 years to a level of approximately 110 m AHD. This is discussed further in **Section 5.1**.

A sensitivity analysis was also completed with regards to climate change. As discussed in **Section 2.3.2**, the rainfall is likely to vary from 5 to -15% in the next 70 years with some events increasing in intensity. The section also discusses that the evaporation and evapotranspiration are likely to increase by 4.6% as per the climate future tools' prediction. A climate change scenario assessment was completed with no change in rainfall depths to represent the likelihood of up to 15% reduction but also accounting for increase in rainfall intensities. The evaporation in the water balance model was increased by 4.6%.

The assessment showed that there was minimal difference in the final level of 107 mAHD which is 3 m lower than the final level without climate change or less than 1% change in depth.

4.2 Lake Water Quality Modelling

4.2.1 Software

A one-dimensional hydrodynamic model of the Final Void was developed using the General Lake Model (version 3.1) software package (GLM). GLM is a one-dimensional lake water balance and stratification model suitable for simulating mixing behaviours in deep stratified lake systems.

4.2.2 Data

4.2.2.1 Historic Climate Data

Long-term historically recorded climatic data for use in the GLM model was extracted from the SILO dataset detailed in Section **4.1.3**.

Additional climate data, i.e. daily wind speed and cloud cover, was sourced from BOM for a period beginning 1 January 1900 and ending 1 July 2009 at the Gayndah Post Office weather station (039039), being the nearest station to the site with datasets of acceptable length and quality. It is noted the Mount Perry the Pines station (039070) dataset analysed in Section **2.3** did not include wind speed and cloud cover data and was therefore not able to be utilised in the GLM model, despite being located nearer to the site than the Gayndah Post Office station.

A summary of the climate data sourced from these datasets is provided in **Table 15.**

Table 15 General Lake Model Input Data – SILO and BOM Historical Climate Data

Climate Data Parameter	Units	Source	Period	Comments
Rainfall	Mm	SILO	1900-2020	Daily total
Air Temperature	°C	SILO	1900-2020	Mean of daily maximum and minimum
Relative Humidity	%	SILO	1900-2020	Mean of daily maximum and minimum
Short Wave Radiation	W/sqm	SILO	1900-2020	Mean of daily maximum and minimum
Cloud Cover	%	BOM	1900-2009	Mean of daily maximum and minimum
Wind Speed	m/s	BOM	1900-2009	Mean of daily maximum and minimum

4.2.2.2 Mt Rawdon Site Weather Station Data

Daily climate data recordings collected at the on-site weather station were provided by MRO. The dataset included recordings for the time period between 18 July 2013 and 20 September 2020 for short wave radiation, air temperature, relative humidity, and rainfall.

Supplementary data was sourced from BOM to complete the dataset to include all required inputs for the GLM model. The Gayndah PO station dataset ceased in 2009 and was therefore not used. The Monto Post Office (39104) was the nearest station to the site with data covering the time period of 2013 to 2020, therefore data from this station was adopted to supplement the MRO site weather station data.

4.2.3 Void Morphometry

The stage-surface area relationship of the Final Void, as illustrated in **Figure 10**, was utilised in the model.

4.2.4 Boundaries

4.2.4.1 Rainfall Runoff

Rain falling directly on the void surface water and rainfall runoff from the exposed banks of the void were applied as inflows in the model.

4.2.4.2 Groundwater Inflows

Inflows from the surrounding groundwater table were applied to the model. As detailed in **Section 4.1.7**, groundwater inflows to the void vary in relation to the void surface water level. Therefore, groundwater flows were applied to the GLM model as a varying time series based on the results of the water balance model, which was simulated using the historic climate data set for 110 years. The resulting groundwater inflow timeseries is illustrated in **Figure 13**.

Based on drilling records of monitoring bores at MRO, 1900 mg/L was adopted as the average salinity concentration of groundwater inflows.

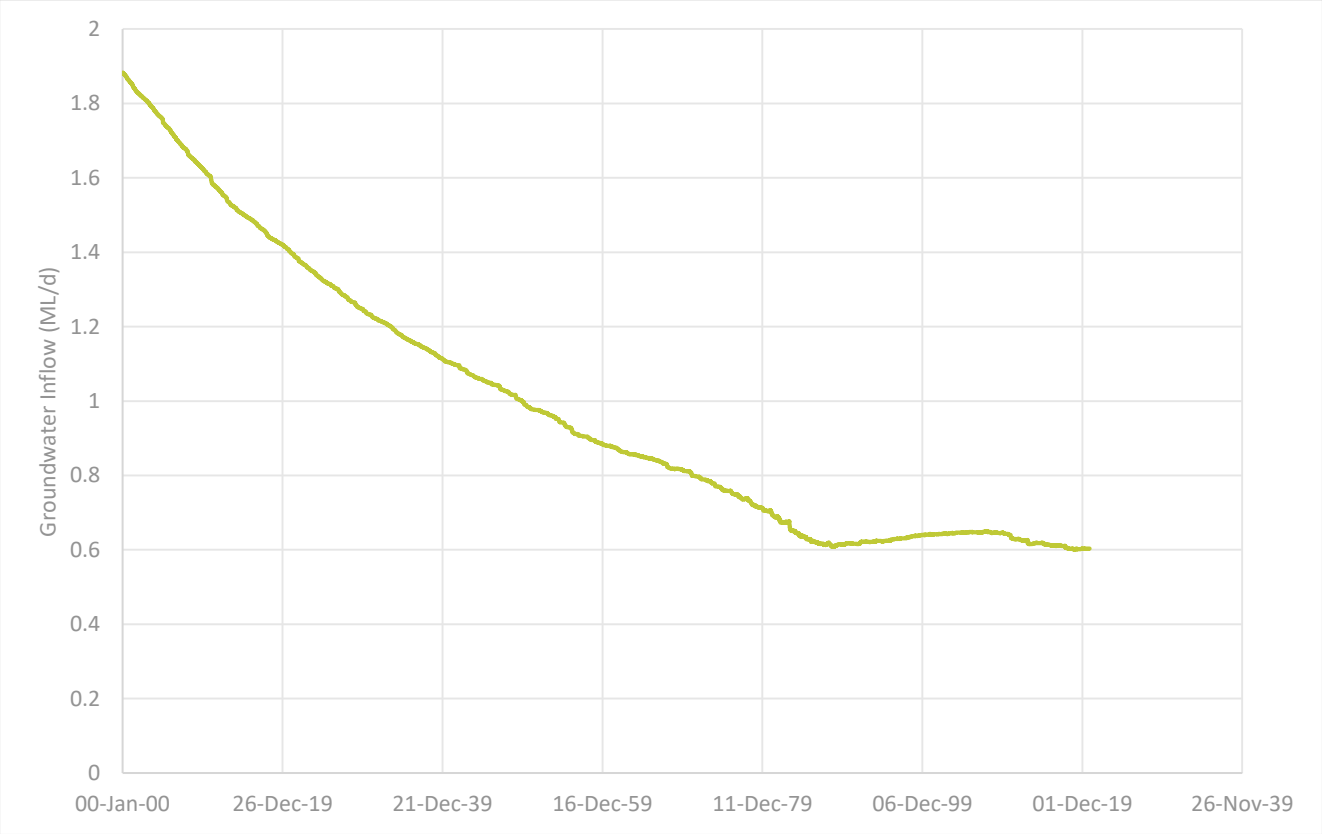


Figure 13 GLM Model – Groundwater Inflows

4.2.4.3 Meteorological Conditions

Meteorological drivers were applied to the model as detailed in **Table 15**.

4.2.4.4 Outflows

The results of the water balance model showed that the water level in the void is unlikely to exceed the overflow level. Additionally, the void will act as a groundwater sink therefore no volume will discharge as groundwater.

Based on the above, evaporation is the primary outflow from the void. GLM calculates the daily evaporation volume based on the input meteorological drivers and current void conditions.

4.2.5 Model Scenarios

Based on the results of the WBM, the final void was predicted to stabilise after 275 years to a level of approximately 110 m AHD (**Figure 20**).

Climate datasets for a time period of this magnitude were not available, therefore the simulation of the entire time period was not possible.

Subsequently, two model scenarios were investigated to simulate the void in varying conditions, as detailed below.

4.2.5.1 Pre-equilibrium Scenario

This scenario modelled the void under rising water level conditions, prior to equilibrium volume conditions being established. The model was simulated for a period of 110 years, with the 110 year period selected to represent the steepest increase in void water levels. A starting void water level of -100 m AHD representing a depth of 139 m was adopted in the model.

The historic climate dataset detailed in **Section 4.2.2.1** was adopted in the model.

4.2.5.2 Equilibrium Scenario

This scenario simulated the void after equilibrium conditions are established. The model was simulated for a period of 8 years and utilised the MRO site weather station dataset as detailed in **Section 4.2.2.2**.

4.2.5.3 Pre-equilibrium Scenario Results

Results of the GLM model indicated the void will be subject to seasonal stratification in warmer months with annual mixing occurring within the upper 15 to 20 m of the void. At depths below this, a generally stable hypolimnion (denser, cooler water) is formed.

The results indicate the salinity within the hypolimnion is generally in the order of 1500 to 1900 mg/L where it is dominated by the inflow of groundwater. At the surface, salinity fluctuates both seasonally and long-term, with concentration oscillation in the range between 0 and 2000 mg/L.

A turnover of the void water column was shown to occur after approximately 65 years of simulation. This turnover can be attributed to successive cooler than average years, causing surface water temperatures to approach temperatures of the hypolimnion, leading to density equalisation and subsequent vertical mixing. As detailed above, salinity concentrations of the water column remain in the range of 0 to 2000 mg/L, therefore the turnover and subsequent mixing is not considered to represent an adverse environmental impact.

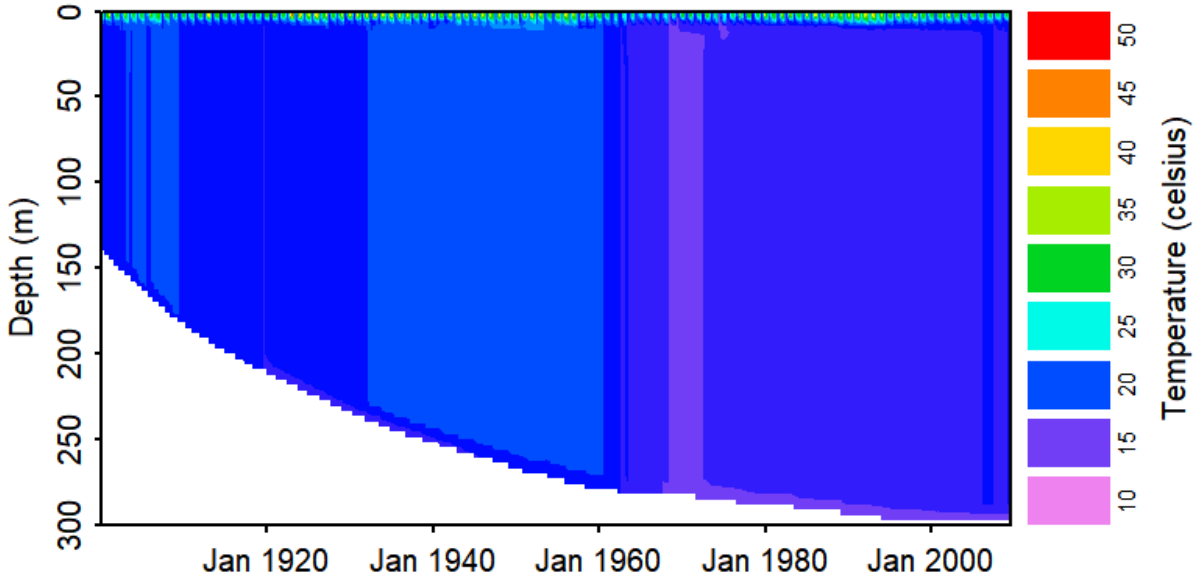
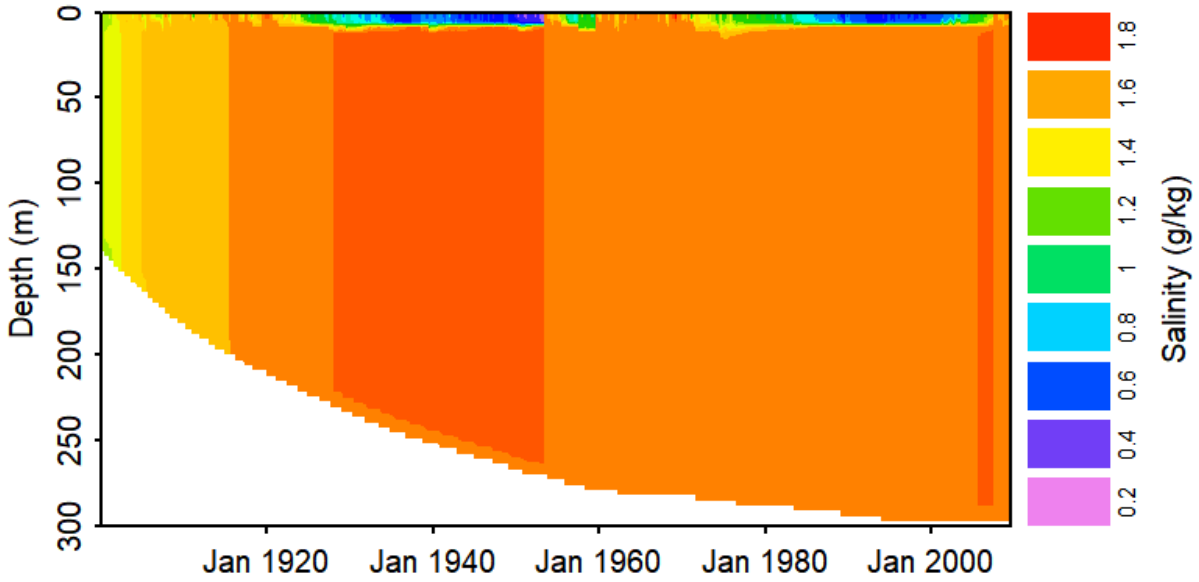
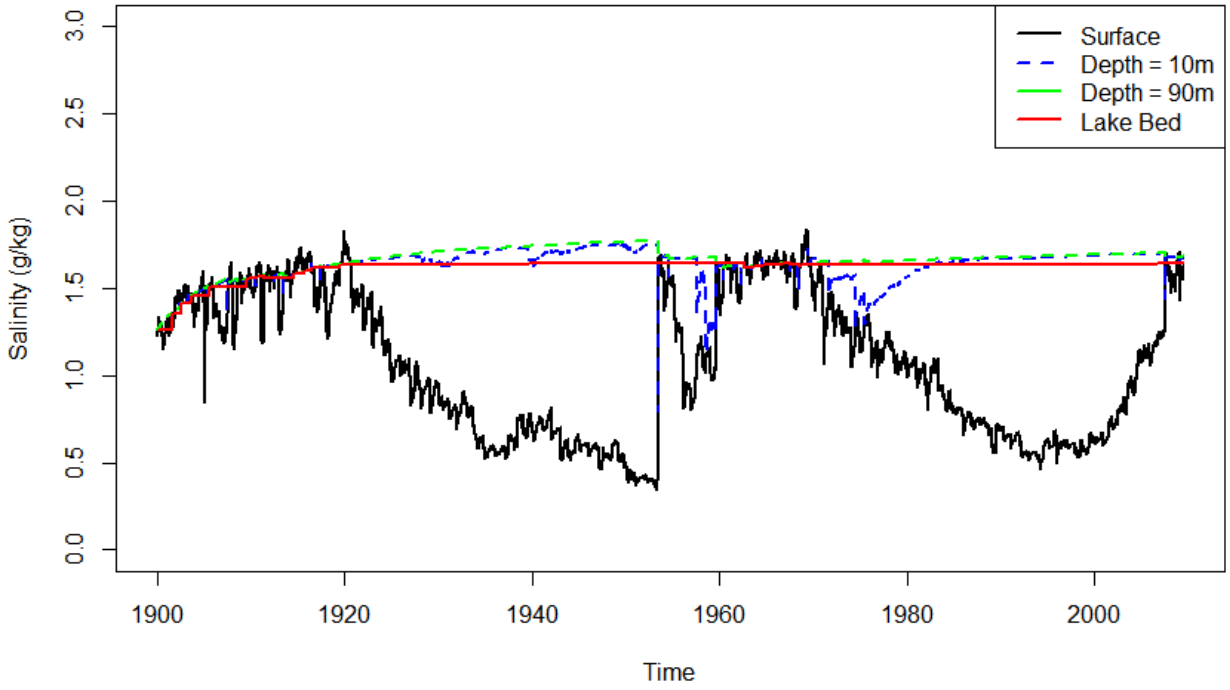


Figure 14 GLM Model Results – Pre-equilibrium Scenario – Temperature



* Salinity concentration 1 g/kg is equivalent to 1000 mg/L

Figure 15 GLM Model Results – Pre-equilibrium Scenario – Salinity Heat Map



* Salinity concentration 1 g/kg is equivalent to 1000 mg/L

Figure 16 GLM Model Results – Pre-equilibrium Scenario – Salinity Time Series

4.2.5.4 Equilibrium Scenario Results

Results of the Equilibrium model scenario further illustrate the tendency of the void to experience seasonal stratification. A hypolimnion is evident below a depth of approximately 20 m, where both water temperature and salinity concentration are shown to be stable at approximately 20°C and 1800 µS/cm respectively as illustrated in **Figure 17** and **Figure 19**. Within the upper 20 m of the water column, salinity concentrations are generally in the order of 0 to 1000 mg/L.

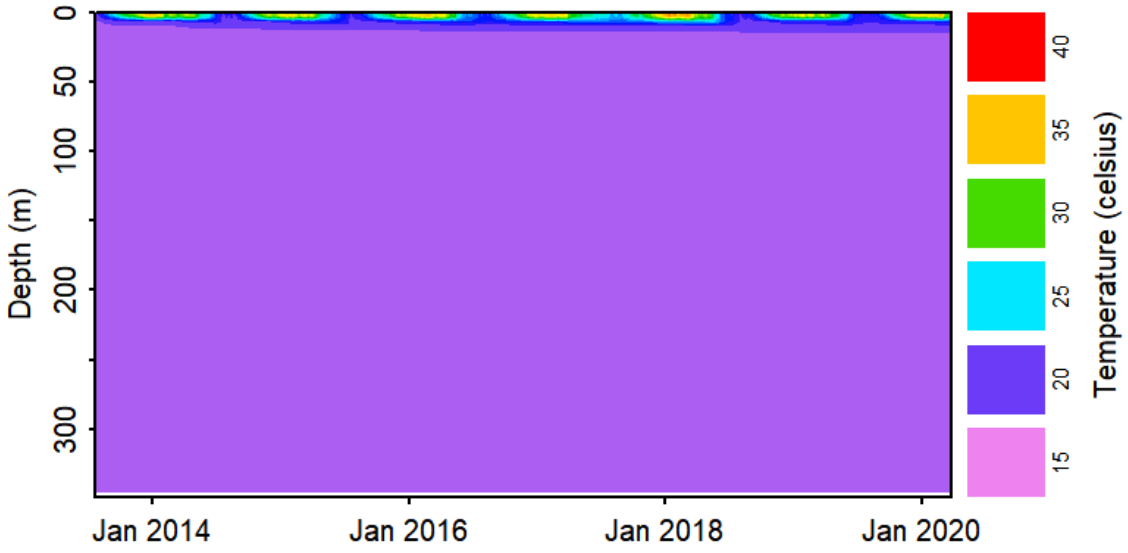
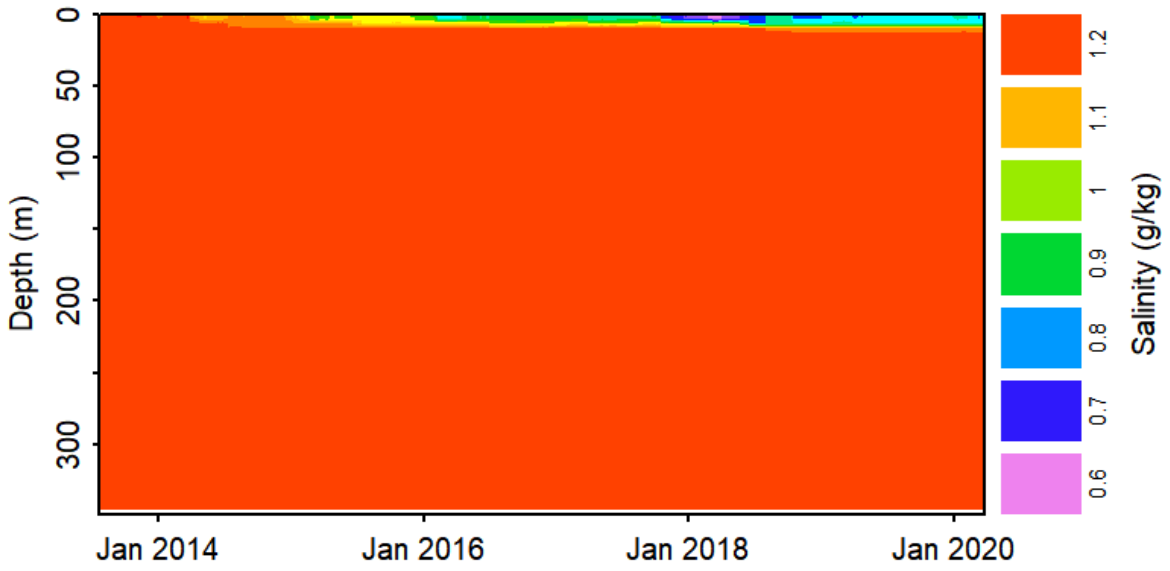
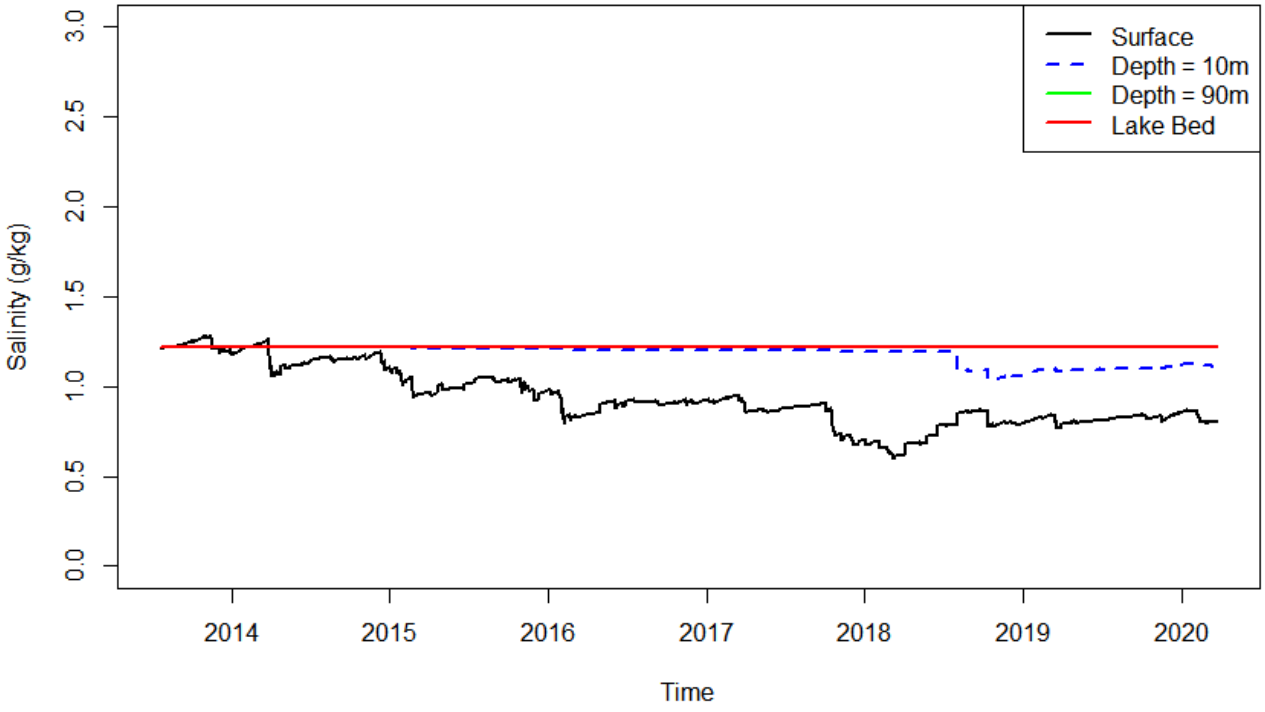


Figure 17 GLM Model Results – Equilibrium Scenario – Temperature



* Salinity concentration 1 g/kg is equivalent to 1000 mg/L

Figure 18 GLM Model Results – Equilibrium Scenario – Salinity Heat Map



* Salinity concentration 1 g/kg is equivalent to 1000 mg/L

Figure 19 GLM Model Results – Equilibrium Scenario – Salinity Time Series

5 Post-Closure Predictions

5.1 Final Void Water Level

The final void was predicted to stabilise after 275 years to a level of approximately 110 m AHD (**Figure 20**). At this level the water would be in the order of 350 m deep and have a surface area of approximately 53 ha.

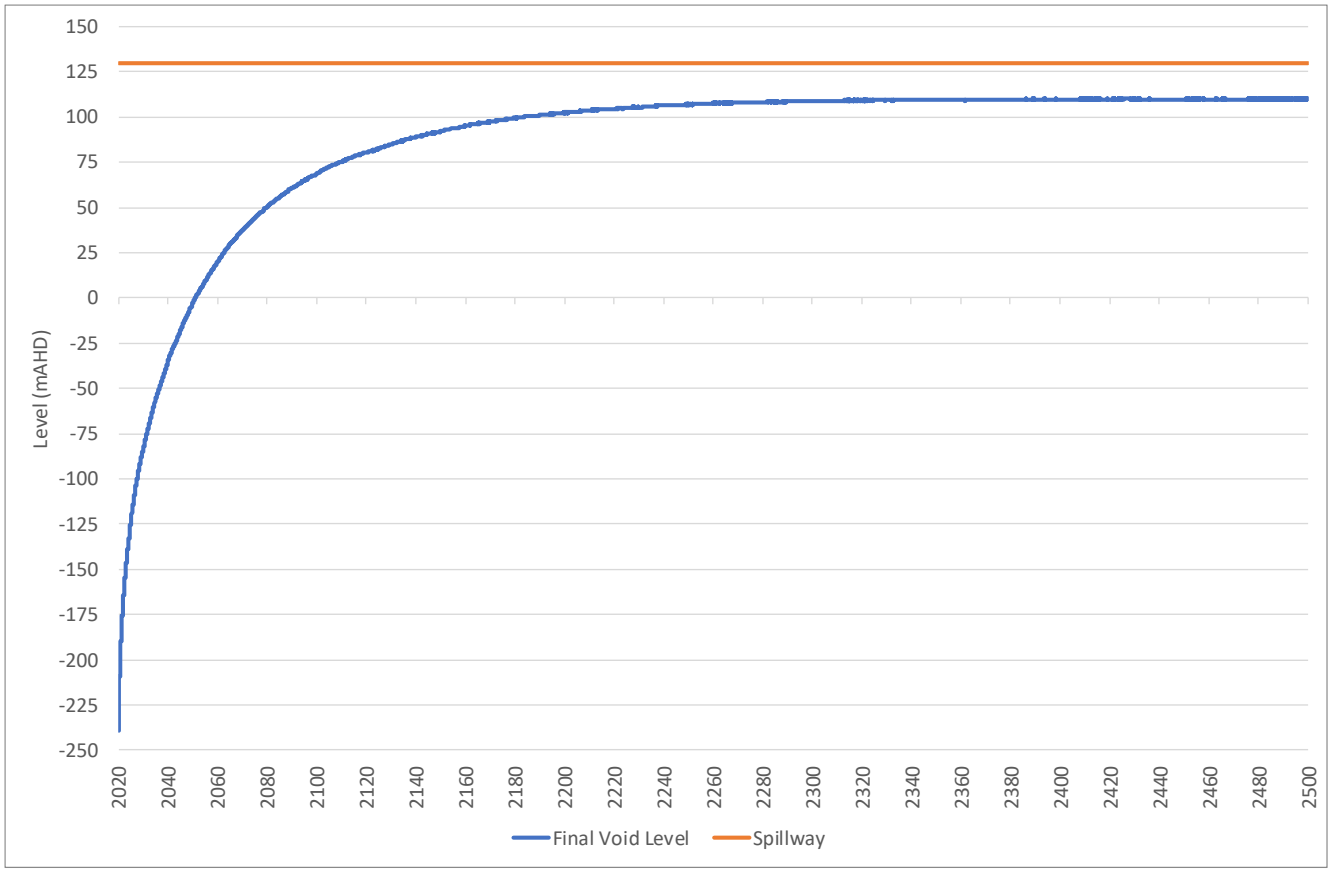


Figure 20 Final Void Water Level

5.2 Groundwater Level and flow directions

Post closure groundwater levels shows that the pit will most likely be a sink with inflows occurring from the north, west and east of the pit. Toward the southern pit wall, flow through conditions may occur due to predicted pit lake elevation being slightly higher than the surrounding groundwater. This is illustrated in two cross sections on **Figure 21**. Cross sections locations are shown on **Figure 22**. The groundwater catchment downgradient of the predicted pit lake elevation (i.e. 110 mAHD) is shown on **Figure 23**.

To the exception of the southern end of the pit, groundwater flow direction will remain as per current conditions, with the majority of the site flowing toward the Perry River Weir and the southern end of the site flowing toward Mingham Creek. Groundwater flow contours under average climate conditions are presented on **Figure 22**.

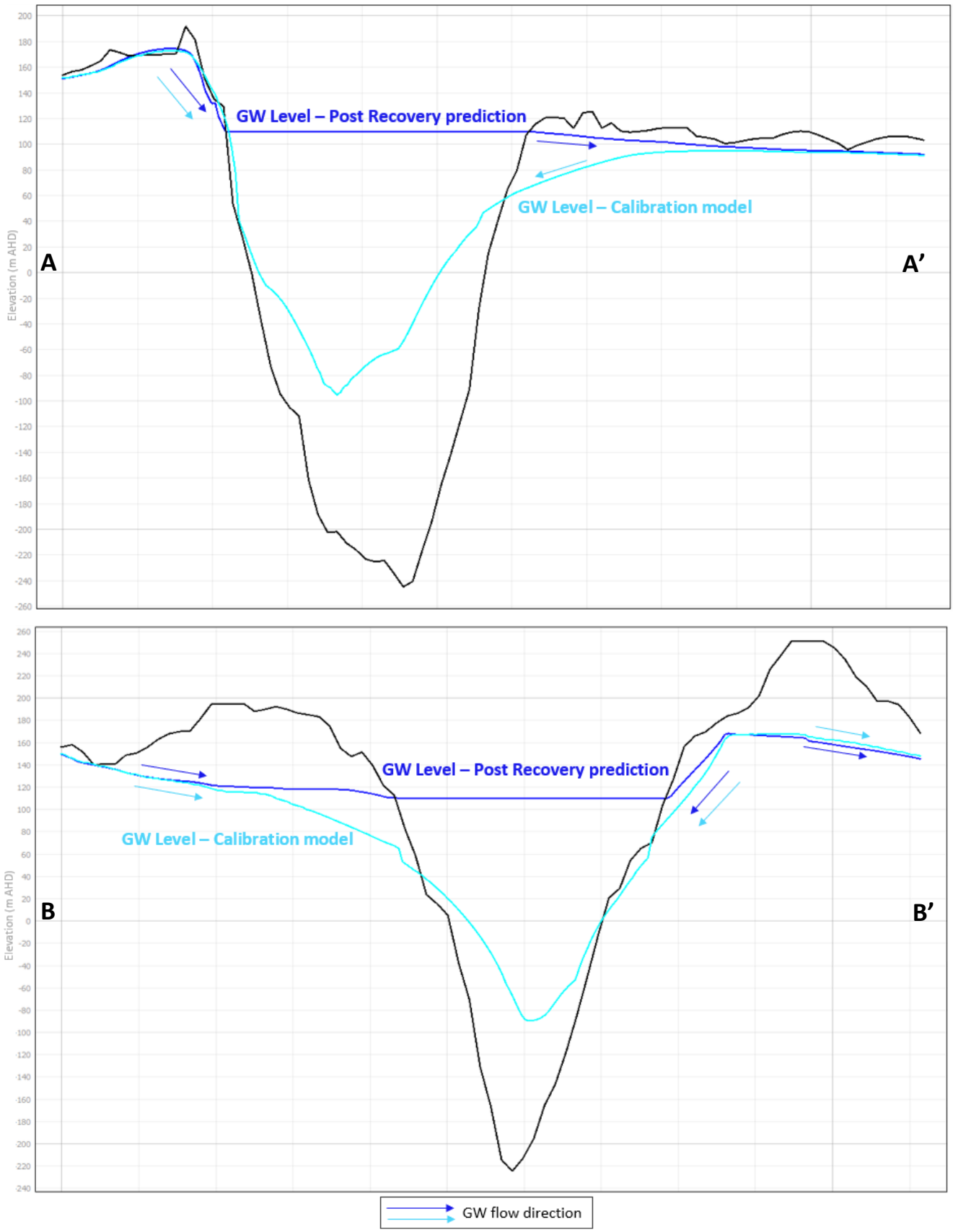
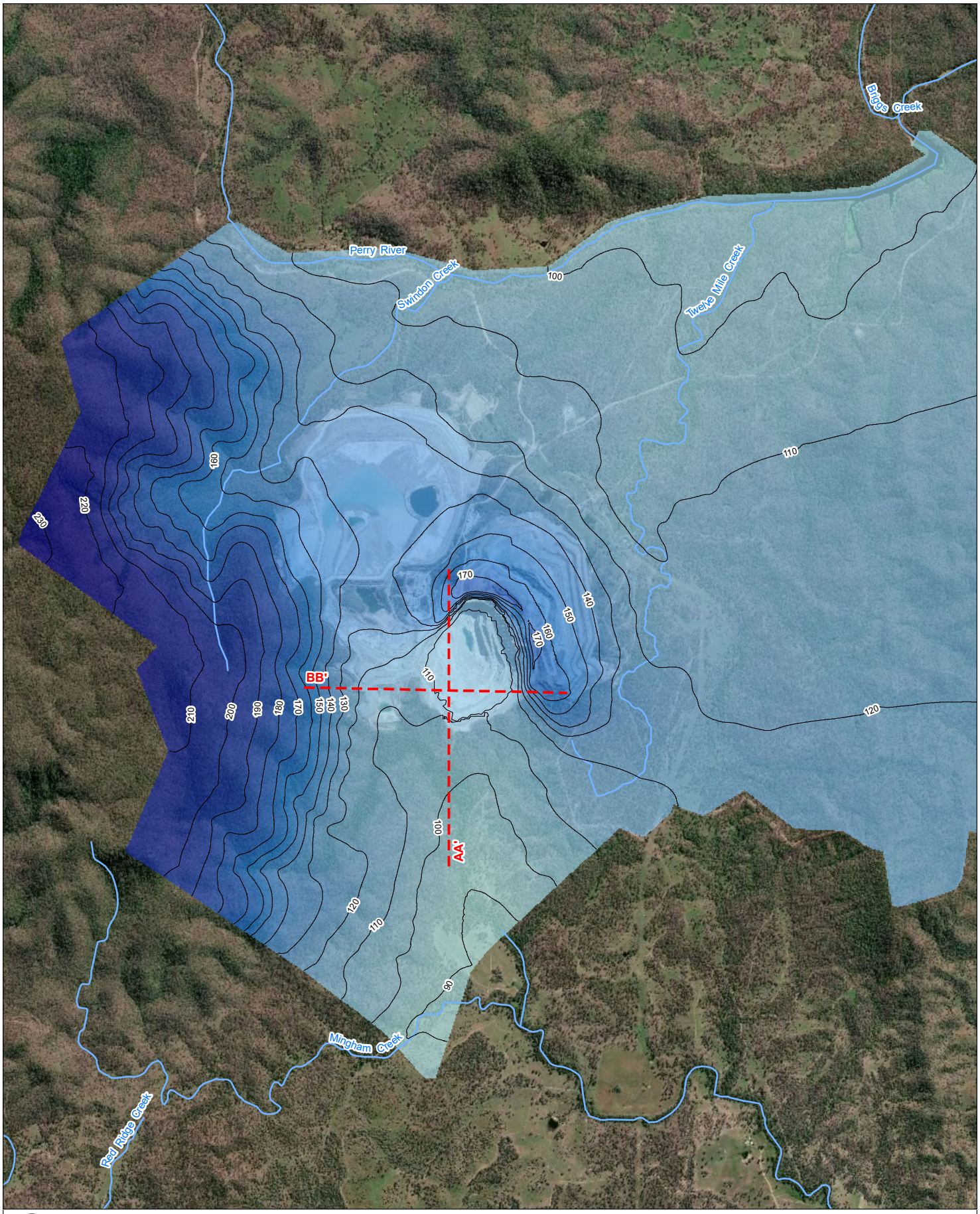


Figure 21 Final Landform Cross Sections showing current (2018) and post recovery groundwater level



0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:40,000 at A4
Project Number:	620.30185
Date:	11-Nov-2020
Drawn by:	JG

Cross Sections

Watercourses

Potentiometric Surface (mAHD)

High : 233.55

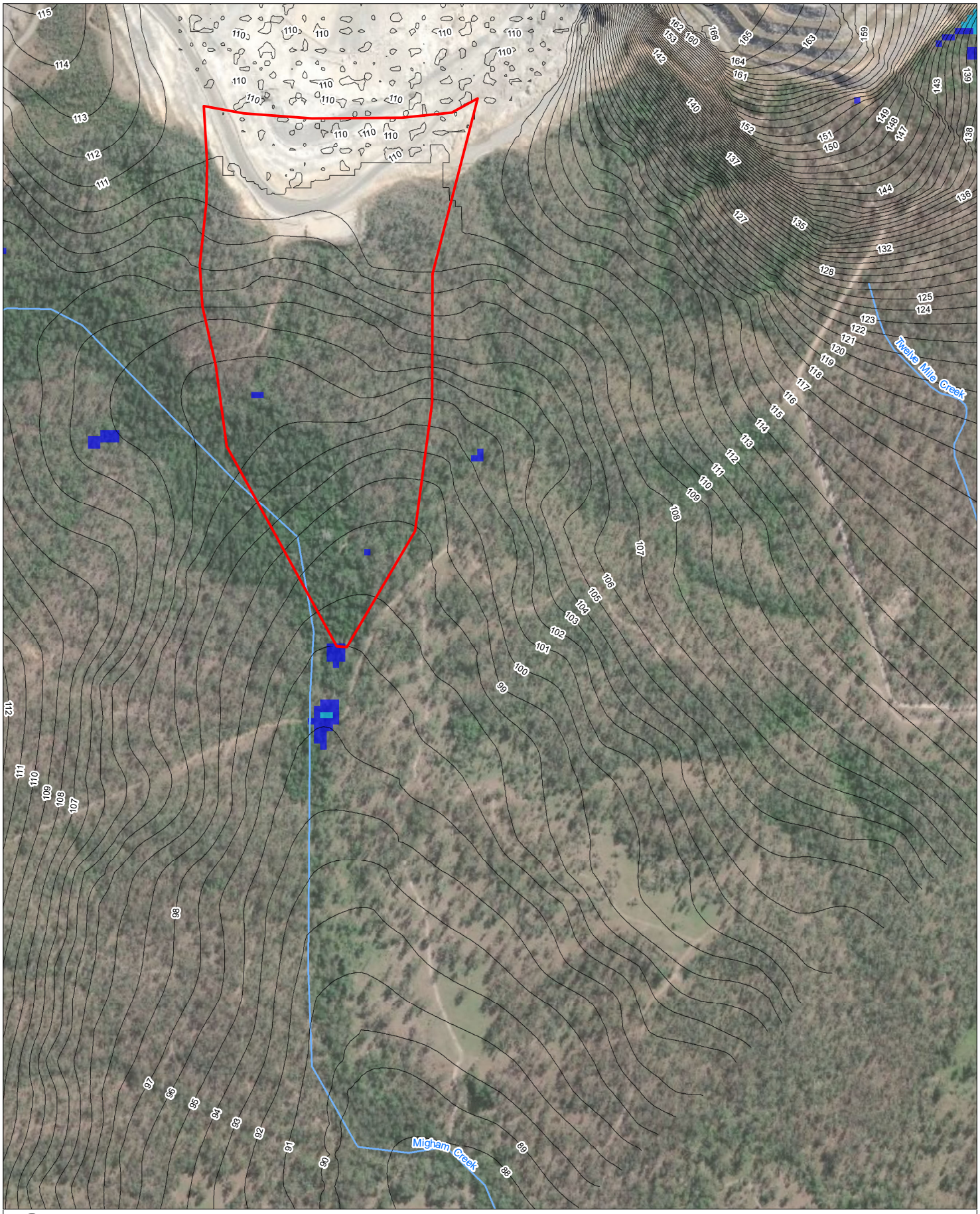
Low : 87.071

MT RAWDON POST-CLOSURE GROUNDWATER MODEL

Post-Closure Potentiometric Surface in the Fractured Rock Aquifer (Layer 5)

FIGURE 22

H:\Projects-SLR\620-BNE\620.30185.00000 Mt Rawdon Post Closure Groundwater model\06 SLR Data\01 CADGIS\GIS\GIS\620301 85 F22 Post-Closure Potentiometric Surface in the Fractured Rock Aquifer (Layer 5).mxd



0 100 200 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:8,000 at A4
Project Number:	620.30185
Date:	11-Nov-2020
Drawn by:	JG

1m Groundwater Contours

Watercourses

Groundwater Cachment Downgradient Pit Lake

Areas of Potential Groundwater Expression

> GL

0 - 1 m BGL

MT RAWDON POST-CLOSURE GROUNDWATER MODEL

Area of Potential Groundwater Expression

FIGURE 23

H:\Projects-SLR\620-BNE\620.30185.00000 Mt Rawdon Post Closure Groundwater model\06 SLR Data\01 CADGIS\GIS\620301 85 F23 Groundwater elevation downgradient of the predicted final pit lake elevation.mxd

5.3 Potential Groundwater Expression

Model results have been used to identify areas where groundwater originating from the pit could potentially express at the surface.

Figure 23 shows potential groundwater expression at the surface, based on standing water levels in the fractured rock aquifer. In **Figure 23**, the distribution of groundwater levels in the fractured rock were compared to surface elevation. Area of potential groundwater expression were defined as groundwater potentiometric surface above or within 1m of the ground surface.

A small area downgradient of the pit, directly below Mingham Creek shows groundwater level within 1m of the ground surface (**Figure 23**). However, it is noted that this area, which is currently monitored by bore MRMB75, is poorly calibrated in the model, with the measured groundwater levels 10m lower than simulated in the calibrated model (i.e. the model is overpredicting the water levels in this area).

Guiding Principle 7.4 of the Groundwater Modelling Guidelines (Barnett, 2012) states "*that there is more uncertainty when reporting confidence intervals around an absolute model output, and less uncertainty when a prediction can be formulated as a subtraction of two model results".* Given the inaccuracy in the model to predict absolute water level elevations in this area, a comparison was made between the calibration model results (i.e. current conditions) and the post-mining predictive results for differential in water levels as a result of the post-mining final land surface and final void level. The results indicate a maximum of a potential rise in water level of 2m within the area surrounding Mingham Creek. Current monitoring shows that water levels are >10m below ground surface. Therefore, a 2m rise in groundwater levels is unlikely to result in expression of groundwater at surface in Mingham Creek.

5.4 Groundwater inflows to the pit

The groundwater inflows to the final void are presented on **Table 16**. Post-closure modelling indicated that water stored in the pit could seep to the groundwater downgradient (south) of the pit at a rate of 0.01ML/day.

Table 16 Pit Water Budget

Groundwater flow component	Model run 2 (Average conditions)	Model run 3 (Climate change likely scenario)
Steady State Groundwater outflow to Groundwater (ML/d)	0.008	0.002
Steady State Groundwater inflow to pit (ML/d)	0.429	0.462
Steady State Groundwater Net Flow to pit (ML/d)	0.421	0.460

5.5 Impact on Environmental Receptors

Post Closure modelling indicated that water stored in the pit could seep to the groundwater downgradient (south) of the pit at a rate of 0.01ML.day. The results of the GLM model indicate the final void water quality is generally acceptable in regard to salinity concentration, with surface water generally maintaining freshwater levels of concentration. The results indicate salinity concentration within the deeper levels of the void are dominated by the inflowing groundwater, and generally maintains an acceptable level of 1000 to 2000 mg/L of salinity concentration. The potential for groundwater originating from the pit to express at the surface is low, as detailed in **Section 5.3.** Considering the above, final void impacts on surface ecosystems is low.

Consultation of the DNRME data set for Groundwater Dependant Ecosystems (GDEs) indicate that no GDEs are located south of the pit. The closest GDE identified is a surface water GDE associated with the Sunday Creek, about 8km upstream of the ML. Post closure impacts on GDE are thus unlikely. Consultation of the DNRME data set for registered private bores indicates that no private bores are located with 8km downstream from the pit. Post closure impacts on landholder bores are thus also unlikely.

6 Conclusion

A coupled groundwater and surface water models have been developed to predict post-closure groundwater levels and assess potential risks to environmental receptors at MRO. The surface water model predicts that the final void will stabilise after 275 years to a level of approximately 110 m AHD. The salt concentration in the final void is expected to remain fresh on the surface and progressively increase with depth, with the deeper levels likely to show salt concentration similar to the surrounding groundwater.

The final void could become a flow through as it reaches near equilibrium. Considering the final void salinity and low seepage rates expected, the potential impact onto the surrounding groundwater quality is expected to be low. The likelihood of impacts on surface water ecosystems is also low, with only a small area below Mingham Creek downgradient of the void showing groundwater levels within 1m of the ground surface. This area has been flagged previously as poorly calibrated (NRC, 2019) and it is recommended for the model to be recalibrated in order to better assess whether groundwater could express at the surface in this area. Nevertheless, current monitoring shows that water levels are >10m below ground surface. Therefore, a 2m rise in groundwater levels is unlikely to result in expression of groundwater at surface in Mingham Creek.

There are no GDE, springs or private groundwater users in the vicinity of MRO and this assessment thus concludes that post-closure impacts onto groundwater and associated environmental receptors are likely to be limited.

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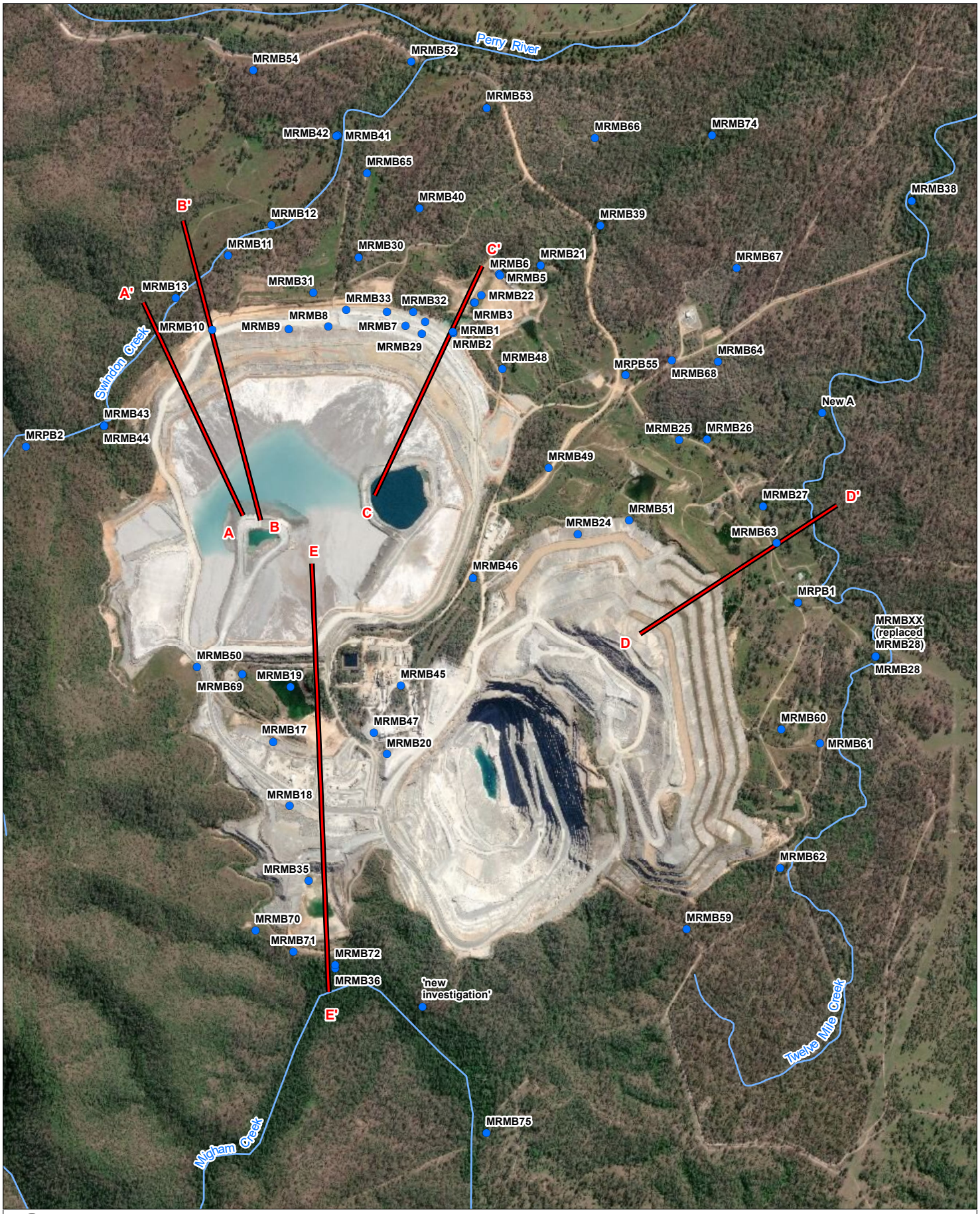
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APPENDIX A

Numerical Model – Post Mining (Recovery) Cross Sections



0 250 500 m

Coordinate System:	GDA 1994 MGA Zone 56
Scale:	1:20,000 at A4
Project Number:	620.30185
Date:	11-Nov-2020
Drawn by:	JG

- Groundwater Monitoring Bores
- Cross Sections
- Watercourses

MT RAWDON POST-CLOSURE GROUNDWATER MODEL

Cross Sections Location

FIGURE A-1

H:\Projects-SLR\620-BNE\620.30185.00000 Mt Rawdon Post Closure Groundwater model\06 SLR Data\01 CADGIS\GIS\S620301185 FA-1 Cross Sections Location.mxd

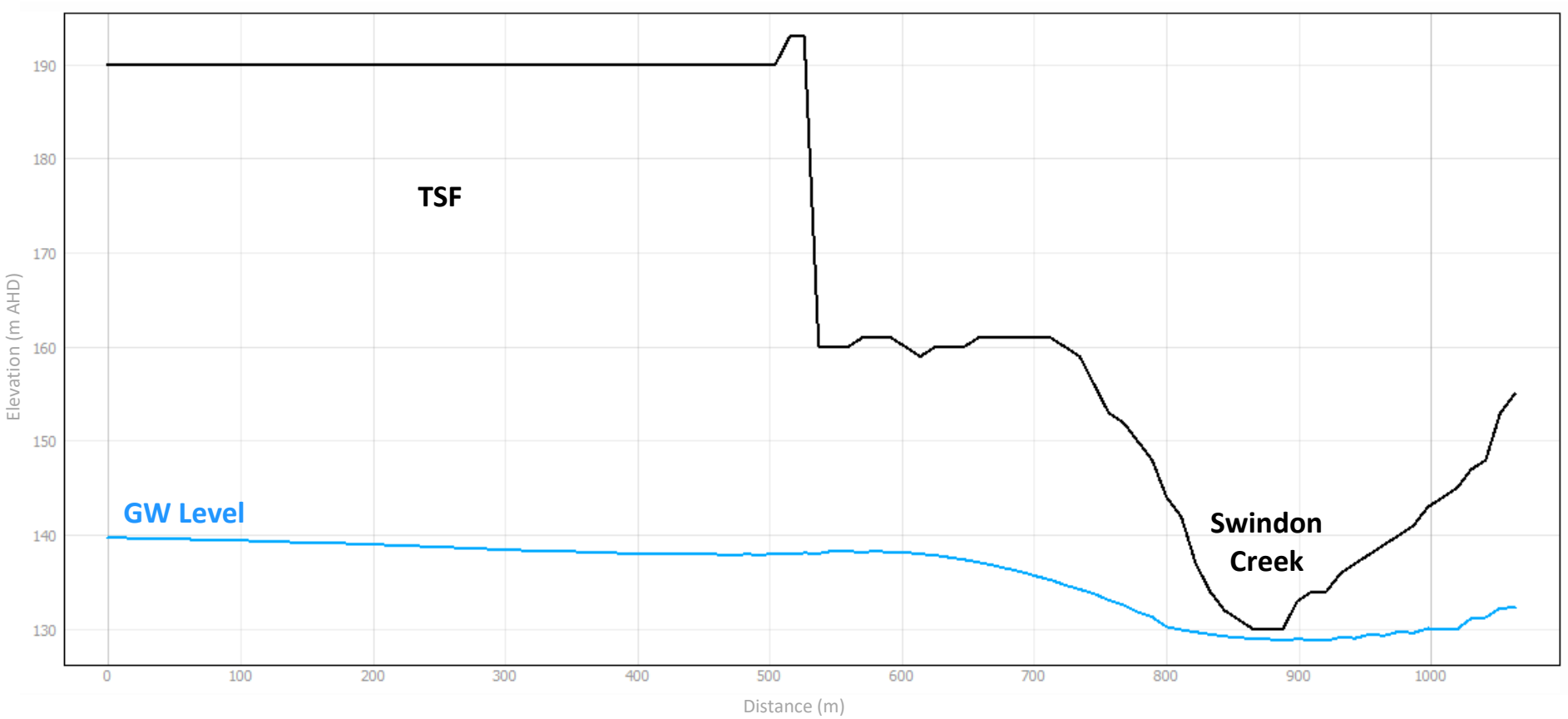


Figure 1 Cross Section AA'

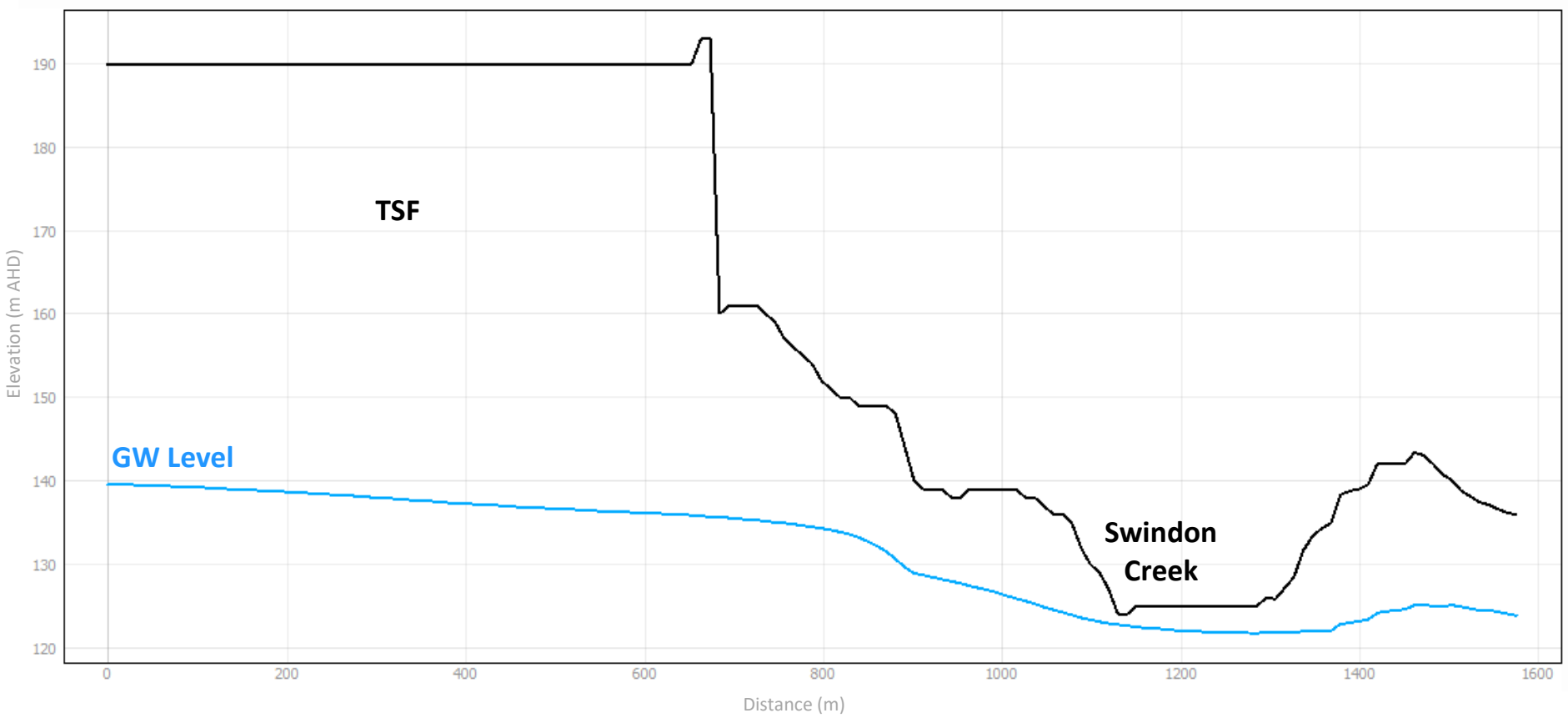


Figure 2 Cross Section BB'

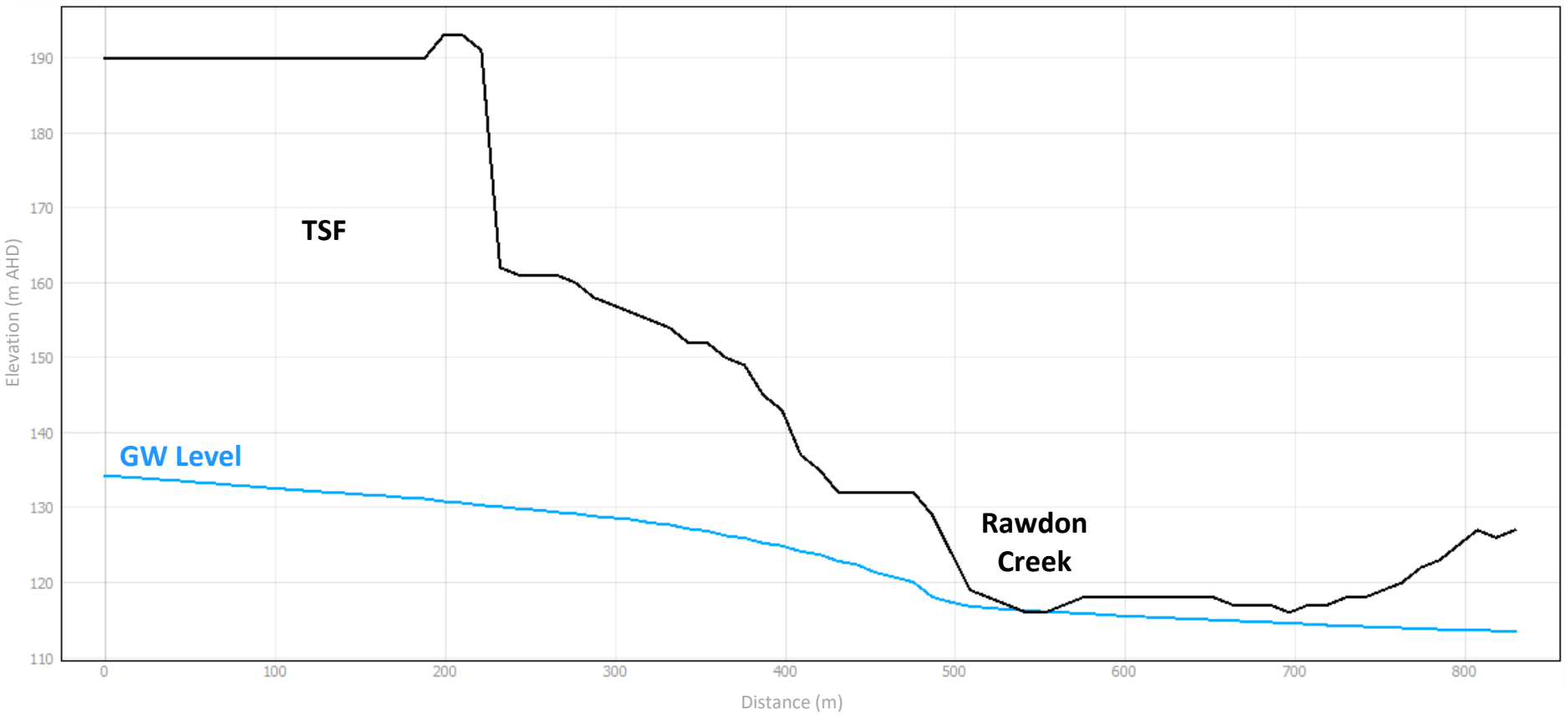


Figure 3 Cross Section CC'

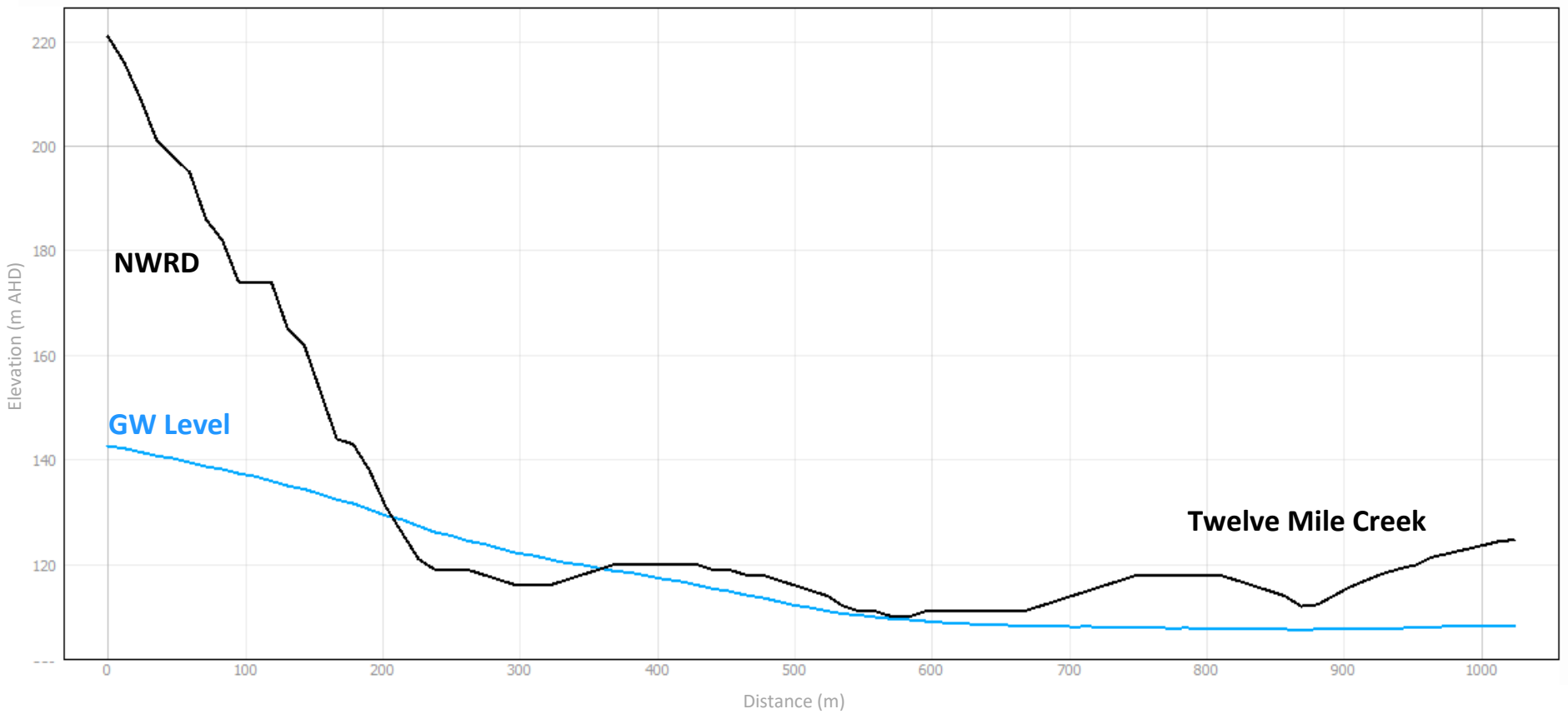


Figure 4 Cross Section DD'

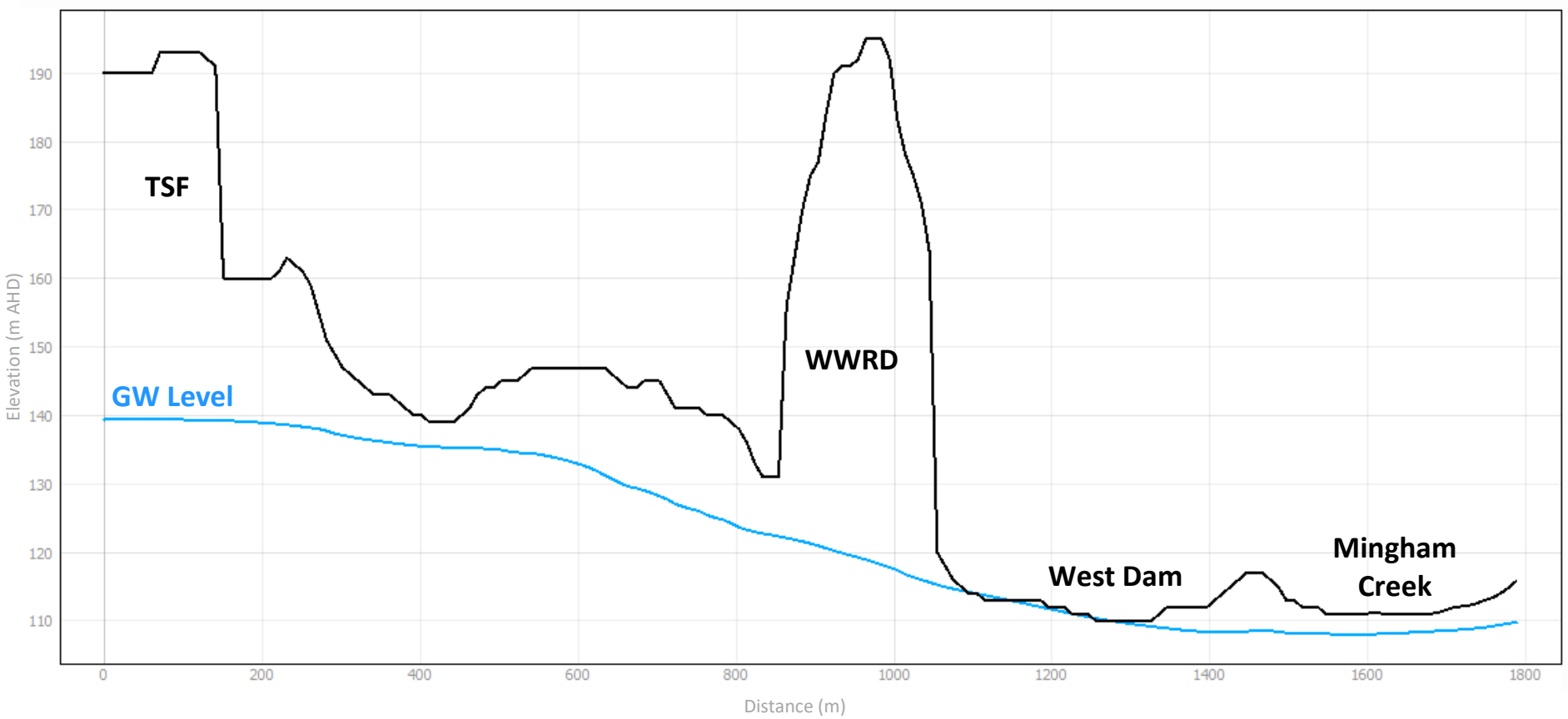


Figure 5 Cross Section EE'

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TECHNICAL REPORT

Assessment of Long-Term Geochemical Characteristics of Mt Rawdon Tailing Materials – Final Report

Mt Rawdon Gold Mine

Prepared for: Mt Rawdon Operations Pty Ltd

RGS

MINE WASTE AND
WATER MANAGEMENT

TECHNICAL REPORT

Assessment of Long-Term Geochemical Characteristics of Mt Rawdon Tailing Materials – Final Report

Mt Rawdon Gold Mine

Prepared for: **Mt Rawdon Operations Pty Ltd**

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Glossary of Terms and Acronyms

Acidity	A measure of hydrogen ion (H+) concentration and latent acidity from dissolved metals; simplistically expressed as pH but more correctly as mg/L ($CaCO_3$ equivalent).
Alkalinity	A measure of the capacity of a water to neutralise acids mg/L ($CaCO_3$ equivalent).
ABA	Acid Base Account, an evaluation of the balance between acid generation and acid neutralisation processes. Generally, determines the MPA and the inherent ANC, as defined below, and is commonly used in assessing the potential for AMD associated with mining.
AMD	Acid and metalliferous drainage caused by exposure of sulfide minerals in mine waste materials to oxygen and water. Typically characterised by low pH and elevated concentrations of salts, sulfate and metals.
ANC	Acid neutralising capacity of a sample as kg H_2SO_4 per tonne of sample. Commonly referred to as the buffering capacity.
ANC:MPA Ratio	Ratio of the acid neutralising capacity and maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
EC	Electrical Conductivity, expressed as µS/cm, is a measure of electrical conductance.
KLC test	Kinetic leach column tests are procedures used to measure the geochemical/ weathering behaviour of a sample of mine material over time.
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity calculated by multiplying the total sulfur content of a sample by 30.625 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAG test	Net acid generation test. Hydrogen peroxide solution is used to oxidise sulfides in a sample, then any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is expressed as kg H_2SO_4 per tonne. The more elaborate extended boil NAG test can be used if a sample has a high organic carbon content to attempt to eliminate interference and false positive results.
NAF	Non-acid forming. Geochemical classification criterion for a sample that will not generate acid conditions.
NAF-Barren	Non-acid forming and barren of sulfur (ie. less than or equal to 0.07% sulfur). Geochemical classification criterion for a sample that will not generate acid conditions.
NAPP	Net acid producing potential expressed as kg H_2SO_4 per tonne. NAPP is the balance between the capacity of a sample to generate acidity (MPA) minus its capacity to neutralise acidity (ANC).
NMD	Neutral mine drainage typically caused by exposure of sulfide minerals in mine waste materials to oxygen and water and then neutralisation by gangue minerals. Typically characterised by neutral pH and elevated concentrations of salts, sulfate and metals.
Ore	Material that is been mined with sufficient value to warrant processing. Low-grade ore may be left as waste.
PAF	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
pH	Measure of the hydrogen ion (H+) activity in a sample solution, expressed in pH units.

PSD	Particle size distribution of a sample material measured by hydrometer.
%S	Percent sulfur. A measurement unit for the sulfur content of a sample material.
Scr	Chromium reducible sulfur test measures the sulfide sulfur content of a sample material.
Static test	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
Tailing	A form of process residue generated as a result of processing ore.
Total Sulfur	Total sulfur content of a sample generally measured using a 'Leco' analyser expressed as % S.
TSS	Total suspended solids is a measurement of the suspended solids concentration in a water sample.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.
Waste Rock	Material that surrounds an ore body and must be removed to mine the ore.
WRD	Waste Rock Dump. A facility used to store waste rock

1 Introduction

Mount Rawdon Operations Pty Ltd (MRO) is owned by Evolution Mining and is located in south-east Queensland, approximately 75 km south-west of Bundaberg, and 300 km north-north west of Brisbane. MRO is an open cut gold mine with facilities for gold recovery by ore processing at a Carbon-in-Leach (CIL) treatment plant, and the tailing retained in an engineered tailing storage facility (TSF). Mining, processing of ore, and tailing deposition commenced in January 2001 and construction of a waste rock dump in March 2002. The anticipated life of the mining operation is currently approximately eight years. MRO carries out its operations in accordance with the current Environmental Authority (EA) document (DES, 2019).

RGS Environmental Pty Ltd (RGS) was commissioned by MRO to complete an assessment of the long term geochemical characteristics of tailing materials stored at the TSF. In order to complete this project, representative samples of near-surface tailing were collected from the isolated south-west cell at the TSF. The MRO site layout including the location of the TSF is provide in **Figure 1-1**. At the time of sampling, some of the near-surface tailing had been exposed to oxidising conditions for a period of up to five years. The tailing materials were characterised using standard static geochemical tests and then kinetic leach column (KLC) tests for a further four year test period.

The geochemical work program described herein was completed to build upon existing knowledge if the geochemistry of the tailings materials (KCB, 2010; RGS, 2011a,b, 2017 and 2020) and to provide important additional information with a view to future closure of the facility and approval of any supplementary TSF (RGS, 2016a). This report summarises the current geochemical characteristics of the tailing materials stored at the TSF and, based on available information, predicts the geochemical characteristics of the tailing materials moving into the future and post-closure. The level of any geochemical risks associated with long term seepage from the tailing materials at the TSF has been investigated based on currently available geochemical and monitoring data (RGS, 2016b). Potential measures that could be considered by MRO as part of closure planning for the TSF have been identified to reduce any identified risks.

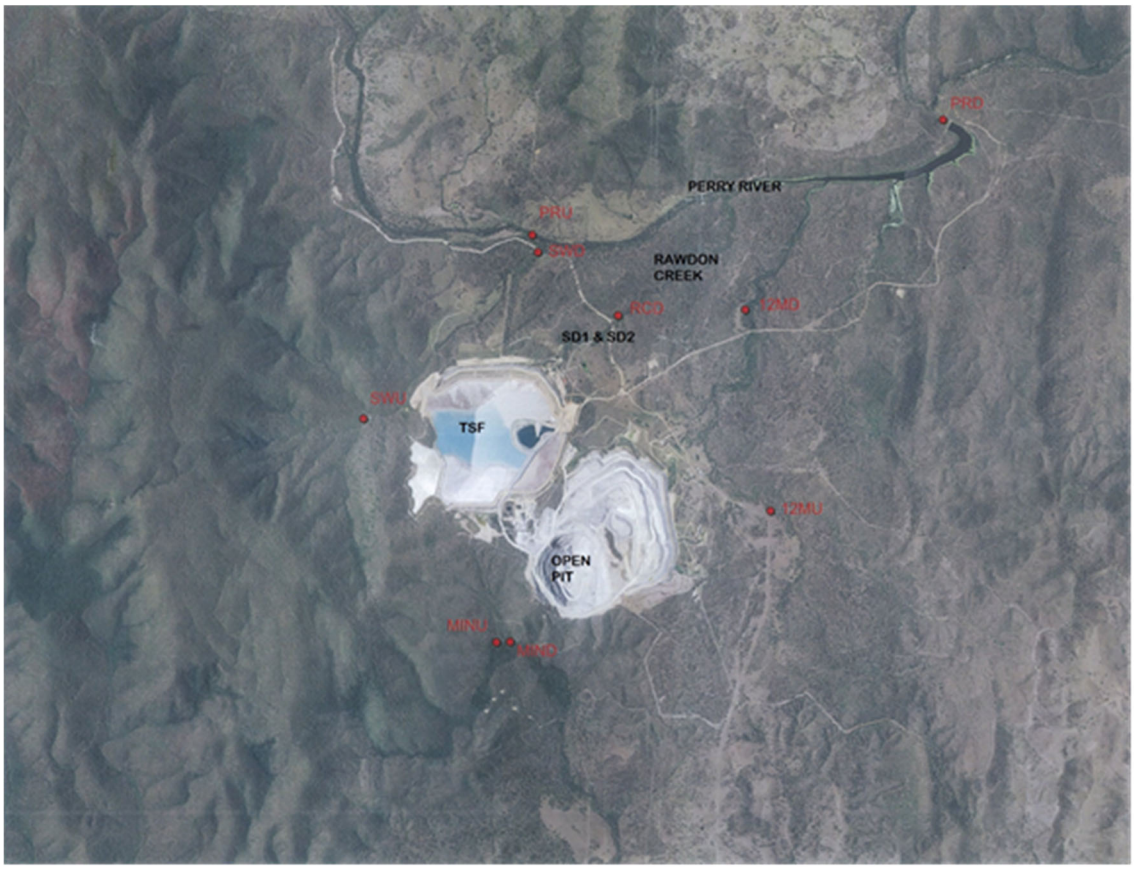


Figure 1-1: MRO Site Layout Including Location of TSF

2 Scope of Work

The Scope of Work completed for this investigation included:

- Collection and static geochemical testing of four representative samples of near-surface tailings from the isolated south-west cell at the TSF.
- Sample compositing and completion of a further two-year KLC test program on tailing materials under saturated (anoxic) and unsaturated (oxic) conditions.
- Tabulation and interpretation of acquired geochemical data.
- Preparation of a technical letter report (this report) presenting the results and findings to date and including potential measures that could be considered by MRO as part of closure planning for the TSF.

3 Methodology

In order to complete this investigation, RGS has relied upon existing knowledge if the geochemistry of the tailing materials (KCB, 2010; RGS, 2011a,b, 2017 and 2020) as well as new static and kinetic geochemical information gathered as part of the current work program. The geochemical sampling and test work program was completed in accordance with existing technical guidelines for the geochemical assessment of mine waste in Queensland (DME, 1995; DEHP, 2013), Australia (AMIRA, 2002; and COA, 2016) and worldwide (INAP, 2009). These guidelines were used to ensure that the sampling and testing program used was appropriate and focused on obtaining and testing representative samples of tailing materials produced at the mine.

Four near-surface tailing samples were collected in 20L plastic buckets by MRO personnel from the isolated south-west cell at the TSF in November 2014 and sent directly to ALS Environmental laboratory in Brisbane (ALS laboratory) for initial static geochemical testing. KLC testing was then completed at the RGS 'in-house' laboratory and collected leachate samples sent to ALS laboratory for further assay. The sampling and geochemical testing process was coordinated by RGS personnel.

A summary of the parameters typically involved in completing a static and kinetic geochemical assessment of tailing materials is provided in **Attachment A**.

3.1 Static Tests

Static geochemical tests provide a 'snapshot' of the characteristics of a sample material at a single point in time. These tests were completed on pulverised samples to check whether the four tailing samples had similar geochemical characteristics and could be composited into a single tailing sample for KLC tests.

The Acid Base Account (ABA) was used to determine the acid-neutralising and acid-generating characteristics of the four tailing samples using the following parameters:

- pH and Electrical Conductivity (EC) (1:5 w:v, sample:deionised water);
- Total sulfur [Leco method];
- Chromium Reducible Sulfur [AS 4969.7-2008 - Standards Australia, 2008 method]
- Acid neutralising capacity (ANC) [AMIRA, 2002 method]; and
- Standard Net Acid Generation (NAG) test [AMIRA, 2002 method].

From the total sulfur and ANC results, the maximum potential acidity (MPA) and net acid producing potential (NAPP) values of the tailings samples were calculated.

The four tailing samples were then subjected to multi-element analysis at ALS laboratory and the solid fraction was specifically tested for:

- Total cations (Ca, Mg, Na and K) [HCl and HNO_3 acid digest followed by ICP-AES/MS]; and
- Total metals/metalloids (Al, As, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Sb, Se and Zn) in solids [HCl and HNO_3 acid digest followed by FIMS and/or ICP-AES/MS].

The raw ALS laboratory test results for the static geochemical tests are provided in **Attachment C**.

The results of the static geochemical tests were interpreted by RGS and the tailing samples were found to have very similar geochemical characteristics. The tailing samples were transferred to the RGS 'in-house' laboratory, where they were combined into a single bulk composite sample for use in the KLC test program.

3.2 Kinetic Tests

Following receipt and interpretation of the static geochemical test results, four KLC tests were set up at the RGS 'in-house' laboratory using sub-samples of the bulk composite tailing sample. The KLC tests comprised:

- Two duplicate KLC columns under permanently saturated (anoxic) conditions - analogous to the conditions experienced by bulk tailings materials in the TSF with a cover system in place.
- Two duplicate free draining KLC columns under unsaturated (oxic) conditions - analogous to freely oxidising surface tailings at the TSF with no cover system).

The KLC tests commenced in December 2014 and were operated for all four samples under a quarterly and then six monthly watering and leaching cycle for the first seven leach events (i.e., two years). Two of the four samples were then tested under a six monthly watering and leaching cycle for a further 24 months (i.e., four additional leach events). The latest two year phase of the KLC test program was completed in December 2018.

Approximately 1.6 kg of the composite tailing sample was accurately weighed and used in each of the four KLC tests. For the two free-draining unsaturated (oxic) KLC tests, heat lamps were used on a daily basis to simulate sunshine and ensure that the KLC test materials were unsaturated and subject to oxidising conditions, between leaching events (essentially an assumed 'worst case' scenario for sulfide oxidation and potential acid/salt generation). For the two saturated (anoxic) KLC tests, a permanent 10 cm head of deionised water was maintained over the tailing surface. A schematic diagram of the free-draining KLC test arrangement is provided in **Attachment A**.

The composite tailing sample was used in the KLC tests with no additional sample preparation. All leachate samples collected from the KLC tests were sent to ALS laboratory for analysis of various parameters including:

- pH and EC (pH and EC probes and meter);
- Acidity and alkalinity [Automatic titrator];
- Dissolved metals/metalloids (Al, As, B, Cd, Cr, Co, Cu, F, Fe, Pb, Mn, Mo, Ni, Sb, Se, Si and Zn) [ICP-AES and FIMS];
- Dissolved major cations (Ca, Mg, Na and K) [ICP-AES]; and
- Dissolved major anions (Cl and SO_4) [ICP-AES].

KLC test results and trends to date are presented in **Attachment B** and a copy of the geochemical results received from ALS laboratory for the KLC tests is provided in **Attachment C**.

4 Results

A summary of the parameters involved in a typical geochemical test program for mine waste materials is provided at **Attachment A**.

4.1 Acid Base Account (ABA) Results

The ABA results for the four Mt Rawdon tailings samples are provided in **Table 4-1**. An explanation of the terminology used in this section, including a description of the ABA test methodology, is provided in **Section 3.1** and **Attachment A**.

Table 4-1: Acid Base Account (ABA) Results for Mt Rawdon Tailing Samples

ALS Laboratory Number	Client ID	Sample Type	pH	EC	Total S	Scr	MPA	ANC	NAPP	ANC: MPA Ratio	NAG pH	NAG capacity at pH 4.5 (kg H_2SO_4/t)	Sample Classification
				(µS/cm)	(%)		(kg H_2SO_4/t)						
EB1446978001	MR01	Tailings	8.2	2,040	1.14	0.795	24.3	47.5	-23.2	1.95	9.5	<0.1	Non-Acid Forming (NAF)
EB1446978002	MR02	Tailings	8.6	3,330	1.15	0.797	24.4	43.3	-18.9	1.77	8.9	<0.1	Non-Acid Forming (NAF)
EB1446978003	MR03	Tailings	8.6	1,530	1.07	0.795	24.3	28.0	-3.7	1.15	9.2	<0.1	Non-Acid Forming (NAF)
EB1446978004	MR04	Tailings	8.3	759	1.16	0.839	25.7	27.5	-1.8	1.07	9.1	<0.1	Non-Acid Forming (NAF)

Notes:
1. Current pH, EC, Alkalinity and Acidity provided for 1:5 sample:water extracts
2. Scr = Chromium Reducible Sulfur; MPA = Maximum Potential Acidity; ANC = Acid Neutralising Capacity; NAPP = Net Acid Producing Potential and NAG = Net Acid Generation.
3. Sample classification detail provided in report text.

The tailings samples are slightly alkaline and have a pH in the range 8.2 to 8.6. The EC value ranges from 759 to 3,330 µS/cm and the samples are slightly brackish.

The total sulfur content of the samples is just over 1 %S and approximately 70 % of this sulfur is present as sulfide sulfur as indicated by the Chromium Reducible Sulfur (Scr) test results. This implies that about 30 % of the total sulfur content is likely to be present as other forms of sulfur such as sulfate and possibly galena and sphalerite which, in comparison to a reactive sulfide sulfur form such as pyrite, have negligible capacity to generate additional acidity if exposed to oxidising conditions.

The Maximum Potential Acidity (MPA) of the four tailing samples ranges from 24.3 to 25.7 kg H_2SO_4/t and is consistent. The ANC value for the samples ranges from 27.5 to 47.5 kg H_2SO_4/t and is consistently moderate. Previous studies (RGS, 2011a,b) have demonstrated that at least half of the ANC value in the Mt Rawdon tailings is likely to be readily available to buffer any acid generated by sulfide oxidation. The remainder of the ANC may be slower to react and only available at lower pH values.

The Net Acid Producing Potential (NAPP) is the balance between the capacity of a sample to generate acidity (MPA) minus its capacity to neutralise acidity (ANC). The calculated NAPP value for the four tailing samples is negative and ranges from -1.8 to -23.2 kg H_2SO_4/t with an average value of -10.9 kg H_2SO_4/t.

The ANC:MPA ratio of the tailing samples ranges from 1.07 to 1.95 and is less than 2. While samples with an ANC:MPA ratio between 1 and 2 generally represent material that has some level of uncertainty regarding the overall potential to generate acidity, the Net Acid Generation (NAG) test pH and NAG capacity results are both indicative of a material that is Non-Acid Forming (NAF).

4.2 Multi-Element Concentration in Tailing Solids

As described in **Section 3.1**, multi-element scans were completed on the four tailing samples to identify any elements (metals/metalloids) present in this material at concentrations that may be important with respect to materials handling, storage, final rehabilitation and potentially water quality. The total metal/metalloid concentration the tailing samples has been compared with the median crustal abundance for unmineralised soils (INAP, 2009; and Bowen, 1979). The extent of any enrichment has been reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average abundance on a $\log^{10}$ scale.

The GAI is expressed in integer increments from 0 to 6, where a GAI value of 0 indicates that the element is present at a concentration less than, or similar to, the median crustal abundance; and a GAI value of 6 indicates an approximate 100-fold enrichment above median crustal abundance **(Table 4-2)**.

Table 4-2: Geochemical Abundance Index (GAI) Values and Enrichment Factor

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 – 48 fold enrichment
1	3 – 6 fold enrichment	5	48 – 96 fold enrichment
2	6 – 12 fold enrichment	6	Greater than 96 fold enrichment
3	12 – 24 fold enrichment		

As a general rule, a GAI of 3 or greater signifies enrichment that may warrant further examination. This is particularly the case with some environmentally important 'trace' elements, such as As, Cr, Cd, Cu, Pb, Se and Zn, more so than with major rock-forming elements, such as Al, Ca, Fe, Mg and Na.

Elements identified as enriched may not necessarily be a concern for revegetation, water quality or public health, but their significance should still be evaluated. Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (e.g., low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

The results from multi-element testing (total metals/metalloids) of the four tailing samples are presented in **Table 4-3**. The relative enrichment of metals/metalloids in the samples compared to median crustal abundance is presented in **Table 4-4**. The results indicate that the metals/metalloids tested in the tailing samples are enriched with arsenic, cadmium, copper and zinc compared to median crustal abundance. These results are expected given that the tailing materials are produced from processing gold bearing ore in a highly mineralised area.

The potential solubility and mobility of these and other metals/metalloids in the tailing sample materials is investigated further using KLC tests in **Section 4.3**.

Table 4-3: Multi-Element Test Results for Mt Rawdon Tailing Samples

	ALS Laboratory Sample ID →	EB1448856005	EB1448856006	EB1514156005	EB1514156006
Parameters	Limit of Reporting	**MR01**	**MR02**	**MR03**	**MR04**
Major Cations	All units mg/kg				
Calcium (Ca)	50	20,800	19,600	13,000	12,000
Magnesium (Mg)	50	6,190	6,140	3,000	3,020
Potassium (K)	50	2,630	2,760	1,120	1,820
Sodium (Na)	50	910	1,880	250	1,240
Major, Minor and Trace Elements	All units mg/kg				
Aluminium (Al)	50	11,600	10,700	4,970	5,410
Antimony (Sb)	5	<5	<5	<5	<5
Arsenic (As)	5	77	95	84	69
Boron (B)	50	<50	<50	<50	<50
Cadmium (Cd)	1	8	9	4	4
Chromium (Cr)	2	38	18	16	61
Cobalt (Co)	2	8	7	6	6
Copper (Cu)	5	262	253	665	335
Iron (Fe)	50	25,300	25,700	16,900	17,200
Lead (Pb)	5	65	72	64	62
Manganese (Mn)	5	1,300	1,300	1,120	1,090
Molybdenum (Mo)	2	<2	<2	<2	<2
Nickel (Ni)	2	6	5	9	8
Selenium (Se)	5	<5	<5	<5	<5
Zinc (Zn)	5	1,440	1,740	843	750

Notes: < indicates less than the laboratory limit of reporting.

Table 4-4: Geochemical Abundance Index Results for Mt Rawdon Tailing Samples

	ALS Laboratory ID→		EB1448856005	EB1448856006	EB1514156005	EB1514156006
Parameters	Limit of Reporting	Median Crustal Abundance[1]	**MR01**	**MR02**	**MR03**	**MR04**
Major Elements	All units mg/kg		GAI value			
Aluminium (Al)	50	71,000	0	0	0	0
Calcium (Ca)	50	15,000	0	0	0	0
Iron (Fe)	50	40,000	0	0	0	0
Magnesium (Mg)	50	5,000	0	0	0	0
Potassium (K)	50	14,000	0	0	0	0
Sodium (Na)	50	5,000	0	0	0	0
Minor Elements	All units mg/kg		GAI value			
Antimony (Sb)	5	5	0	0	0	0
Arsenic (As)	5	6	3	3	3	3
Boron (B)	50	100	0	0	0	0
Cadmium (Cd)	1	0.35	4	4	3	3
Chromium (Cr)	2	70	0	0	0	0
Cobalt (Co)	2	8	0	0	0	0
Copper (Cu)	5	30	3	2	4	3
Lead (Pb)	5	35	0	0	0	0
Manganese (Mn)	5	1,000	0	0	0	0
Molybdenum (Mo)	2	2	0	0	0	0
Nickel (Ni)	2	50	0	0	0	0
Selenium (Se)	5	0.4	0	0	0	0
Zinc (Zn)	5	90	3	4	3	2

Notes: GAI's greater than or equal to 3 are highlighted.

1. Median Crustal Abundance values sourced from the "GARD Guide", Chapter 5 (INAP, 2009) and Bowen H.J.M.(1979) Environmental Chemistry of the Elements, pages 60-61. .

4.3 Kinetic Leach Column (KLC) Test Results

As described in **Section 3.2**, four KLC tests were undertaken on a sub-samples of a bulk composite sample of tailing material under saturated (anoxic) and unsaturated (oxic) conditions (ie. KLC 1 to KLC 4). The bulk composite KLC sample was made up of equal portions of the four 'as received' samples from the TSF. After the initial two year test period, two samples (KLC1 and KLC3) were subjected to KLC testing for a further two years.

The KLC test results and trends are presented in **Attachment B** and interpreted in this section. The static ABA test results for the four individual samples used to make up the bulk composite tailing samples have previously been provided in **Section 4.1**.

The KLC leachate concentrations are presented alongside Australian Water Quality Guideline values (AWQG, 2018; ANZECC & ARMCANZ, 2000). These guidelines are provided for context only and are not intended to be interpreted as 'maximum permissible levels' for site water storage or discharge. It should be noted that the ratio of sample to water in most of the KLC tests is typically 2:1 (w/v) (i.e. concentrated), whereas the ratio of sample to water generally used in tests where results can (arbitrarily) be compared against guideline concentrations to provide some context is an order of magnitude more dilute at 1:5 (w/v). Whilst arbitrary comparisons against guideline concentrations can be useful in some situations and help to provide relevant context, such comparisons cannot be directly extrapolated to the field situation at the project.

4.3.1 KLC Leachate Quality

The KLC leachate pH trends show that the leachate pH from the tailing samples is fairly consistent over the four year test period and remains within the pH range 6.0 to 7.8. Dynamic contact with the tailing typically adds some alkalinity to the deionised water used in the KLC tests (the typical pH of the deionised water used in the tests is in the pH range 5.5 to 6.5). The pH of the leachate from the KLC tests operated under unsaturated (oxic) conditions is generally slightly higher than under saturated (anoxic) conditions and in both cases the pH exhibits a steady trend over the four year test period.

The acidity value for the KLC leachate is low compared to the alkalinity value and generally shows a decreasing trend over time. In all cases the net alkalinity value is positive indicating an excess of alkalinity in leachate from all tailing samples. The net alkalinity value is higher in leachate from the KLC tests operated under saturated (anoxic) conditions and in both cases shows a steady trend over the four year test period.

The Weak Acid Dissociable (WAD) cyanide concentration is less than the laboratory Limit of Reporting (LoR) (0.004 mg/L) in leachate collected from all of the tailing samples, confirming that the south west cell had not been actively used to store fresh tailing materials for several (up to 5) years.

The EC value of KLC leachate from the tailing samples is initially elevated and ranges from 6,780 to 8,160 µS/cm at the start of the KLC tests. This is probably due to 'first flush' effect through agitation and disturbance during composite sample preparation and remnant surface moisture/pore water from the TSF south-west cell. The EC shows a steady decreasing trend over the four year test period, towards an EC value of 1,220 µS/cm or less. The EC value tends to be slightly lower in the KLC tests operated under saturated (anoxic) conditions.

The dominant major ions in the KLC leachate are calcium and sulfate with lesser concentrations of potassium, magnesium sodium and chloride, which tend to decrease over time. The concentration of sulfate in leachate from the KLC tests has been used to calculate the residual sulfur content of the tailing materials. The results show that at least 82.9 % of the total sulfur content remains in the tailing samples at the end of the four year test period. Whilst initially elevated (between 2,930 and 3,590 mg/L), the sulfate concentration in KLC leachate shows a similar reducing trend to the EC and is similar to or less than the applied guideline value (1,000 mg/L) for this anion towards the end of the first year of the four year test period (AWQG, 2018). It is therefore expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure of the TSF.

The concentrations of dissolved calcium and magnesium in leachate from the KLC tests have been used to calculate the residual ANC remaining in the tailing materials. The results indicate that at least 87.0 % of the measured ANC remains in the tailing samples at the end of the four year test period. It is noted that the concentration of silicon in KLC leachate from the columns is elevated and after an initial increasing trend is

relatively steady over the test period. Previous investigations have suggested the potential for significant medium to long-term ANC (in addition to that readily available from calcite (KCB, 2011)) to be available from some of the major non-sulfide alumino-silicate mineral phases in the mine materials (eg. chlorite and albite), which contain silicon (RGS, 2011a).

The concentration of dissolved trace metals/metalloids in leachate from the KLC tests is typically very low, below the laboratory LoR, and within applied water quality guideline values. The exceptions are cadmium and manganese concentrations in leachate from the saturated (anoxic) columns and the molybdenum concentration in the initial leachate sample from the unsaturated (oxic) KLC tests, compared to livestock drinking water guideline values (ANZECC & ARMCANZ, 2000). The cadmium and manganese concentrations in leachate collected from the KLC tests operated under saturated conditions show a decreasing trend over time and are generally within the applied livestock drinking water guideline values for the last three years of the four year test period. It is also noted that the concentrations of copper and zinc in KLC leachate are above the laboratory LoR, although they remain within the relevant livestock drinking water guideline values for these metals and show a steady or decreasing concentration trend over the test period.

A review of a sulfate non-compliance investigation at Mt Rawdon Sediment Dam 2 (SD2) (RGS, 2016b) found that since December 2012 there have been three instances of non-compliance storm overflow events from SD2 to Rawdon Creek involving elevated metal concentrations with respect to relevant EA release criteria. The cause of the observed elevated metal concentrations (cadmium, copper and zinc) was two storm overflow events from Sediment Dam 1 (SD1) to SD2. SD1 collects TSF seepage via engineered drains and surface runoff from the northern and north-eastern TSF batters and is maintained in a near empty state under normal operating conditions by continuously dewatering SD1 back to the TSF. These results suggest that whilst TSF seepage and/or surface runoff from TSF batters can contain elevated concentrations of some metals (and sulfate), under normal operating conditions this is controlled by the SD1 and SD2 infrastructure.

Groundwater studies indicate that hydraulic gradients near the TSF are influenced by groundwater mounding below the TSF and the relatively high water table in the TSF. Notwithstanding, groundwater quality monitored in the TSF seepage bores has typically remained within the limits prescribed in the EA and that the current infrastructure for containment of any TSF seepage appears to be working efficiently (KCB, 2011; NRC, 2013 and 2015).

Overall, these results indicate that the risk of release of significantly elevated concentrations of dissolved metal/metalloids into surface contact water and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site.

4.3.2 Sulfate Generation and Sulfide Oxidation Rates

The sulfate generation rate results obtained for the four KLC tests on tailings have been used to determine the rate of sulfide oxidation in these materials. Most sulfate salts generated from sulfide reaction involving materials with a relatively low sulfide sulfur concentration are highly soluble, and therefore will be collected in column leachate. Whilst the dissolved sulfate (and calcium) concentrations in the KLC leachate are initially close to (and could be influenced by) the solubility limit of gypsum ($CaSO_4$) for the first few leachate events, the concentrations are lower (and sulfate generation is likely to be independent of gypsum dissolution) in the last three years of the four year test period. Overall, the sulfate concentrations and oxidation rate calculations provide reasonable estimates of these parameters, albeit that the results are likely to be higher than in the field situation where the tailing materials are not physically disturbed (ie. the average tailing oxidation rate results are elevated/skewed by the initial sample preparation (physical disturbance) and flushing of residual sulfate/supernatant from the tailing pores). It is noted that the measured sulfate dissolution (release) rate reduces asymptotically from about 2,000 mg/kg/flush in the initial leachate to less than 200 mg/kg/flush by the end of the four year test period and tends towards a relatively low long term equilibrium value.

Overall, these results align well with existing static and dynamic geochemical data derived from a wide range of mine waste materials (AMIRA, 1995). The sulfate generation rate and associated sulfide oxidation rate for the four KLC tests are shown in **Table 4-5**.

The sulfate generation rate from the tailings KLC samples ranges from 33.1 to 49.9 mg/kg/week indicating that the rate of sulfide oxidation is low in these materials (equivalent to an oxidation rate which ranges from

4.1 x 10^{-9} to 6.5 x 10^{-9} kg $O_2/m^3/s$). Mine waste materials with an oxidation rate in this range and moderate ANC levels have an increased factor of safety, and are likely to generate leachate that is pH neutral and/or has very low levels of acidity (AMIRA, 1995; Bennett *et al*., 2000). Hence, the tailing samples fall into this category and the KLC results reflect the NAF material classification predicted from static geochemical test results in **Section 4.1**.

Table 4-5: Sulfide Generation and Sulfide Oxidation Rates for KLC Tests on Tailing Samples

KLC Sample Number	Sample Description	Sulfate Generation Rate (mg/kg/week)	Oxidation Rate (kg $O_2/m^3/s$)
KLC 1	Saturated Tailings	36.2	4.6 x 10^{-9}
KLC 2	Saturated Tailings	49.9	6.5 x 10^{-9}
KLC 3	Unsaturated Tailings	33.1	4.1 x 10^{-9}
KLC 4	Unsaturated Tailings	44.8	5.8 x 10^{-9}

The results of the KLC tests are similar to existing KLC results for fresh tailing materials (RGS, 2011 a,b, 2017 and 2020) in that the tailing materials are very slow to react and based on the KLC results to date, a long period of time (several decades) is predicted before the residual ANC could potentially be consumed (although this outcome is extremely unlikely. Notwithstanding, it is not expected that lower pH conditions would occur at the TSF as the total sulfur appears to be oxidising at a similar (slow) rate to the ANC consumption rate. It is also likely that significant medium to long-term ANC (in addition to that readily available from calcite) is likely to be available from some of the major non-sulfide alumino-silicate mineral phases in the mine materials (e.g., chlorite and albite).

5 Conclusions

RGS has completed a four year investigation into the long term geochemical characteristics of tailing materials stored at the MRO TSF. The results of the study and previous studies to date have been interpreted in this report and indicate that:

- Tailing materials tested to date have relatively consistent static geochemical characteristics and are classified as NAF. Some uncertainty remains over the long term geochemical characteristics of tailing materials that will be produced by MRO and report to the TSF through to the end of mine life. However, based on KLC test and field monitoring data on tailing materials currently stored at the TSF, the risk of any acid generation now and following closure is expected to be very low.
- Contact water and leachate from tailing materials are likely to be pH neutral (in the range pH 7 to 8) and contain excess alkalinity.
- The quality of the tailing pore water and any TSF seepage is likely to gradually improve when supernatant/fresh tailings (and waste rock materials) are no longer added to the TSF following closure of this facility.
- Whilst tailing solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to relatively immobile and sparingly soluble at neutral pH.
- The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site.
- It is expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure and rehabilitation of the TSF.

6 Management Measures

Potential management measures that could be considered by MRO as part of the closure planning process that is currently being completed for the TSF, in order to reduce any identified risks include:

- Continue the KLC test program on tailing materials for a further two years. It is recommended that the number of KLC tests be two (ie. one saturated and one unsaturated), with six monthly leaching intervals (i.e., four leach events over two years).
- Complete of a forensic examination of the tailings materials used in the two KLC tests completed above including Acid Base Account and Mineralogical tests.
- Continue to monitor pH, EC, acidity, alkalinity, and the concentration of major ions and soluble metals/metalloids in TSF decant water and in any surface or groundwater seepage collected downstream of the facility (eg. SD1, SD2 and groundwater monitoring bores).
- Review the intensive geochemical testing program (daily, weekly, monthly and quarterly) completed on MRO tailings and develop a plan for ongoing targeted geochemical testing of tailing samples through to the end of mine life.
- Subject selected tailing samples (and/or composite samples) from the intensive tailings geochemical test program to additional KLC tests (ie. samples should be selected and tested based on interpretation of static geochemical test results).

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8 Limitations

This report has been prepared based on accepted consulting practices and standards for the sole use of MRO. No other warranty is made as to the professional advice included in this report. The report has been prepared in accordance with the scope of work detailed in **Section 2**.

This report was prepared using geochemical data collected from December 2014 to December 2018 and is based on the information and samples provided by MRO at the time of preparation. RGS disclaims responsibility for any changes that may have occurred after this time.

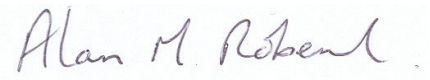
The sources of information and methodology used by RGS are outlined in this report and no independent verification of this information has been made. RGS assumes no responsibility for any inaccuracies or omissions, although no indication was found that any information contained in this report as provided to RGS was incorrect.

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If you have any questions regarding the information presented in this report, please contact the undersigned on (+617) 3344 1222 or (+61) 431 620 623.

Yours sincerely,

RGS ENVIRONMENTAL PTY LTD



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9 Attachments

9.1 Attachment A: Geochemical Assessment of Mining Waste Materials

Geochemical Assessment of Mine Waste Materials

Acid generation and prediction

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite (FeS_2), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum amount of acid that could be generated by a material based on either direct measurement of the pyritic S content, or assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the following overall reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

According to this reaction, the maximum potential acidity (MPA) of a sample containing 1%S as pyrite would be 30.6 kg H_2SO_4/t. The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralization, which is mainly provided by inherent carbonates and to a lesser extent silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

Net Acid Producing Potential

The net acid producing potential (NAPP) is used as an indicator of materials that may be of concern with respect to acid generation. The NAPP calculation represents the balance between the maximum potential acidity (MPA) of a sample, which is derived from the sulfide sulfur content, and the acid neutralising capacity (ANC) of the material, which is determined experimentally. By convention, the NAPP result is expressed in units of kg H_2SO_4/t sample. If the capacity of the solids to neutralise acid (ANC) exceeds their capacity to generate acid (MPA), then the NAPP of the material is negative. Conversely, if the MPA exceeds the ANC, the NAPP of the material is positive. A NAPP assessment involves a series of analytical tests that include:

Determination of pH and EC

pH and EC measured on 1:5 w/w water extract. This gives an indication of the inherent acidity and salinity of the mining waste material when initially exposed in an emplacement area.

Total sulfur content and Maximum Potential Acidity (MPA)

Total sulfur content is determined by the Leco high temperature combustion method. The total sulfur content is then used to calculate the MPA which is based on the assumption that the entire sulfur content is present as reactive pyrite. Direct determination of the pyritic sulfur content can provide a more accurate estimate of the MPA.

Acid neutralising capacity (ANC)

The ANC is determined by addition of acid to a known weight of sample, then titration with NaOH to determine the amount of residual acid. The ANC measures the capacity of a sample to react with and neutralise acid. The ANC can be further evaluated by slow acid titration to a set end-point in the Acid Buffering Characteristic Curve (ABCC) test through calculation of the acid consumed and evaluation of the resultant titration curve.

Net Acid Generation (NAG)

The standard net acid generation (NAG) test involves the addition of hydrogen peroxide to a sample of mine waste to oxidise reactive sulfide, then measurement of pH and titration of any net acidity produced by the acid generation and neutralisation reactions occurring in the sample. A significant NAG result (*i.e.* final NAG_{pH} < 4.5) indicates that the sample is potentially acid forming (PAF) and the test provides a direct measure of the net amount of acid remaining in the sample after all acid generating and acid neutralising reactions have taken place. A NAG_{pH} > 4.5 indicates that the sample is non-acid forming (NAF). The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure and weathering and is used to refine the results of the theoretical NAPP predictions. The NAG test can be used as a stand-alone test but is recommended that this only be considered after site specific calibration work is carried out, especially at coal mining operations where the carbon content of the samples can produce a false positive result.

Assessment of element enrichment and solubility

In mineralised areas it is common to find a suite of enriched elements that have resulted from natural geological processes. Multi-element scans are carried out to identify any elements that are present in a material (or readily leachable from a material) at concentrations that may be of environmental concern with respect to surface water quality, revegetation and public health. The samples are generally analysed for the following elements:

Major elements	Al, Ca, Fe, K, Mg, Na and S.
Minor elements	As, B, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, Pb, Sb, Se and Zn.

The concentration of these elements in samples can be directly compared with the median concentration in un-mineralised soils to determine the Geochemical Abundance Index (GAI) and level of significance. Water extracts are used to determine the immediate element solubilities under the existing sample pH conditions of the sample. The following tests are normally carried out:

Multi-element composition of solids.

Multi-element composition of solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Multi-element composition of water extracts (1:5 sample:deionised water).

Multi-element composition of 1:5 (solid:water) water extracts from solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Under some conditions (eg. low pH) the solubility and mobility of common environmentally important elements can increase significantly. If element mobility under initial pH conditions is deemed likely and/or subsequent low pH conditions may occur, kinetic leach column test work may be completed on representative samples.

Kinetic leach column tests

Kinetic leach column (KLC) tests can be used to provide information on the reaction kinetics of mine waste materials. The major objectives of kinetics tests are to:

- Provide time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions);
- Investigate metal release and drainage/seepage quality; and
- Assess treatment options such as addition of alkaline materials.

The KLC tests simulate the weathering process that leads to acid and base generation and reaction under laboratory controlled or site conditions. The kinetic tests allow an assessment of the acid forming characteristics and indicate the rate of acid generation, over what period it will occur, and what management controls may be required.

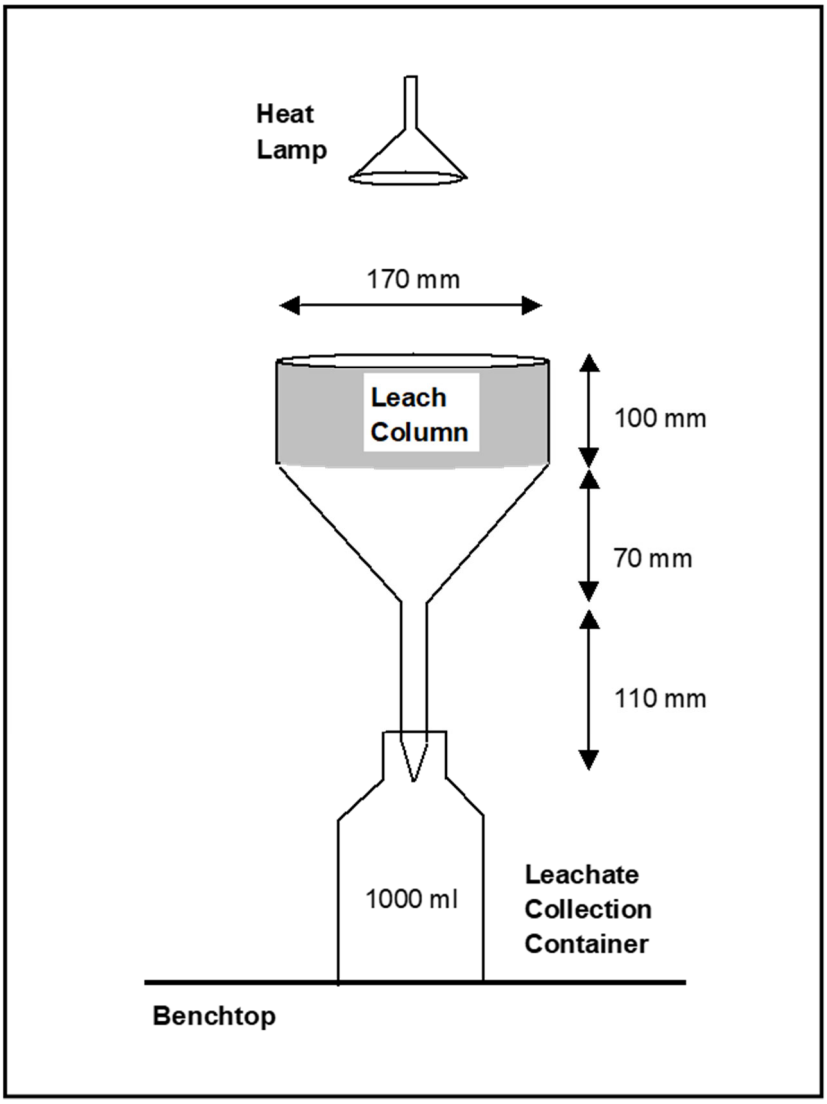
In KLC tests, water is added to a sample and the mixture allowed to leach products and by-products of acid producing and consuming reactions. Samples of leachate are then collected and analysed. Intermittent water application is applied to simulate rainfall and heat lamps are used to simulate sunshine. These tests provide real-time information and may have to continue for months or years. Monitoring includes trends in pH, sulfate, acidity or alkalinity, and metals, for example. The pH of the collected leachate simulates the acid drainage process, acidity or alkalinity levels indicate the rate of acid production and acid neutralisation, and sulfate production can be related to the rate of sulfide oxidation. Metal concentration data provides an assessment of metal solubility and leaching behaviour.

KLC tests can be operated under saturated or unsaturated (free draining) conditions. **Figure A1** shows the typical KLC set up used by RGS under free draining conditions, adapted from *AMIRA, 2002*. When operated under free draining (unsaturated) conditions, the columns are placed under heat lamps to allow the sample to dry between water additions to ensure adequate oxygen ingress into the sample material.

Approximately 2 kg of sample is accurately weighed and used in the leach columns and depending on the physical nature of the material and particle size can be used on an as-received basis (*i.e.* no crushing as with process residues) or crushed to nominal 5-10 mm particle size (as with waste rock). The sample in the column is initially leached with deionised water at a rate of about 400 ml/kg of sample and the initial leachate from the columns collected and analysed. Subsequent column leaching is carried out at a rate of about 400 ml/kg per month and again collected and analysed. The leaching rate can be varied to better simulate expected site conditions or satisfy test program data requirements. Under free draining conditions, the column is exposed to drying conditions in between watering events. The residual water content and air void content in the column can be determined by comparing the wet and dry column weights. A heat lamp is generally used above the free draining samples during daylight hours to maintain the leach column surface temperature at about 30^{o}C.

Figure A1

Kinetic Leach Column Setup (Free Draining)



9.2 Attachment B: KLC Test Results and Trends

RGS-KLC # 1 : Mt Rawdon Tailing (Saturated)

Weight (kg)	1.608	**Total S (%)**	1.13	**ANC**	36.58	**NAG pH**	9.12
pH (1:5)	8.39	**Scr (%)**	0.807	**NAPP**	-11.88	**NAG capacity**	<0.1 kgH_2SO_4/t
EC (µS/cm)	1,915	**MPA**	24.70	**ANC:MPA**	1.48		

Date	**04-Dec-14**	**03-Mar-15**	**04-Jun-15**	**03-Sep-15**	**03-Dec-15**	**02-Jun-16**	**02-Dec-16**	**22-Aug-17**	**20-Feb-18**	**28-Aug-18**	**18-Dec-18**
Week	**0**	**13**	**26**	**39**	**52**	**78**	**104**	**142**	**168**	**195**	**211**
Leach Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
ALS Laboratory Number	EB1447785	EB1513989	EB1520149	EB1528976	EB1536536	EB1615076	EB1628822	EB1717132	EB1804711	EB1820822	EB1830124
Volume ON (L)	3.0	1.5	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.0
Volume OFF (L)	1.058	0.875	0.860	0.780	0.496	0.929	0.740	0.946	0.746	0.946	0.942
Cum. Volume (L)	1.06	1.93	2.79	3.57	4.07	5.00	5.74	6.68	7.43	8.38	9.32
Pore Volumes	0.9	1.7	2.4	3.1	3.5	4.3	5.0	5.8	6.5	7.3	8.1
pH	6.5	6.9	7.3	7.2	7.2	7.7	7.5	7.3	6.8	7.5	7.5
EC (µS/cm) - RGS record	8,160	2,780	2,410	2,430	1,657	1,329	1,013	1,045	569	669	680
Acidity (mg/L)*	22	15	8	10	12	4	<1	7	6	1	1
Alkalinity (mg/L)*	244	112	114	115	88	94	92	101	121	97	90
Net Alkalinity (mg/L)*	222	97	106	105	76	90	92	94	115	96	89
WAD Cyanide^ (mg/L)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-	-	-	-
Major Ions (mg/L)	**WQ Guidelines #**										
Calcium (Ca)	1,000	534	529	506	510	332	248	178	155	115	150	140
Potassium (K)	-	370	86	52	42	36	31	22	17	12	10	9
Magnesium (Mg)	-	73	24	13	11	8	7	4	4	2	3	3
Sodium (Na)	-	1,360	149	76	61	48	37	21	15	7	6	7
Chloride (Cl)	-	576	45	24	15	14	11	9	6	2	2	1
Fluoride (F)	2	0.5	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Sulfate (SO_4)	1,000	2,970	1,530	1,570	1,380	852	662	476	389	172	274	260
Trace metals/ metalloids (mg/L)	**WQ Guidelines #**										
Aluminium (Al)	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.002	0.002	0.001	0.001	0.004	0.002	0.002	0.002	0.004	0.001	0.001
Boron (B)	5	0.12	0.13	0.11	0.1	0.09	<0.05	0.07	0.08	<0.05	0.10	0.05
Cadmium (Cd)	0.01	0.073	0.028	0.035	0.031	0.018	0.007	0.003	0.007	0.005	0.006	0.005
Cobalt (Co)	1	0.01	0.001	<0.001	<0.001	0.003	0.004	0.002	0.002	0.002	0.002	0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	0.035	0.010	0.010	0.009	0.015	0.004	0.003	0.003	0.005	0.008	0.007
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	0.34	0.13	0.06	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	2.280	2.170	0.805	0.306	2.340	2.560	1.180	0.701	0.625	0.463	0.422
Molybdenum (Mo)	0.15	0.143	0.071	0.035	0.018	0.028	0.034	0.031	0.029	0.035	0.021	0.020
Nickel (Ni)	1	0.002	0.002	0.002	0.002	0.002	0.002	0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.003	0.003	0.002	0.002	0.002	<0.001	<0.001	0.001	<0.001	0.001	0.001
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	3.7	5.8	11.3	10.3	9.3	10.3	9.6	9.8	9.8	3.9	3.7
Zinc (Zn)	20	2.61	3.47	4.23	3.89	1.92	1.02	0.537	0.390	0.285	1.020	0.981
Calculations**											
SO_4 Release Rate	1,954	832	840	669	263	382	219	229	80	161	152
Cumulative SO_4 Release	1,954	2,786	3,626	4,295	4,558	4,940	5,159	5,388	5,468	5,629	5,781
Ca Release Rate	351	288	271	247	102	143	82	91	53	88	82
Cumulative Ca Release	351	639	910	1,157	1,259	1,403	1,485	1,576	1,629	1,717	1,799
Mg Release Rate	48.0	13.1	7.0	5.3	2.5	4.0	1.8	2.4	0.9	1.8	1.8
Cumulative Mg Release	48.0	61.1	68.0	73.4	75.8	79.9	81.7	84.1	85.0	86.8	88.5
Residual ANC (%)	97.1	95.1	93.2	91.5	90.7	89.7	89.2	88.5	88.2	87.6	87.0
Residual Sulfur (%)	94.2	91.8	89.3	87.3	86.5	85.4	84.8	84.1	83.9	83.4	82.9
SO_4/(Ca+Mg) molar ratio	1.89	1.12	1.24	1.09	1.03	1.06	1.08	1.00	0.61	0.74	0.75

< indicates less than the laboratory limit of reporting. * Acidity and alkalinity data calculated in mg $CaCO_3$/L.

** SO_4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

AWQG (2018) and ANZECC & ARMCANZ (2000). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 2 : Mt Rawdon Tailing (Saturated) - duplicate

Weight (kg)	1.664	**Total S (%)**	1.13	**ANC**	36.58	**NAG pH**	9.12
pH (1:5)	8.39	**Scr (%)**	0.807	**NAPP**	-11.88	**NAG capacity**	<0.1 kgH_2SO_4/t
EC (µS/cm)	1,915	**MPA**	24.70	**ANC:MPA**	1.48		

Date		**04-Dec-14**	**03-Mar-15**	**04-Jun-15**	**03-Sep-15**	**03-Dec-15**	**02-Jun-16**	**02-Dec-16**
Week		**0**	**13**	**26**	**39**	**52**	**78**	**104**
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**
ALS Laboratory Number		EB1447785	EB1513989	EB1520149	EB1528976	EB1536536	EB1615076	EB1628822
Volume ON (L)		3.0	1.5	1.0	1.5	1.5	1.0	1.0
Volume OFF (L)		1.015	0.962	0.993	1.050	0.915	0.928	0.799
Cum. Volume (L)		1.02	1.98	2.97	4.02	4.94	5.86	6.66
Pore Volumes		0.9	1.7	2.6	3.5	4.3	5.1	5.8
pH		6.0	6.9	7.1	7.4	7.4	7.7	7.7
EC (µS/cm) - RGS record		7,870	2,900	2,750	1,499	1,207	937	814
Acidity (mg/L)*		22	23	12	1	7	2	<1
Alkalinity (mg/L)*		237	161	121	74	86	104	108
Net Alkalinity (mg/L)*		215	138	109	73	79	102	108
WAD Cyanide^ (mg/L)		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Major Ions (mg/L)	**WQ Guidelines #**							
Calcium (Ca)	1,000	499	503	378	251	194	163	142
Potassium (K)	-	356	95	51	33	26	23	19
Magnesium (Mg)	-	71	28	12	7	5	4	3
Sodium (Na)	-	1,310	192	94	58	38	28	17
Chloride (Cl)	-	559	60	36	18	11	8	6
Fluoride (F)	2	0.6	0.3	0.2	0.2	0.2	0.2	0.2
Sulfate (SO_4)	1,000	2,930	1,500	1,550	754	529	397	345
Trace metals/ metalloids (mg/L)	**WQ Guidelines #**							
Aluminium (Al)	5	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.002	0.003	0.001	<0.001	0.001	0.002	0.002
Boron (B)	5	0.12	0.15	0.14	<0.05	0.08	<0.05	0.06
Cadmium (Cd)	0.01	0.062	0.030	0.020	0.013	0.011	0.008	0.009
Cobalt (Co)	1	0.01	0.003	0.002	<0.001	0.001	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	0.036	0.012	0.013	0.008	0.008	0.006	0.006
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	2.060	5.440	1.960	0.231	0.452	0.821	0.679
Molybdenum (Mo)	0.15	0.136	0.063	0.031	0.016	0.024	0.031	0.035
Nickel (Ni)	1	0.003	0.004	0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.003	0.002	0.002	0.001	0.001	0.001	0.001
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	3.4	6.3	12.5	7.3	8.2	9.9	10.0
Zinc (Zn)	20	2.24	4.76	3.09	1.28	1.1	0.815	0.636
Calculations**								
SO_4 Release Rate		1,788	867	925	476	291	221	166
Cumulative SO_4 Release		1,788	2,655	3,580	4,056	4,347	4,568	4,734
Ca Release Rate		304	291	226	158	107	91	68
Cumulative Ca Release		304	595	821	979	1,086	1,177	1,245
Mg Release Rate		43.3	16.2	7.2	4.4	2.7	2.2	1.4
Cumulative Mg Release		43.3	59.5	66.7	71.1	73.8	76.1	77.5
Residual ANC (%)		97.5	95.4	93.8	92.7	91.9	91.3	90.8
Residual Sulfur (%)		94.7	92.2	89.4	88.0	87.2	86.5	86.0
SO_4/(Ca+Mg) molar ratio		1.98	1.14	1.63	1.20	1.09	0.98	0.98

< indicates less than the laboratory limit of reporting. * Acidity and alkalinity data calculated in mg $CaCO_3$/L.

** SO_4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

AWQG (2018) and ANZECC & ARMCANZ (2000). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 3 : Mt Rawdon Tailing (Unsaturated)

Weight (kg)	1.746	**Total S (%)**	1.13	**ANC**	36.58	**NAG pH**	9.12
pH (1:5)	8.39	**Scr (%)**	0.807	**NAPP**	-11.88	**NAG capacity**	<0.1 kgH_2SO_4/t
EC (µS/cm)	1,915	**MPA**	24.70	**ANC:MPA**	1.48		

Date		**04-Dec-14**	**03-Mar-15**	**04-Jun-15**	**03-Sep-15**	**03-Dec-15**	**02-Jun-16**	**02-Dec-16**	**22-Aug-17**	**20-Feb-18**	**28-Aug-18**	**18-Dec-18**
Week		**0**	**13**	**26**	**39**	**52**	**78**	**104**	**142**	**168**	**195**	**211**
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
ALS Laboratory Number		EB1447785	EB1513989	EB1520149	EB1528976	EB1536536	EB1615076	EB1628822	EB1717132	EB1804711	EB1820822	EB1830124
Volume ON (L)		1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Volume OFF (L)		0.771	0.714	0.514	0.483	0.512	0.505	0.514	0.606	0.514	0.511	0.580
Cum. Volume (L)		0.77	1.49	2.00	2.48	2.99	3.50	4.01	4.62	5.13	5.64	6.22
Pore Volumes		0.7	1.3	1.7	2.2	2.6	3.0	3.5	4.0	4.5	4.9	5.4
pH		7.1	7.4	7.6	7.7	7.7	7.8	7.5	7.6	6.9	7.6	7.5
EC (µS/cm) - RGS record		7,560	5,530	3,520	2,410	2,007	1,631	1,526	1,500	1,369	1,311	1,220
Acidity (mg/L)*		5	9	3	2	6	2	2	2	3	2	1
Alkalinity (mg/L)*		28	68	34	39	37	56	35	54	48	44	40
Net Alkalinity (mg/L)*		23	59	31	37	31	54	33	52	45	42	39
WAD Cyanide^ (mg/L)		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	-	-	-	-
Major Ions (mg/L)	**WQ Guidelines #**											
Calcium (Ca)	1,000	499	493	395	367	318	311	295	316	295	282	262
Potassium (K)	-	409	223	128	93	74	56	53	42	36	28	25
Magnesium (Mg)	-	74	34	26	22	16	16	11	13	9	9	8
Sodium (Na)	-	1,580	744	382	165	60	30	13	9	7	7	7
Chloride (Cl)	-	701	307	124	31	8	6	4	3	1	1	1
Fluoride (F)	2	0.6	0.6	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.1
Sulfate (SO_4)	1,000	3,590	2,790	1,970	1,330	1,120	911	886	750	730	668	600
Trace metals/ metalloids (mg/L)	**WQ Guidelines #**											
Aluminium (Al)	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.003	0.003	0.002	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.001
Boron (B)	5	0.08	0.11	0.09	0.06	0.10	<0.05	0.07	0.08	0.10	0.10	0.10
Cadmium (Cd)	0.01	0.010	0.009	0.009	0.009	0.007	0.008	0.007	0.009	0.007	0.007	0.006
Cobalt (Co)	1	0.011	0.006	0.005	0.002	0.002	0.002	0.001	<0.001	0.002	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.005	0.002	0.002	<0.001	<0.001
Copper (Cu)	1	0.010	0.022	0.016	0.012	0.012	0.019	0.016	0.022	0.018	0.015	0.012
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.046	0.030	0.052	0.031	0.026	0.033	0.038	0.046	0.042	0.028	0.022
Molybdenum (Mo)	0.15	0.180	0.109	0.081	0.038	0.046	0.031	0.038	0.027	0.042	0.026	0.023
Nickel (Ni)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.003	0.004	0.003	0.004	0.003	0.002	0.003	0.002	0.002	0.002	0.001
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	2.9	3.0	6.4	5.9	7.5	6.0	7.9	6.6	8.4	8.4	8.3
Zinc (Zn)	20	0.22	0.17	0.273	0.307	0.208	0.267	0.194	0.338	0.183	0.242	0.232
Calculations**												
SO_4 Release Rate		1,586	1,141	580	368	329	264	261	260	215	196	199
Cumulative SO_4 Release		1,586	2,727	3,307	3,675	4,004	4,267	4,528	4,788	5,003	5,199	5,398
Ca Release Rate		220	202	116	102	93	90	87	110	87	83	87
Cumulative Ca Release		220	422	538	640	733	823	910	1,020	1,107	1,189	1,276
Mg Release Rate		32.7	13.9	7.7	6.1	4.7	4.6	3.2	4.5	2.7	2.6	2.7
Cumulative Mg Release		32.7	46.6	54.3	60.3	65.0	69.7	72.9	77.4	80.1	82.7	85.4
Residual ANC (%)		98.2	96.7	95.8	95.1	94.4	93.7	93.1	92.3	91.7	91.1	90.5
Residual Sulfur (%)		95.3	91.9	90.2	89.1	88.2	87.4	86.6	85.9	85.2	84.6	84.1
SO_4/(Ca+Mg) molar ratio		2.41	2.12	1.88	1.38	1.36	1.13	1.18	0.93	0.98	0.94	0.91

< indicates less than the laboratory limit of reporting. * Acidity and alkalinity data calculated in mg $CaCO_3$/L.

** SO_4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

AWQG (2018) and ANZECC & ARMCANZ (2000). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC # 4 : Mt Rawdon Tailing (Unsaturated) - duplicate

Weight (kg)	1.630	**Total S (%)**	1.13	**ANC**	36.58	**NAG pH**	9.12
pH (1:5)	8.39	**Scr (%)**	0.807	**NAPP**	-11.88	**NAG capacity**	<0.1 kgH_2SO_4/t
EC (µS/cm)	1,915	**MPA**	24.70	**ANC:MPA**	1.48		

Date		**04-Dec-14**	**03-Mar-15**	**04-Jun-15**	**03-Sep-15**	**03-Dec-15**	**02-Jun-16**	**02-Dec-16**
Week		**0**	**13**	**26**	**39**	**52**	**78**	**104**
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**
ALS Laboratory Number		EB1447785	EB1513989	EB1520149	EB1528976	EB1536536	EB1615076	EB1628822
Volume ON (L)		1.0	1.2	1.0	1.0	1.0	1.0	1.0
Volume OFF (L)		0.798	0.721	0.529	0.522	0.527	0.515	0.468
Cum. Volume (L)		0.80	1.52	2.05	2.57	3.10	3.61	4.08
Pore Volumes		0.7	1.3	1.8	2.2	2.7	3.1	3.5
pH		7.1	7.4	7.6	7.8	7.7	7.8	7.5
EC (µS/cm) - RGS record		6,780	4,540	3,070	2,050	1,703	1,384	1,253
Acidity (mg/L)*		6	3	2	2	4	2	2
Alkalinity (mg/L)*		28	32	33	37	34	46	36
Net Alkalinity (mg/L)*		22	29	31	35	30	44	34
WAD Cyanide^ (mg/L)		<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Major Ions (mg/L)	**WQ Guidelines #**							
Calcium (Ca)	1,000	519	477	386	325	274	261	249
Potassium (K)	-	411	169	111	76	58	45	35
Magnesium (Mg)	-	72	27	22	18	13	12	8
Sodium (Na)	-	1,530	549	300	115	41	23	8
Chloride (Cl)	-	671	209	93	20	7	6	4
Fluoride (F)	2	0.6	0.6	0.4	0.3	0.3	0.2	0.2
Sulfate (SO_4)	1,000	3,570	2,040	1,760	1,090	903	739	663
Trace metals/ metalloids (mg/L)	**WQ Guidelines #**							
Aluminium (Al)	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.004	0.003	0.002	0.001	0.002	0.001	0.001
Boron (B)	5	0.11	0.11	0.06	0.06	0.08	<0.05	<0.05
Cadmium (Cd)	0.01	0.010	0.008	0.009	0.007	0.006	0.007	0.005
Cobalt (Co)	1	0.010	0.004	0.004	0.002	0.002	0.002	0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	0.002	0.002	0.003	0.005
Copper (Cu)	1	0.012	0.021	0.018	0.017	0.012	0.02	0.011
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.053	0.030	0.037	0.030	0.028	0.034	0.030
Molybdenum (Mo)	0.15	0.167	0.083	0.071	0.033	0.04	0.027	0.031
Nickel (Ni)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.003	0.004	0.003	0.003	0.003	0.002	0.002
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	2.9	3.0	6.0	5.6	6.9	5.8	7.8
Zinc (Zn)	20	0.22	0.16	0.266	0.264	0.173	0.223	0.066
Calculations**								
SO_4 Release Rate		1,747	902	571	349	292	233	190
Cumulative SO_4 Release		1,747	2,649	3,220	3,569	3,861	4,095	4,285
Ca Release Rate		254	211	125	104	89	82	71
Cumulative Ca Release		254	465	590	694	783	865	937
Mg Release Rate		35.2	11.9	7.1	5.8	4.2	3.8	2.3
Cumulative Mg Release		35.2	47.2	54.3	60.1	64.3	68.1	70.4
Residual ANC (%)		97.9	96.4	95.5	94.7	94.1	93.5	93.0
Residual Sulfur (%)		94.8	92.2	90.5	89.5	88.6	87.9	87.3
SO_4/(Ca+Mg) molar ratio		2.34	1.63	1.74	1.28	1.28	1.10	1.06

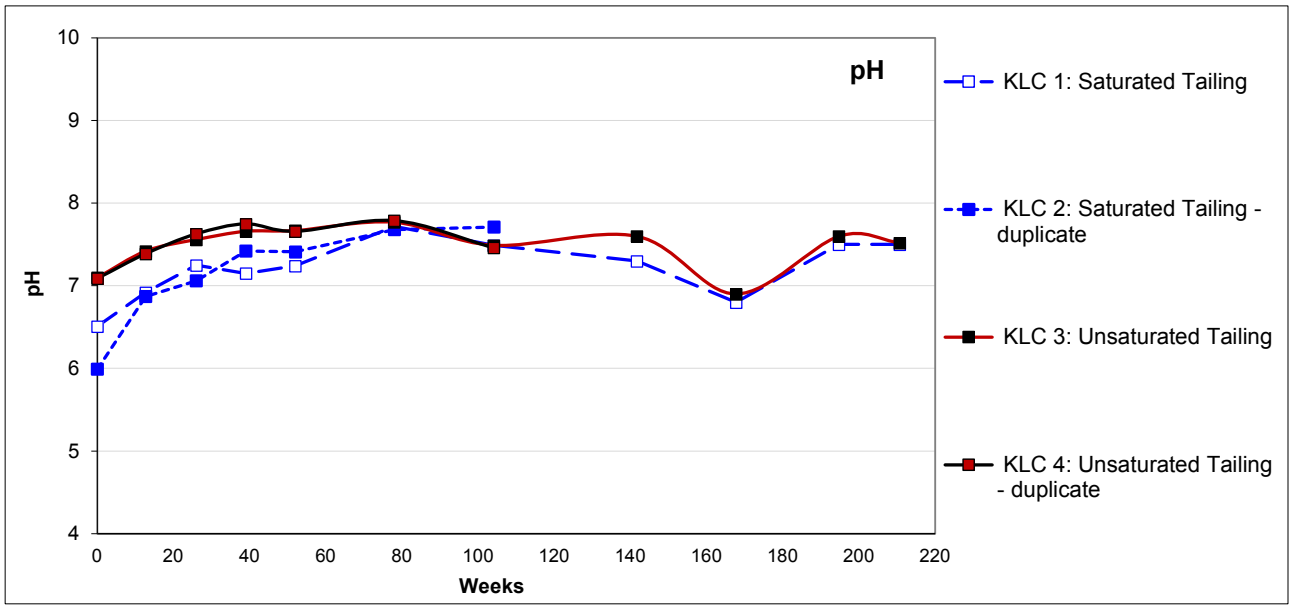
< indicates less than the laboratory limit of reporting. * Acidity and alkalinity data calculated in mg $CaCO_3$/L.

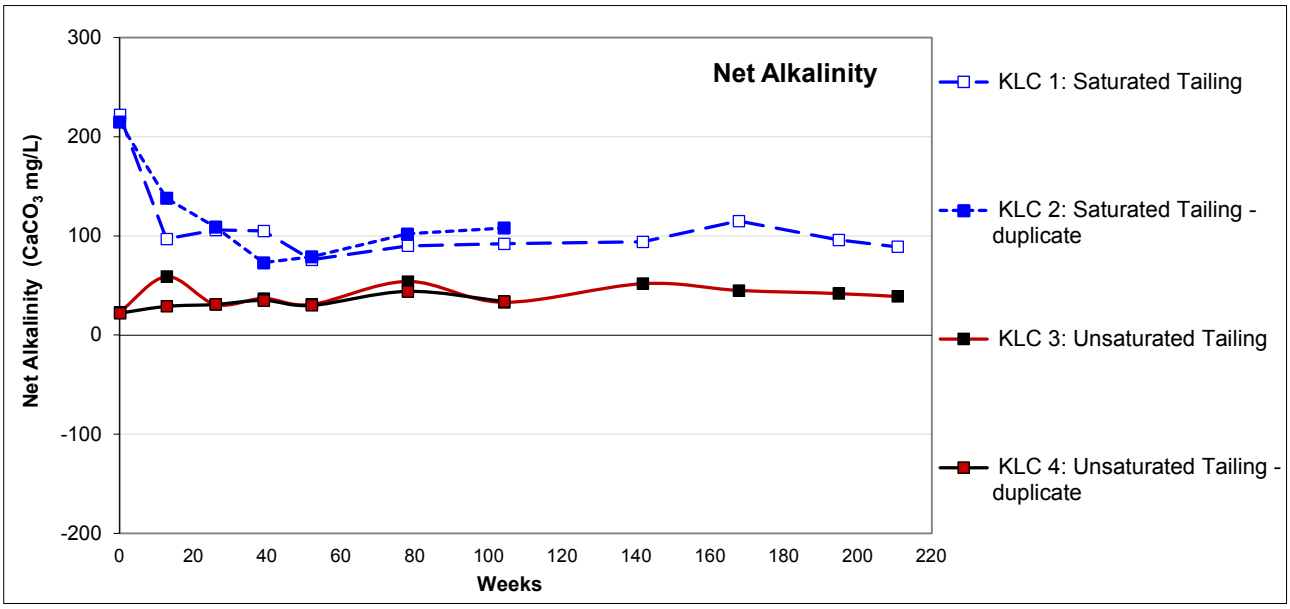
** SO_4, Ca and Mg release rates calculated in mg/kg/flush.

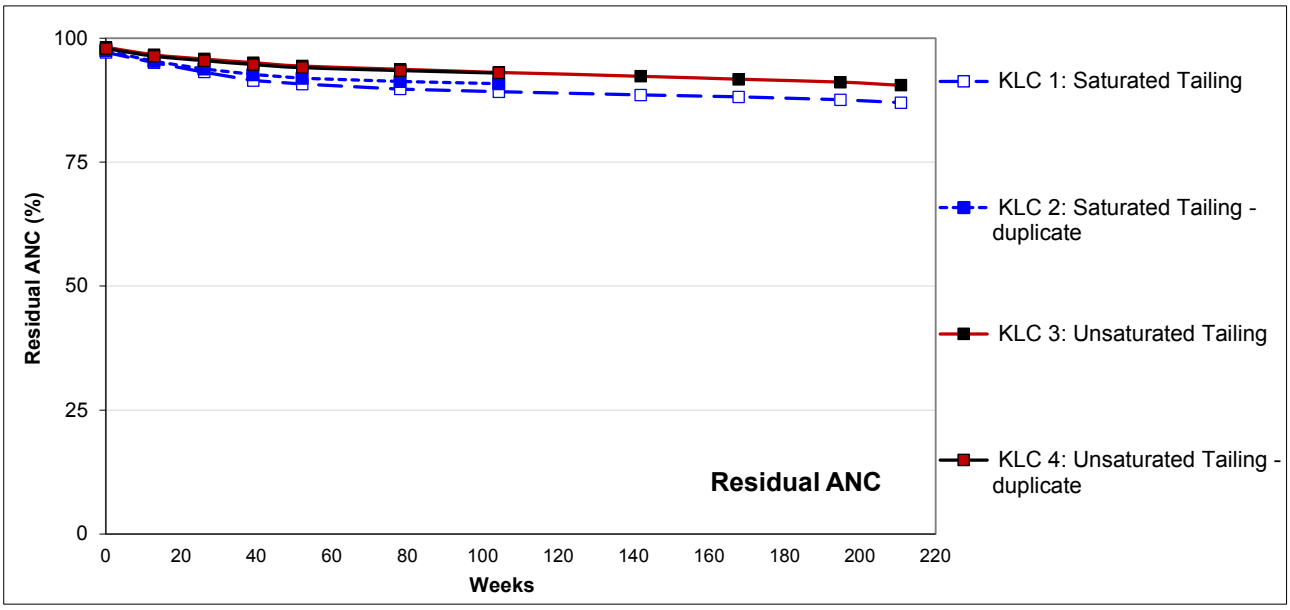
Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

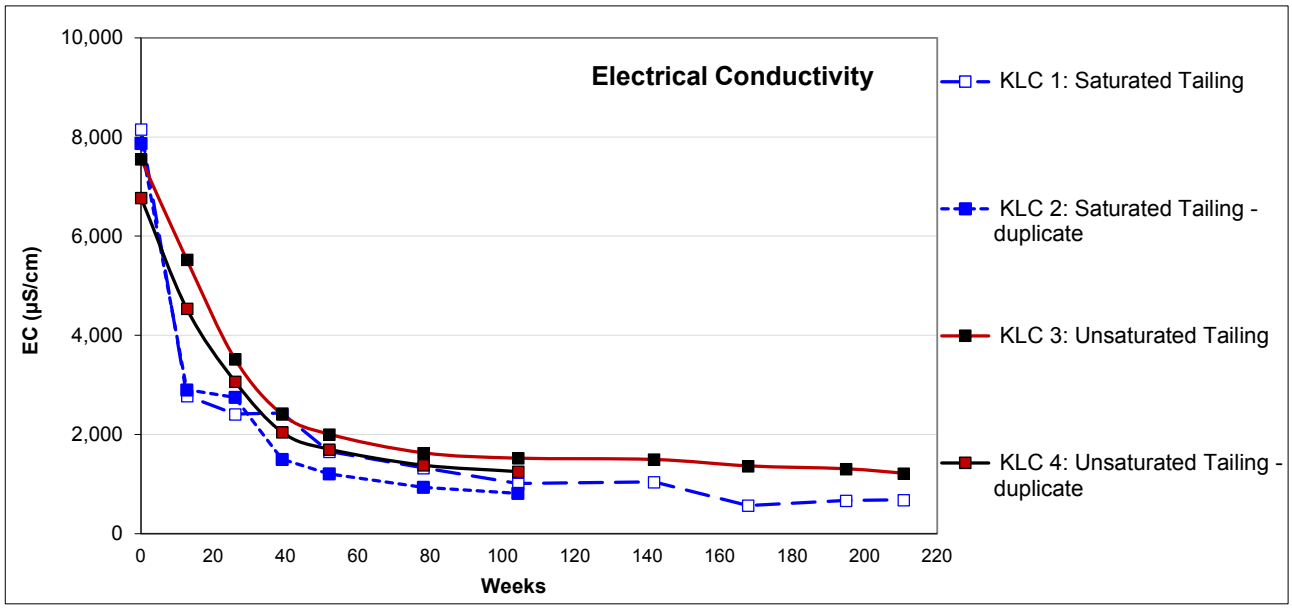
MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

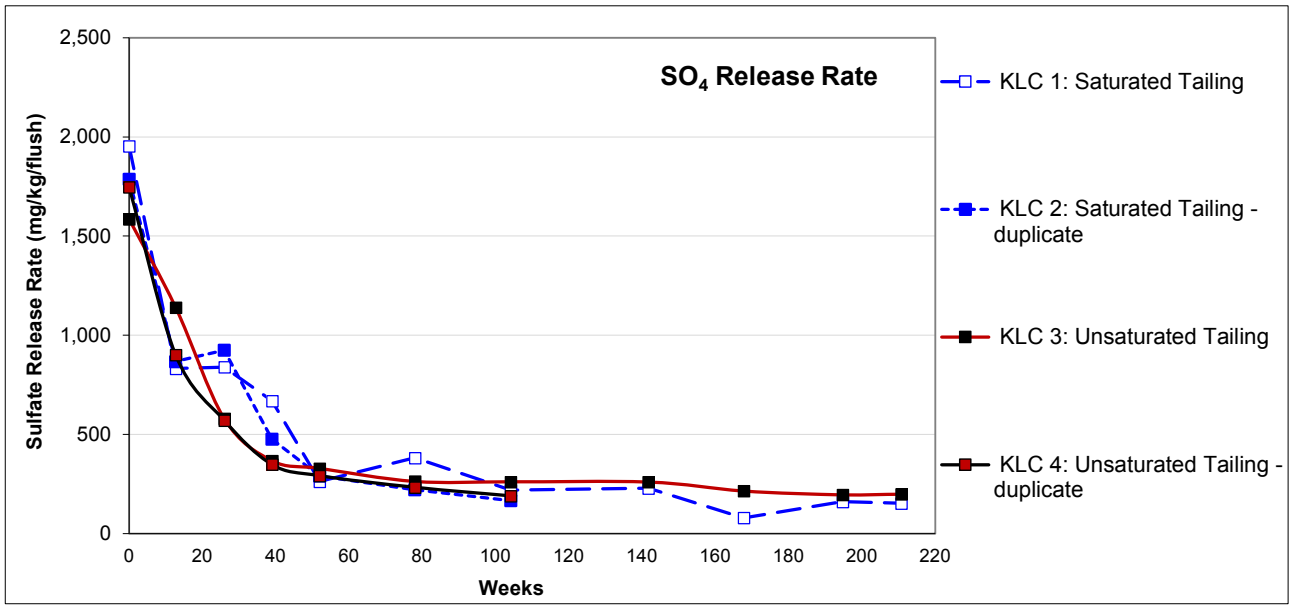
AWQG (2018) and ANZECC & ARMCANZ (2000). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

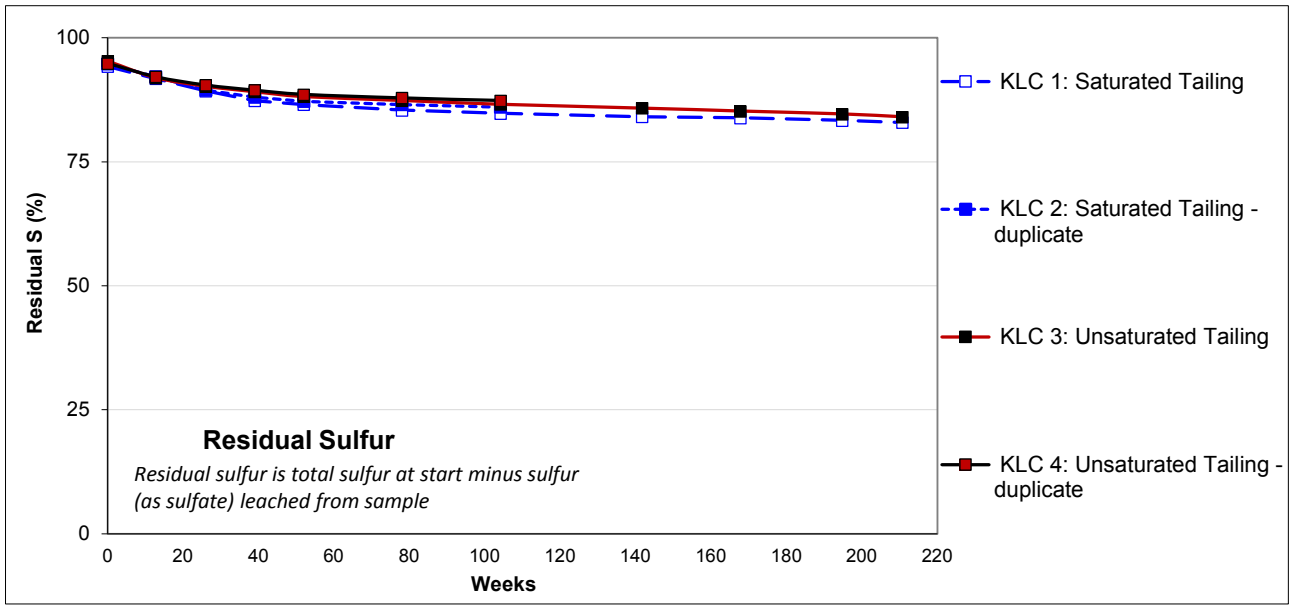

pH
pH
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

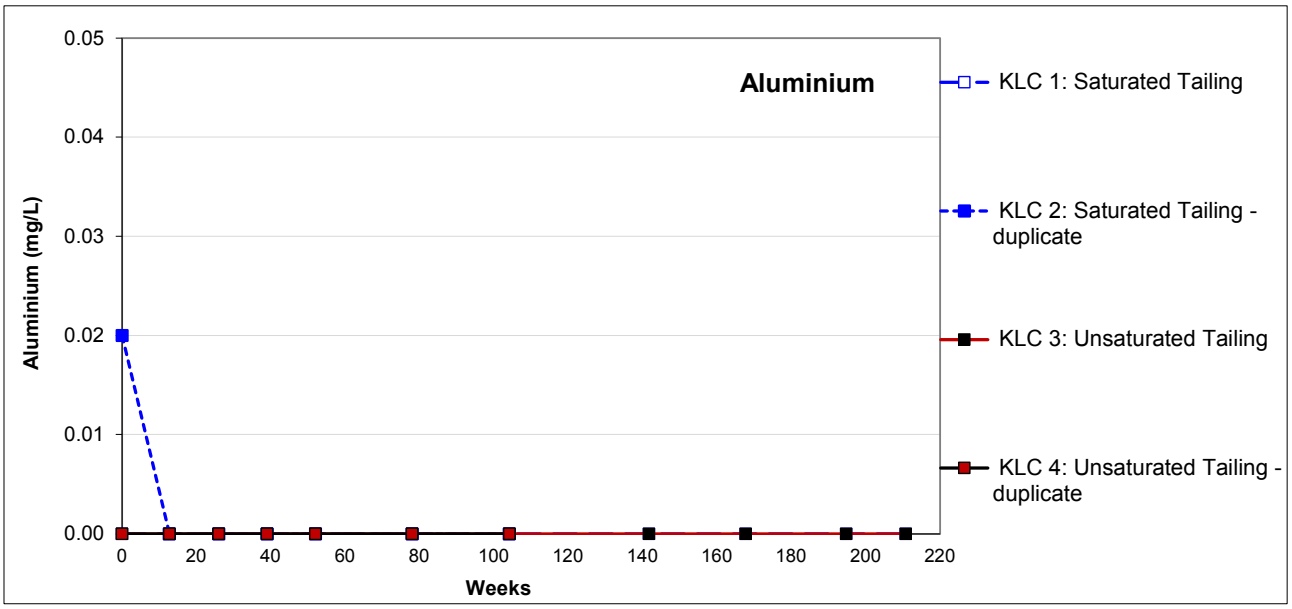

Net Alkalinity
Net Alkalinity (CaCO3 mg/L)
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

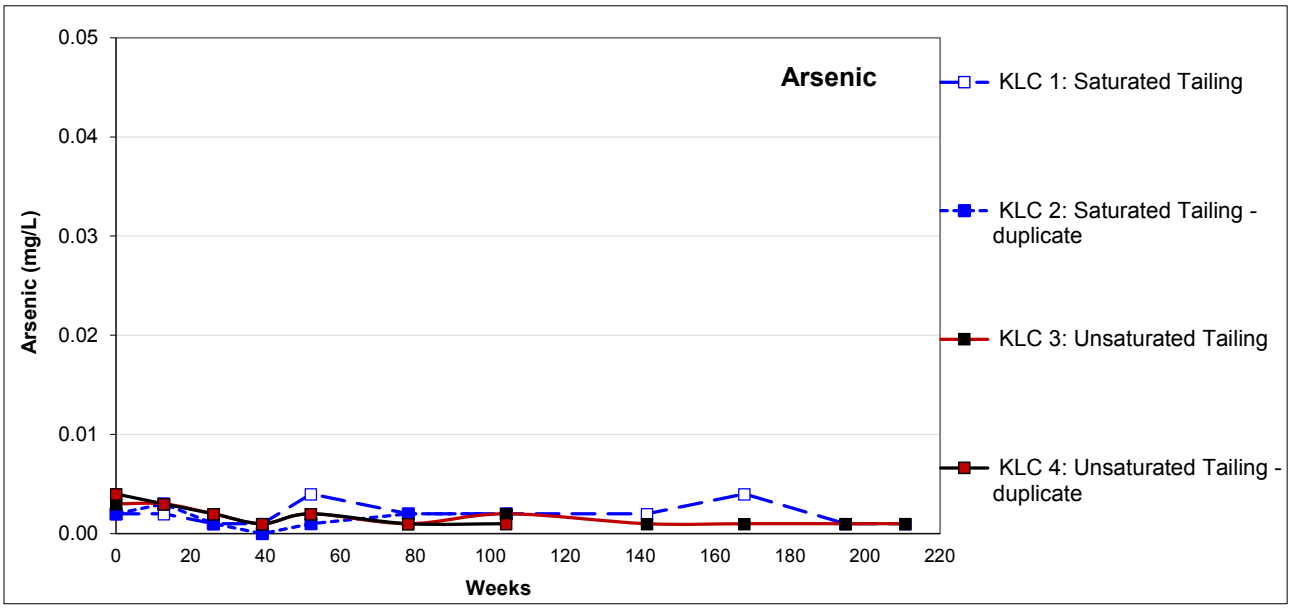

Residual ANC
Residual ANC (%)
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

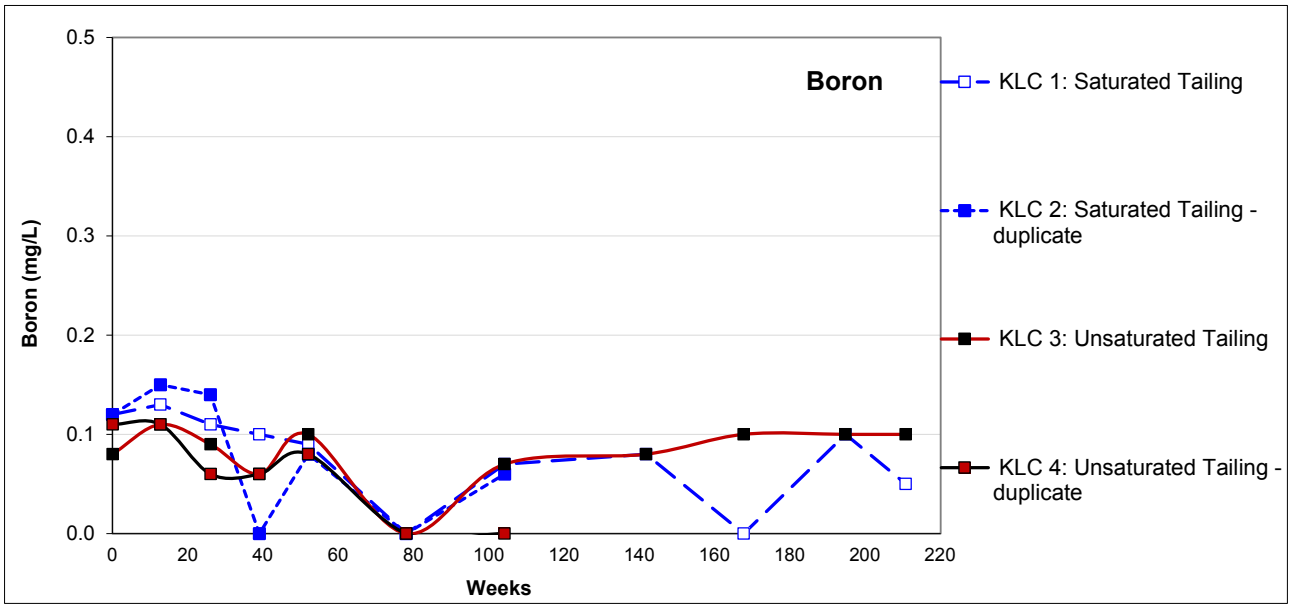

Electrical Conductivity
EC (µS/cm)
10,000
8,000
6,000
4,000
2,000
0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

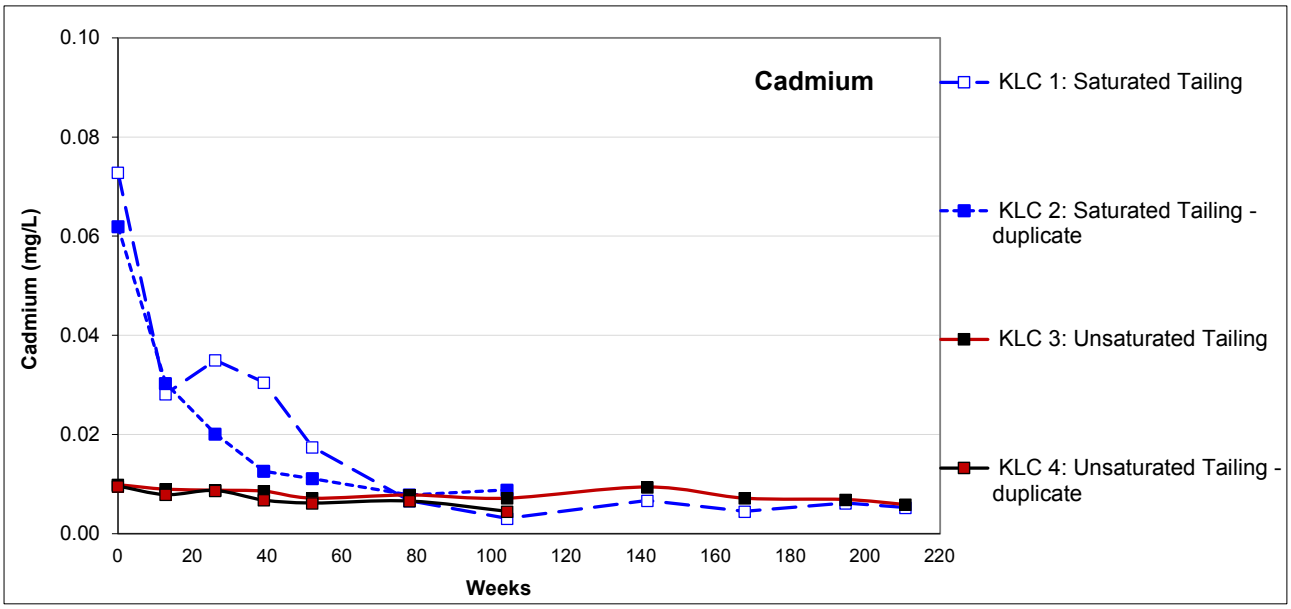

SO4 Release Rate
Sulfate Release Rate (mg/kg/flush)
2,500
2,000
1,500
1,000
500
0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

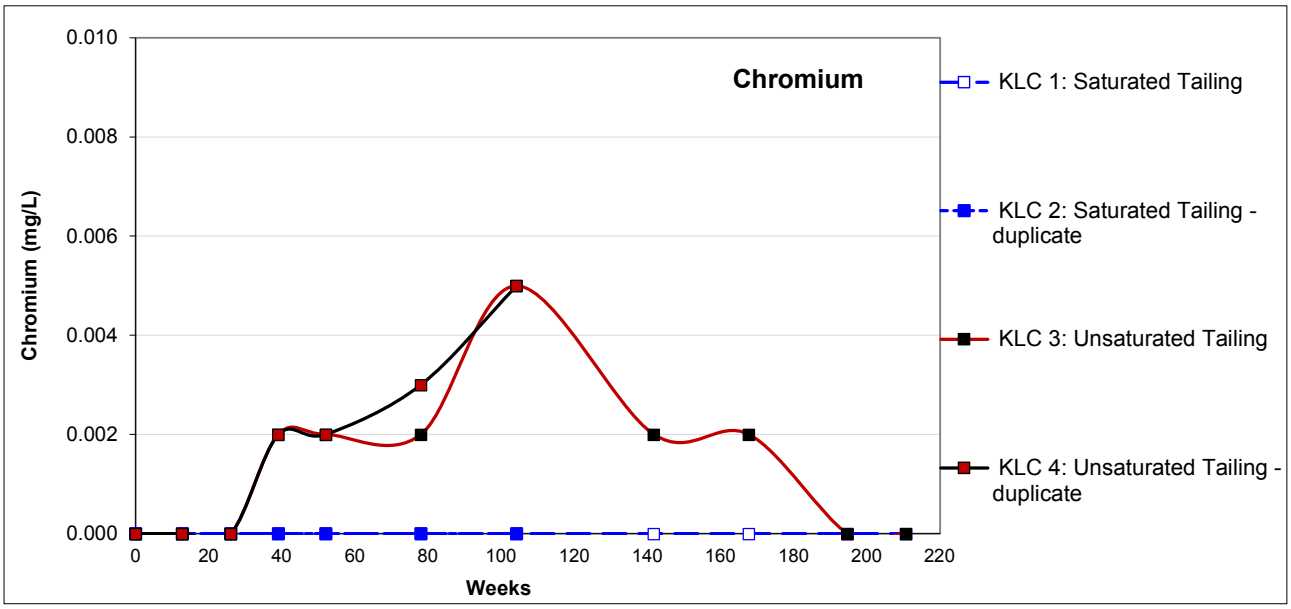

Residual S (%)
100
75
50
25
0
Residual Sulfur
Residual sulfur is total sulfur at start minus sulfur (as sulfate) leached from sample
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

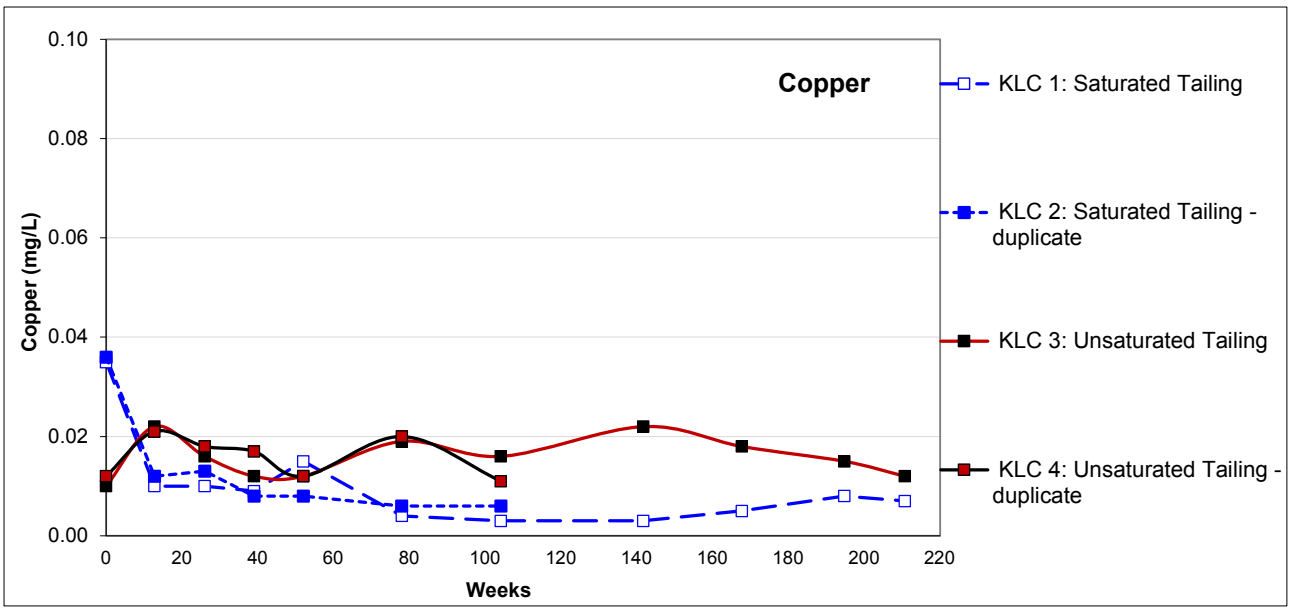

Aluminium
Aluminium (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

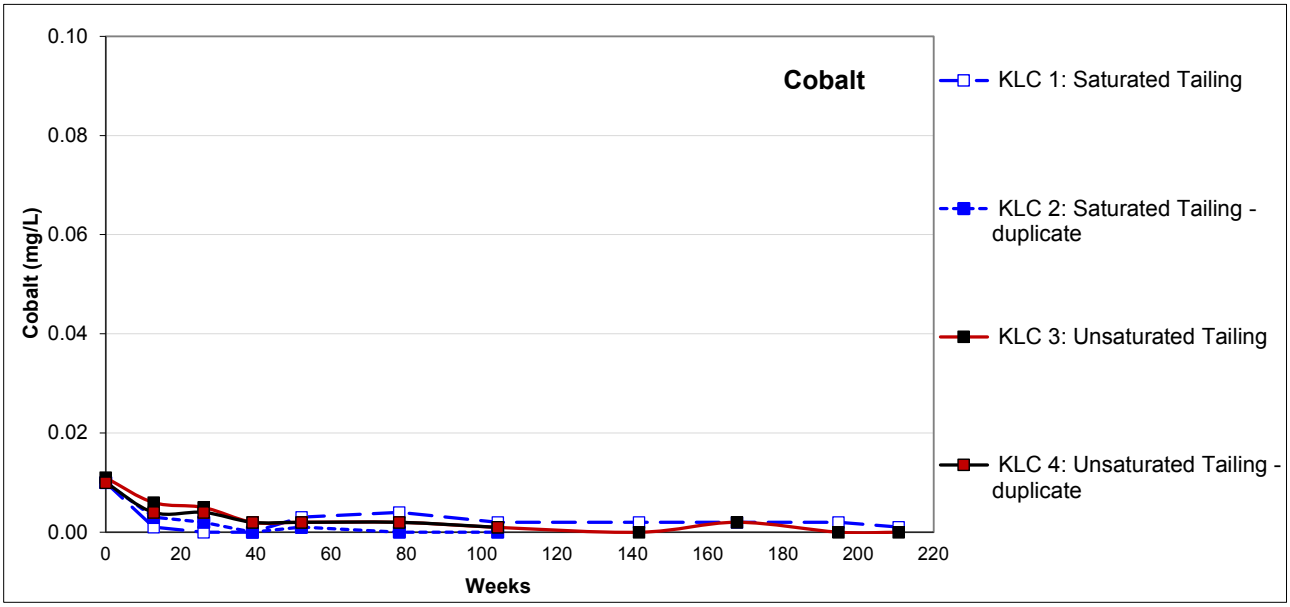

Arsenic
Arsenic (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

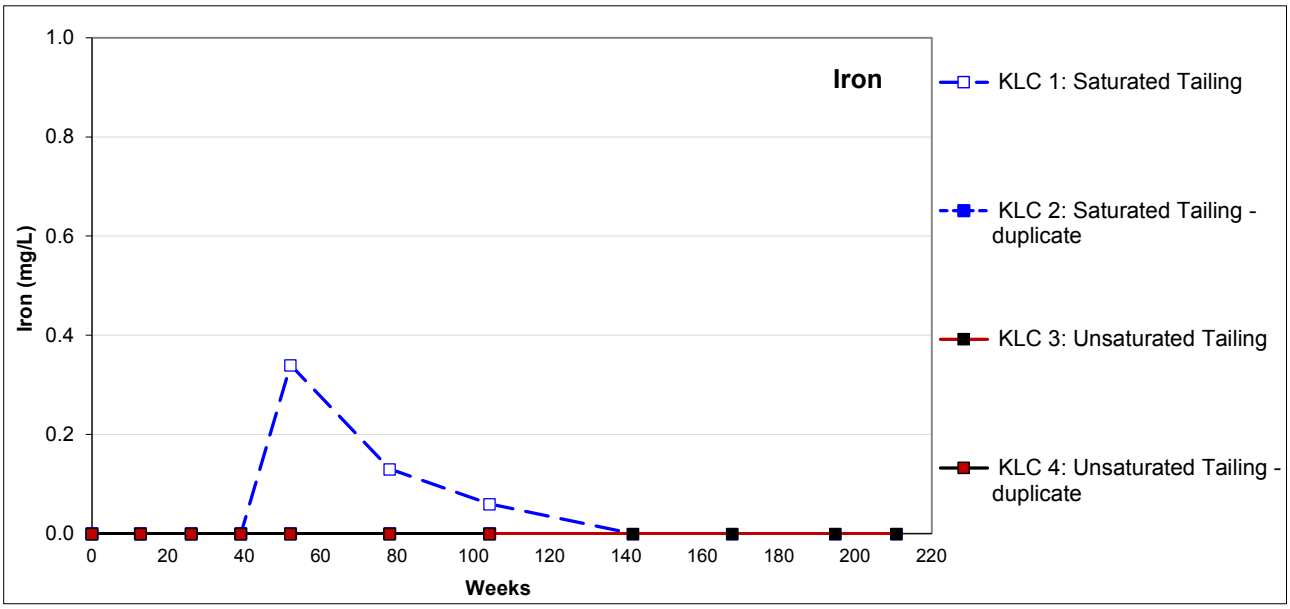

Boron
Boron (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

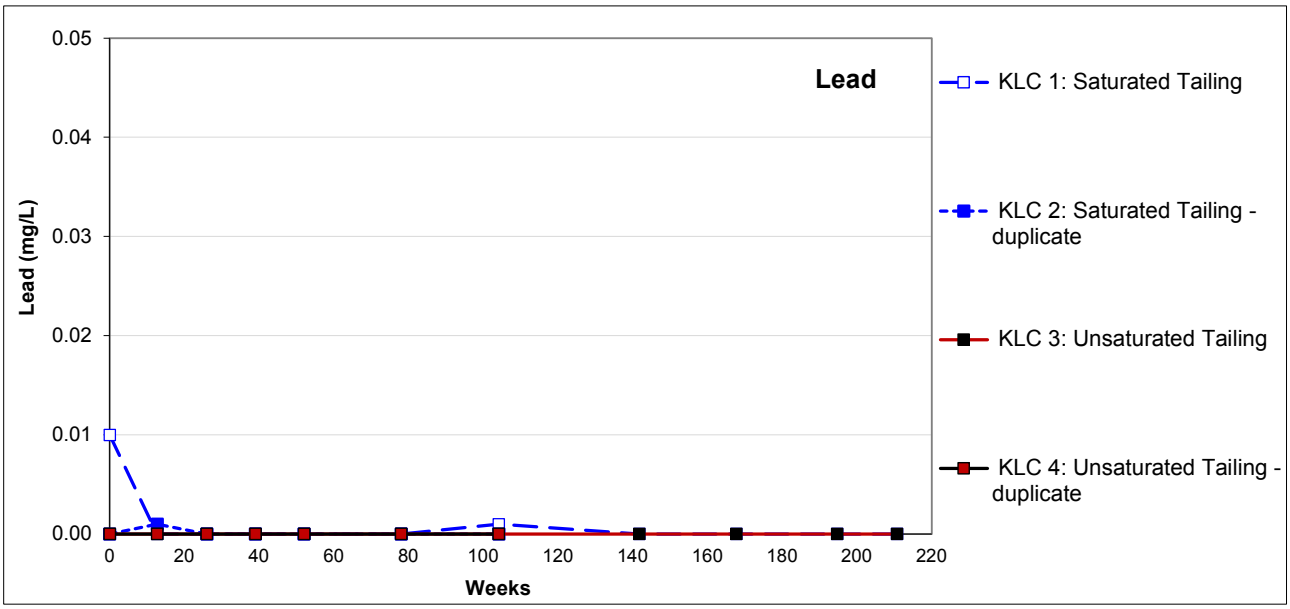

Cadmium
Cadmium (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

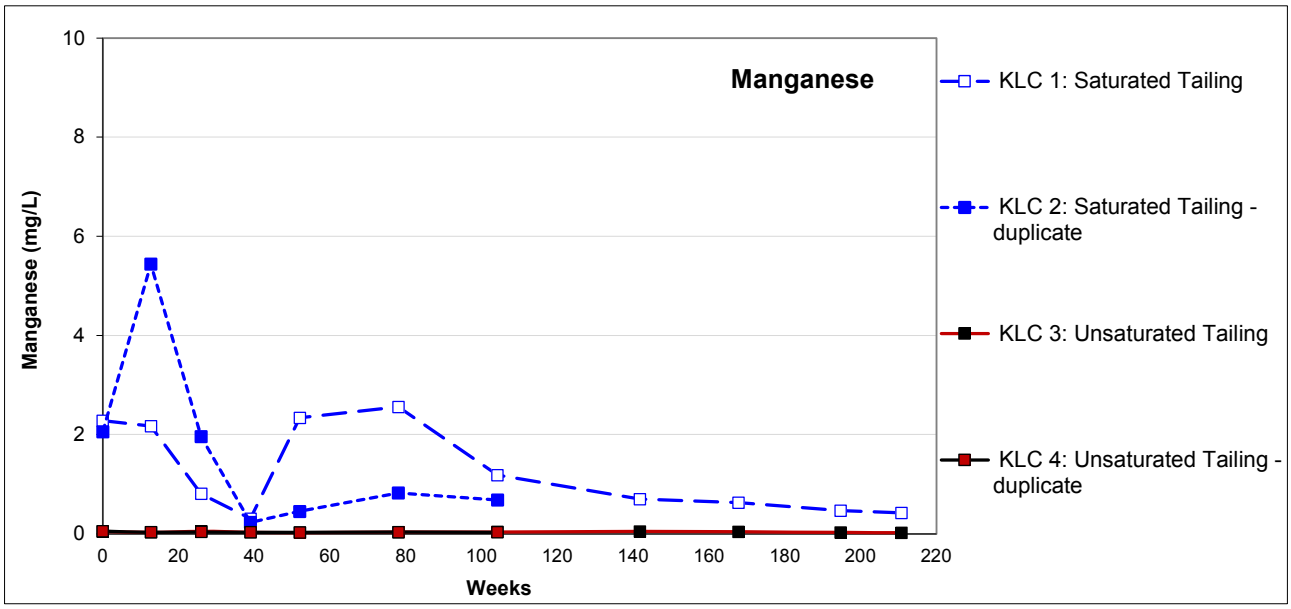

Chromium
Chromium (mg/L)
0.010
0.008
0.006
0.004
0.002
0.000
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

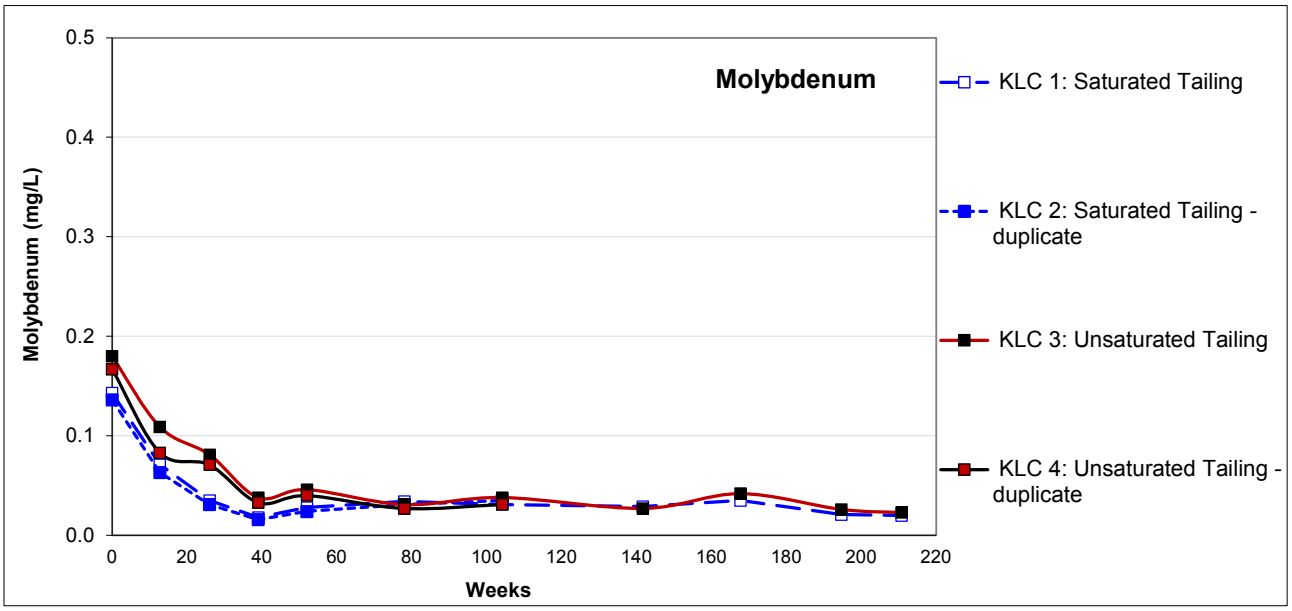

Copper
Copper (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

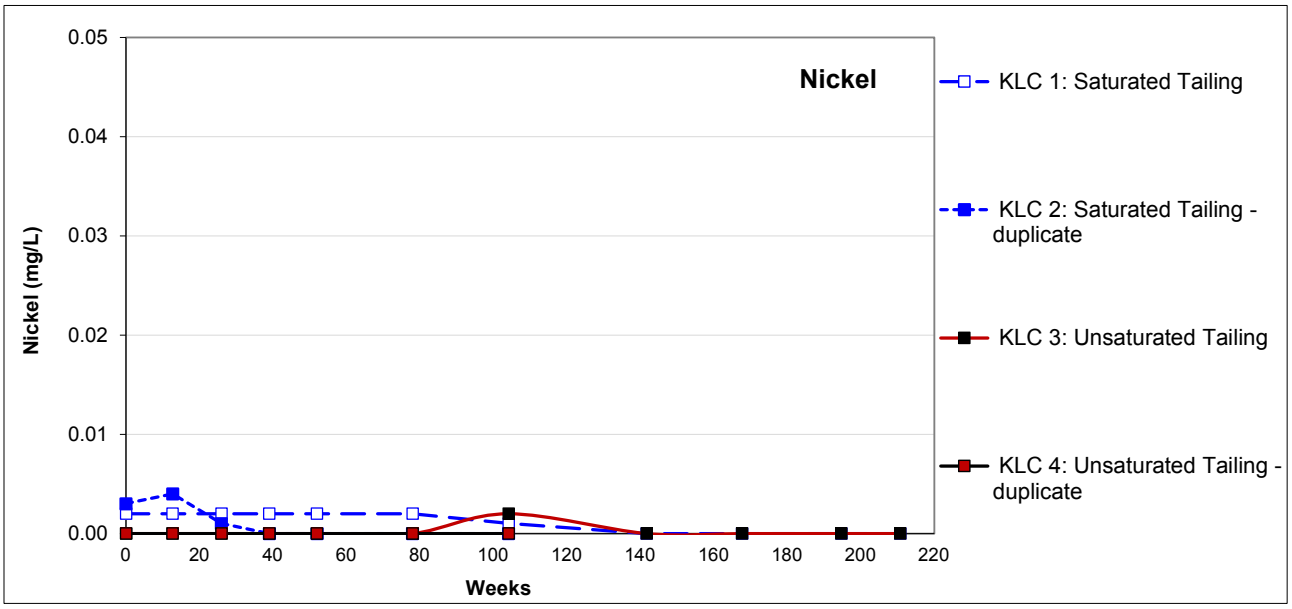

Cobalt
Cobalt (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

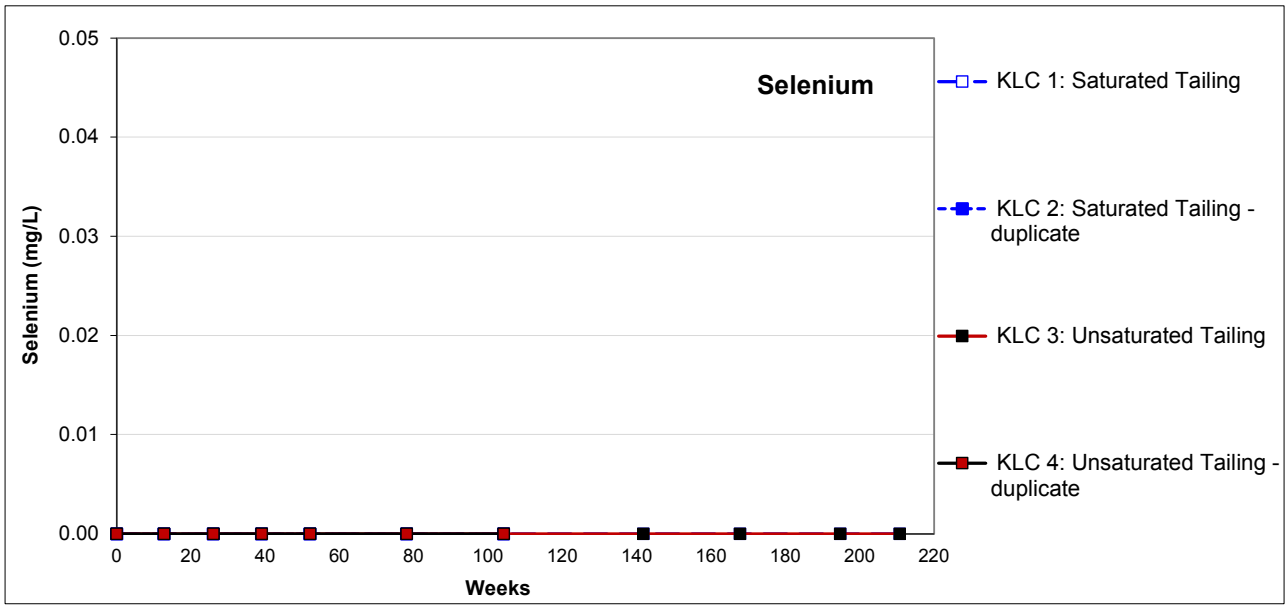

Iron
Iron (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

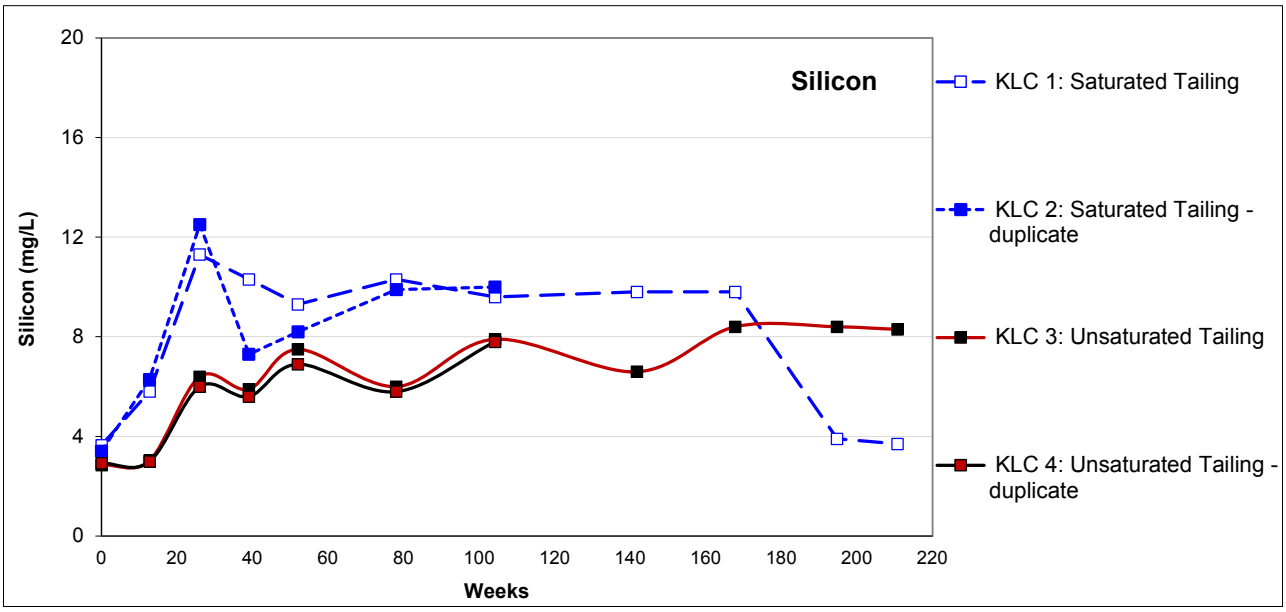

Lead
Lead (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

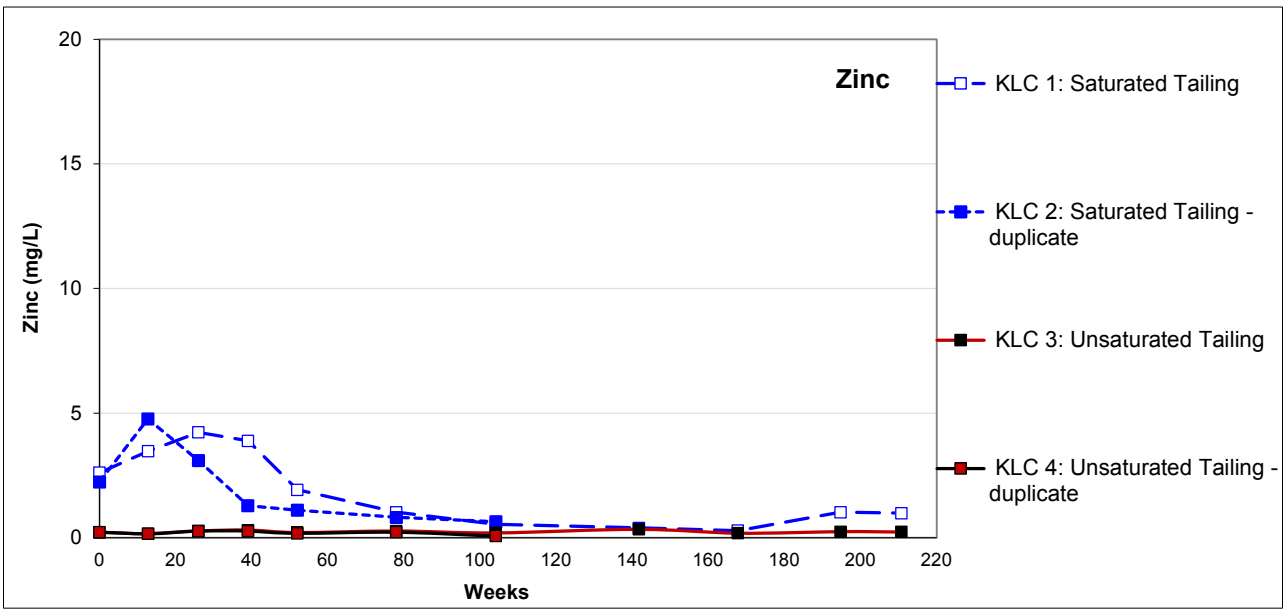

Manganese
Manganese (mg/L)
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate


Molybdenum
Molybdenum (mg/L)
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate


Nickel
Nickel (mg/L)
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate


Selenium
Selenium (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate


Silicon
Silicon (mg/L)
20
16
12
8
4
0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate


Zinc
Zinc (mg/L)
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
200
220
Weeks
KLC 1: Saturated Tailing
KLC 2: Saturated Tailing - duplicate
KLC 3: Unsaturated Tailing
KLC 4: Unsaturated Tailing - duplicate

9.2 Attachment B: KLC Test Results and Trends

CERTIFICATE OF ANALYSIS

Work Order	: **EB1446978**	Page	: 1 of 2
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: Mt Rawdon	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 24-Nov-2014 15:00
C-O-C number	: ----	Date Analysis Commenced	: 26-Nov-2014
Sampler	: SCOTT WALLACE (MT. RAWDON)	Issue Date	: 01-Dec-2014 17:50
Site	: Mt Rawdon Gold Mine		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Satishkumar Trivedi	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- **ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.**

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)			Client sample ID	**MR01**	**MR02**	**MR03**	**MR04**	**----**
			Client sampling date / time	20-Nov-2014 11:00	20-Nov-2014 11:00	20-Nov-2014 11:00	20-Nov-2014 11:00	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1446978-001**	**EB1446978-002**	**EB1446978-003**	**EB1446978-004**	**--------**
				Result	Result	Result	Result	Result
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**8.2**	**8.6**	**8.6**	**8.3**	**----**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2040**	**3330**	**1530**	**759**	**----**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**47.5**	**43.3**	**28.0**	**27.5**	**----**
^ **ANC as CaCO3**	----	0.1	% CaCO3	**4.8**	**4.4**	**2.9**	**2.8**	**----**
Fizz Rating	----	0	Fizz Unit	**2**	**2**	**1**	**1**	**----**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**1.14**	**1.15**	**1.07**	**1.16**	**----**

CERTIFICATE OF ANALYSIS

Work Order	: **EB1447772**	Page	: 1 of 3
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 04-Dec-2014 23:51
C-O-C number	: ----	Date Analysis Commenced	: 08-Dec-2014
Sampler	: SCOTT WALLACE (MT. RAWDON)	Issue Date	: 16-Dec-2014 18:26
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Satishkumar Trivedi	2 IC Acid Sulfate Soils Supervisor	Brisbane Acid Sulphate Soils

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

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Analytical Results

Sub-Matrix: PULP (Matrix: SOIL)			Client sample ID	MR01	MR02	MR03	MR04	----
			Client sampling date / time	[20-Nov-2014]	[20-Nov-2014]	[20-Nov-2014]	[20-Nov-2014]	----
Compound	CAS Number	LOR	Unit	EB1447772-001	EB1447772-002	EB1447772-003	EB1447772-004	--------
				Result	Result	Result	Result	Result
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	9.5	8.9	9.2	9.1	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	0.795	0.797	0.795	0.839	----
ED093T: Total Major Cations								
Calcium	7440-70-2	50	mg/kg	20800	19600	13000	12000	----
Magnesium	7439-95-4	50	mg/kg	6190	6140	3000	3020	----
Sodium	7440-23-5	50	mg/kg	910	1880	250	1240	----
Potassium	7440-09-7	50	mg/kg	2630	2760	1120	1820	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	11600	10700	4970	5410	----
Antimony	7440-36-0	5	mg/kg	<5	<5	<5	<5	----
Arsenic	7440-38-2	5	mg/kg	77	95	84	69	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Cadmium	7440-43-9	1	mg/kg	8	9	4	4	----
Chromium	7440-47-3	2	mg/kg	38	18	16	61	----
Cobalt	7440-48-4	2	mg/kg	8	7	6	6	----
Copper	7440-50-8	5	mg/kg	262	253	665	335	----
Iron	7439-89-6	50	mg/kg	25300	25700	16900	17200	----
Lead	7439-92-1	5	mg/kg	65	72	64	62	----
Manganese	7439-96-5	5	mg/kg	1300	1300	1120	1090	----
Molybdenum	7439-98-7	2	mg/kg	<2	<2	<2	<2	----
Nickel	7440-02-0	2	mg/kg	6	5	9	8	----
Selenium	7782-49-2	5	mg/kg	<5	<5	<5	<5	----
Zinc	7440-66-6	5	mg/kg	1440	1740	843	750	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1447785**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 04-Dec-2014 18:45
C-O-C number	: ----	Date Analysis Commenced	: 08-Dec-2014
Sampler	: MANDIE MATHESON	Issue Date	: 11-Dec-2014 16:41
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

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NATA Accredited Laboratory 825

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Signatories

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Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

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Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
			Client sampling date / time	[04-Dec-2014]	[04-Dec-2014]	[04-Dec-2014]	[04-Dec-2014]	----
Compound	CAS Number	LOR	Unit	EB1447785-001	EB1447785-002	EB1447785-003	EB1447785-004	--------
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.96	6.36	7.36	7.38	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	8320	8050	9210	8910	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	244	237	28	28	----
Total Alkalinity as CaCO3	----	1	mg/L	244	237	28	28	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	22	22	5	6	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	3.65	3.41	2.85	2.93	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	2970	2930	3590	3570	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	576	559	701	671	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	534	499	499	519	----
Magnesium	7439-95-4	1	mg/L	73	71	74	72	----
Sodium	7440-23-5	1	mg/L	1360	1310	1580	1530	----
Potassium	7440-09-7	1	mg/L	370	356	409	411	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.02	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	0.003	0.003	0.003	0.003	----
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.003	0.004	----
Cadmium	7440-43-9	0.0001	mg/L	0.0729	0.0619	0.0099	0.0096	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	0.035	0.036	0.010	0.012	----
Cobalt	7440-48-4	0.001	mg/L	0.010	0.010	0.011	0.010	----
Nickel	7440-02-0	0.001	mg/L	0.002	0.003	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	0.010	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	2.61	2.24	0.215	0.220	----
Manganese	7439-96-5	0.001	mg/L	2.28	2.06	0.046	0.053	----
Molybdenum	7439-98-7	0.001	mg/L	0.143	0.136	0.180	0.167	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	[04-Dec-2014]	[04-Dec-2014]	[04-Dec-2014]	[04-Dec-2014]	----
Compound	CAS Number	LOR	Unit		EB1447785-001	EB1447785-002	EB1447785-003	EB1447785-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Boron	7440-42-8	0.05	mg/L		**0.12**	**0.12**	**0.08**	**0.11**	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EG052F: Dissolved Silica by ICPAES									
^ **Silicon as SiO2**	14464-46-1	0.1	mg/L		**7.8**	**7.3**	**6.1**	**6.3**	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.5**	**0.6**	**0.6**	**0.6**	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1513989**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 03-Mar-2015 18:30
C-O-C number	: ----	Date Analysis Commenced	: 04-Mar-2015
Sampler	: MANDIE MATHESON	Issue Date	: 12-Mar-2015 17:07
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

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Signatories

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Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

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- The presence of high SO4 may bias the EC low.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
			Client sampling date / time	[03-Mar-2015]	[03-Mar-2015]	[03-Mar-2015]	[03-Mar-2015]	----
Compound	CAS Number	LOR	Unit	EB1513989-001	EB1513989-002	EB1513989-003	EB1513989-004	--------
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.52	7.55	7.29	7.25	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2860	2990	5610	4600	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	112	161	68	32	----
Total Alkalinity as CaCO3	----	1	mg/L	112	161	68	32	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	15	23	9	3	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	5.80	6.29	3.04	2.99	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1530	1500	2790	2040	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	45	60	307	209	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	529	503	493	477	----
Magnesium	7439-95-4	1	mg/L	24	28	34	27	----
Sodium	7440-23-5	1	mg/L	149	192	744	549	----
Potassium	7440-09-7	1	mg/L	86	95	223	169	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	0.003	0.002	0.004	0.004	----
Arsenic	7440-38-2	0.001	mg/L	0.002	0.003	0.003	0.003	----
Cadmium	7440-43-9	0.0001	mg/L	0.0282	0.0303	0.0090	0.0079	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	0.010	0.012	0.022	0.021	----
Cobalt	7440-48-4	0.001	mg/L	0.001	0.003	0.006	0.004	----
Nickel	7440-02-0	0.001	mg/L	0.002	0.004	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	3.47	4.76	0.166	0.156	----
Manganese	7439-96-5	0.001	mg/L	2.17	5.44	0.030	0.030	----
Molybdenum	7439-98-7	0.001	mg/L	0.071	0.063	0.109	0.083	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	[03-Mar-2015]	[03-Mar-2015]	[03-Mar-2015]	[03-Mar-2015]	----
Compound	CAS Number	LOR	Unit		EB1513989-001	EB1513989-002	EB1513989-003	EB1513989-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Boron	7440-42-8	0.05	mg/L		**0.13**	**0.15**	**0.11**	**0.11**	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.3**	**0.6**	**0.6**	----

CERTIFICATE OF ANALYSIS

Work Order	: **EB1520149**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 02-Jun-2015 14:10
C-O-C number	: ----	Date Analysis Commenced	: 04-Jun-2015
Sampler	: VERONICA CANALES	Issue Date	: 10-Jun-2015 13:07
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

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Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	[02-Jun-2015]	[02-Jun-2015]	[02-Jun-2015]	[02-Jun-2015]	----
Compound	CAS Number	LOR	Unit		EB1520149-001	EB1520149-002	EB1520149-003	EB1520149-004	--------
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.55	7.47	7.51	7.50	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		2530	2610	3810	3310	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		114	121	34	33	----
Total Alkalinity as CaCO3	----	1	mg/L		114	121	34	33	----
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		8	12	3	2	----
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		1460	1420	1800	1610	----
^ Silicon as SiO2	14464-46-1	0.1	mg/L		11.3	12.5	6.4	6.0	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		1570	1550	1970	1760	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		24	36	124	93	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		506	378	395	386	----
Magnesium	7439-95-4	1	mg/L		13	12	26	22	----
Sodium	7440-23-5	1	mg/L		76	94	382	300	----
Potassium	7440-09-7	1	mg/L		52	51	128	111	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L		0.002	0.002	0.003	0.003	----
Arsenic	7440-38-2	0.001	mg/L		0.001	0.001	0.002	0.002	----
Cadmium	7440-43-9	0.0001	mg/L		0.0350	0.0201	0.0088	0.0087	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L		0.010	0.013	0.016	0.018	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	0.002	0.005	0.004	----
Nickel	7440-02-0	0.001	mg/L		0.002	0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L		4.23	3.09	0.273	0.266	----
Manganese	7439-96-5	0.001	mg/L		0.805	1.96	0.052	0.037	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	[02-Jun-2015]	[02-Jun-2015]	[02-Jun-2015]	[02-Jun-2015]	----
Compound	CAS Number	LOR	Unit		EB1520149-001	EB1520149-002	EB1520149-003	EB1520149-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Molybdenum	7439-98-7	0.001	mg/L		**0.035**	**0.031**	**0.081**	**0.071**	**----**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**----**
Boron	7440-42-8	0.05	mg/L		**0.11**	**0.14**	**0.09**	**0.06**	**----**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	**----**
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	**----**
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.4**	**0.4**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1528976**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 15-Sep-2015 15:00
C-O-C number	: ----	Date Analysis Commenced	: 18-Sep-2015
Sampler	: VERONICA CANALES	Issue Date	: 22-Sep-2015 15:29
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1) Leachate	Mt Rawdon Tailings (2) Leachate	Mt Rawdon Tailings (3) Leachate	Mt Rawdon Tailings (4) Leachate	----
			Client sampling date / time	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	----
Compound	CAS Number	LOR	Unit	EB1528976-001	EB1528976-002	EB1528976-003	EB1528976-004	--------
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.44**	**7.59**	**7.49**	**7.53**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2300**	**1490**	**2420**	**2010**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**115**	**74**	**39**	**37**	----
Total Alkalinity as CaCO3	----	1	mg/L	**115**	**74**	**39**	**37**	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**10**	**1**	**2**	**2**	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**1380**	**754**	**1330**	**1090**	----
^ Silicon as SiO2	14464-46-1	0.1	mg/L	**10.3**	**7.3**	**5.9**	**5.6**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1410**	**741**	**1310**	**1090**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**15**	**18**	**31**	**20**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**510**	**251**	**367**	**325**	----
Magnesium	7439-95-4	1	mg/L	**11**	**7**	**22**	**18**	----
Sodium	7440-23-5	1	mg/L	**61**	**58**	**165**	**115**	----
Potassium	7440-09-7	1	mg/L	**42**	**33**	**93**	**76**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	**0.002**	**0.001**	**0.004**	**0.003**	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	**0.001**	**0.001**	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0305**	**0.0126**	**0.0086**	**0.0068**	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	**0.002**	**0.002**	----
Copper	7440-50-8	0.001	mg/L	**0.009**	**0.008**	**0.012**	**0.017**	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	**0.002**	**0.002**	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	**3.89**	**1.28**	**0.307**	**0.264**	----

Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1) Leachate	Mt Rawdon Tailings (2) Leachate	Mt Rawdon Tailings (3) Leachate	Mt Rawdon Tailings (4) Leachate	----
				Client sampling date / time	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	----
Compound	CAS Number	LOR	Unit		EB1528976-001	EB1528976-002	EB1528976-003	EB1528976-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.306**	**0.231**	**0.031**	**0.030**	**----**
Molybdenum	7439-98-7	0.001	mg/L		**0.018**	**0.016**	**0.038**	**0.033**	**----**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**----**
Boron	7440-42-8	0.05	mg/L		**0.10**	<0.05	**0.06**	**0.06**	**----**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	**----**
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	**----**
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.4**	**0.3**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1528976**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: carsten.emrich@alsenviro.com
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7123
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----	Date Samples Received	: 15-Sep-2015 15:00
C-O-C number	: ----	Date Analysis Commenced	: 18-Sep-2015
Sampler	: VERONICA CANALES	Issue Date	: 22-Sep-2015 15:29
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1) Leachate	Mt Rawdon Tailings (2) Leachate	Mt Rawdon Tailings (3) Leachate	Mt Rawdon Tailings (4) Leachate	----
			Client sampling date / time	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	----
Compound	CAS Number	LOR	Unit	EB1528976-001	EB1528976-002	EB1528976-003	EB1528976-004	--------
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.44**	**7.59**	**7.49**	**7.53**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2300**	**1490**	**2420**	**2010**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**115**	**74**	**39**	**37**	----
Total Alkalinity as CaCO3	----	1	mg/L	**115**	**74**	**39**	**37**	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**10**	**1**	**2**	**2**	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**1380**	**754**	**1330**	**1090**	----
^ Silicon as SiO2	14464-46-1	0.1	mg/L	**10.3**	**7.3**	**5.9**	**5.6**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1410**	**741**	**1310**	**1090**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**15**	**18**	**31**	**20**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**510**	**251**	**367**	**325**	----
Magnesium	7439-95-4	1	mg/L	**11**	**7**	**22**	**18**	----
Sodium	7440-23-5	1	mg/L	**61**	**58**	**165**	**115**	----
Potassium	7440-09-7	1	mg/L	**42**	**33**	**93**	**76**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	**0.002**	**0.001**	**0.004**	**0.003**	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	<0.001	**0.001**	**0.001**	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0305**	**0.0126**	**0.0086**	**0.0068**	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	**0.002**	**0.002**	----
Copper	7440-50-8	0.001	mg/L	**0.009**	**0.008**	**0.012**	**0.017**	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	**0.002**	**0.002**	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	**3.89**	**1.28**	**0.307**	**0.264**	----

Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1) Leachate	Mt Rawdon Tailings (2) Leachate	Mt Rawdon Tailings (3) Leachate	Mt Rawdon Tailings (4) Leachate	----
				Client sampling date / time	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	[15-Sep-2015]	----
Compound	CAS Number	LOR	Unit		EB1528976-001	EB1528976-002	EB1528976-003	EB1528976-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.306**	**0.231**	**0.031**	**0.030**	**----**
Molybdenum	7439-98-7	0.001	mg/L		**0.018**	**0.016**	**0.038**	**0.033**	**----**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**----**
Boron	7440-42-8	0.05	mg/L		**0.10**	<0.05	**0.06**	**0.06**	**----**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	**----**
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	**----**
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.4**	**0.3**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1536536**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: alan@rgsenv.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Facsimile	: +61 07 3344 1222	Facsimile	: +61-7-3243 7218
Project	: 201417 Mt Rawdon Tailings Project	QC Level	: NEPM 2013 B3 & ALS QC Standard
Order number	: ----	Date Samples Received	: 01-Dec-2015 13:30
C-O-C number	: ----	Date Analysis Commenced	: 07-Dec-2015
Sampler	: VERONICA CANALES	Issue Date	: 11-Dec-2015 07:16
Site	: ----		
		No. of samples received	: 4
Quote number	: ----	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

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- General Comments
- Analytical Results

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Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics

General Comments

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Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.

- EK028SF:Poor spike recovery for (Weak Acid Dissociable Cyanide) due to matrix interferences(confirmed by re-analysis).

Analytical Results

Sub-Matrix: **LIQUID**
(Matrix: **WATER**)

				Client sample ID	Mt Rawdon Tailings (1) -KLC 1 Leachate	Mt Rawdon Tailings (2) -KLC 2 Leachate	Mt Rawdon Tailings (3) -KLC 3 Leachate	Mt Rawdon Tailings (4) -KLC 4 Leachate	----
				Client sampling date / time	[01-Dec-2015]	[01-Dec-2015]	[01-Dec-2015]	[01-Dec-2015]	----
Compound	CAS Number	LOR	Unit		EB1536536-001	EB1536536-002	EB1536536-003	EB1536536-004	--------
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.62	7.74	7.41	7.42	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		1740	1260	2080	1760	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		88	86	37	34	----
Total Alkalinity as CaCO3	----	1	mg/L		88	86	37	34	----
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		12	7	6	4	----
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		864	538	1100	859	----
Silicon as SiO2	14464-46-1	0.1	mg/L		9.3	8.2	7.5	6.9	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		852	529	1120	903	----
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		14	11	8	7	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		332	194	318	274	----
Magnesium	7439-95-4	1	mg/L		8	5	16	13	----
Sodium	7440-23-5	1	mg/L		48	38	60	41	----
Potassium	7440-09-7	1	mg/L		36	26	74	58	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L		0.002	0.001	0.003	0.003	----
Arsenic	7440-38-2	0.001	mg/L		0.004	0.001	0.002	0.002	----
Cadmium	7440-43-9	0.0001	mg/L		0.0175	0.0111	0.0072	0.0062	----
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	0.002	0.002	----
Copper	7440-50-8	0.001	mg/L		0.015	0.008	0.012	0.012	----
Cobalt	7440-48-4	0.001	mg/L		0.003	0.001	0.002	0.002	----
Nickel	7440-02-0	0.001	mg/L		0.002	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	----

Analytical Results

Sub-Matrix: **LIQUID**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Tailings (1) -KLC 1 Leachate	Mt Rawdon Tailings (2) -KLC 2 Leachate	Mt Rawdon Tailings (3) -KLC 3 Leachate	Mt Rawdon Tailings (4) -KLC 4 Leachate	----
				Client sampling date / time	[01-Dec-2015]	[01-Dec-2015]	[01-Dec-2015]	[01-Dec-2015]	----
					EB1536536-001	EB1536536-002	EB1536536-003	EB1536536-004	--------
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		**1.92**	**1.10**	**0.208**	**0.173**	----
Manganese	7439-96-5	0.001	mg/L		**2.34**	**0.452**	**0.026**	**0.028**	----
Molybdenum	7439-98-7	0.001	mg/L		**0.028**	**0.024**	**0.046**	**0.040**	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Boron	7440-42-8	0.05	mg/L		**0.09**	**0.08**	**0.10**	**0.08**	----
Iron	7439-89-6	0.05	mg/L		**0.34**	<0.05	<0.05	<0.05	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	0.004	mg/L		<0.004	<0.004	<0.004	<0.004	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.3**	**0.3**	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1615076**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 08-Jun-2016 11:40
Order number	: ----	Date Analysis Commenced	: 08-Jun-2016
C-O-C number	: 201417	Issue Date	: 15-Jun-2016 17:37
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

NATA Accredited Laboratory 825
Accredited for compliance with
ISO/IEC 17025.

NATA
WORLD RECOGNISED ACCREDITATION

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
			Client sampling date / time	[07-Jun-2016]	[07-Jun-2016]	[07-Jun-2016]	[07-Jun-2016]	----
Compound	CAS Number	LOR	Unit	EB1615076-001	EB1615076-002	EB1615076-003	EB1615076-004	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.65**	**7.74**	**7.55**	**7.55**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1400**	**974**	**1700**	**1440**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**94**	**104**	**56**	**46**	----
Total Alkalinity as CaCO3	----	1	mg/L	**94**	**104**	**56**	**46**	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**4**	**2**	**2**	**2**	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**716**	**408**	**940**	**753**	----
Silicon as SiO2	14464-46-1	0.1	mg/L	**10.3**	**9.9**	**6.0**	**5.8**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**662**	**397**	**911**	**739**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**11**	**8**	**6**	**6**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**248**	**163**	**311**	**261**	----
Magnesium	7439-95-4	1	mg/L	**7**	**4**	**16**	**12**	----
Sodium	7440-23-5	1	mg/L	**37**	**28**	**30**	**23**	----
Potassium	7440-09-7	1	mg/L	**31**	**23**	**56**	**45**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	<0.001	**0.001**	**0.002**	**0.002**	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	**0.001**	**0.001**	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0066**	**0.0078**	**0.0078**	**0.0066**	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	**0.002**	**0.003**	----
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.006**	**0.019**	**0.020**	----
Cobalt	7440-48-4	0.001	mg/L	**0.004**	<0.001	**0.002**	**0.002**	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	<0.001	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	**1.02**	**0.815**	**0.267**	**0.223**	----
Manganese	7439-96-5	0.001	mg/L	**2.56**	**0.821**	**0.033**	**0.034**	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	[07-Jun-2016]	[07-Jun-2016]	[07-Jun-2016]	[07-Jun-2016]	----
Compound	CAS Number	LOR	Unit		EB1615076-001	EB1615076-002	EB1615076-003	EB1615076-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Molybdenum	7439-98-7	0.001	mg/L		**0.034**	**0.031**	**0.031**	**0.027**	**----**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**----**
Boron	7440-42-8	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	**----**
Iron	7439-89-6	0.05	mg/L		**0.13**	<0.05	<0.05	<0.05	**----**
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.3**	**0.2**	**----**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**16.0**	**10.6**	**20.2**	**16.5**	**----**
Total Cations	----	0.01	meq/L		**15.4**	**10.3**	**19.6**	**16.2**	**----**
Ionic Balance	----	0.01	%		**1.92**	**1.39**	**1.66**	**0.90**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1628822**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 06-Dec-2016 16:25
Order number	: ----	Date Analysis Commenced	: 07-Dec-2016
C-O-C number	: ----	Issue Date	: 13-Dec-2016 09:45
Sampler	: MINGRUI YUAN		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
			Client sampling date / time	06-Dec-2016 00:00	06-Dec-2016 00:00	06-Dec-2016 00:00	06-Dec-2016 00:00	----
Compound	CAS Number	LOR	Unit	EB1628822-001	EB1628822-002	EB1628822-003	EB1628822-004	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.69**	**7.94**	**7.55**	**7.51**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1050**	**836**	**1570**	**1300**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**92**	**108**	**35**	**36**	----
Total Alkalinity as CaCO3	----	1	mg/L	**92**	**108**	**35**	**36**	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	<1	**2**	**2**	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**476**	**345**	**886**	**663**	----
Silicon as SiO2	14464-46-1	0.1	mg/L	**9.6**	**10.0**	**7.9**	**7.8**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**455**	**317**	**822**	**656**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**9**	**6**	**4**	**4**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**178**	**142**	**295**	**249**	----
Magnesium	7439-95-4	1	mg/L	**4**	**3**	**11**	**8**	----
Sodium	7440-23-5	1	mg/L	**21**	**17**	**13**	**8**	----
Potassium	7440-09-7	1	mg/L	**22**	**19**	**53**	**35**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	----
Antimony	7440-36-0	0.001	mg/L	<0.001	**0.001**	**0.003**	**0.002**	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	**0.002**	**0.001**	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0031**	**0.0088**	**0.0072**	**0.0045**	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	**0.005**	**0.005**	----
Copper	7440-50-8	0.001	mg/L	**0.003**	**0.006**	**0.016**	**0.011**	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	<0.001	**0.001**	**0.001**	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	<0.001	**0.002**	<0.001	----
Lead	7439-92-1	0.001	mg/L	**0.001**	<0.001	<0.001	<0.001	----
Zinc	7440-66-6	0.005	mg/L	**0.537**	**0.636**	**0.194**	**0.066**	----
Manganese	7439-96-5	0.001	mg/L	**1.18**	**0.679**	**0.038**	**0.030**	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Mt Rawdon Tailings (1)	Mt Rawdon Tailings (2)	Mt Rawdon Tailings (3)	Mt Rawdon Tailings (4)	----
				Client sampling date / time	06-Dec-2016 00:00	06-Dec-2016 00:00	06-Dec-2016 00:00	06-Dec-2016 00:00	----
Compound	CAS Number	LOR	Unit		EB1628822-001	EB1628822-002	EB1628822-003	EB1628822-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Molybdenum	7439-98-7	0.001	mg/L		**0.031**	**0.035**	**0.038**	**0.031**	**----**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**----**
Boron	7440-42-8	0.05	mg/L		**0.07**	**0.06**	**0.07**	<0.05	**----**
Iron	7439-89-6	0.05	mg/L		**0.06**	<0.05	<0.05	<0.05	**----**
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	**0.3**	**0.2**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1717132**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 22-Aug-2017 15:35
Order number	: ----	Date Analysis Commenced	: 22-Aug-2017
C-O-C number	: ----	Issue Date	: 29-Aug-2017 13:13
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	----	----	----
			Client sampling date / time	[22-Aug-2017]	[22-Aug-2017]	----	----	----
Compound	CAS Number	LOR	Unit	EB1717132-001	EB1717132-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.14**	**7.73**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**952**	**1530**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**101**	**54**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**101**	**54**	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**7**	**2**	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**9.8**	**6.6**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**389**	**750**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**6**	**3**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**155**	**316**	----	----	----
Magnesium	7439-95-4	1	mg/L	**4**	**13**	----	----	----
Sodium	7440-23-5	1	mg/L	**15**	**9**	----	----	----
Potassium	7440-09-7	1	mg/L	**17**	**42**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.001**	**0.002**	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.001**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0067**	**0.0094**	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.003**	**0.022**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.390**	**0.338**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.701**	**0.046**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.029**	**0.027**	----	----	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1	KLC 3	----	----	----
				Client sampling date / time	[22-Aug-2017]	[22-Aug-2017]	----	----	----
Compound	CAS Number	LOR	Unit		EB1717132-001	EB1717132-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.08**	**0.08**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.2**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**10.3**	**16.8**	----	----	----
Total Cations	----	0.01	meq/L		**9.15**	**18.3**	----	----	----
Ionic Balance	----	0.01	%		**5.84**	**4.35**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1804711**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 20-Feb-2018 17:35
Order number	: ----	Date Analysis Commenced	: 21-Feb-2018
C-O-C number	: ----	Issue Date	: 01-Mar-2018 15:28
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 2		
No. of samples analysed	: 2		

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Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Nutrients Section Supervisor	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	----	----	----
			Client sampling date / time	20-Feb-2018 00:00	20-Feb-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1804711-001	EB1804711-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.93**	**7.35**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**619**	**1460**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**121**	**48**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**121**	**48**	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**6**	**3**	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**9.8**	**8.4**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**172**	**730**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**2**	**1**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**115**	**295**	----	----	----
Magnesium	7439-95-4	1	mg/L	**2**	**9**	----	----	----
Sodium	7440-23-5	1	mg/L	**7**	**7**	----	----	----
Potassium	7440-09-7	1	mg/L	**12**	**36**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	<0.001	**0.002**	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.004**	**0.001**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0045**	**0.0072**	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	**0.002**	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.005**	**0.018**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	**0.002**	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.285**	**0.183**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.625**	**0.042**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.035**	**0.042**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 1	KLC 3	----	----	----
				Client sampling date / time	20-Feb-2018 00:00	20-Feb-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1804711-001	EB1804711-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	**0.10**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.1**	**0.2**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**6.06**	**16.2**	----	----	----
Total Cations	----	0.01	meq/L		**6.51**	**16.7**	----	----	----
Ionic Balance	----	0.01	%		**3.66**	**1.52**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1820822**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 28-Aug-2018 16:15
Order number	: ----	Date Analysis Commenced	: 28-Aug-2018
C-O-C number	: ----	Issue Date	: 03-Sep-2018 15:42
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 2		
No. of samples analysed	: 2		

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This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	----	----	----
			Client sampling date / time	28-Aug-2018 00:00	28-Aug-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1820822-001	EB1820822-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.79	7.64	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	736	1300	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	97	44	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	97	44	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	1	2	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	3.94	3.33	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	274	658	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	2	1	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	150	282	----	----	----
Magnesium	7439-95-4	1	mg/L	3	9	----	----	----
Sodium	7440-23-5	1	mg/L	8	7	----	----	----
Potassium	7440-09-7	1	mg/L	10	28	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	0.001	0.002	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0062	0.0069	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	0.008	0.015	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.002	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	1.02	0.242	----	----	----
Manganese	7439-96-5	0.001	mg/L	0.463	0.028	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.021	0.026	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 1	KLC 3	----	----	----
				Client sampling date / time	28-Aug-2018 00:00	28-Aug-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1820822-001	EB1820822-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.10**	**0.10**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.1**	**0.2**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**7.70**	**17.3**	----	----	----
Total Cations	----	0.01	meq/L		**8.34**	**15.8**	----	----	----
Ionic Balance	----	0.01	%		**3.97**	**4.39**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1830124**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222 :
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	18-Dec-2018 15:15 :
Order number	: ----	Date Analysis Commenced	18-Dec-2018
C-O-C number	: ----	Issue Date	: 23-Dec-2018 15:40
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 2		
No. of samples analysed	: 2		

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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Where moisture determination has been performed, results are reported on a dry weight basis.

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Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 3	----	----	----
			Client sampling date / time	23-Dec-2018 00:00	23-Dec-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1830124-001	EB1830124-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.60**	**7.54**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**700**	**1210**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**90**	**40**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**90**	**40**	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	**1**	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**3.70**	**8.30**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**260**	**600**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**1**	**1**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**140**	**262**	----	----	----
Magnesium	7439-95-4	1	mg/L	**3**	**8**	----	----	----
Sodium	7440-23-5	1	mg/L	**7**	**7**	----	----	----
Potassium	7440-09-7	1	mg/L	**9**	**25**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.001**	**0.001**	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.001**	**0.001**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0052**	**0.0059**	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.007**	**0.012**	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.001**	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.981**	**0.232**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.422**	**0.022**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.020**	**0.023**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 1	KLC 3	----	----	----
				Client sampling date / time	23-Dec-2018 00:00	23-Dec-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1830124-001	EB1830124-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.05**	**0.05**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.1**	**0.1**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**7.70**	**17.3**	----	----	----
Total Cations	----	0.01	meq/L		**8.34**	**15.8**	----	----	----
Ionic Balance	----	0.01	%		**3.97**	**4.39**	----	----	----



MINE WASTE AND
WATER MANAGEMENT

TECHNICAL REPORT

Geochemical Assessment of Waste Rock and Tailing Materials

Mt Rawdon Gold Mine

Prepared for: **Mt Rawdon Operations Pty Ltd**

RGS

MINE WASTE AND WATER MANAGEMENT

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Executive Summary

Introduction

RGS Environmental Pty Ltd (RGS) was commissioned by Mt Rawdon Operations Pty Ltd (MRO) to undertake static and kinetic geochemical laboratory scale testing of waste rock types that are currently being tested in field pads on site, and tailings and waste rock mixtures that reflect potential long term field storage situations for these materials at the Tailings Storage Facility (TSF).

Scope of work

The RGS scope of work was to complete a static and kinetic geochemical assessment of representative bulk samples of Non-Acid Forming (NAF) and Potentially Acid Forming (PAF) waste rock materials and NAF/Uncertain tailing materials from the Project. This included:

- Undertaking a brief review of existing geological and geochemical information;
- Design of a sampling program to align with the likely management methods for waste rock and tailing materials at the site;
- Coordination of a static geochemical test program at ALS laboratory;
- Design and coordination of an initial 12 month kinetic geochemical test program at RGS and ALS laboratories followed by a further 12 month kinetic geochemical test program; and
- Provision of a technical report describing the main findings of the geochemical assessment and providing recommendations for any future geochemical work programs.

The outcome of completion of the above scope of work is this stand-alone technical report, which provides: geochemical information on waste rock and tailing materials; a description of the sampling and geochemical testing methodology; assessment of the results and findings; and conclusions and recommendations.

Methodology

The sampling strategy and subsequent geochemical characterisation strategy for waste rock and tailing materials from the Project was guided by Australian (DME, 1995, DEHP, 2013; and COA, 2016) and international (INAP, 2009) technical guidelines for the geochemical assessment of mining wastes. The sampling strategy involved working closely with MRO personnel to identify and collect representative bulk samples of NAF and PAF waste rock materials and NAF/Uncertain tailing materials for geochemical testing.

Four bulk samples were collected by MRO personnel and transferred to ALS Environmental Laboratory in Stafford (ALS Stafford) for sample preparation and geochemical testing. These samples comprised:

- NAF waste rock from waste material being used in the current MRO field pad trials;
- Medium PAF waste rock from waste material being used in the current MRO field pad trials;
- High PAF waste rock from waste material being used in the current MRO field pad trials; and
- Tailing material recovered from the discharge line into the TSF.

These samples were subjected to a program of static geochemical, mineralogical and physical tests and then used to set up six Kinetic Leach Column (KLC) tests.

Conclusions

RGS has completed a static and kinetic geochemical assessment of representative waste rock and tailing samples from MRO. The main findings of the geochemical assessment are:

- The KLC test results indicate that some of the MRO samples (eg. PAF waste rock) are geochemically more benign (or certainly much slower to react) than expected from the initial static geochemical test results.

- NAF waste rock materials have negligible sulfur content, elevated ANC and a high factor of safety with respect to potential for Acid and Metalliferous Drainage (AMD) (including Neutral Metalliferous Drainage (NMD) or Saline Drainage (SD)). In contrast, PAF waste rock materials have elevated sulfur content, moderate ANC, and have a reduced factor of safety with respect to potential for AMD, if exposed to long term oxidising/weathering conditions. Tailings have finely balanced acid generating and acid neutralising capacities but continue to generate pH neutral conditions even after extended exposure to idealised oxidising/weathering conditions (at least nine years). The concentrations of existing major ions leached into contact water from the tailing matrix, including sulfate, are likely to be elevated.
- Initial surface runoff and seepage from NAF and PAF waste rock materials (and ongoing surface runoff and seepage from NAF waste rock materials) is likely to be pH neutral to slightly alkaline and have a low level of salinity. Initial and ongoing surface runoff and seepage from NAF waste rock materials is likely to contain excess alkalinity.
- KLC test data indicates the lag period preceding acid generation from PAF waste rock materials exposed to idealised oxidising/weathering conditions is likely to be greater than 24 months.
- Metal/metalloid enrichment in waste rock and tailing materials compared to median crustal abundance in unmineralised soils is likely to be limited to cadmium and silver in some PAF waste rock materials and arsenic, cadmium, silver and zinc in the tailing. These results are expected given that the samples are derived from waste rock (and processed ore) materials surrounding a mineralised gold ore body.
- Most metals/metalloids are sparingly soluble at the neutral to slightly alkaline pH of contact water with waste rock and tailing materials at MRO. However, a number of metals including aluminium, copper and iron are likely to become more soluble in surface runoff and seepage from PAF waste rock materials, if these materials are exposed to ongoing oxidising/weathering conditions and acidic pH conditions develop.
- Encapsulation of High PAF waste rock at the TSF, within a reasonable period of time (ie. 24 months), is likely to reduce the risk of AMD and maintain the overall quality of surface runoff and seepage from the TSF.
- Given the current management strategy employed by MRO for waste rock and tailings, the potential for AMD from these materials is relatively low. The static and kinetic geochemical information obtained to date suggests that existing management and rehabilitation strategy at MRO are likely to meet the long term Department of Environment and Science (DES) rehabilitation objectives.

Recommendations

As a result of the static and kinetic geochemical assessment work completed on waste rock and tailing materials at MRO, a number of additional recommendations are provided for waste rock materials. It is recommended that MRO considers:

- Addition of crushed limestone to PAF waste rock materials if stored for more than 24 months in an uncovered state (ie. exposed to oxidising/weathering conditions), and in any case prior to placement of the cover system described in the Closure Decommissioning and Rehabilitation Plan (RGS, 2016a).
- Reinstatement of KLC testing of waste rock and tailing materials for a further 12 to 24 months or until steady-state is attained. Kinetic testing is long-term testing and, as such, much of the value is only obtained once the samples have reached a geochemical steady-state. Testing should continue until metal/metalloid, sulfate salt and acidity release rates are obtained from samples that are considered to have reached a geochemical steady-state.
- Geochemical and water quality modelling for waste rock and tailings using KLC test leachate release rate data (i.e., the load of trace metals/metalloids released from the waste rock and tailing samples in units of mg/kg per flush). This method normalises the data to allow better comparison and provides a conservative approach, as the waste rock samples have been crushed to pass a 10 mm sieve size and therefore had a higher surface area for potential geochemical reaction that would generally be found for waste rock materials in the field at MRO. Similarly, the tailings samples are allowed to dry between leaching events and this simulates idealised oxidising/weathering conditions for surface tailings at a TSF

rather than for bulk tailing materials, which remain relatively saturated and are periodically re-covered with fresh tailing materials over time. RGS has already measured the particle size distribution of the waste rock materials included in the KLC test and therefore a specific surface area can be calculated for these materials. This could then be extrapolated to the field waste rock storage situation where the particle size distribution and specific surface area for waste rock could be calculated from waste rock photographs.

- Post KLC testing of selected sample materials after decommissioning of the KLC tests. The testing should comprise Acid Base Accounting (pH, EC, total sulfur, ANC and acidity/alkalinity), whole-rock metal analysis, X-ray diffraction (XRD) mineralogical analysis and Quantitative Evaluation of Mineralogy by Scanning Electron Microscope (QEMScan®).
- Using the inferred sulfate production rate and sulfide oxidation rate from the KLC tests to predict, the time to depletion of ANC/sulfide content and potential lag period. It should be noted that the KLC tests may not have reached a steady state in terms of reaction kinetics after the initial 24 months of testing and therefore there may be some inherent limitations in the accuracy of such predictions. However, the combined use of KLC and mineralogical data will improve the level of confidence in such predictions; and
- Continuing to implement the existing surface water and groundwater monitoring programs as defined in the Environmental Authority for the site (DES, 2019).

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Glossary of Terms and Acronyms

Acidity	A measure of hydrogen ion (H+) concentration and latent acidity from dissolved metals; simplistically expressed as pH but more correctly as mg/L ($CaCO_3$ equivalent).
Alkalinity	A measure of the capacity of a water to neutralise acids mg/L ($CaCO_3$ equivalent).
ABA	Acid Base Account, an evaluation of the balance between acid generation and acid neutralisation processes. Generally, determines the MPA and the inherent ANC, as defined below, and is commonly used in assessing the potential for AMD associated with mining.
AMD	Acid and metalliferous drainage caused by exposure of sulfide minerals in mine waste materials to oxygen and water. Typically characterised by low pH and elevated concentrations of salts, sulfate and metals.
ANC	Acid neutralising capacity of a sample as kg H_2SO_4 per tonne of sample. Commonly referred to as the buffering capacity.
ANC:MPA Ratio	Ratio of the acid neutralising capacity and maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
Dispersive	Dispersive soil and rock materials are structurally unstable and disperse into basic particles such as sand, silt and clay in water. When a dispersive soil is wet, the basic structure may collapse, whereas when it is dry it is prone to surface sealing and crusting.
EC	Electrical Conductivity, expressed as µS/cm, is a measure of electrical conductance.
eCEC	Effective cation exchange capacity provides a measure of the amount of exchangeable cations (Ca, Mg, Na and K) in a sample.
ESP	Exchangeable sodium percentage provides a measure of the sodicity of a materials and propensity to erode.
Interburden	The waste rock material found in between coal seams.
KLC test	Kinetic leach column tests are procedures used to measure the geochemical/ weathering behaviour of a sample of mine material over time.
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity calculated by multiplying the total sulfur content of a sample by 30.625 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAG test	Net acid generation test. Hydrogen peroxide solution is used to oxidise sulfides in a sample, then any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is expressed as kg H_2SO_4 per tonne. The more elaborate extended boil NAG test can be used if a sample has a high organic carbon content to attempt to eliminate interference and false positive results.
NAF	Non-acid forming. Geochemical classification criterion for a sample that will not generate acid conditions.
NAF-Barren	Non-acid forming and barren of sulfur (ie. less than or equal to 0.07% sulfur). Geochemical classification criterion for a sample that will not generate acid conditions.
NAPP	Net acid producing potential expressed as kg H_2SO_4 per tonne. NAPP is the balance between the capacity of a sample to generate acidity (MPA) minus its capacity to neutralise acidity (ANC).

NMD	Neutral and metalliferous drainage typically caused by exposure of sulfide minerals in mine waste materials to oxygen and water and then neutralisation by gangue minerals. Typically characterised by neutral pH and elevated concentrations of salts, sulfate and metals.
Ore	Material that is been mined with sufficient value to warrant processing. Low-grade ore may be left as waste.
PAF	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
pH	Measure of the hydrogen ion (H+) activity in a sample solution, expressed in pH units.
PSD	Particle size distribution of a sample material measured by hydrometer.
%S	Percent sulfur. A measurement unit for the sulfur content of a sample material.
Scr	Chromium reducible sulfur test measures the sulfide sulfur content of a sample material.
Sodic	Sodic soil and rock materials are characterized by a disproportionately high concentration of sodium (Na) in their cation exchange complex and are innately unstable, exhibiting poor physical and chemical properties, which impede water infiltration, water availability, and ultimately plant growth.
Static test	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
Tailing	A form of process residue generated as a result of washing coal at the CHPP. Represents the finer size fraction of the coal reject produced.
Total Sulfur	Total sulfur content of a sample generally measured using a 'Leco' analyser expressed as % S.
TSS	Total suspended solids is a measurement of the suspended solids concentration in a water sample.
Uncertain	Geochemical classification criterion for a sample where the potential to generate acid conditions remains uncertain and may require further analysis.
Waste Rock	Material that surrounds an ore body and must be removed to mine the ore.
WRD	Waste Rock Dump. A facility used to store waste rock

1 Introduction

1.1 Background

Mount Rawdon Operations (MRO) is owned by Evolution Mining and is located in south-east Queensland, approximately 75 km south-west of Bundaberg, and 300 km north-north west of Brisbane. MRO is an open cut gold mine with facilities for gold recovery by ore processing at a Carbon-in-Leach (CIL) treatment plant, and the tailing retained in an engineered tailing storage facility (TSF). Mining, processing of ore, and tailing deposition commenced in January 2001 and construction of a waste rock dump in March 2002. The current anticipated life of the mining operation is approximately eight years.

RGS Environmental Pty Ltd (RGS) has previously developed a conceptual closure, decommissioning and rehabilitation plan (CDaR Plan) for the MRO TSF (RGS, 2016a). The plan provides a conceptual cover design and rehabilitation strategy that is suitable for mine closure, and which meets the Queensland Government's rehabilitation objectives of being safe stable, sustainable and non-polluting.

During development of the conceptual model for the MRO TSF CDaR Plan the following Potentially Acid Forming (PAF) waste rock management strategies were identified.

- Medium PAF waste rock is proposed to be placed onto an area of tailings at the west of the TSF. Conceptually, the Medium PAF waste rock is proposed to be placed onto the tailings in 0.5 to 1 m lifts and covered in layers of tailings. It is intended that the tailings would flow into the waste rock and fill the voids thereby cutting off pathways for oxidation of sulfide minerals and the production of acid, salts and metals. This type of mixing approach is known as co-mingling (ie. there is opportunistic/partial filling of voids with tailings and some reduction of acid production).
- High PAF waste rock is being used to construct a 100 m wide internal groin into the centre of the TSF that will then form a circular decant structure to improve dewatering of the TSF. The High PAF waste rock will be pushed into the tailings. This type of mixing is known as co-disposal and the objective is to ensure that all voids in the waste rock are filled with tailings. The material above the tailings will be progressively covered with tailings (this may be co-mingled or co-disposed depending on the rate of rise and mixing method).

RGS was commissioned by MRO to undertake static and kinetic geochemical laboratory scale testing of waste rock types that are currently being tested in field pads on site (see **Figure 1-1**); and tailing and waste rock mixtures, that reflect potential long term field storage situations for these materials at the TSF. It is typical industry practice to undertake static and kinetic geochemical tests at a laboratory scale and then upscale to field trials.

The advantage of laboratory testing is that (1) reactions can be enhanced as the material is crushed to pass a 10 mm sieve, therefore increasing the surface area of the rock and (2) there is control of the leach testing and application and recovery of water thereby reducing uncertainty in the interpretation of results that can occur in field tests.

1.2 Geology and Geochemistry

MRO has completed a number of studies over the past few years to confirm the geology and geochemical nature of waste rock (and tailings) materials produced and stored on site as a result of mining and processing ore (RGS, 2011 and 2016b). The geology of the waste rock is variable however waste rock materials are generally classified into three material types on site:

- Non-Acid Forming waste rock (NAF waste rock);
- Medium Potentially Acid Forming waste rock (moderate PAF waste rock); and
- High PAF waste rock.

In contrast, the tailing is generally uniformly classified on site as NAF or Uncertain and additional studies are continuing to confirm that the predicted classification remains valid in the longer term and that the geochemical

nature of the tailing will not change significantly over time (eg. if ore is being processed from deeper elevations and/or different locations within the open pit).



Figure 1-1: Field pad trials for waste rock materials currently being operated at MRO

2 Scope of Work

The RGS scope of work was to complete a static and kinetic geochemical assessment of representative bulk samples of NAF and PAF waste rock materials and NAF/Uncertain tailing materials from the Project. This included:

- Undertaking a brief review of existing geological and geochemical information;
- Design of a sampling program to align with the likely management methods for waste rock and tailing materials at the site;
- Coordination of a static geochemical test program at ALS laboratory;
- Design and coordination of an initial 12 month kinetic geochemical test program at RGS and ALS laboratories followed by a further 12 month kinetic geochemical test program; and
- Provision of a technical report describing the main findings of the geochemical assessment and providing recommendations for any future geochemical work programs.

The outcome of completion of the above scope of work is this stand-alone technical report, which provides geochemical information on waste rock and tailing materials; a description of the sampling and geochemical testing methodology; presentation and discussion of the results and findings; and development of conclusions and recommendations.

3 Methodology

3.1 Material Sampling

The sampling strategy and subsequent geochemical characterisation strategy for waste rock and tailing materials from the Project was guided by Australian (DME, 1995, DEHP, 2013; and COA, 2016) and international (INAP, 2009) technical guidelines for the geochemical assessment of mining wastes. The more recent guidelines favour a risk-based approach to development of a sampling and geochemical testing strategy at a mining operation.

The sampling strategy utilised by RGS at the Project involved working closely with MRO personnel to identify and collect representative bulk samples of NAF and PAF waste rock materials and NAF/Uncertain tailing materials for geochemical testing.

Four bulk samples were collected by MRO personnel and transferred to ALS Environmental Laboratory in Brisbane (ALS Brisbane) for sample preparation and geochemical testing. These samples comprised:

- NAF waste rock from waste material being used in the current MRO field pad trials;
- Medium PAF waste rock from waste material being used in the current MRO field pad trials;
- High PAF waste rock from waste material being used in the current MRO field pad trials; and
- Tailing materials recovered from the discharge line into the TSF.

These samples were subjected to a program of static geochemical, mineralogical and physical tests and then used to set up six Kinetic Leach Column (KLC) tests as described in **Section 3.2**.

3.2 Geochemical Characterisation

All geochemical test work completed in this project was based on industry recognised procedures for the geochemical characterisation and assessment of mine materials (Parker and Robertson, 1999; AMIRA, 2002; INAP, 2009 and COA, 2016). A summary of those parameters involved in completing a static and kinetic geochemical characterisation and assessment of mine waste materials is provided in **Attachment A**.

3.2.1 Static Tests

Static geochemical tests provide a ‘snapshot’ of the characteristics of a sample material at a single point in time. These tests were completed to screen the four samples before undertaking more detailed static test and kinetic geochemical tests.

The three bulk waste rock samples (approximately 150 kg each) received by ALS were crushed (to pass 10 mm sieve size), sub-sampled and pulverised before being subjected to a series of static geochemical tests on the pulverised (<75 µm) sample fractions. Similarly, the bulk (60 L) tailing sample was subsampled and dried as received at 60 ^{o}C, before being subjected to a series of static geochemical tests. The geochemical test program was coordinated by RGS personnel and designed to assess the degree of risk from potential oxidation of sulfides, acid generation, and the presence of (and leaching of) soluble metals/metalloids and salts.

Each solid sample underwent static geochemical testing for:

- pH (1:5 w:v);
- Electrical conductivity (EC) (1:5 w:v);
- Total sulfur content [Leco method];
- Acid neutralising capacity (ANC) [AMIRA, 2002]; and
- Chromium Reducible Sulfur (Scr) [AS , AS 4969.7-2008 method].

From the total sulfur and ANC results, maximum potential acidity (MPA) and net acid producing potential (NAPP) values were calculated.

The three pulverised waste rock samples and single tailing sample were also subjected to whole rock multi-element tests. The samples were tested for:

- Total metals/metalloids (Al, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Sb, Se, Th, U and Zn) in solids [HCl and HNO_3 acid digest followed by FIMS for Hg, discrete analyser for SiO_2 and ICP-MS / -AES for all other elements];
- Total cations (Ca, Mg, Na and K) [HCl and HNO_3 acid digest followed by ICP-AES]; and
- Particle size distribution [by Hydrometer].

The tailing sample was also subjected to total and weak acid dissociable (WAD) cyanide analysis using a segmented flow analyser.

Additional mineralogical (X-ray Diffraction - XRD) tests were completed on the three waste rock and single tailing sample at Levay and Co. Laboratory at the University of South Australia. Particle size distribution (PSD) tests were also completed on the waste rock samples used in kinetic tests at Trilab laboratory in Brisbane. A copy of the geochemical results from ALS, mineralogical results from Levay and Co., and PSD results from Trilab for the static test program is provided in **Attachment C**.

3.2.2 Kinetic Tests

Following receipt and interpretation of the static geochemical test results, six Kinetic Leach Column (KLC) tests were set up at the RGS in-house laboratory using crushed waste rock samples (passing 10mm sieve size), tailings (as received), and mixtures of PAF waste rock materials and tailings. A schematic of the KLC test set up utilised by RGS is provided in **Figure 3-1**.

The KLC tests utilised large columns (30 L) and represent:

- Low PAF waste rock being used in the field pad trials – KLC1;
- Moderate PAF waste rock being used in the field pad trials – KLC2;
- High PAF waste rock being used in the field pad trials – KLC3;
- Tailings collected from the discharge line into the TSF – KLC4;
- Tailings placed on top of PAF waste rock simulating co-mingling – KLC5; and
- Tailings mixed intimately with PAF waste rock simulating co-disposal – KLC6.

The six KLC tests for waste rock and tailing materials commenced in August 2016 at the RGS in-house laboratory and were operated under a monthly watering and leaching cycle for three months and then a quarterly watering and leaching cycle until August 2018. Essentially, 11 KLC leach events have occurred over 12 months and leachate quality results from these events are provided in this report.

The KLC tests were allowed to dry between monthly leaching events to ensure that the waste rock materials were unsaturated and subject to oxidising conditions. This is essentially an assumed ‘worst case’ scenario for potential sulfide oxidation, acidity generation and metal/metalloid and salt release.

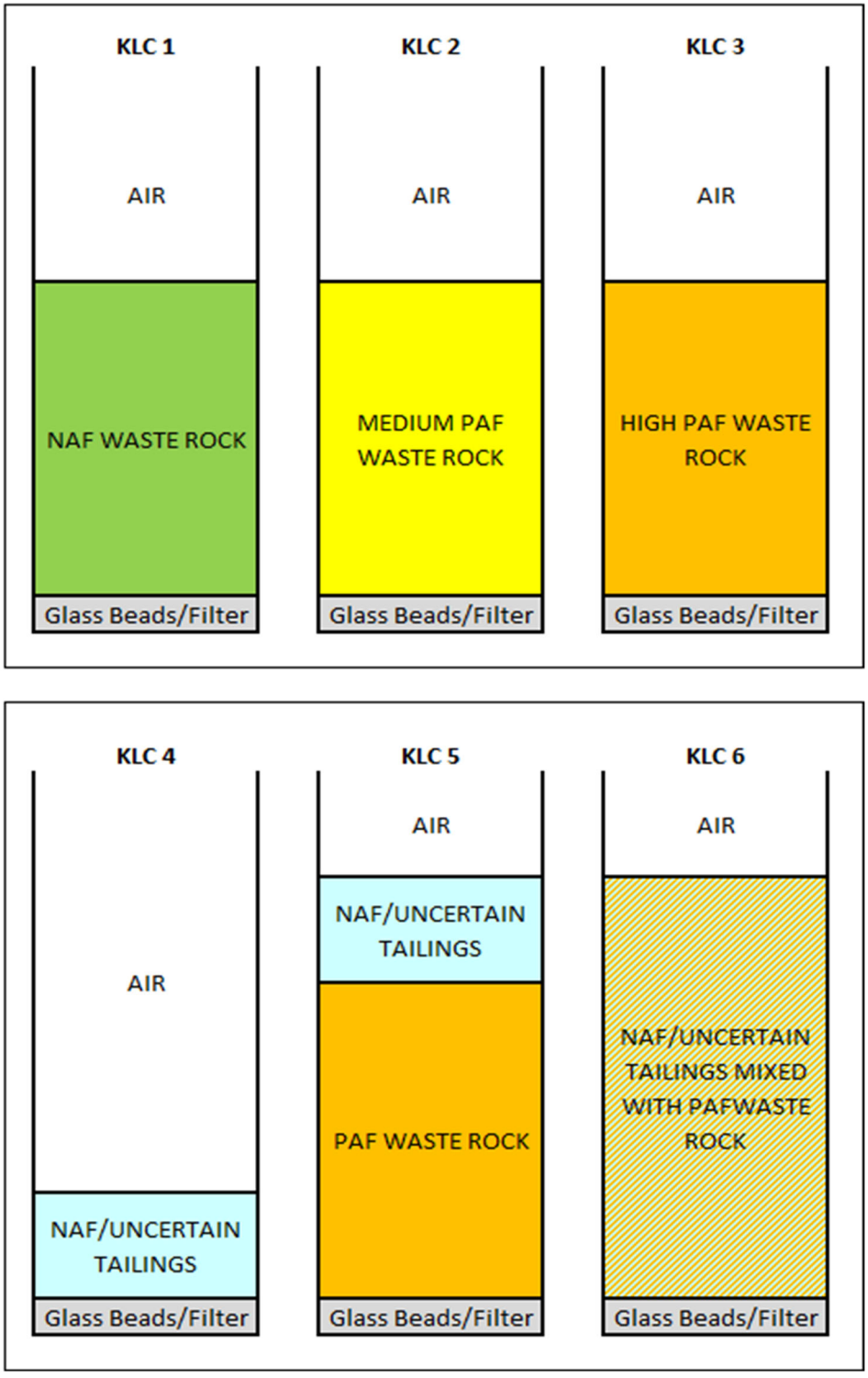


Figure 3-1: Schematic illustrating the KLC test setup (not to scale)

All leachate samples collected from the KLC tests were sent to ALS Brisbane for analysis of:

- pH and EC;
- Acidity and alkalinity [Automatic titrator];
- Dissolved metals/metalloids (Al, As, Cd, Cr, Co, Cu, F, Fe, Pb, Mn, Mo, Ni, Sb, Se, Si and Zn) [ICP-AES];
- Dissolved major cations (Ca, Mg, Na and K) [ICP-AES]; and
- Dissolved major anions (Cl, SO_4) [ICP-AES].

The KLC leachate test results are tabulated and presented graphically in **Attachment B** and the geochemical results received from ALS Brisbane for the KLC tests are provided in **Attachment C.**

4 Geochemical Test Results

4.1 Acid Base Account Test Data

Acid Base Account (ABA) test results for the three bulk waste rock samples and single tailings sample from MRO are presented in **Attachment C** and summarised in **Table 4-1**, below

Table 4-1: Acid Base Account Results for MRO Waste Rock and Tailing Materials

RGS Sample Number	ALS Laboratory Number	Date	Client Sample ID	Sample Type	Location	pH[1]	EC[1]	Total S	Scr[2]	MPA[2]	ANC[2]	NAPP[2]	ANC: MPA Ratio	Sample Classification[3]
							(µS/cm)	(%)		(kg H_2SO_4/t)				
1	EB1619048001	26/07/2016	NAF	Waste Rock	Mt Rawdon	9.5	104	0.54	0.355	10.9	90.2	-79.3	8.3	Non-Acid Forming
2	EB1619048002	26/07/2016	Medium PAF	Waste Rock	Mt Rawdon	9.4	120	1.49	1.340	41.0	66.1	-25.1	1.6	Uncertain
3	EB1619048003	26/07/2016	High PAF	Waste Rock	Mt Rawdon	9.0	187	4.29	3.600	110.3	37.7	72.6	0.3	Potentially Acid Forming
4	EB1619582001	2/8/16	Tailings	Tailings	Mt Rawdon	10.1	335	1.51	1.220	37.4	35.4	2.0	0.9	Uncertain

Notes:
1. Current pH, EC, Alkalinity and Acidity provided for 1:5 sample:water extracts
2. Scr = Chromium Reducible Sulfur; MPA = Maximum Potential Acidity; ANC = Acid Neutralising Capacity; and NAPP = Net Acid Producing Potential.
3. Sample classification detail provided in report text.

- **pH:** The $pH_{(1:5)}$ of the waste rock and tailing samples is alkaline and within the range 9.0 to 10.1. (the deionised water used by ALS in the tests typically has a pH value of pH 5.0 to 6.5).
- **EC:** The $EC_{(1:5)}$ of the waste rock and tailing samples is relatively low and ranges from 104 to 335 µS/cm (higher for the tailings sample compared to the waste rock samples).

The pH and EC tests described above were completed on pulverised waste rock samples (≤ 75 µm) or 'as received' tailing material with a large exposed surface area in contact with the leaching solution, thereby providing a high potential for dissolution and reaction, and represent an assumed 'worst case' scenario. It is also expected that the salinity of leachate from low sulfur NAF waste rock materials will diminish with time as salts are flushed from the rock matrix and a state of equilibrium develops. At that point, the salinity of seepage/runoff should stabilise at a lower asymptotic concentration relative to the weathering/erosion of the materials. In contrast, the salinity of leachate from higher sulfur PAF waste rock materials may increase if these materials are allowed to oxidise over time.

- **Total Sulfur**: The total sulfur content for the waste rock samples ranges from 0.54 to 4.29 %S and is lowest in the NAF waste rock and highest in the High PAF waste rock. The total sulfur content of the tailings sample is 1.51 %S. All samples have elevated total sulfur content compared to the average crustal abundance (0.1 %) for this element (INAP, 2009). Materials with a total sulfur content less than or equal to 0.1 %S are essentially barren of sulfur, represent background concentrations, and have negligible capacity to generate acidity.
- **Sulfide Sulfur**. The sulfide sulfur content of the four samples as measured in the Scr test ranges from 0.355 to 3.600 %S. The results indicate that approximately 83 % of the total sulfur content of the samples is present as sulfide and may have some potential to generate acidity, with the remainder likely to be present as other forms of sulfur such as sulfate, galena and sphalerite which in fresh materials, generally produce negligible acidity.
- **MPA**: Based on the sulfide sulfur content, the maximum potential acidity (MPA) that could be generated by the waste rock samples ranges from 10.9 kg H_2SO_4/t in the NAF waste rock sample to 110.3 kg H_2SO_4/t in the High PAF waste rock sample. The medium PAF waste rock sample and the tailings sample have MPA values of 41.0 and 37.4 kg H_2SO_4/t, respectively.
- **ANC**: The ANC value ranges from 90.2 to 37.7 kg H_2SO_4/t in the NAF and PAF waste rock samples, respectively. The tailings sample has an ANC value of 35.4 kg H_2SO_4/t.
- **ANC:MPA ratio**: The ANC:MPA ratio ranges from 8.3 to 0.3 for the NAF and High PAF waste rock samples, respectively. The ANC:MPA ratio for the tailing sample is 0.9. Generally, those samples with an ANC/MPA ratio of greater than 2 are considered to have a low to negligible risk of acid generation and a

high factor of safety in terms of potential for AMD (INAP, 2009[1]; COA, 2016). The results indicate that the NAF waste rock sample has a negligible risk of acid generation and a relatively high factor of safety with respect to potential for AMD. In contrast the high PAF sample has a reduced factor of safety and increased risk of acid generation. The medium PAF and tailing samples have some uncertainty regarding their potential to generate acidity.

- **NAPP**: The calculated NAPP value ranges from negative (-79.3 kg H_2SO_4/t) in the NAF waste rock sample to positive (+72.6 kg H_2SO_4/t) in the High PAF waste rock sample. The tailing sample has a slightly positive NAPP value of +2 kg H_2SO_4/t).

Figures 4-1 and **4-2** show plots of ANC and MPA and the resultant NAPP values for the four MRO waste rock and tailing samples, respectively.

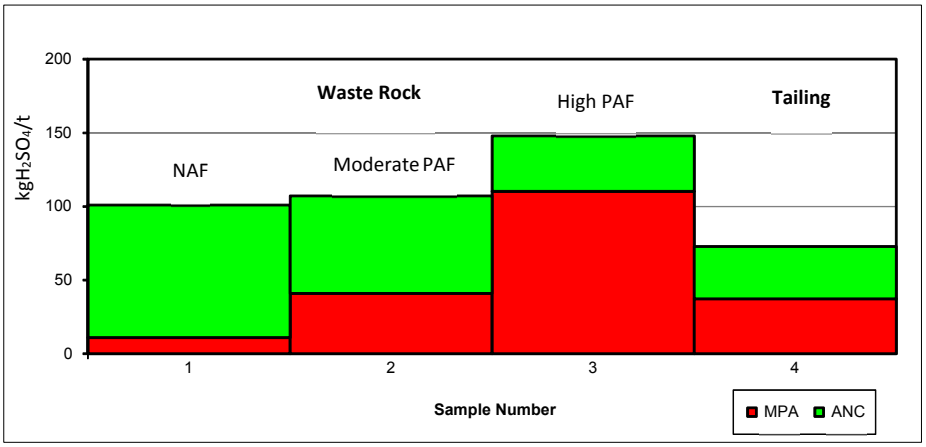


Figure 4-1: MPA and ANC Results for Waste Rock and Tailing Materials

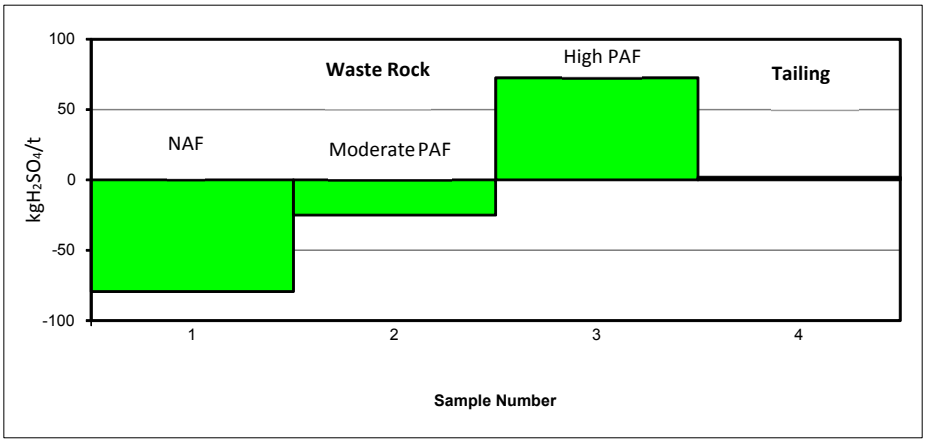


Figure 4-2: NAPP Results for Waste Rock and Tailing Materials

[1] INAP considers that mine materials with an ANC/MPA ratio greater than 2 are likely to be NAF unless significant preferential exposure of sulfides along fracture planes occurs in combination with insufficiently reactive ANC.

Table 4-2 provides a summary of the geochemical classification criteria used by RGS to classify the acid forming nature of the four waste rock and tailings samples, and a breakdown of the type of samples in each classification category.

Table 4-2: Geochemical Classification Criteria for MRO Waste Rock and Tailings Samples

Geochemical Classification	Total Sulfur (%)	ANC: MPA Ratio	NAPP (kg H_2SO_4/t)	Samples
Non-Acid Forming (Barren)	≤ 0.1	-	-	-
Non-Acid Forming	> 0.1	> 2	≤ 0	NAF waste rock
Uncertain[1]	> 0.1	< 2	≤ 0	Medium PAF waste rock and tailing
	> 0.1	< 2	> 0	
Potentially Acid Forming	> 0.1	< 2	> 10	High PAF waste rock

Notes:
1. Samples that fall outside the stated NAF/PAF classifications based on the criteria provided are classified as Uncertain.

Overall, NAF waste rock materials represented by the sample have low sulfur content, elevated ANC and a high factor of safety with respect to potential for AMD. In contrast, High PAF waste rock has elevated sulfur content, lower ANC, and has the potential to generate AMD after exposure to oxidising/ weathering conditions.

Both the Medium PAF waste rock and tailings materials represented by the samples have some uncertainty associated with their potential to generate AMD and are therefore classified as Uncertain. In particular the tailing sample has a finely balanced MPA and ANC values and a NAPP value close to zero. KLC test results described later in this report are required to provide some insight into the actual longer term geochemical nature of these materials.

The results of mineralogical analysis of the three waste rock and single tailings samples completed by Levay & Co Environmental Services laboratory in Adelaide (**Attachment C**) using Semi Quantitative X-Ray Diffraction (QXRD) are generally in agreement with the ABA results described above. In particular the QXRD results showed a decreasing carbonate (as calcite) and increasing sulfide (pyrite) content from NAF to High PAF waste rock samples. The tailing sample also contained pyrite and calcite, although the QXRD method tended to overestimate the pyrite content.

4.3 Multi-Element Concentration in Solids

Multi-element scans were completed on the four waste rock and tailing samples to identify any elements (metals/metalloids) present in these materials at concentrations that may be important with respect to materials handling, storage, final rehabilitation and water quality. RGS has compared the total metal/metalloid concentration the four samples with the median crustal abundance for unmineralised soils (INAP, 2009; and Bowen, 1979). The extent of any enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with median crustal abundance on a $\log^{10}$ scale.

The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration in a sample with the median (or average) crustal abundance on a $\log^{10}$ scale. The GAI is expressed in integer increments from 0 to 6, where a GAI value of 0 indicates that the element is present at a concentration less than, or similar to, the median crustal abundance; and a GAI value of 6 indicates approximately a 100-fold enrichment above median crustal abundance (**Table 4-3**).

Table 4-3: Geochemical Abundance Index (GAI) Values and Enrichment Factor

GAI	Enrichment factor	GAI	Enrichment factor
0	Less than 3-fold enrichment	4	24 – 48 fold enrichment
1	3 – 6 fold enrichment	5	48 – 96 fold enrichment
2	6 – 12 fold enrichment	6	Greater than 96 fold enrichment
3	12 – 24 fold enrichment		

As a general rule, a GAI of 3 or greater signifies enrichment that may warrant further examination. This is particularly the case with some environmentally important 'trace' elements, such as As, Cr, Cd, Cu, Pb, Se and Zn, more so than with major rock-forming elements, such as Al, Ca, Fe, Mg and Na.

Elements identified as enriched may not necessarily be a concern for revegetation, drainage water quality or public health, but their significance should still be evaluated. The GAI only provides an indication of metals/metalloids that may be enriched relative to the global median crustal abundance, and some points to consider are:

- The median crustal abundance varies between different literature sources, therefore affecting the calculated GAI values.
- If a sample is shown to be enriched relative to the median crustal abundance, there is no direct correlation that that particular sample will also leach metal/metalloid at elevated concentrations. The mobility of metal/metalloid is dependent on mineralogy, adsorption/desorption and the environment in which it occurs.
- Whilst some element concentrations can be elevated relative to the median crustal abundance, the nature of an ore deposit means the background levels are generally expected to be elevated.

Similarly, because an element is not enriched does not mean it will never be a concern, because under some conditions (eg. low pH) the solubility of common environmentally important elements such as Al, Cu, Cd, Fe and Zn increases significantly.

Table 4-4 provides total metal/metalloid concentrations for the four waste rock and tailing samples and the total and Weak Acid Dissociable (WAD) cyanide concentration in the tailing sample**.** The relative enrichment of metals/metalloids in the waste rock and tailing samples compared to median crustal abundance (the Geochemical Abundance Index - GAI) is presented in **Table 4-5**.

Table 4-4: Multi-Element Test Results for MRO Waste Rock and Tailing Samples

Parameters	RGS Sample Number →	1	2	3	4
	ALS Laboratory ID →	EB1621104001	EB1621104002	EB1621104003	EB1621104004
	Client Sample ID →	NAF Waste Rock	Medium PAF Waste Rock	High PAF Waste Rock	Uncertain Tailing
	Limit of Reporting				
Major Elements	All units mg/kg				
Aluminium (Al)	50	22,700	12,200	8,000	11,300
Calcium (Ca)	50	33,500	27,300	17,600	14,000
Iron (Fe)	50	39,200	24,200	39,700	28,500
Magnesium (Mg)	50	16,000	11,000	6,660	5,720
Potassium (K)	50	1,440	1,410	2,050	2,490
Sodium (Na)	50	810	380	120	590
Minor Elements	All units mg/kg				
Antimony (Sb)	0.1	0.6	3.5	1.3	0.5
Arsenic (As)	0.1	7.5	25.5	25.9	134.0
Barium (Ba)	0.1	28.9	39.8	19.7	68.5
Beryllium (Be)	0.1	0.6	0.6	0.4	0.5
Boron (B)	50	<50	<50	<50	<50
Cadmium (Cd)	0.1	<0.1	0.2	4.0	8.6
Chromium (Cr)	0.1	35.1	82.5	30.0	25.8
Cobalt (Co)	0.1	15.4	9.0	9.8	6.9
Copper (Cu)	0.1	8.8	26.9	140.0	358.0
Lead (Pb)	0.1	4.0	8.3	160.0	52.6
Lithium (Li)	0.1	50.3	30.8	17.8	10.6
Mercury (Hg)	0.1	<0.1	<0.1	<0.1	<0.1
Manganese (Mn)	0.1	2,260	1,940	1,950	1,180
Molybdenum (Mo)	0.1	0.6	1.9	1.0	1.9
Nickel (Ni)	0.1	10.4	28.6	12.1	12.2
Selenium (Se)	1	<1	<1	<1	<1
Silver (Ag)	0.1	<0.1	0.2	2.5	1.3
Strontium (Sr)	0.1	109	70	43	68
Thorium (Th)	0.1	1.4	2.4	1.7	4.2
Tin (Sn)	0.1	1.2	0.9	0.6	0.7
Uranium (U)	0.1	0.1	0.4	0.2	0.6
Vanadium (V)	1	72	25	11	17
Zinc (Zn)	0.5	141	126	748	1,490
Cyanide Species	All units mg/kg				
Total Cyanide	1	-	-	-	12
WAD Cyanide	1	-	-	-	<1

Notes: < indicates less than the laboratory limit of reporting.

Table 4-5: GAI Results for MRO Waste Rock and Tailing Samples

Parameters	RGS Sample Number →	1	2	3	4
	ALS Laboratory ID →	EB1621104001	EB1621104002	EB1621104003	EB1621104004
	Client Sample ID →	NAF Waste Rock	Medium PAF Waste Rock	High PAF Waste Rock	Uncertain Tailing
	Average Crustal Abundance[1]				
Major Elements	mg/kg	Geochemical Abundance Index			
Aluminium (Al)	71,000	0	0	0	0
Calcium (Ca)	15,000	1	0	0	0
Iron (Fe)	40,000	0	0	0	0
Magnesium (Mg)	5,000	1	1	0	0
Potassium (K)	14,000	0	0	0	0
Sodium (Na)	5,000	0	0	0	0
Minor Elements	mg/kg	Geochemical Abundance Index			
Antimony (Sb)	1	0	1	0	0
Arsenic (As)	6	0	2	2	4
Barium (Ba)	500	0	0	0	0
Beryllium (Be)	0.3	0	0	0	0
Boron (B)	20	0	0	0	0
Cadmium (Cd)	0.35	0	0	3	4
Chromium (Cr)	70	0	0	0	0
Cobalt (Co)	8	0	0	0	0
Copper (Cu)	30	0	0	2	3
Lead (Pb)	35	0	0	2	0
Lithium (Li)	25	0	0	0	0
Mercury (Hg)	0.06	0	0	0	0
Manganese (Mn)	1000	1	0	0	0
Molybdenum (Mo)	1.2	0	0	0	0
Nickel (Ni)	50	0	0	0	0
Selenium (Se)	0.4	0	0	0	0
Silver (Ag)	0.05	0	1	5	4
Strontium (Sr)	250	0	0	0	0
Thorium (Th)	9	0	0	0	0
Tin (Sn)	4	0	0	0	0
Uranium (U)	2	0	0	0	0
Vanadium (V)	90	0	0	0	0
Zinc (Zn)	90	0	0	2	3

Notes:

GAI's greater than or equal to 3 are highlighted.

1. Average crustal abundance (ie. median elemental composition of soils) taken from Bowen H.J.M.(1979) Environmental Chemistry of the Elements, Academic Press, New York, p60-61.

The GAI results indicate that most of the metals/metalloids measured in the waste rock and tailing samples are not enriched compared to median crustal abundance for soils. The High PAF waste rock sample is enriched in cadmium and silver and the tailing sample is enriched with arsenic, cadmium, silver and zinc compared to median crustal abundance in unmineralised soils. These results are expected given that the samples are derived from waste rock materials surrounding a mineralised gold ore body.

The enriched silver concentration is most likely an artefact of the very low median value for this metal in soils (0.05 mg/kg), and typical background concentrations in unmineralised soils can range up to 8 mg/kg (Bowen, 1979).

The potential solubility and mobility of these and other metals/metalloids and the potential for effect on water quality was investigated further through the use of KLC tests as presented in **Section 4.3**.

4.4 Water Quality Kinetic Tests

The six KLC tests for waste rock and tailing materials described in **Section 3.2.2** commenced in August 2016 at the RGS in-house laboratory and were operated under a monthly watering and leaching cycle for three months and then a quarterly watering and leaching cycle until August 2018. Leachate quality results from these events are provided and interpreted in this report. The KLC tests were operated to align with relevant mining industry guidelines for such tests (AMIRA, 2002; COA, 2016), albeit on a larger scale.

The leachate concentrations from the KLC test program over the 24 month test period are presented in **Attachment B** alongside livestock drinking water guideline values (ANZECC & ARMCANZ, 2000). These guideline values are provided for context only and are not intended to be interpreted as actual concentrations likely to occur at site water storage or discharge points. It should be noted that the waste rock KLC samples were crushed to pass a 10 mm sieve size and the tailing sample was used 'as received'. Therefore both materials have a high surface area for potential geochemical reaction compared to the field situation.

The ratio of sample to water in the KLC test for the MRO waste rock and tailings materials varied from approximately 10:1 to 20:1 (w/v) depending upon the experimental conditions (i.e., concentrated), whereas the ratio of sample to water generally used in tests where results can (arbitrarily) be compared against guideline concentrations to provide relevant context is significantly more dilute at 1:5 (w/v). Whilst arbitrary comparisons against guideline concentrations can be helpful in some situations to provide relevant context, such comparisons cannot be directly extrapolated to the field situation at MRO.

The concentrations trends for major ions and trace metal/metalloids from the waste rock and tailing materials used in the KLC tests are presented in **Attachment B,** alongside other useful parameters (such as pH, EC, acidity, alkalinity, net alkalinity, residual sulfur and residual ANC).

Tables **KLC 1** to **KLC 6** (**Attachment B**) provide the KLC test results and relevant graphs**.** The KLC test results obtained to date (ie. after 11 leach events) indicate that:

- Leachate from the waste rock and tailing samples is likely to be pH neutral to slightly alkaline (in the range pH 6.55 to 9.11) for at least the first 24 months of exposure to ideal oxidising/weathering conditions[2].
- The acidity value in leachate from the waste rock and tailings samples is typically very low (≤ 5 mg/L, as $CaCO_3$) for all samples, but was slightly elevated for the third leach event (up to 14 mg/L) for the Medium PAF waste rock sample.
- The alkalinity value in leachate from the waste rock and tailing samples is elevated (up to 73 mg/L as $CaCO_3$) and typically has a value in the range 15 to 40 mg/L.
- The net alkalinity value in leachate from all of the waste rock and tailing samples is positive (up to 70 mg/L, as $CaCO_3$) and typically has a value in the range 10 to 40 mg/L.
- The EC value of KLC leachate from the waste rock samples is generally less than 1,500 µS/cm and is higher in the leachate from the tailing sample (KLC4) (up to 5,000 µS/cm with a downward trend) and tailing mixed with High PAF sample (KLC6)(typically around 2,000 µS/cm). The elevated salinity level in the leachate from the tailing sample is most likely attributable to salts being flushed from the tailing matrix (e.g. gypsum ($CaSO_4$) solubility) rather than through significant sulfide oxidation (the leachate pH is neutral; the concentration of some major ions is elevated; and the dissolved iron concentration is less than the laboratory LoR (<0.05 mg/L).
- The concentrations of major ions in leachate from waste rock materials are generally low and dominated by calcium, sodium and sulfate. The concentration of major ions in leachate from the tailing sample are elevated and dominated by calcium, magnesium, potassium, chloride and sulfate, most of which generally show a relatively stable concentration trend. The main exception is the dissolved magnesium concentration, which appears to show a spike in concentration trend after 12 months of testing for the tailing (KLC4) and tailing/waste rock (KLC5 and KLC6) samples.

[2] It should be noted that the pH of the deionised water used in the KLC tests was typically in the pH range pH 5.02 to 6.01.

- Following the first flush leaching event, the sulfate concentration in leachate from most waste rock and waste rock/tailing samples is generally below or close to the applied livestock drinking water guideline limit (1,000 mg/L). The sulfate concentration for tailings sample (KLC4) exceeds the applied livestock drinking water guideline from the fourth leaching event to the end of the 24 month test period (> 2,000 mg/L), but also shows a downward concentration trend for the remainder of the test period.
- The six KLC test samples retain most of their inherent total sulfur value (≈ 96 %) after 24 months of exposure to ideal oxidising/weathering conditions, which suggests that the rate of sulfide oxidation is relatively slow for materials represented by these samples.
- The six KLC test samples retain most of their inherent ANC value (≈ 96 %) after 24 months of exposure to ideal oxidising/weathering conditions, which suggests that the rate of depletion of the inherent ANC in these materials is relatively slow and similar to the sulfide oxidation rate for materials represented by these samples.
- The sulfate generation rate results obtained for the six KLC tests on waste rock and tailing samples have been used to determine the rate of sulfide oxidation in these materials. Most sulfate salts generated from sulfide reaction involving materials with a relatively low or slow reacting sulfide sulfur concentration are highly soluble, and therefore will be collected in column leachate. The dissolved sulfate (and calcium) concentrations in the KLC leachates (apart from the KLC4 tailing sample) are typically less than the solubility limit of gypsum ($CaSO_4$), for example, which indicates that sulfate generation is not controlled by gypsum dissolution in most of the KLC test materials. Therefore, the sulfate concentrations and oxidation rate calculations provide reasonable estimates of these parameters and the results align well with existing static and dynamic geochemical data derived from a wide range of mine waste materials (AMIRA, 1995). The sulfate generation rate and associated sulfide oxidation rate for the six KLC tests are shown in **Table 4-6**.

Table 4-6: Sulfate Generation and Sulfide Oxidation Rates for KLC Tests on Waste Rock and Tailing Materials

KLC Sample No.	Sample Description	Sulfate Generation Rate (mg/kg/week)	Oxidation Rate (kg $O_2/m^3/s$)
KLC 1	NAF Waste Rock	1.03	3.47×10^{-10}
KLC 2	Medium PAF Waste Rock	3.93	1.27×10^{-9}
KLC 3	High PAF Waste Rock	1.71	5.56×10^{-10}
KLC 4	Uncertain Tailing	17.09	4.02×10^{-9}
KLC 5	High PAF Waste Rock and Uncertain Tailing	3.27	1.26×10^{-9}
KLC 6	High PAF Waste Rock and Uncertain Tailing	4.28	1.24×10^{-9}

- The concentration of dissolved sulfate in leachate from the KLC samples is elevated in the tailing samples compared to the waste rock samples. However, the dissolved sulfate concentration in leachate from all samples (apart from KLC4) currently shows a relatively steady concentration trend. The leachate from the tailing sample (KLC4) initially shows an increasing sulfate concentration trend which peaks by about the fourth leach event and decreases throughout the remainder of the test period. It is expected that these leachate characteristics result from pore water being flushed from the sample, rather than through any significant sulfide oxidation (the leachate pH is neutral; the concentration of some major ions is elevated; and the dissolved iron concentration is less than the laboratory LoR (<0.05 mg/L).
- The sulfate generation rate from the KLC samples ranges from 1.03 to 17.09 mg/kg/week indicating that the rate of sulfide oxidation is low in these materials (equivalent to an oxidation rate ranging from 3.47×10^{-10} to 4.02×10^{-9} kg $O_2/m^3/s$). Mining waste materials with an oxidation rate in this range and a moderate ANC level have an increased factor of safety, and are likely to generate leachate that is pH neutral and/or

has low levels of acidity (AMIRA, 1995; Bennett *et al*., 2000). Hence, all of the waste rock and tailing samples fall into this category and the KLC results indicate that some of these samples (eg. the High PAF Waste Rock Sample KLC3) are geochemically more benign (or certainly much slower to react) than predicted from the static geochemical test results presented in **Table 4-1**.

- The concentrations of trace metals/metalloids in leachate from the waste rock and tailing samples cannot be directly compared against livestock drinking water guideline values, as the ratio of solid to water can be up to two orders of magnitude greater than that whereby any arbitrary comparison could be made for context. A more appropriate way to present the KLC test leachate data for geochemical and water quality modelling purposes would be to calculate release rates (ie. the load of trace metals/metalloids released from the waste rock and tailing samples in units of mg/kg per flush). This method normalises the data to allow better comparison and provides a conservative approach, as the waste rock samples have been crushed to pass a 10 mm sieve size and therefore had a higher surface area for potential geochemical reaction that would generally be found for waste rock materials in the field at MRO. Similarly, the tailing sample/mixtures are allowed to dry between leaching events and this simulates idealised oxidising/weathering conditions for surface tailing at a TSF rather than for bulk tailing materials, which remain relatively saturated and are periodically re-covered with fresh tailing materials over time. Geochemical data release calculations and a geochemical/water quality modelling task are not included in the current scope of work.
- KLC leachate results for several environmentally important metals/metalloids (Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Si and Zn) are presented as graphs in **Attachment B** for the six waste rock and tailing samples. The graphed data illustrates that the concentration of metals/metalloids released from waste rock and tailing materials is typically low and less than applied livestock drinking water guideline values. The only exceptions are for the tailing sample (KLC4) and the waste rock/tailing samples (KLC5 and KLC6), which can have elevated concentrations in KLC leachate for copper (and manganese in KLC5) only in the initial ('first flush') event. The concentration of cadmium was also generally elevated from the fourth KLC flush events for the tailing sample (KLC4) and marginally elevated from the sixth KLC flush event for the mixed waste rock/tailing sample (KLC6). The concentration of manganese was also elevated in the fourth and last two KLC flush events for the tailing sample (KLC4).

Potential implications of these results with respect to the management of waste rock and tailing materials, and recommendations for further geochemical investigations for these materials are discussed further in **Sections 5.0** and **6.0.**

5 Discussion

5.1 AMD Potential and Management

The results of the static geochemical (ABA) tests on waste rock and tailings samples presented in **Section 4.1** confirm the likely geochemical nature of these materials at the field pad trials and at the TSF. In particular, the NAF waste rock sample has low sulfur content, elevated ANC and a high factor of safety with respect to potential for AMD (including neutral mine drainage (NMD) and/or saline drainage (SD)). In contrast, the Medium and High PAF samples have elevated sulfur content, moderate ANC, and have a reduced factor of safety with respect to potential to generate AMD. However, the static and kinetic geochemical results in this project and previous geochemical results on waste rock materials (EGi, 1996, RGS, 2011) indicate that an extended period of exposure time to oxidising/weathering conditions (lag period) is required before acidic conditions may become apparent.

The tailing sample also has elevated sulfur content and a moderate ANC value, the magnitudes of which are finely balanced. Whilst there is still some uncertainty regarding the potential for tailing materials to generate acid at some point in the future, current geochemical data (RGS, 2020) suggests that tailing materials remain pH neutral after exposure to idealised oxidising/weathering conditions for at least nine years.

The lag period for the PAF waste rock samples and Uncertain tailing sample has not yet been defined. However, at the end of the 24 month KLC test period the inferred sulfate production rate and sulfide oxidation rate from the KLC tests indicates that the time to depletion of ANC/sulfide content in the waste rock and tailing materials and potential lag period could be measured in decades. It should be noted that the KLC tests may not have reached a steady state in terms of reaction kinetics after the 24 month test period and therefore there are currently limitations in the accuracy of such long term predictions.

RGS has already measured the particle size distribution of the waste rock materials included in the KLC test program (**Attachment C**) and therefore a specific surface area could be calculated for these materials. This could then be extrapolated to the field waste rock storage situation where the particle size distribution and specific surface area for waste rock could be calculated from waste rock photographs. This information could then be used with KLC test data as an input into future geochemical and water quality modelling programs at the site.

Notwithstanding, the current conservative management strategy for waste rock and tailing materials at MRO of placing High and Medium PAF waste rock in the TSF appears sound as most waste rock will be covered/mixed with tailing materials within the expected lag period and therefore significant AMD generation from waste rock materials at the TSF is not expected. However, given the finely balanced geochemical nature of MRO tailing materials, it is recommended that addition of finely ground agricultural limestone to the PAF waste rock and tailing surface should be considered as part of the operational and final closure strategy for the TSF, as described in the CDaR Plan for the TSF (RGS, 2017). The plan provides a conceptual cover design and rehabilitation strategy that is suitable for mine closure, and which meets the Queensland Government's rehabilitation objectives of being safe stable, sustainable and non-polluting.

5.2 Multi-element Composition and Enrichment

The multi-element concentrations of metal/metalloids in waste rock and tailing materials are presented in **Section 4.2**, along with a comparison with median crustal abundance values for soils. The results indicate that most of the metals/metalloids measured in the waste rock and tailing samples are not enriched compared to median crustal abundance for soils. The PAF waste rock sample is enriched in cadmium and silver and the tailing sample is enriched with arsenic, cadmium, silver and zinc compared to median crustal abundance. These results are expected given that the samples are derived from waste rock materials surrounding a mineralised gold ore body.

The enriched silver concentration is most likely an artefact of the very low median value for this metal in soils (0.05 mg/kg), although the typical concentration soils can range up to 8 mg/kg (Bowen, 1979).

5.2.1 Water Quality

Kinetic geochemical test results indicate that initial surface run-off and seepage from waste rock and tailing materials is likely to be pH neutral to slightly alkaline and have a relatively low salinity value, although the salinity of tailing contact water may temporarily increase as major ions are released from the tailing matrix.

The concentrations of major ions in leachate from waste rock materials are relatively low and dominated by calcium, sodium and sulfate. For uncovered PAF waste rock materials, the concentration of sulfate in surface runoff and seepage would be expected increase over time with continued exposure to oxidising/weathering conditions however this has not occurred for a period of 24 months under idealised oxidising conditions. The concentrations of major ions in leachate from the tailing sample are elevated and dominated by calcium, magnesium, potassium, chloride and sulfate, most of which after the first few flushes show a relatively steady concentration trend. Following the first flush leaching event, the sulfate concentration in leachate from all waste rock and mixed waste rock/tailing samples is typically below or close to the applied livestock drinking water guideline value(1,000 mg/L), apart from the tailing sample (KLC4) which exceeds the applied guideline value for the fourth leaching event (> 2,000 mg/L), but shows a decreasing concentration trend over the remainder of the 24 month test period.

Most trace metals/metalloids tested in leachate from NAF and PAF waste rock and Uncertain tailing materials are sparingly soluble under KLC leachate test pH conditions and typically less than applied livestock drinking water guideline values (ANZECC and ARMCANZ, 2000). The only exceptions are for the tailing sample (KLC4) and the waste rock/tailing samples (KLC5 and KLC6), which can have elevated concentrations in KLC leachate for copper (and manganese in KLC5) only in the initial ('first flush') event. The concentration of cadmium was also generally elevated from the fourth KLC flush events for the tailing sample (KLC4) and marginally elevated from the sixth KLC flush event for the mixed waste rock/tailing sample (KLC6). The concentration of manganese was also elevated in the fourth and last two KLC flush events for the tailing sample (KLC4).

On the basis of these results, and given the waste rock, tailing and water management strategy employed at MRO, it is expected that the risk of potential significant impact on the quality of surface water and groundwater from waste rock and tailing contact water at MRO should be relatively low (although it is recommended that the water quality monitoring program for the WRD and TSF facilities continue to confirm this conclusion).

6 Conclusions and Recommendations

6.1 Conclusions

RGS has completed a static and kinetic geochemical assessment of representative waste rock and tailing samples from MRO. The main findings of the geochemical assessment are:

- The KLC test results indicate that some of the MRO samples (e.g., PAF waste rock) are geochemically more benign (or certainly much slower to react) than expected from the initial static geochemical test results.
- NAF waste rock materials have negligible sulfur content, elevated ANC and a high factor of safety with respect to potential for AMD (including NMD SD). In contrast, PAF waste rock materials have elevated sulfur content, moderate ANC, and have a reduced factor of safety with respect to potential for AMD, if exposed to long term oxidising/weathering conditions. Tailing materials have finely balanced acid generating and acid neutralising capacities but continue to generate pH neutral conditions even after extended exposure to idealised oxidising/weathering conditions (at least nine years (RGS, 2020)). The concentrations of existing major ions leached into contact water from the tailing matrix, including sulfate, are likely to be elevated.
- Initial surface runoff and seepage from NAF and PAF waste rock materials (and ongoing surface runoff and seepage from NAF waste rock materials) is likely to be pH neutral to slightly alkaline and have a low level of salinity. Initial and ongoing surface runoff and seepage from NAF waste rock materials is likely to contain excess alkalinity.
- KLC test data indicates the lag period preceding acid generation from PAF waste rock materials exposed to idealised oxidising/weathering conditions is likely to be greater than 24 months.
- Metal/metalloid enrichment in waste rock and tailing materials compared to median crustal abundance in unmineralised soils is likely to be limited to cadmium and silver in some PAF waste rock materials and arsenic, cadmium, silver and zinc in some tailings. These results are expected given that the samples are derived from waste rock (and processed ore) materials surrounding a mineralised gold ore body.
- Most metals/metalloids are sparingly soluble at the neutral to slightly alkaline pH of contact water with waste rock and tailing materials at MRO. However, a number of metals including aluminium, copper and iron are likely to become more soluble in surface runoff and seepage from PAF waste rock materials, if these materials are exposed to ongoing oxidising/weathering conditions and acidic pH conditions develop.
- Encapsulation of High PAF waste rock at the TSF, within a reasonable period of time (ie. 24 months), is likely to reduce the risk of AMD and maintain the overall quality of surface runoff and seepage from the TSF.
- Given the current management strategy employed by MRO for waste rock and tailings, the potential for AMD from these materials is relatively low. The static and kinetic geochemical information obtained to date suggests that existing management and rehabilitation strategy at MRO are likely to meet the long term DES rehabilitation objectives.

6.2 Recommendations

As a result of the static and kinetic geochemical assessment work completed on waste rock and tailing materials at MRO, a number of additional recommendations are provided for waste rock materials. It is recommended that MRO considers:

- Addition of crushed limestone to PAF waste rock materials if stored for more than 24 months in an uncovered state (ie. exposed to oxidising/weathering conditions), and in any case prior to placement of the cover system described in the CDaRP (RGS, 2016a).
- Reinstatement of KLC testing of waste rock and tailing materials for a further 12 to 24 months or until steady-state is attained. Kinetic testing is long-term testing and, as such, much of the value is only

obtained once the samples have reached a geochemical steady-state. Testing should continue until metal/metalloid, sulfate salt and acidity release rates are obtained from samples that are considered to have reached a geochemical steady-state.

- Geochemical and water quality modelling for waste rock and tailings using KLC test leachate release rate data (i.e., the load of trace metals/metalloids released from the waste rock and tailing samples in units of mg/kg per flush). This method normalises the data to allow better comparison and provides a conservative approach, as the waste rock samples have been crushed to pass a 10 mm sieve size and therefore had a higher surface area for potential geochemical reaction that would generally be found for waste rock materials in the field at MRO. Similarly, the tailings samples are allowed to dry between leaching events and this simulates idealised oxidising/weathering conditions for surface tailings at a TSF rather than for bulk tailing materials, which remain relatively saturated and are periodically re-covered with fresh tailing materials over time. RGS has already measured the particle size distribution of the waste rock materials included in the KLC test and therefore a specific surface area can be calculated for these materials. This could then be extrapolated to the field waste rock storage situation where the particle size distribution and specific surface area for waste rock could be calculated from waste rock photographs.
- Post KLC testing of selected sample materials after decommissioning of the KLC tests. The testing should comprise Acid Base Accounting (pH, EC, total sulfur, ANC and acidity/alkalinity), whole-rock metal analysis, X-ray diffraction (XRD) mineralogical analysis and Quantitative Evaluation of Mineralogy by Scanning Electron Microscope (QEMScan®).
- Using the inferred sulfate production rate and sulfide oxidation rate from the KLC tests to predict, the time to depletion of ANC/sulfide content and potential lag period. It should be noted that the KLC tests may not have reached a steady state in terms of reaction kinetics after the initial 24 months of testing and therefore there may be some inherent limitations in the accuracy of such predictions. However, the combined use of KLC and mineralogical data will improve the level of confidence in such predictions; and
- Continuing to implement the existing surface water and groundwater monitoring programs as defined in the Environmental Authority for the site (DES, 2019).

7 References

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8 Limitations

RGS has prepared this technical report in accordance with the generally accepted practices and standards of the consulting profession for the use of MRO and only those third parties who have been authorised in writing by RGS to rely on the report. No other warranty is made as to the professional advice in this report. It is prepared in accordance with the scope of work and for the purpose outlined in **Section 2.0**.

The methodology adopted and information sources used by RGS are outlined in this report. RGS has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to RGS was false.

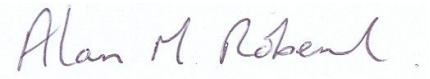
This report was prepared in December 2020 and is based on the information and samples provided by MRO prior to the time of preparation. RGS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not provide legal advice which, can only be given by qualified legal practitioners.

If you have any questions regarding the information presented in this report, please contact the undersigned on (+617) 3344 1222 or (+61) 431 620 623.

Yours sincerely,

RGS ENVIRONMENTAL PTY LTD



Dr. Alan Robertson
Principal Geochemist/Director

9 Attachments

9.1 Attachment A: Geochemical Assessment of Mining Waste Materials

Geochemical Assessment of Mining Waste Materials

Acid generation and prediction

Acid generation is caused by the exposure of sulfide minerals, most commonly pyrite (FeS_2), to atmospheric oxygen and water. Sulfur assay results are used to calculate the maximum amount of acid that could be generated by a material based on either direct measurement of the pyritic S content, or assuming that all sulfur not present as sulfate occurs as pyrite. Pyrite reacts under oxidising conditions to generate acid according to the following overall reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

According to this reaction, the maximum potential acidity (MPA) of a sample containing 1%S as pyrite would be 30.6 kg H_2SO_4/t. The chemical components of the acid generation process consist of the above sulfide oxidation reaction and acid neutralization, which is mainly provided by inherent carbonates and to a lesser extent silicate materials. The amount and rate of acid generation is determined by the interaction and overall balance of the acid generation and neutralisation components.

Net Acid Producing Potential

The net acid producing potential (NAPP) is used as an indicator of materials that may be of concern with respect to acid generation. The NAPP calculation represents the balance between the maximum potential acidity (MPA) of a sample, which is derived from the sulfide sulfur content, and the acid neutralising capacity (ANC) of the material, which is determined experimentally. By convention, the NAPP result is expressed in units of kg H_2SO_4/t sample. If the capacity of the solids to neutralise acid (ANC) exceeds their capacity to generate acid (MPA), then the NAPP of the material is negative. Conversely, if the MPA exceeds the ANC, the NAPP of the material is positive. A NAPP assessment involves a series of analytical tests that include:

Determination of pH and EC

pH and EC measured on 1:5 w/w water extract. This gives an indication of the inherent acidity and salinity of the mining waste material when initially exposed in an emplacement area.

Total sulfur content and Maximum Potential Acidity (MPA)

Total sulfur content is determined by the Leco high temperature combustion method. The total sulfur content is then used to calculate the MPA which is based on the assumption that the entire sulfur content is present as reactive pyrite. Direct determination of the pyritic sulfur content can provide a more accurate estimate of the MPA.

Acid neutralising capacity (ANC)

The ANC is determined by addition of acid to a known weight of sample, then titration with NaOH to determine the amount of residual acid. The ANC measures the capacity of a sample to react with and neutralise acid. The ANC can be further evaluated by slow acid titration to a set end-point in the Acid Buffering Characteristic Curve (ABCC) test through calculation of the amount of acid consumed and evaluation of the resultant titration curve.

Assessment of element enrichment and solubility

In mineralised areas it is common to find a suite of enriched elements that have resulted from natural geological processes. Multi-element scans are carried out to identify any elements that are present in a material (or readily leachable from a material) at concentrations that may be of environmental concern with respect to surface water quality, revegetation and public health. The samples are generally analysed for the following elements:

Major elements	Al, Ca, Fe, K, Mg, Na and S.
Minor elements	As, B, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Ni, Pb, Sb, Se and Zn.

The concentration of these elements in samples can be directly compared with the median concentration in un-mineralised soils to determine the Geochemical Abundance Index (GAI) and level of significance. Water

extracts are used to determine the immediate element solubilities under the existing sample pH conditions of the sample. The following tests are normally carried out:

Multi-element composition of solids.

Multi-element composition of solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Multi-element composition of water extracts (1:5 sample:deionised water).

Multi-element composition of 1:5 (solid:water) water extracts from solid samples determined using a combination of ICP-mass spectroscopy (ICP-MS), ICP-optical emission spectroscopy (OES), and atomic absorption spectrometry (AAS).

Under some conditions (eg. low pH) the solubility and mobility of common environmentally important elements can increase significantly. If element mobility under initial pH conditions is deemed likely and/or subsequent low pH conditions may occur, kinetic leach column test work may be completed on representative samples.

Kinetic leach column tests

Kinetic leach column (KLC) tests can be used to provide information on the reaction kinetics of mine waste materials. The major objectives of kinetics tests are to:

- Provide time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions);
- Investigate metal release and drainage/seepage quality; and
- Assess treatment options such as addition of alkaline materials.

The KLC tests simulate the weathering process that leads to acid and base generation and reaction under laboratory controlled or site conditions. The kinetic tests allow an assessment of the acid forming characteristics and indicate the rate of acid generation, over what period it will occur, and what management controls may be required.

In KLC tests, water is added to a sample and the mixture allowed to leach products and by-products of acid producing and consuming reactions. Samples of leachate are then collected and analysed. Intermittent water application is applied to simulate rainfall and heat lamps are used to simulate sunshine. These tests provide real-time information and may have to continue for months or years. Monitoring includes trends in pH, sulfate, acidity or alkalinity, and metals, for example. The pH of the collected leachate simulates the acid drainage process, acidity or alkalinity levels indicate the rate of acid production and acid neutralisation, and sulfate production can be related to the rate of sulfide oxidation. Metal concentration data provides an assessment of metal solubility and leaching behaviour.

Figure 3-1 shows the kinetic leach column set up used by RGS adapted from *AMIRA, 2002*. The columns are allowed to dry between water additions to ensure adequate oxygen ingress into the sample material.

Sample materials is accurately weighed and used in the leach columns and depending on the physical nature of the material and particle size can be used on an as-received basis (*i.e.* no crushing as with process residues) or crushed to pass nominal 10 mm particle size (as with waste rock). The sample in the column is initially leached with deionised water and the initial leachate from the columns collected and analysed. Subsequent column leaching is carried out on a monthly or quarterly basis and again collected and analysed. The leaching rate can be varied to better simulate expected site conditions or satisfy test program data requirements. The column must be exposed to drying conditions in between watering events. The residual water content and air void content in the column can be determined by comparing the wet and dry column weights.

9.2 Attachment B: KLC Test Results and Trends

RGS-KLC 1 : NAF Waste Rock

Weight (kg)	14.000	Total S (%)	0.54	ANC	90.20
pH (1:5)	9.50	Scr (%)	0.355	NAPP	-79.33
EC (µS/cm)	94	MPA	10.87	ANC:MPA	8.30

Date		29-Aug-16	27-Sep-16	31-Oct-16	28-Nov-16	28-Feb-17	29-May-17	29-Aug-17	28-Nov-17	28-Mar-18	29-May-18	28-Aug-18
Months		**0**	**1**	**2**	**3**	**6**	**9**	**12**	**15**	**19**	**21**	**24**
Weeks		**0**	**4**	**9**	**13**	**26**	**39**	**52**	**65**	**82**	**91**	**104**
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1703876	EB1711556	EB1718207	EB1725119	EB1808038	EB1813063	EB1820820
Volume ON (L)		1.5	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Volume OFF (L)		0.781	1.131	0.970	0.992	0.675	0.694	0.721	0.676	0.649	0.831	0.695
Cum. Volume (L)		0.78	1.91	2.88	3.87	4.55	5.24	5.96	6.64	6.61	7.47	7.31
Pore Volumes		0.7	1.7	2.5	3.4	4.0	4.6	5.2	5.8	5.8	6.5	6.4
pH		7.91	8.39	7.84	8.00	8.50	8.13	8.42	6.93	8.27	6.80	8.18
EC (µS/cm) - RGS record		282	298	375	421	396	383	323	258	305	268	328
Acidity (mg/L)*		<1	<1	10	2	1	1	2	1	2	1	<1
Alkalinity (mg/L)*		65	43	34	34	26	42	33	32	35	31	45
Net Alkalinity (mg/L)*		65	43	24	32	25	41	31	31	33	30	44
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	14	20	30	36	35	20	24	23	19	24	33
Potassium (K)	-	6	3	3	3	3	1	5	2	2	2	2
Magnesium (Mg)	-	4	6	8	10	10	5	15	5	4	7	8
Sodium (Na)	-	40	32	34	33	30	18	1	19	21	19	19
Chloride (Cl)	-	7	4	3	2	<1	<1	<1	1	<1	1	1
Fluoride (F)	2	0.6	0.4	0.4	0.4	0.4	0.6	0.3	0.3	0.4	0.3	0.3
Sulfate (SO_4)	1,000	74	110	144	167	152	140	81	93	80	100	119
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	0.01	0.06	0.04	0.06	0.02	<0.01	<0.01	0.04	0.06	0.02	0.01
Arsenic (As)	0.5	0.002	0.002	0.002	0.003	0.002	0.002	<0.001	0.002	0.002	0.002	0.003
Boron (B)	5	0.07	0.19	0.21	0.35	0.44	0.31	0.12	0.39	0.58	0.45	0.29
Cadmium (Cd)	0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt (Co)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	0.009	0.001	0.001	0.007	0.002	0.001	<0.001	0.004	0.001	0.002	<0.001
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.020	0.026	0.040	0.024	0.019	0.005	0.014	0.033	0.025	0.019	0.018
Molybdenum (Mo)	0.15	0.011	0.010	0.010	0.010	0.012	0.007	0.003	0.011	0.007	0.014	0.017
Nickel (Ni)	1	0.035	0.001	<0.001	<0.001	0.005	0.005	<0.001	0.002	0.001	<0.001	<0.001
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.029	0.167	0.079	0.106	0.05	0.05	0.013	0.04	0.05	0.064	0.032
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	7.7	11.1	10.3	8.2	6.3	12.0	4.0	13.2	14.0	5.8	6.1
Zinc (Zn)	20	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Calculations**												
SO_4 Release Rate		4	9	10	12	7	7	4	4	4	6	6
Cumulative SO_4 Release		4	13	23	35	42	49	53	58	61	67	73
Ca Release Rate		0.8	1.6	2.1	2.6	1.7	1.0	1.2	1.1	0.9	1.4	1.6
Cumulative Ca Release		0.8	2.4	4.5	7.0	8.7	9.7	10.9	12.1	12.9	14.4	16.0
Mg Release Rate		0.2	0.5	0.6	0.7	0.5	0.2	0.8	0.2	0.2	0.4	0.4
Cumulative Mg Release		0.2	0.7	1.3	2.0	2.5	2.7	3.5	3.7	3.9	4.3	4.7
Residual ANC (%)		100.00	99.99	99.98	99.97	99.97	99.96	99.95	99.95	99.95	99.94	99.94
Residual Sulfur (%)		99.97	99.92	99.86	99.78	99.74	99.70	99.67	99.64	99.62	99.58	99.55
SO_4/(Ca+Mg) molar ratio		1.5	1.5	1.4	1.3	1.2	2.1	0.7	1.2	1.3	1.2	1.1

< indicates less than the laboratory limit of reporting. *Acidity and alkalinity calculated in mg $CaCO_3$/L. ** SO4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC 2 : Medium PAF Waste Rock

Weight (kg)	14.000	**Total S (%)**	1.49	**ANC**	66.10
pH (1:5)	9.40	**Scr (%)**	1.340	**NAPP**	-25.06
EC (µS/cm)	120	**MPA**	41.04	**ANC:MPA**	1.61

Date		**29-Aug-16**	**27-Sep-16**	**31-Oct-16**	**28-Nov-16**	**28-Feb-17**	**29-May-17**	**29-Aug-17**	**28-Nov-17**	**28-Mar-18**	**29-May-18**	**30-Aug-18**
Months		**0**	**1**	**2**	**3**	**6**	**9**	**12**	**15**	**19**	**21**	**24**
Weeks		**0**	**4**	**9**	**13**	**26**	**39**	**52**	**65**	**82**	**91**	**104**
Leach Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1703876	EB1711556	EB1718207	EB1725119	EB1808038	EB1813063	EB1820820
Volume ON (L)		1.5	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Volume OFF (L)		0.775	1.244	0.985	1.021	0.934	0.436	0.855	0.975	1.012	1.025	1.027
Cum. Volume (L)		0.78	2.02	3.00	4.03	4.96	5.40	6.25	7.23	8.24	9.26	10.29
Pore Volumes		0.7	1.8	2.6	3.5	4.3	4.7	5.4	6.3	7.2	8.1	8.9
pH		7.81	7.76	7.53	7.44	7.86	7.75	7.83	7.03	7.76	6.74	7.92
EC (µS/cm) - RGS record		692	769	778	1,019	1,006	1,410	660	808	778	560	664
Acidity (mg/L)*		2	2	14	2	2	1	3	3	3	2	2
Alkalinity (mg/L)*		45	28	32	26	21	29	26	22	21	16	42
Net Alkalinity (mg/L)*		43	26	18	24	19	28	23	19	18	14	40
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	92	111	136	182	192	196	133	150	143	102	122
Potassium (K)	-	19	11	7	8	7	6	8	4	4	2	3
Magnesium (Mg)	-	14	17	15	18	16	15	11	10	8	6	7
Sodium (Na)	-	28	24	19	18	23	17	4	16	18	11	12
Chloride (Cl)	-	8	4	2	2	<1	<1	<1	<1	<1	<1	<1
Fluoride (F)	2	0.3	0.3	0.3	0.4	0.4	0.6	0.3	0.4	0.4	0.2	0.3
Sulfate (SO_4)	1,000	316	389	419	559	547	832	323	405	406	273	332
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	<0.01	0.02	0.02	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.004	0.008	0.01	0.015	0.021	0.018	0.006	0.017	0.016	0.011	0.013
Boron (B)	5	<0.05	0.12	0.15	0.30	0.81	0.50	0.18	0.70	0.85	0.46	0.54
Cadmium (Cd)	0.01	0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0002	<0.0001	0.0002	0.0001	0.0001	0.0001
Cobalt (Co)	1	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	0.006	0.001	0.001	0.001	0.005	0.002	<0.001	0.003	0.001	0.001	<0.001
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.238	0.487	0.179	0.069	0.014	0.002	0.012	0.024	0.016	0.021	0.022
Molybdenum (Mo)	0.15	0.029	0.026	0.025	0.041	0.053	0.038	0.013	0.035	0.031	0.021	0.025
Nickel (Ni)	1	0.060	0.003	0.002	0.002	0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.018	0.101	0.046	0.063	0.099	0.062	0.018	0.092	0.094	0.07	0.077
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	6.8	11.0	11.4	9.8	7.9	10.0	5.0	18.9	17.7	5.6	7.3
Zinc (Zn)	20	<0.005	0.005	0.007	0.015	0.017	0.034	0.01	0.019	0.015	0.016	0.026
Calculations**												
SO_4 Release Rate		17	35	29	41	36	26	20	28	29	20	24
Cumulative SO_4 Release		17	52	82	122	159	185	204	233	262	282	306
Ca Release Rate		5.1	9.9	9.6	13.3	12.8	6.1	8.1	10.4	10.3	7.5	8.9
Cumulative Ca Release		5.1	15.0	24.5	37.8	50.6	56.7	64.8	75.3	85.6	93.1	102.0
Mg Release Rate		0.8	1.5	1.1	1.3	1.1	0.5	0.7	0.7	0.6	0.4	0.5
Cumulative Mg Release		0.8	2.3	3.3	4.7	5.7	6.2	6.9	7.6	8.1	8.6	9.1
Residual ANC (%)		99.98	99.93	99.89	99.83	99.78	99.75	99.72	99.68	99.63	99.60	99.57
Residual Sulfur (%)		99.96	99.88	99.82	99.73	99.64	99.59	99.54	99.48	99.41	99.37	99.31
SO_4/(Ca+Mg) molar ratio		1.1	1.2	1.1	1.1	1.0	1.6	0.9	1.0	1.1	1.0	1.0

< indicates less than the laboratory limit of reporting. *Acidity and alkalinity calculated in mg $CaCO_3$/L. ** SO4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC 3 : High PAF Waste Rock

Weight (kg)	14.000	Total S (%)	4.29	ANC	37.70
pH (1:5)	9.00	Scr (%)	3.600	NAPP	72.55
EC (µS/cm)	187	MPA	110.25	ANC:MPA	0.34

Date		29-Aug-16	27-Sep-16	31-Oct-16	28-Nov-16	28-Feb-17	29-May-17	29-Aug-17	28-Nov-17	28-Mar-18	29-May-18	28-Aug-18
Months		0	1	2	3	6	9	12	15	19	21	24
Weeks		0	4	9	13	26	39	52	65	82	91	104
Leach Number		1	2	3	4	5	6	7	8	9	10	11
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1703876	EB1711556	EB1718207	EB1725119	EB1808038	EB1813063	EB1820820
Volume ON (L)		1.5	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Volume OFF (L)		0.801	1.001	1.013	1.030	0.854	0.946	0.927	0.080	0.771	0.910	0.908
Cum. Volume (L)		0.80	1.80	2.82	3.85	4.70	5.65	6.57	6.65	7.42	8.33	9.24
Pore Volumes		0.7	1.6	2.4	3.3	4.1	4.9	5.7	5.8	6.5	7.2	8.0
pH		7.80	7.79	7.59	7.61	8.10	7.54	7.64	7.04	7.89	6.90	7.61
EC (µS/cm) - RGS record		584	299	486	455	512	703	281	294	304	398	466
Acidity (mg/L)*		1	1	6	2	2	1	2	2	2	2	2
Alkalinity (mg/L)*		43	27	30	22	20	46	15	16	13	16	15
Net Alkalinity (mg/L)*		42	26	24	20	18	45	13	14	11	14	13
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	69	38	66	62	82	62	46	43	42	55	68
Potassium (K)	-	16	2	4	3	4	2	4	2	2	2	2
Magnesium (Mg)	-	14	6	12	11	11	8	5	4	4	6	8
Sodium (Na)	-	25	12	17	12	11	6	2	6	7	9	8
Chloride (Cl)	-	9	2	1	1	<1	<1	<1	<1	<1	<1	<1
Fluoride (F)	2	0.4	0.2	0.3	0.3	0.3	0.4	0.1	0.2	0.1	<0.1	0.2
Sulfate (SO_4)	1,000	267	128	220	186	228	338	116	120	124	170	202
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	0.01	0.05	0.01	0.01	0.01	<0.01	<0.01	0.02	0.01	<0.01	<0.01
Arsenic (As)	0.5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron (B)	5	<0.05	0.20	0.16	0.16	0.27	0.16	0.07	0.2	0.24	0.34	0.3
Cadmium (Cd)	0.01	0.0004	0.0001	0.0007	0.0009	0.0012	0.0010	0.0006	0.0009	0.0010	0.0015	0.0024
Cobalt (Co)	1	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	0.025	0.004	0.002	0.002	0.004	0.002	0.005	0.003	0.002	0.002	0.004
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.396	0.143	0.262	0.165	0.093	0.024	0.055	0.087	0.113	0.059	0.071
Molybdenum (Mo)	0.15	0.004	0.002	0.004	0.005	0.011	0.004	0.001	0.003	0.001	0.002	0.002
Nickel (Ni)	1	0.025	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	0.002	0.002	0.004	0.005	0.002	0.001	<0.001	0.002	0.001	0.001	<0.001
Antimony (Sb)	-	0.011	0.051	0.075	0.045	0.053	0.027	0.013	0.032	0.032	0.071	0.052
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	4.4	6.0	12.6	8.8	5.1	6.5	2.4	7.0	6.4	5.0	4.6
Zinc (Zn)	20	0.01	<0.005	0.016	0.024	0.036	0.041	0.027	0.030	0.026	0.067	0.127
Calculations**												
SO_4 Release Rate		15	9	16	14	14	23	8	1	7	11	13
Cumulative SO_4 Release		15	24	40	54	68	91	98	99	106	117	130
Ca Release Rate		3.9	2.7	4.8	4.6	5.0	4.2	3.0	0.2	2.3	3.6	4.4
Cumulative Ca Release		3.9	6.7	11.4	16.0	21.0	25.2	28.2	28.5	30.8	34.4	38.8
Mg Release Rate		0.8	0.4	0.9	0.8	0.7	0.5	0.3	0.0	0.2	0.4	0.5
Cumulative Mg Release		0.8	1.2	2.1	2.9	3.6	4.1	4.5	4.5	4.7	5.1	5.6
Residual ANC (%)		99.97	99.94	99.90	99.87	99.83	99.79	99.77	99.77	99.75	99.72	99.69
Residual Sulfur (%)		99.99	99.98	99.97	99.96	99.95	99.93	99.92	99.92	99.92	99.91	99.90
SO_4/(Ca+Mg) molar ratio		1.2	1.1	1.1	1.0	1.0	1.9	0.9	1.0	1.1	1.1	1.0

< indicates less than the laboratory limit of reporting. *Acidity and alkalinity calculated in mg $CaCO_3$/L. ** SO4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC 4 : Tailing

Weight (kg)	7.000	Total S (%)	1.51	ANC	35.40
pH (1:5)	10.10	Scr (%)	1.220	NAPP	1.96
EC (µS/cm)	335	MPA	37.36	ANC:MPA	0.95

Date		29-Aug-16	27-Sep-16	31-Oct-16	28-Nov-16	03-Mar-17	29-May-17	29-Aug-17	01-Dec-17	10-Apr-18	01-Jun-18	30-Aug-18
Months		0	1	2	3	6	9	12	15	19	21	24
Weeks		0	4	9	13	27	39	52	66	84	92	104
Leach Number		1	2	3	4	5	6	7	8	9	10	11
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1704234	EB1711556	EB1718207	EB1725503	EB1808901	EB1813420	EB1821049
Volume ON (L)		1.0	1.2	1.6	1.0	2.4	2.5	2.2	2.2	1.2	2.2	2.2
Volume OFF (L)		0.723	0.842	0.572	0.351	1.003	0.987	0.920	0.808	0.383	0.970	0.986
Cum. Volume (L)		0.72	1.57	2.14	2.49	3.49	4.48	5.40	6.21	6.59	7.56	8.55
Pore Volumes		0.6	1.4	1.9	2.2	3.0	3.9	4.7	5.4	5.7	6.6	7.4
pH		9.11	7.95	8.09	7.62	7.00	7.55	7.33	7.14	6.55	6.68	7.32
EC (µS/cm) - RGS record		517	1,272	507	4,460	4,970	3,500	2,790	2,725	2,640	2,239	2,085
Acidity (mg/L)*		<1	4	1	2	2	2	6	4	4	2	3
Alkalinity (mg/L)*		40	42	34	70	28	41	38	40	43	35	64
Net Alkalinity (mg/L)*		40	38	33	68	26	39	32	36	39	33	61
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	14	56	19	606	479	473	512	535	619	467	528
Potassium (K)	-	18	43	13	178	198	128	34	76	87	51	45
Magnesium (Mg)	-	2	6	2	58	62	56	119	29	31	22	17
Sodium (Na)	-	80	172	83	556	558	299	82	74	80	44	25
Chloride (Cl)	-	28	126	24	185	117	45	9	3	3	2	1
Fluoride (F)	2	0.1	0.1	<0.1	0.3	0.4	0.6	0.4	0.2	0.5	0.4	0.3
Sulfate (SO_4)	1,000	182	469	183	2,840	2,750	2,230	1,790	1,350	1,950	1,440	1,330
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	0.27	0.05	0.12	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic (As)	0.5	0.18	0.014	0.006	0.013	0.022	0.005	0.005	0.008	0.033	0.005	0.005
Boron (B)	5	0.07	0.2	0.07	0.56	0.40	0.34	0.21	0.25	0.52	0.24	0.18
Cadmium (Cd)	0.01	<0.0001	0.0004	0.0002	0.0207	0.1040	0.0091	0.0115	0.0155	0.0130	0.0246	0.0318
Cobalt (Co)	1	0.004	0.004	<0.001	0.014	0.013	0.005	0.003	0.003	0.002	0.003	0.002
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	3.080	0.005	<0.001	0.010	0.014	0.011	0.007	0.004	0.01	0.006	0.003
Iron (Fe)	1#	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.009	0.073	0.043	6.170	1.800	1.610	1.530	1.920	1.310	2.170	2.460
Molybdenum (Mo)	0.15	0.032	0.018	0.002	0.042	0.097	0.064	0.077	0.105	0.137	0.095	0.054
Nickel (Ni)	1	0.044	0.003	<0.001	0.101	0.168	0.054	0.019	0.016	0.006	0.005	0.004
Lead (Pb)	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.022	0.169	0.008	0.091	0.057	0.068	0.031	0.044	0.06	0.027	0.026
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	3.0	8.9	2.5	5.5	9.5	9.1	9.0	21.5	13.0	9.2	8.6
Zinc (Zn)	20	<0.005	0.014	<0.005	1.320	0.352	0.367	0.339	0.516	0.197	0.595	0.752
Calculations**												
SO_4 Release Rate		19	56	15	142	394	314	235	156	107	200	187
Cumulative SO_4 Release		19	75	90	233	627	941	1176	1332	1439	1638	1826
Ca Release Rate		1.4	6.7	1.6	30.4	68.6	66.7	67.3	61.8	33.9	64.7	74.4
Cumulative Ca Release		1.4	8.2	9.7	40.1	108.8	175.4	242.7	304.5	338.4	403.1	477.4
Mg Release Rate		0.2	0.7	0.2	2.9	8.9	7.9	15.6	3.3	1.7	3.0	2.4
Cumulative Mg Release		0.2	0.9	1.1	4.0	12.9	20.8	36.4	39.8	41.5	44.5	46.9
Residual ANC (%)		99.99	99.93	99.92	99.68	99.10	98.55	97.91	97.44	97.19	96.71	96.17
Residual Sulfur (%)		99.96	99.83	99.80	99.49	98.62	97.92	97.40	97.06	96.82	96.38	95.96
SO_4/(Ca+Mg) molar ratio		4.4	3.0	3.4	1.7	2.0	1.6	1.1	1.0	1.2	1.2	1.0

< indicates less than the laboratory limit of reporting. *Acidity and alkalinity calculated in mg $CaCO_3$/L. ** SO4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC 5 : Tailing on top of High PAF Waste Rock

Weight (kg)	18.000	Total S (%)	3.36	ANC	36.93
pH (1:5)	9.37	Scr (%)	2.807	NAPP	49.03
EC (µS/cm)	236	MPA	85.96	ANC:MPA	0.43

Date		29-Aug-16	27-Sep-16	31-Oct-16	28-Nov-16	28-Feb-17	29-May-17	29-Aug-17	28-Nov-17	28-Mar-18	29-May-18	30-Aug-18
Months		0	1	2	3	6	9	12	15	19	21	24
Weeks		0	4	9	13	26	39	52	65	82	91	104
Leach Number		1	2	3	4	5	6	7	8	9	10	11
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1703876	EB1711556	EB1718207	EB1725119	EB1808038	EB1813063	EB1820820
Volume ON (L)		1.5	1.5	1.6	1.2	1.2	1.2	1.2	1.8	1.2	1.2	1.2
Volume OFF (L)		0.698	1.013	0.671	0.633	0.375	0.418	0.468	0.512	0.625	0.408	0.391
Cum. Volume (L)		0.70	1.71	2.38	3.02	3.39	3.81	4.28	4.79	5.41	5.82	6.21
Pore Volumes		0.6	1.5	2.1	2.6	2.9	3.3	3.7	4.2	4.7	5.1	5.4
pH		7.78	6.97	7.17	7.12	7.89	8.01	7.88	7.08	7.78	7.22	7.76
EC (µS/cm) - RGS record		3,560	1,072	525	460	648	1,132	1,024	571	847	584	712
Acidity (mg/L)*		3	3	3	4	4	1	1	1	2	<1	1
Alkalinity (mg/L)*		73	26	28	25	24	29	27	17	25	24	21
Net Alkalinity (mg/L)*		70	23	25	21	20	28	26	16	23	23	20
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	363	97	48	49	91	59	81	58	120	59	65
Potassium (K)	-	64	21	10	12	14	7	21	12	13	10	10
Magnesium (Mg)	-	82	18	6	6	12	6	129	10	14	13	15
Sodium (Na)	-	427	94	38	25	36	34	20	34	41	38	51
Chloride (Cl)	-	313	52	7	7	3	2	2	<1	<1	2	1
Fluoride (F)	2	0.7	0.2	0.3	0.2	0.3	0.4	0.2	0.1	0.2	<0.1	0.1
Sulfate (SO_4)	1,000	2,180	461	218	194	303	555	503	250	428	272	344
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	<0.01	0.02	0.03	0.02	0.02	<0.01	<0.01	0.02	0.01	0.01	<0.01
Arsenic (As)	0.5	0.002	0.005	0.004	0.004	0.006	0.002	0.001	0.003	0.004	0.002	0.002
Boron (B)	5	0.05	0.07	0.06	0.10	0.15	0.09	<0.05	0.14	0.33	0.1	0.09
Cadmium (Cd)	0.01	0.0016	0.0015	0.0008	0.0013	0.0022	0.0018	0.0018	0.0019	0.0039	0.003	0.0033
Cobalt (Co)	1	0.022	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	11.000	0.012	0.003	0.002	0.010	0.002	0.002	0.004	0.005	0.003	0.004
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	2.900	0.592	0.386	0.421	0.487	0.383	0.271	0.217	0.246	0.167	0.161
Molybdenum (Mo)	0.15	0.025	0.007	0.003	0.004	0.005	0.004	0.003	0.005	0.006	0.003	0.005
Nickel (Ni)	1	0.077	0.006	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Lead (Pb)	0.1	0.003	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.028	0.059	0.018	0.014	0.013	0.014	0.003	0.008	0.029	0.007	0.007
Selenium (Se)	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	14.0	6.9	6.4	4.9	3.3	5.9	1.4	4.3	11.0	1.4	1.6
Zinc (Zn)	20	0.277	0.037	0.022	0.028	0.030	0.033	0.021	0.024	0.053	0.04	0.049
Calculations**												
SO_4 Release Rate		85	26	8	7	6	13	13	7	15	6	7
Cumulative SO_4 Release		85	110	119	125	132	145	158	165	180	186	193
Ca Release Rate		14.1	5.5	1.8	1.7	1.9	1.4	2.1	1.6	4.2	1.3	1.4
Cumulative Ca Release		14.1	19.5	21.3	23.0	24.9	26.3	28.4	30.1	34.2	35.6	37.0
Mg Release Rate		3.2	1.0	0.2	0.2	0.3	0.1	3.4	0.3	0.5	0.3	0.3
Cumulative Mg Release		3.2	4.2	4.4	4.6	4.9	5.0	8.4	8.7	9.1	9.4	9.8
Residual ANC (%)		99.87	99.82	99.81	99.80	99.78	99.77	99.72	99.71	99.67	99.66	99.65
Residual Sulfur (%)		99.92	99.89	99.88	99.88	99.87	99.86	99.84	99.84	99.82	99.82	99.81
SO_4/(Ca+Mg) molar ratio		1.8	1.5	1.6	1.4	1.1	3.4	0.7	1.4	1.2	1.4	1.6

< indicates less than the laboratory limit of reporting. *Acidity and alkalinity calculated in mg $CaCO_3$/L. ** SO4, Ca and Mg release rates calculated in mg/kg/flush.

Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

RGS-KLC 6 : Tailing mixed with High PAF Waste Rock

Weight (kg)	21.000	Total S (%)	3.36	ANC	36.93
pH (1:5)	9.37	Scr (%)	2.807	NAPP	49.03
EC (µS/cm)	236	MPA	85.96	ANC:MPA	0.43

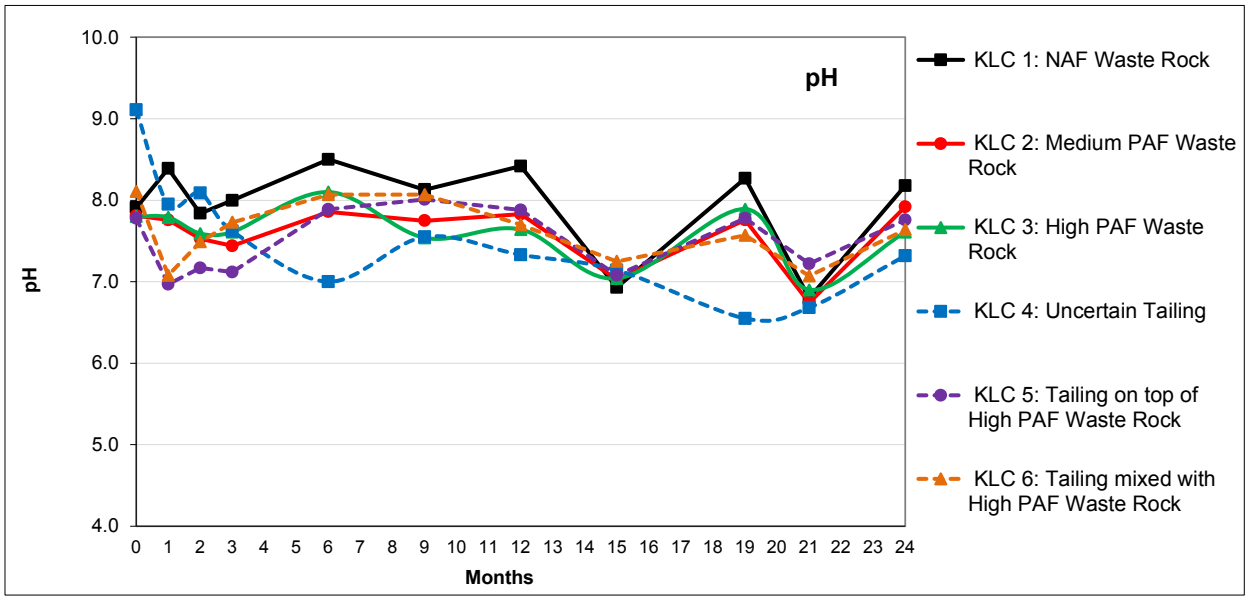
Date		29-Aug-16	27-Sep-16	31-Oct-16	28-Nov-16	28-Feb-17	29-May-17	29-Aug-17	01-Dec-17	28-Mar-18	29-May-18	30-Aug-18
Months		0	1	2	3	6	9	12	15	19	21	24
Weeks		0	4	9	13	26	39	52	66	82	91	104
Leach Number		1	2	3	4	5	6	7	8	9	10	11
ALS Laboratory Number		EB1621323	EB1623451	EB1626138	EB1628241	EB1703876005	EB1711556	EB1718207	EB1725503	EB1808038	EB1813063	EB1820820
Volume ON (L)		1.5	1.5	1.6	1.2	1.2	2.2	1.2	2.2	1.8	1.2	1.2
Volume OFF (L)		0.720	0.728	0.740	0.767	0.941	1.039	0.891	1.039	0.428	0.708	0.820
Cum. Volume (L)		0.72	1.45	2.19	2.96	3.90	7.70	8.59	9.63	10.06	10.77	11.59
Pore Volumes		0.6	1.3	1.9	2.6	3.4	6.7	7.5	8.4	8.7	9.4	10.1
pH		8.11	7.08	7.49	7.73	8.07	8.07	7.70	7.25	7.57	7.07	7.64
EC (µS/cm) - RGS record		1,340	1,241	1,756	1,769	1,681	1,919	2,079	1,936	1,796	1,850	1,970
Acidity (mg/L)*		1	5	3	3	1	1	2	3	3	2	2
Alkalinity (mg/L)*		52	60	32	27	21	30	30	37	36	28	30
Net Alkalinity (mg/L)*		51	55	29	24	20	29	29	34	33	26	28
Major Ions (mg/L)	**Guidelines #**											
Calcium (Ca)	1,000	82	90	187	136	141	210	208	236	285	193	238
Potassium (K)	-	40	27	44	37	40	38	48	45	42	52	50
Magnesium (Mg)	-	14	19	32	29	34	35	246	35	32	44	36
Sodium (Na)	-	174	140	232	172	170	168	52	130	110	168	141
Chloride (Cl)	-	90	34	47	32	31	16	24	18	12	21	14
Fluoride (F)	2	0.3	0.2	0.3	0.2	0.3	0.4	0.4	0.3	0.4	<0.1	0.4
Sulfate (SO_4)	1,000	614	594	1,130	855	745	994	1,010	931	958	928	1,040
Trace metals/ metalloids (mg/L)	**Guidelines #**											
Aluminium (Al)	5	0.06	0.02	0.02	0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Arsenic (As)	0.5	0.035	0.003	0.003	0.002	0.003	0.003	<0.001	0.004	0.005	0.002	0.004
Boron (B)	5	0.08	<0.05	0.14	0.14	0.11	0.18	0.05	0.25	0.51	0.19	0.24
Cadmium (Cd)	0.01	0.0003	0.0014	0.0033	0.0049	0.0065	0.0108	0.0054	0.0097	0.0117	0.0159	0.0176
Cobalt (Co)	1	0.006	0.002	0.002	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
Chromium (Cr)	1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu)	1	1.660	0.008	0.002	0.004	0.010	0.010	0.003	0.002	0.006	0.006	0.005
Iron (Fe)	1#	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Manganese (Mn)	2#	0.082	0.607	1.300	1.210	0.607	0.160	0.051	0.057	0.035	0.064	0.033
Molybdenum (Mo)	0.15	0.036	0.003	0.006	0.009	0.009	0.010	0.003	0.014	0.018	0.006	0.007
Nickel (Ni)	1	0.011	<0.001	0.001	<0.001	0.004	0.014	0.001	0.015	0.035	0.003	0.008
Lead (Pb)	0.1	<0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Antimony (Sb)	-	0.093	0.011	0.032	0.011	0.018	0.031	0.004	0.034	0.048	0.013	0.018
Selenium (Se)	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silicon (Si)	-	6.7	2.8	8.6	5.3	2.7	4.8	2.6	11.5	17.1	2.8	4.0
Zinc (Zn)	20	0.014	0.032	0.082	0.108	0.076	0.388	0.123	0.345	0.34	0.421	0.486
Calculations**												
SO_4 Release Rate		21	21	40	31	33	49	43	46	20	31	41
Cumulative SO_4 Release		21	42	81	113	146	195	238	284	304	335	376
Ca Release Rate		2.8	3.1	6.6	5.0	6.3	10.4	8.8	11.7	5.8	6.5	9.3
Cumulative Ca Release		2.8	5.9	12.5	17.5	23.8	34.2	43.0	54.7	60.5	67.0	76.3
Mg Release Rate		0.5	0.7	1.1	1.1	1.5	1.7	10.4	1.7	0.7	1.5	1.4
Cumulative Mg Release		0.5	1.1	2.3	3.3	4.8	6.6	17.0	18.7	19.4	20.9	22.3
Residual ANC (%)		99.98	99.95	99.89	99.85	99.79	99.70	99.53	99.43	99.39	99.33	99.25
Residual Sulfur (%)		99.98	99.96	99.92	99.89	99.85	99.81	99.76	99.72	99.70	99.67	99.63
SO_4/(Ca+Mg) molar ratio		2.4	2.0	2.0	1.9	1.6	1.5	0.7	1.3	1.2	1.5	1.5

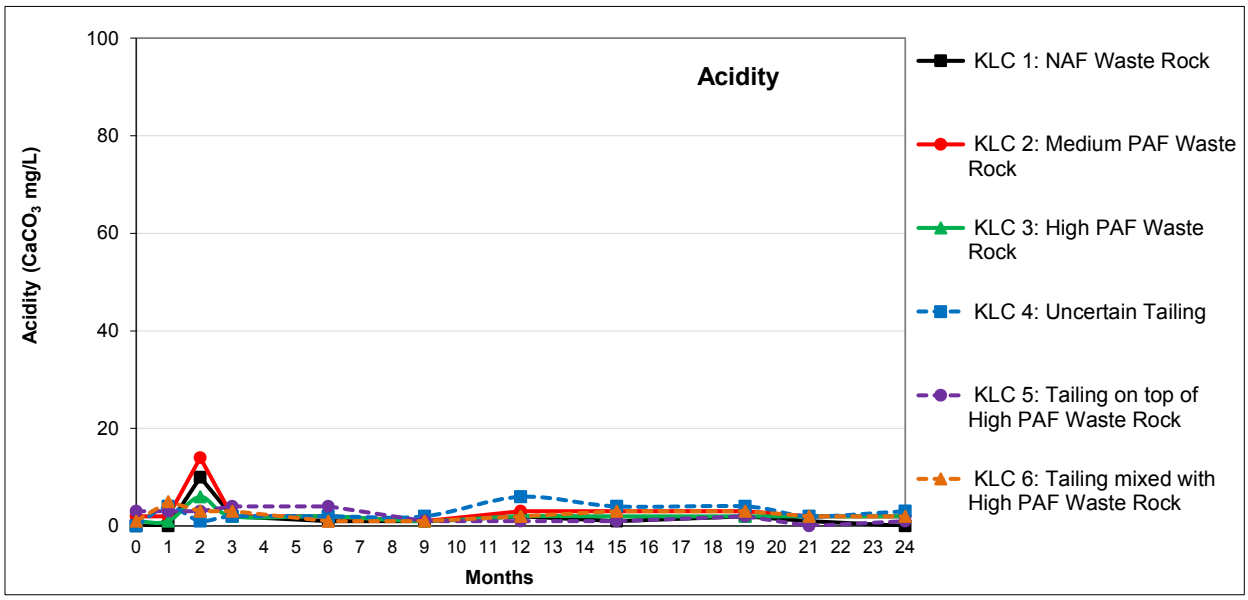
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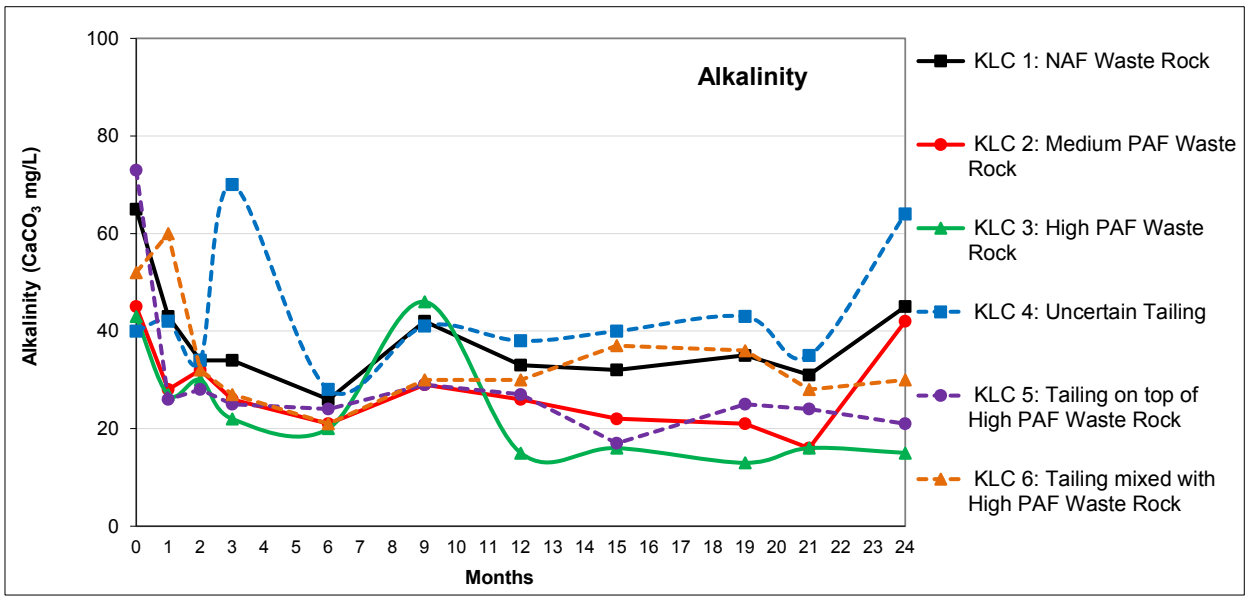
Total S = Total Sulfur; Scr = Chromium Reducible Sulfur; and ANC = Acid Neutralising Capacity.

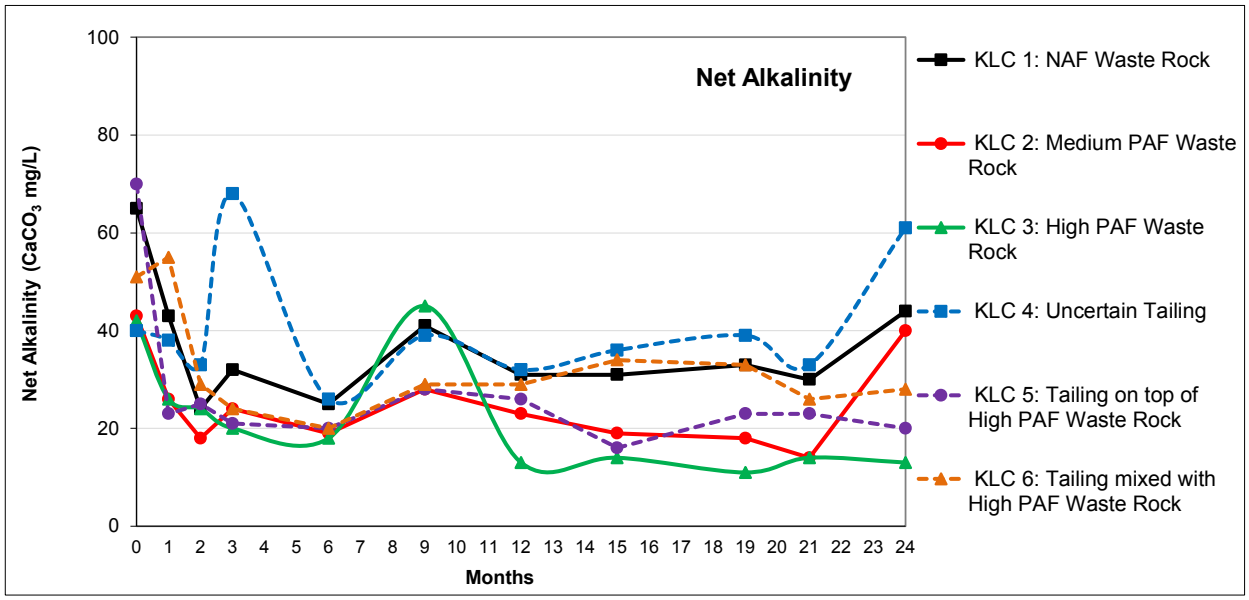
MPA = Maximum Potential Acidity, and NAPP = Net Acid Producing Potential.

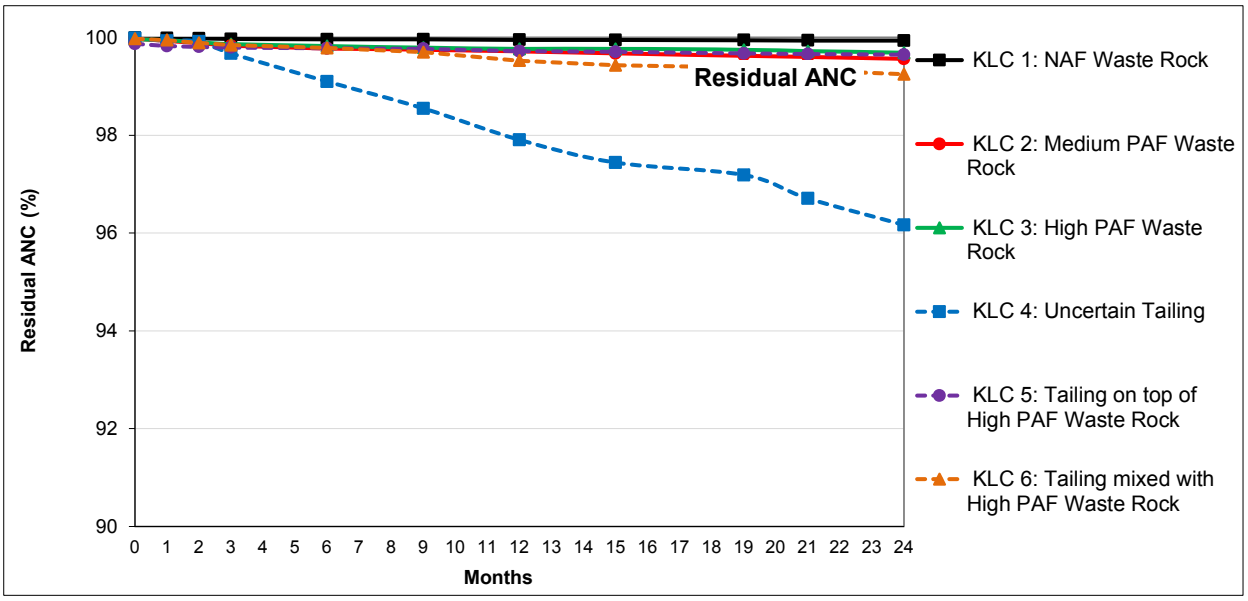
ANZECC & ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, 2000, ANZECC (Australian and New Zealand Environment Conservation Council) and ARMCANZ (Agriculture and Resource Management Council of Australia and New Zealand). Livestock Drinking Water Levels (Irrigation Levels used for Fe and Mn).

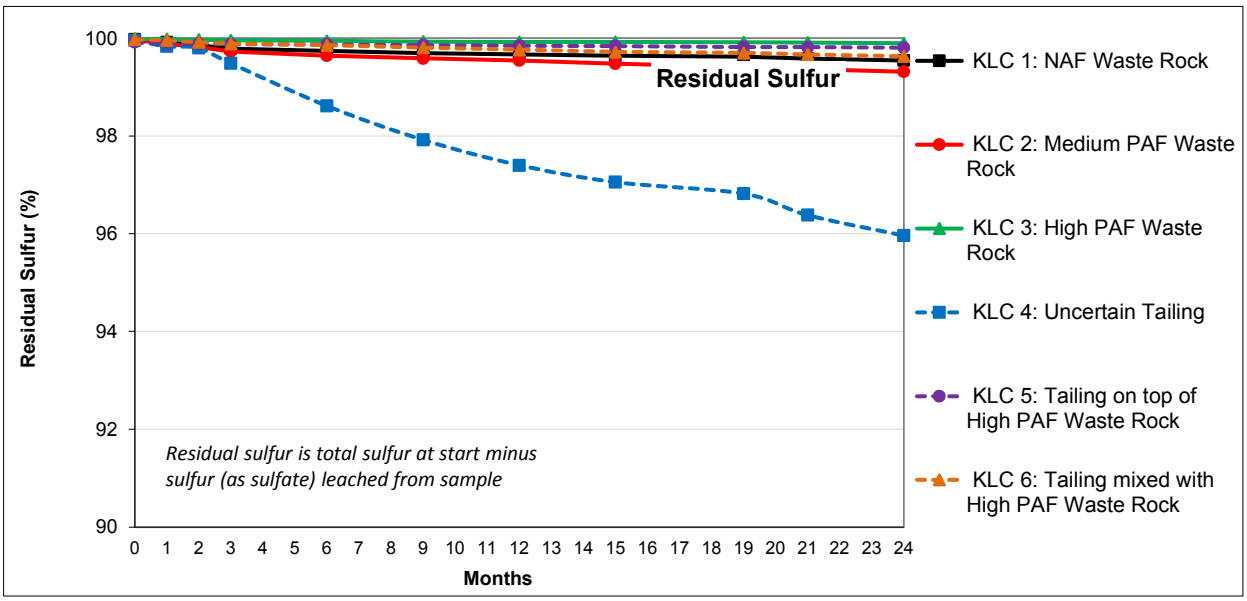

pH
pH
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

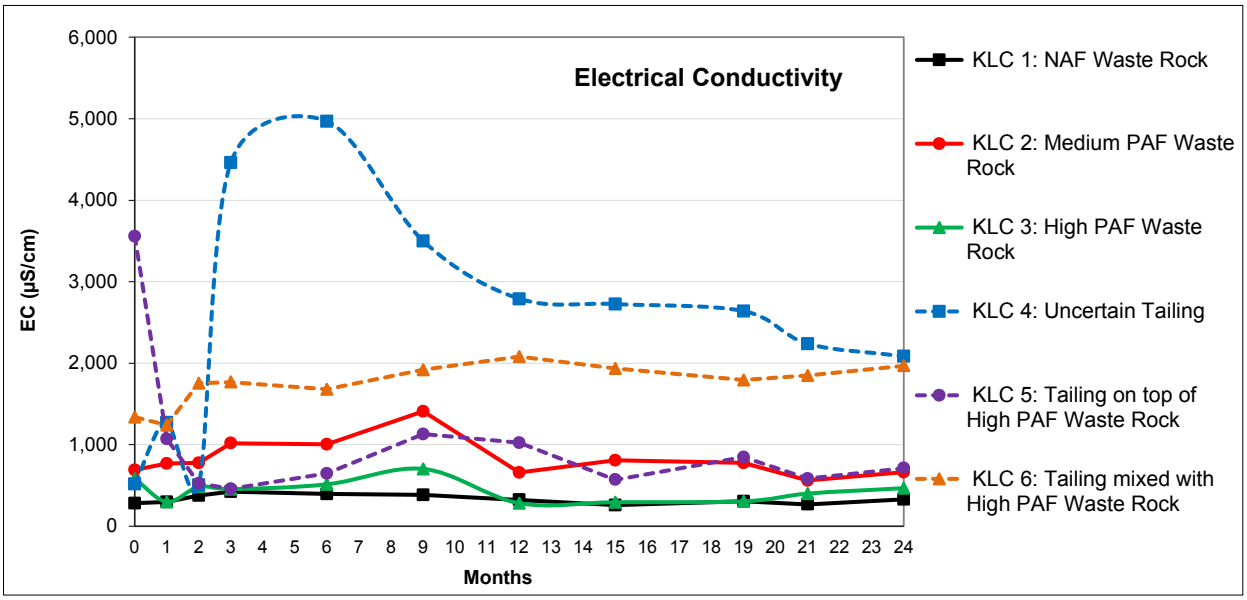

Acidity
Acidity (CaCO3 mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

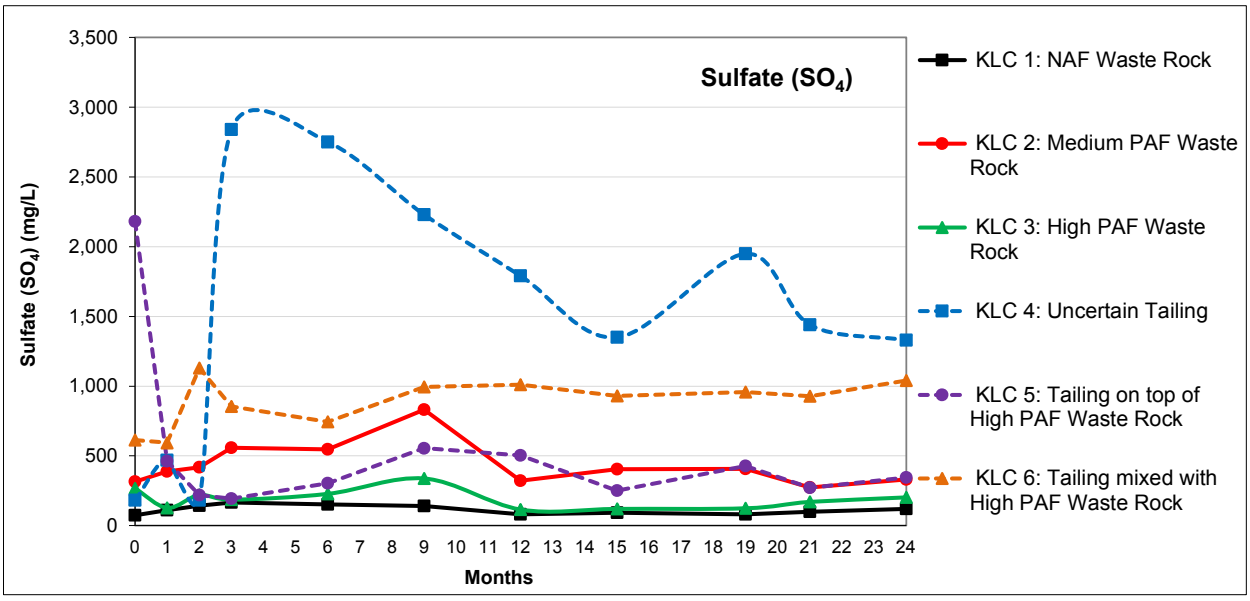

Alkalinity
Alkalinity (CaCO3 mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

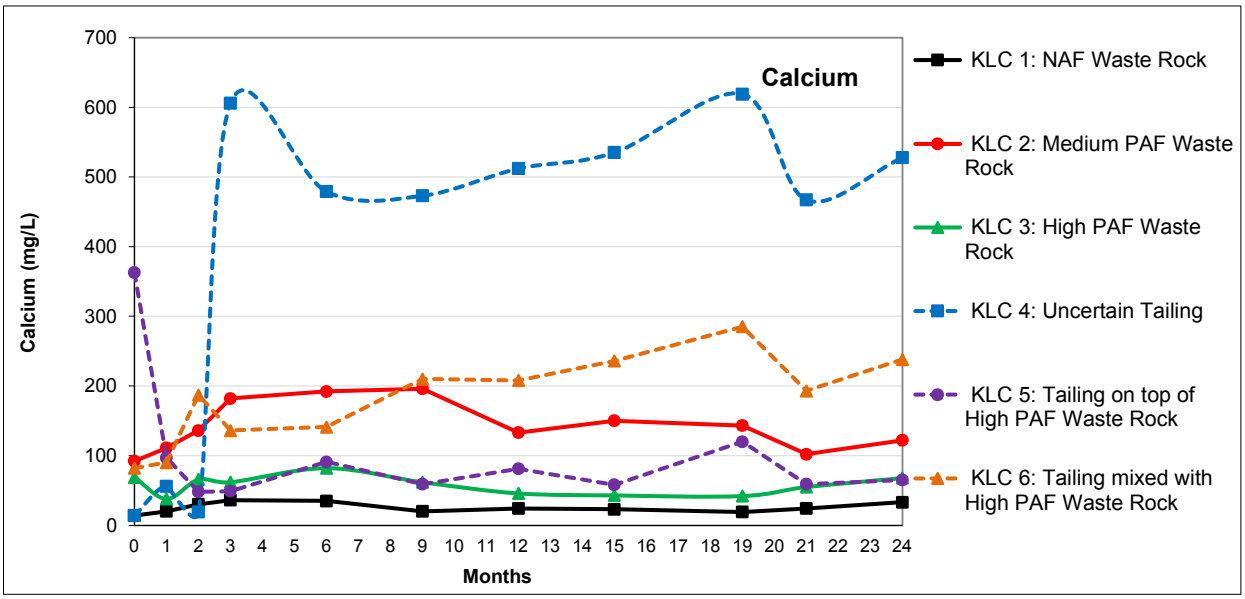

Net Alkalinity
Net Alkalinity (CaCO3 mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

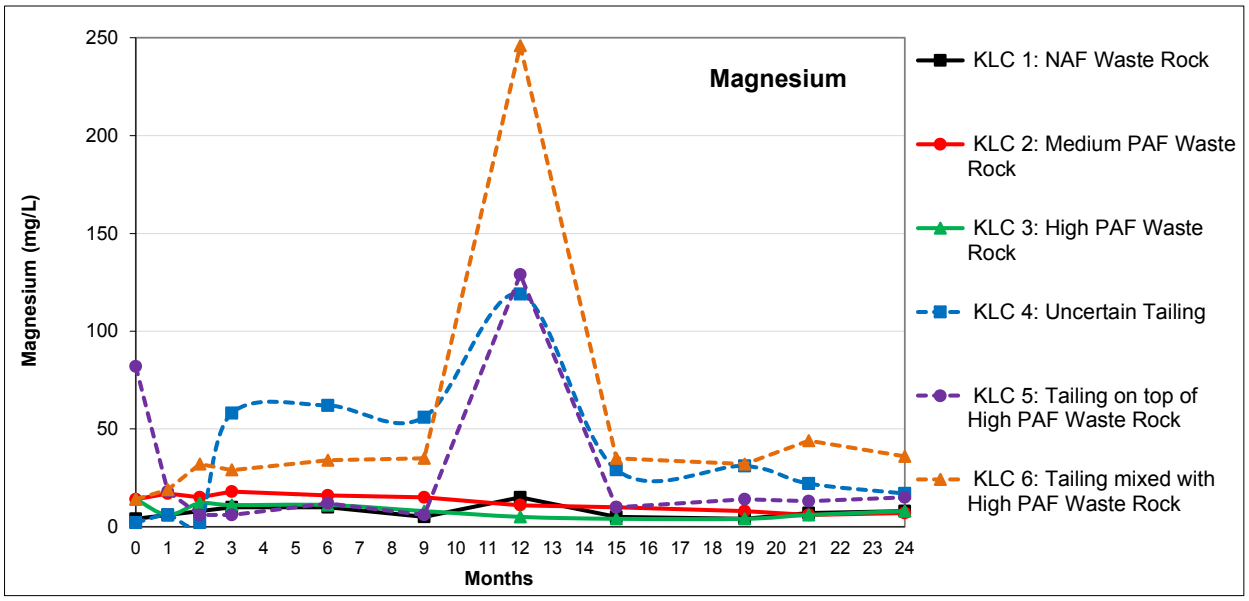

Residual ANC
Residual ANC (%)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

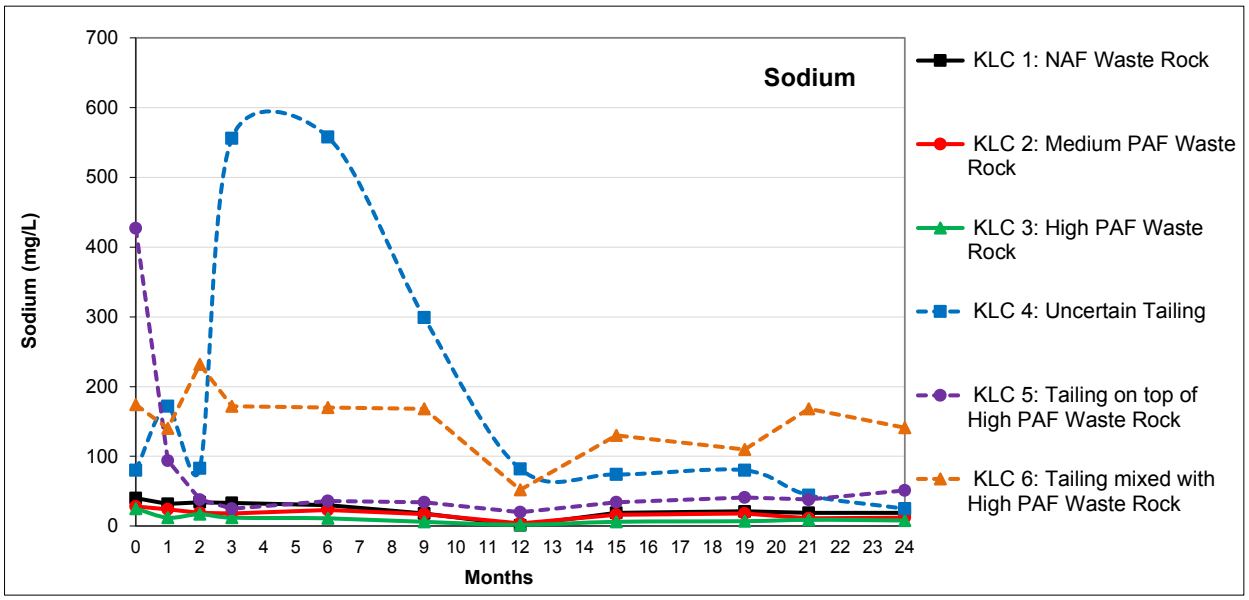

Residual Sulfur
Residual Sulfur (%)
Months
Residual sulfur is total sulfur at start minus sulfur (as sulfate) leached from sample
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

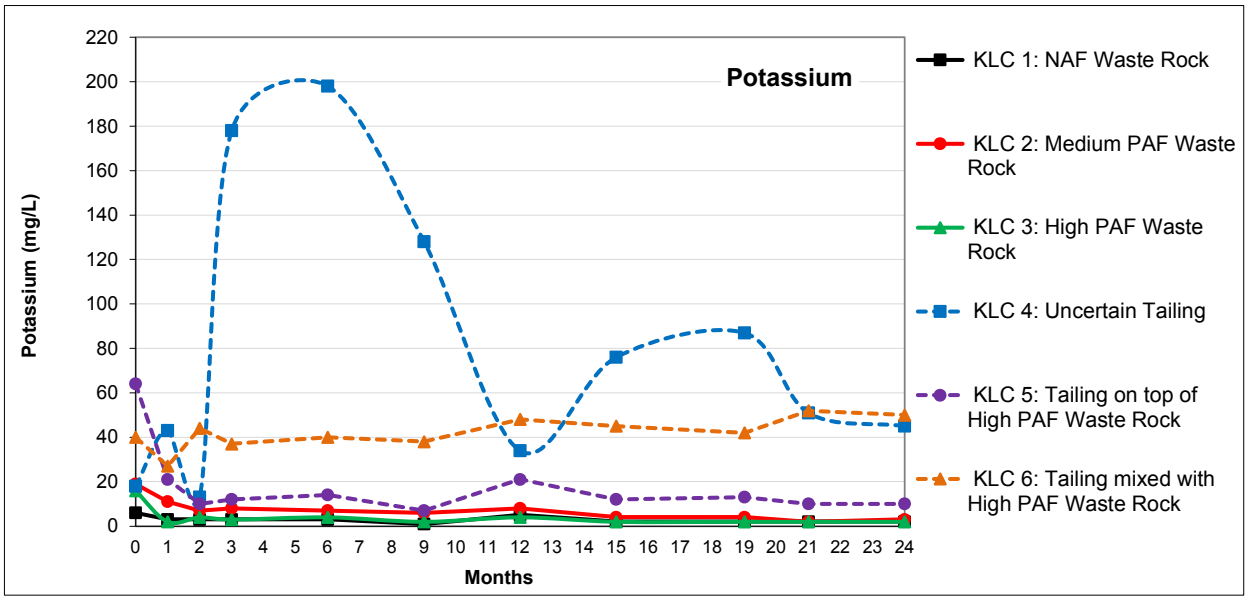

Electrical Conductivity
EC (µS/cm)
6,000
5,000
4,000
3,000
2,000
1,000
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

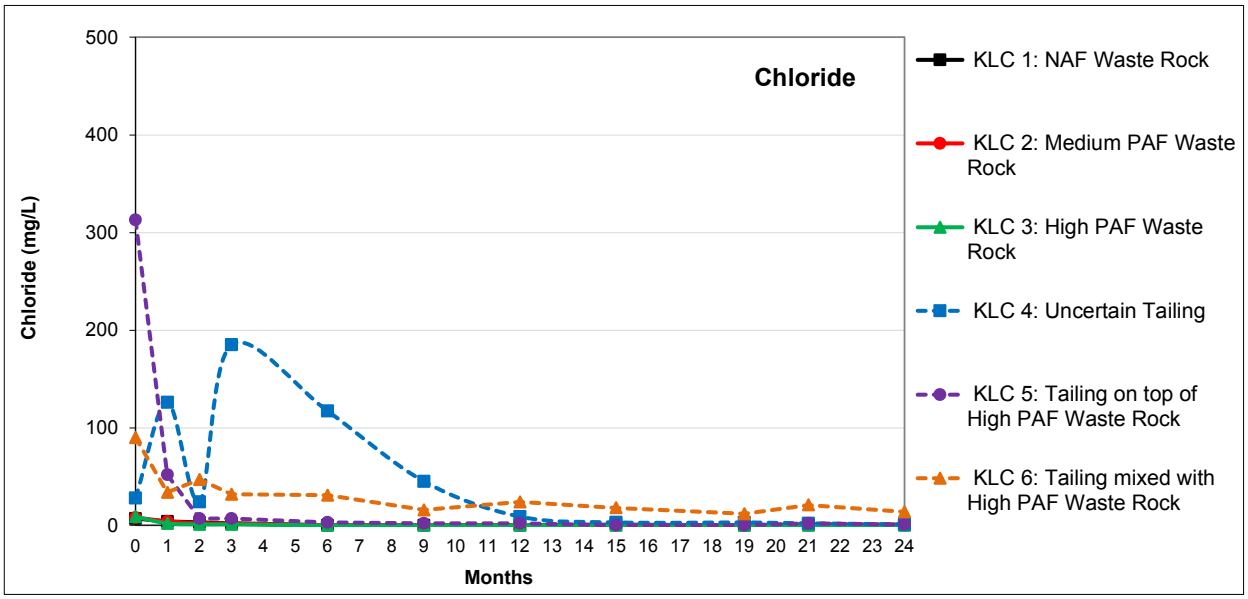

Sulfate (SO4)
Sulfate (SO4) (mg/L)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

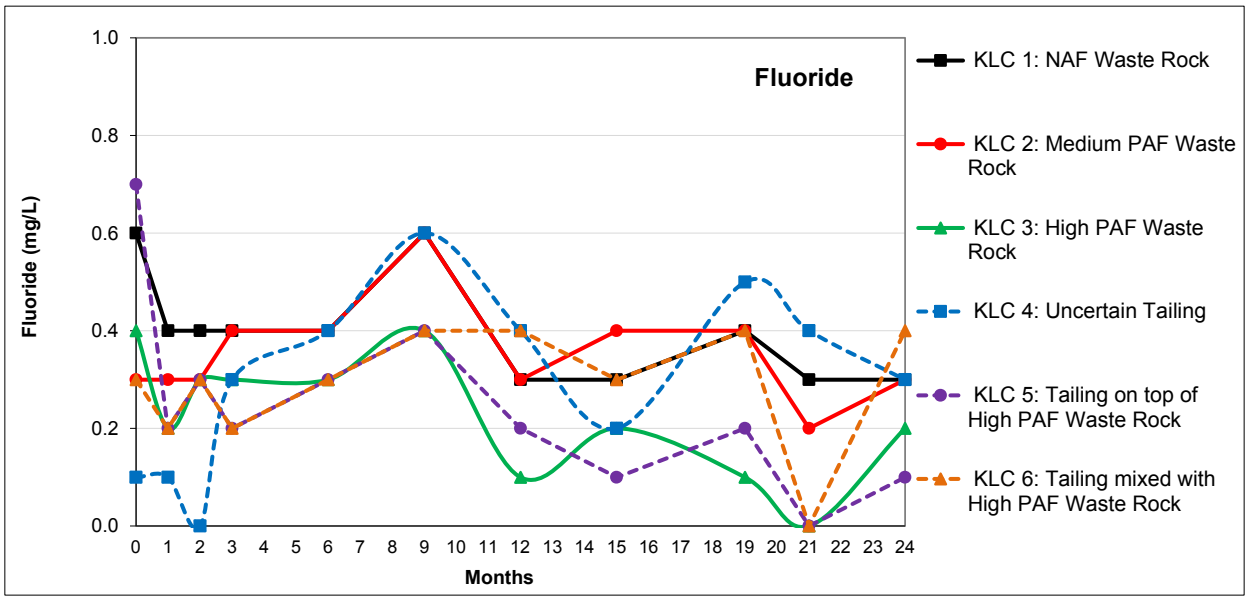

Calcium
Calcium (mg/L)
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

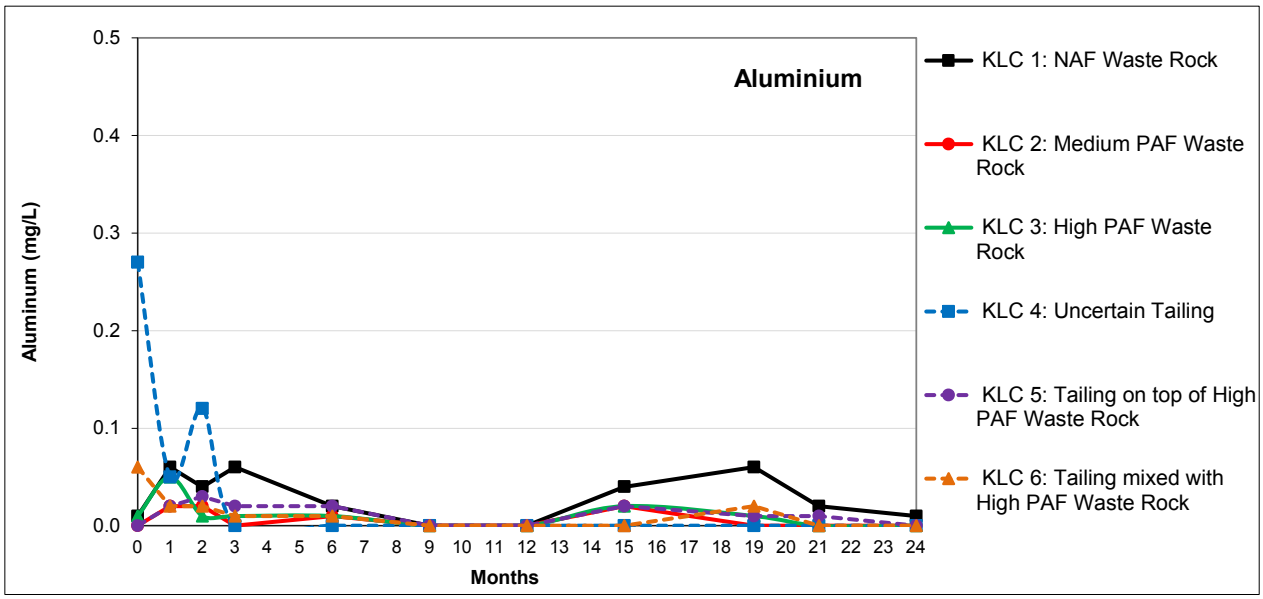

Magnesium
Magnesium (mg/L)
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

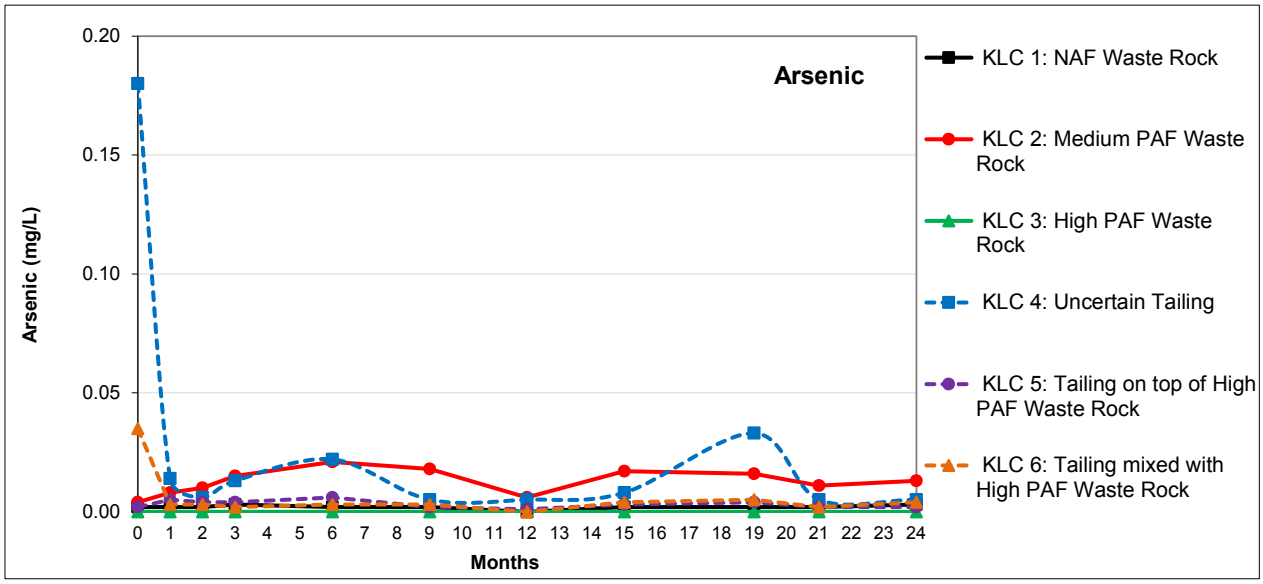

Sodium
Sodium (mg/L)
700
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

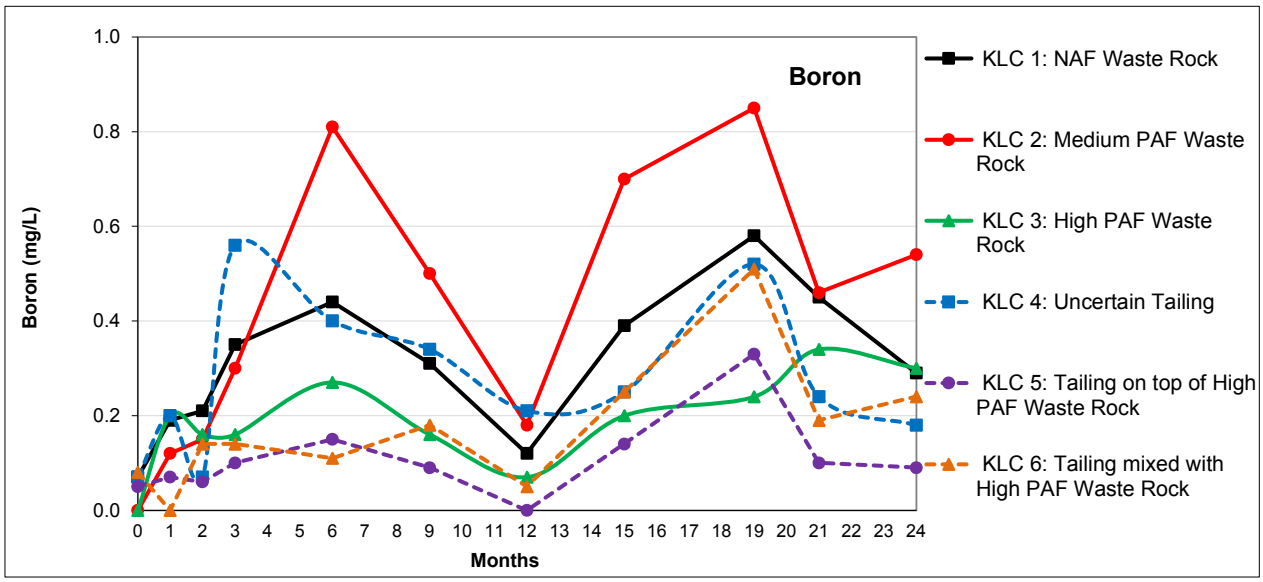

Potassium
Potassium (mg/L)
220
200
180
160
140
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

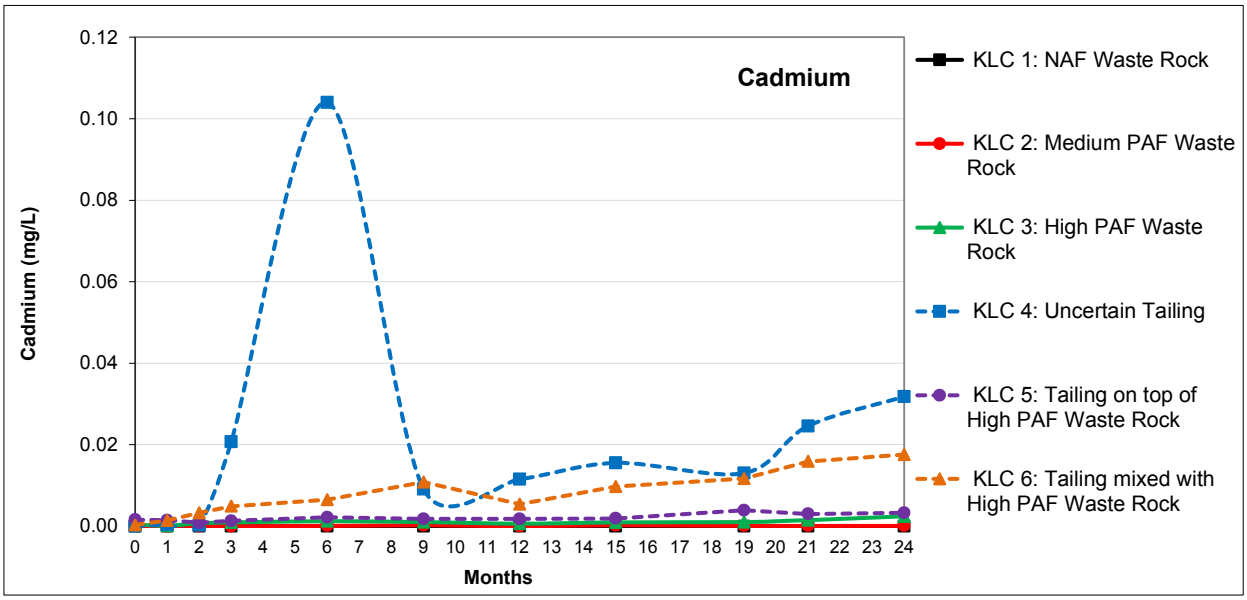

Chloride
Chloride (mg/L)
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

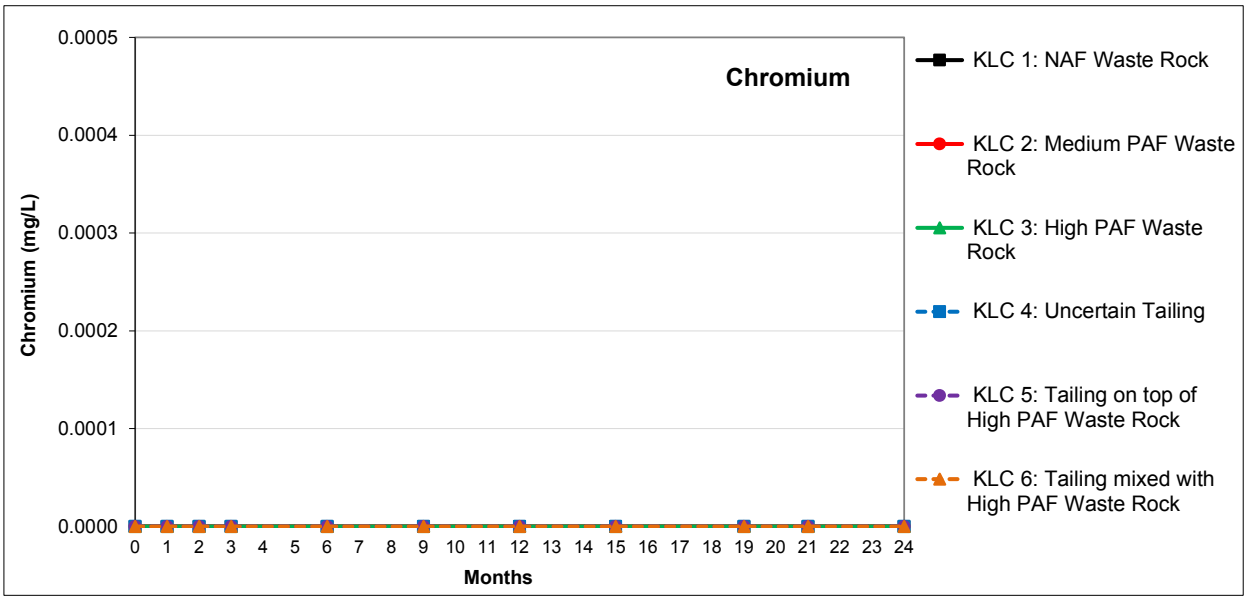

Fluoride
Fluoride (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

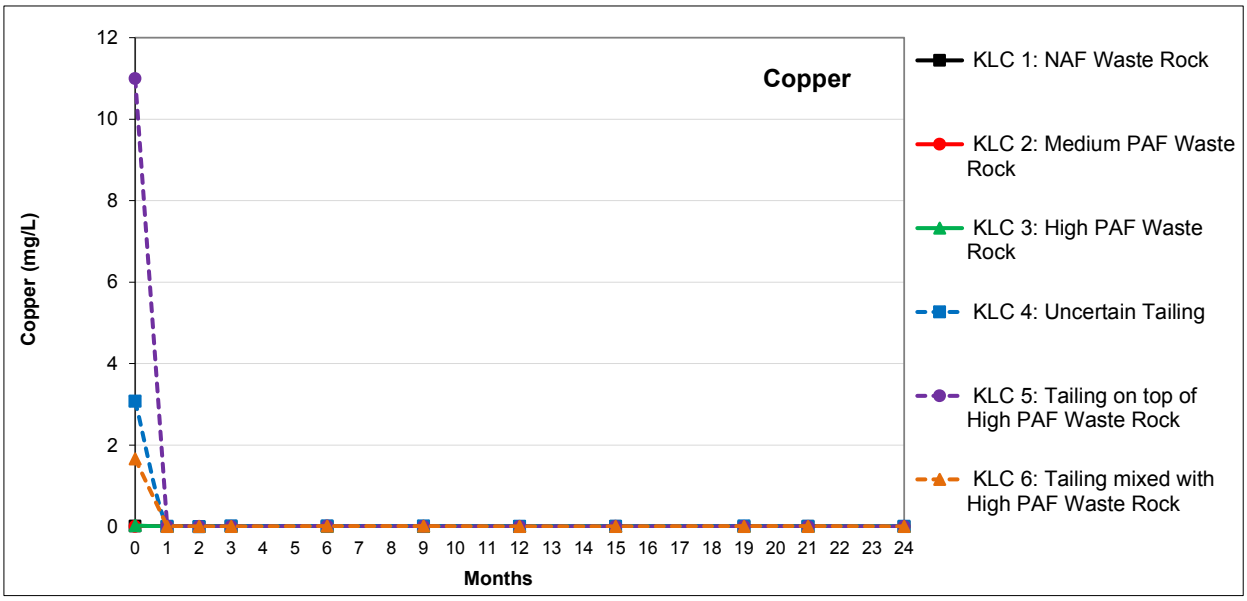

Aluminium
Aluminum (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

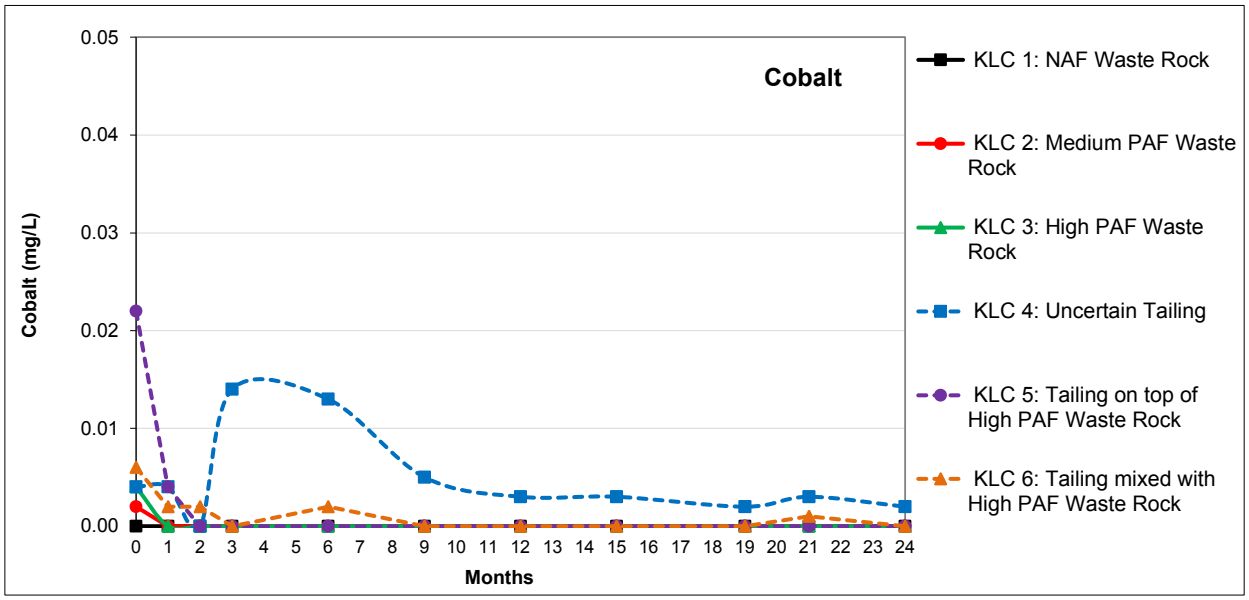

Arsenic
Arsenic (mg/L)
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

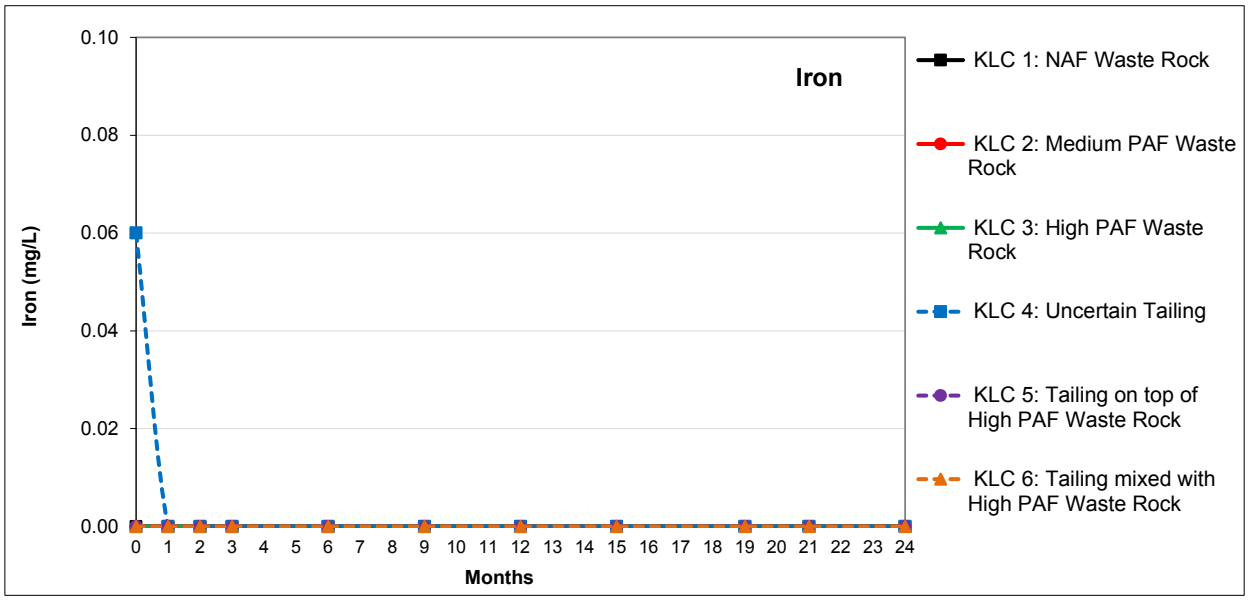

Boron
Boron (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

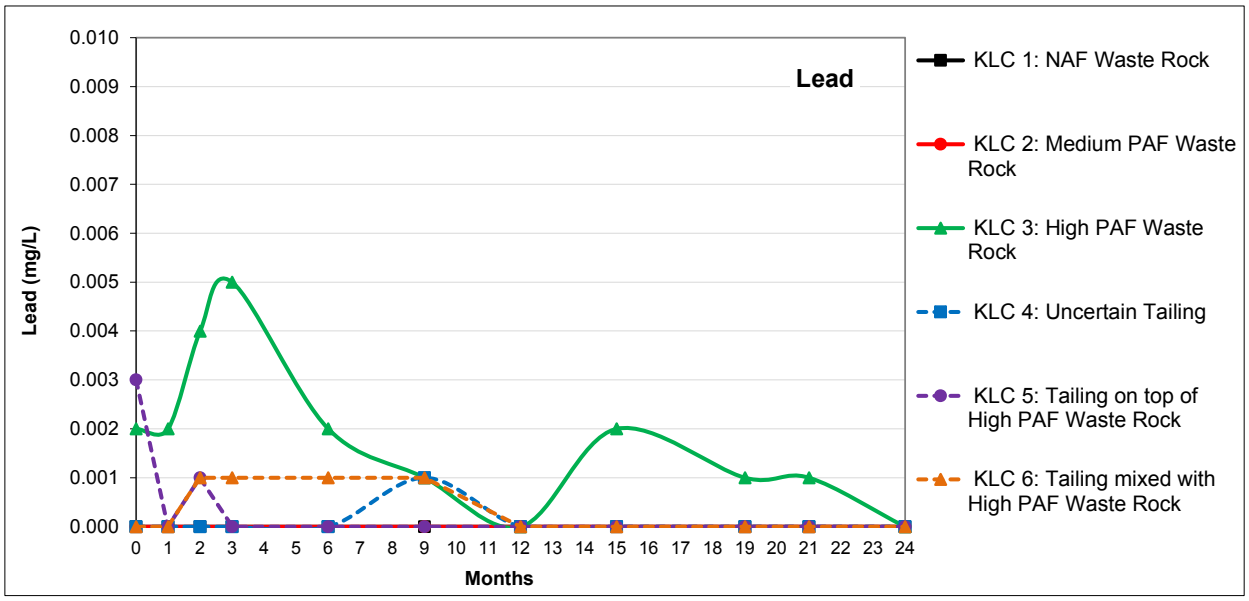

Cadmium
Cadmium (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

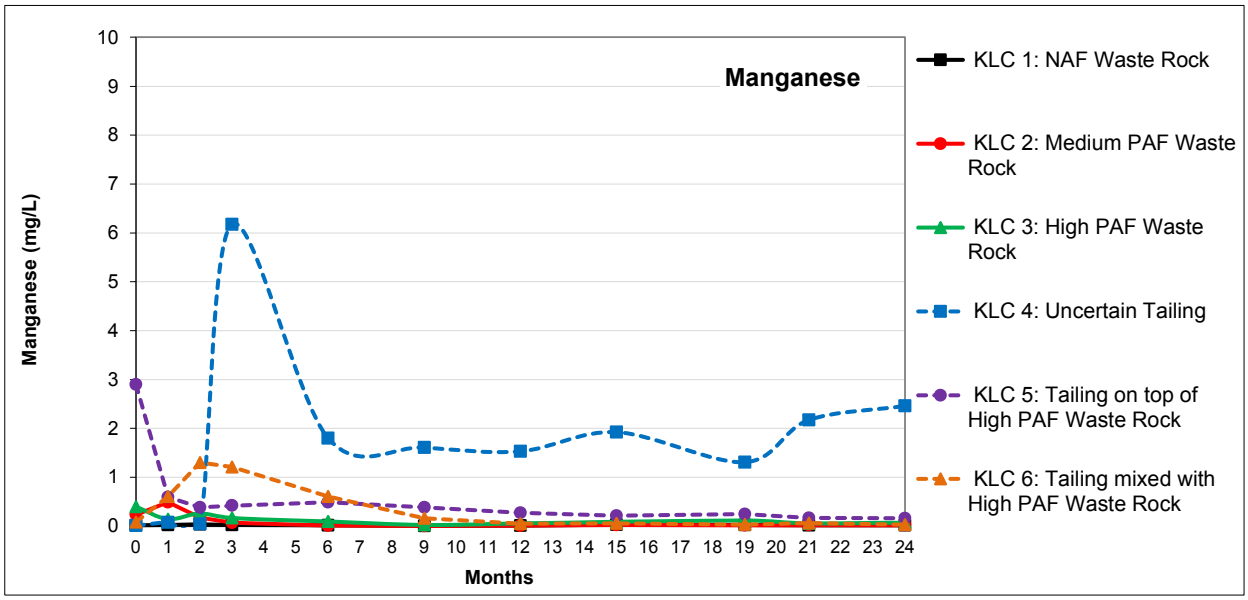

Chromium
Chromium (mg/L)
0.0005
0.0004
0.0003
0.0002
0.0001
0.0000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

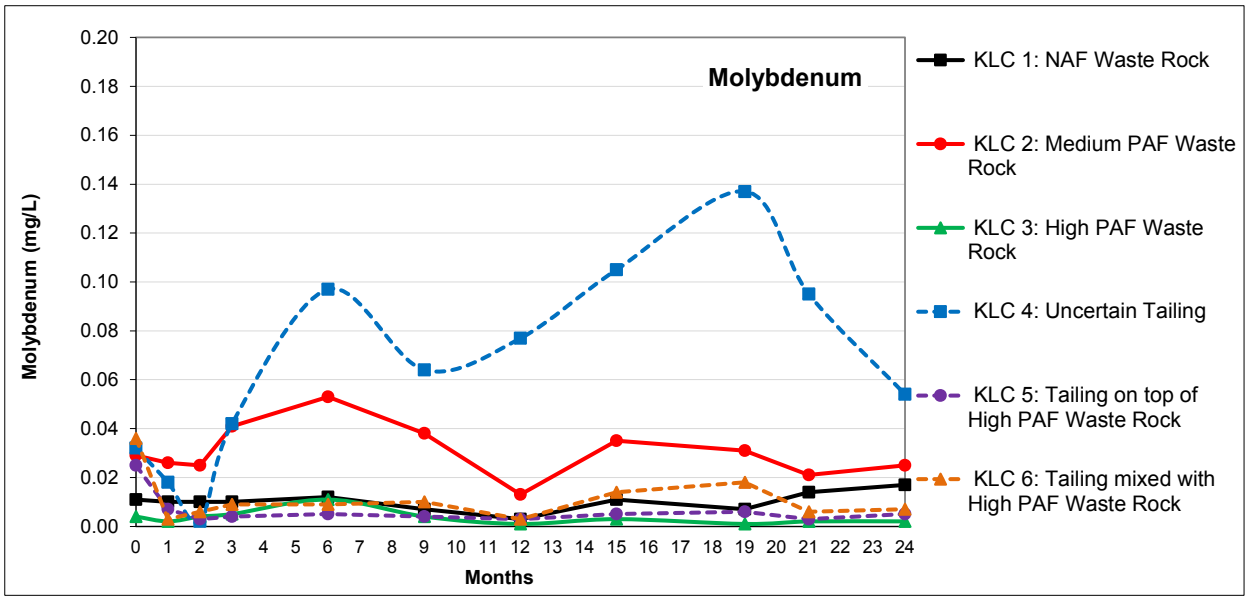

Copper
Copper (mg/L)
12
10
8
6
4
2
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

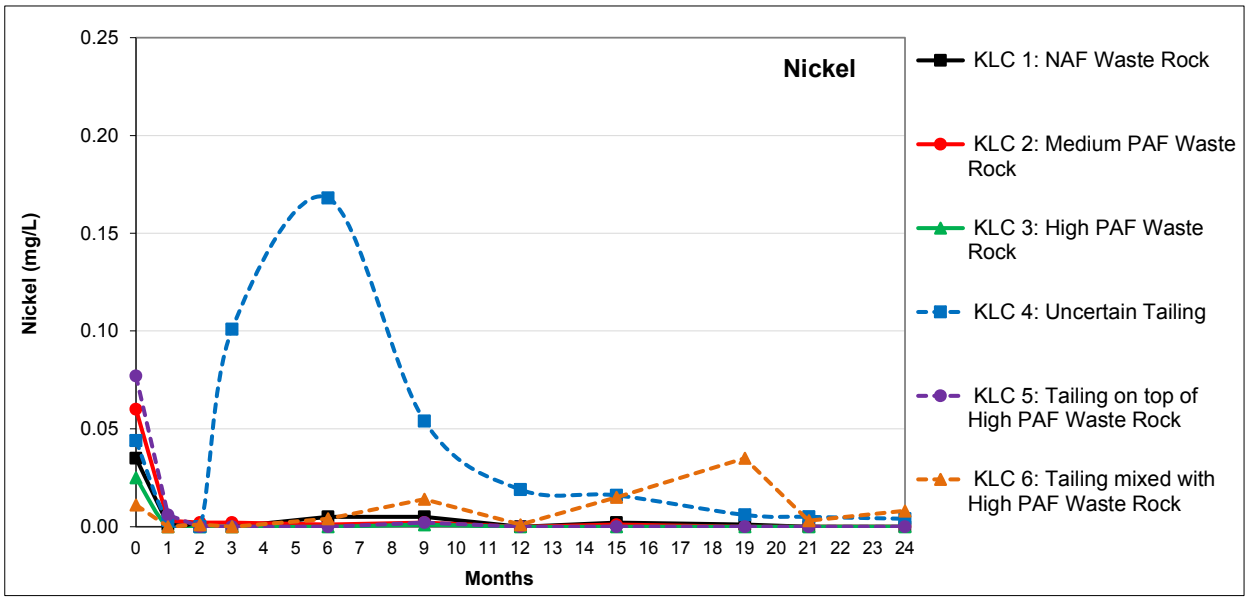

Cobalt
Cobalt (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

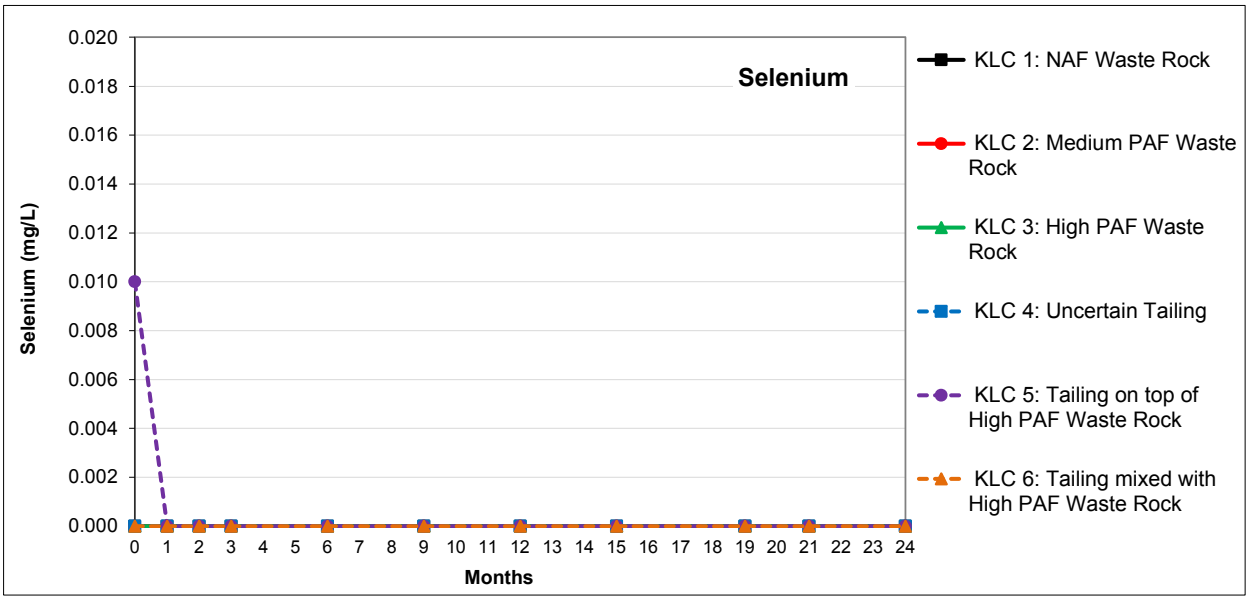

Iron
Iron (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

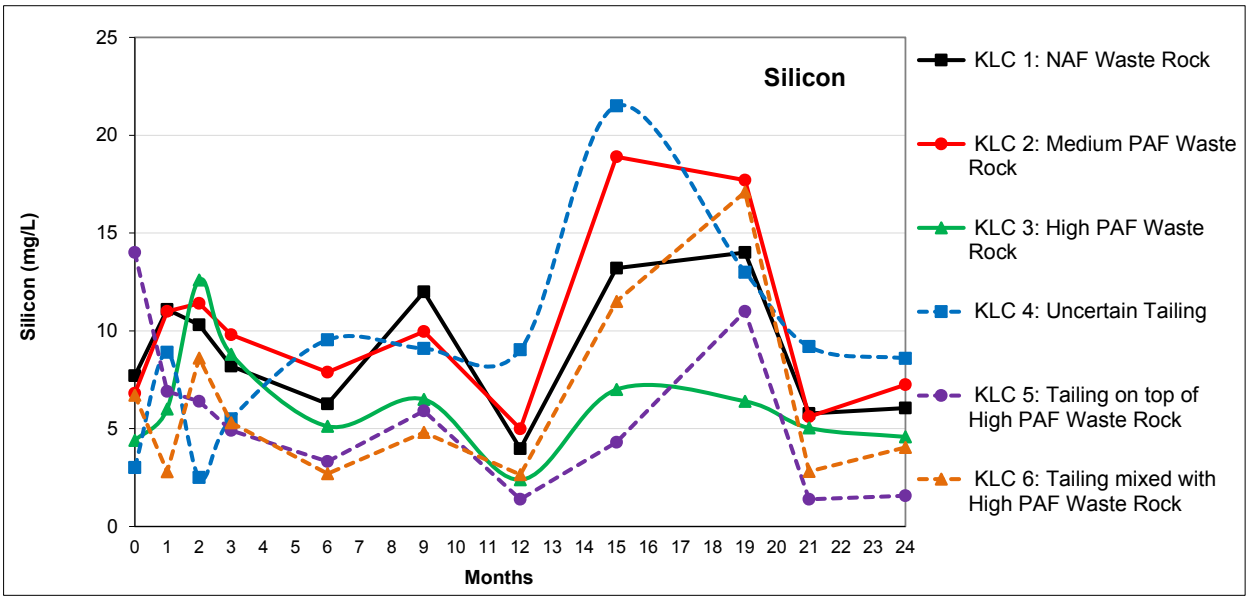

Lead
Lead (mg/L)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

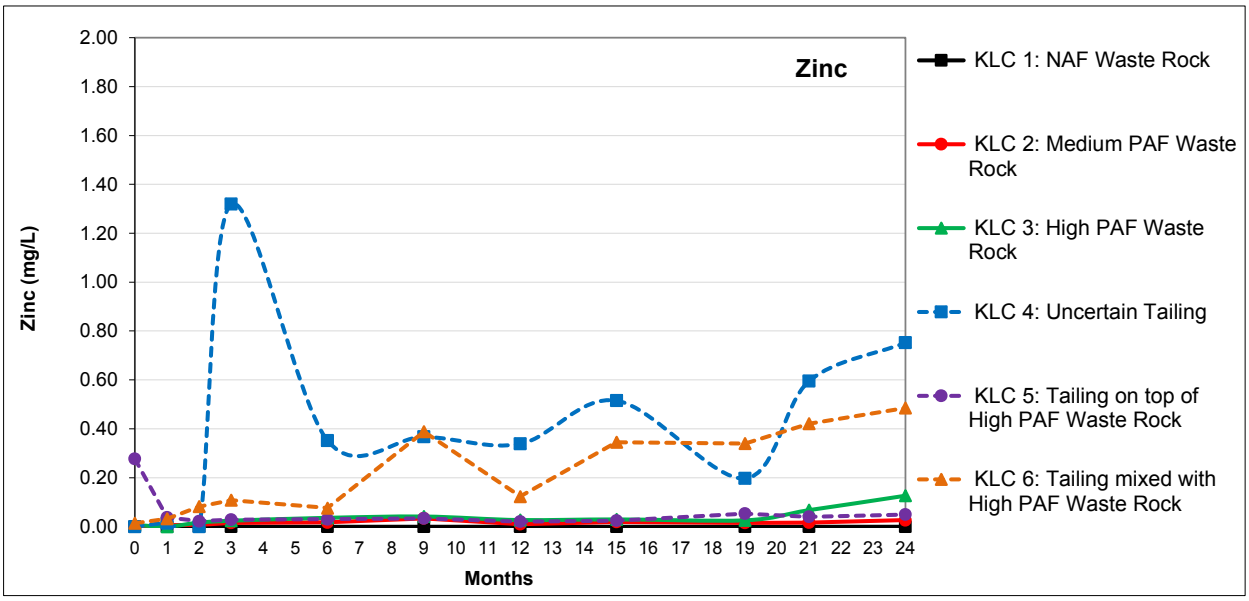

Manganese
Manganese (mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock


Molybdenum
Molybdenum (mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock


Nickel
Nickel (mg/L)
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock


Selenium
Selenium (mg/L)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock


Silicon
Silicon (mg/L)
25
20
15
10
5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock


Zinc
Zinc (mg/L)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Months
KLC 1: NAF Waste Rock
KLC 2: Medium PAF Waste Rock
KLC 3: High PAF Waste Rock
KLC 4: Uncertain Tailing
KLC 5: Tailing on top of High PAF Waste Rock
KLC 6: Tailing mixed with High PAF Waste Rock

9.3 Attachment C: ALS, Trilab and Levay & Co. Laboratory results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1619048**	Page	: 1 of 2
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	:
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon	Date Samples Received	: 28-Jul-2016 09:40
Order number	: ----	Date Analysis Commenced	: 29-Aug-2016
C-O-C number	: ----	Issue Date	: 31-Aug-2016 17:00
Sampler	: MARK GASTALDON - MT RAWDON		
Site	: ----		
Quote number	: ----		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Acid Sulphate Soils, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: **ROCK** (Matrix: **SOIL**)			*Client sample ID*	**N**	**M**	**H**	**----**	**----**
			Client sampling date / time	[26-Jul-2016]	[26-Jul-2016]	[26-Jul-2016]	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1619048-001**	**EB1619048-002**	**EB1619048-003**	**--------**	**--------**
				Result	Result	Result	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**9.5**	**9.4**	**9.0**	**----**	**----**
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**-73.7**	**-20.5**	**93.6**	**----**	**----**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**104**	**120**	**187**	**----**	**----**
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**90.2**	**66.1**	**37.7**	**----**	**----**
ANC as CaCO3	----	0.1	% CaCO3	**9.2**	**6.7**	**3.8**	**----**	**----**
Fizz Rating	----	0	Fizz Unit	**2**	**2**	**2**	**----**	**----**
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**0.355**	**1.34**	**3.60**	**----**	**----**
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**0.54**	**1.49**	**4.29**	**----**	**----**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1619582**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7222
Project	: 2016019 Mt Rawdon	Date Samples Received	: 03-Aug-2016 10:55
Order number	: ----	Date Analysis Commenced	: 08-Aug-2016
C-O-C number	: ----	Issue Date	: 18-Aug-2016 13:30
Sampler	: Mark Gastaldon - Mt Rawdon		
Site	: ----		
Quote number	: ----		
No. of samples received	: 2		
No. of samples analysed	: 2		

NATA Accredited Laboratory 825
Accredited for compliance with
ISO/IEC 17025.

NATA
WORLD RECOGNISED ACCREDITATION

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris		Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	Tailings	----	----	----	----
			Client sampling date / time	[02-Aug-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1619582-001	--------	--------	--------	--------
				Result	----	----	----	----
EA002 : pH (Soils)								
pH Value	----	0.1	pH Unit	**10.1**	----	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	**10.8**	----	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**335**	----	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	**35.4**	----	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	**3.6**	----	----	----	----
Fizz Rating	----	0	Fizz Unit	**2**	----	----	----	----
EA026 : Chromium Reducible Sulfur								
Chromium Reducible Sulphur	----	0.005	%	**1.22**	----	----	----	----
EA055: Moisture Content								
Moisture Content (dried @ 103°C)	----	1	%	**25.3**	----	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	**1.51**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Client sample ID	**Blank DI water used in 1:5.**	----	----	----	----
			Client sampling date / time	[02-Aug-2016]	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB1619582-002**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.19**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	<1	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1621104**	Page	: 1 of 3
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	:
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon	Date Samples Received	: 26-Aug-2016 11:08
Order number	: ----	Date Analysis Commenced	: 26-Aug-2016
C-O-C number	: ----	Issue Date	: 01-Sep-2016 15:50
Sampler	: ----		
Site	: ----		
Quote number	: ----		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **This work order has been created to rebatch samples from previous ALS workorder EB1619048 and EB1619582.**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	EB1619048-001 N	EB1619048-002 M	EB1619048-003 H	EB1619582-001 Tailings SLurry	----
			Client sampling date / time	[26-Jul-2016]	[26-Jul-2016]	[26-Jul-2016]	[26-Jul-2016]	----
Compound	CAS Number	LOR	Unit	EB1621104-001	EB1621104-002	EB1621104-003	EB1621104-004	--------
				Result	Result	Result	Result	----
ED093S: Soluble Major Cations								
Calcium	7440-70-2	10	mg/kg	90	100	70	90	----
Magnesium	7439-95-4	10	mg/kg	20	20	10	20	----
Sodium	7440-23-5	10	mg/kg	70	50	20	220	----
Potassium	7440-09-7	10	mg/kg	50	90	80	110	----
EG005T: Total Metals by ICP-AES								
Aluminium	7429-90-5	50	mg/kg	22700	12200	8000	11300	----
Boron	7440-42-8	50	mg/kg	<50	<50	<50	<50	----
Iron	7439-89-6	50	mg/kg	39200	24200	39700	28500	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.1	mg/kg	7.5	25.5	25.9	134	----
Selenium	7782-49-2	1	mg/kg	<1	<1	<1	<1	----
Silver	7440-22-4	0.1	mg/kg	<0.1	0.2	2.5	1.3	----
Barium	7440-39-3	0.1	mg/kg	28.9	39.8	19.7	68.5	----
Thallium	7440-28-0	0.1	mg/kg	<0.1	<0.1	<0.1	0.1	----
Beryllium	7440-41-7	0.1	mg/kg	0.6	0.6	0.4	0.5	----
Cadmium	7440-43-9	0.1	mg/kg	<0.1	0.2	4.0	8.6	----
Bismuth	7440-69-9	0.1	mg/kg	0.2	1.1	11.6	22.2	----
Cobalt	7440-48-4	0.1	mg/kg	15.4	9.0	9.8	6.9	----
Chromium	7440-47-3	0.1	mg/kg	35.1	82.5	30.0	25.8	----
Copper	7440-50-8	0.1	mg/kg	8.8	26.9	140	358	----
Thorium	7440-29-1	0.1	mg/kg	1.4	2.4	1.7	4.2	----
Manganese	7439-96-5	0.1	mg/kg	2260	1940	1950	1180	----
Strontium	7440-24-6	0.1	mg/kg	109	70.0	43.1	68.4	----
Molybdenum	7439-98-7	0.1	mg/kg	0.6	1.9	1.0	1.9	----
Nickel	7440-02-0	0.1	mg/kg	10.4	28.6	12.1	12.2	----
Lead	7439-92-1	0.1	mg/kg	4.0	8.3	160	52.6	----
Antimony	7440-36-0	0.1	mg/kg	0.6	3.5	1.3	0.5	----
Uranium	7440-61-1	0.1	mg/kg	0.1	0.4	0.2	0.6	----
Zinc	7440-66-6	0.5	mg/kg	141	126	748	1490	----
Lithium	7439-93-2	0.1	mg/kg	50.3	30.8	17.8	10.6	----
Vanadium	7440-62-2	1	mg/kg	72	25	11	17	----
Tin	7440-31-5	0.1	mg/kg	1.2	0.9	0.6	0.7	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1621999**	Page	: 1 of 2
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7222
Project	: 2016019 Mt Rawdon	Date Samples Received	: 07-Sep-2016 10:37
Order number	: ----	Date Analysis Commenced	: 08-Sep-2016
C-O-C number	: ----	Issue Date	: 13-Sep-2016 12:49
Sampler	: Mark Gastaldon - Mt Rawdon		
Site	: ----		
Quote number	: ----		
No. of samples received	: 1		
No. of samples analysed	: 1		

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This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **SOIL** (Matrix: **SOIL**)				Client sample ID	**Tailings**	----	----	----	----
				Client sampling date / time	[02-Aug-2016]	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**EB1621999-001**	--------	--------	--------	--------
					Result	----	----	----	----
EA055: Moisture Content									
Moisture Content (dried @ 103°C)	----	1	%		**20.6**	----	----	----	----
EK026SF: Total CN by Segmented Flow Analyser									
Total Cyanide	57-12-5	1	mg/kg		**12**	----	----	----	----
EK028SF: Weak Acid Dissociable CN by Segmented Flow Analyser									
Weak Acid Dissociable Cyanide	----	1	mg/kg		<1	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1621323**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7222
Project	: 201417 Mt Rawdon Tailings Project	Date Samples Received	: 30-Aug-2016 13:50
Order number	: ----	Date Analysis Commenced	: 01-Sep-2016
C-O-C number	: ----	Issue Date	: 05-Sep-2016 08:54
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: ----		
No. of samples received	: 6		
No. of samples analysed	: 6		

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **LIQUID**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Waste Rock (NAF) Leachate	Mt Rawdon Waste Rock (Moderate PAF) Leachate	Mt Rawdon Waste Rock (High PAF) Leachate	Mt Rawdon Tailings Leachate	Mt Rawdon Waste Rock (High PAF) + Tailings Leachate
				Client sampling date / time	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]
					EB1621323-001	EB1621323-002	EB1621323-003	EB1621323-004	EB1621323-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.82**	**7.68**	**7.71**	**8.53**	**7.79**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**315**	**735**	**623**	**559**	**3880**
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	**6**	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**65**	**45**	**43**	**35**	**73**
Total Alkalinity as CaCO3	----	1	mg/L		**65**	**45**	**43**	**40**	**73**
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		<1	**2**	**1**	<1	**3**
ED040F: Dissolved Major Anions									
Sulfate as SO4 2-	14808-79-8	1	mg/L		**74**	**316**	**267**	**182**	**2180**
Silicon as SiO2	14464-46-1	0.1	mg/L		**7.7**	**6.8**	**4.4**	**3.0**	**14.0**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**77**	**314**	**232**	**158**	**1920**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**7**	**8**	**9**	**28**	**313**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**14**	**92**	**69**	**14**	**363**
Magnesium	7439-95-4	1	mg/L		**4**	**14**	**14**	**2**	**82**
Sodium	7440-23-5	1	mg/L		**40**	**28**	**25**	**80**	**427**
Potassium	7440-09-7	1	mg/L		**6**	**19**	**16**	**18**	**64**
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.01**	<0.01	**0.01**	**0.27**	<0.01
Antimony	7440-36-0	0.001	mg/L		**0.029**	**0.018**	**0.011**	**0.022**	**0.028**
Arsenic	7440-38-2	0.001	mg/L		**0.002**	**0.004**	<0.001	**0.180**	**0.002**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	**0.0001**	**0.0004**	<0.0001	**0.0016**
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		**0.009**	**0.006**	**0.025**	**3.08**	**11.0**
Cobalt	7440-48-4	0.001	mg/L		<0.001	**0.002**	**0.004**	**0.004**	**0.022**
Nickel	7440-02-0	0.001	mg/L		**0.035**	**0.060**	**0.025**	**0.044**	**0.077**
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	**0.002**	<0.001	**0.003**

Analytical Results

Sub-Matrix: **LIQUID** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Waste Rock (NAF) Leachate	Mt Rawdon Waste Rock (Moderate PAF) Leachate	Mt Rawdon Waste Rock (High PAF) Leachate	Mt Rawdon Tailings Leachate	Mt Rawdon Waste Rock (High PAF) + Tailings Leachate
				Client sampling date / time	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]	[30-Aug-2016]
					EB1621323-001	**EB1621323-002**	**EB1621323-003**	**EB1621323-004**	**EB1621323-005**
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		<0.005	<0.005	**0.007**	<0.005	**0.277**
Manganese	7439-96-5	0.001	mg/L		**0.020**	**0.238**	**0.396**	**0.009**	**2.90**
Molybdenum	7439-98-7	0.001	mg/L		**0.011**	**0.029**	**0.004**	**0.032**	**0.025**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	**0.01**
Boron	7440-42-8	0.05	mg/L		**0.07**	<0.05	<0.05	**0.07**	**0.05**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	**0.06**	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.6**	**0.3**	**0.4**	**0.1**	**0.7**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**3.10**	**7.66**	**5.94**	**4.88**	**50.3**
Total Cations	----	0.01	meq/L		**2.92**	**7.45**	**6.09**	**4.80**	**45.1**
Ionic Balance	----	0.01	%		**2.98**	**1.39**	**1.26**	**0.80**	**5.43**

Analytical Results

Sub-Matrix: **LIQUID** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID: Mt Rawdon Waste Rock (High PAF) + Tailings Leachate	----	----	----	----
Client sampling date / time				[30-Aug-2016]	----	----	----	----
				EB1621323-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.71**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1410**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**52**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**52**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	----	----	----	----
ED040F: Dissolved Major Anions								
Sulfate as SO4 2-	14808-79-8	1	mg/L	**614**	----	----	----	----
Silicon as SiO2	14464-46-1	0.1	mg/L	**6.7**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**473**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**90**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**82**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**14**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**174**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**40**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.06**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.093**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.035**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0003**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**1.66**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.006**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.011**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----

Analytical Results

Sub-Matrix: LIQUID (Matrix: WATER)				Client sample ID	Mt Rawdon Waste Rock (High PAF) + Tailings Leachate	----	----	----	----
				Client sampling date / time	[30-Aug-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1621323-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Zinc	7440-66-6	0.005	mg/L		**0.014**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.082**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.036**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.08**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**13.4**	----	----	----	----
Total Cations	----	0.01	meq/L		**13.8**	----	----	----	----
Ionic Balance	----	0.01	%		**1.50**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1623451**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	:
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 201417 Mt Rawdon Waste Rock Project	Date Samples Received	: 28-Sep-2016 13:40
Order number	: ----	Date Analysis Commenced	: 29-Sep-2016
C-O-C number	: ----	Issue Date	: 05-Oct-2016 09:32
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: ----		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
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- General Comments
- Analytical Results

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **LEACHATE** (Matrix: **WATER**)

				Client sample ID	Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF + Tailings)
				Client sampling date / time	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]
Compound	CAS Number	LOR	Unit		EB1623451-001	EB1623451-002	EB1623451-003	EB1623451-004	EB1623451-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		7.38	6.81	6.86	7.06	6.68
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		318	815	312	1520	1110
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		43	28	27	42	26
Total Alkalinity as CaCO3	----	1	mg/L		43	28	27	42	26
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		<1	2	1	4	3
ED040F: Dissolved Major Anions									
Silicon as SiO2	14464-46-1	0.1	mg/L		11.1	11.0	6.0	8.9	6.9
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		110	389	128	469	461
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		4	4	2	126	52
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		20	111	38	56	97
Magnesium	7439-95-4	1	mg/L		6	17	6	6	18
Sodium	7440-23-5	1	mg/L		32	24	12	172	94
Potassium	7440-09-7	1	mg/L		3	11	2	43	21
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.06	0.02	0.05	0.05	0.02
Antimony	7440-36-0	0.001	mg/L		0.167	0.101	0.051	0.169	0.059
Arsenic	7440-38-2	0.001	mg/L		0.002	0.008	<0.001	0.014	0.005
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	0.0001	0.0004	0.0015
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		0.001	0.001	0.004	0.005	0.012
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	0.004	0.004
Nickel	7440-02-0	0.001	mg/L		0.001	0.003	<0.001	0.003	0.006
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	0.002	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L		<0.005	0.005	<0.005	0.014	0.037

Analytical Results

Sub-Matrix: **LEACHATE** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF + Tailings)
				Client sampling date / time	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]	[27-Sep-2016]
					EB1623451-001	EB1623451-002	EB1623451-003	EB1623451-004	EB1623451-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.026**	**0.487**	**0.143**	**0.073**	**0.592**
Molybdenum	7439-98-7	0.001	mg/L		**0.010**	**0.026**	**0.002**	**0.018**	**0.007**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.19**	**0.12**	**0.20**	**0.20**	**0.07**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	**0.3**	**0.2**	**0.1**	**0.2**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**3.26**	**8.77**	**3.26**	**14.2**	**11.6**
Total Cations	----	0.01	meq/L		**2.96**	**8.26**	**2.96**	**11.9**	**10.9**
Ionic Balance	----	0.01	%		**4.86**	**2.94**	**4.76**	**8.80**	**2.81**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	Mt Rawdon Waste Rock (High PAF + Tailings)	----	----	----	----
			Client sampling date / time	[27-Sep-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1623451-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.62**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1340**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**60**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**60**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**5**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**2.8**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**594**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**34**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**90**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**19**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**140**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**27**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.011**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0014**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.008**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.032**	----	----	----	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	Mt Rawdon Waste Rock (High PAF + Tailings)	----	----	----	----
				Client sampling date / time	[27-Sep-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1623451-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.607**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.003**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**14.5**	----	----	----	----
Total Cations	----	0.01	meq/L		**12.8**	----	----	----	----
Ionic Balance	----	0.01	%		**6.18**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1626138**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Carsten Emrich
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61 7 3243 7222
Project	: 201417 Mt Rawdon Waste Rock Project	Date Samples Received	: 02-Nov-2016 14:10
Order number	: ----	Date Analysis Commenced	: 02-Nov-2016
C-O-C number	: ----	Issue Date	: 15-Nov-2016 14:25
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: ----		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

				Client sample ID	Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF) + Tailings
				Client sampling date / time	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]
Compound	CAS Number	LOR	Unit		EB1626138-001	EB1626138-002	EB1626138-003	EB1626138-004	EB1626138-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		8.04	7.52	7.54	8.16	7.15
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		423	853	516	535	550
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		34	32	30	34	28
Total Alkalinity as CaCO3	----	1	mg/L		34	32	30	34	28
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		10	14	6	1	3
ED040F: Dissolved Major Anions									
Silicon as SiO2	14464-46-1	0.1	mg/L		10.3	11.4	12.6	2.5	6.4
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		144	419	220	183	218
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		3	2	1	24	7
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		30	136	66	19	48
Magnesium	7439-95-4	1	mg/L		8	15	12	2	6
Sodium	7440-23-5	1	mg/L		34	19	17	83	38
Potassium	7440-09-7	1	mg/L		3	7	4	13	10
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		0.04	0.02	0.01	0.12	0.03
Antimony	7440-36-0	0.001	mg/L		0.079	0.046	0.075	0.008	0.018
Arsenic	7440-38-2	0.001	mg/L		0.002	0.010	<0.001	0.006	0.004
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	0.0007	0.0002	0.0008
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		0.001	0.001	0.002	<0.001	0.003
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	0.002	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	0.004	<0.001	0.001
Zinc	7440-66-6	0.005	mg/L		<0.005	0.007	0.016	<0.005	0.022

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF) + Tailings
				Client sampling date / time	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]	[02-Nov-2016]
					EB1626138-001	EB1626138-002	EB1626138-003	EB1626138-004	EB1626138-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**0.040**	**0.179**	**0.262**	**0.043**	**0.386**
Molybdenum	7439-98-7	0.001	mg/L		**0.010**	**0.025**	**0.004**	**0.002**	**0.003**
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.21**	**0.15**	**0.16**	**0.07**	**0.06**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	**0.3**	**0.3**	<0.1	**0.3**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**3.76**	**9.42**	**5.21**	**5.17**	**5.30**
Total Cations	----	0.01	meq/L		**3.71**	**9.03**	**5.12**	**5.06**	**4.80**
Ionic Balance	----	0.01	%		**0.68**	**2.13**	**0.82**	**1.08**	**4.93**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Mt Rawdon Waste Rock (High PAF) + Tailings	----	----	----	----
			Client sampling date / time	[02-Nov-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1626138-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.52**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2240**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**32**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**32**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**3**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**8.6**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1130**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**47**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**187**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**32**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**232**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**44**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.02**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.032**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0033**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.001**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.082**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Mt Rawdon Waste Rock (High PAF) + Tailings	----	----	----	----
				Client sampling date / time	[02-Nov-2016]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1626138-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**1.30**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.006**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.14**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**25.5**	----	----	----	----
Total Cations	----	0.01	meq/L		**23.2**	----	----	----	----
Ionic Balance	----	0.01	%		**4.75**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1628241**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 29-Nov-2016 15:45
Order number	: ----	Date Analysis Commenced	: 30-Nov-2016
C-O-C number	: ----	Issue Date	: 12-Dec-2016 14:35
Sampler	: MINGRUI YUAN		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 6		
No. of samples analysed	: 6		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF) + Tailings
				Client sampling date / time	29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00
					EB1628241-001	EB1628241-002	EB1628241-003	EB1628241-004	EB1628241-005
					Result	Result	Result	Result	Result
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**7.52**	**7.43**	**7.44**	**7.49**	**7.20**
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**441**	**1060**	**471**	**5220**	**492**
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**34**	**26**	**22**	**70**	**25**
Total Alkalinity as CaCO3	----	1	mg/L		**34**	**26**	**22**	**70**	**25**
ED038A: Acidity									
Acidity as CaCO3	----	1	mg/L		**2**	**2**	**2**	**2**	**4**
ED040F: Dissolved Major Anions									
Silicon as SiO2	14464-46-1	0.1	mg/L		**15.8**	**16.7**	**11.9**	**22.9**	**6.0**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**167**	**559**	**186**	**2840**	**194**
ED045G: Chloride by Discrete Analyser									
Chloride	16887-00-6	1	mg/L		**2**	**2**	**1**	**185**	**7**
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**36**	**182**	**62**	**606**	**49**
Magnesium	7439-95-4	1	mg/L		**10**	**18**	**11**	**58**	**6**
Sodium	7440-23-5	1	mg/L		**33**	**18**	**12**	**556**	**25**
Potassium	7440-09-7	1	mg/L		**3**	**8**	**3**	**178**	**12**
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.06**	<0.01	**0.01**	<0.01	**0.02**
Antimony	7440-36-0	0.001	mg/L		**0.106**	**0.063**	**0.045**	**0.091**	**0.014**
Arsenic	7440-38-2	0.001	mg/L		**0.003**	**0.015**	<0.001	**0.013**	**0.004**
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	**0.0009**	**0.0207**	**0.0013**
Chromium	7440-47-3	0.001	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L		**0.007**	**0.001**	**0.002**	**0.010**	**0.002**
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	<0.001	**0.014**	<0.001
Nickel	7440-02-0	0.001	mg/L		<0.001	**0.002**	<0.001	**0.101**	<0.001
Lead	7439-92-1	0.001	mg/L		<0.001	<0.001	**0.005**	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L		<0.005	**0.015**	**0.024**	**1.32**	**0.028**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID: Mt Rawdon Waste Rock (NAF)	Mt Rawdon Waste Rock (Moderate PAF)	Mt Rawdon Waste Rock (High PAF)	Mt Rawdon Tailings	Mt Rawdon Waste Rock (High PAF) + Tailings
Client sampling date / time				29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00	29-Nov-2016 00:00
				EB1628241-001	**EB1628241-002**	**EB1628241-003**	**EB1628241-004**	**EB1628241-005**
				Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued								
Manganese	7439-96-5	0.001	mg/L	**0.024**	**0.069**	**0.165**	**6.17**	**0.421**
Molybdenum	7439-98-7	0.001	mg/L	**0.010**	**0.041**	**0.005**	**0.042**	**0.004**
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L	**0.35**	**0.30**	**0.16**	**0.56**	**0.10**
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	**0.4**	**0.3**	**0.3**	**0.2**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	Mt Rawdon Waste Rock (High PAF) + Tailings	----	----	----	----
			Client sampling date / time	29-Nov-2016 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1628241-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.41**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1800**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**27**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**27**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**3**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**6.4**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**855**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**32**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**136**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**29**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**172**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**37**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.01**	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.011**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0049**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.004**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.001**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.108**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Mt Rawdon Waste Rock (High PAF) + Tailings	----	----	----	----
				Client sampling date / time	29-Nov-2016 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1628241-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Manganese	7439-96-5	0.001	mg/L		**1.21**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.009**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.14**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1703876**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 28-Feb-2017 16:40
Order number	: ----	Date Analysis Commenced	: 02-Mar-2017
C-O-C number	: ----	Issue Date	: 07-Mar-2017 21:12
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 5		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
			Client sampling date / time	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00
Compound	CAS Number	LOR	Unit	EB1703876-001	EB1703876-002	EB1703876-003	EB1703876-004	EB1703876-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.22	7.13	7.15	7.34	7.25
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	398	1030	522	701	1600
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	26	21	20	24	21
Total Alkalinity as CaCO3	----	1	mg/L	26	21	20	24	21
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	1	2	2	4	1
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	6.27	7.88	5.12	3.32	2.69
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	152	547	228	303	745
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	3	31
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	35	192	82	91	141
Magnesium	7439-95-4	1	mg/L	10	16	11	12	34
Sodium	7440-23-5	1	mg/L	30	23	11	36	170
Potassium	7440-09-7	1	mg/L	3	7	4	14	40
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.01	0.01	0.02	0.01
Antimony	7440-36-0	0.001	mg/L	0.050	0.099	0.053	0.013	0.018
Arsenic	7440-38-2	0.001	mg/L	0.002	0.021	<0.001	0.006	0.003
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0001	0.0012	0.0022	0.0065
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.005	0.004	0.010	0.010
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.002
Nickel	7440-02-0	0.001	mg/L	0.005	0.001	<0.001	<0.001	0.004
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.002	<0.001	0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.017	0.036	0.030	0.076
Manganese	7439-96-5	0.001	mg/L	0.019	0.014	0.093	0.487	0.607
Molybdenum	7439-98-7	0.001	mg/L	0.012	0.053	0.011	0.005	0.009

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
				Client sampling date / time	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00	28-Feb-2017 00:00
Compound	CAS Number	LOR	Unit		EB1703876-001	EB1703876-002	EB1703876-003	EB1703876-004	EB1703876-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.44**	**0.81**	**0.27**	**0.15**	**0.11**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	**0.4**	**0.3**	**0.3**	**0.3**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1704234**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 03-Mar-2017 14:25
Order number	: ----	Date Analysis Commenced	: 07-Mar-2017
C-O-C number	: ----	Issue Date	: 13-Mar-2017 16:56
Sampler	: Mary MacElroy		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KCL 4	----	----	----	----
			Client sampling date / time	[03-Mar-2017]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1704234-001	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.70**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**4830**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**28**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**28**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**2**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**9.54**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2750**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**117**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**479**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**62**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**558**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**198**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.057**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.022**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0104**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.014**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.013**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.168**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.352**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**1.80**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.097**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KCL 4	----	----	----	----
				Client sampling date / time	[03-Mar-2017]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1704234-001	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.40**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**61.1**	----	----	----	----
Total Cations	----	0.01	meq/L		**58.3**	----	----	----	----
Ionic Balance	----	0.01	%		**2.32**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1711556**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 06-Jun-2017 15:40
Order number	: ----	Date Analysis Commenced	: 09-Jun-2017
C-O-C number	: ----	Issue Date	: 13-Jun-2017 17:00
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
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- Analytical Results

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

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When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Ionic Balance out of acceptable limits due to analytes not quantified in this report.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	[30-May-2017]	[30-May-2017]	[30-May-2017]	[06-Jun-2017]	[30-May-2017]
Compound	CAS Number	LOR	Unit	EB1711556-001	EB1711556-002	EB1711556-003	EB1711556-004	EB1711556-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.55	7.21	7.27	7.25	7.22
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	398	1480	741	3850	1180
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	42	29	46	41	29
Total Alkalinity as CaCO3	----	1	mg/L	42	29	46	41	29
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	1	1	1	2	1
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	12.0	9.97	6.53	9.08	5.90
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	140	832	338	2230	555
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	45	2
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	20	196	62	473	59
Magnesium	7439-95-4	1	mg/L	5	15	8	56	6
Sodium	7440-23-5	1	mg/L	18	17	6	299	34
Potassium	7440-09-7	1	mg/L	1	6	2	128	7
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.047	0.062	0.027	0.068	0.014
Arsenic	7440-38-2	0.001	mg/L	0.002	0.018	<0.001	0.005	0.002
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0002	0.0010	0.0091	0.0018
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.002	0.002	0.011	0.002
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.005	<0.001
Nickel	7440-02-0	0.001	mg/L	0.005	0.002	0.001	0.054	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.001	0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.034	0.041	0.367	0.033
Manganese	7439-96-5	0.001	mg/L	0.005	0.002	0.024	1.61	0.383
Molybdenum	7439-98-7	0.001	mg/L	0.007	0.038	0.004	0.064	0.004

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
				Client sampling date / time	[30-May-2017]	[30-May-2017]	[30-May-2017]	[06-Jun-2017]	[30-May-2017]
Compound	CAS Number	LOR	Unit		EB1711556-001	EB1711556-002	EB1711556-003	EB1711556-004	EB1711556-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.31**	**0.50**	**0.16**	**0.34**	**0.09**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.6**	**0.6**	**0.4**	**0.6**	**0.4**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**3.75**	**17.9**	**7.96**	**48.5**	**12.2**
Total Cations	----	0.01	meq/L		**2.22**	**11.9**	**4.06**	**44.5**	**5.10**
Ionic Balance	----	0.01	%		**25.7**	**20.1**	**32.4**	**4.33**	**41.0**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 6	----	----	----	----
			Client sampling date / time	[06-Jun-2017]	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1711556-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.06**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2010**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**30**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**30**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**4.83**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**994**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**16**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**210**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**35**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**168**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**38**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.031**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.003**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0108**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.010**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.014**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.001**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.388**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.160**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.010**	----	----	----	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 6	----	----	----	----
				Client sampling date / time	[06-Jun-2017]	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1711556-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.18**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**21.7**	----	----	----	----
Total Cations	----	0.01	meq/L		**21.6**	----	----	----	----
Ionic Balance	----	0.01	%		**0.25**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1718207**	Page	: 1 of 6
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 05-Sep-2017 17:05
Order number	: ----	Date Analysis Commenced	: 06-Sep-2017
C-O-C number	: ----	Issue Date	: 13-Sep-2017 09:19
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: BNBQ/218/16		
No. of samples received	: 6		
No. of samples analysed	: 6		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
			Client sampling date / time	29-Aug-2017 00:00	29-Aug-2017 00:00	29-Aug-2017 00:00	05-Sep-2017 00:00	29-Aug-2017 00:00
Compound	CAS Number	LOR	Unit	EB1718207-001	EB1718207-002	EB1718207-003	EB1718207-004	EB1718207-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.40	7.15	7.07	7.38	7.43
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	239	690	284	2840	1090
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	33	26	15	38	27
Total Alkalinity as CaCO3	----	1	mg/L	33	26	15	38	27
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	3	2	6	1
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	3.97	4.98	2.39	9.03	1.38
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	81	323	116	1790	503
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	9	2
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	24	133	46	512	81
Magnesium	7439-95-4	1	mg/L	5	8	4	34	21
Sodium	7440-23-5	1	mg/L	15	11	5	119	129
Potassium	7440-09-7	1	mg/L	1	4	2	82	20
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.013	0.018	0.013	0.031	0.003
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.006	<0.001	0.005	0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0006	0.0115	0.0018
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.005	0.007	0.002
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	0.003	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.019	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.010	0.027	0.339	0.021
Manganese	7439-96-5	0.001	mg/L	0.014	0.012	0.055	1.53	0.271
Molybdenum	7439-98-7	0.001	mg/L	0.003	0.013	0.001	0.077	0.003

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 4	KLC 5
				Client sampling date / time	29-Aug-2017 00:00	29-Aug-2017 00:00	29-Aug-2017 00:00	05-Sep-2017 00:00	29-Aug-2017 00:00
Compound	CAS Number	LOR	Unit		EB1718207-001	EB1718207-002	EB1718207-003	EB1718207-004	EB1718207-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.12**	**0.18**	**0.07**	**0.21**	<0.05
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.3**	**0.1**	**0.4**	**0.2**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**2.34**	**7.24**	**2.71**	**38.3**	**11.1**
Total Cations	----	0.01	meq/L		**2.29**	**7.88**	**2.89**	**35.6**	**11.9**
Ionic Balance	----	0.01	%		**----**	**4.18**	**3.18**	**3.60**	**3.59**

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 6	----	----	----	----
			Client sampling date / time	29-Aug-2017 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1718207-006	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.40**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2120**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**30**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**30**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**2**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**2.64**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1010**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**24**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**208**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**48**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**246**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**52**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.004**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0054**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.003**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.001**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.123**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.051**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.003**	----	----	----	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 6	----	----	----	----
				Client sampling date / time	29-Aug-2017 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1718207-006	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.05**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**22.3**	----	----	----	----
Total Cations	----	0.01	meq/L		**26.4**	----	----	----	----
Ionic Balance	----	0.01	%		**8.33**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1725119**	Page	: 1 of 4
Amendment	: **1**		
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 28-Nov-2017 16:45
Order number	: ----	Date Analysis Commenced	: 29-Nov-2017
C-O-C number	: ----	Issue Date	: 09-Apr-2018 13:19
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 4		
No. of samples analysed	: 4		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	----
			Client sampling date / time	28-Nov-2017 00:00	28-Nov-2017 00:00	28-Nov-2017 00:00	28-Nov-2017 00:00	----
Compound	CAS Number	LOR	Unit	EB1725119-001	EB1725119-002	EB1725119-003	EB1725119-004	--------
				Result	Result	Result	Result	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.75**	**7.44**	**7.34**	**7.65**	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**267**	**842**	**294**	**604**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**32**	**22**	**16**	**17**	----
Total Alkalinity as CaCO3	----	1	mg/L	**32**	**22**	**16**	**17**	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**1**	**3**	**2**	**1**	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**13.2**	**18.9**	**7.0**	**4.3**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**93**	**405**	**120**	**250**	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**1**	<1	<1	<1	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**23**	**150**	**43**	**58**	----
Magnesium	7439-95-4	1	mg/L	**5**	**10**	**4**	**10**	----
Sodium	7440-23-5	1	mg/L	**19**	**16**	**6**	**34**	----
Potassium	7440-09-7	1	mg/L	**2**	**4**	**2**	**12**	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.04**	**0.02**	**0.02**	**0.02**	----
Antimony	7440-36-0	0.001	mg/L	**0.040**	**0.092**	**0.032**	**0.008**	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.017**	<0.001	**0.003**	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	**0.0002**	**0.0009**	**0.0019**	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Copper	7440-50-8	0.001	mg/L	**0.004**	**0.003**	**0.003**	**0.004**	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----
Nickel	7440-02-0	0.001	mg/L	**0.002**	**0.001**	<0.001	<0.001	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	**0.002**	<0.001	----
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.019**	**0.030**	**0.024**	----
Manganese	7439-96-5	0.001	mg/L	**0.033**	**0.024**	**0.087**	**0.217**	----
Molybdenum	7439-98-7	0.001	mg/L	**0.011**	**0.035**	**0.003**	**0.005**	----

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	----
				Client sampling date / time	28-Nov-2017 00:00	28-Nov-2017 00:00	28-Nov-2017 00:00	28-Nov-2017 00:00	----
Compound	CAS Number	LOR	Unit		EB1725119-001	EB1725119-002	EB1725119-003	EB1725119-004	--------
					Result	Result	Result	Result	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
Boron	7440-42-8	0.05	mg/L		**0.39**	**0.70**	**0.20**	**0.14**	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.4**	**0.1**	**0.1**	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**2.60**	**8.87**	**2.82**	**5.54**	----
Total Cations	----	0.01	meq/L		**2.44**	**9.11**	**2.79**	**5.50**	----
Ionic Balance	----	0.01	%		**----**	**1.30**	**----**	**0.38**	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1725503**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 01-Dec-2017 15:20
Order number	: ----	Date Analysis Commenced	: 04-Dec-2017
C-O-C number	: ----	Issue Date	: 11-Dec-2017 15:27
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 4	KLC 6	----	----	----
			Client sampling date / time	01-Dec-2017 00:00	01-Dec-2017 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1725503-001	EB1725503-002	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.65	6.96	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	2700	1940	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	40	37	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	40	37	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	4	3	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	21.5	11.5	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	1350	931	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	3	18	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	535	236	----	----	----
Magnesium	7439-95-4	1	mg/L	29	35	----	----	----
Sodium	7440-23-5	1	mg/L	74	130	----	----	----
Potassium	7440-09-7	1	mg/L	76	45	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	----	----	----
Antimony	7440-36-0	0.001	mg/L	0.044	0.034	----	----	----
Arsenic	7440-38-2	0.001	mg/L	0.008	0.004	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	0.0155	0.0097	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	0.004	0.002	----	----	----
Cobalt	7440-48-4	0.001	mg/L	0.003	<0.001	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.016	0.015	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	0.516	0.345	----	----	----
Manganese	7439-96-5	0.001	mg/L	1.92	0.057	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	0.105	0.014	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 4	KLC 6	----	----	----
				Client sampling date / time	01-Dec-2017 00:00	01-Dec-2017 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1725503-001	EB1725503-002	--------	--------	--------
					Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.25**	**0.25**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.2**	**0.3**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**29.0**	**20.6**	----	----	----
Total Cations	----	0.01	meq/L		**34.2**	**21.5**	----	----	----
Ionic Balance	----	0.01	%		**8.31**	**1.98**	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1808038**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 28-Mar-2018 13:30
Order number	:	Date Analysis Commenced	: 29-Mar-2018
C-O-C number	: ----	Issue Date	: 06-Apr-2018 15:23
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 5		
No. of samples analysed	: 5		

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- Analytical Results

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: LEACHATE (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
			Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	CAS Number	LOR	Unit	EB1808038-001	EB1808038-002	EB1808038-003	EB1808038-004	EB1808038-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.33	7.19	7.28	7.47	7.48
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	237	822	309	893	1930
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	35	21	13	25	36
Total Alkalinity as CaCO3	----	1	mg/L	35	21	13	25	36
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	2	3	2	2	3
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	14.0	17.7	6.4	11.0	17.1
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	80	406	124	428	958
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	<1	<1	12
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	19	143	42	120	285
Magnesium	7439-95-4	1	mg/L	4	8	4	14	32
Sodium	7440-23-5	1	mg/L	21	18	7	41	110
Potassium	7440-09-7	1	mg/L	2	4	2	13	42
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.06	<0.01	0.01	0.01	0.02
Antimony	7440-36-0	0.001	mg/L	0.050	0.094	0.032	0.029	0.048
Arsenic	7440-38-2	0.001	mg/L	0.002	0.016	<0.001	0.004	0.005
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0001	0.0010	0.0039	0.0117
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.001	0.001	0.002	0.005	0.006
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	0.001	<0.001	<0.001	<0.001	0.035
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.015	0.026	0.053	0.340
Manganese	7439-96-5	0.001	mg/L	0.025	0.016	0.113	0.246	0.035
Molybdenum	7439-98-7	0.001	mg/L	0.007	0.031	0.001	0.006	0.018

Analytical Results

Sub-Matrix: **LEACHATE** (Matrix: **WATER**)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
				Client sampling date / time	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00	28-Mar-2018 00:00
Compound	*CAS Number*	*LOR*	*Unit*		**EB1808038-001**	**EB1808038-002**	**EB1808038-003**	**EB1808038-004**	**EB1808038-005**
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.58**	**0.85**	**0.24**	**0.33**	**0.51**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	**0.4**	**0.1**	**0.2**	**0.4**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1808901**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 10-Apr-2018 16:00
Order number	:	Date Analysis Commenced	: 12-Apr-2018
C-O-C number	: ----	Issue Date	: 17-Apr-2018 12:19
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 1		
No. of samples analysed	: 1		

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Signatories

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Signatories	*Position*	*Accreditation Category*
Andrew Epps	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

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Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 4	----	----	----	----
			Client sampling date / time	10-Apr-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1808901-001	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.58**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2770**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**43**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**43**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**4**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**13.0**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1950**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**3**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**619**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**31**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**80**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**87**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.060**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.033**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0130**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.010**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.006**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.197**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**1.31**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.137**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 4	----	----	----	----
				Client sampling date / time	10-Apr-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1808901-001	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.52**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.5**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**41.5**	----	----	----	----
Total Cations	----	0.01	meq/L		**39.1**	----	----	----	----
Ionic Balance	----	0.01	%		**2.97**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1813063**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 29-May-2018 16:15
Order number	:	Date Analysis Commenced	: 30-May-2018
C-O-C number	: ----	Issue Date	: 04-Jun-2018 13:58
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 5		
No. of samples analysed	: 5		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
			Client sampling date / time	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00
Compound	CAS Number	LOR	Unit	EB1813063-001	EB1813063-002	EB1813063-003	EB1813063-004	EB1813063-005
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	6.97	6.73	6.71	6.85	6.89
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	294	598	422	625	1930
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	31	16	16	24	28
Total Alkalinity as CaCO3	----	1	mg/L	31	16	16	24	28
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	1	2	2	<1	2
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	5.78	5.61	5.03	1.39	2.81
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	100	273	170	272	928
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	1	<1	<1	2	21
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	24	102	55	59	193
Magnesium	7439-95-4	1	mg/L	7	6	6	13	44
Sodium	7440-23-5	1	mg/L	19	11	9	38	168
Potassium	7440-09-7	1	mg/L	2	2	2	10	52
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	<0.01	<0.01	0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.064	0.070	0.071	0.007	0.013
Arsenic	7440-38-2	0.001	mg/L	0.002	0.011	<0.001	0.002	0.002
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0001	0.0015	0.0030	0.0159
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.001	0.002	0.003	0.006
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.003
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.016	0.067	0.040	0.421
Manganese	7439-96-5	0.001	mg/L	0.019	0.021	0.059	0.167	0.064
Molybdenum	7439-98-7	0.001	mg/L	0.014	0.021	0.002	0.003	0.006

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
				Client sampling date / time	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00	29-May-2018 00:00
Compound	CAS Number	LOR	Unit		EB1813063-001	EB1813063-002	EB1813063-003	EB1813063-004	EB1813063-005
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.45**	**0.46**	**0.34**	**0.10**	**0.19**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.2**	<0.1	<0.1	<0.1
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**2.73**	**6.00**	**3.86**	**6.20**	**20.5**
Total Cations	----	0.01	meq/L		**2.65**	**6.11**	**3.68**	**5.92**	**21.9**
Ionic Balance	----	0.01	%		**----**	**0.90**	**2.36**	**2.28**	**3.34**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1813420**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 01-Jun-2018 16:10
Order number	: 2016019	Date Analysis Commenced	: 04-Jun-2018
C-O-C number	: ----	Issue Date	: 07-Jun-2018 09:17
Sampler	: MARY MACELROY		
Site	: ----		
Quote number	: EN/222/17		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories

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Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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^ = This result is computed from individual analyte detections at or above the level of reporting
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Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 4	----	----	----	----
			Client sampling date / time	01-Jun-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1813420-001	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.45**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**35**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**35**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**2**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**9.19**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1440**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**2**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**467**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**22**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**44**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**51**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.027**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.005**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0246**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.006**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.003**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.005**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.595**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**2.17**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.095**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.24**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 4	----	----	----	----
				Client sampling date / time	01-Jun-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1813420-001	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.4**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**30.7**	----	----	----	----
Total Cations	----	0.01	meq/L		**28.3**	----	----	----	----
Ionic Balance	----	0.01	%		**4.07**	----	----	----	----

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1820820**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 28-Aug-2018 16:15
Order number	:	Date Analysis Commenced	: 28-Aug-2018
C-O-C number	: ----	Issue Date	: 03-Sep-2018 15:41
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 6		
No. of samples analysed	: 5		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

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~ = Indicates an estimated value.

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Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
			Client sampling date / time	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00
Compound	CAS Number	LOR	Unit	EB1820820-001	EB1820820-002	EB1820820-003	EB1820820-005	EB1820820-006
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	7.86	7.45	7.11	7.59	7.47
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	346	709	499	768	2060
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	45	42	15	21	30
Total Alkalinity as CaCO3	----	1	mg/L	45	42	15	21	30
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	<1	2	2	1	2
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	6.05	7.25	4.57	1.57	4.03
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	119	332	202	344	1040
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	1	<1	<1	1	14
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	33	122	68	65	238
Magnesium	7439-95-4	1	mg/L	8	7	8	15	36
Sodium	7440-23-5	1	mg/L	19	12	8	51	141
Potassium	7440-09-7	1	mg/L	2	3	2	10	50
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Antimony	7440-36-0	0.001	mg/L	0.032	0.077	0.052	0.007	0.018
Arsenic	7440-38-2	0.001	mg/L	0.003	0.013	<0.001	0.002	0.004
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.0001	0.0024	0.0033	0.0176
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.004	0.004	0.005
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.008
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	7440-66-6	0.005	mg/L	<0.005	0.026	0.127	0.049	0.486
Manganese	7439-96-5	0.001	mg/L	0.018	0.022	0.071	0.161	0.033
Molybdenum	7439-98-7	0.001	mg/L	0.017	0.025	0.002	0.005	0.007

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 1	KLC 2	KLC 3	KLC 5	KLC 6
				Client sampling date / time	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00	28-Aug-2018 00:00
Compound	CAS Number	LOR	Unit		EB1820820-001	EB1820820-002	EB1820820-003	EB1820820-005	EB1820820-006
					Result	Result	Result	Result	Result
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.05	mg/L		**0.29**	**0.54**	**0.30**	**0.09**	**0.24**
Iron	7439-89-6	0.05	mg/L		<0.05	<0.05	<0.05	<0.05	<0.05
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**0.3**	**0.2**	**0.1**	**0.4**
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**3.40**	**7.75**	**4.50**	**7.61**	**22.6**
Total Cations	----	0.01	meq/L		**3.18**	**7.26**	**4.45**	**6.95**	**22.2**
Ionic Balance	----	0.01	%		**3.37**	**3.26**	**0.61**	**4.52**	**0.88**

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1821049**	Page	: 1 of 4
Client	: **RGS ENVIRONMENTAL PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MR ALAN ROBERTSON	Contact	: Customer Services EB
Address	: PO Box 3091 SUNNYBANK SOUTH QLD, AUSTRALIA 4109	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: +61 07 3344 1222	Telephone	: +61-7-3243 7222
Project	: 2016019 Mt Rawdon Waste Rock Project	Date Samples Received	: 30-Aug-2018 14:15
Order number	:	Date Analysis Commenced	: 31-Aug-2018
C-O-C number	: ----	Issue Date	: 05-Sep-2018 14:50
Sampler	: VERONICA CANALES		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 1		
No. of samples analysed	: 1		

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Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

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Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KLC 4	----	----	----	----
			Client sampling date / time	30-Aug-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1821049-001	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**7.17**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2160**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**64**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**64**	----	----	----	----
ED038A: Acidity								
Acidity as CaCO3	----	1	mg/L	**3**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon	7440-21-3	0.05	mg/L	**8.59**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**1330**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**1**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**528**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**17**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**25**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**45**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Antimony	7440-36-0	0.001	mg/L	**0.026**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.005**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0318**	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.003**	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.004**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.752**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**2.46**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.054**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KLC 4	----	----	----	----
				Client sampling date / time	30-Aug-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1821049-001	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L		**0.18**	----	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	----	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**29.0**	----	----	----	----
Total Cations	----	0.01	meq/L		**30.0**	----	----	----	----
Ionic Balance	----	0.01	%		**1.67**	----	----	----	----

Trilab
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PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS 1289 3.6.1, 2.1.1

Client	RGS Environmental Pty Ltd	**Report No.**	16090382-G
Address	PO Box 3091, Sunnybank South QLD 4109	**Report Date**	21/09/2016
Project	RGSMRO KLC Project		

Sample No.	16090382	16090383	16090384	-	-	-	-
Test Date	21/09/2016	8/09/2016	21/09/2016	-	-	-	-
Client ID	1_NAF Rock - Rock Sample	2_Moderate PAF Rock - Rock Sample	3_High PAF Rock - Rock Sample	-	-	-	-
Depth (m)	Not Supplied	Not Supplied	Not Supplied	-	-	-	-
Moisture (%)	0.3	0.2	0.2	-	-	-	-
AS SIEVE SIZE (mm)	**PERCENT PASSING**						
150				-	-	-	-
75				-	-	-	-
63				-	-	-	-
53				-	-	-	-
37.5				-	-	-	-
26.5	100	100	100	-	-	-	-
19	99	96	96	-	-	-	-
13.2	78	61	64	-	-	-	-
9.5	51	34	37	-	-	-	-
6.7	33	20	24	-	-	-	-
4.75	25	13	19	-	-	-	-
2.36	9	4	9	-	-	-	-
1.18	5	1	5	-	-	-	-
0.600	3	1	3	-	-	-	-
0.425	3	1	3	-	-	-	-
0.300	2	1	2	-	-	-	-
0.150	2	1	2	-	-	-	-
0.075	1	0	1	-	-	-	-

NOTES/REMARKS:

Sample/s supplied by the client

Accredited for compliance with ISO/IEC 17025.
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
J. Russell

NATA
ACCREDITED FOR TECHNICAL COMPETENCE

Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.
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Trilab Pty Ltd ABN 25 065 630 506

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING

LEVAY & CO. ENVIRONMENTAL SERVICES
Water Quality, Water Treatment and Environmental Pollution Research Laboratories

Job No.
L&C-16-232

REPORT

QXRD Analysis of Waste Rock and Tailings from Mt. Rawdon Gold Mine

Prepared for:

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Date: 12 September 2016

Introduction

Levay & Co. Environmental Services received three waste rock and one tailings sample originating from the Mt. Rawdon Gold Mine from RGS Environmental to determine their mineralogical content by (semi-) quantitative x-ray diffraction (QXRD) analysis. The sample details are provided in the table below.

Table 1. List of samples received for QXRD analysis

Sample ID.	Sample Description
KLC1	NAF waste rock
KLC2	Moderate PAF waste rock
KLC3	High PAF waste rock
KLC 4	Uncertain tailings

(Semi) - Quantitative X-Ray Diffraction (QXRD)

X-ray diffraction traces were obtained with a Panalytical XPERT POWDER X-Ray Diffractometer using a graphite monochrometer and CoK_{α} radiation. Operating conditions were 36kV/30mA, step scan 0.02θ/2θ at 1^{o}/2θ/min, range 5^{o} to 76^{o} 2θ, fixed 1^{o} divergence and receiving slits and a 0.15^{o} scatter slit. Mineral phases present were identified by computer-aided (Panalytical X'Pert HighScore Plus, Bruker Diffrac Plus EVA) searches of the 2013 ICDD PDF4 minerals sub-file. Quantitative XRD results were obtained using SiroQuant™ ver 4.0 and refinement of the most suitable mineral structures available in the current software package databank.

Results

The results of QXRD analysis of the waste rock and tailings samples are shown in Table 2 below. Results are generally in agreement with ABA results, with decreasing carbonate and increasing pyrite content from NAF to high PAF wastes. The pyrite content is also in general agreement with CRS results, although a CRS of 3.6% for the high PAF waste may suggest the pyrite content of 9.6% from QXRD may be slightly over-estimated.

Table 2 QXRD results

Phase	Weight %			
	KLC1	**KLC2**	**KLC3**	**KLC4**
	NAF Waste Rock	**Moderate PAF Waste Rock**	**HIGH PAF Waste Rock**	**Uncertain Tailings**
Albite	36.9	27.5	1.7	12.2
Ankerite	-	-	0.1	-
Calcite	8.9	3.1	3.3	1.6
Chlorite	13.2	12.4	12.0	8.9
Gypsum	-	0.1	0.5	0.2
Jarosite	-	-	0.1	0.1
Microcline	-	0.9	0.9	0.9
Muscovite	18.3	20.7	33.6	27.5
Pyrite	0.6	2.0	9.6	8.2
Quartz	22.2	33.1	38.1	40.5



MINE WASTE AND
WATER MANAGEMENT

CARTLEDGE
MINING AND GEOTECHNICS

EVO010006

Mt Rawdon Mine Progressive Rehabilitation Closure Plan (PRCP) Geotechnical Assessments – North Waste Rock Dump (NWRD)

Report No.: Rev 1_Final
11 November 2022

EVOLUTION MINING AUSTRALIA

MT RAWDON MINE PROGRESSIVE REHABILITATION CLOSURE PLAN (PRCP) GEOTECHNICAL ASSESSMENTS – NORTH WASTE ROCK DUMP (NWRD)

Cartledge Mining and Geotechnics
Report No.: Rev 1_Final
Date: 11 November 2022

Rev	Date	Author	RPEQ No.	Reviewer	RPEQ No.	Description
0	3 November 2022	Adam Kerr		Keith Mandisodza	25401	Draft
1	11 November 2022	Adam Kerr		Keith Mandisodza	25401	Final

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1 Introduction

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the Mt Rawdon Mine Operations (MRO) Open Pit, North Waste Rock Dump (NWRDP), and the MRO Tailings Storage Facility (TSF) as part of the Progressive Rehabilitation and Closure Plan (PRCP) Guideline which is a critical component of the rehabilitation policy under Queensland Government's Mine Land Rehabilitation Policy (DES, 2021).

The geotechnical assessments followed individual studies for all the infrastructures that were analysed. Geotechnical stability was assessed for post-closure and long-term stability as indicated by the landform modelling results. For the final waste dump, the geotechnical stability considered the effects of long-term erosion and weathering of the dump and the effects of significant hydrological events as outlined in the *Mount Rawdon Final Voids Study Report (SLR Ref: 620.30185-R01 Version No: v2.0 December 2020)*

According to the PRCP Guidelines, the "the final landform design must include modelling predicting the long-term stability of the final landform design" (Department of Environment and Science, 2021). The requirement of the Guidelines has been undertaken in this report in the analysis of the provided post-closure final waste dump slopes.

1.1 Scope of Work

The scope of work was split into two main categories following a meeting held between MRO Site representatives and CM&G Principal Engineer. The two main categories to be addressed in the scope were:

- Addressing the PRCP Guideline requirements and the DES feedback.
- Review and incorporate results from other relevant work being completed by other consulting parties, i.e., TSF LOM and hydraulic studies, waste dump capping design and erosion modelling.

From these two main categories, the detailed scope of work is outlined below:

1. Address the PRCP Guideline requirements and feedback from the Department of Environment & Science, which requires the following to be captured within a high-level geotechnical report:

- *Geotechnical modelling predicting long-term stability (factor of safety etc.) of TSF and NWRD*
- *Information about the final waste rock dump wall geotechnical stability and a 3D design and consideration of the effects of long-term erosion and weathering of the final waste rock dump and the effects of significant hydrological events (where possible/practicable/relevant)*
- *The description of how the final waste rock dump will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure waste rock dump. Mechanisms for achieving acceptable geotechnical stability must be detailed in the plan. This includes excavation, reshaping and dump configuration through earthwork methods such as backfilling, regrading, buttressing, and benching. Where applicable, methods and techniques for achieving safe slopes must be detailed.*

2. As discussed, work completed by others that may or may not be relevant to this study includes:

- *TSF LOM design – ATC Williams*
- *NWRD capping design – RGS Consultants – refer to capping option 1B.*
- *Hydraulic Assessment – ATC Williams (refer to an initial report which is being updated to reflect reshaping the TSF at closure.*
- *Long-term landform evolution (erosion) modelling of low slope angles for NWRD and TSF cover systems – RGS Consultants*

2 Background

The MRO Site is located approximately 100km inland from Bundaberg in southeast Queensland, within the Burnett region. The open pit operation has existed for over twenty years and has been managed by multiple owners. Evolution Mining currently owns MRO and has been the sole operator since 2011. The operation has a life of mine that extends to 2027.

The extent of the rehabilitation works for the MRO open pit currently extends to the NWRD through the placement of clay seals along the eastern berms. These seals will progressively be implemented until pit mining activities are completed, and the temporary ore stockpiles are rehandled for processing.

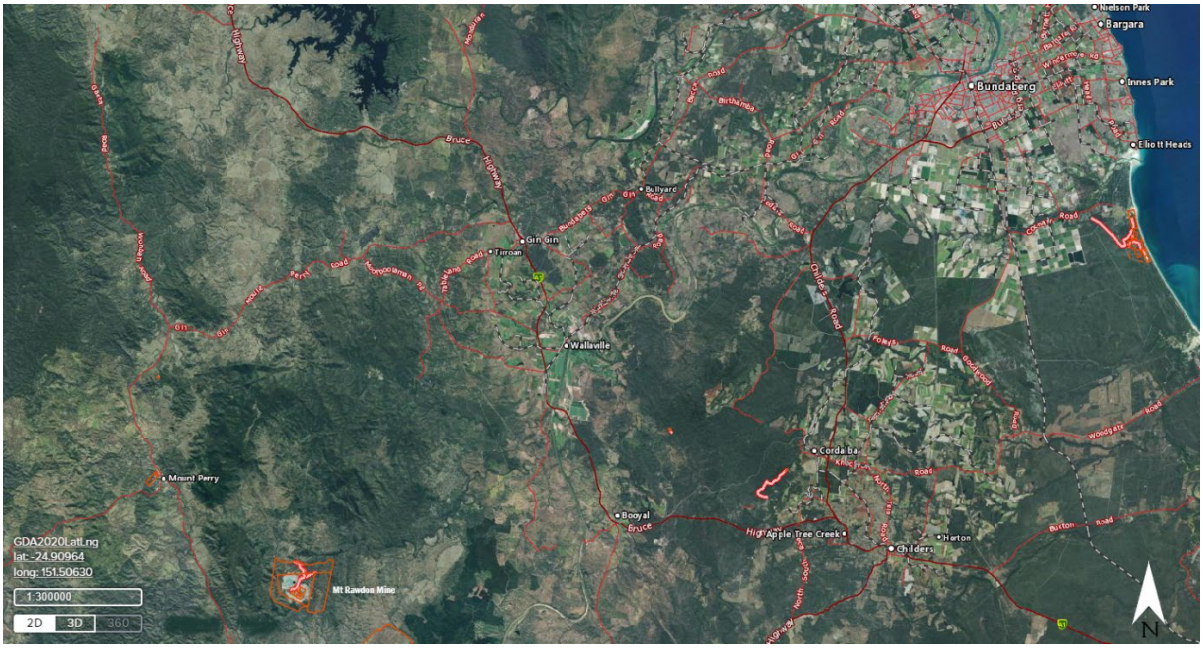


Figure 1: Mt Rawdon Operation site location

2.1 Information Provided

- TSF LOM design – ATC Williams consultants
- NWRD capping design – RGS consultants – refer to capping option 1B.
- Hydraulic Assessment, June 2021 – ATC Williams consultants (refer to an initial report which is being updated to reflect reshaping the TSF at closure.)
- Long-term landform evolution (erosion) modelling of low slope angles for NWRD and TSF cover systems – RGS Consultants
- Topographic survey (original pre-mining surface)
- As-built surfaces and modelled closure surfaces (i.e., open pit, NWRD and TSF)
- TSF closure decommissioning and rehab plan – ATC Williams consultants, December 2017
- TSF conceptual closure and rehabilitation plan – RGC consultants, December 2017
- MRO Geochemical Report – RGS consultants, January 2021
- Open pit geotechnical review – PSM consultants, July 2021
- Assessment of long-term geochemical characteristics of Mt Rawdon tailings material-Final Report – RGS Consultants, January 2021

3 Document Reviews

Reviewed documents in section 2.1 define different strategies and methodologies applied to analyse various aspects of the infrastructure relative to the closure requirements. Relevant information critical to the stability analysis of the infrastructure was extracted and used in the model setup for geotechnical stability assessments. MRO provided final design survey profiles at closure and post-closure, and geotechnical input parameters inferred from other studies were indicated in section 2.1.

Since the landform modelling and erosion studies were still being undertaken during the geotechnical analyses, only the final landform infrastructure was geotechnically assessed for stability. Fin Waste Dump Stability Assessment

3.1 Geotechnical Input Parameters

The input parameters considered in the final rock waste dump analysis are below. Rockmass domains for the in situ material were defined by SRK Consulting (2017), and material properties (Table 1) were adopted from Itasca (2017).

Material properties for the upper 4.5 m clayey soil layer and the waste rock were adopted from previous studies completed by AWA (2006). Correlation data from Leps (1970) was applied to determine the approximate friction angle of the waste dump material under normal stress produced by the final dump height. With a final dump height of 251 mAHD, the normal stress was calculated to be approximately 5 MPa in Figure 3.

As shown in Figure 2, a dry density of 2.2 t/m3 (22 kN/m3) was correlated against the final dump height using correlation data from Valenzuela et al. (2008).

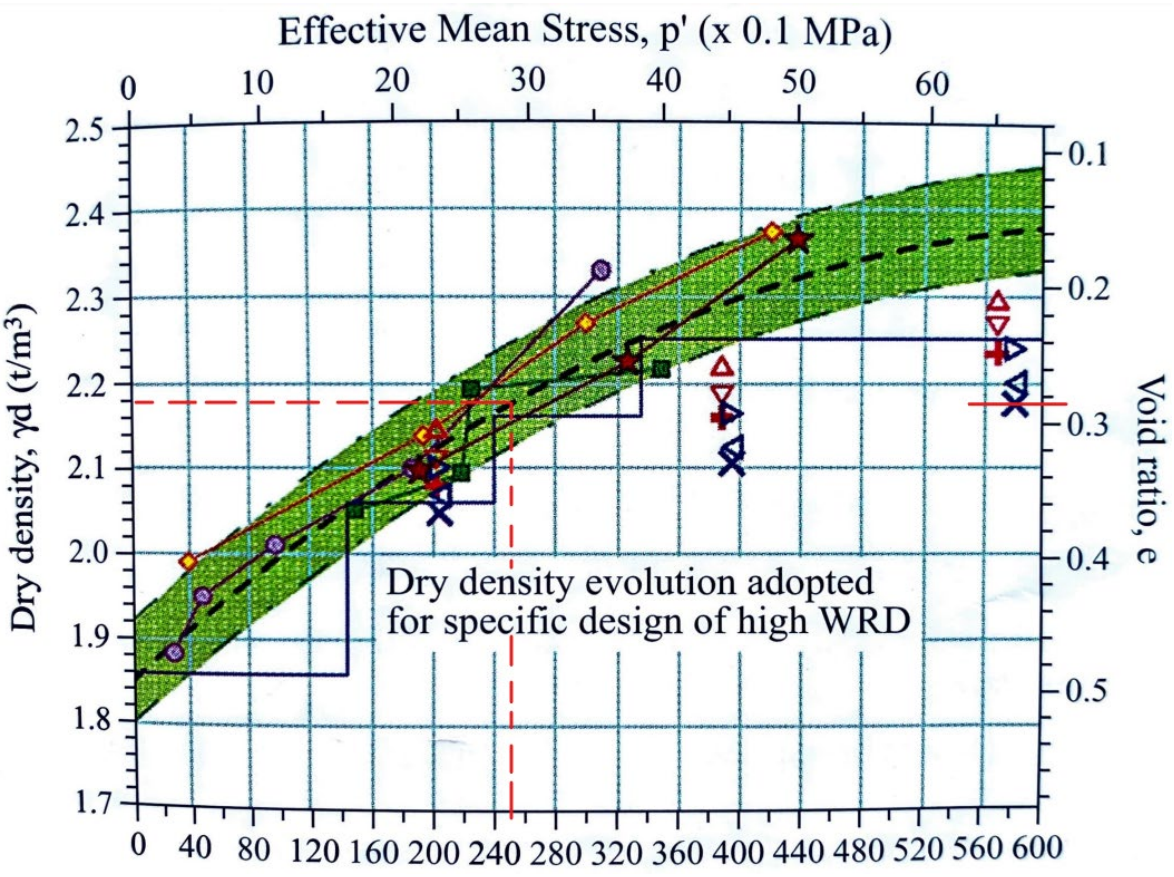


Figure 2: Effective mean stress versus void ratio for waste rock (Valenzuela et al., 2008)

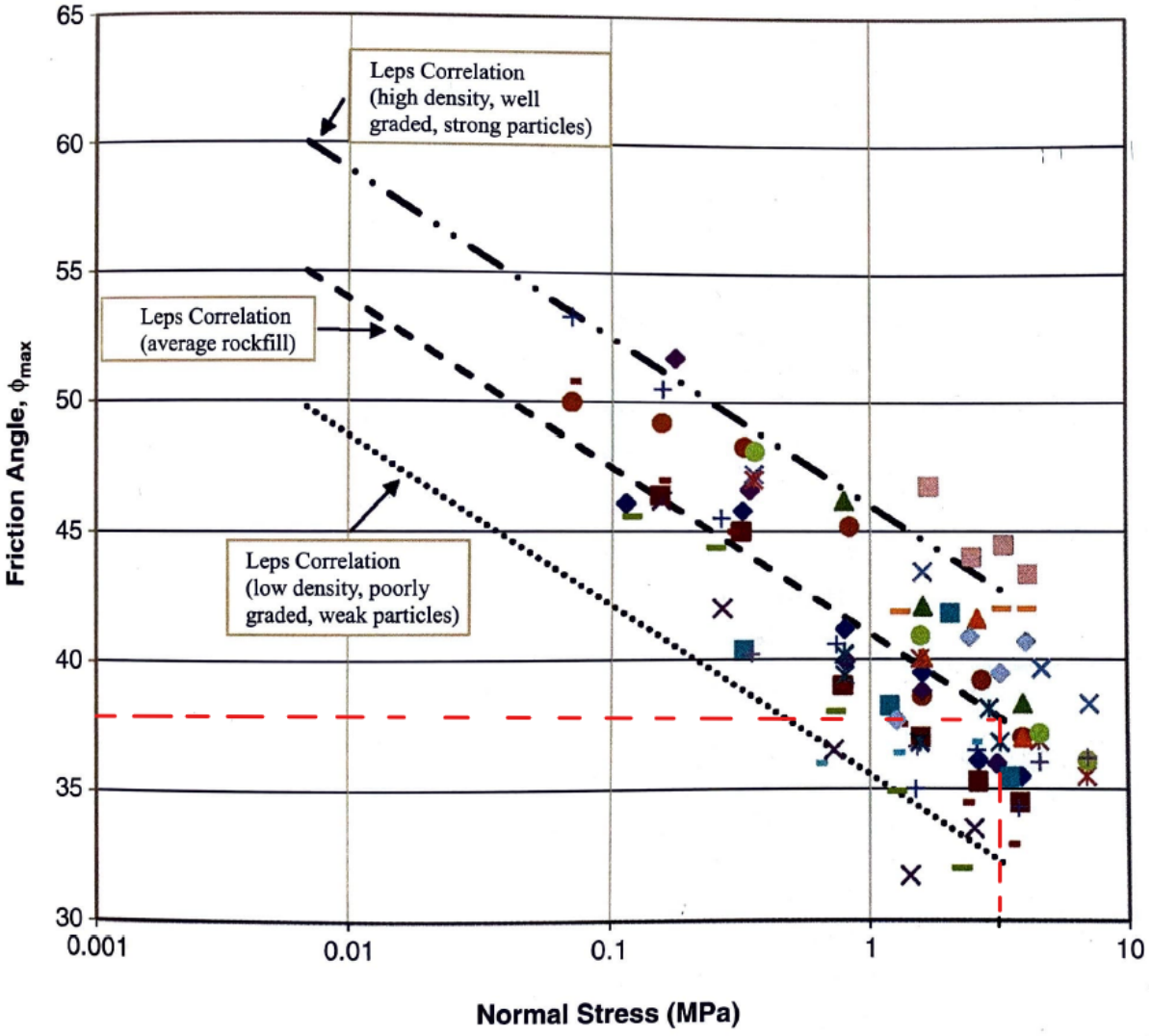


Figure 3: Shear strength of rockfill from large triaxial testing data from Leps (1970) and more recent testing (Hawley & Cunning, 2017)

From the previous studies and correlations above, the following rockmass properties are summarised in Table 1

Table 1: Modeling material properties

Domain	ρ (kt/m^3)	c (MPa)	ϕ (°)	σ_{tm} (MPa)
Domain 4	26	201	37	24
Waste Rock	22	0	38	-
Clayey Soils	18	2	30	-

ρ – Rock Mass Density

c – Rock Mass Cohesion

ϕ – Rock Mass Friction Angle

σ_{tm} – Rock Mass Tensile Strength

3.2 Modelling Methodology

The PRCP Guideline (DES,2021) requires that the assessment of landforms, specifically the NWRD for MRO, for closure planning must include the modelling predicting the long-term stability of the final landform design.

The landform design objective must be targeted at achieving long-term stability through analysis of future stability status based on predicted and forecasted post-closure conditions. As alluded to in the preceding sections, other relative studies have been conducted for the NWRD. The methodology presented herein is only for determining the stability and deformation conditions of the waste dump under established and analysed post-closure conditions.

Rocscience software Slide 3 (Version 3.020) was used to analyse the stability of the waste dump.

Material properties were first assigned by dividing the dump geometry against the initial topography of the site to determine the in-situ boundary. A subsoil clayey-sand layer was modelled based on the hydrogeological units defined in the final void study report (SLR, 2020) as a 4.5 m thick unit. Below this unit is the regolith, composed of highly weathered igneous rocks of up to 15 m (SLR, 2020). This regolith unit was assigned the domain 4 material properties to align with the material properties used for the final void analysis.

Two analysis methods were applied; the Spencer method and the Morgenstern-Price Global Limit Equilibrium (GLE) method. These methods were selected as they resolve both horizontal and vertical force equilibrium and moment equilibrium. Because of this, the failure surfaces calculated resolve well against the weaker clay layer at the model's base; therefore, these two methods are considered suitable for the analysis. Results were assessed for both to ensure a similar result and thus validate the failure surfaces.

3.3 Stability Assessment Criteria

The adopted assessment criteria for the slope stability analysis are based on the overall slope scale under the high consequence of failure, as listed in Hawley and Cunning(2009). This is summarised below based on a static and pseudo-static factor of safety values. A minimum FoS of 1.5 and 1.15 has been adopted for static and dynamic analyses. Based on the waste dump stability rating discussed in section 4.8, the MRO waste dump waste is classified with a stability rating of WHC 3, moderate hazard. From this classification, it can be followed that the consequence of the dump will be moderate, and the target factor of safety (FoS) for static and pseudo-static conditions be determined. With an assumption of moderate confidence in Table 2, the target factors of safety are shown below.

Table 2: Typical FoS and PoF acceptance criteria values (Hawley & Cunning, 2009)

		Static analysis		Pseudo-static analysis	Maximum allowable strain[5]
Consequence[1,3]	Confidence[2,3]	Minimum FoS	Maximum PoF[4]	Minimum FoS	
Low	Low	1.3–1.4	10–15%	1.05–1.1	≤1%
	Moderate	1.2–1.3	15–25%	1.0–1.05	≤1.5%
	High	1.1–1.2	25–40%	1.0	≤2%
Moderate	Low	1.4–1.5	2.5–5%	1.1–1.15	≤0.75%
	Moderate	1.3–1.4	5–10%	1.05–1.1	≤1%
	High	1.2–1.3	10–15%	1.0–1.05	≤1.5%
High	Low	≥1.5	≤1%	1.15	≤0.5%
	Moderate	1.4–1.5	1–2.5%	1.1–1.15	≤0.75%
	High	1.3–1.4	2.5–5%	1.05–1.1	≤1%

3.4 Seismic Loading

A probabilistic seismic analysis (PSHA) was conducted at MRO in 2020. The PSHA concluded that MRO is in a low seismicity region of Australia. For the final landform analysis, the two design events considered were the operational basis earthquake (OBE) of peak ground acceleration of 0.09g and the site evaluation earthquake (SEE) of peak ground acceleration of 0.25g, both having a magnitude of 7.5 (ATC, 2020). For post-closure analysis, the SEE design event was applied to assess the stability of the final waste rock dump landform.

3.5 Phreatic Surface

A phreatic surface created from the Mt Rawdon Post-Closure Groundwater Model (SLR, 2020) was used as the groundwater table for the open pit model and applied to the final landform analysis.

The analysis was conducted with the Hu value, the hydrogeological coefficient for the material type, in the Auto mode. This groundwater modelling used the stabilised groundwater elevation to assess the post-closure WRD landform stability conditions, as shown in Figure 4

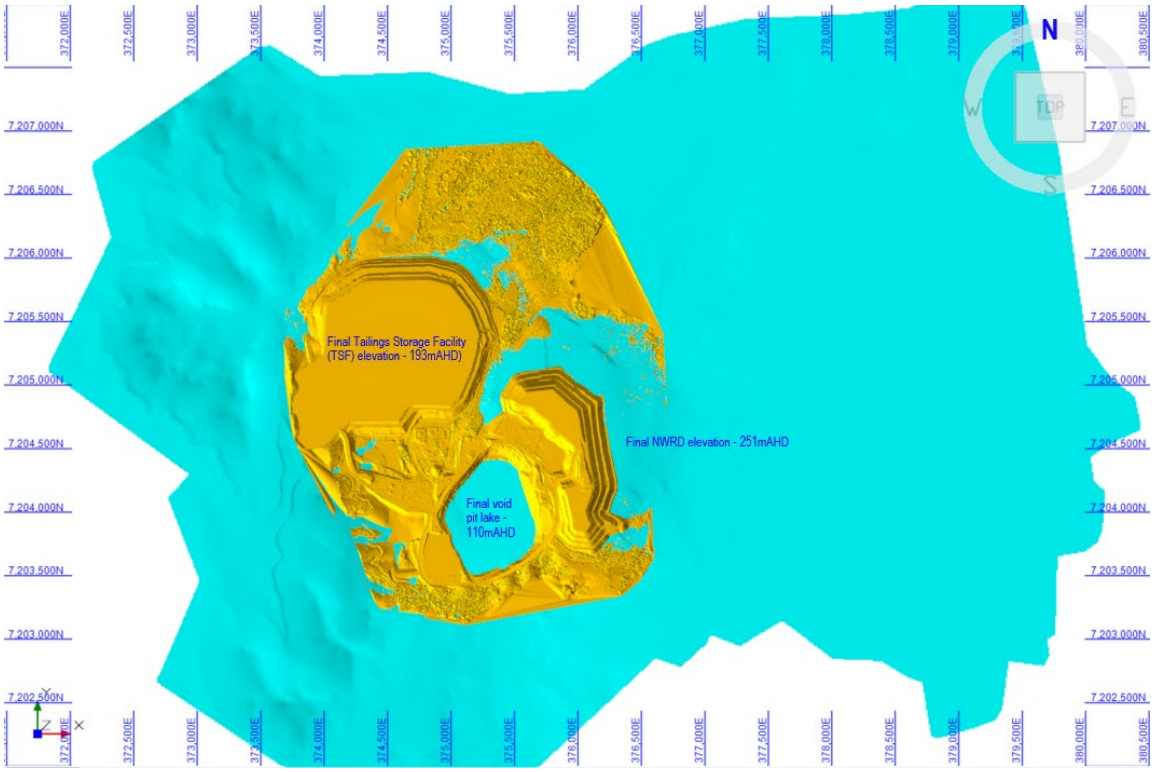


Figure 4: MRO Infrastructure showing the stabilised water balance after 275 years at elevation 110mAHD

3.6 Modelling Assumptions

The following design assumptions were adopted to analyse the final waste rock dump.

- Rockmass parameters were obtained from Itasca (2017).
- Final slopes were analysed based on the planned final waste rock dump slopes at closure. There is no consideration for long-term erosion in the geometry or material parameters of the dump.

3.7 Stability Analysis Results

3.7.1 Limit Equilibrium Analysis (Slide3)

The factor of safety results for the static and dynamic scenarios of the Slide3 Limit Equilibrium analysis is shown below. A minimum global factor of safety values is below the prescribed criteria. However, these failure surfaces include all intra-bench slumps. Small-scale slumping of the final WRD can be expected over time and is not considered high severity.

No inter-bench failure surfaces were noted below the acceptance criteria for static analysis.

Table 3: Stability analysis results

Scenario	FoS (Spencer)*	FoS (GLE/Morgenstern-Price)*
Static	0.45	0.45
Pseudo-static (PGA: 0.25g or 1:10000)	0.46	0.45

*Results show the global lowest calculated FoS. No FoS <1.5 for static or <1.15 for dynamic scenarios was found to create deep-seated instabilities

It should be emphasised that the highlighted global minimum factor of safety (Figure 5) is localised, due to the shape and geometry of the bench, for the static analysis and does not affect the overall stability of the dump. Figure 6 indicates that the majority of the dump will have a factor of safety greater than 1.3, which Is a minimum requirement per Table 2 for dumps of moderate consequences as classified for the MRO NWRD.

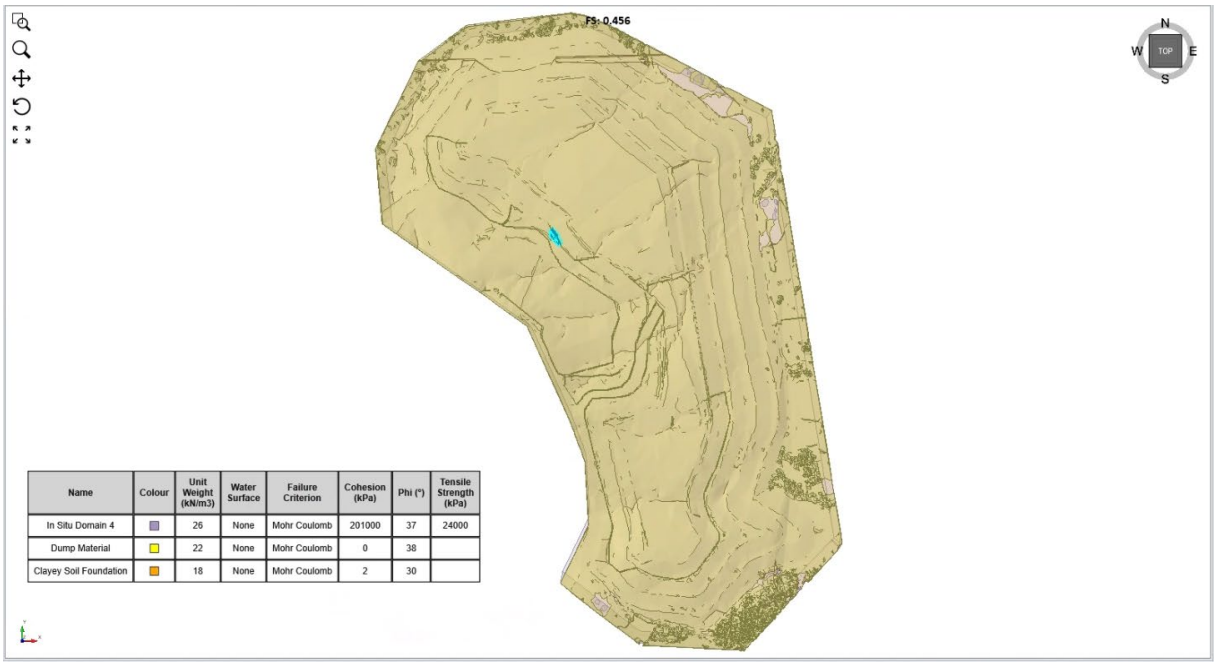


Figure 5: Limit Equilibrium Slide3 results under static conditions, showing global minimum failure surface

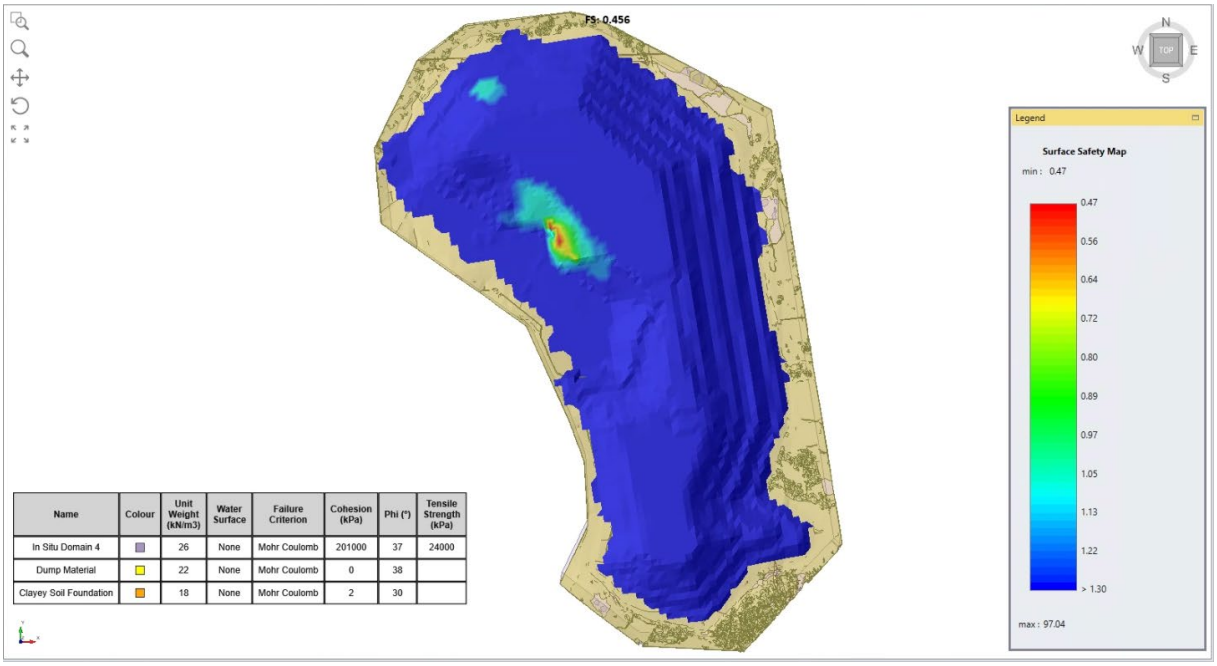


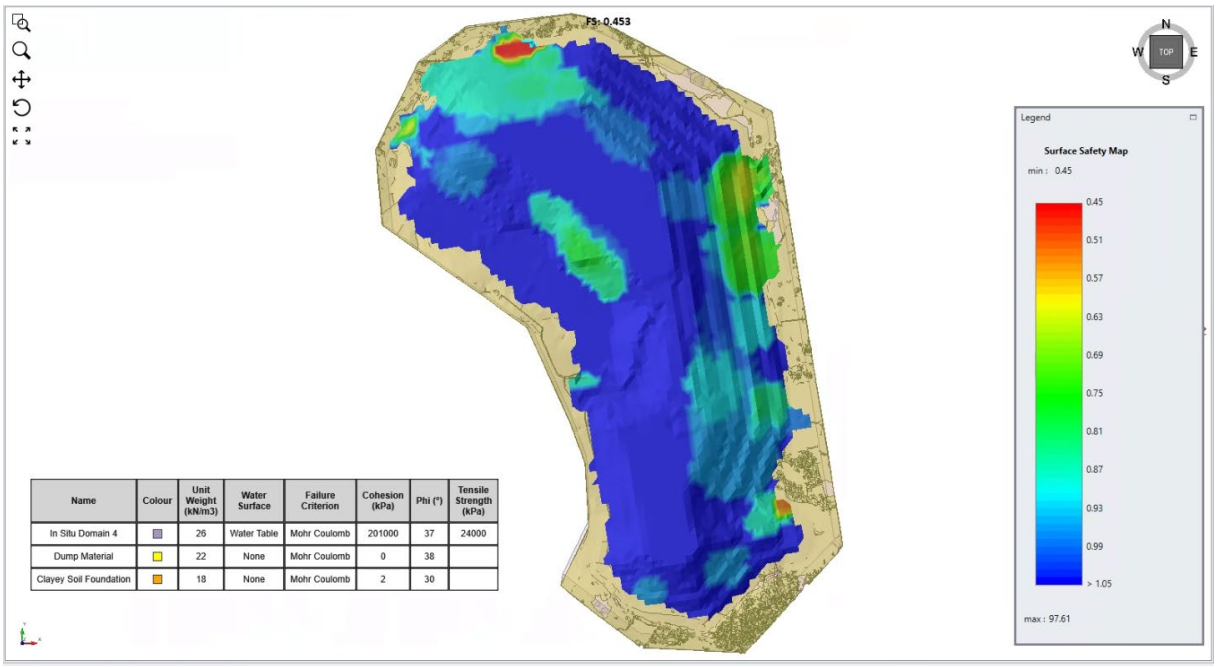
Figure 6: Limit Equilibrium Slide3 results under static conditions safety map, showing location with a factor of safety less than 1.3 as per Table 2 requirement for long-term static conditions

For pseudo-static seismic analysis, the global minimum indicates a localised failure surface on the north wall middle bench where the phreatic surface intersects the wall. However, other locations along the eastern wall also indicate a factor of safety of less than 1, indicating failure. Considering the localised areas where there is a marginal factor of safety, buttressing these areas can be implemented to enhance the factor of safety for long-term stability.



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	Cohesion (kPa)	Phi (°)	Tensile Strength (kPa)
In Situ Domain 4		26	Water Table	Mohr Coulomb	201000	37	24000
Dump Material		22	None	Mohr Coulomb	0	38	
Clayey Soil Foundation		18	None	Mohr Coulomb	2	30	

Figure 7: Limit Equilibrium Slide3 results under pseudo-static seismic conditions, showing global minimum failure surface



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	Cohesion (kPa)	Phi (°)	Tensile Strength (kPa)
In Situ Domain 4		26	Water Table	Mohr Coulomb	201000	37	24000
Dump Material		22	None	Mohr Coulomb	0	38	
Clayey Soil Foundation		18	None	Mohr Coulomb	2	30	

Figure 8: Limit Equilibrium Slide3 results under pseudo-static seismic conditions safety map, showing location with a factor of safety less than 1.05 as per Table 2 requirement for long-term static conditions

3.8 Waste Dump Stability Rating (WSR)

The final waste dump model elements were incorporated into the Waste dump and stockpile stability rating and hazard classification system (Hawley & Cunning, 2017).

This system requires the evaluation of 22 key factors or attributes that are thought to affect stability. These factors have been organised into seven groups. Numerical ratings are assigned to each factor, and the sum of these ratings defines the waste dump and stockpile stability rating (WSR) (Figure 9).

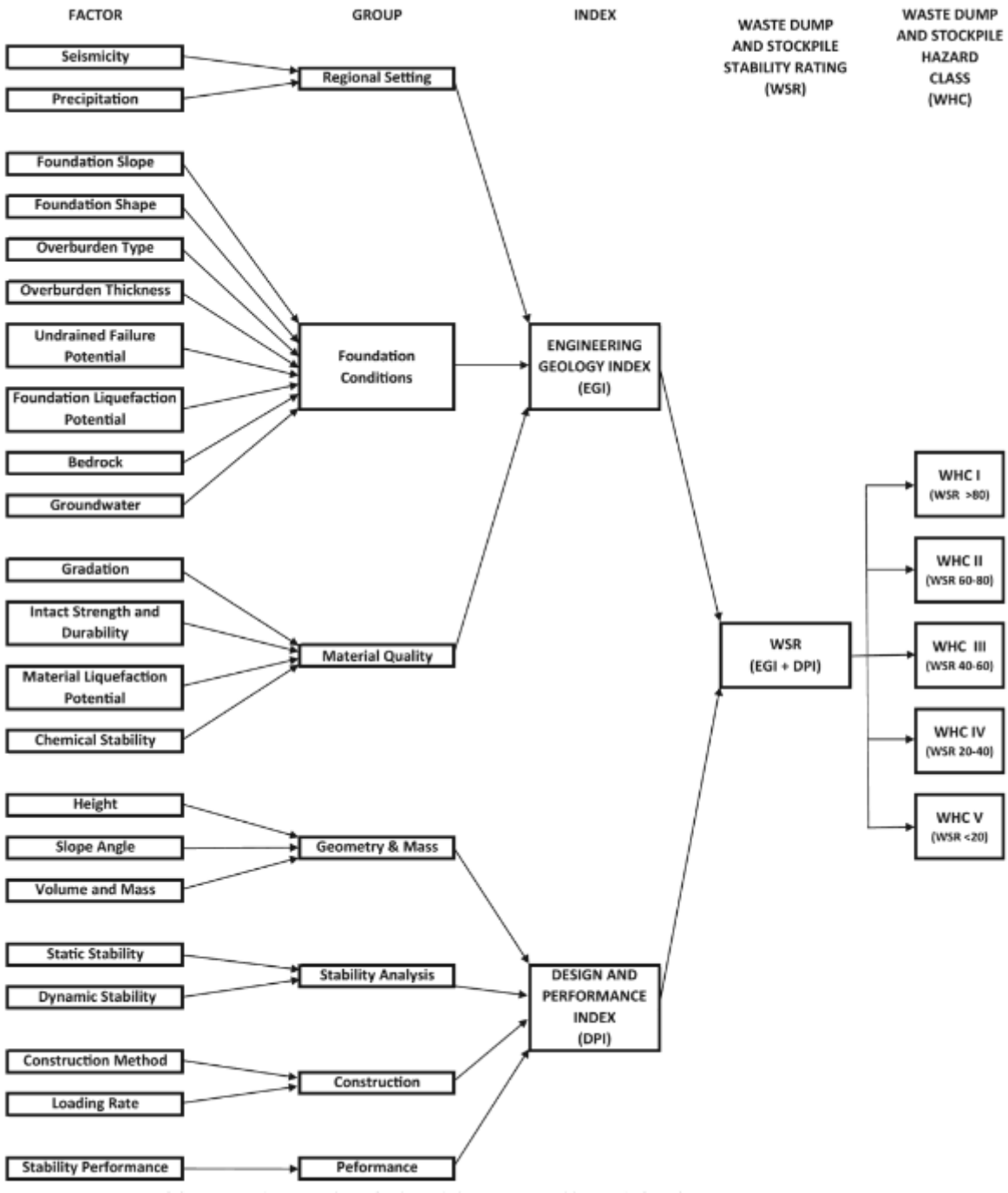


Figure 9: Structure of the waste dump stability rating and hazard classification system

The waste dump stability rating was scored against all factors to resolve the Engineering Geology Index (EGI) and the Design and Performance Index (DPI).

Table 4: Waste Dump Stability Rating and Hazard Classification System

Index	Group	Factor	Value	Rating
Engineering Geology Index (EGI)	Regional Setting	Seismicity	OBE – 0.09 g SSE – 0.25 g	1.5
		Precipitation	1000-2000mm	2
	Foundation Conditions	Foundation Slope	Flat (<5°)	5
		Foundation Shape	Planar or concave on gentle slopes	1.5
		Overburden Type	Typically highly weathered with minor partially weathered rock	3
		Overburden Thickness	3-5 m	1
		Undrained Failure Potential	Moderate	-5
		Foundation Liquefaction Potential	Low	-2.5
		Bedrock	Type D	3
		Groundwater	Moderate	1.5
	Material Quality	Gradation	Coarse-Grained	7
		Intact Strength and Durability	Very Strong to Extremely Strong (100-130 MPa)	8
		Material Liquefaction Potential	Low	-2.5
		Chemical Stability	Relatively Low	2.5
	Geometry and Mass	Height	High – 251 m	1
		Slope Angle	Moderate - 27°	2

Design And Performance Index (DPI)		Volume and Mass	Large - 38 Mm^3	1
	Stability Analysis	Static Stability	>1.5	7
		Dynamic Stability	>1.15	3
	Construction	Construction Method	Method IV	6
		Loading Rate	Low	5
	Performance	Stability Performance	Very Good	15

Table 5: Waste Dump Stability Rating Summary

	Rating	Group Score	Index Score
Engineering Geology Index (EGI)			
Regional Setting	Neutral	3.5	**25.5**
Foundation Condition	Neutral	7.0	
Material Quality	Good	15.0	
Design and Performance Index (DPI)			
Geometry and Mass	Medium	4.0	**32.0**
Construction	Very Favourable	13.0	
Performance	Very Good	15.0	

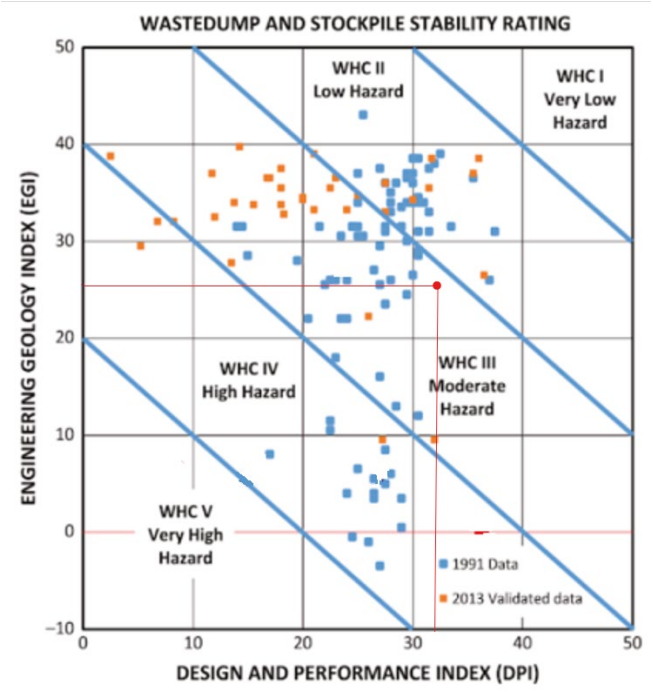


Figure 10: Waste dump stability and hazard chart showing MRO NWRD stability rating (red dot)

As per the WRS classification system (Hawley & Cunning, 2017), the intersection of the EGI and DPI results places the MRO final waste dump within the moderate hazard classification (red dot). Guidelines for the investigation & characterisation, analysis & design, and construction & operation phases are described below.

Applying this to post-closure conditions, as per the WRS guidelines, a moderate hazard classification should require adherence to the following:

Moderate site preparation may include diversions and underdrainage; limited foundation instrumentation to verify performance; runout/rollout mitigation measures, if required; moderately constrained construction sequence; control of fill quality and placement as necessary; loading/advance rate restrictions; standard instrumentation and visual monitoring with well-defined TARPs; periodic (minimum annual) inspections by an experienced geotechnical specialist.

4 Recommendations

The following recommendations have been made to ensure safe operations around the final waste rock dump and maintain stability.

- Static and pseudo-static stability analyses indicate localised global minimum factors of safety, respectively. These are mainly attributable to the shape and geometry of the bench for static analysis. For the pseudo-static analysis, the emergent phreatic surface on the north slope creates a localised area of instability. However, most of the dump will meet the design requirements under the design acceptance criteria in Table 2 for the classified dump conditions for MRO.
- Considering that only the final waste dump shell was used in the stability and deformation analysis, it is recommended that long-term erosion effects be integrated into the final landform to ascertain the inherent effects on stability. Considering the long-term effects of erosion of the waste dump slope, the analysed slopes in this report provide stability and deformation only for the dump soon after operations cessation and closure.
- Surface water management should be implemented on the final landform design to minimise infiltration and inflow of water into the waste dump. Measures considered appropriate would include upslope diversions, profiling of the waste dump and formation of dedicated discharge channels/chutes to direct runoff from the dump
- One of the most sensitive components of this model is the hydrogeological surface used for the analysis. As stated, the surface used was predicted by previous consultants as an expected final phreatic surface. The actual surface may vary if groundwater levels exceed that as modelled, and an additional assessment should be carried out.

5 Conclusion

A summary of the results from stability analysis was discussed in the report, and the methodology was undertaken to obtain the results. Based on the undertaken approach, the geotechnical dump analysis can be concluded.

The mechanisms to achieve acceptable stability were detailed in the report to align with best leading practices. Other supporting reporting in the closure, post-closure, and rehabilitation strategies were reviewed to ensure that the post-closure conditions analysed in the report aligned with the rest of the considered closure plan. Based on this background, the analyses demonstrated that the MRO dump would be globally stable under post-closure conditions. Localised sections require reshaping on the upper western bench and the north and eastern lower benches under dynamic conditions.

It should be emphasised that the final waste rock dump shell analysed for geotechnical stability does not include the effects of erosion. Therefore the results from this assessment should be considered valid for the point of mine closure and for a short time afterwards. Any detailed erosion modelling should be fed back into this model to determine the long-term slope stability of the waste rock dump.

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Department of Environment and Science (2021), Guideline – Progressive Rehabilitation and Closure Plans, 17/03/2021

Hawley, M., Cunning, J. (2017). Guidelines for Mine Waste Dump and Stockpile Design, CSIRO, pg. 31-54

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MINING AND GEOTECHNICS

EVO010007

Mt Rawdon Mine Progressive Rehabilitation Closure Plan (PRCP) Geotechnical Assessments – Open Pit

Report No.: Rev 1_Final
11 November 2022

EVOLUTION MINING AUSTRALIA

MT RAWDON MINE PROGRESSIVE REHABILITATION CLOSURE PLAN (PRCP) GEOTECHNICAL ASSESSMENTS – OPEN PIT

Cartledge Mining and Geotechnics
Report No.: Rev 1_Final
Date: 11 November 2022

Rev	Date	Author	RPEQ No.	Reviewer	RPEQ No.	Description
0	31 October 2022	Adam Kerr		Keith Mandisodza	25401	Draft
1	11 November 2022	Adam Kerr		Keith Mandisodza	25401	Final

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1 Introduction

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the Mt Rawdon Mine Operations (MRO) Open Pit, North Waste Rock Dump (NWRDP), and the MRO Tailings Storage Facility (TSF) as part of the Progressive Rehabilitation and Closure Plan (PRCP) Guideline which is a critical component of the rehabilitation policy under Queensland Government's Mine Land Rehabilitation Policy (DES, 2021).

The geotechnical assessments followed individual studies for all the infrastructures that were analysed. Geotechnical stability was assessed for post-closure and long-term stability as indicated by the landform modelling results. For the open pit, the geotechnical stability considered the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events as outlined in the *Mount Rawdon Final Voids Study Report (SLR Ref: 620.30185-R01 Version No: v2.0 December 2020)*

According to the PRCP Guidelines, the "geotechnical report should focus on how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void". The requirement of the Guidelines has been undertaken in this report in the analysis of the provided post-closure final void slopes.

1.1 Scope of work

The scope of work was split into two main categories following a meeting held between MRO Site representatives and CM&G Principal Engineer. The two main categories to be addressed in the scope were:

- Addressing the PRCP Guideline requirements and the DES feedback.
- Review and incorporate results from other relevant work being completed by other consulting parties, i.e., TSF LOM and hydraulic studies, waste dump capping design and erosion modelling.

From these two main categories, the detailed scope of work is outlined below:

1. Address the PRCP Guideline requirements and feedback from the Department of Environment & Science, which requires the following to be captured within a high-level geotechnical report:
    - *Geotechnical modelling predicting long-term stability (factor of safety etc.) of TSF and NWRD*
    - *Information about the void (pit) wall geotechnical stability and a 3D void design and consideration of the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events (where possible/practicable/relevant)*
    - *The description of how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void. Mechanisms for achieving acceptable geotechnical stability must be detailed in the plan. This includes any void filling, partial void filling, reshaping and void configuration through earthwork methods such as backfilling, regrading, buttressing, and benching. Where applicable, methods and techniques for achieving safe slopes must be detailed.*
2. As discussed, work completed by others that may or may not be relevant to this study includes:
    - *Mt Rawdon Post-Closure Groundwater Model - SLR*

2 Background

The MRO Site is located approximately 100km inland from Bundaberg in southeast Queensland, within the Burnett region. The open pit operation has existed for over twenty years and has been managed by multiple owners. Evolution Mining currently owns MRO and has been the sole operator since 2011. Mining will cease in October 2024, and processing will cease in March 2026.

The extent of the rehabilitation works for the MRO open pit currently extends to the NWRD through the placement of clay seals along the eastern berms. These seals will progressively be implemented until pit mining activities are completed, and the temporary ore stockpiles are rehandled for processing.

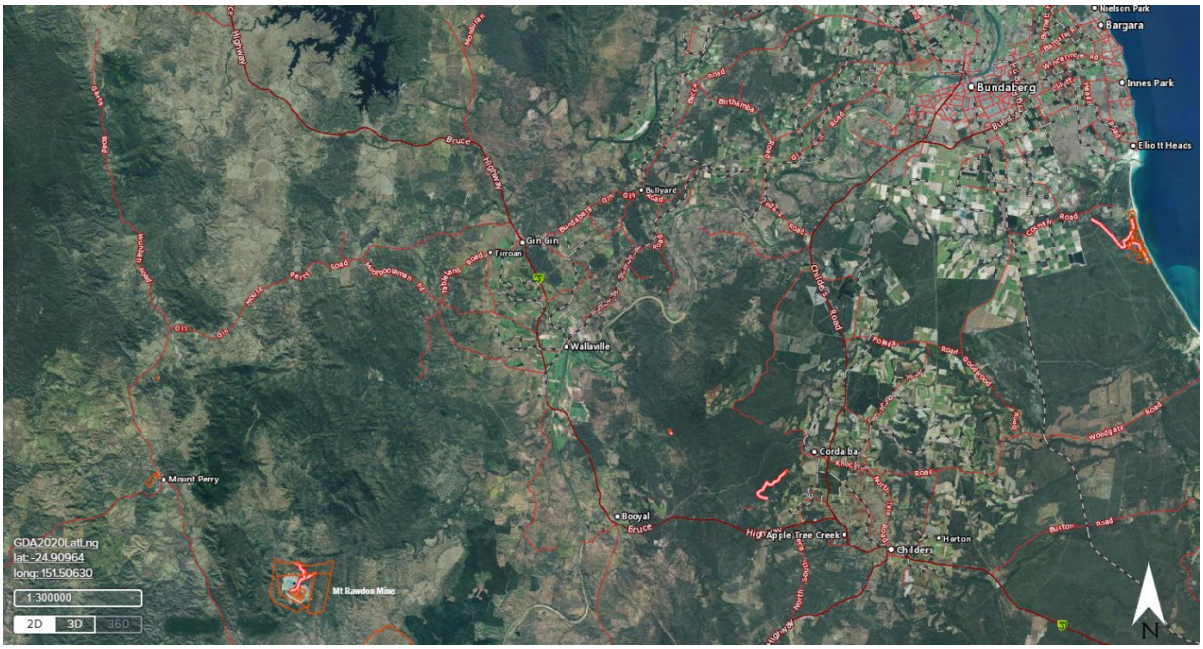


Figure 1: Mt Rawdon Operation site location

2.1 Information Provided

- TSF LOM design – ATC Williams consultants
- NWRD capping design – RGS consultants – refer to capping option 1B.
- Hydraulic Assessment, June 2021 – ATC Williams consultants (refer to an initial report which is being updated to reflect reshaping the TSF at closure.
- Long-term landform evolution (erosion) modelling of low slope angles for NWRD and TSF cover systems – RGS Consultants
- Topographic survey (original pre-mining surface)
- As-built surfaces and modelled closure surfaces (i.e., open pit, NWRD and TSF)
- TSF closure decommissioning and rehab plan – ATC Williams consultants, December 2017
- TSF conceptual closure and rehabilitation plan – RGC consultants, December 2017
- MRO Geochemical Report – RGS consultants, January 2021
- Open pit geotechnical review – PSM consultants, July 2021
- Assessment of long-term geochemical characteristics of Mt Rawdon tailings material-Final Report – RGS Consultants, January 2021

3 Document reviews

Reviewed documents in section 2.1 define different strategies and methodologies applied to analyse various aspects of the infrastructure relative to the closure requirements. Relevant information critical to the stability analysis of the infrastructure was extracted and used in the model setup for geotechnical stability assessments. MRO provided final design survey profiles at closure and post-closure, and geotechnical input parameters inferred from other studies were indicated in section 2.1.

Since the landform modelling and erosion studies were still being undertaken during the geotechnical analyses, only the final landform infrastructure was geotechnically assessed for stability. Once the landform modelling and long-term erosion analysis studies have been finalised, geotechnical investigations will be conducted on those final landforms.

4 Final void stability assessment

4.1 Geotechnical input parameters

The input parameters considered in the final void analysis are provided below. Rockmass domains defined by SRK Consulting (2017) and used in previous 3D numerical modelling of the final pit shell (Itasca, 2017,2019,2021), as shown in Figure 2, were used in the model and are provided in Table 1. The final pit lake elevation of 110mAHD (SLR,2020), which was defined by the stabilisation of the water balance model after a period of 275 years, was used in the geotechnical model, as depicted in Figure 3. Stability under these conditions was analysed as it will be the "worst-case" scenario post-closure.

The structural model used in the final void stability analysis was provided by MRO and developed by Mining One Consultants.

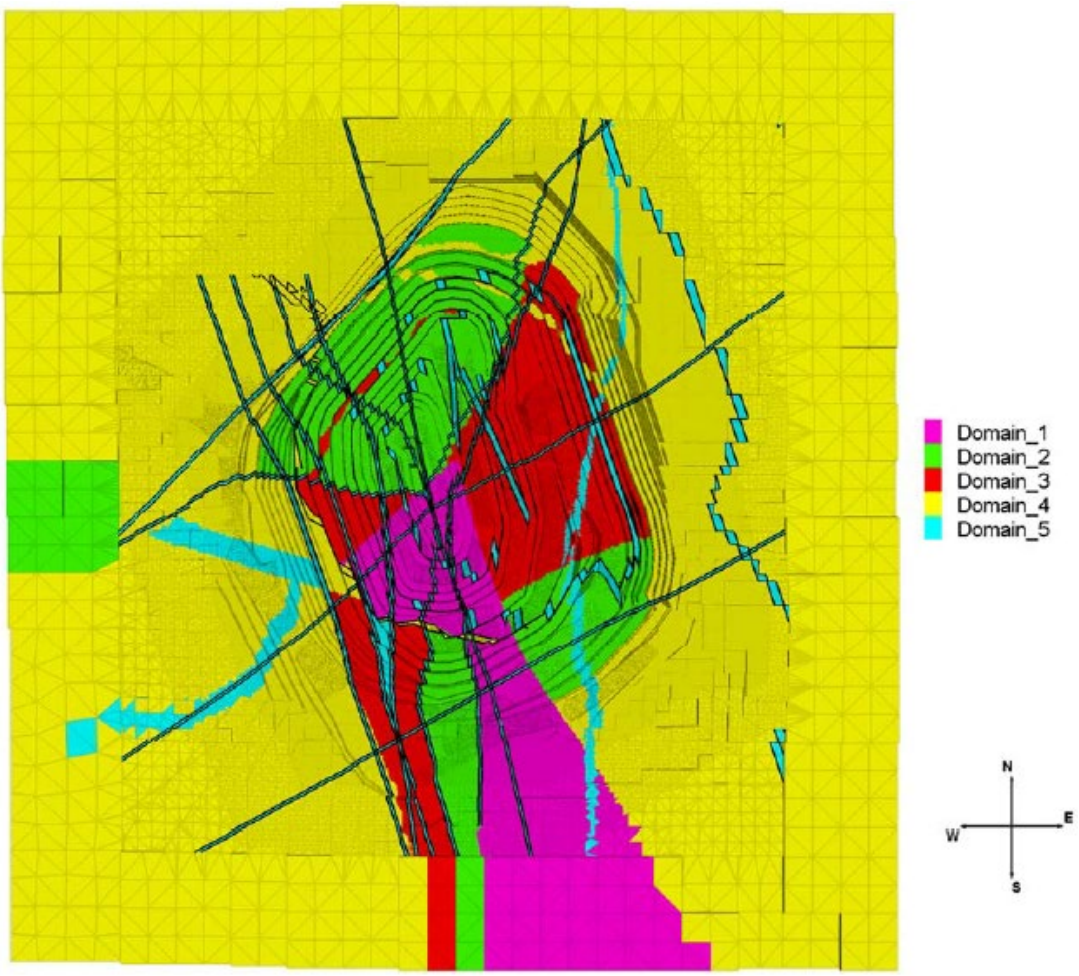


Figure 2: MRO rockmass domains

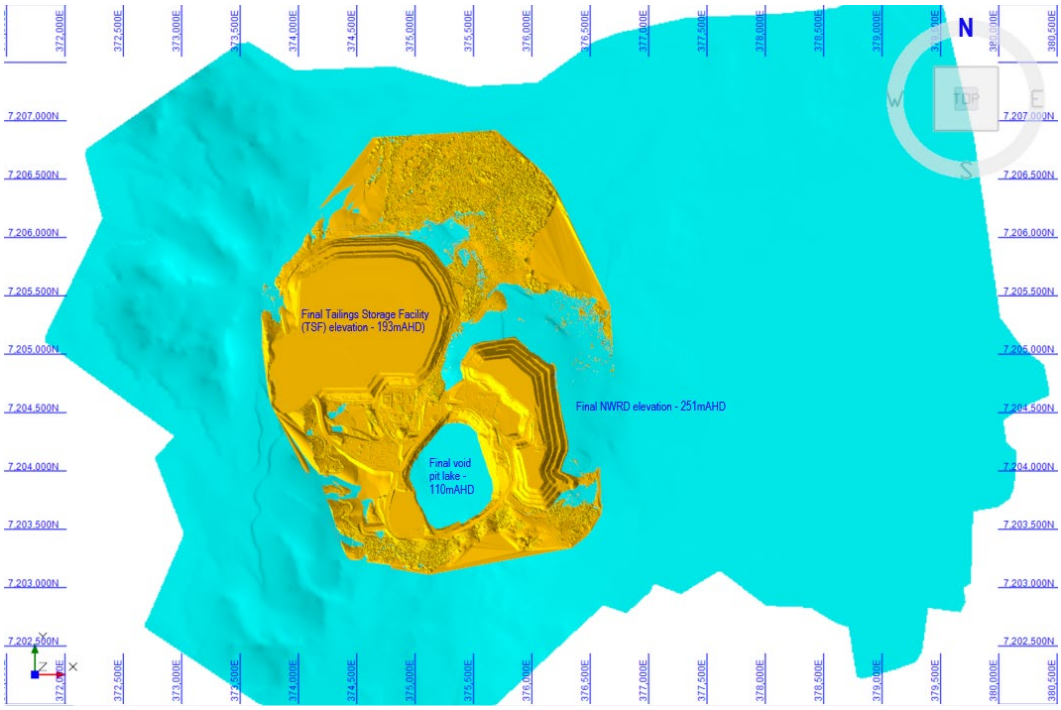


Figure 3: MRO Infrastructure showing the stabilised water balance after 275 years at elevation 110mAHD

Table 1: Rockmass material properties

Domain	Description	ρ (t/m³)	E_i (GPa)	σ_{ci} (MPa)	GSI	m_i	c (MPa)	ϕ (°)	σ_{tm} (MPa)	ψ (°)	E_{rm} (GPa)	ν_{rm}
1	Massive rock	2.7	60	130	82	25	3822	57	937	10	21	0.20
2	Very large blocky rock	2.7	60	130	78	25	2741	57	640	10	18	0.20
3	Blocky rock	2.7	60	120	70	25	1339	54	276	10	13	0.22
4	Small (to medium) blocky rock	2.6	40	90	45	20	201	37	24	10	2	0.25
5	Friable and very small blocky rock	2.6	40	90	35	15	84	24	7	10	1	0.27

ρ = Density
E_i = Young's modulus for the Intact Rock
σ_{ci} = Uniaxial Compressive Strength of Intact Rock
GSI = Geological Strength Index
m_i = Hoek-Brown Material Constant for Intact Rock
c = Rock Mass Cohesion
ϕ = Rock Mass Friction Angle
σ_{tm} = Rock Mass Tensile Strength
ψ = Rock Mass Dilation Angle
E_{rm} = Young's modulus for the Rock Mass
ν_{rm} = Poisson's ratio for the Rock Mass

The faults and joint properties used in the model were adopted from the numerical modelling that has been conducted before, as discussed above. Each fault structure was modelled with a 5m width to represent the fault zones typical in the field. Domain 5 rockmass properties were assigned to the fault structures in the deformation analysis model using the software from Rocscience, RS3. For stability analysis, using Rocscience Slide 3 software, the parameters are in Table 2.

Table 2: Joint strength properties (SRK, 2017c)

Domain	Description	ρ (t/m³)	Joint shear properties				Comments
			Characteristic		Lower bound		
			c (MPa)	ϕ (°)	c (MPa)	ϕ (°)	
1	Massive rock	2.7	-	-	-	-	It is not included in the model due to a few structures.
2	Very large blocky rock	2.7	10	36	25	25	Lower bound – fault gouge (sand, sericite, clay)
3	Blocky rock	2.7	10	36	0	25	Lower bound – sericite, chlorite or thin clay
4	Small (to medium) blocky rock	2.6	10	36	0	25	Lower bound – sericite, chlorite or thin clay
5	Friable and very small blocky rock	2.6	-	-	-	-	Not included in the model due to poor rockmass

For in-situ stress, the adopted ratio of horizontal to vertical stress was 2.2:1.5.

4.2 Modelling Methodology

The PRCP Guideline (DES,2021) requires that the assessment of voids for closure planning must include the following:

- Pit wall geotechnical stability considering the effects of long-term erosion and weathering of pit walls and the effects of significant hydrological events
- Proposed final slope angles of highwall of each void
- A geotechnical report focussing on how void will be achieved post-closure slopes that will exhibit stability characteristics consistent with planning and design of post-closure mine void.
- Mechanisms for achieving acceptable geotechnical stability must be detailed in the plan. This includes void filling, partial void filling, reshaping and void configuration through earthwork methods such as backfilling, regrading, buttressing, and benching. Where applicable, methods and techniques for achieving safe slopes must be detailed.

Rocscience software RS3 (Version 4.025) and Slide 3 (Version 3.020) were used to analyse the deformation and stability of the final void conditions using provided site-specific rockmass domains.

Domains were first assigned by dividing the pit geometry with all structural surfaces for Mount Rawdon provided by the client. These domains' parameters were assigned according to the domains presented by Itasca and mapped and defined by SRK (2017), as shown in Figure 2.

Two analysis methods were applied: the Spencer and Morgenstern-Price Global Limit Equilibrium (GLE). These methods were selected as they resolve both horizontal and vertical force equilibrium and moment equilibrium. Because of this, the failure surfaces calculated resolve well against weak layers. As the site is heavily faulted, failure surfaces are likely to plane against the weaker fault zones, and therefore these methods are more suitable for this analysis. Results were assessed for both to ensure a similar result and thus validate the failure surfaces.

The Slide3 model was built and run, with the associated RS3 model, to validate other failure surfaces and areas of lower Factor of Safety (FoS) to determine displacement across the pit.

4.3 Stability Assessment Criteria

The adopted assessment criteria for the slope stability analysis are based on the overall slope scale and the high consequence of failure, as listed in Stacey and Read, 2009. Table 3 describes the FoS and Probability of Failure (PoF) for the respective slope scale and consequence. Moreover, it is summarised below based on a static and dynamic factor of safety values. A minimum FoS of 1.5 and 1.1 has been adopted for static and dynamic analyses.

Table 3: Typical FoS and PoF acceptance criteria values (Stacey & Read, 2009)

		Acceptance criteria[a]		
Slope scale	Consequences of failure	FoS (min) (static)	FoS (min) (dynamic)	PoF (max) P[FoS ≤ 1]
Bench	Low–high[b]	1.1	NA	25–50%
Inter-ramp	Low	1.15–1.2	1.0	25%
	Moderate	1.2	1.0	20%
	High	1.2–1.3	1.1	10%
Overall	Low	1.2–1.3	1.0	15–20%
	Moderate	1.3	1.05	10%
	High	1.3–1.5	1.1	5%

a: Needs to meet all acceptance criteria
b: Semi-quantitatively evaluated

4.4 Seismic Loading

A probabilistic seismic hazard analysis (PSHA) was conducted at MRO in 2020. For the final void analysis, the two design events considered were the operational basis earthquake (OBE) of peak ground acceleration of 0.09g and the site evaluation earthquake (SEE) of peak ground acceleration of 0.25g, both having a magnitude of 7.5 (ATC, 2020). For post-closure analysis, the SEE design event was applied to assess the stability of the final void under dynamic conditions.

4.5 Stress Regime Loading,

It is understood that no stress measurement data is available for Mt Rawdon. The following stresses from Evolution's Cracow Mine (also in Queensland) have been adopted for the analyses, as suggested by Evolution (Itasca, 2017a):

- S1 is horizontal trending SSW-NNE; S2 is horizontal trending NW-SE; S3 is steeply dipping
- S1/S3 ≈2.2
- S2/S3 ≈ 1.5

4.6 Phreatic Surface

A phreatic surface created from the Mt Rawdon Post-Closure Groundwater Model (SLR, 2020) was used as the groundwater table for the open pit model.

The analysis was conducted with the Hu value, the hydrogeological coefficient for the material type, in the Auto mode. According to the post-closure groundwater model, the MRO void cannot contain the runoff volume, and groundwater flows for the first 100 years. The modelling also predicted it would take 300 years to reach final void levels, where the water balance will stabilise after 275 years to a level of 110mAHD and overflow at 130mAHD (SLR,2020).

This groundwater modelling used the stabilised groundwater elevation to assess the post-closure void stability conditions.

4.7 Modelling Assumptions

The following design assumptions were adopted to analyse the final void for the open pit.

- Rockmass parameters were obtained from previous numerical stability assessments.
- Faults be persistent throughout the model, as per the provided structural model (MRO, 2022).
- Excavation is assumed to be saturated below the projected final groundwater surface, with constant water pressure.
- The fault structures have been assumed to have a 5m width, per the Itasca stability model.
- The final slopes analysed were based on the planned final pit shell at closure since the long-term erosion modelling was ongoing at the time of writing the geotechnical report.

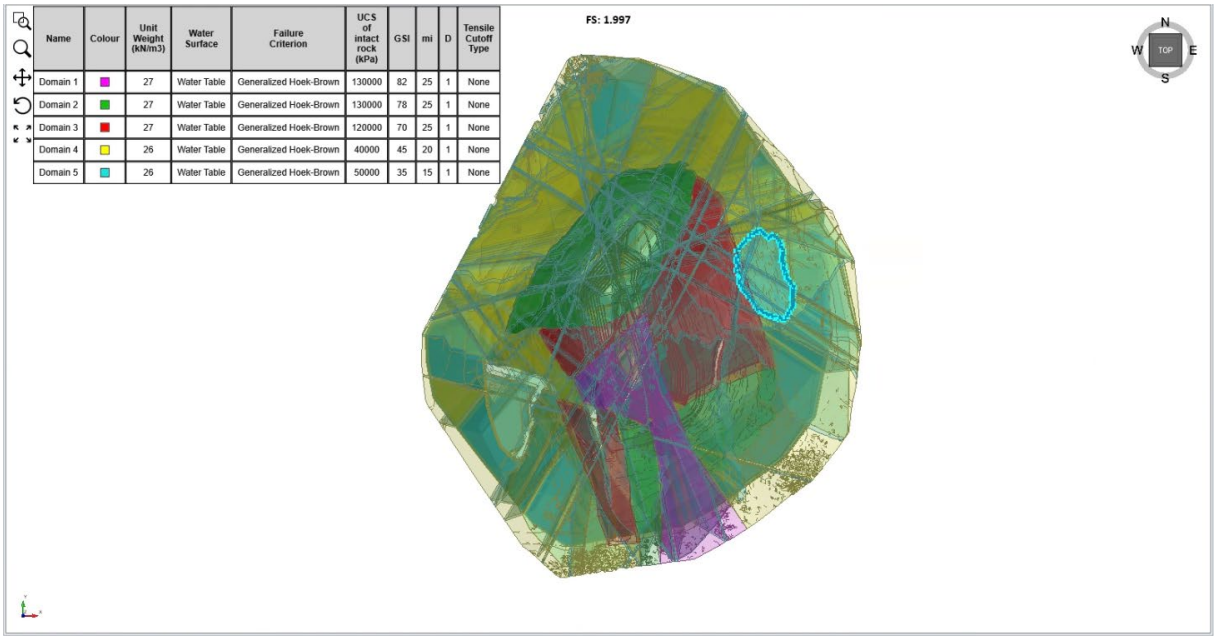
4.8 Stability Analysis Results

4.8.1 Stability Analysis (Slide3)

The factor of safety results for the static and dynamic scenarios of the Slide3 Limit Equilibrium analysis is shown below in Table 4 and in Figure, 4 to Figure 7. A suitable factor of safety was achieved for static conditions. Spencer's results for the dynamic seismic analysis were marginally below the assessment criteria, however, considering the likelihood of the event, this is considered acceptable.

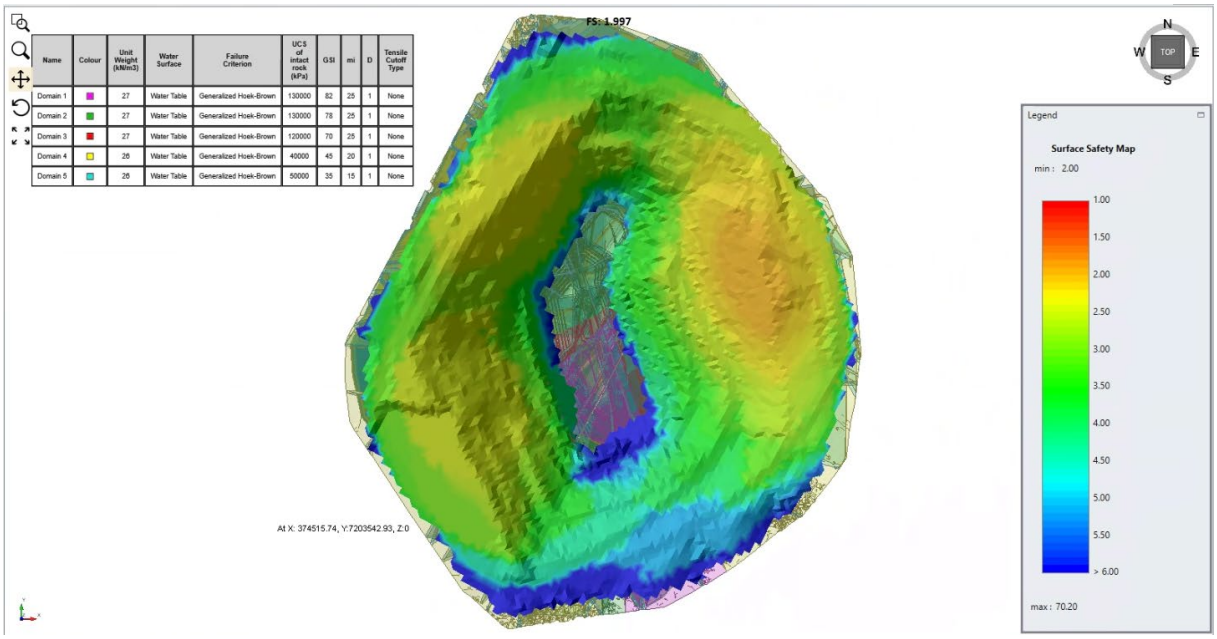
Table 4: Limit Equilibrium Slide3 results under static and dynamic conditions

Model	FoS (Spencer)	FoS (GLE/Morgenstern-Price)
Static Model	2.01	1.99
Dynamic Model (PGA: 0.25g or 1:10000)	1.09	1.10



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	UCS of intact rock (kPa)	GSI	mi	D	Tensile Cutoff Type
Domain 1		27	Water Table	Generalized Hoek-Brown	130000	82	25	1	None
Domain 2		27	Water Table	Generalized Hoek-Brown	130000	78	25	1	None
Domain 3		27	Water Table	Generalized Hoek-Brown	120000	70	25	1	None
Domain 4		26	Water Table	Generalized Hoek-Brown	40000	45	20	1	None
Domain 5		26	Water Table	Generalized Hoek-Brown	50000	35	15	1	None

Figure 4: Limit Equilibrium Slide3 results under static conditions, showing global minimum failure surface on the east wall



Name	Colour	Unit Weight (kN/m3)	Water Surface	Failure Criterion	UCS of intact rock (kPa)	GSI	mi	D	Tensile Cutoff Type
Domain 1		27	Water Table	Generalized Hoek-Brown	130000	82	25	1	None
Domain 2		27	Water Table	Generalized Hoek-Brown	130000	78	25	1	None
Domain 3		27	Water Table	Generalized Hoek-Brown	120000	70	25	1	None
Domain 4		26	Water Table	Generalized Hoek-Brown	40000	45	20	1	None
Domain 5		26	Water Table	Generalized Hoek-Brown	50000	35	15	1	None

Figure 5: Limit Equilibrium Slide3 Spencer's under static conditions safety map

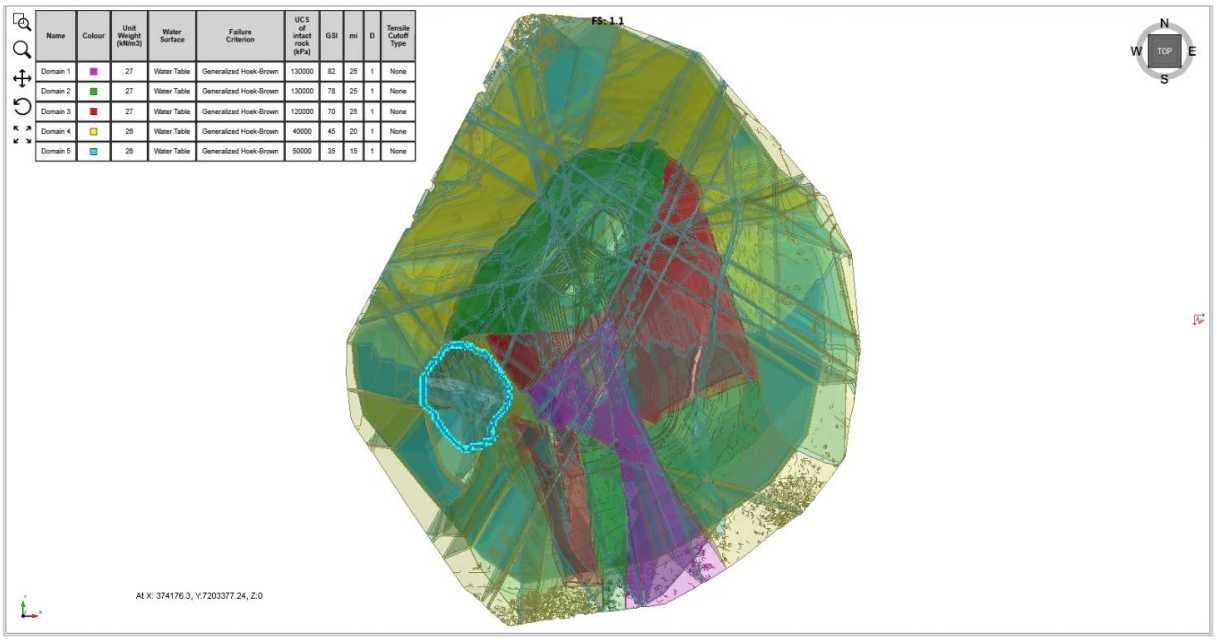


Figure 6: Limit Equilibrium Slide3 result,lts under dynamic seismic conditions, sh, owing global minimum failure surface on the west wall

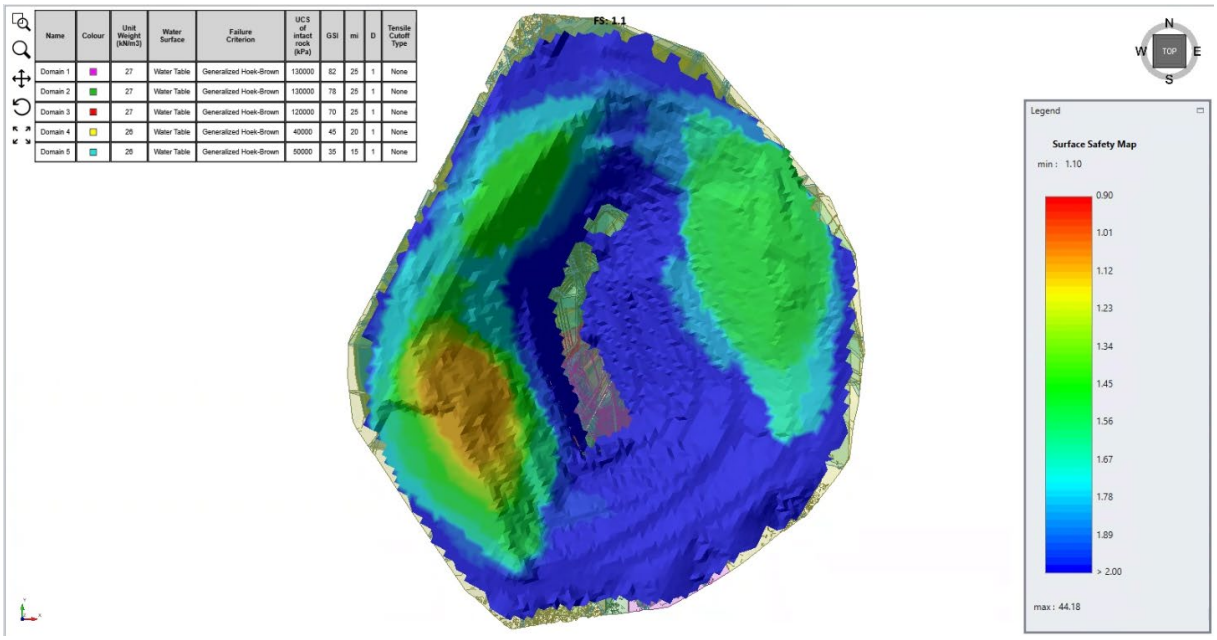
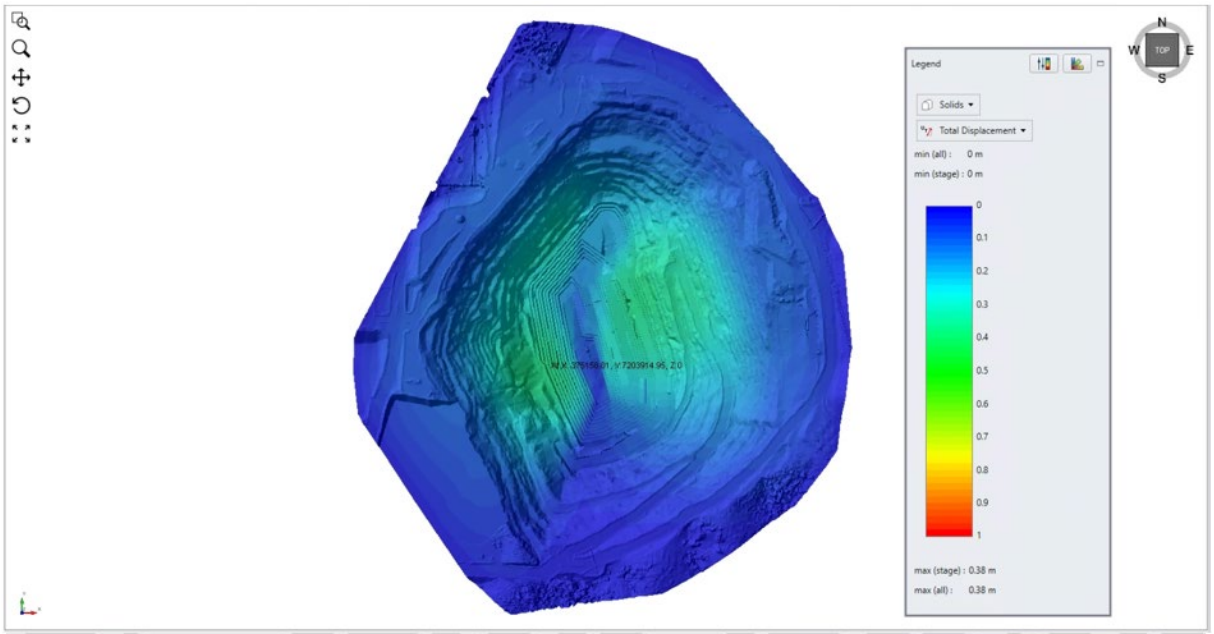


Figure 7: Limit Equilibrium Slide3 results under dynamic seismic conditions

4.8.2 Deformation Analysis (RS3)

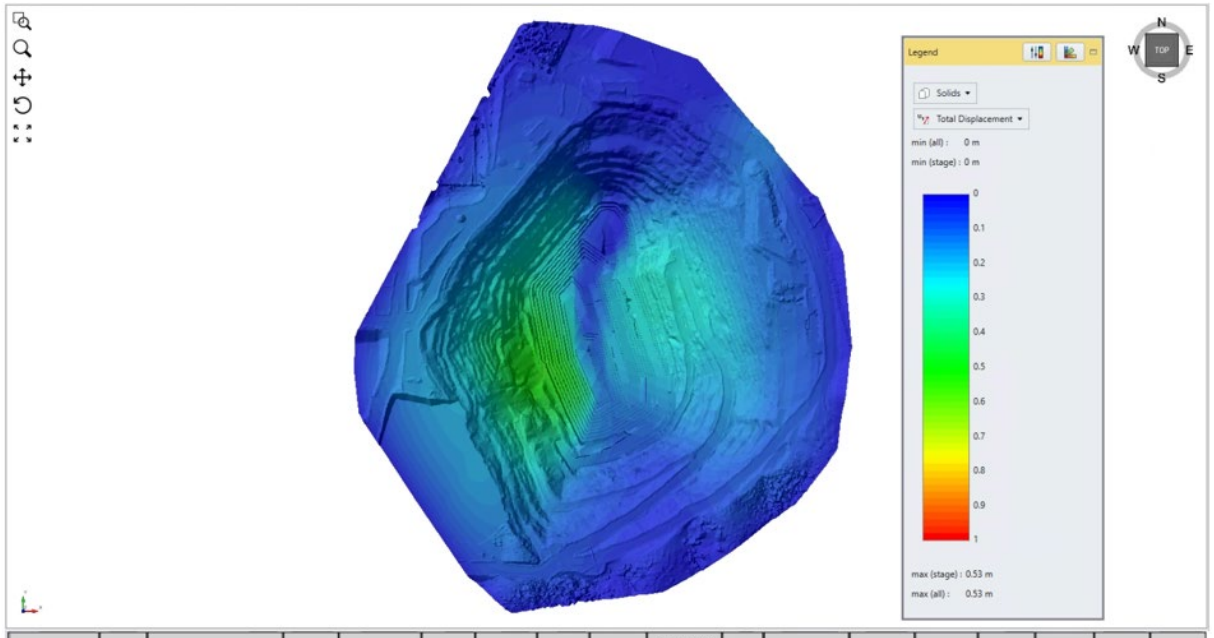
Finite element analysis using the Rocscience software RS3 was used to assess the deformation of the pit slope under closure conditions. The modelling results, as shown below in Figure 8 and Figure 9, illustrate a correlation with Limit Equilibrium (LE) analysis results, with a maximum total displacement of approximately 400 mm (an equivalent strain of 0.23%) recorded more on the west wall and east within range, under static conditions, and 530 mm (an equivalent strain of 0.32%) on the west wall under dynamic conditions, respectively. This displacement will be around areas known to have marginal stability during the operational phase of the mine and caused some instabilities during the operational phase of the Mine. However, this deformation estimate is not expected to instigate large scale failures.



Name	Colour	Initial Element Loading	Unit Weight (MN/m3)	Failure Criterion	Material Type	Peak Cohesion (MPa)	Peak Friction Angle (°)	Peak Tensile Strength (MPa)	Unsaturated Shear Strength Angle (°)	Air Entry Value	Elastic Type	Use Unloading Condition	Poisson's Ratio	Young's Modulus (MPa)	Material Behavior Type	Porosity Type	Porosity
Joints		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Domain 1		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	3822	57	0.937	0	0	Linear Isotropic	No	0.2	21000	Drained	Porosity	0.3
Domain 2		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	2741	57	0.64	0	0	Linear Isotropic	No	0.2	18000	Drained	Porosity	0.3
Domain 3		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	1339	54	0.276	0	0	Linear Isotropic	No	0.22	13000	Drained	Porosity	0.3
Domain 4		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	201	37	0.024	0	0	Linear Isotropic	No	0.25	2000	Drained	Porosity	0.3
Domain 5		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Faults structures		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	27	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3

Figure 8: Result showing total displacement of 380 mm at post-closure conditions s under static conditions

u



Name	Colour	Initial Element Loading	Unit Weight (MN/m3)	Failure Criterion	Material Type	Peak Cohesion (MPa)	Peak Friction Angle (°)	Peak Tensile Strength (MPa)	Unsaturated Shear Strength Angle (°)	Air Entry Value	Elastic Type	Use Unloading Condition	Poisson's Ratio	Young's Modulus (MPa)	Material Behavior Type	Porosity Type	Porosity
Joints		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Domain 1		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	3822	57	0.937	0	0	Linear Isotropic	No	0.2	21000	Drained	Porosity	0.3
Domain 2		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	2741	57	0.64	0	0	Linear Isotropic	No	0.2	18000	Drained	Porosity	0.3
Domain 3		Field Stress & Body Force	0.027	Mohr Coulomb	Elastic	1339	54	0.276	0	0	Linear Isotropic	No	0.22	13000	Drained	Porosity	0.3
Domain 4		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	201	37	0.024	0	0	Linear Isotropic	No	0.25	2000	Drained	Porosity	0.3
Domain 5		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	24	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3
Faults structures		Field Stress & Body Force	0.026	Mohr Coulomb	Elastic	84	27	0.007	0	0	Linear Isotropic	No	0.27	1000	Drained	Porosity	0.3

Figure 9: Result showing total displacement of 530 mm at post-closure conditions under dynamic conditions

5 Recommendations

The following recommendations have been made to ensure safe operations around the final pit void and maintain stability.

- Stability and deformation analyses indicate that the pit void will meet design acceptance criteria factors of safety and will be stable under analysed post-closure conditions.
- Considering that only the final pit shell was used in the stability and deformation analysis, it is recommended that long-term erosion effects be integrated into the final landform to ascertain the inherent effects on stability. However, considering the long-term effects of erosion and the expected re-profiling of the pit slopes, this report is analysed slopes to predict the pit slope's stability and deformation soon after operations cessation and closure.
- Following closure, much slope monitoring can be discontinued by ensuring that access to the pit is closed off with a physical barrier. However, a post-closure monitoring plan should be in place for intermittent void monitoring if access to the pit must be re-established following closure.
- One of the most sensitive components of this model is the hydrogeological surface used for the analysis. As stated, the surface used was predicted by previous consultants as an expected final void phreatic surface. The actual surface may vary; if groundwater levels exceed that as modelled, an additional assessment should be undertaken based on the most current information.
- The proposed rehabilitation and management strategy demonstrates that the post-closure conditions for the pit void meet stability conditions

6 Conclusion

A summary of the results from stability and deformation analysis was discussed in the report, and the methodology was undertaken to obtain the results. Based on the undertaken approach, it can be concluded that the geotechnical void analysis for the planned MRO post-closure pit conditions meets the post-closure slopes and will exhibit stability characteristics consistent with the planning and design of the post-closure mine void.

The mechanisms to achieve acceptable stability were detailed in the report to align with the best available leading practices. Other supporting reporting in the closure, post-closure and rehabilitation strategies were reviewed to ensure that the post-closure conditions analysed in the report aligned with the rest of the considered closure plan.

Due to the ongoing modelling of the final pit shell to include the long-term effect of erosion processes on the final shell, the final pit shell geotechnical analysed for stability does not include the effects of erosion. However, considering the rockmass conditions and modelled groundwater conditions, minimal changes in the slope profile will be anticipated and hence should not deviate much from the modelled slope configurations.

Alluding to the requirements of the PRCP guideline section 3.8, monitoring and maintenance will be critical for the pit void. Monitoring systems proposed in the closure plan should be maintained and sustained through the closure and post-closure periods to demonstrate the attainment of each proposed milestone.

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ATC Williams (2021) Mount Rawdon Operations – Progressive Rehabilitation and Closure Planning – Hydraulic Assessment, 29/06/2021

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CARTLEDGE
MINING AND GEOTECHNICS

EVO010006

Mt Rawdon Mine Progressive Rehabilitation Closure Plan (PRCP) Geotechnical Assessments – Tailings Storage Facility (TSF)

Report No.: Rev 0_Final
12 November 2022

EVOLUTION MINING AUSTRALIA

MT RAWDON MINE PROGRESSIVE REHABILITATION CLOSURE PLAN (PRCP) GEOTECHNICAL ASSESSMENTS – TAILINGS STORAGE FACILITY (TSF)

Cartledge Mining and Geotechnics
Report No.: Rev 0_Final
Date: 12 November 2022

Rev	Date	Author	RPEQ No.	Reviewer	RPEQ No.	Description
0	11 November 2022	Adam Kerr		Keith Mandisodza	25401	Draft
1	12 November 2022	Adam Kerr		Keith Mandisodza	25401	Final

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1 Introduction

Cartledge Mining and Geotechnics (CM&G) undertook geotechnical assessments of the Mt Rawdon Mine Operations (MRO) Open Pit, North Waste Rock Dump (NWRDP), and the MRO Tailings Storage Facility (TSF) as part of the Progressive Rehabilitation and Closure Plan (PRCP) Guideline which is a critical component of the rehabilitation policy under Queensland Government's Mine Land Rehabilitation Policy (DES, 2021).

The geotechnical assessments followed individual studies for all the infrastructures that were analysed. Geotechnical stability was assessed for post-closure and long-term stability as indicated by the landform modelling results. For the tailings storage facility, the geotechnical stability considered the effects of long-term erosion and weathering and the effects of significant hydrological events as outlined in the *Mount Rawdon Final Voids Study Report (SLR Ref: 620.30185-R01 Version No: v2.0 December 2020)*

According to the PRCP Guidelines, the tailings require characterisation to determine the geochemistry, rheology, and geotechnical parameters that influence the rehabilitation or management strategies and the capacity of the Site to support revegetation. The requirement of the Guidelines has been undertaken in this report in the analysis of the provided post-closure final TSF slopes.

1.1 Scope of Work

The scope of work was split into two main categories following a meeting held between MRO Site representatives and CM&G Principal Engineer. The two main categories to be addressed in the scope were:

- Addressing the PRCP Guideline requirements and the DES feedback.
- Review and incorporate results from other relevant work being completed by other consulting parties, i.e., TSF LOM and hydraulic studies, waste dump capping design and erosion modelling.

From these two main categories, the detailed scope of work is outlined below:

1. Address the PRCP Guideline requirements and feedback from the Department of Environment & Science, which requires the following to be captured within a high-level geotechnical report:

- *Geotechnical modelling predicting long-term stability (factor of safety etc.) of TSF and NWRD*
- *Information about the void (pit) wall geotechnical stability and a 3D void design and consideration of the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events (where possible/practicable/relevant)*
- *The description of how the void will achieve post-closure slopes that will exhibit stability characteristics consistent with the planning and design of the post-closure mine void. Mechanisms for achieving acceptable geotechnical stability must be detailed in the plan. This includes any void filling, partial void filling, reshaping and void configuration through earthwork methods such as backfilling, regrading, buttressing, and benching. Where applicable, methods and techniques for achieving safe slopes must be detailed.*

2. Work completed by others includes:

- *TSF LOM design – ATC Williams*
- *Mine Material Management Plan – Landform, cover system and final void design and assessment – RGS Consultants 2022*
- *Progressing Rehabilitation and Closure Planning - Hydraulic Assessment – ATC Williams*
- *Long-term landform evolution (erosion) modelling of low slope angles for NWRD and TSF cover systems – RGS Consultants*

2 Background

The MRO Site is located approximately 100km inland from Bundaberg in southeast Queensland, within the Burnett region. The open pit operation has existed for over twenty years and has been managed by multiple operators. Evolution Mining currently operates MRO and has been the sole operator since 2011. The operation has a life of mine that extends to 2027.

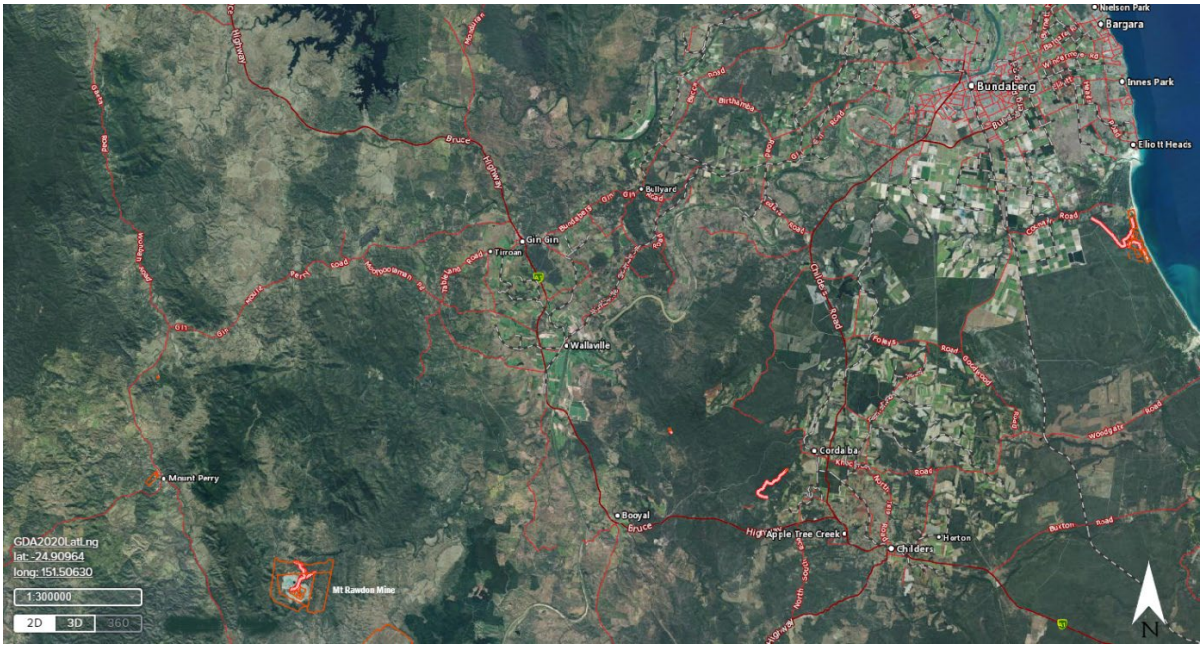


Figure 1: Mt Rawdon Operation site location

2.1 Information Provided

- TSF LOM design – ATC Williams consultants
- Hydraulic Assessment, June 2021 – ATC Williams consultants (refer to an initial report which is being updated to reflect reshaping the TSF at closure.
- Long-term landform evolution (erosion) modelling of low slope angles for NWRD and TSF cover systems – RGS Consultants
- Topographic survey (original pre-mining surface)
- As-built surfaces and modelled closure surfaces (i.e., open pit, NWRD and TSF)
- TSF closure decommissioning and rehab plan – ATC Williams consultants, December 2017
- TSF conceptual closure and rehabilitation plan – RGC consultants, December 2017
- MRO Geochemical Report – RGS consultants, January 2021
- Assessment of long-term geochemical characteristics of Mt Rawdon tailings material-Final Report – RGS Consultants, January 2021

2.2 Document Reviews

Reviewed documents in section 2.1 define different strategies and methodologies applied to analyse various aspects of the infrastructure relative to the closure requirements. Relevant information critical to the stability analysis of the infrastructure was extracted and used in the model setup for geotechnical stability assessments. MRO provided final design survey profiles at closure and post-closure, and geotechnical input parameters inferred from other studies were indicated in section 2.1.

Since the landform modelling and erosion studies were still being undertaken during the geotechnical analyses, only the final landform infrastructure was geotechnically assessed for stability. Once the landform modelling and long-term erosion analysis studies have been finalised, geotechnical investigations will be conducted on those final landforms.

3 Final Tailings Storage Facility Stability Assessment

3.1 Geotechnical Input Parameters

The input parameters considered in the final TSF analysis are provided below in Table 1 to Table 3 and are split up by their inputs into the Long-Term (LT), Undrained (UD), and Post-Seismic (PS) scenarios.

Table 1: Summary of material parameters used for the Long-Term TSF scenarios

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)
LT Unconsolidated Tailings	Mohr-Coulomb	16	0	28
LT Consolidated Tailings	Mohr-Coulomb	18	0	32
LT Rockfill Starter Embankment	Mohr-Coulomb	21	5	38
LT Rockfill Raises	Mohr-Coulomb	20	5	38
LT Rockfill Buttress	Mohr-Coulomb	21	5	38
LT Rockfill Zone 2	Mohr-Coulomb	21	0	38
LT Clay Fill	Mohr-Coulomb	18	2	32
LT Earth Fill	Mohr-Coulomb	18	2	35
LT Surface Soils	Mohr-Coulomb	18	4	24
LT Foundation	Mohr-Coulomb	24	5	45
LT Engineered Tailings	Undrained (Phi = 0)	16	90	0

Table 2: Summary of material parameters used for the Undrained TSF scenarios

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)	Angle (ccw to 1) (°)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
UD Consolidated Tailings (0.25)	Vertical Stress Ratio	18	-	-	-	0.25	20
UD Consolidated Tailings (0.35)	Vertical Stress Ratio	18	-	-	-	0.35	20
UD Consolidated tailings (0.5)	Vertical Stress Ratio	18	-	-	-	0.05	20

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)	Angle (ccw to 1) (°)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
UD Surface Soils	Anisotropic Strength	18	5	30	0	-	-
UD Rockfill Raises	Mohr-Coulomb	21	0	38	-	-	-
UD Rockfill Starter	Mohr-Coulomb	21	0	38	-	-	-
UD Rockfill Buttress	Mohr-Coulomb	21	0	38	-	-	-
UD Rockfill Zone 2	Mohr-Coulomb	21	0	38	-	-	-
UD Foundation	Mohr-Coulomb	24	5	45	-	-	-
UD Clay Fill	Undrained	18	90	-	-	-	-
UD Earth Fill	Undrained	18	90	-	-	-	-
UD Engineered Tailings	Undrained	16	90	-	-	-	-

Table 3: Summary of material parameters used for the Post-Seismic TSF scenarios

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
PS Consolidated Tailings	Vertical Stress Ratio	18	-	-	0.04	0
PS Unconsolidated Tailings	Vertical Stress Ratio	18	-	-	0.04	0
PS Surface Soils	Mohr-Coulomb	20	4	24	-	-
PS Rockfill Raises	Mohr-Coulomb	21	0	38	-	-
PS Rockfill Starter	Mohr-Coulomb	21	0	38	-	-

Material	Strength Type	Unit Weight (kN/m^3)	Cohesion (kPa)	Phi (°)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
PS Rockfill Buttress	Mohr-Coulomb	21	0	38	-	-
PS Rockfill Zone 2	Mohr-Coulomb	21	0	38	-	-
PS Foundation	Mohr-Coulomb	24	5	45	-	-
PS Clay Fill	Undrained	18	90	-	-	-
PS Earth Fill	Undrained	18	90	-	-	-
PS Engineered Tailings	Undrained	16	90	-	-	-

3.2 Modelling Methodology

Rocscience software RS2 (Version 11.017) and Slide2 (Version 9.025) were used to analyse the deformation and stability of the final TSF conditions.

Five sections in the 2020 TSF LOM Stability Assessment, completed by ATC, were replicated for this study with the updated final shell design for the TSF. These five sections are designated by their chainage in meters around the extent of the TSF, including:

- CH359m
- CH898m
- CH2059m
- CH3128m
- CH3536m

Three scenarios were analysed for each chainage section:

- Long-term drained, considering stability under steady-state seepage conditions
- Undrained, considering poor drainage
- Post-seismic, considering liquefaction of TSF material

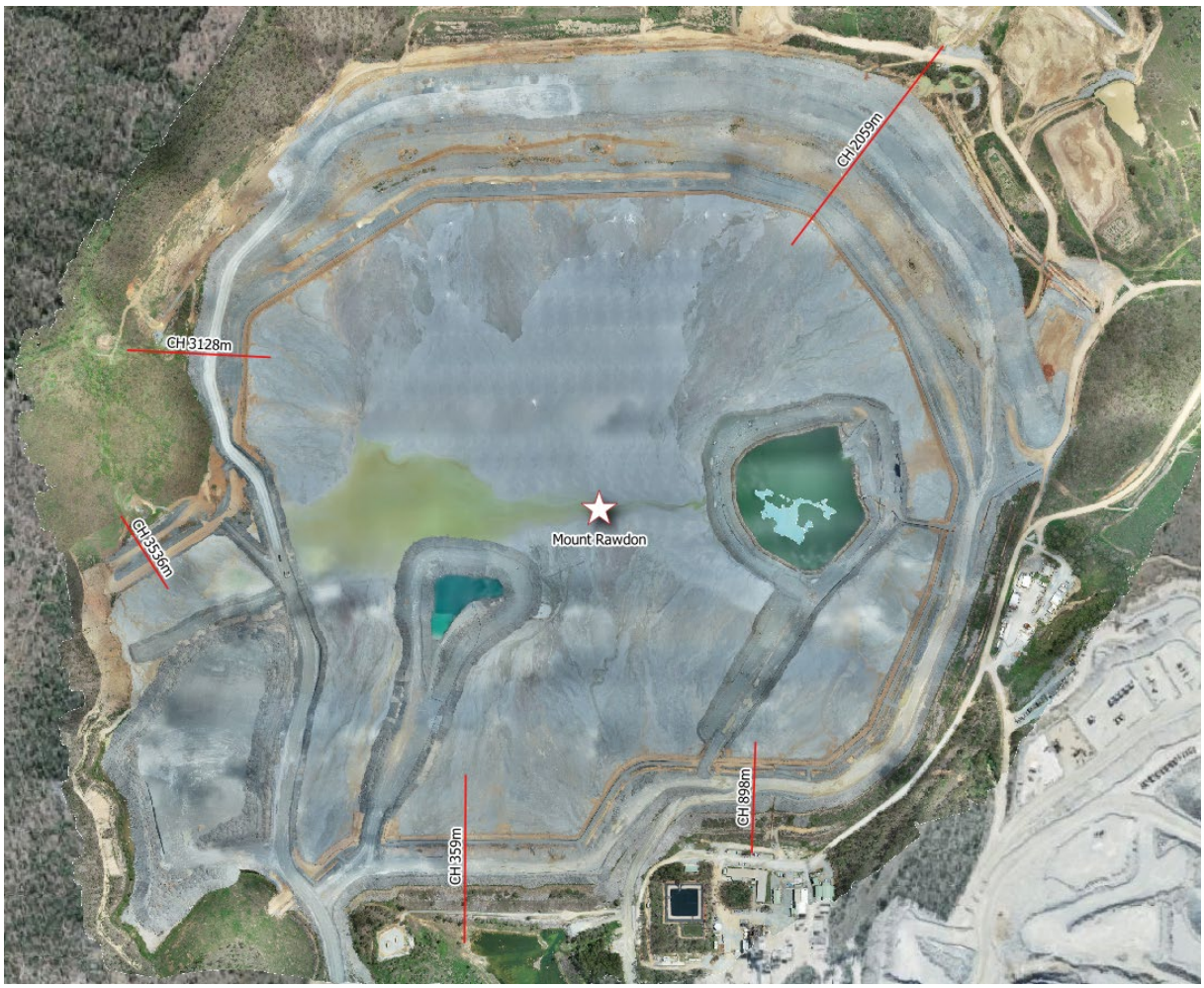


Figure 2: Aerial map highlighting sections used for 2D stability analyses

Two analysis methods were applied: the Spencer and Morgenstern-Price Global Limit Equilibrium (GLE). These methods were selected as they resolve both horizontal and vertical force equilibrium and moment equilibrium. Results were assessed for both to ensure a similar result and thus validate the failure surfaces.

3.3 Stability Assessment Criteria

The adopted assessment criteria for the slope stability analysis are based on ANCOLD guidelines (2019) for the expected range of stability conditions for the embankment.

Table 4: ANCOLD Guidelines factor of safety (ANCOLD, 2019)

Loading Condition	Recommended Minimum FoS for Tailings Dams	Shear Strength to be used for Evaluation
Long-term drained	1.50	Effective Strength
Undrained	1.30	Consolidated Undrained Strength
Post-Seismic	1.00	Post-Seismic Shear Strength

3.4 TSF Liquefaction

Previous investigations have indicated that the MRO tailings material is potentially liquefiable and flowable, which may result in lower post-liquefaction shear strength than the adopted shear strength. A post-seismic event scenario has been modelled with significantly reduced shear strength to emulate the liquefied tailings material.

3.5 Phreatic Surface

The final groundwater surface derived from the Mt Rawdon Post-Closure Groundwater Model (SLR, 2020) could not be used in the TSF study, as it does not represent realistic hydrogeological conditions in the TSF, and saturated conditions were considered instead for all sections under analysis. Groundwater surfaces were inferred and appraised from historical studies conducted for the MRO TSF.

3.6 Modelling Assumptions

The following design assumptions were adopted to analyse the final waste rock dump.

- Material properties used in the analysis were obtained from previous studies conducted for MRO TSF and all the provided reports associated with the Site's closure planning strategy
- Modelled geometry is based on the previous 2020 TSF LOM Stability Assessment report by ATC, with the inclusion of the updated final design profile
- Final slopes were analysed based on the planned TSF at closure. There is no consideration for long-term erosion in the geometry or material parameters of the dump.
- Sections were taken on previously analysed sections from other studies for the MRO TSF since survey data for all the as-built surfaces was missing some critical stages for the facility.

3.7 Stability Analysis Results

Results for the slope stability analyses are shown below.

Table 5: Stability Analysis Results

Chainage Section	FoS (Spencer)	FoS (GLE / Morgenstern-Price)
Long-Term Stability Scenario		
CH359m	1.88	1.87
CH898m	2.50	2.51
CH2059m	2.32	2.32
CH3128m	2.41	2.40
CH3536m	1.94	1.91
Undrained Scenario		
CH359m	1.92	1.92
CH898m	2.23	2.22
CH2059m	2.27	2.27
CH3128m	1.93	1.92
CH3536m	2.16	2.14

Chainage Section	FoS (Spencer)	FoS (GLE / Morgenstern-Price)
Post-Seismic Scenario		
CH359m	1.07	1.05
CH898m	1.96	1.98
CH898m (with additional buttressing)	1.09	1.07
CH2059m	1.19	1.16
CH3128m	1.30	1.28
CH3536m	1.05	1.30

All analysed sections returned acceptable FoS results as required by the ANCOLD guidelines for long-term, undrained and post-seismic global stability conditions, shown in Table 5: Stability Analysis ResultsTable 5 above. The deformation settlement of each section was analysed for the five sections, and the results indicate settlements between 0.02 to 0.14 m, as shown in Table 6, for the different critical strength reduction factors.

Table 6: Seismic displacement results for 1:10000 event (SEE with a PGA of 0.25, Magnitude 7.5)

Section	Scenario	Critical SRF	Vertical Displacement/settlement (m)
CH359m	Post-Seismic	1.05	0.05
CH898m	Post-Seismic	0.69*	0.09
CH2059m	Post-Seismic	1.04	0.14
CH3128m	Post-Seismic	1.30	0.02
CH3536m	Post-Seismic	1.00	0.00

*The critical SRF is lower than the FOS in Table 5

3.7.1 Section Results

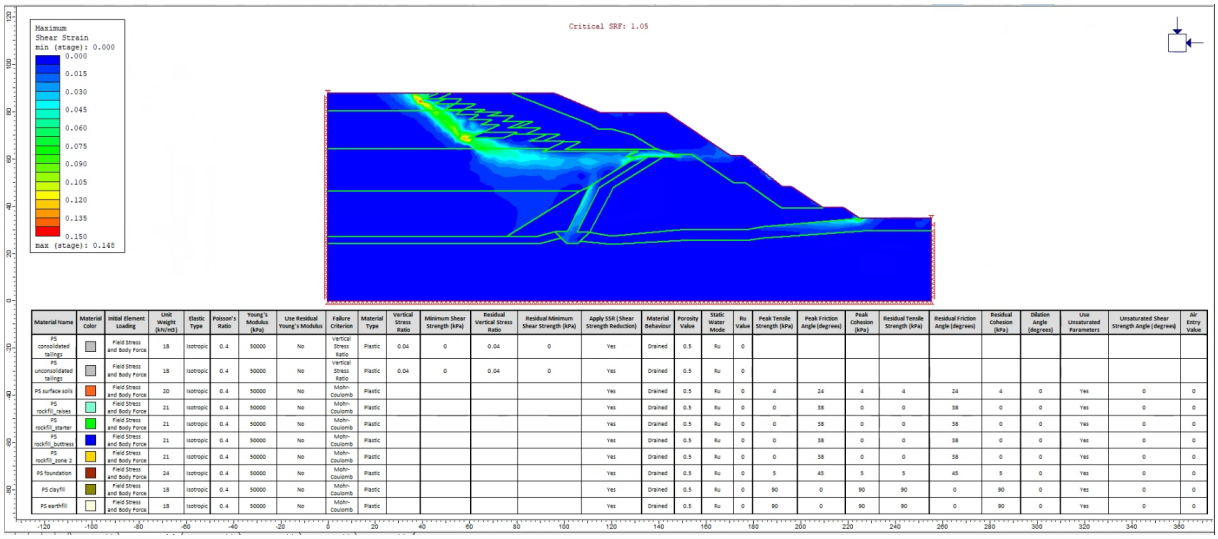


Figure 3: Section CH359m maximum shear strain and critical SRF

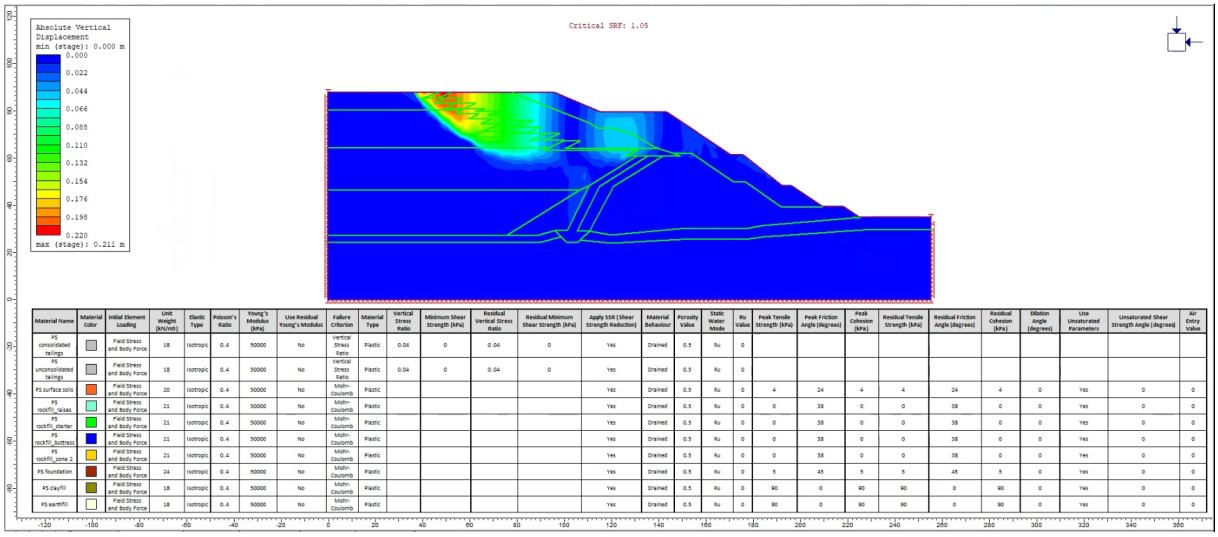


Figure 4: Section CH359m vertical displacement

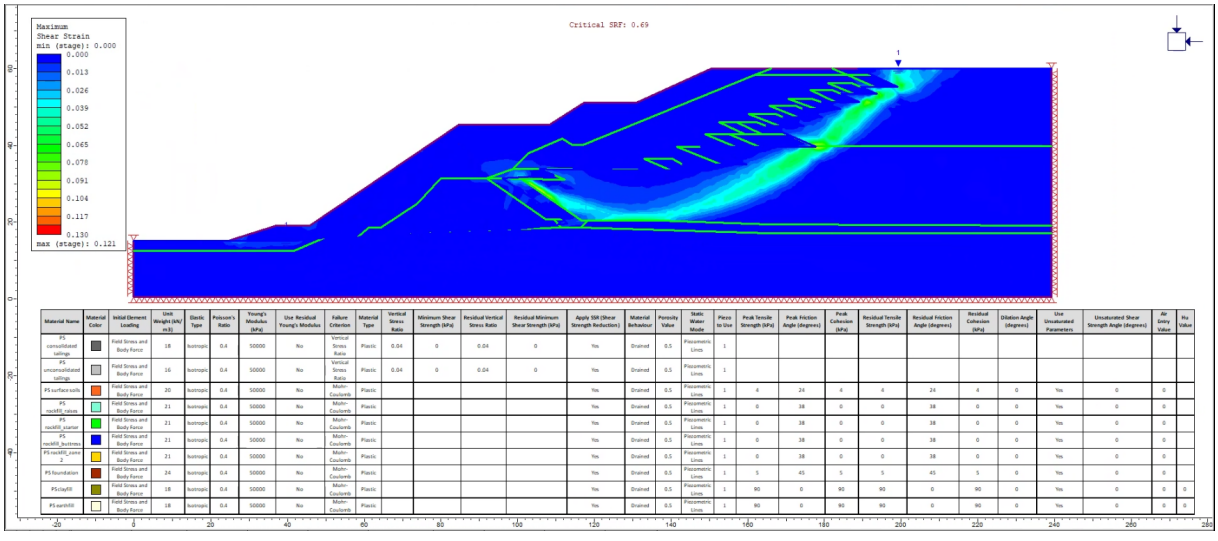


Figure 5: Section CH898m maximum shear strain and critical SRF

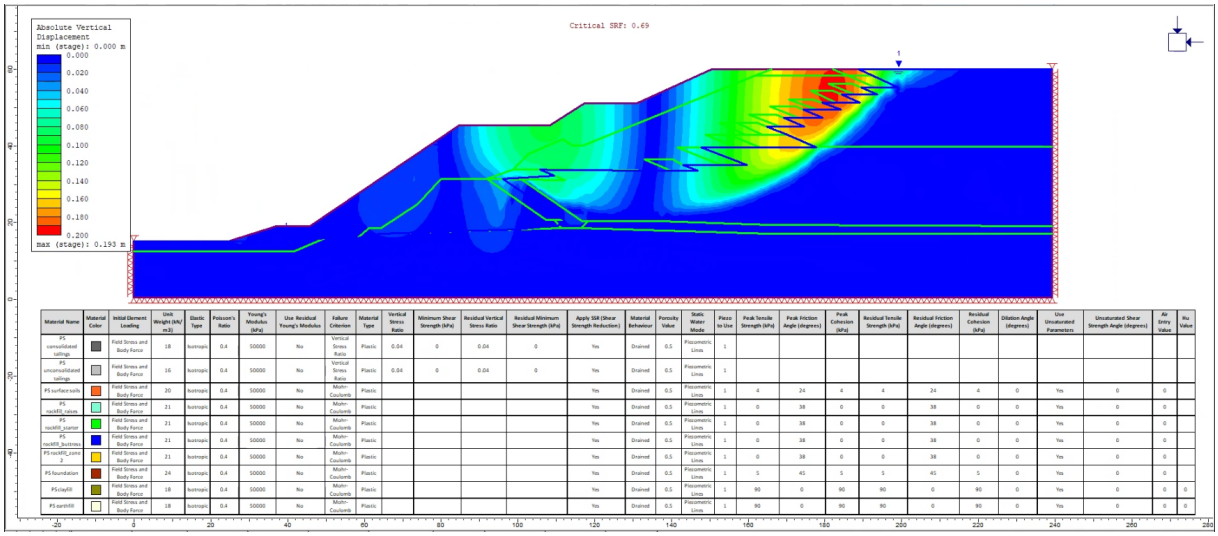


Figure 6: Section CH898m vertical displacement

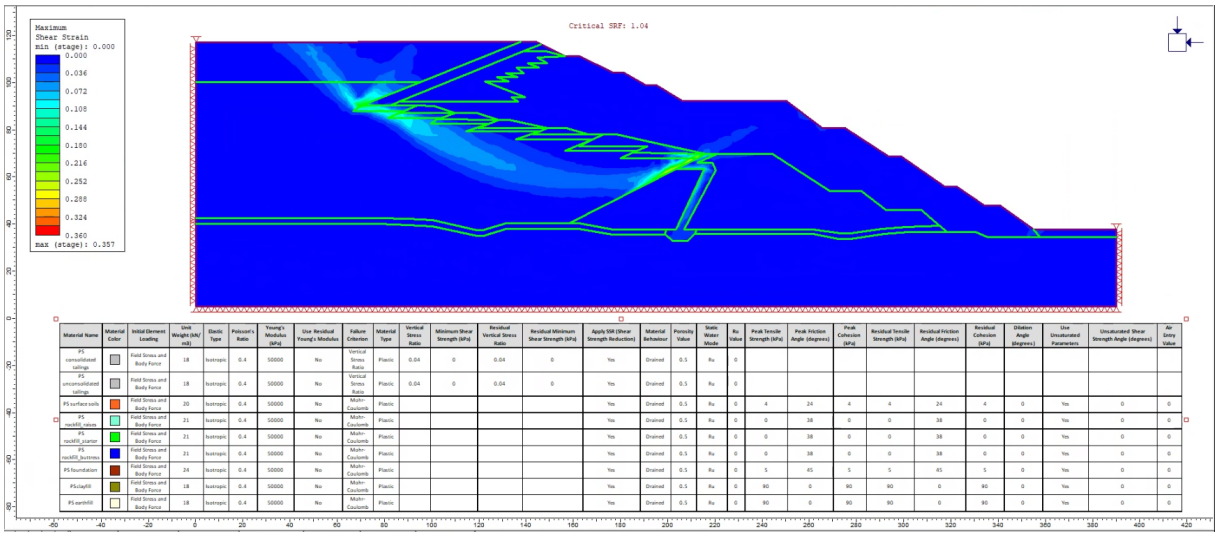


Figure 7: Section CH2059m maximum shear strain and critical SRF

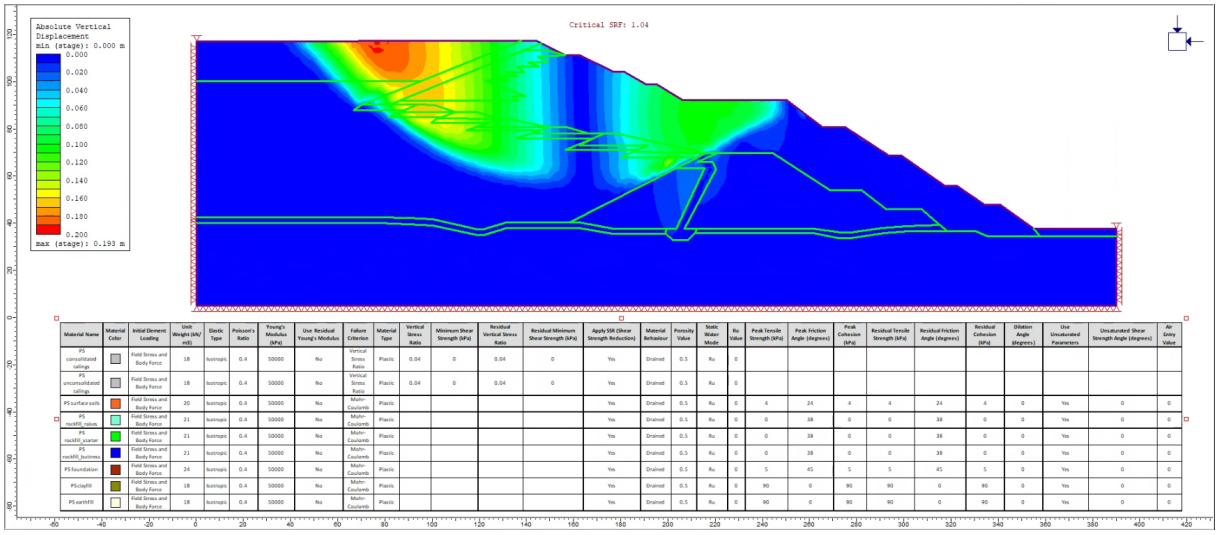


Figure 8: Section CH2059m vertical displacement

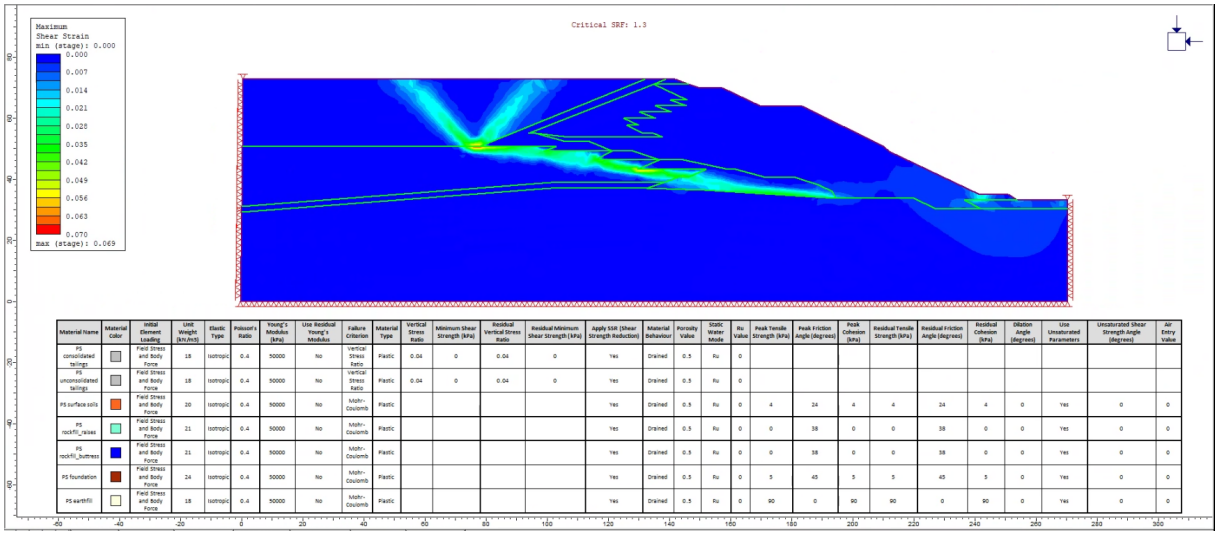


Figure 9: Section CH3128m maximum shear strain and critical SRF

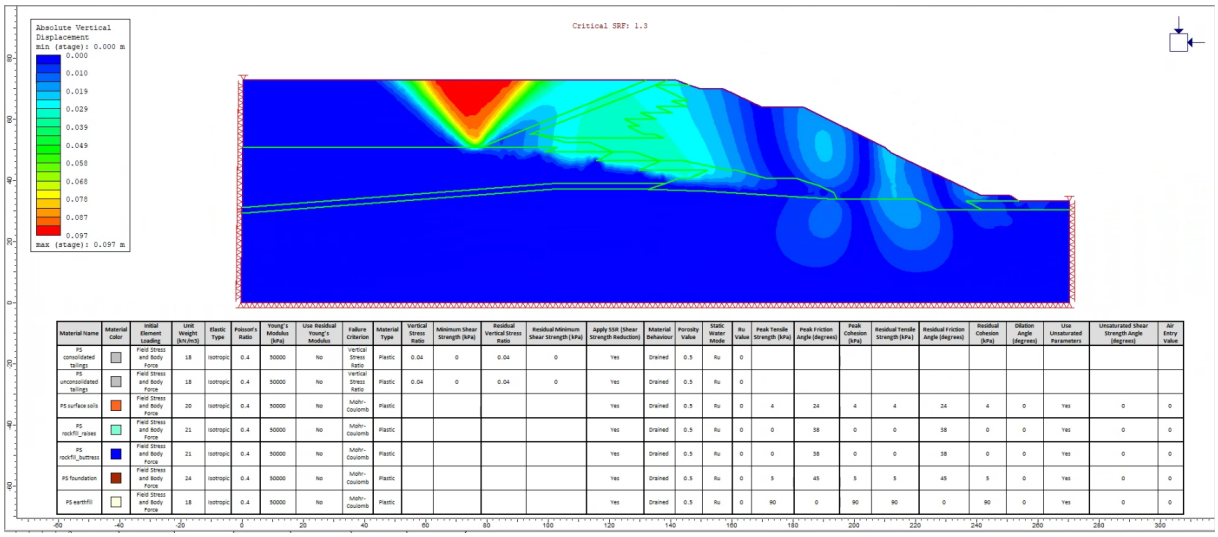


Figure 10: Section CH3128m vertical displacement

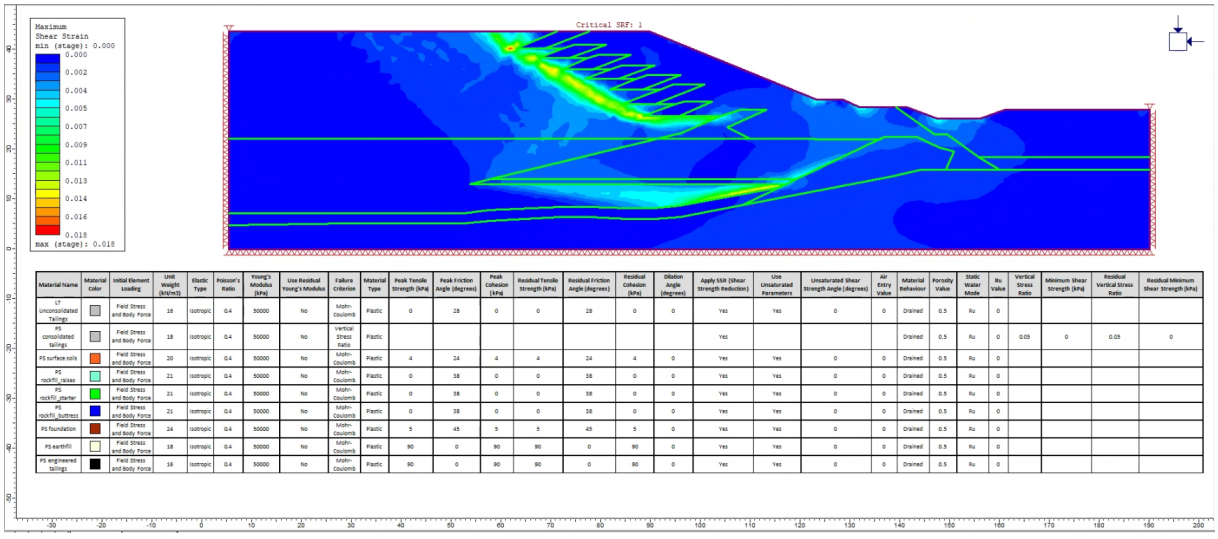


Figure 11:Section CH3156m maximum shear strain and critical SRF

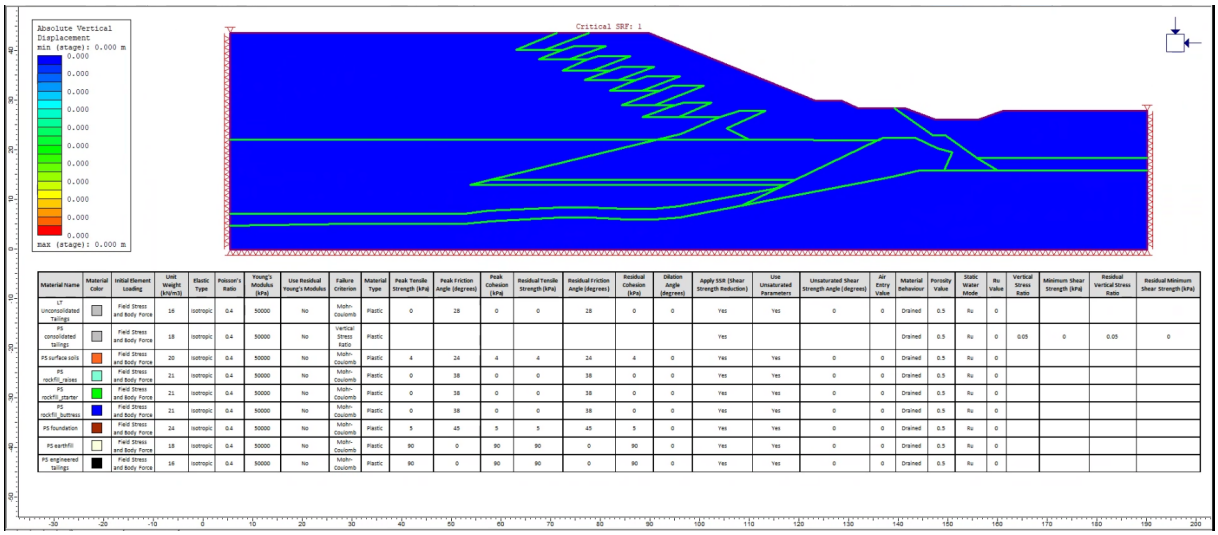


Figure 12: Section CH3156m vertical displacement

4 Recommendations

The following recommendations have been made to ensure safe operations around and to maintain the stability of the final TSF design.

- The analysed results indicate that all the sections in consideration were within the acceptable ANCOLD limits for long-term, undrained, and post-seismic recommended factors of safety
- Considering that only the final TSF shell was used in the stability and deformation analysis, it is recommended that long-term erosion effects be integrated into the final landform to ascertain the inherent effects on stability. Considering the long-term effects of erosion of the TSF, the analysed slopes in this report provide stability only for the TSF soon after operations cease and closure.
- Surface water management is considered a high priority to minimise water inflow into the TSF, as this will change the analysed conditions for long-term stability. The proposed surface water management strategies for closure should be adhered to minimise the change in proposed closure plan conditions.

5 Conclusion

A summary of the results from the stability analysis was discussed in the report. All sections analysed met the acceptable FoS criteria, demonstrating required geotechnical stability during closure and post-closure periods before the effects of erosion lead to reprofiling of the analysed final landform conditions. Changes to the profile analyses require further analyses to ascertain the inherent stability conditions.

The final TSF shell analysed for geotechnical stability does not include the effects of erosion, and results only indicate conditions during the closure period. Long-term effects need to be integrated into the analyses to investigate the associated effects on stability.

References

ANCOLD (2019), Guidelines on tailings dams – planning, design, construction, operation, and closure, July 2019

ATC Williams (2020), Mount Rawdon tailings storage facility LOM design review

Department of Environment and Science (2021), Guideline – Progressive Rehabilitation and Closure Plans, 17/03/2021

RGS (2021), Assessment of long-term geochemical characteristics of Mt Rawdon tailings material, January 2021

Mt Rawdon

GROWTH MEDIA MANAGEMENT PROCEDURE

Version	Date	Description	Prepared By	Approved By	Position	Signature
3.1	27/01/15	Growth Media Management	Enviro Dept	M.Boon	SSE	
3.2	31.10.16	Review	S. Sewell	B. Cleary	SSE	
3.3	Oct 2018	Review	Enviro Dept	A. Matison	HSE Manager	

Mt Rawdon

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7. RESPONSIBILITIES 4

Mt Rawdon

1. INTRODUCTION

Mt Rawdon is aware that growth media is limited and has stockpiled as much of the surface materials as is available. This limited surface material needs to be retained for its best use.

This procedure is designed to assist personnel at Mt Rawdon to identify resources which may be useful as “growth media” to assist rehabilitation of disturbed areas

2. SCOPE

This procedure describes the techniques to identify suitable growth media, the requirements for storage or stockpiling and the utilisation of the available resources for rehabilitation.

3. LEGISLATION

Queensland Legislation
Work Health and Safety Act 2011 & Work Health and Safety Regulations 2011
Mining and Quarrying Act 1999 & Mining and Quarrying Regulations 2017
Environmental Protection Act 1994

4. DETAIL

The location and volume of existing stockpiled growth media (including top soil or other suitable material) has been mapped for the site. These resources have been allocated for future rehabilitation programs according to the agreed rehabilitation plan to ensure that these limited resources are utilised in the best possible way. These mapped resources cannot be moved and used without the agreement of the Environmental Superintendent, or the General Manager, in the absence of the Environmental Superintendent.

Prior to any new ground disturbing activity commencing, the Environmental Superintendent will examine the surface and near surface materials will identify both surface and near surface materials that should be retained, either in separate stockpiles, or in a combined stockpile.

Following analysis, suitable growth media to be stockpiled and the location to be stored will be identified for and discussed with relevant Managers. On completion of stockpiling, the site and volume of the stockpile(s) will be mapped.

If the topsoil is to be stored for a period of less than six months, no treatment of the stockpile(s) is required. If storage is planned to occur for more than six months, then vegetation which was cleared from the site prior to growth media stockpiling is to be spread over the stockpiles to encourage revegetation.

For stockpiles of growth media that are held for longer than two years, if native vegetation does not regrow ("self seed") on the stockpiles, then it may be necessary to apply seed to protect the stockpile.

Wherever possible and as a first principle, growth media is to be directly placed at MT Rawdon on sites prepared for rehabilitation, if so agreed by the environmental superintendent.

In addition to identifying growth media at sites to be disturbed, the Environmental Superintendent will undertake surveys, sampling and analyses as appropriate, to identify and map possible resources for future rehabilitation.

5. ATTACHMENTS

None

6. RELATED DOCUMENTS

Procedure MRO ENV PRO 0209 - "Ground Disturbance Permit"
Procedure MRO ENV PRO 0218 - "Revegetation"

7. RESPONSIBILITIES

Position	Responsibilities
Site Senior Executive	Accountable to ensure the resources required to develop, implement and maintain effectiveness of the site safety and health management system is made available.
Managers	Accountable to ensure that all requirements in the relevant sections of the site safety and health management system are implemented and remain effective in their area/s of responsibility.
Superintendents and Supervisors	Accountable to ensure all requirements of individual documents in the site safety and health management system are implemented and complied with in their area/s of responsibilities
Workers, contractors and visitors	Comply with the site safety and health management system.

REPORT

EVOLUTION MINING LTD

Mount Rawdon Operations – Progressive Rehabilitation and Closure Planning – Hydraulic Assessment

111359.83
JUNE 2021

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Document Control

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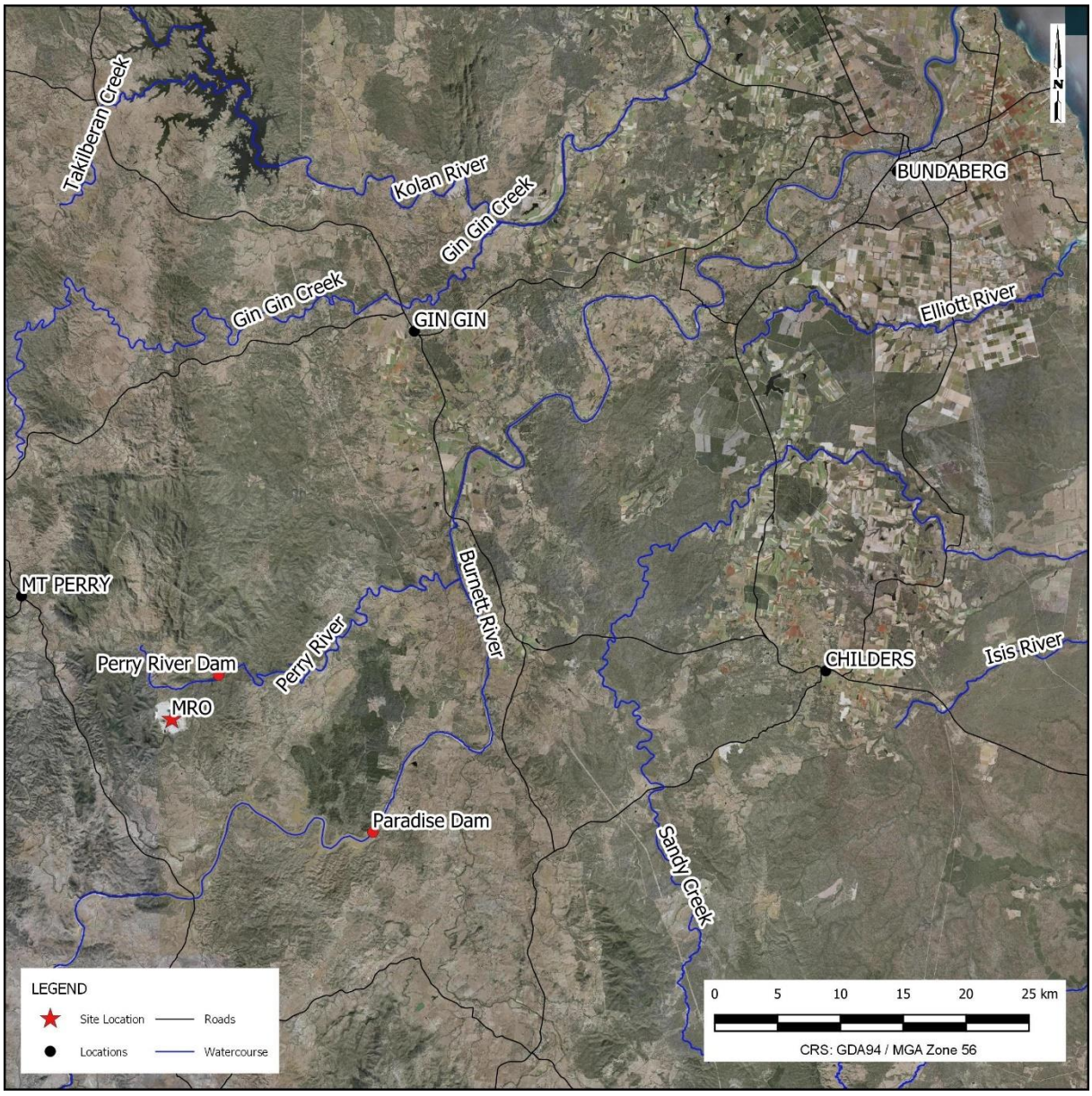
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1 INTRODUCTION

1.1 Background and Purpose

Evolution Mining Ltd (Evolution) owns and operates the Mt Rawdon Operation (MRO), which spans nine (9) mining leases in the Wide Bay-Burnett region of Queensland. The MRO is located approximately 14 km southwest of Mt Perry, and approximately 73 km southwest of Bundaberg. Most of the MRO site drains north towards the Perry River. The remainder of the site drains south, via Mingham Creek, to the Burnett River, as shown on **DIAGRAM 2**. The Burnett River is impounded by Paradise Dam, approximately 18 km southeast of the site, as shown on **DIAGRAM** 1. Paradise Dam does not have any impact on the hydraulic regimes at the MRO site.

DIAGRAM 1: SITE LOCATION



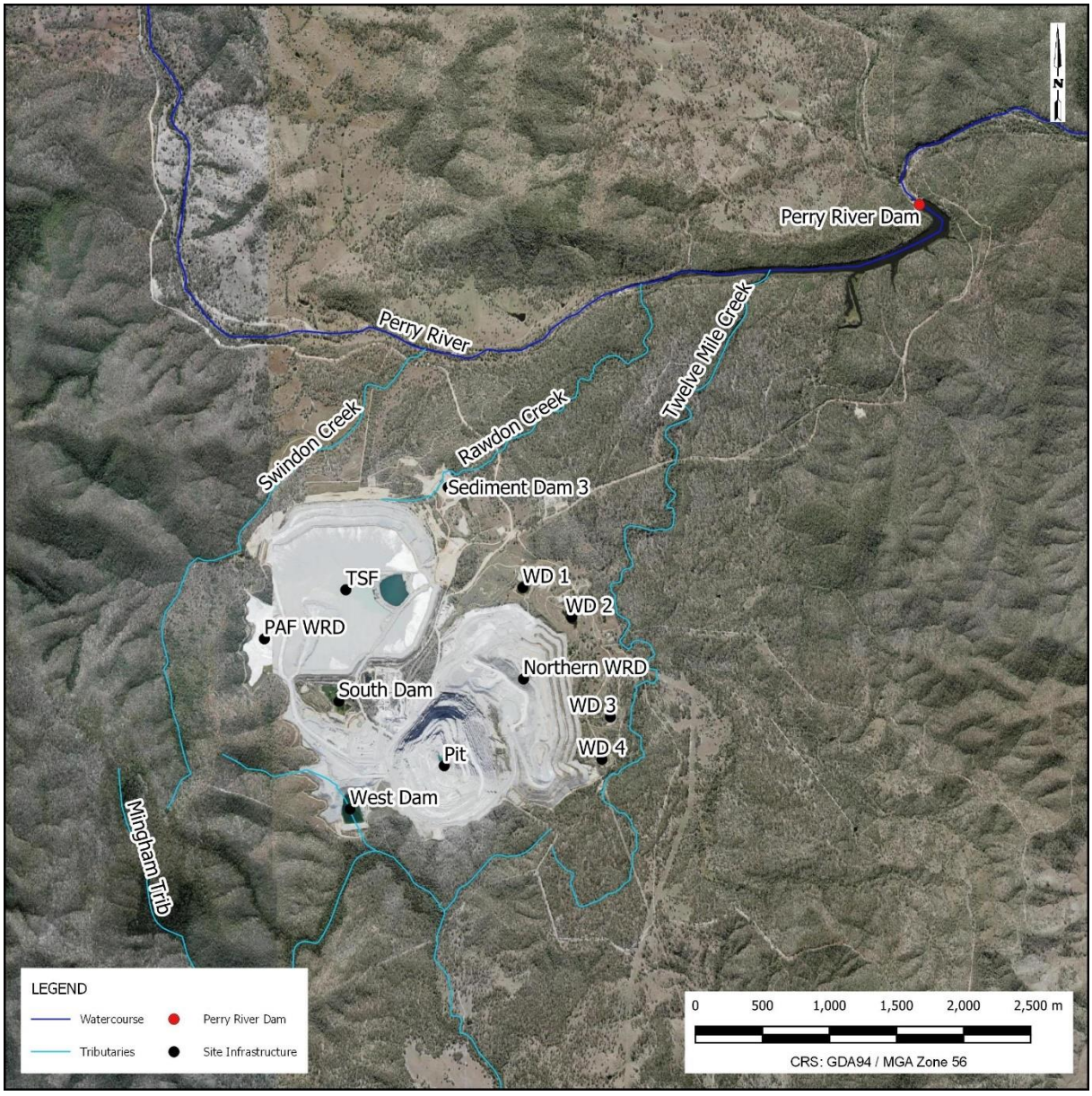
The purpose of this report is to develop a flood profile for the MRO site as part of the Progressive Closure and Rehabilitation Plan (PCRP). The flood profile will be developed for the Probable Maximum Flood, 1:1,000 and 1:100 Annual Exceedance Probability (AEP) design storm events.

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1.2 Site Watercourses/Drainage Setting

The MRO is located approximately 2 km south of the Perry River. Swindon Creek conveys flows from the catchment to the west of the Tailings Storage Facility (TSF) north towards the Perry River. Rawdon Creek and Twelve Mile Creek convey flows from the catchments downstream of the TSF and east of the Northern Waste Rock Dump (WRD) respectively, north towards the Perry River. Mingham Creek receives flows from 'Mingham Trib', 'Mingham Trib West' and 'Mingham Trib East' south towards the Burnett River. The locations of these tributaries are depicted on **DIAGRAM 2**, along with key existing mine infrastructure. The West Dam, Sediment Dam 3, WD1, WD2, WD3 and WD4 are to be retained for erosion and sediment control purposes post closure. Currently, WD1, WD2, WD3 and WD4 receive mine impacted runoff from the Northern WRD. Under post closure conditions, the dams will continue to receive runoff from the Northern WRD, however the Northern WRD will be capped and rehabilitated, such that surface runoff will no longer be mine impacted.

DIAGRAM 2: SITE TRIBUTARIES AND INFRASTRUCTURE



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The Perry River has been impounded by the Perry River Dam (PRD) approximately 4.5 km to the northeast of the site. Flows from the Perry River enter the Burnett River approximately 21 km east of the PRD. The Perry River and the Burnett River are in the Burnett River Basin. The Burnett River discharges into the Coral Sea at Burnett Heads, approximately 13 km northeast of Bundaberg.

1.3 Scope of Work

The following scope of work is required by Evolution to complete their PRCP submission.

- To provide a flood risk profile for the site under post closure conditions
- To provide flood mapping to show water depths and velocities on the final landform design.

The flood risk profile for the TSF and the Pit at MRO was required to be developed in accordance with the PRCP guidelines **[4]**. In consultation with Evolution, it was agreed to model the following events:

- Probable Maximum Flood (PMF) resulting from the Probable Maximum Precipitation (PMP);
- 1:1,000 AEP (0.1% AEP); and
- 1:100 AEP (1% AEP) storm events.

Australian Rainfall and Runoff (ARR) **[1]** was utilised to develop the rainfall estimates for input into a TUFLOW hydraulic model.

1.4 Methodology

The methodology adopted to achieve the scope of works for the PRCP flood study consists of the following three tasks.

- Hydrologic assessment of the site and upstream catchments. This will include:
  - Estimation of site rainfall for the 0.1% AEP, 1% AEP and 5% AEP events from the Bureau of Meteorology (BoM) datasets;
  - Estimation of Probable Maximum Precipitation; and,
  - Regional Flood Frequency Estimates for peak discharge in the Perry River.
- Hydraulic modelling of the site and upstream catchments. This will include:
  - Setting up a Digital Elevation Model (DEM) of the site that conceptually represents the post closure site conditions;
  - Estimation of surface roughness conditions;
  - Application of direct rainfall over the model domain with RFFE flows at the upstream inflow location;
  - Undertaking grid size sensitivity testing;
  - Undertaking model sensitivity testing for rainfall and roughness variations; and
  - Producing mapping of flood depths and velocities for the modelled storm events
- Preparation of a report to present the results of the modelling for inclusion in Evolution's PRCP submission.

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1.5 Structure of Report

The structure of the report, to address the above scope of works, is as follows.

Section 2 Details the hydrological estimations undertaken for the site. This section includes the inputs and outcomes of the rainfall estimation process for the PMP, 0.1% AEP and 1% AEP design events and the Regional Flood Frequency Estimate (RFFE) for the Perry River.

Section 3 Details the development of the TUFLOW hydraulic model utilised for estimating the response of site areas to the hydrographs determined in **Section 2.0.**

Section 4 This section presents and discusses the results of the post closure conditions.

Section 5 This section discusses relevant results to inform the PCRP planning and design.

Section 6 Provides a summary and conclusions from the hydraulic assessment.

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2 HYDROLOGIC ASSESSMENT

2.1 General

As the MRO site is located at the upper extents of Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham Creek, it will not receive flows from any external or upstream catchments. Direct rainfall was applied to the hydraulic model grid so a one dimensional hydrologic model was not required to estimate any other inflows to the hydraulic model domain.

2.2 Coincident Flooding Scenarios

The Perry River Dam (PRD) impounds flows from an upstream catchment area of approximately 97 km². The travel length from the upstream catchment to the PRD headwall is approximately 18 km. Swindon Creek has a flow length of approximately 4.6 km to its junction with the Perry River. Due to this difference in travel length, and therefore time of concentration, it is anticipated that the peak flows from the upstream Perry River catchment would arrive at the confluence with Swindon Creek after the peak flows from Swindon Creek, Rawdon Creek and Twelve Mile Creek catchments.

If the same magnitude event in the local MRO catchment and the regional Perry River catchment were modelled, the combined magnitude of the modelled event would be greater than that in either the local or regional events for the reason stated above. It is good practice to assume that coincident flood scenarios apply in this case to avoid over design or over estimation of flood levels. Coincident flood event scenarios for the local MRO site and the Perry River catchments have been applied, as detailed in **TABLE 1**.

TABLE 1: COINCIDENT FLOODING SCENARIOS

MRO Site Rainfall Event	Perry River Rainfall Event
PMP	1 % AEP (1:100 AEP)
0.1 % AEP (1:1,000 AEP)	1 % AEP (1:100 AEP)
1 % AEP (1:100 AEP)	5 % AEP (1:20 AEP)

The input hydrology for the PMP, 1:1,000, 1:100 and 1:20 AEP events was developed in accordance with Australian Rainfall & Runoff guidelines **[1]**. The different methodologies used to estimate the hydrology are detailed in **Sections 2.3, 2.4** and **2.5**.

2.3 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) for the site has been assessed in accordance with Australian Rainfall and Runoff (2019) **[1]**. The site is located in the generalised tropical storm coastal zone and therefore the Generalised Short Duration Method (GSDM) **[2]** was adopted for event durations between 0.25 hrs and 6 hrs.

The GSDM requires catchment factors to be applied to the initial rainfall depth to estimate the PMP for the site. The site specific values of the catchment factors utilised in deriving the PMP estimates are summarised in **TABLE 2**. A summary of the GSDM PMP calculations is provided in **Appendix A**.

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TABLE 2: GSDM FACTORS FOR PMP ESTIMATE

Parameter	Value
Duration Limit	0.25 - 6 hours
Proportion Smooth	0.0
Proportion Rough*	1.0
Mean elevation at site (m AHD)	140
Moisture Adjustment Factor (MAF)	0.860

*Rough terrain is classified at that in which elevation changes of 50 m or more within horizontal distances of 400 m are common **[1]**.

These factors were applied to generate the PMP depths for 0.25 hr to 6 hr durations, as shown on **DIAGRAM 3** and in **TABLE 3**.

DIAGRAM 3: PMP DEPTH ESTIMATE

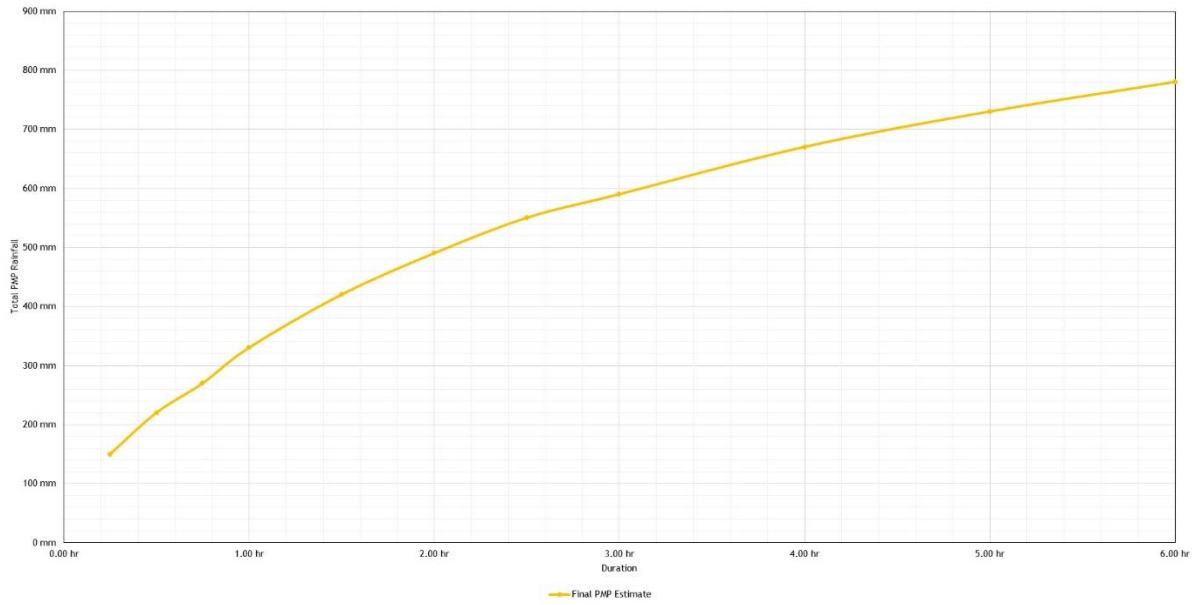


TABLE 3: PMP DEPTH ESTIMATE

Duration (hr)	Total Rainfall Depth (mm)
0.25	150
0.5	220
0.75	270
1.0	330
1.5	420
2.0	490
2.5	550
3.0	590
4.0	670
5.0	730
6.0	780

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2.4 Rare Precipitation Estimation

Rare events are defined as events with an AEP equal to or greater than the 5% AEP event. Rainfall estimates for the 1% and 0.1% AEP storm events for the MRO site were obtained from the Bureau of Meteorology's 'Design Rainfall Data System' **[3]**. The rainfall depths for these events are summarised in **TABLE 4**.

TABLE 4: RARE RAINFALL DEPTH ESTIMATES [3]

Duration	Rainfall Depth (mm)		
	5% AEP	1% AEP	0.1% AEP
1 min	5.1	6.59	9.44
2 min	8.76	11.4	16.5
3 min	12.3	16	23
4 min	15.5	20.1	28.9
5 min	18.5	23.9	34.3
10 min	30.2	39	55.7
15 min	38.6	49.8	71.2
20 min	45	58.1	83.2
25 min	50.2	64.9	93
30 min	54.4	70.6	101
45 min	64.1	83.7	120
1 hour	71	93.3	134
1.5 hour	80.8	107	154
2 hour	88	118	169
3 hour	98.7	134	191
4.5 hour	111	151	216
6 hour	120	165	236
9 hour	136	188	268
12 hour	149	207	295
18 hour	170	238	339
24 hour	187	262	376
30 hour	202	283	411
36 hour	215	300	440
48 hour	236	329	483
72 hour	264	367	535
96 hour	282	390	562
120 hour	291	402	576
144 hour	295	408	582
168 hour	295	409	582

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Each duration event is further divided into an ensemble of ten temporal patterns (TP), as detailed in the Australian Rainfall and Runoff (ARR) Datahub **[1]**. The variations in the temporal patterns account for rainfall patterns not being uniform for their duration, with periods of more intense and less intense rainfall occurring within a single rainfall event. Rainfall estimates from **TABLE 3** and **TABLE 4** were applied directly to the hydraulic model as rain on grid. This is discussed further in **Section 3.2**.

2.5 Regional Flood Frequency Estimate

The Regional Flood Frequency Estimator (RFFE) utilises the data from 853 gauged catchments across Australia and utilises Log Pearson Type 3 distributions to estimate flows based on records in similar catchments. It is understood that the RFFE provides a less accurate estimation of peak discharge in a watercourse than would be obtained from the development of a hydrologic model. In this case, the estimates of peak discharge in the Perry River were used to investigate whether the river had any backwater impacts on the local discharges from the MRO site rather than for modelling of the Perry River. To represent the impact and risk of coincident flooding from the Perry River, flood discharge estimates were included in the hydraulic model as inflows at the upstream boundary in the TUFLOW hydraulic model. **[15]**. The estimates were made at the location immediately upstream of the confluence with Swindon Creek, as indicated in **DIAGRAM 4**.

In the absence of LiDAR data for the wider area external to the MRO site, the upstream catchment area and characteristics for the Perry River were derived from 30 m gridded SRTM data **[13]**.

Due to the distance from the MRO site to the Perry River, it was considered there would be little impact on the site. This was tested by using the mean discharge and 95th percentile flow estimates. It was observed there was no impact to the MRO site from flooding in the Perry River.

The peak flow estimates for the Perry River are summarised in **TABLE 5**.

TABLE 5: RFFE RESULT SUMMARY – PERRY RIVER

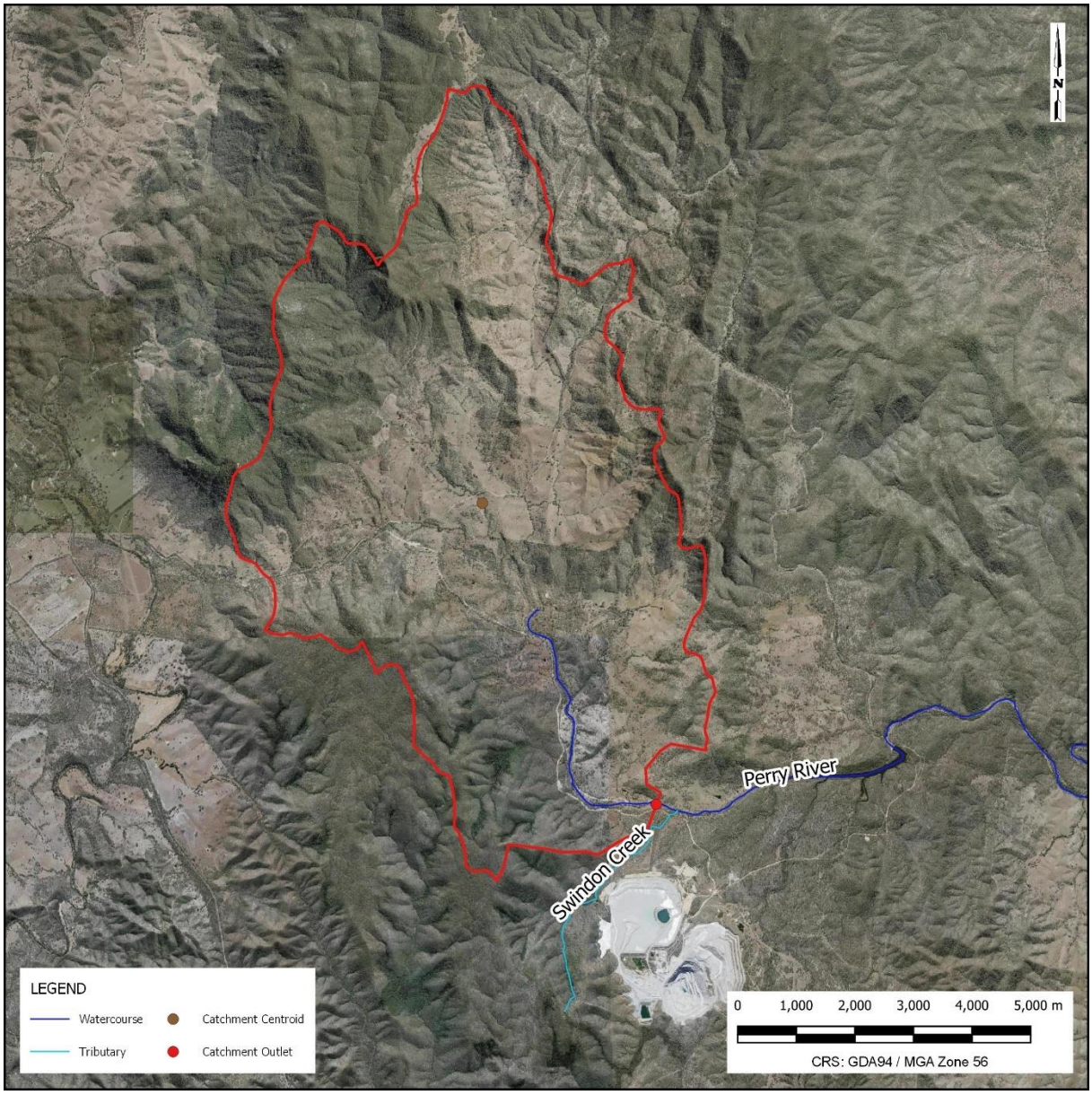
AEP (%)	Mean Discharge (m^3/s)
50	41.3
20	105
10	172
5	261
2	421
1	581

The RFFE estimates peak flows only and does not generate or estimate flow hydrographs. While generally considered to be a validation tool, as mentioned above, the RFFE estimate was adopted to calculate the extent of impacts to the MRO site due to the presence of the impounded lake behind the Perry River Dam and the potential interaction on the flow regimes of Swindon Creek, Rawdon Creek and Twelve Mile Creek.

The catchment boundary, outlet location and centroid location for the Perry River upstream of Swindon Creek are shown on **DIAGRAM 4**.

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DIAGRAM 4: PERRY RIVER CATCHMENT



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3 HYDRAULIC ASSESSMENT

3.1 Model Overview

Hydraulic analysis of the study area has been undertaken using the two dimensional (2D) finite difference program TUFLOW, which is an industry accepted software package highly suited to the investigation of flood behaviour in complex flow scenarios. The model can simulate unsteady hydrodynamic flow in two dimensions on a rectilinear grid, as well as a one-dimensional unsteady hydrodynamic flow through waterway structures such as culverts. The model is based on a robust finite difference solution scheme that is able to compute both sub-critical and supercritical flow regimes. The selected hydraulic solver for the 2D model was the HPC scheme.

3.2 Model Domain

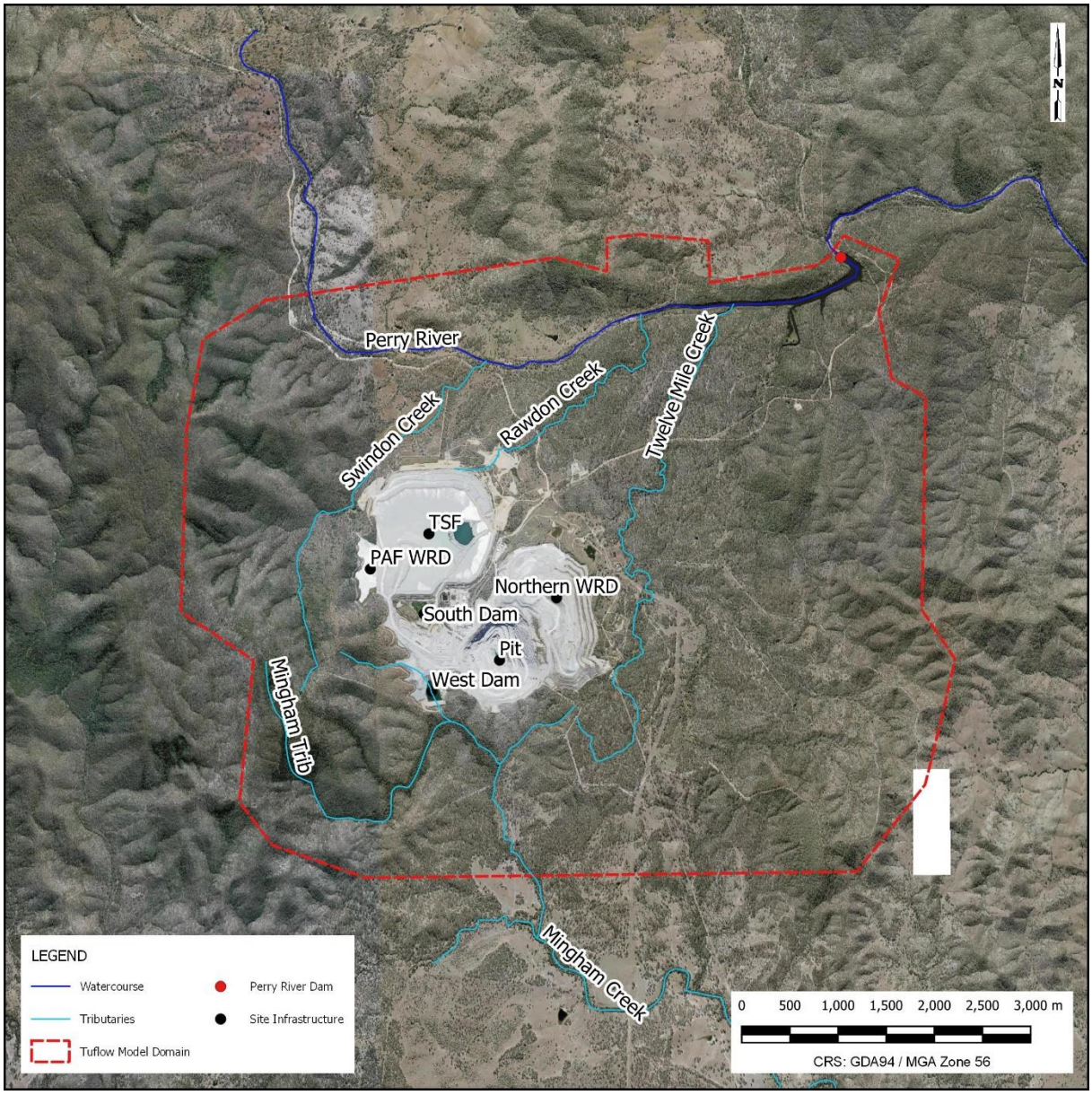
The TUFLOW model was set up to quantify the impacts of the PMP, 0.1% AEP and 1% AEP design storms. The model domain is depicted on **DIAGRAM 5** and includes the following structures and areas.

- TSF (Post closure surface and spillway)
- Pit (including a 2 m abandonment bund around the crest)
- Northern WRD and the potentially acid forming (PAF) WRD
- South Dam and West Dam

In conjunction with the site extents, the model domain includes Swindon Creek, Rawdon Creek and Twelve Mile Creek, which all flow north towards the Perry River, as well as Mingham Creek, which flows south towards the Burnett River.

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DIAGRAM 5: TUFLOW MODEL DOMAIN



3.3 Digital Elevation Model

3.3.1 Base Topography

The topographical base for the TUFLOW model was developed from a series of regional survey and site specific LiDAR datasets. The site survey datasets were resampled into Digital Elevation Models (DEMs). The following datasets were input into the topographical model.

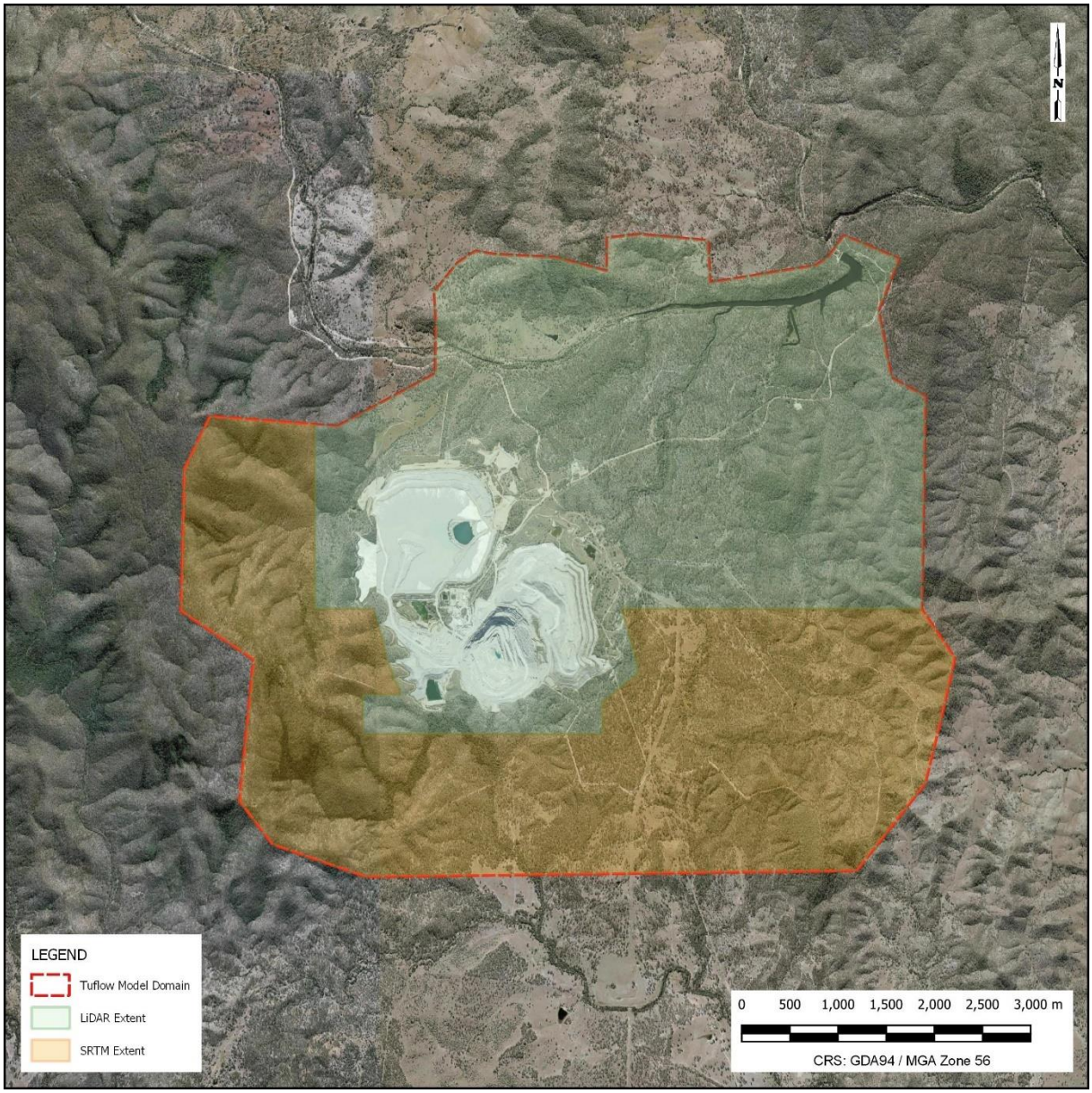
- Hydro Enforced 1 Second DEM **[13]**
- Perry River Dam Grid **[12]**
- Site Survey 1 March 2021 **[6]**
- Site Survey 7 March 2021 **[7]**
- Site Survey 10 February 2021 **[8]**
- Site Survey 23 February 2021 **[9]**

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- Site Survey October 2020 **[10]**
- Site Survey 13 March 2018 **[11]**
- 30 m gridded SRTM data **[13]**

The quality of the LiDAR datasets is substantially higher than that of the SRTM dataset. Consequently, the DEM area based on SRTM topography will create 'modelling noise' in the modelled depths and velocities. The inclusion of SRTM data in the model is to allow for the runoff from upstream areas of Swindon Creek and Mingham Creek to be incorporated into the model. With the exception of the results reported in Mingham Creek, all detailed assessments on the MRO site and its downstream areas were based upon LiDAR topographic data. The extents of the LiDAR and SRTM datasets within the modelling domain are depicted on **DIAGRAM 6**.

DIAGRAM 6: LIDAR AND SRTM DATA EXTENTS



In addition to the base LiDAR and SRTM datasets, the following topographic elements were included to represent the post closure site conditions at the concept stage.

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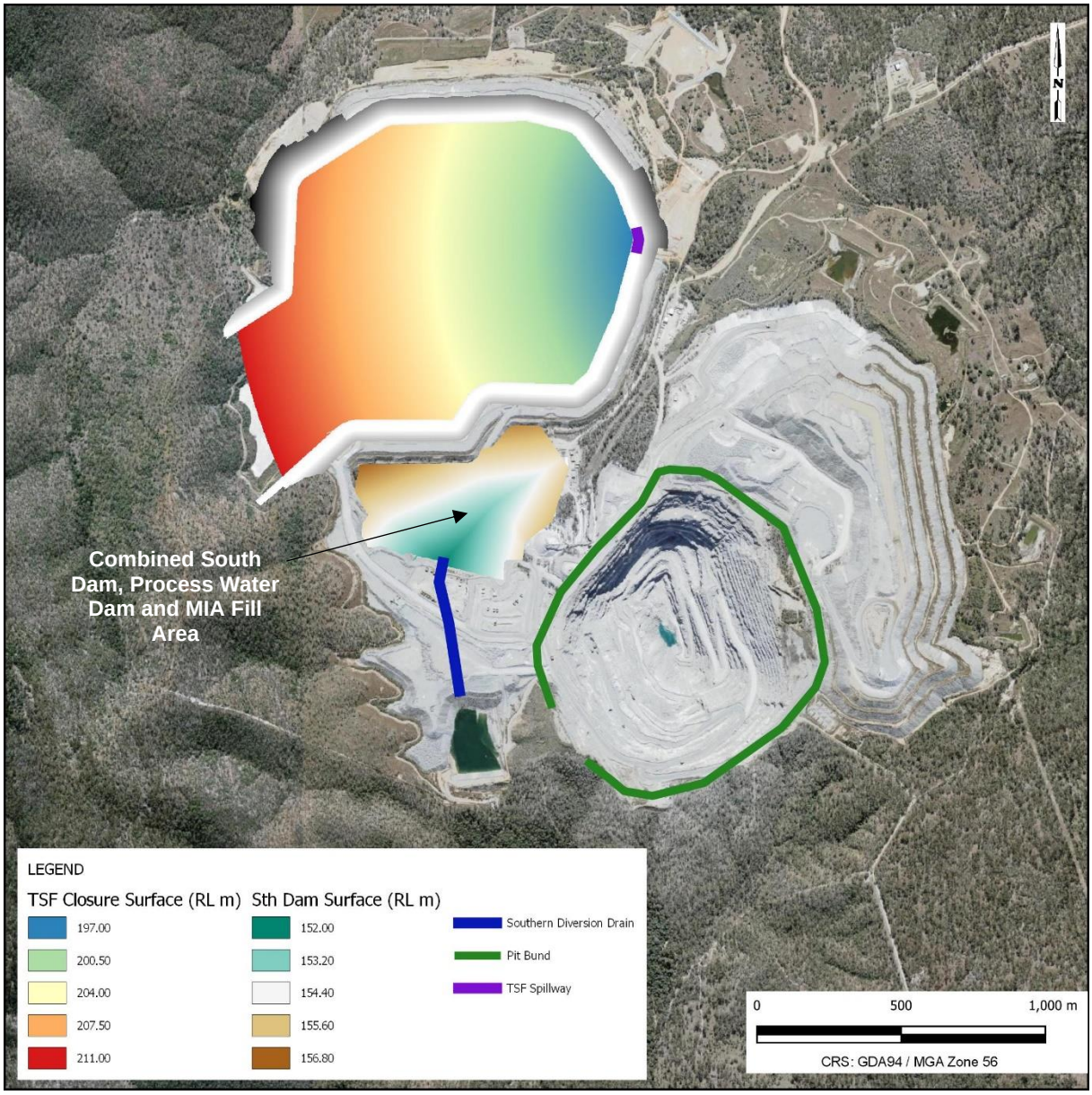
- The TSF embankment was raised to a crest level of 198 m AHD at the east extent, rising to 211 m AHD at the western extent, representing the conceptual closure conditions of the embankment.
- The TSF closure surface incorporated a 0.5% shedding profile to the closure spillway at its eastern extent. The western elevation is at approximately 211 m AHD, falling to 197 m AHD at the spillway location.
- The TSF Closure Spillway arrangement, located at the eastern edge of the TSF, is discussed in **Section 3.3.3**.
- The combined area of the South Dam, Process Water Dam and the mine infrastructure area (MIA) will be filled with NAF rock to a minimum level of 152 m AHD to allow flows to discharge south towards the West Dam.
- A Pit abandonment bund, at least 2 m high, surrounding the Pit.
- A Southern Diversion Drain conveying flows from the South Dam filled area to the West Dam.

Closure capping surfaces of the WRDs have not been incorporated in the hydraulic model at this stage in the design process.

The locations of the TSF Embankment, TSF Closure Surface, TSF Closure Spillway, South Dam Fill Area, Pit Abandonment Bund and South Diversion Drain are shown on **DIAGRAM 7**.

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DIAGRAM 7: POST CLOSURE FEATURES



The sizing and geometric parameters of these features are detailed below.

3.3.2 TSF Closure Surface

The levels of the conceptual closure surface for the TSF were based on the TSF embankment being raised to 198 m AHD at the location of the spillway, increasing to 211 m AHD at the western TSF extents. This surface incorporated a 0.5% longitudinal grade draining towards the east, in conjunction with a 0.5% longitudinal surface towards the centre. This is depicted on **DIAGRAM 7**.

3.3.3 TSF Closure Spillway

The TSF closure spillway has been sized to convey PMP flows. It is proposed to incorporate a spillway based on the details listed in **TABLE 6**.

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TABLE 6: TSF CLOSURE SPILLWAY DETAILS

Parameter	Value
Upstream Invert Level	197.0 m AHD
Downstream Invert Level	196.65 m AHD
Base Width	50.0 m
Side Slopes	1 (V) :1 (H)
Length	35 m
Longitudinal Grade	1 %

3.3.4 Pit Abandonment Bund

The Pit Abandonment Bund has been sized with the parameters listed in **TABLE 7**. The conceptual bund has been designed in accordance with DIR (1997) **[5]**, and is sized to prevent the unintentional access of the abandoned pit void by humans.

TABLE 7: PIT ABNDONMENT BUND DETAILS

Parameter	Value
Crest Width	5 m
Minimum Height	2 m
Batter Slopes	1 (V) :2 (H)

3.3.5 South Dam Fill Area

The area that is currently occupied by the South Dam, Process Water Dam and MIA is to be filled and shaped so that any surface runoff will drain south towards the Southern Diversion Drain and West Dam. The minimum fill levels are listed in **TABLE 8**.

TABLE 8: SOUTH DAM FILL AREA

Parameter	Value
Minimum Upstream Fill Level	154.74 m AHD
Minimum Downstream Fill Level	152.0 m AHD
Longitudinal Grade	0.5%

3.3.6 Southern Diversion Drain

The Southern Diversion Drain has been sized to convey PMP flows from the South Dam Fill Area to the West Dam. The diversion drain is to be constructed through the existing formation between the South Dam and West Dam. It is proposed to construct the diversion drain based on the details listed in **TABLE** 9**.**

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TABLE 9: SOUTHERN DIVERSION DRAIN DETAILS

Parameter	Value
Upstream Invert Level	152.0 m AHD
Downstream Invert Level	147.5 m AHD
Base Width	10 m
Side Slopes	1 (V) : 2 (H)
Length	450 m
Longitudinal Grade	1 %

3.4 Grid Size Selection and Time Step

The choice of grid cell size is important to ensure that the final solution converges with accuracy whilst saving simulation time. This is done by running the model with a number of grid cell sizes and selecting the largest cell size that provides results that match the smaller grid sizes. In this project, the TUFLOW hydraulic model was run to assess the sensitivity to grid size on water surface elevations for four different grid sizes:

- 20 m x 20 m (20 m grid);
- 15 m x 15 m (15 m grid);
- 10 m x 10 m (10 m grid); and
- 5 m x 5 m (5 m grid).

Based upon the results of the model runs, it was determined that that 15 m grid size was most appropriate. A full discussion of the grid size selection is included in **Appendix B**. Based upon the grid size of 15 m, an initial time step of 7.5 seconds was selected.

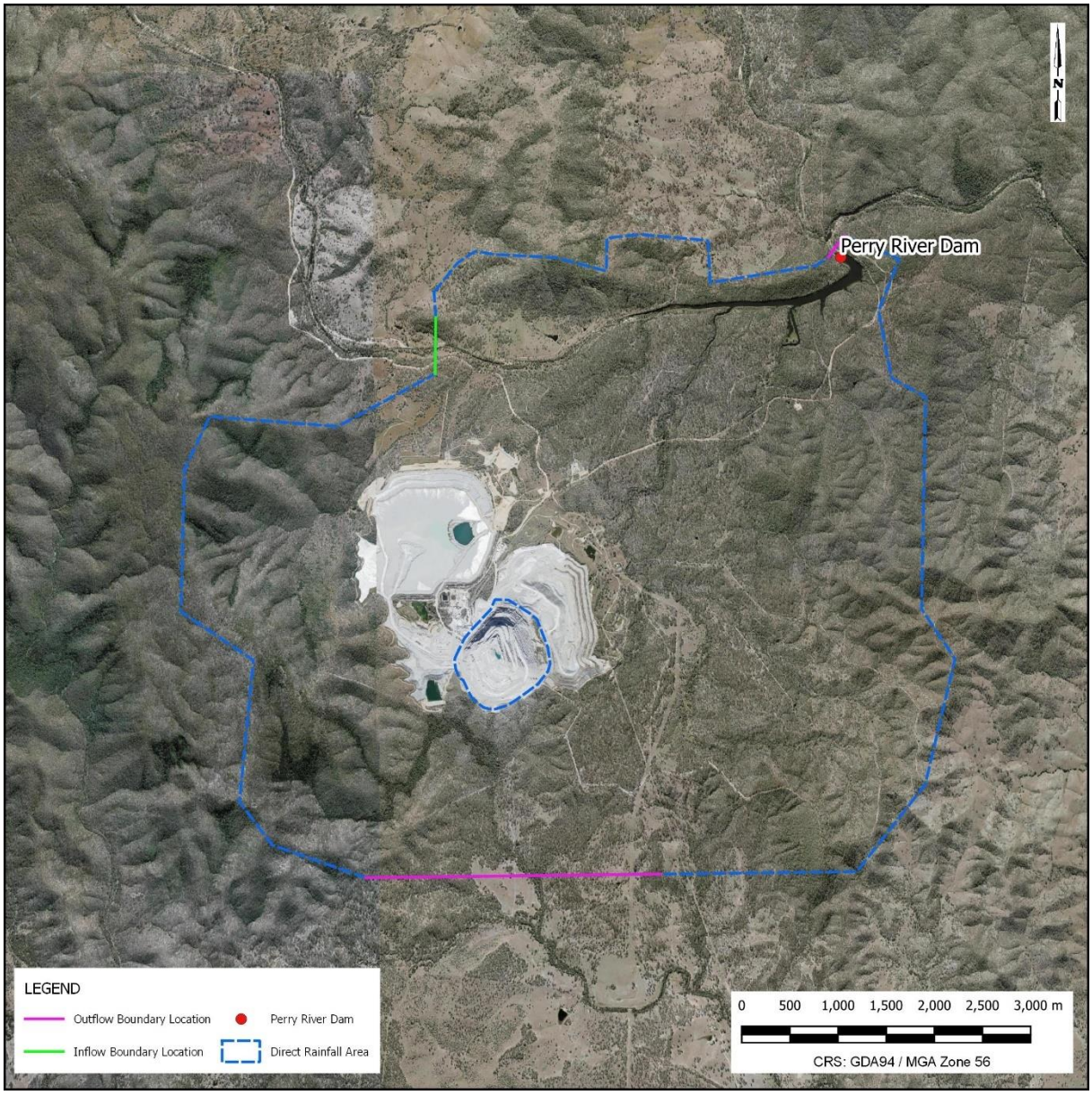
3.5 Boundary Conditions

As detailed in **Section 2.5**, RFFE flows form the upstream inflow boundary for the Perry River in the model domain. The location of upstream flow is depicted on **DIAGRAM 8** and the steady state flows are provided in **TABLE 10**. To allow the full steady state flow conditions to develop in the Perry River before the storm flows from the MRO occurred, a lag time was applied to the direct rainfall over the model domain. The lag time applied to the application of the direct rainfall was 3 hours.

The perimeter of the model had a boundary condition applied to allow rainfall to exit the model. This was done to ensure the model does not allow for the ponding of waters at the model edge. This boundary is not shown on **DIAGRAM 8** for clarity. Boundary conditions at the outflow locations on the Perry River (downstream of the Perry River Dam) and Mingham Creek assumed a normal depth of 1.2% and 2% respectively.

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DIAGRAM 8: BOUNDARY LOCATIONS



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TABLE 10: BOUNDARY CONDITIONS

MRO Site Rainfall Event	Perry River RFFE Event	Perry River RFFE Estimate (m^3/s)
PMP	1 % AEP Mean Flow	581
0.1 % AEP	1 % AEP Mean Flow	581
0.1 % AEP Sensitivity	1% AEP 95th Percentile Flow	2320
1 % AEP	5% AEP Mean Flow	261

In addition to the model boundaries, the dams that are to be retained on site, in conjunction with the Perry River Dam, were set to full supply level so that any inflows to the dam from the upstream catchment would result in the dam spilling. This was based on the conservative assumption that there will have been wet weather preceding the design storm events so that the dams would already be full. The Perry River Dam has a full supply level (FSL) of 98.0 m AHD, which extends up the Twelve Mile Creek and Rawdon Creek tributaries. As such, it has been assumed that any flows entering the dam do not activate friction at the creek bed, but flow across upper layers of water in the dam. The Perry River Dam does not have an emergency spillway; the embankment crest of the dam forms a broad crested weir configuration for the spillway.

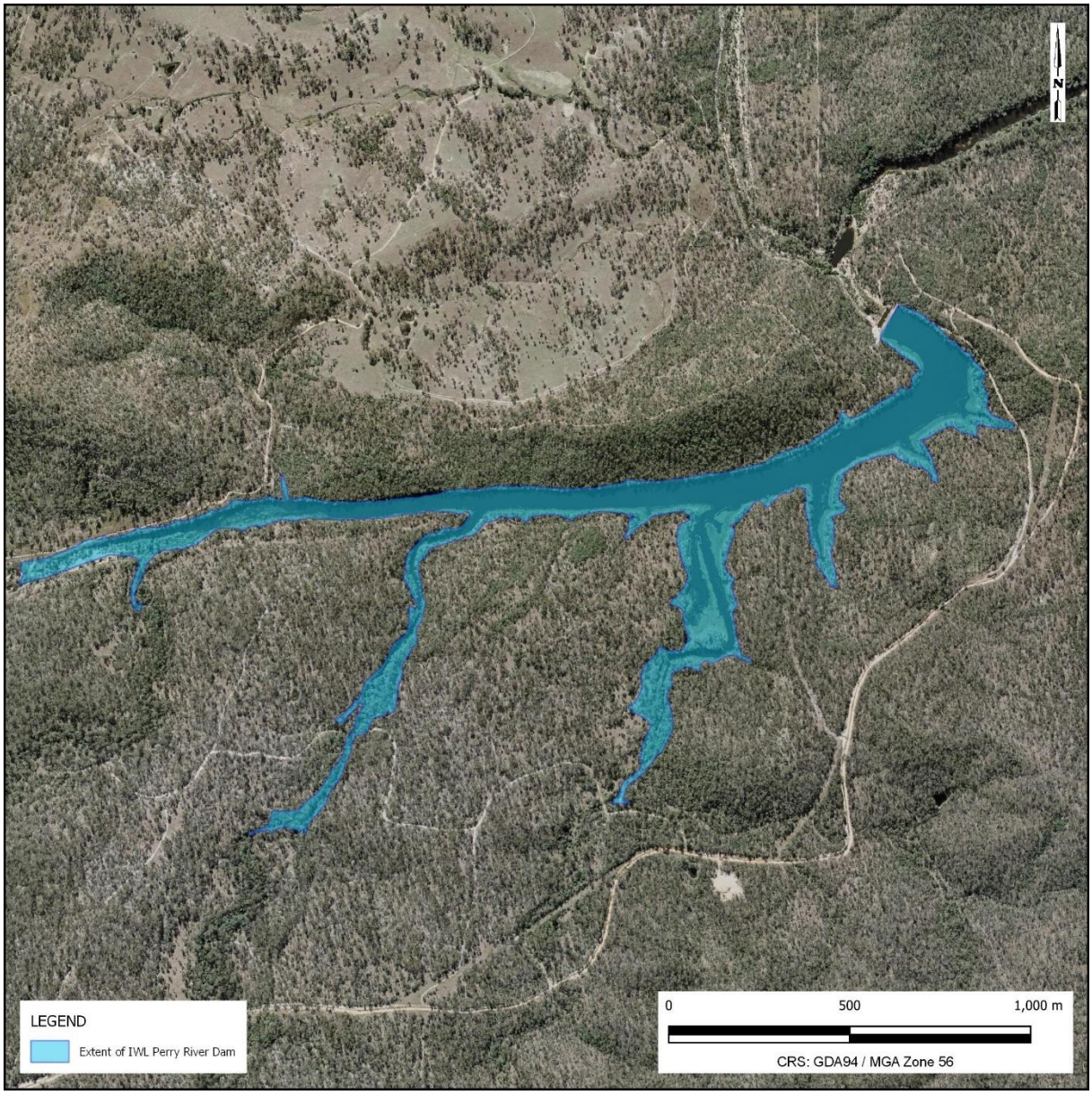
The adopted initial water levels (IWLs) are detailed in **TABLE 11**. The extents of the adopted IWL in the Perry River Dam is depicted on **DIAGRAM 9**.

TABLE 11: DAM INITIAL WATER LEVELS

Site Rainfall Event	Initial Water Level (m AHD)
Perry River Dam	98.0
Sediment Dam 3 (SD3)	119.1
WD 1	126.7
WD 2	120.0
WD 3	125.1
WD 4	134.4
West Dam	123.8

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DIAGRAM 9: PERRY RIVER DAM INITAIL WATER LEVEL EXTENTS



3.6 Surface Roughness

The Manning's 'n' surface roughness coefficient was used to describe the surface conditions within the model domain. Manning's 'n' roughness coefficients were assigned to the model domain based on land use type and characteristics, as depicted on **DIAGRAM 10**. Selection of the coefficient values was made considering the apparent roughness of surfaces based upon inspection of available aerial imagery and assumption of the proposed surface conditions post closure. The reference values detailed in Innovyze (2019) **[14]** were utilised to represent natural channels and post closure site conditions. The main flow regime in a direct rainfall model is overland flow, which results in higher Manning's 'n' values than in river channels and floodplains. A default surface roughness of n = 0.4 was adopted for non-mine impacted areas. A description of each adopted Manning's 'n' coefficients is provided in **TABLE 12**.

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DIAGRAM 10: MANNINGS ROUGHNESS

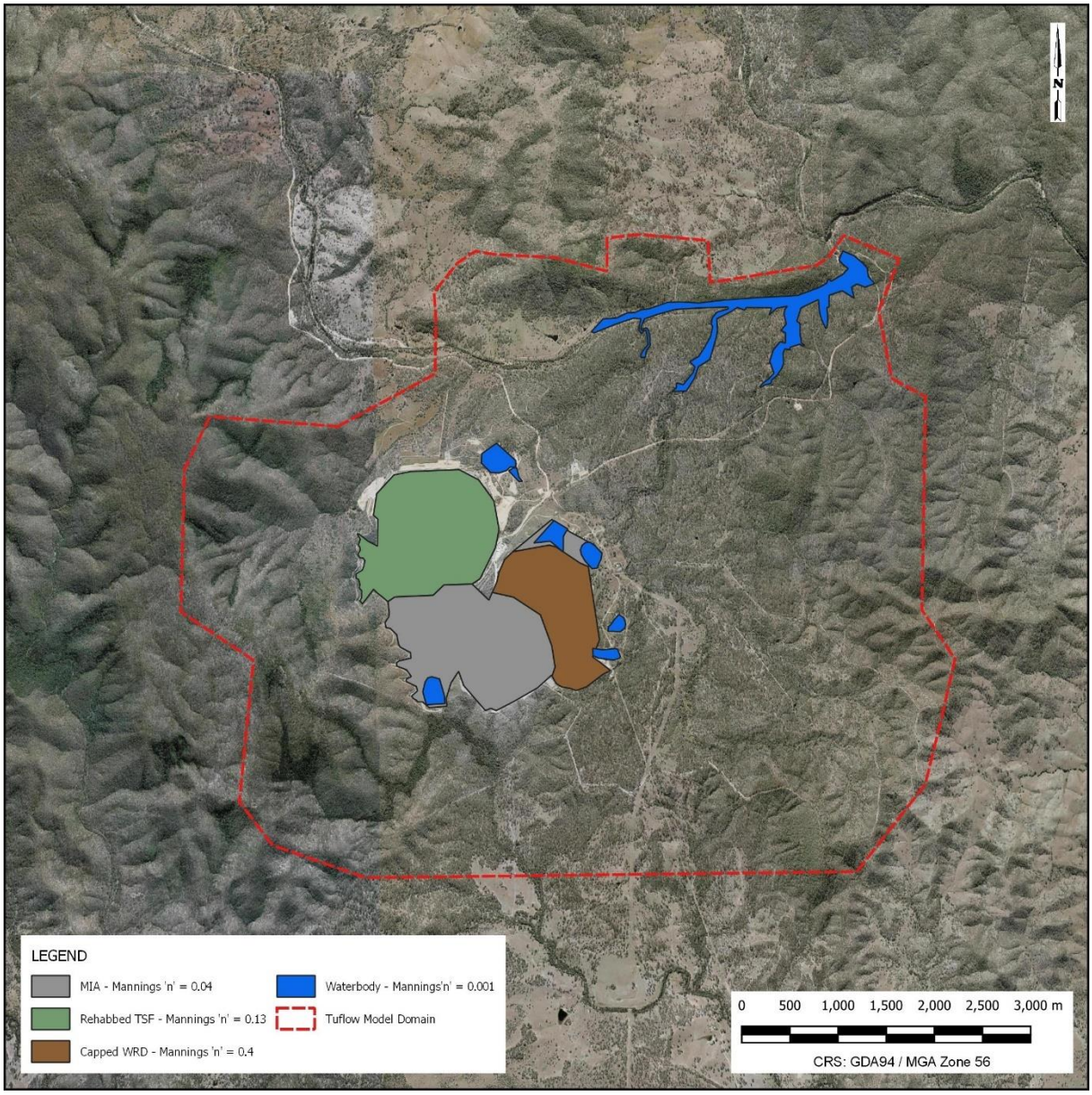


TABLE 12: MANNINGS 'n' ROUGNESS COEFFICIENT

Mannings 'n' coefficient	Description
0.001	Still water/dams
0.04	Areas of sparse vegetation, with exposed rocky surfaces
0.13	Areas of short to medium grasses and short scrubby vegetation
0.40	Light underbrush of grasses and vegetation. Tall canopy above.

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3.7 Sensitivity Analysis

A sensitivity analysis was undertaken for the TSF closure conditions to understand the model's response to changes in values of key parameters, such as changes in rainfall estimates and surface roughness. This provides an improved understanding of the potential impacts in the uncertainties in estimation of these parameters. The following sensitivity scenarios were assessed:

- A ± 20% change in rainfall depths to account for the uncertainty in the estimated rainfall and those associated with climate change impacting extreme rainfall events.
- A ± 20% change in assumed Manning's 'n' roughness coefficients. In general, higher roughness coefficients reduce flow velocities and therefore increase modelled flood depths. Lower roughness coefficients have a converse effect.

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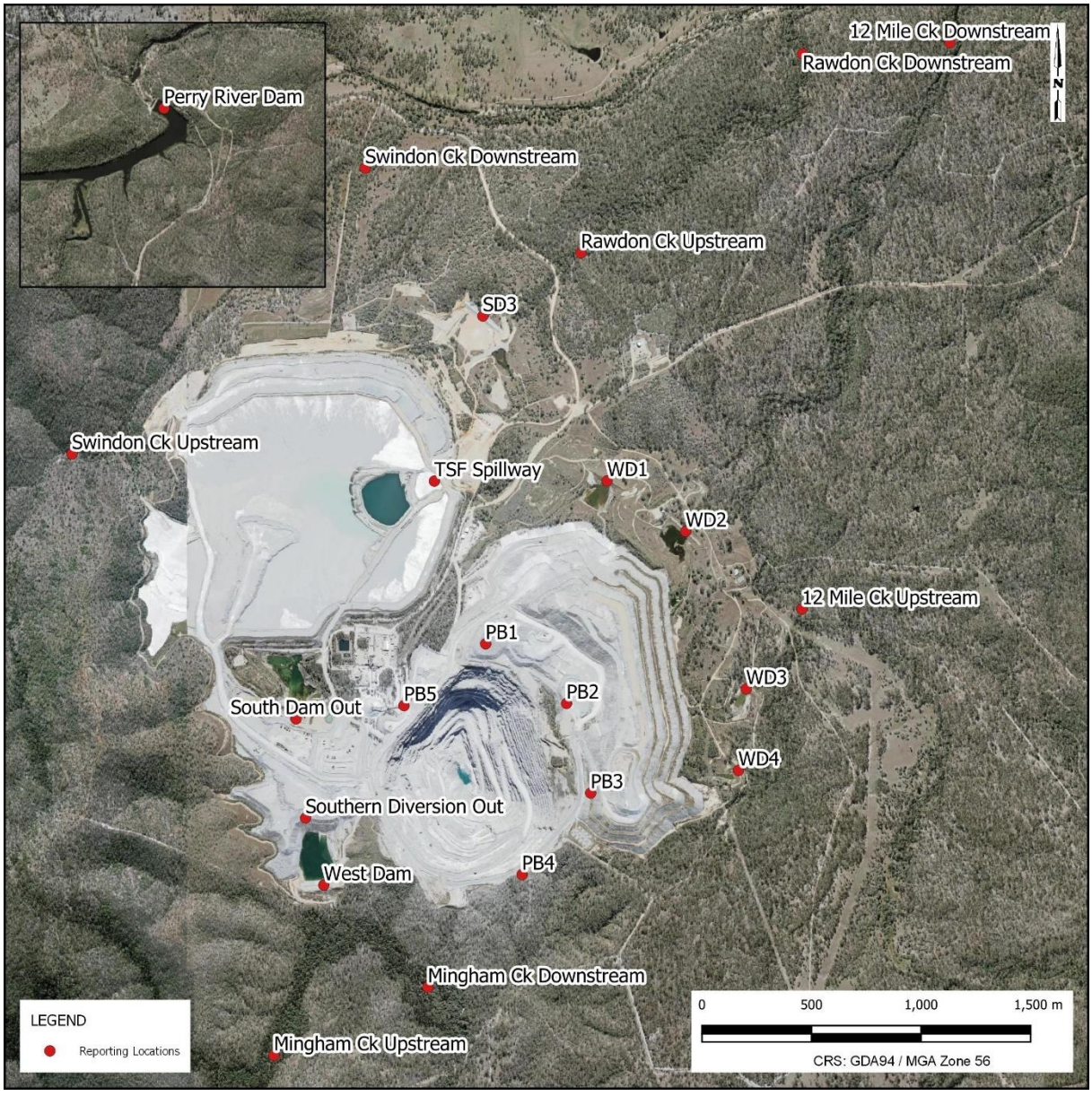
4 RESULTS

4.1 Introduction

The results of the TUFLOW model showing maximum water depths and velocities are shown on **Figure 001** to **Figure 006**.

A summary of the results of flooding on the post closure conditions of the TSF, West Dam, South Dam Fill Area, Southern Diversion Drain, Pit Bund, Perry River Dam, retained dams on site and the downstream tributaries are summarised below. The locations at which results are reported are depicted on **DIAGRAM 11**.

DIAGRAM 11: RESULTS REPORTING LOCATIONS



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4.2 TSF

The maximum recorded flow rates, depths and velocities in the TSF spillway and in the middle of the TSF closure surface are summarised in **TABLE 13**. PMF flood depths are depicted on **DIAGRAM 11** and on **Figure 001**. Upon discharging from the TSF, flows enter Rawdon Creek. The PMF rainfall event produces the highest water surface elevation, peak flow rate and peak velocity in the TSF. As rainfall depth decreases in conjunction with the return period (0.1% AEP and 1% AEP), the modelled depths, flow rates and velocities also decrease, as expected.

The results also indicate that there is a fall in water surface elevation across the TSF closure surface. The maximum velocities across the TSF closure surface are less than 1 m/s, so erosion of emerging vegetation is unlikely to occur in extreme rainfall events.

TABLE 13: TSF RESULTS

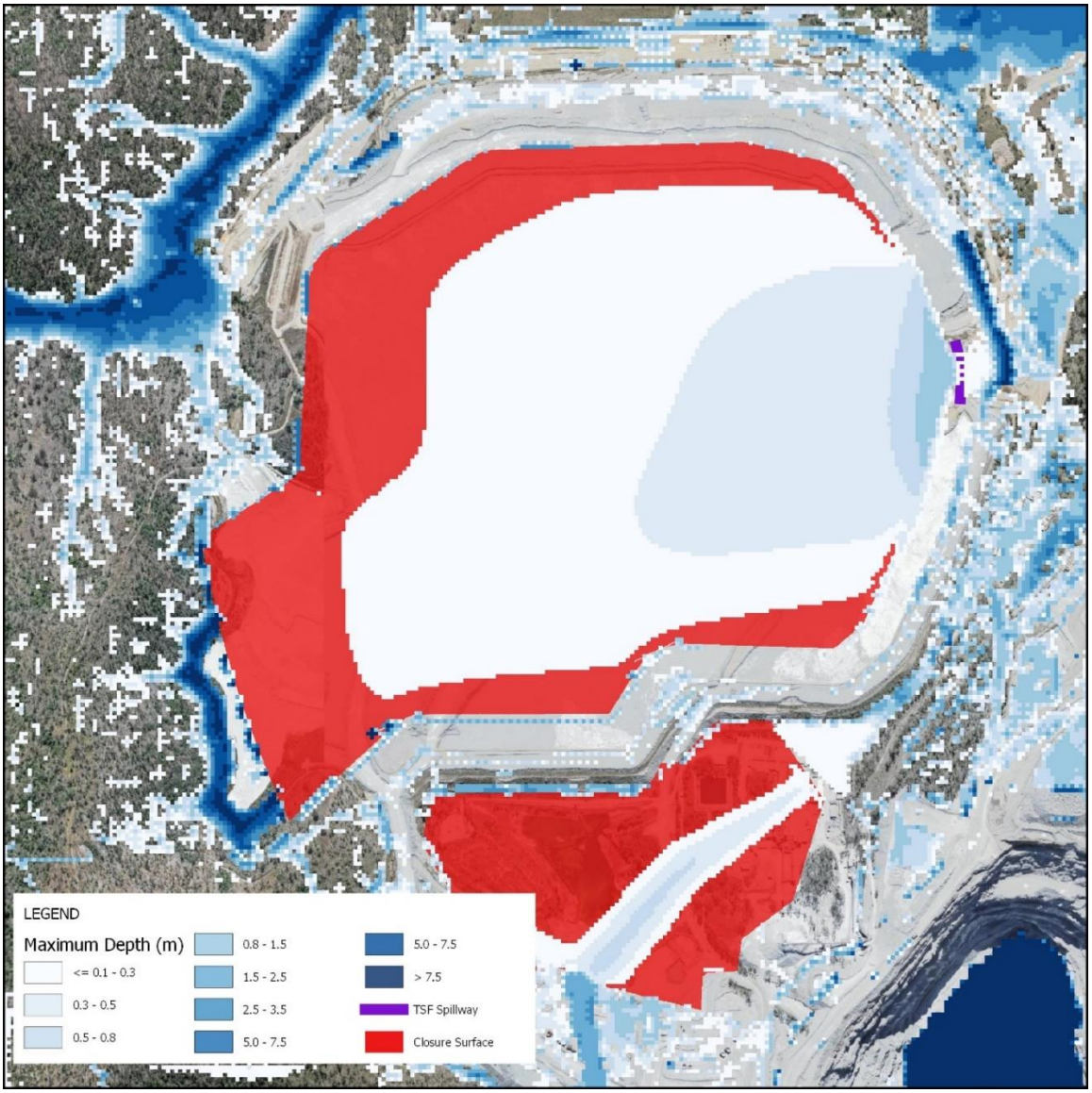
Location	Parameter	PMF	0.1% AEP	1% AEP
TSF Spillway	Peak Flow Rate (m^3/s)	46.8	23.1	16.0
	TSF Embankment Level (m AHD)	198.0	198.0	198.0
	Spillway Elevation (m AHD)	197.0	197.0	197.0
	Spillway Maximum Water Surface Elevation (m AHD)	197.77	197.47	197.43
	Spillway Maximum Flood Depth (m)	0.77	0.47	0.43
	Spillway Flow Velocity (m/s)	1.0	0.6	0.6
	Critical Storm Duration and Temporal Pattern	90 min	360 min TP07	360 min TP07
TSF Centre	TSF Surface Maximum Water Surface Elevation (m AHD)	202.06	201.83	201.79
	TSF Surface Maximum Flood Depth (m)	0.32	0.17	0.13
	TSF Surface Flow Velocity (m/s)	0.4	0.2	0.2
	Critical Storm Duration and Temporal Pattern	60 min	360 min TP07	360 min TP07

As can be seen the above, the PMF rainfall event produces the highest water surface elevation, peak flow rate and peak velocity. As the applied rainfall depth decreases in conjunction with the return period (0.1% AEP and 1% AEP), the modelled depths, flow rates and velocities also decrease, as expected.

There is a fall in water surface elevation across the TSF closure surface. The maximum velocities across the TSF closure surface are less than 1 m/s, so erosion of emerging vegetation is unlikely to occur in extreme rainfall events. The peak velocities in are shown on **Figures 002**, **004** and **006**.

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DIAGRAM 12: TSF SPILLWAY PMF MAXIMUM FLOOD DEPTH RESULTS



4.3 West Dam

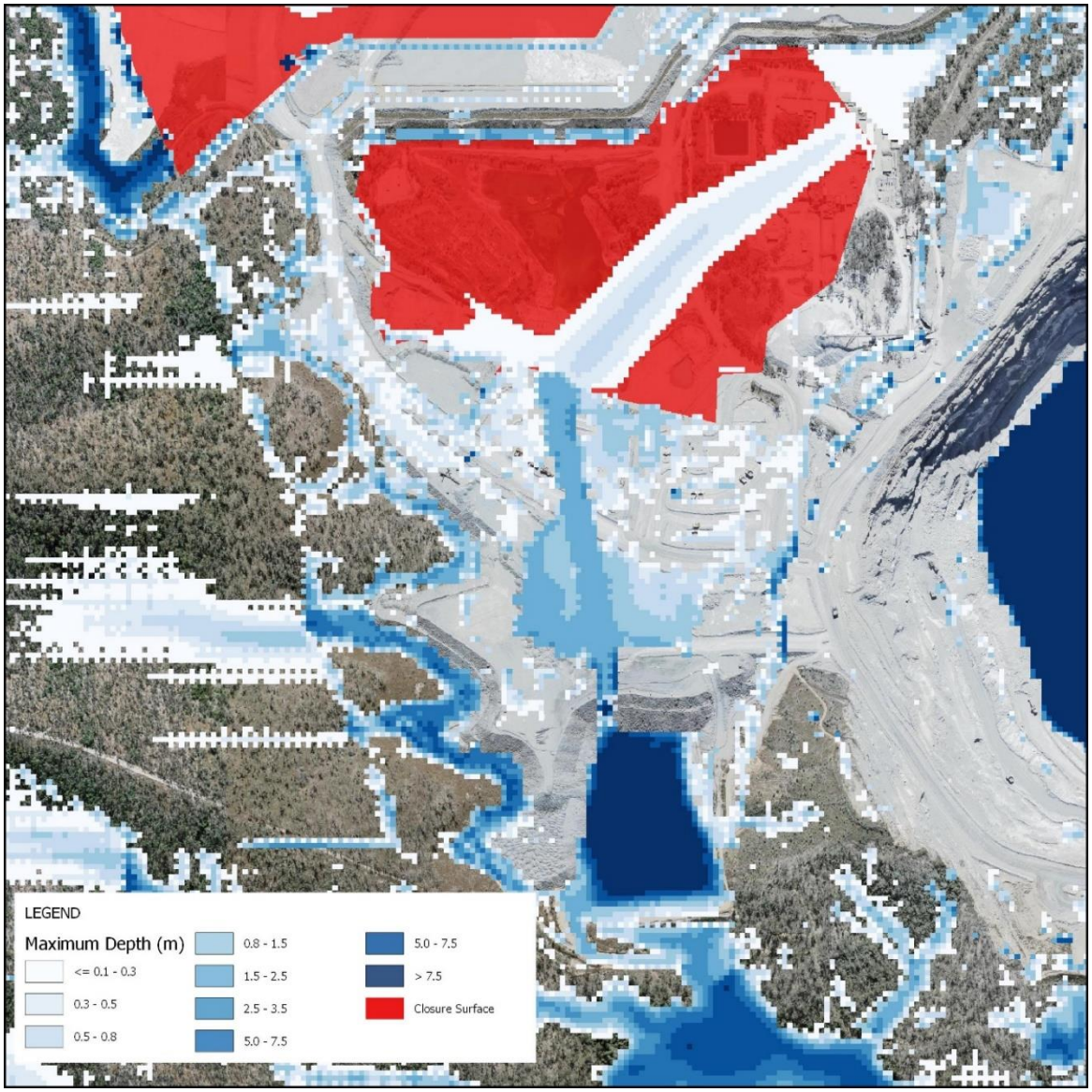
The maximum recorded flow rates, water surface elevations and velocities over the West Dam embankment are summarised in **TABLE 14**. PMF flood depths are depicted on **DIAGRAM 13**.

TABLE 14: WEST DAM RESULTS

	PMF	0.1% AEP	1% AEP
Peak Flow Rate (m^3/s)	120.1	27.6	18.0
Embankment Crest Level (m AHD)	123.80	123.80	123.80
Maximum Water Surface Elevation (m AHD)	124.41	123.93	123.83
Maximum Flood Depth over embankment (m)	0.61	0.13	0.03
Maximum Velocity over embankment (m/s)	3.1	2.0	0.9
Critical Storm Duration and Temporal Pattern	90 min	360 min TP07	360 min TP07

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DIAGRAM 13: WEST DAM, SOUTH DAM AREA AND SOUTHERN DIVERION DRAIN PMF MAXIMUM FLOOD DEPTH RESULTS



As can be seen in **TABLE 14**, the PMF rainfall event produces the largest flood depth and velocity over the West Dam embankment. As rainfall depth decreases in conjunction with the return period (0.1% AEP and 1% AEP), the modelled depths and velocities also decrease, as expected.

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4.4 South Dam Fill Area Dam

The maximum recorded flow rates, water surface elevations and velocities at the downstream location of the South Dam Fill Area are summarised in **TABLE 15**. PMF flood depths are depicted on **DIAGRAM 13**.

TABLE 15: SOUTH DAM FILL AREA RESULTS

	PMF	0.1% AEP	1% AEP
Peak Flow Rate (m^3/s)	51.4	7.1	4.7
Fill Area Elevation at South Dam Out (m AHD)	152.0	152.0	152.0
Maximum Water Surface Elevation at South Dam Out (m AHD)	152.68	152.40	152.36
Maximum Flood Depth (m)	0.68	0.40	0.36
Maximum Velocity (m/s)	1.5	0.8	0.7
Critical Storm Duration and Temporal Pattern	60 min	270 min TP04	270 min TP04

As can be seen the above, the PMF rainfall event produces the highest water depth and velocity at the downstream end of the South Dam Fill Area. As rainfall depth decreases in conjunction with the return period (0.1% AEP and 1% AEP), the modelled depths and velocities also decrease, as expected.

4.5 Southern Diversion Drain

The maximum recorded flow rates, water surface elevations and velocities at the outlet of the Southern Diversion Drain are summarised in **TABLE 16**. PMF flood depths are depicted on **DIAGRAM 13**.

TABLE 16: SOUTHERN DIVERSION DRAIN RESULTS

	PMF	0.1% AEP	1% AEP
Peak Flow Rate (m^3/s)	70.9	10.1	6.6
Diversion Drain Outlet Level (m AHD)	150.0	150.0	150.0
Maximum Water Surface Elevation (m AHD)	152.21	150.58	150.47
Maximum Flood Depth (m)	2.21	0.58	0.47
Maximum Velocity (m/s)	1.1	0.6	0.6
Critical Storm Duration and Temporal Pattern	90 min	270 min TP04	270 min TP04

4.6 Pit Bund

The maximum recorded water surface elevations adjacent to the Pit Bund at locations PB1, PB2, PB3, PB4 and PB5 are summarised in **TABLE 17**. The locations of the reference points are provided on **DIAGRAM 11**.

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TABLE 17: PIT BUND RESULTS

Location	Parameter	PMF	0.1% AEP	1% AEP
PB1	Ground Elevation Level (m AHD)	184.22	184.22	184.22
	Maximum Water Surface Elevation (m AHD)	184.89	184.39	184.24
	Bund Elevation (m AHD)	186.22	186.22	186.22
	Freeboard (m)	1.33	1.83	1.98
	Critical Storm Duration and Temporal Pattern	120 min	20 min TP02	20 min TP02
PB2	Ground Elevation Level (m AHD)	210.84	210.84	210.84
	Maximum Water Surface Elevation (m AHD)	211.02	210.98	210.96
	Bund Elevation (m AHD)	212.84	212.84	212.84
	Freeboard (m)	1.82	1.86	1.88
	Critical Storm Duration and Temporal Pattern	120 min	25 min TP02	25 min TP02
PB3	Ground Elevation Level (m AHD)	202.95	202.95	202.95
	Maximum Water Surface Elevation (m AHD)	203.92	203.42	202.99
	Bund Elevation (m AHD)	204.95	204.95	204.95
	Freeboard (m)	1.03	1.53	1.96
	Critical Storm Duration and Temporal Pattern	180 min	20 min TP02	20 min TP02
PB4	Ground Elevation Level (m AHD)	152.68	152.68	152.68
	Maximum Water Surface Elevation (m AHD)	153.93	153.92	153.88
	Bund Elevation (m AHD)	154.68	154.68	154.68
	Freeboard (m)	0.75	0.76	0.80
	Critical Storm Duration and Temporal Pattern	120 min	20 min TP02	20 min TP02
PB5	Ground Elevation Level (m AHD)	155.60	155.60	155.60
	Maximum Water Surface Elevation (m AHD)	155.72	155.69	155.64
	Bund Elevation (m AHD)	157.60	157.60	157.60
	Freeboard (m)	1.88	1.91	1.96
	Critical Storm Duration and Temporal Pattern	15 min	20 min TP02	20 min TP02

As can be seen in **TABLE 17**, the Pit Bund has sufficient height to ensure no ingress of waters into the pit under post closure conditions. The freeboard at locations PB1, PB2, PB3 and PB5 exceeds 1 m in the PMF event. At PB4 there is freeboard of 0.75 m in the PMF event. While this may indicate hydraulic overdesign of the Pit Bund, the primary purpose of the Pit Bund is to prevent unintended human access to the pit void during closure conditions. Therefore, it is not recommended to reduce the minimum Pit Bund height of 2 m in the detailed design stage.

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4.7 Perry River Dam

The maximum recorded flow rates, water surface elevations and velocities at the Perry River Dam embankment crest are summarised in **TABLE 18**.

TABLE 18: PERRY RIVER DAM RESULTS

	PMF	0.1% AEP	1% AEP
PRD Embankment Crest Level (m AHD)	98.0	98.0	98.0
Spillway Elevation (m AHD)	98.0	98.0	98.0
Maximum Water Surface Elevation (m AHD)	104.60	102.60	101.21
Maximum Flood Depth (m)	6.60	4.60	3.21
Maximum Flow Velocity (m/s)	2.7	1.9	1.0
Critical Storm Duration and Temporal Pattern	240 min	720 min TP08	720 min TP08

As can be seen in **TABLE 18**, during the 1% AEP event, the Perry River Dam has a modelled flood depth of 3.21 m, increasing to 6.6 m in the modelled PMF event. The crest of the Perry River Dam forms the spillway, so that any flows passing over the crest will extend up to 145 m in width during the modelled PMF flood event.

The Perry River Dam was constructed to provide a process water source for the MRO operations. The dam was not designed to control downstream releases to the Perry River; the crest level was set to provide sufficient storage volume and so is lower than the 1% AEP level as can be seen in **TABLE 18**.

4.8 Retained Dams

The maximum recorded flow rates, water surface elevations and velocities at the Sediment Dam 3 embankment crest are summarised in **TABLE 19**. The maximum recorded flow rates, water surface elevations and velocities at the embankment crests of WD1, WD2, WD3 and WQ4 are summarised in **TABLE 20**.

TABLE 19: SEDIMENT DAM 3 RESULTS

	PMF	0.1% AEP	1% AEP
Peak Flow Rates (m^3/s)	82.6	27.6	25.6
Embankment Level (m AHD)	119.1	119.1	119.1
Maximum Water Surface Elevation (m AHD)	120.36	119.53	119.52
Maximum Flood Depth (m)	1.26	0.43	0.42
Maximum Flow Velocity (m/s)	3.4	2.7	1.6
Critical Storm Duration and Temporal Pattern	120 min	360 min TP07	360 min TP07

As can be seen in **TABLE 19**, Sediment Dam 3 overtops during flood events equal to and greater than the 1% AEP event. During the 1% AEP flood event, the maximum flood depth over the crest is 0.42 m, increasing to 1.26 m in the PMF flood event.

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TABLE 20: WD1, WD2, WD3 AND WD4 RESULTS

Dam Number	Parameter	PMF	0.1% AEP	1% AEP
WD1	Peak Flow Rates (m³/s)	82.0	26.1	24.0
	Embankment Level (m AHD)	126.7	126.7	126.7
	Maximum Water Surface Elevation (m AHD)	127.83	127.38	127.28
	Maximum Flood Depth (m)	1.13	0.68	0.58
	Maximum Flood Velocity (m/s)	1.2	1.0	1.0
	Critical Storm Duration and Temporal Pattern	90 min	360 min TP07	360 min TP07
WD2	Peak Flow Rates (m³/s)	20.5	3.7	2.6
	Embankment Level (m AHD)	120.0	120.0	120.0
	Maximum Water Surface Elevation (m AHD)	120.52	120.09	120.05
	Maximum Flood Depth (m)	0.52	0.09	0.05
	Maximum Flood Velocity (m/s)	0.7	0.3	0.1
	Critical Storm Duration and Temporal Pattern	120 min	360 min TP07	360 min TP07
WD3	Peak Flow Rates (m³/s)	13.3	4.7	1.7
	Embankment Level (m AHD)	125.1	125.1	125.1
	Maximum Water Surface Elevation (m AHD)	125.39	125.21	125.18
	Maximum Flood Depth (m)	0.29	0.11	0.08
	Maximum Flood Velocity (m/s)	1.5	0.8	0.5
	Critical Storm Duration and Temporal Pattern	25 min	270 min TP04	270 min TP04
WD4	Peak Flow Rates (m³/s)	2.3	1.7	1.7
	Embankment Level (m AHD)	134.4	134.4	134.4
	Maximum Water Surface Elevation (m AHD)	134.41	134.41	134.41
	Maximum Flood Depth (m)	0.01	0.01	0.01
	Maximum Flood Velocity (m/s)	0.5	0.3	0.2
	Critical Storm Duration and Temporal Pattern	25 min	20 min TP02	20 min TP02

The maximum WSE in WD4 appears to be similar in all storm events. The small flow rates over the 150 m length broad crested weir has little measurable impact on observed water surface elevations.

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4.9 Tributaries

The maximum recorded flow rates, water surface elevations and velocities in the downstream tributaries are summarised in **TABLE 21** to **TABLE 24**.

TABLE 21: TRIBUTARIES RESULTS – SWINDON CREEK

	PMF	0.1% AEP	1% AEP
Peak Downstream Flow Rates (m³/s)	360.7	75.6	54.5
Upstream Maximum Water Surface Elevation (m AHD)	148.99	146.93	146.05
Upstream Bed Elevation (m AHD)	141.39	141.39	141.39
Downstream Maximum Water Surface Elevation (m AHD)	117.21	115.51	113.67
Downstream Bed Elevation (m AHD)	110.71	110.71	110.71
Upstream Maximum Flow Depth (m)	7.60	5.54	4.66
Downstream Maximum Flow Depth (m)	6.50	4.80	2.96
Upstream Maximum Velocity (m/s)	1.2	0.9	0.8
Downstream Maximum Velocity (m/s)	0.6	0.4	0.5
Critical Storm Duration and Temporal Pattern	60 min	360 min TP07	360 min TP07

TABLE 22: TRIBUTARIES RESULTS – RAWDON CREEK

	PMF	0.1% AEP	1% AEP
Peak Downstream Flow Rates (m³/s)	120.6	33.1	16.6
Upstream Maximum Water Surface Elevation (m AHD)	114.82	113.09	112.72
Upstream Bed Elevation (m AHD)	110.85	110.85	110.85
Downstream Maximum Water Surface Elevation (m AHD)	104.72	103.08	101.42
Downstream Bed Elevation (m AHD)	99.67	99.67	99.67
Upstream Maximum Flow Depth (m)	3.97	2.24	1.87
Downstream Maximum Flow Depth (m)	5.05	3.41	1.75
Upstream Maximum Velocity (m/s)	0.5	0.4	0.3
Downstream Maximum Velocity (m/s)	2.6	2.6	2.3
Critical Storm Duration and Temporal Pattern	180 min	360 min TP07	360 min TP07

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TABLE 23: TRIBUTARIES RESULTS – TWELVE MILE CREEK

	PMF	0.1% AEP	1% AEP
Peak Downstream Flow Rates (m^3/s)	416.6	91.8	56.0
Upstream Maximum Water Surface Elevation (m AHD)	116.70	114.57	113.98
Upstream Bed Elevation (m AHD)	111.22	111.22	111.22
Downstream Maximum Water Surface Elevation (m AHD)	103.97	102.46	101.13
Downstream Bed Elevation (m AHD)	99.68	99.68	99.68
Upstream Maximum Flow Depth (m)	5.48	3.35	2.76
Downstream Maximum Flow Depth (m)	4.29	2.78	1.45
Upstream Maximum Velocity (m/s)	0.6	0.4	0.3
Downstream Maximum Velocity (m/s)	3.1	1.5	1.5
Critical Storm Duration and Temporal Pattern	180 min	720 min TP08	720 min TP08

TABLE 24: DOWNSTREAM TRIBUTARIES RESULTS – MINGHAM CREEK

	PMF	0.1% AEP	1% AEP
Peak Downstream Flow Rates (m^3/s)	355.6	90.0	57.9
Upstream Maximum Water Surface Elevation (m AHD)	117.20	115.90	115.45
Upstream Bed Elevation (m AHD)	113.72	113.72	113.72
Downstream Maximum Water Surface Elevation (m AHD)	101.27	99.46	98.93
Downstream Bed Elevation (m AHD)	96.85	96.85	96.85
Upstream Maximum Flow Depth (m)	3.48	2.18	1.73
Downstream Maximum Flow Depth (m)	4.42	2.61	2.08
Upstream Maximum Velocity (m/s)	0.6	0.5	0.4
Downstream Maximum Velocity (m/s)	0.9	0.6	0.5
Critical Storm Duration and Temporal Pattern	60 min	360 min TP07	360 min TP07

As can be seen in **TABLE 21** to **TABLE 24** the modelled results in the downstream tributaries produce the largest peak flow rates, flood depths and flood velocities in the PMF event, as expected. These results should be read in conjunction with **Figure 001** to **Figure 006**.

In Swindon Creek, that maximum WSE varies by approximately 3 m between the 1% AEP and PMF events. With the variation in peak flow rate between the events, this indicates that the creek extends into its floodplain along its entire length. With the exception of the PMF event, the peak velocities in the creek do not exceed 1 m/s in the modelled storm events.

In Rawdon Creek there is a similar pattern of flooding to Swindon Creek, however the results indicate that the creek channel contains for of the flood flow with less overbank flooding in the extreme flood events. Rawdon Creek has the smallest catchments of the four creeks modelled, which is reflected in the peak flow rates.

Twelve Mile Creek has the largest catchment area of the modelled creeks, and this is reflected in the modelled peak flow rates. The PMF flood event has a peak flow rate approximately 4.5 times greater than the 0.1% AEP event.

From the results, Mingham Creek has a large floodplain and velocities less than 1 m/s in all modelled events.

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4.10 Sensitivity Analysis

A sensitivity analysis was undertaken for the TSF and the MRO site. Due to the distance of the MRO site and TSF from the Perry River, sensitivity testing of the flow rates in the Perry River was not undertaken, except to assess whether the flood levels in the Perry River impacted the upstream water surface elevations at the upstream MRO site, which they did not.

A comparison of peak water surface elevation (WSE), flood depths and velocities at the middle of the TSF Surface, Swindon Creek, Rawdon Creek and Mingham Creek are summarised in **TABLE 25**.

As can be seen in **TABLE 25**, the waterways adjacent to the MRO site are sensitive to variations in applied rainfall depth and surface roughness. Changes in the rainfall depth applied to the model have similar increases and decreases for the 20% increases and decreases. Increases in the surface roughness have approximately three times the impact on flood depth in the watercourses as decreasing the roughness.

The TSF closure surface is also subject to variations in maximum water surface elevation, with increases in rainfall depth having approximately double the impact of decreases in rainfall depth. Increases in the surface roughness on the TSF have a far greater impact on flood depth than decreases. Overall, a 20% increase in assumed roughness results in larger variations than the 20% increase in rainfall depth. The sensitivity modelling indicated that changes in rainfall depth or surface roughness had little to no measurable impact on velocities across the surface.

From the results, it can be taken that the model is sensitive to changes in both applied rainfall depth and surface roughness, with the greatest impacts being made by 20% increases in the surface roughness coefficients.

If further modelling is to be undertaken, it is recommended that photographs of site conditions in the creeks and an understanding likely surface treatments to the overland flow areas are used to reassess surface roughness estimates at the closure site.

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TABLE 25: SENSITIVITY ANALYSIS RESULTS – PMF EVENT

Location	Sensitivity Scenario	Peak WSE (m AHD)	Change in Peak WSE (m AHD)	Flood Depth (m)	Change in Depth (m)	Flow Velocity (m/s)	Change in Velocity (m/s)
TSF Surface	Base Model	201.97	-	0.24	-	0.3	-
	+ 20% Rainfall Depth	202.03	0.06	0.30	0.06	0.3	0.0
	- 20 % Rainfall Depth	201.91	-0.06	0.18	-0.06	0.2	-0.1
	+ 20% Mannings 'n'	202.07	0.10	0.33	0.10	0.3	0.0
	- 20 % Mannings 'n'	201.94	-0.03	0.21	-0.03	0.3	0.0
Swindon Creek	Base Model	147.66		5.55		1.0	
	+ 20% Rainfall Depth	148.66	1.00	6.56	1.01	1.1	0.1
	- 20 % Rainfall Depth	146.60	-1.06	4.49	-1.06	0.8	-0.2
	+ 20% Mannings 'n'	149.18	1.52	7.08	1.53	1.0	0.0
	- 20 % Mannings 'n'	147.16	-0.50	5.05	-0.50	1.1	0.1
Rawdon Creek	Base Model	114.99		4.29		0.5	
	+ 20% Rainfall Depth	115.69	0.70	4.99	0.70	0.6	0.1
	- 20 % Rainfall Depth	114.30	-0.69	3.60	-0.69	0.5	0.0
	+ 20% Mannings 'n'	115.98	0.99	5.28	0.99	0.5	0.0
	- 20 % Mannings 'n'	114.73	-0.25	4.04	-0.26	0.6	0.1
Mingham Creek	Base Model	100.58		4.15		0.8	
	+ 20% Rainfall Depth	101.29	0.71	4.86	0.72	0.9	0.1
	- 20 % Rainfall Depth	99.83	-0.75	3.40	-0.75	0.7	-0.1
	+ 20% Mannings 'n'	101.64	1.06	5.22	1.07	0.8	0.0
	- 20 % Mannings 'n'	100.24	-0.34	3.81	-0.34	0.9	0.1

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5 PRCP INPUTS AND DISCUSSION

5.1 General

With reference to the PRCP Guidelines **[4]**, a key focus of this flood risk assessment was to identify two aspects of closure planning:

- ensuring that any residual voids are not located wholly or partly in the food plain (defined as the 0.1% AEP flood extent).
- Assess the flood risk to any remaining infrastructure.

Detailed below is a discussion on the flood risk profile for the infrastructure on site that is to be retained, which includes:

- South Dam, Process Water Dam and the MIA
- Pit
- TSF
- West Dam
- Sediment Dam 3, WD1, WD2, WD3 and WD4
- Perry River Dam

A discussion of the impacts to the infill areas and the infrastructure that will remain on site is provided in the following sections.

5.2 The South Dam, Process Water Dam and the MIA

The area of the South Dam, Process Water Dam, and MIA is to be filled to restore hydraulic connectivity with Mingham Creek. A Southern Diversion Drain will be constructed to convey flows from this area to the West Dam. A summary of the flood profile for the South Dam Filled Area and Southern Diversion Drain is summarised in **TABLE 15** and **TABLE 16** respectively.

5.3 Pit

When assessed against the PRCP Guidelines **[4]**, the pit void has been determined not to be located in the extents of the PMF or 0.1% AEP flood plain of either Rawdon Creek or Twelve Mile Creek.

It is proposed to construct a 2 m high abandonment bund around the pit crest to prevent the ingress of surface runoff from upstream catchments. The flood modelling presented in **Section 4.6** indicates that a diversion drain will be required on the upstream side of the abandonment bund to divert runoff away from the pit void to either Twelve Mile Creek or Rawdon Creek. Flows to the south of the pit will discharge to Mingham Creek.

Any rainfall over the pit surface will be retained within the pit void and will evaporate during the dry season.

By diverting flows away from the pit to Twelve Mile Creek and Rawdon Creek, the pit abandonment bund and diversion drain will partially restore the pre-mining hydraulic regime. Flows south towards Mingham Creek will be restored to pre-mining conditions as the natural ridge skirted the southern extent of the pit.

The upstream extents of Rawdon Creek and Twelve Mile Creek are located within the area of pit void. The pit void has a storage volume such that it is unlikely to fill and spill and so will be removed from the local watercourse network.

The design of the required abandonment bund and the associated diversion drain will be undertaken at the future detailed design phase.

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5.4 TSF

Post closure, the TSF will be retained, although the surface will be capped and graded to ensure the surface is free draining to the closure spillway at the eastern edge. This conceptual design incorporates a 0.5% self-shedding surface and a modified embankment on the downstream face. The embankment will be modified with a shallower gradient on the downstream face for post closure stability. A closure spillway (sized for PMF flows) will be incorporated to ensure the following occurs:

- Prevention of water ponding against the upstream face of the embankment;
- Prevention of flow over the top of the embankment; and
- To ensure all flows from the TSF are conveyed to and within Rawdon Creek.

The flood modelling results presented in **Section 4.2** demonstrated that the proposed spillway design (**TABLE 6**) will be suitable to safely convey design storm events up to and including the PMF. Flooding from Rawdon Creek and Mingham Creek does not extend to the TSF embankment.

All surface runoff from the TSF will enter Rawdon Creek, which restores the pre-mining hydraulic regime.

The exact location and configuration of the closure spillway will be set during the detailed design phase. A summary of the flood profile in the TSF spillway and surface is provided in **TABLE 13**.

5.5 West Dam and Retained Dams

Post closure, the West Dam and retained dams (Sediment Dam 3, WD1, WD2, WD3 and WD4) will be used for passive sediment and erosion control purposes. The flood modelling presented in **Section 0** indicates that all the structures will overtop in events equal to and greater than the 1% AEP storm event. It is possible that overtopping of the retained dams would occur in storm events more frequent than the 1% AEP, but these have not been assessed in this project.

The West Dam will receive flows from the South Dam Fill Area via the Southern Diversion Drain. Flows from the West Dam will enter Mingham Creek. The flood profile for the West Dam is summarised in **TABLE 14**.

Sediment Dam 3 receives flows from a portion of the TSF embankment face, but not from the TSF closure spillway. Flows from Sediment Dam 3 enter Rawdon Creek. The flood profile for Sediment Dam 3 is summarised in **TABLE 19**.

WD1, WD2, WD3 and WD4 all receives flows form the Northern WRD. All flow that overtop these dam embankments will enter the Perry River via Twelve Mile Creek. The flood profiles for the WD1, WD2, WD3 and WD4 are summarised in **TABLE 20**

The overtopping of these retained dams will not impact the TSF or Pit. It is expected that sediment will gradually accumulate within the dams such that the dams will not have a functional storage volume.

Flows from the retained dams will enter the downstream tributaries to the Perry River or Mingham Creek, maintaining the pre-mining hydraulic regime.

5.6 Perry River Dam

Post closure, the Perry River Dam will be retained. Due to its configuration, the embankment crest is also the emergency spillway. As such, the Perry River Dam will overtop in storm events between the 1% AEP and the PMF. The flood risk profile at the Perry River Dam is summarised in **TABLE 18**.

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6 SUMMARY AND CONCLUSIONS

ATCW were commissioned by Evolution to prepare a flood risk profile for the MRO site to meet the requirements of the PRCP guidelines at closure. The PRCP requires flood risk assessments for two aspects of closure: to identify whether any mine voids will remain in the floodplain post-closure; and to assess the flood risk to remaining infrastructure.

To prepare the flood risk profile, hydraulic analysis of the site was undertaken using the two dimensional (2D) finite difference program TUFLOW. ARR **[1]** guidelines were utilised to develop the hydrology inputs to the hydraulic model. It is understood that Evolution intends to rehabilitate the site to the pre-mining topography as far as is practically possible.

As a result of this hydraulic analysis, flood risk profiles have been developed for key infrastructure that will remain at the MRO site. Flood mapping has been generated for maximum flood depths and maximum velocities for the PMF, 0.1% AEP and 1% AEP design storm events.

Hydraulic analysis indicates that pit will not be impacted by flows from upstream catchments due to the construction of a 2 m high abandonment bund. The pit is not located within the extents of the floodplains of Rawdon Creek, Twelve Mile Creek or Mingham Creek.

The TSF is to be capped and rehabilitated, with its surface shedding to the closure spillway that has been designed to convey flows up to the PMF event.

The South Dam area is to be filled, with a diversion drain constructed to convey flows to the West Dam, which will assist in restoring the pre-mining hydraulic regime at the site.

The West Dam and other retained dams will all experience overtopping during PMF, 0.1% AEP and 1% AEP flow conditions. These overtopping flood depths and flood velocities will not cause significant impacts to these structures.

The Perry River Dam will overtop in events greater than the 1% event.

Hydraulic analysis indicates that the modelled maximum flood depths and maximum flood velocities will not result in significant impacts to the TSF closure surface or embankment, Northern WRD or filled area of the current South Dam. Hydraulic analysis indicates that the West Dam will overtop, however, the maximum flood depths and maximum flood velocity of overtopping flows will not result in significant impacts to the West Dam. All other areas of the site (with the exception of the pit void) drains freely to Swindon Creek, Rawdon Creek, Twelve Mile Creek and Mingham. No other structures experience significant impacts from flooding.

The pre-mining flow regimes to the local watercourses across the MRO site have been maintained in the post closure design, as far as practicable. The exception to this is the pit void where rainfall falling over its surface will be retained and will evaporate in dryer months.

Detailed design of the following elements will be required at a future stage:

- TSF Closure Spillway
- TSF Closure Surface
- South Dam Fill Area
- Southern Diversion Drain
- Pit Abandonment Bund
- Northern WRD capping surface and profile

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[2] Bureau of Meteorology (2003), 'The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method', Bureau of Meteorology, Melbourne, Australia, June 2003

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[4] Department of Environment and Science (2021), 'Guideline Progressive rehabilitation and closure plans (PRC plans)', ESR/2019/4964, March 2021, version 2.00.

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[14] Innovyze (2019), 'Manning's n Roughness Coefficients – Open Channel', October 2019.

[15] Rahmen A, Haddad, K (2021), 'Regional Flood Frequency Estimation Model,' Accessed 15 April 2021, https://rffe.arr-software.org/ .

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FIGURES

374000E

376000E

378000E

7206000N

7204000N

N

W

E

S

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Depth (m)

<= 0.1 - 0.3

0.3 - 0.5

0.5 - 0.8

0.8 - 1.5

1.5 - 2.5

2.5 - 3.5

5.0 - 7.5

5.0 - 7.5

> 7.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS
PROBABLE MAXIMUM FLOOD - MAXIMUM FLOOD DEPTH

ATC WILLIAMS

FIGURE 001

111359.83

DATE: 2021-06-10

M:\Synergy\Projects\111\111359 Mt Rawdon Gold Mine\83 PRCP Hydraulic modelling\Data

374000E

376000E

378000E

7206000N

7204000N

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Velocity (m/s)

- 0.3 - 0.6
- 0.6 - 0.8
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS
PROBABLE MAXIMUM FLOOD - MAXIMUM FLOOD VELOCITY

ATC WILLIAMS

FIGURE 002

111359.83

DATE: 2021-06-10

M:\Synergy\Projects\111\111359 Mt Rawdon Gold Mine\83 PRCP Hydraulic modelling\Data

374000E

376000E

378000E

7206000N

7204000N

N

W

E

S

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Depth (m)

<= 0.1 - 0.3

0.3 - 0.5

0.5 - 0.8

0.8 - 1.5

1.5 - 2.5

2.5 - 3.5

5.0 - 7.5

5.0 - 7.5

> 7.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS

0.1% ANNUAL EXCEEDANCE PROBABILITY - MAXIMUM FLOOD DEPTH

ATC WILLIAMS

FIGURE 003

111359.83

DATE: 2021-06-10

M:\Synergy\Projects\111\111359 Mt Rawdon Gold Mine\83 PRCP Hydraulic modelling\Data

374000E

376000E

378000E

7206000N

7204000N

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Velocity (m/s)

- 0.3 - 0.6
- 0.6 - 0.8
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.5
- 1.5 - 2.5
- > 2.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS

0.1% ANNUAL EXCEEDANCE PROBABILITY - MAXIMUM FLOOD VELOCITY

ATC WILLIAMS

FIGURE 004

111359.83

DATE: 2021-06-10

M:\Synergy\Projects\111\111359 Mt Rawdon Gold Mine\83 PRCP Hydraulic modelling\Data

374000E

376000E

378000E

7206000N

7204000N

N

W

E

S

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Depth (m)

<= 0.1 - 0.3

0.3 - 0.5

0.5 - 0.8

0.8 - 1.5

1.5 - 2.5

2.5 - 3.5

5.0 - 7.5

5.0 - 7.5

> 7.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS

1.0% ANNUAL EXCEEDANCE PROBABILITY - MAXIMUM FLOOD DEPTH

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FIGURE 005

111359.83

DATE: 2021-06-10

M:\Synergy\Projects\111\111359 Mt Rawdon Gold Mine\83 PRCP Hydraulic modelling\Data

374000E

376000E

378000E

7206000N

7204000N

N

W

E

S

0 500 1,000 1,500 m

CRS: GDA94 / MGA Zone 56

Maximum Velocity (m/s)

0.3 - 0.6

0.6 - 0.8

0.6 - 0.8

0.8 - 1.0

1.0 - 1.5

1.5 - 2.5

> 2.5

EVOLUTION MINING LIMITED

MOUNT RAWDON OPERATIONS

1.0% ANNUAL EXCEEDANCE PROBABILITY - MAXIMUM FLOOD VELOCITY

ATC WILLIAMS

FIGURE 006

111359.83

DATE: 2021-06-10

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APPENDICES

APPENDIX A – GSDM PROBABLE MAXIMUM PRECIPITATION CALCULATIONS

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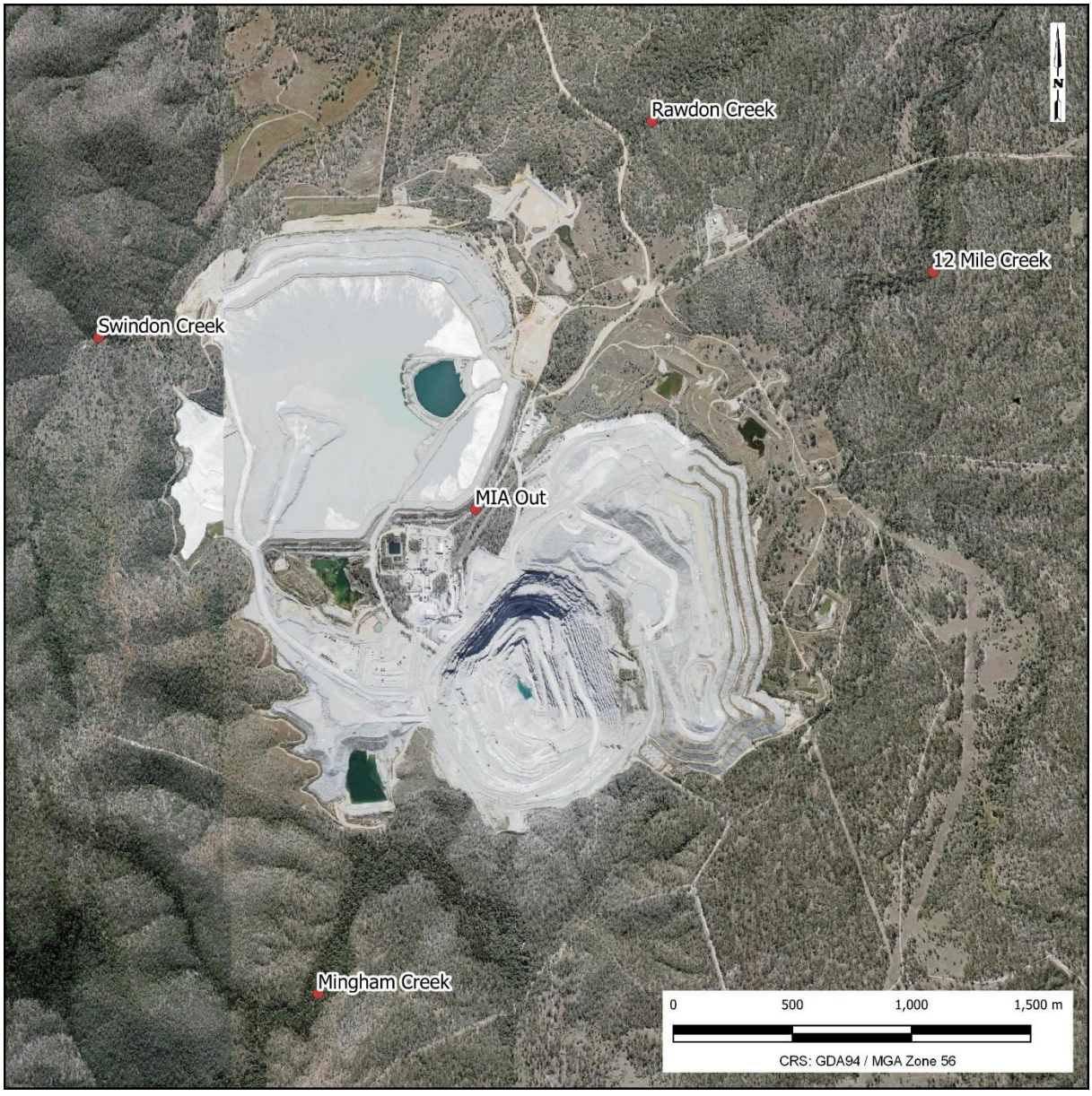
APPENDIX B – GRID SIZE SENSITIVITY

In order to determine the most appropriate grid cell size, the model was run to assess the sensitivity to grid size on water surface elevations for four different grid sizes:

- 20 m x 20 m (20 m grid)
- 15 m x 15 m (15 m grid)
- 10 m x 10 m (10 m grid)
- 5 m x 5 m (5 m grid)

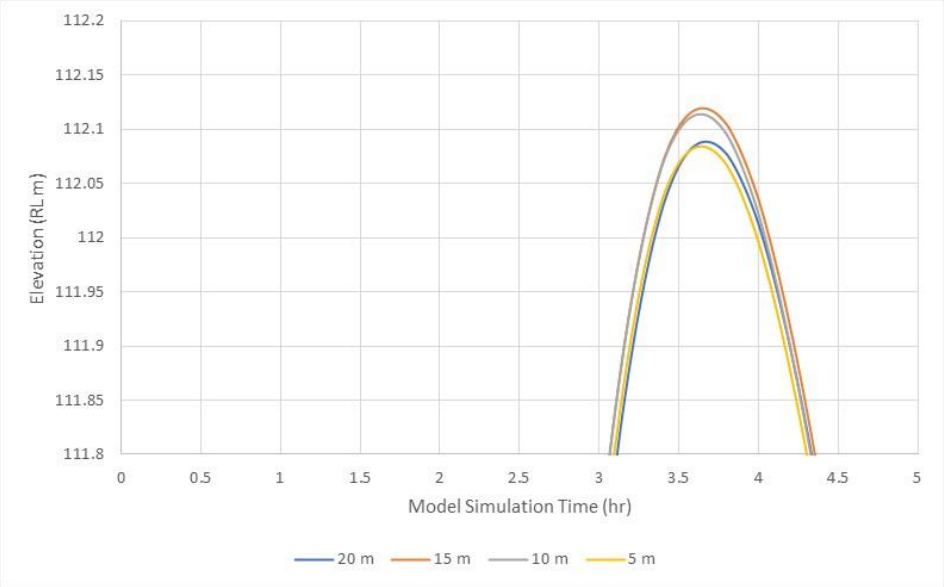
The locations at which grid sensitivity was assessed are shown on **DIAGRAM B1**. The sensitivity was based upon the PMP duration that produced the maximum water surface elevations at the sensitivity locations. The PMP durations that resulted in maximum water surface elevations varied between the 1 hour and 4 hour events. The same duration event was assessed at each location to ensure an appropriate comparison.

DIAGRAM B1: MODEL SENSITIVITY ANALYSIS LOCATIONS



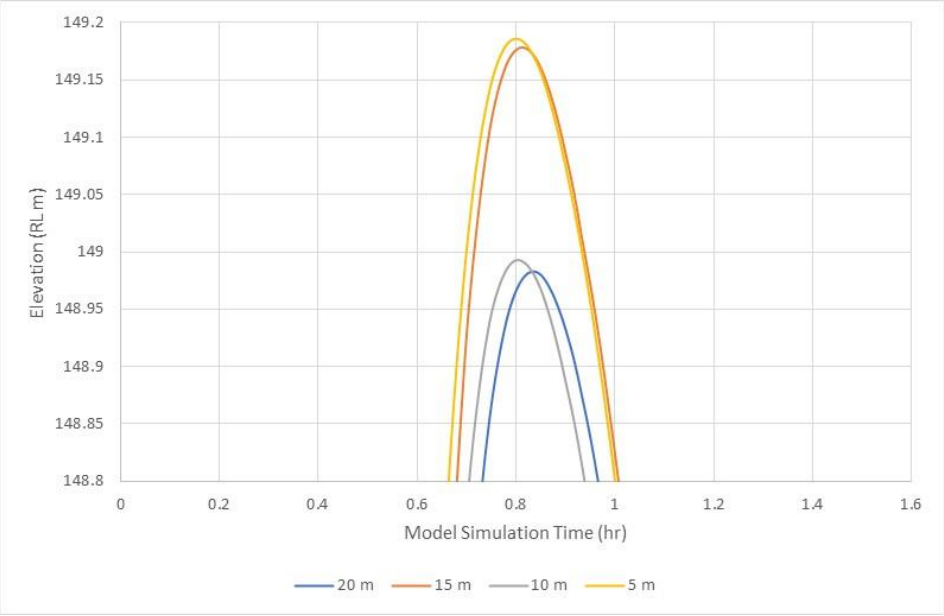
The water levels at Twelve Mile Creek, Swindon Creek, Rawdon Creek, Mingham Creek and MIA Out are shown on **DIAGRAM B2**, **DIAGRAM B3, DIAGRAM B4**, **DIAGRAM B5** and **DIAGRAM B6** respectively.

DIAGRAM B2: TWELVE MILE CREEK PEAK WATER SURFACE ELEVATION



As can be seen in **DIAGRAM B2**, the peak water surface elevation at Twelve Mile Creek is produced in the model run on the 15 m grid. The 10 m grid produces a similar peak water surface elevation. It is noted the maximum difference in elevation between the modelled water surface elevation is 35 mm. Therefore the 15 m grid or 10 m grid would be suitable for full assessment.

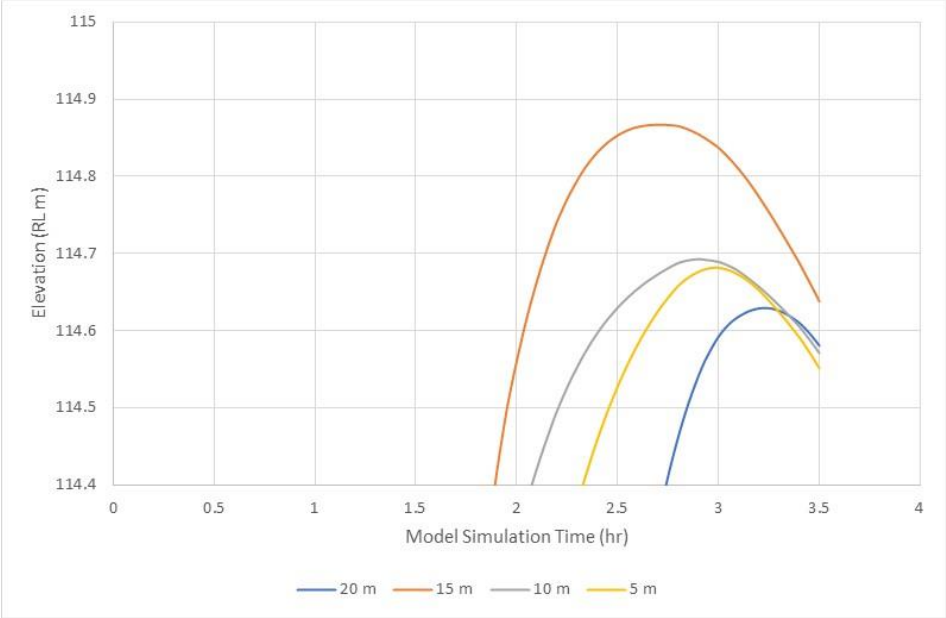
DIAGRAM B3: SWINDON CREEK PEAK WATER SURFACE ELEVATION



As can be seen in **DIAGRAM B3**, the peak water surface elevation at Swindon Creek is produced in the model run on the 5 m grid. It is noted the 5 m grid produces a similar peak water surface elevation in the 15 m grid. It is noted the difference between the 5 m grid and 15 m grid is less than 10 mm. Due to this small difference, it was determined the 5 m or 15 m grid would be suitable for detailed assessment.

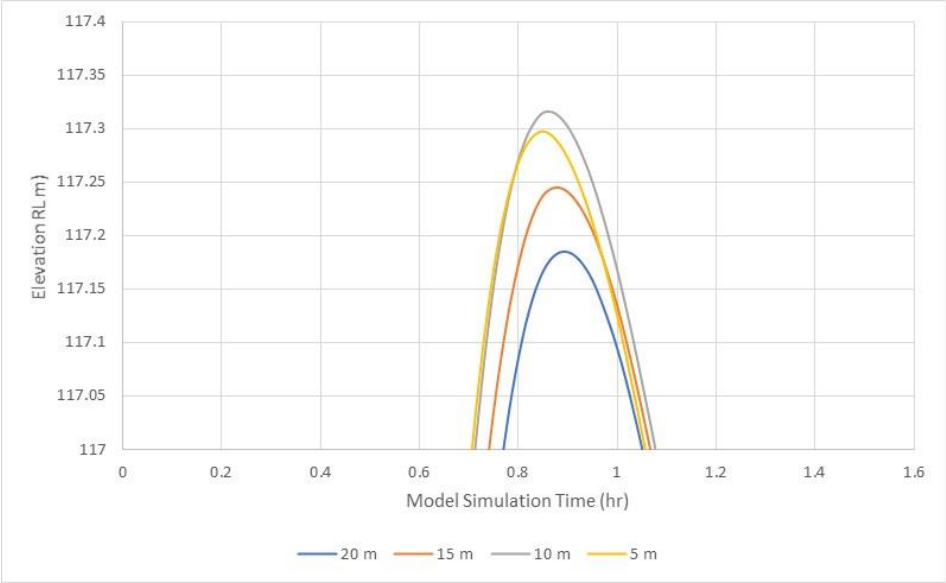
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DIAGRAM B4: RAWDON CREEK PEAK WATER SURFACE ELEVATION



As can be seen in **DIAGRAM B4**, the peak water surface elevation at Rawdon Creek is produced in the model run on the 15 m grid. It is noted the maximum difference in elevation between the modelled water surface elevation is 230 mm. It was determined the 15 m grid would be suitable for detailed assessment.

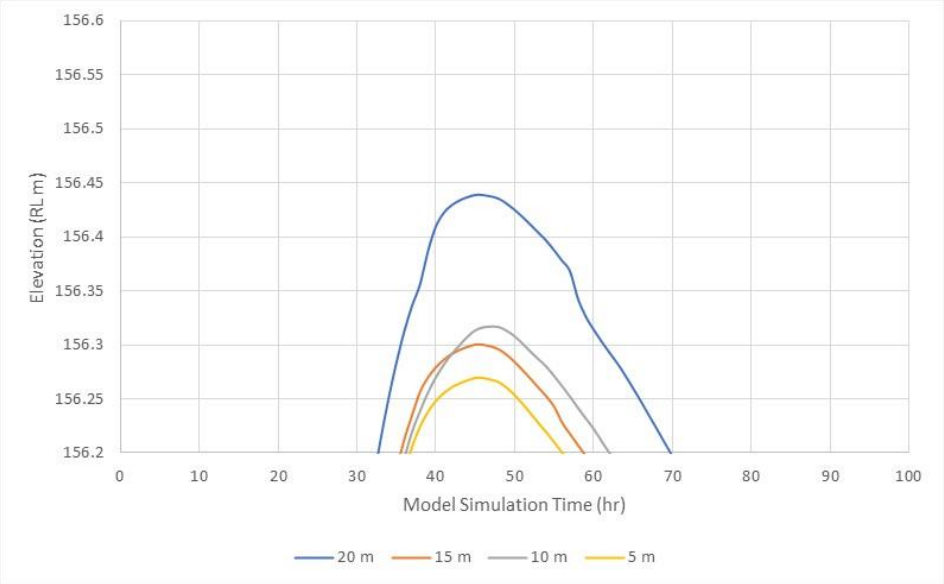
DIAGRAM B5: MINGHAM CREEK PEAK WATER SURFACE ELEVATION



As can be seen in **DIAGRAM B5**, the peak water surface elevation at Mingham Creek is produced in the model run on the 10 m grid. It is noted the maximum difference in elevation between the modelled water surface elevation run on the 15 m grid is 70 mm.

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DIAGRAM B6: MIA OUT PEAK WATER SURFACE ELEVATION



As can be seen in **DIAGRAM B6**, the peak water surface elevation at MIA Out is produced in the model run on the 20 m grid. It is noted this value is approximately 130 mm higher than the 15 m grid.

Due to the variation in peak results produced by the various grid sizes, based the overall results of the 16m grid providing higher levels, and higher convergence of results, it was determined the 15 m grid was the most suitable for detailed assessment as it produced results that were validated by 10 m x

Mine Material Management Plan

Landform, cover system and final void design and assessment

Mount Rawdon Operations

Prepared for: Evolution Mining

MINE WASTE AND WATER MANAGEMENT

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Mine Material Management Plan

Landform, cover system and final void design and assessment

Mount Rawdon Operations

Prepared for: **Evolution Mining**

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This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Glossary of terms and acronyms

Acidity	A measure of hydrogen ion (H+) concentration; generally expressed as pH.
ABA	Acid Base Account. Evaluation of the balance between acid generation and acid neutralisation processes. Determines the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below.
AHD	Australian Height Datum used for altitude measurement in Australia.
ALS	Australian Laboratory Services.
AMD	Acid and metalliferous drainage from mine waste materials characterised by low pH, elevated metal concentrations, high sulfate concentrations and high salinity.
ANC	Acid Neutralising Capacity expressed as kg H_2SO_4 per tonne of sample. A measure of a sample's maximum potential ability to neutralise acid.
ANC:MPA	The ratio of the acid neutralising capacity to the maximum potential acidity of a sample. Used to assess the risk of a sample generating acid conditions.
CML	Constructed mine landform e.g. TSF or WRSF
Domain	An area within a mining precinct usually associated with a constructed mine landform
EIS	Environmental Impact Statement.
FS	Feasibility Study. A comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The confidence level of the study will be higher than that of a Pre-Feasibility Study".
INAP	International Network on Acid Prevention
KLC	Kinetic Leach Column. Leaching setup that generates time-dependent data on the kinetics and rate of acid generation and acid neutralising reactions under laboratory controlled (or onsite conditions)
LOA	Life of asset – maximum probable extent of the deposit
LOM	Life of mine – extent of active mine plan
LoR	Limit of Reporting. Laboratory detection limit for the reporting of results for a particular geochemical test.
MPA	Maximum Potential Acidity. Calculated by multiplying the total sulfur or sulfide-sulfur (CRS) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne.
NAF	Non-Acid Forming. Geochemical classification criterion for a sample that will not generate acid conditions.
NAF_{BARREN}	Non-acid forming and barren of sulfur (i.e. less than or equal to 0.1% sulfur).
NAPP	Net Acid Producing Potential, expressed as kg H_2SO_4 per tonne. Calculated by subtracting the ANC from the MPA.
NMD	Neutral mine drainage. Typically caused by exposure of sulfide minerals in mine waste materials to oxygen and water and then neutralisation by gangue minerals. Typically characterised by neutral pH and elevated concentrations of salts, sulfate and metals.
Ore	Material that has been mined with sufficient value to warrant processing.

Overburden	The waste rock material found overlying the first ore horizon within the stratigraphic profile.
PAF	Potentially Acid Forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions.
PFS	Pre-feasibility Study (PFS). A comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumptions on the Modifying Factors and the evaluation of any other relevant factors which are sufficient to determine if all or part of the Mineral Resources may be converted to an Ore Reserve at the time of reporting". Basic designs are completed for most facilities.
pH	A measure of hydrogen ion (H^+) concentration.
PSD	Particle size distribution.
S	Sulfur.
Scoping study	A scoping study is an order of magnitude technical and economic study of the potential viability of Mineral Resources. It includes appropriate assessments of realistically assumed Modifying Factors together with any other relevant operational factors that are necessary to demonstrate at the time of reporting that progress to a Pre-Feasibility level.
SD	Saline Drainage. Water that is elevated in dissolved salts (e.g., Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, and SO_4^{2-}), but may have acidic, neutral, or alkaline pH.
SO_4^{2-}	Sulfate.
Static analysis	Procedure for characterising the geochemical nature of a sample at a single point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid Base Account.
SEEP/W	Vadose (unsaturated) zone modelling package for soil cover assessment
SWCC	Soil water characteristic curve
TSS	Total suspended solids. A measurement of the suspended solids concentration in a water sample.
TS	Total sulfur content of a sample generally measured using a 'LECO' analyser expressed as total sulfur%.
TSF	Tailings storage facility
w:v	Weight to volume ratio.
WOM	Whole of mine
WRD	Waste rock dump
WRSF	Waste rock storage facility

1 Introduction

The Mount Rawdon Operations (MRO) operates the Mt Rawdon gold mine, which incorporates a cyanide in leach (CIL) process circuit, that deposits tailings into a valley fill/turkey nest tailings storage facility (TSF).

An economic evaluation of the deposit by MRO indicates the cessation of mining is likely to be in Q4 2024 and cessation of processing is likely to be in Q2 2026.

RGS Environmental Consultants Pty Ltd (RGS) has undertaken extensive geochemical technical studies for MRO since 2009. More recently, RGS was commissioned to assist with technical studies to support the development of the Progressive Rehabilitation and Closure Plan (PRC Plan). The technical work completed by RGS and Deswik for the PRC Plan:

- Expanded conceptual closure plans for the site domains
- Integrated the technical teams at MRO and key technical consultants including the tailings dam engineer
- Enabled the teams to identify and mitigate technical assumptions
- Included development of a landform haulage schedule for the life of mine and processing to 2026
- Allowed for a range of defined closure options to be simulated and verified for required and available material balances to develop final landforms and cover systems
- Provided the geometric inputs for:
    - a GoldSim water balance and water quality model to define probable ranges in water quality at defined locations within the mine including the final void
    - SEEP/W modelling of the WRD cover system to determine how this cover might perform under field conditions.

This document is a Mine Material Management Plan for the Northern Waste Rock Dump (NWRD) (specifically) but because the NWRD is part of the whole of mine this plan addresses the whole of mine over the life of mine.

Attachment D includes a Performance Monitoring Plan for the NWRD.

1.3 Purpose of the Mine Material Management Plan

The purpose of this Mine Material Management Plan (MMM Plan) includes the following:

- Summarise the knowledge gained by MRO over the life of mine (LOM) relating to mine materials.
- Document the site layout and knowledge of the main site domains.
- Describe the work that was undertaken by RGS / Deswik in 2022 to develop a final landform inclusive of proposed cover systems and final void water quality model.
- Provide an overview of ongoing work being completed by RGS to support the delivery of a PRC Plan.
- Document field trials that will be used to verify how the NWRD cover system will perform.

1.4 Objectives of the MMM Plan

The objectives of the MMM Plan are to document and map out the following:

- Why the Plan is required.
- When the Plan is to be updated.
- How changes to the Plan are to be tracked to enable the reasons for changes to the Plan over the life of mine to be understood.

- Who is to plan and implement the tasks required to be undertaken by each department.
- How the data collected from departmental tasks, such as waste characterisation or developing material balances, is to be stored and made accessible to other departments who are required to make use of the data.
- How the data is to be used and which other plans the MMM Plan should integrate with e.g. Water Management Plan, Mine Plan, and PRC plan.
- When tasks in the MMM Plan are required to be undertaken and what the outputs should be.

1.5 Implementing and using this plan

The MMM Plan will be managed by MRO.

MRO has existing process in place to develop, update and track mine plans using Deswik.CAD and Deswik Landform and Haulage Schedule (Deswik.LHS).

MRO's mine planning team has developed an Operational Deswik.LHS model for their LOM plan (referred to as an OPS_{PLAN}). The OPS_{PLAN} was primarily used to communicate the mining sequence to the key stakeholders, and to calculate truck hours to make sure they could achieve the mine plan with the number of trucks they had on site.

This MMM Plan integrates the $OPS_{PLAN.LHS}$ with the $PRC_{PLAN.LHS}$ using Deswik.CAD and Deswik.LHS.

The MMM Plan will enable the operational plans and schedules produced by the site teams to be carried forward to facilitate successful designing for closure.

1.6 Document control and review process

A record of each version of the MMM Plan and associated Deswik.CAD and Deswik.LHS files is recorded in the document control table at the beginning of this plan. Each version requires sign off by the person responsible for the MMM Plan.

This MMM Plan will require an annual review by a suitably qualified person and a record of this must be kept.

RGS will certify that this MMM Plan meets the intent of the EA conditions, i.e. the plan enables site personnel to progressively characterise, mine, and place the mined materials so that their potential to contribute to (or to mitigate) environmental harm can be determined.

Effective implementation of the MMM Plan requires input and integration from the Geology, Environment, Mine Planning, and Technical Services Departments and Tailings Dam engineering groups.

1.7 Quality, standards, regulation, legislation, and guidelines

This MMM Plan has been developed according to requirements prescribed in the following legislation, regulations, guidelines, standards relevant to the mine:

- DEHP (2013) Application Requirements for Activities with Impacts to Land Guideline. Queensland Department of Environment and Heritage Protection.
- DES (2013) Department of Environment and Science. Application for the certification of progressive rehabilitation: ESR/2015/1563 • Version 2.01 • Effective 23 MAY 2013.
- DES (2014) Department of Environment and Science. Rehabilitation report: as appropriate for mining resource activities: ESR/2015/1616 • Version 1.04 • Effective 25 JUNE 2014.
- DSITI (2017). Using monitoring data to assess groundwater quality and potential environmental impacts. Version 1. Department of Science, Information Technology and Innovation (DSITI), Queensland Government, Brisbane.
- DES (2018) Department of Environment and Science. Rehabilitation requirements: as appropriate for mining resource activities: ESR/2016/1875 • Version 2.01 • Effective 23 May 2014.
- The *Mineral Resources and Energy (Financial Provisioning) Act 2018* amended the *Environmental Protection Act 1994* and the Environmental Protection (Rehabilitation Reform) Amendment Regulation 2019 implements key elements of the Mined Land Rehabilitation Policy. This includes introducing the new requirements for a Progressive Rehabilitation and Closure Plan (PRC plan) progressive rehabilitation and closure plan guideline ESR/2019/4964 • Version 2.00 • Last reviewed: 17 MAR 2021.
- National Environment Protection Council (Queensland) Act 1994 (Qld). National Environment Protection (Assessment of Site Contamination) Measure.
- DES (2020) Department of Environment and Science. Residual Risk Assessment Guideline - Interim ESR/2020/5433 • Version 1.00 • Effective: 2 OCTOBER 2020.

1.8 License conditions

1.8.1 Environmental Authority

MRO operate under Environmental Authority EPML00712113 (dated 16 August 2022) and EPBC 2013/6886.

1.8.2 Progressive rehabilitation and closure plan (PRC Plan)

MRO is required to develop a PRC Plan. The PRC Plan has the following mandatory content:

- A rehabilitation planning component (**Section 2),** which documents the:
  - Consultation processes undertaken to develop the plan;
  - The proposed design of the mine;
  - The final landform including encapsulation and cover design requirements;
  - Different post-mining land uses or non-use management areas for the site,
  - Methodologies and trials for rehabilitation; and
  - Any post-closure management requirements for the site.
- A scheduling component **(Section 3)** which includes:
  - All mined units (not just waste);
  - Maps of final rehabilitation outcomes for each area;
  - Tables of time-based milestones for achieving each post-mining land use or non-use management areas; and,
  - Any conditions imposed on the schedule by the administering authority.

The content in this MMM Plan complies with (and in most cases exceeds) the planning and scheduling components of the PRC Plan requirements.

1.8.2.1 Purpose of the PRC Plan

One of the main purposes of the PRC Plan is to document how and where environmentally relevant activities will be carried out on land in a way that maximises the progressive rehabilitation of the land to a stable condition.

The rehabilitation planning part of the PRC plan must explain how progressive rehabilitation and closure has been considered in the design of the mine site. Proactively designing for closure will maximise the progressive rehabilitation of the land to a stable condition and will minimise the long-term management requirements and costs at closure.

All aspects of the mine site should be designed for closure including mine landform locations, construction and operation of the mine. For example, the locations of mine structures should be planned to ensure they do not limit options for future rehabilitation or delay an area of land becoming available for rehabilitation or improvement. To demonstrate that rehabilitation will be maximised for the mine site, the rehabilitation planning part of the PRC plan for new or expanding sites must include a description of how the following aspects have been designed for closure:

- location of mine features/infrastructure, having regard to the following considerations:
  - protection of environmental values of the site and receiving environment, including matters of National Environmental Significance, matters of State Environmental Significance and matters of Local Environmental Significance
  - surrounding land uses and proximity to sensitive receptors
  - proximity to the open-pit exit or exits
  - the gradient of the footprint area, both for the direction of drainage from the landform and for the dumping costs
  - local and regional topography
  - surface and ground water features (quality, quantity, and seasonal variation)
  - geotechnical conditions (i.e. soil/rock characteristics) and suitability for the structure type (i.e. presence of structural features that may transmit seepage)
  - competing water and land uses
  - visual impact
- size, shape, and design of mine features/infrastructure (e.g. waste rock dump design)
- mining methods (such as utilising underground methods versus extraction via an open cut pit).

1.8.2.2 Limitations of the PRC Plan guideline in respect to "design"

Common terms for engineering design include scoping, pre-feasibility study (PFS) and feasibility study (FS) (JORC).

Table 1-1: JORC descriptions for common levels of design

STUDY LEVEL	JORC CODE REQUIREMENTS
Scoping	"is an order of magnitude technical and economic study of the potential viability of Mineral Resources. It includes appropriate assessments of realistically assumed Modifying Factors together with any other relevant operational factors that are necessary to demonstrate at the time of reporting that progress to a Pre-Feasibility level".
Pre-Feasibility	"is a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method, in the case of underground mining, or the pit configuration, in the case of an open pit, is established and an effective method of mineral processing is determined. It includes a financial analysis based on reasonable assumptions on the Modifying Factors and the evaluation of any other relevant factors which are sufficient . . .to determine if all or part of the Mineral Resources may be converted to an Ore Reserve at the time of reporting". Basic designs are completed for most facilities.
Feasibility	"is a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate at the time of reporting that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The confidence level of the study will be higher than that of a Pre-Feasibility Study".

1.8.2.3 Addressing PRC Plan limitations in respect to "design" and environmental assessment

Although the term design is used in the PRC Plan guideline, the level of design, or level of reliability associated with the closure plan (as a whole) and the level of design, or level of reliability of each constructed mine landform designs is not defined.

In this management plan RGS refer to scoping or concept, PFS and FS levels of design and align these levels of design with the intent of the JORC guideline, namely:

- scoping = order of magnitude
- pre-feasibility study (PFS) = basic designs are completed for most facilities
- feasibility study (FS) = results of study may enable a decision to be made on whether something is viable and should proceed or requires additional assessment.

Whereas the JORC terminology and intent of the terms and processes JORC use, address technical and financial aspects they do not enable an assessment of reliability or confidence associated with environmental impact, for which there are no equivalent terms.

Regarding environmental assessment it is reasonable to assume that an environmental assessment is as reliable as the level of design that has been applied to the mine, the mine domains, and each of the constructed mine landforms within them.

Reliability can be assured when the environmental assessment is being undertaken on as-built constructed mine landform using measured data from past or current conditions. Conversely, reliability decreases when an environmental assessment of future conditions is required, and is usually made, using numerical modelling methods (simulations) for future events.

Because the PRC Plan is being used to plan, schedule, and assess future conditions it carries inherent uncertainty.

2 PRCP planning

2.1 Mine material characterisation

In this MMM Plan, RGS refer to mine materials that comprise deleterious and beneficial units.

- Deleterious units include low grade ore, tailings and potentially acid forming (PAF) waste rock
- Beneficial units comprise topsoil, subsoil, saprolite and saprock, and non-acid forming (NAF) and acid consuming (AC) rock.

2.1.1 Soil and capping materials

The soil quality geochemical and physical properties have been defined from a number of sampling and analytical programs by MRO over the LOM and are described in the PRC Plan.

RGS completed a test pit and drilling program in 2016 to quantify volumes and soil quality, geochemical and physical properties of pedolith units that could be used to construct the cover system on the TSF (RGS, 2016b). The data was subsequently used to develop a pre-feasibility level tailings cap design.

2.1.1.1 Laboratory assessment of soil and capping materials

In September 2022, RGS commenced additional soil quality, geochemical and physical characterisation of five bulk ($1 m^3$) samples of:

- topsoil provided from an existing stockpile,
- topsoil from a location to the north of TSF, and
- topsoil, saprolite and saprock form West Hill

Splits of these bulk samples are undergoing soil quality, geochemical and physical characterisation. These bulk samples are also being used to quantify erosion rates to enable erosion modelling of proposed soil cover systems for the TSF and NWRD using MinErosion v.4. The results for the laboratory testing and modelling work will are estimated to be completed end December 2022.

Should the MinErosion v.4 indicate there is a need for landform evaluation modelling this work can be using $CAESAR_{LISFLOOD}$ or SIBERIA.

2.1.2 Regolith and fresh rock

Mine materials at MRO include deleterious (waste) and beneficial (rehabilitation and construction) materials.

RGS has been doing static and kinetic assessment of tailings and waste rock at MRO since 2009.

RGS (2009). *Geochemical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials at Mt Rawdon Gold Mine – Stage 1*. Report No. R001-A (890013) prepared by RGS Environmental Pty Ltd for Mount Rawdon Gold Mine. 28 August.

- Initial surface runoff and leachate from waste rock and low-grade ore materials is likely to be alkaline and non-saline.
- Total metal concentrations in waste rock and low-grade ore materials are unlikely to present any concerns related to mine operation and final rehabilitation. In particular, the low-risk waste rock materials appear to be amenable for use as
    - the final surface and batters of the WRD and as part of a final cover system over tailings at the TSF.
    - The selective handling and encapsulation control strategies employed by Mt Rawdon Mine (MRM) for the management of waste rock and low-grade ore materials currently appear to be successful, as indicated by ongoing surface and groundwater monitoring programs downstream of the NWRD facility.

RGS (2011b). Geochemical and Mineralogical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials Mt Rawdon Gold Mine – Stage 2. Report prepared by RGS Environmental Pty Ltd for LGL Mt Rawdon Gold Mine, 8 November.

- Kinetic Leach Column (KLC) test results suggest that surface runoff and seepage from waste rock and low grade ore materials will remain slightly alkaline to pH neutral and contain a low concentration of salts and metal(loid)s for a significant period of time (> 20 years).

MRO (2016). 2016 geochemical (total sulfur and total carbon) database generated from tailings sampling program (3 August to 8 September 2016) using on-site Leco analyser. September.

- Interpretation of the MRO total sulfur and total carbon databases from 2003 to 2016 indicates that these data sets can be used to accurately predict the NAF, PAF- medium capacity (MC) and PAF-high capacity) HC waste rock materials.

RGS (2020). Geochemical Assessment of Waste Rock and Tailings Materials. Mt Rawdon Gold Mine. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 4 December.

- KLC test work on six columns from 2016-2018 including NAF waste rock, PAF-MC waste rock, PAF-HC waste rock, tailing, tailing on top of PAF-HC waste rock, and tailings mixed with PAF-HC waste rock
- NAF waste rock materials have negligible sulfur content, elevated acid neutralisation capacity (ANC) and a high factor of safety with respect to potential for acid and metalliferous drainage (AMD) (including neutral metalliferous drainage (NMD) or saline drainage (SD)).
- Initial surface runoff and seepage from NAF and PAF waste rock materials (and ongoing surface runoff and seepage from NAF waste rock materials) is likely to be pH neutral to slightly alkaline and have a low level of salinity. Initial and ongoing surface runoff and seepage from NAF waste rock materials is likely to contain excess alkalinity.

Mt Rawdon Operations Waste Rock Test Pile Review RGS Environmental Pty Ltd, 2018.

- Review of design, construction, and sampling results of the waste rock test pile field leaching project.

RGS (2021). Assessment of Long-Term Geochemical Characteristics of Mt Rawdon Tailing Materials – Final Report. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.

- Static testing on four tailings samples and kinetic test work of four columns containing tailings from 2014-2018.
- Tailing materials tested to date have relatively consistent static geochemical characteristics and are classified as NAF.
- Contact water and leachate from tailing materials are likely to be pH neutral (in the range pH 7 to 8) and contain excess alkalinity.
- The quality of the tailing pore water and any TSF seepage is likely to gradually improve when supernatant/fresh tailings (and waste rock materials) are no longer added to the TSF following closure of this facility.
- Whilst tailing solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to relatively immobile and sparingly soluble at neutral pH.
- The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site.
- It is expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure and rehabilitation of the TSF.

2.1.3 Field assessment of mine materials

As part of MROs ongoing commitment to understanding waste rock geochemical characteristics and to assist with the development of rehabilitation and closure strategies for waste rock facilities, MRO designed and constructed a field test pile project in 2016 (**Figure 2-1**).

The aim of the project is to “determine how specific waste rock dump design types will affect water quality characteristics of leachate produced from rainfall events”.



Figure 2-1: Field trials of mine waste

The test pile experiments are typically designed to:

- Assess the sulfide oxidation/metal leaching rates and weathering rates of waste rock materials under site-specific field conditions;
- Assess leachate quality generated under site-specific field conditions;
- Provide information that can be used to understand and scale sulfide oxidation, weathering reaction rates from laboratory tests to site-specific field conditions;
- Provide information that can be used for water quality estimation; and,
- Evaluate the effectiveness of various treatments (e.g. cover design; alkaline dosing, etc.) on oxygen ingress and water infiltration as an engineered strategy to minimise/mitigate AMD [including ML and SD].

In 2018, RGS carried out a review of the construction of the test pile and made recommendations. An interpretation of the leachate data obtained was also carried out along with a comparison to waste rock dump seepage (i.e. NRWD) and pit water quality. A summary of the reporting on leachate results from the test piles is listed below (RGS 2018).

2.1.3.1 pH/ Acidity/ Alkalinity

Almost all pH values reported in leachates from all waste rock types are circumneutral over the duration of the testing. These pH values are within the release limits specified for the contaminant dams and for regional groundwater tolerable limits (i.e. pH 6.0 – 9.0). The pH values typically ranged from pH 7.0 to 7.5, with slightly higher pH values evident for the NAF (C–N) and PAF-MC (C–M) test piles.

On two occasions the PAF-HC (C–H: R3) test piles reported acidic pH values (pH < 4.5); however, later leach events reported circumneutral pH values. This is likely to reflect the depletion of available ANC at these times, with the particle size of pyrite and carbonates likely to play an important role in the balance of weathering of these minerals.

The acidity generation from the tests piles was negligible, except for when the leachate pH dropped below ~pH 6 (ie. for the PAF-HC test pile on two occasions), in which case up to 41 mg/L (as $CaCO_3$) of acidity was produced. The leachates generally produced alkalinity in the form of bicarbonate, with measured total alkalinity typically ranging between ~15 to 70 mg/L (as $CaCO_3$). Total alkalinity was below instrumental detection limits for C–H: R3, for the two acidic leachate events.

2.1.3.2 Salinity/ Metal(loid)s

The key metal(loid) concentrations corresponding to the receiving water monitoring requirements (Schedule E - Table 4 of the EA: SO42-, TDS, Cu, Zn, As, Cd and WAD CN) are discussed below – excluding CN (not measured).

- Generally, the concentrations of each of the chemical parameters are sporadic and reflect rainfall intensity and frequency. The low rainfall events, which are sufficient enough to produce leachate, are more concentrated, particularly after extended dry periods where soluble oxidation products accumulate within the waste material and are flushed (ie. first-
- flush) (e.g. 19/07/2016). In contrast, high rainfall events are generally associated with dilution of chemical constituents, even after time of extended dry periods (e.g. 24/10/2017).
- The seasonality and variation of leached metal(loid)/salinity concentrations relative to rainfall intensity and frequency are highlighted in Figure 4-1 where leached TDS concentration for each of the test piles is compared to cumulative rainfall (from the Mt Perry BOM SILO data drill; Station number 39070) over the test period. The figure highlights the elevated TDS concentrations after low rainfall events relative to low TDS concentrations after large rainfall events due to dilution.
- The leached TDS concentrations varied considerably for leachate from a particular test pile (from ~30 mg/L to 2,500 mg/L) (Figure 33), reflecting seasonal variations in rainfall and intensity. Higher concentration leachates are most evident towards the start of each wet season, particularly after the test piles commenced. This reflects the flushing of soluble oxidation products (secondary mineral precipitates) that accumulate over the dry season.
- The leached sulfate concentrations essentially mirror leached TDS concentrations. The leached sulfate concentrations ranged from ~50 – 1,400 mg/L for the test piles. The leached sulfate concentrations were generally lower for the NAF test piles (~100 to 900 mg/L) than the PAF-MC (~100 – 1,400 mg/L) and PAF-HC (~50 – 1,100 mg/L) test piles reflecting the total sulfur content of the waste rock samples. Although there is sufficient ANC in the waste rock test piles to typically inhibit (currently) the onset of acidification, the sulfides present are reacting and, although being neutralised, are producing sulfate. The sulfate concentrations also reflect the seasonal variations in rainfall with concertation and dilution effects.
- Ideally the sulfate production rates could be calculated, to show that sulfate production is likely to be similar for each of the test piles regardless of starting sulfur content and waste rock type. This would suggest that sulfide oxidation rates are approximately the same regardless of the starting total sulfur concentration, and/or, sulfate loading may be controlled by secondary mineral precipitates (e.g. gypsum [CaSO4.2H2O)] precipitation).
- Higher leached metal(loid) concentrations are associated with the two acidic leach events for test pile C-H: R3. This is particularly evident for elements such as (amongst others): Al, Cd, Cu, Mn and Zn. This highlights the need to maintain neutral leachate conditions.
- The Cu leach concentrations are generally elevated for the majority of test piles relative to the contaminant release limits (Schedule E – Table 2) which is either < 0.04 mg/L Cu or <0.0025 mg/L Cu depending on the dam. However, there are only two measurements that exceed the regional ground water contaminant limits (Schedule E – Table 10), which are associated with the acidic leaches from the PAF-HC test piles.
- The leached Cu concentrations were more elevated in the initial flush events for the NAF (up to 0.012 mg/L Cu), PAF-MC (up to 0.01 mg/L Cu) and trial (up to 0.017 mg/L Cu) test piles, which reflects the flushing of oxidation products accumulating in the test piles; this is enhanced during the excavation and stockpiling of waste rock followed by construction phases of the test piles.
- Generally, the NAF, PAF-MC and trial test piles leached Cu concentrations below 0.004 mg/L after the initial first flush. The exception was for the PAF-HC test pile when acidic leachates occurred.
- The leached Zn concentrations are relatively low for the majority of test piles (excluding the PAF-HC test piles) relative to the contaminant release limits (Schedule E – Table 2), which is either < 0.15 mg/L Zn or <0.031 mg/L Zn, depending on the dam. All leached Zn concentrations from the NAF, PAF-MC and trial test piles are well below 0.1 mg/L Zn. However, the PAF-HC test pile concentrations are orders of magnitude higher than the other test piles, particularly during the acidic leach events, with the majority of values above 0.1 mg/L Zn. This may reflect the total Zn concentrations of the waste rock material in the PAF-HC test piles (not available), or the mineralogy/ speciation of Zn in the test piles.

- The leached Zn concentrations show a somewhat inverse trend compared to the Cu concentrations, with a generally lower first flush concentration, followed by a general increase in leached Cu concentrations over the testing period.
- The leached As concentrations are generally below instrumental detection limits for each of the test piles, including for the acidic leach events associated with PAF-HC test pile.
- The leached Cd concentrations are relatively low for the majority of test piles (excluding the PAF-HC test piles) relative to the contaminant release limits (Schedule E – Table 2), which is either < 0.005 mg/L Cd or <0.0008 mg/L Cd, depending on the dam. All leached Cd concentrations from the NAF, PAF-MC and trial test piles is well below 0.05 mg/L Cd, and the majority below 0.0008 mg/L Cd (the few exceptions are from the trial test pile).
- However, once again, the PAF-HC test pile concentrations are orders of magnitude higher than the other test piles, particularly during the acidic leach events, with several values above 0.01 mg/L Cd. This may reflect the total Cd concentrations of the waste rock material in the PAF-HC test piles (not available), or the mineralogy/ speciation of Cd in the test piles.
- The leached Mn concentrations are generally elevated for the PAF-HC test piles relative to ANZECC & ARMCANZ (2000) guideline values for Livestock Drinking Water Levels. The elevated values typically correspond to the acidic leachates.

2.2 Ore and tailings

2.2.1 Low grade ore

Low grade ore stockpiles have been established on the NWRD and will be either processed or remain *in situ* and rehabilitated. The stockpiling strategy enables better control of blending of rock type and grade control for the processing plant.

The NWRD is utilised for the disposal of both NAF and PAF waste rock material (namely PAF-MC). The facility covers an area of approximately 105 ha. The outer batters will remain at angle of repose as a rock face only.

The Western Waste Rock Dump (WWRD) is utilised for temporary storage of NAF only. The final approved footprint of the facility is 73 ha however the current disturbance footprint is 49.1 ha.

2.2.2 Tailings

RGS (2021). Geochemical Assessment of MRO Tailing Materials, Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.

- RGS completed an intensive investigation into the geochemical characteristics of tailing materials generated at MRO over a period of 12 months.
- Daily tailing samples generated at the MRO processing plant have variable geochemical characteristics and these materials range in classification from NAF, Uncertain, PAF-LC through to PAF. However, most samples are classified as NAF and/or Uncertain and PAF-LC and PAF materials appear to be generated for a small proportion of the time.
- Results from weekly and monthly composite tailing samples indicate that when most tailing materials are mixed at the TSF, the resulting tailings blend is likely to be mostly NAF.
- There is a strong correlation between the total sulfur content of the tailing samples and their geochemical classification. The total sulfur content of the tailing materials generally has to be consistently greater than 1.5 % for tailings batches to be classified as PAF.
- The tailing materials have a significant amount of readily available alkalinity and buffering capacity that neutralises any acidity generate from sulfide oxidation and generally maintains an alkaline pH.
- Based on the static geochemistry results in this report, previous long term KLC test results (RGS, 2020, 2021), and field monitoring data on tailing materials currently stored at the TSF, the risk of any acid generation now and following closure and rehabilitation of the TSF is expected to be very low.
- Whilst tailing solids contained enriched concentrations of some metals/metalloids compared to typical soil background concentrations, most metals/metalloids appear to relatively immobile and sparingly soluble at neutral to alkaline pH.

- The risk of release of significantly elevated concentrations of dissolved metal/metalloids and sulfate into surface runoff and any seepage from the TSF is relatively low and manageable, as confirmed by the results of surface water, seepage and groundwater monitoring at the site.
- It is expected that the concentration of major ions (including sulfate) in any seepage from the TSF will gradually decrease over time following closure and rehabilitation of the TSF.

2.3 Mine domains

The **draft PRC Plan** identifies six rehabilitation areas and five main mine domains (**Figure 2-2**).

- RA 1 – Residual Void (PIT)
- RA 2 – WRDs, ROM and Stockpiles
  - Northern WRD (NWRD)
  - Long Term ore stockpiles (LTSP)
  - West WRD (WWRD)
- RA 3 – TSF inclusive of PAF cells
- RA 4 – Roads and Access Tracks
- RA 5 – Processing Plant, Workshops, and Infrastructure Management Areas
- RA 6 – Water Management Infrastructure and Dams (i.e. South dam, West dam,. Wastewater Dams 1-4).



Figure 2-2: Major site domains

2.3.1 Open pit, mine plan and processing

The open pit mining is scheduled to end in October 2024.

- The open pit has a pit rim surface area of 75 ha.
- Increased rate of mining through 2025 to stockpile ore.
- Cessation of mining and closure of the open pit in late 2026.
- Development of infrastructure from late 2026 to early 2027 to enable ponded water in the TSF to be discharged into the open pit
- Processing of stockpiled ore throughout 2027 and cessation of processing in March 2026.

2.3.2 Northern WRD (NWRD)

The NWRD, has a final approved footprint of 103 ha (**Figure 2-3**), contains PAF material encapsulated by NAF, coupled with low permeability clay layers on the benches that limit the ingress of water into the NAF embankments. The final landform design intent will aim to shed rainfall and channel runoff along the benches through stormwater infrastructure and drop structures to the existing interception dams. During operations water is collected within these dams and pumped back through the processing circuit. Upon decommissioning of the processing plant and rehabilitation of the NWRD, rainfall captured within the interception dams will either be pumped to the pit or undergo passive treatment via constructed wetlands which are currently being trialled on site.

2.3.3 West WRD (WWRD)

The WWRD is comprised of NAF material and is currently acting as a stockpiled reserve of NAF for use across the site where required. The material has many uses across site rehabilitation areas including capping, construction of berms, erosion and sediment control structures and for rehabilitation purposes. Progressive rehabilitation of the WRD cannot be initiated given the extensive use of the NAF material under current operational strategy.

Under the draft PRC Plan the materials balance for the WWRD will be consumed for rehabilitation of other domains, such as the TSF and NWRD. Therefore, the remaining disturbed footprint surface will be prepared and revegetated to an open woodland/low intensity grazing post mine land use.

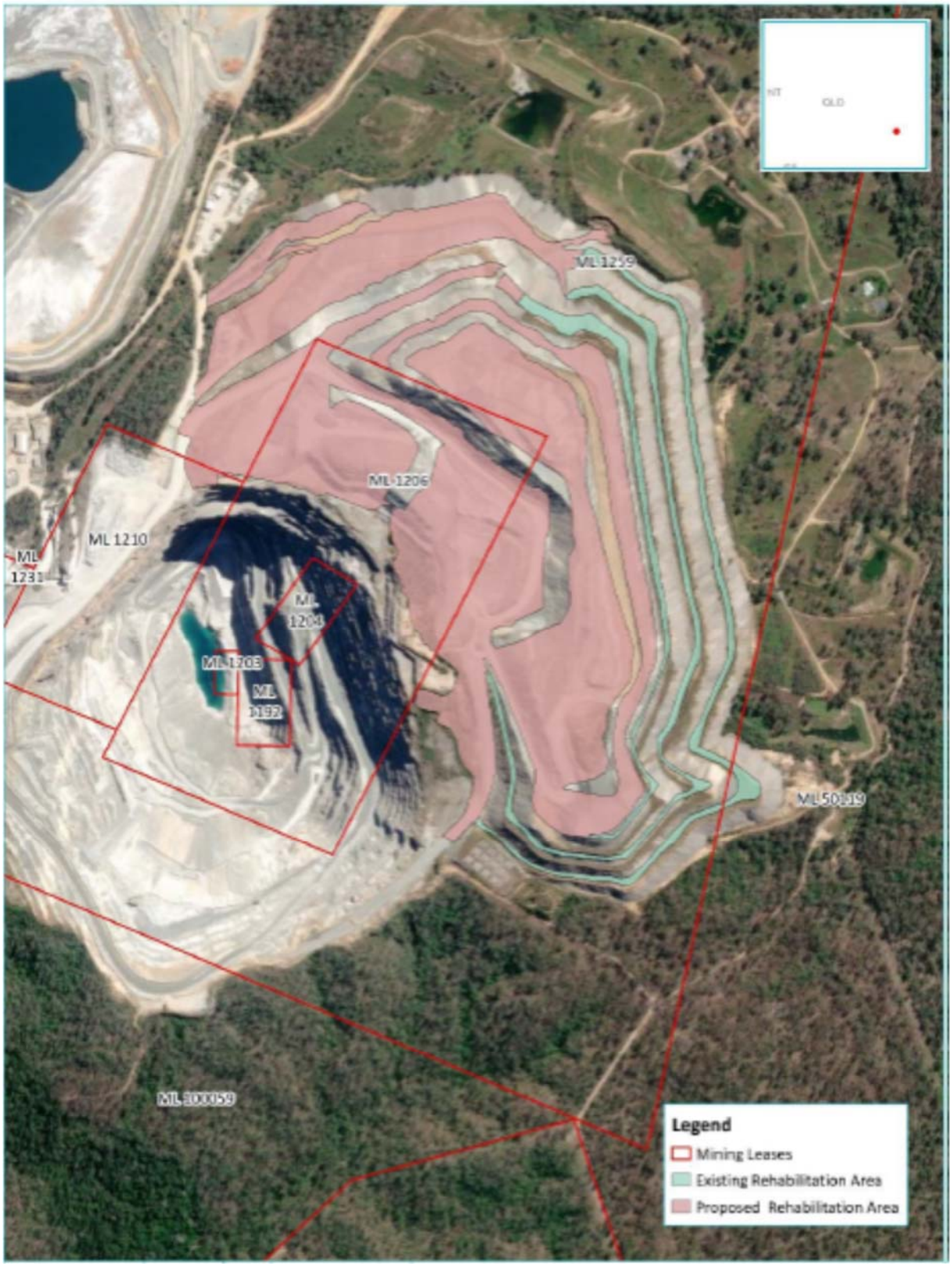


Figure 2-3: Plan view of NWRD

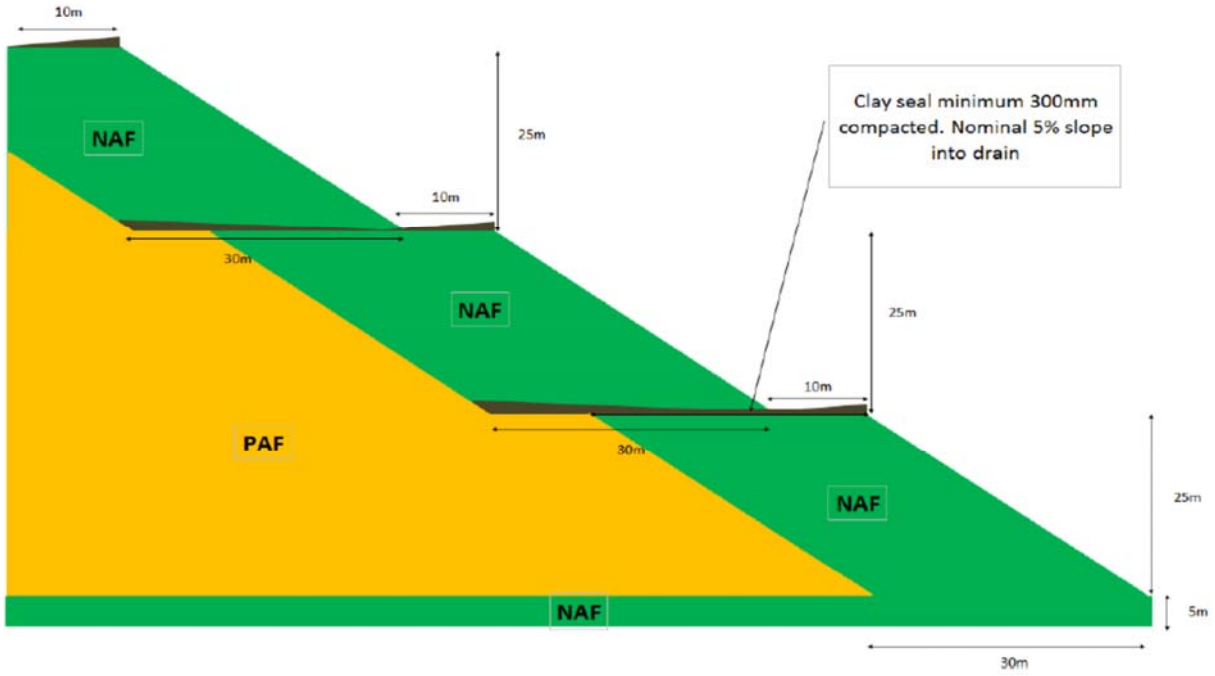


Figure 2-4: Cross-Section Illustration of Conceptual North WRD Berm Design

2.3.4 Tailings storage facility (TSF)

The TSF comprises valley-type storage, formed by a primary embankment at the northern end of the site (referred to as Northern Embankment), an embankment at the southern end that extends around the eastern perimeter (referred to as Southern Embankment), and a saddle embankment formed on the western perimeter (referred to as Western Saddle Embankment).

The proposed ultimate design configuration is in Table2-2**.** The TSF will be rehabilitated to the final land use of open woodland and low-intensity grazing purposes where practicable. This involves the decommissioning and removal of pumping and piping infrastructure followed by the installation of an appropriate cover system and revegetation.

Table 2-1: TSF design criteria

Parameter	Final Year Ultimate Design
Embankment Crest Level	RL 197.5 m
Total Storage Capacity (tailings, waste rock, water & airspace)	64,838ML
Maximum Northern Embankment Height	81m
Maximum Southern Embankment Height	62m
Maximum Western Embankment Height	27m
Spillway invert level RL	RL 192.0 m
Spillway width	10 m

3 Operational schedule and constructed mine landform

MRO's mine planning team developed an Operational Deswik.LHS model for their life of mine plan (referred to as an $OPS_{PLAN.DESWIK.LHS}$). The $OPS_{PLAN.DESWIK.LHS}$ was primarily used to communicate the mining sequence to the key stakeholders, and to calculate truck hours to make sure they could achieve the mine plan with the number of trucks they had on site.

However, because the focus of the $OPS_{PLAN.DESWIK.LHS}$ was on calculating truck hours, it lacked the detail needed to design final landforms and final cover systems. The end point of the $OPS_{PLAN.DESWIK.LHS}$ did not represent the final landform because the complex interactions between the long-term ore stockpiles and North Waste Rock Dump had not been addressed. The model also finished when the pit was depleted in Q4 2024 and did not include any subsequent closure activities, such as re-processing low grade ore, reshaping landforms, developing borrow areas and placing cover systems.

There were also instances where the domain designs for the TSF and WRDs were not aligned and the $OPS_{PLAN.DESWIK.LHS}$ had not been co-ordinated to design for closure. These inconsistencies required changes to be evaluated and simulated to enable viable landform designs to be developed.

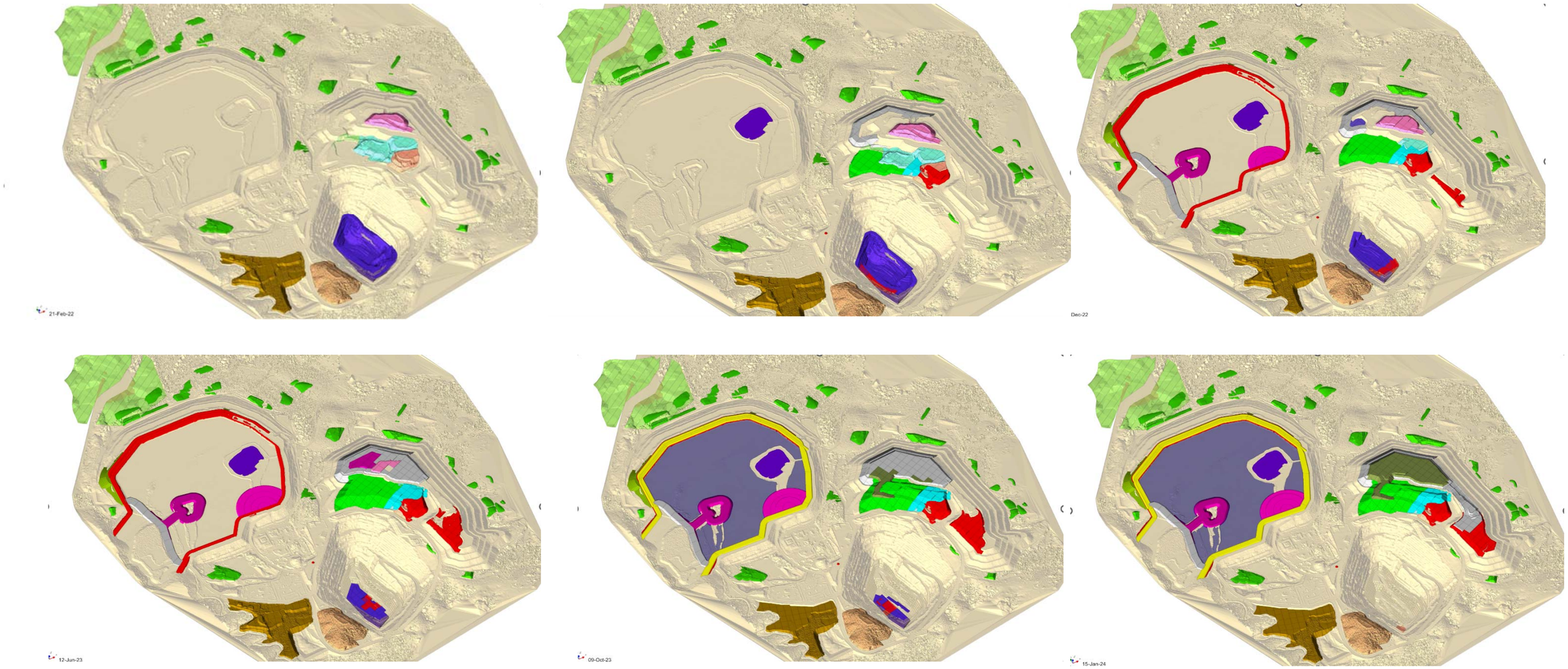


Figure 3-1: $OPS_{PLAN.LHS}$ from Q1 2022 to end of mining Q4 2024

4 PRC Plan schedule and final mine landform

The $PRC_{PLAN.LHS}$ work encompasses the whole of mine (WOM) over the LOM and life of asset (LOA) final void assessment that includes a 100-year post closure timeframe: the NWRD, WWRD, TSF and Open Pit are addressed in detail.

4.1 WWRD progressive rehabilitation plan

The WWRD is remined and used for construction and rehabilitation. Not all mine material in the WWRD is removed to pre-mine topography.

A NAF rock land bridge is retained from the TSF to the open pit to enable the movement of water from the TSF to the open pit during Phase 2 to Phase 4 of the water management planning (**Section 0** and **4.3.3.4**). The West Dam is also retained during and post rehabilitation work.

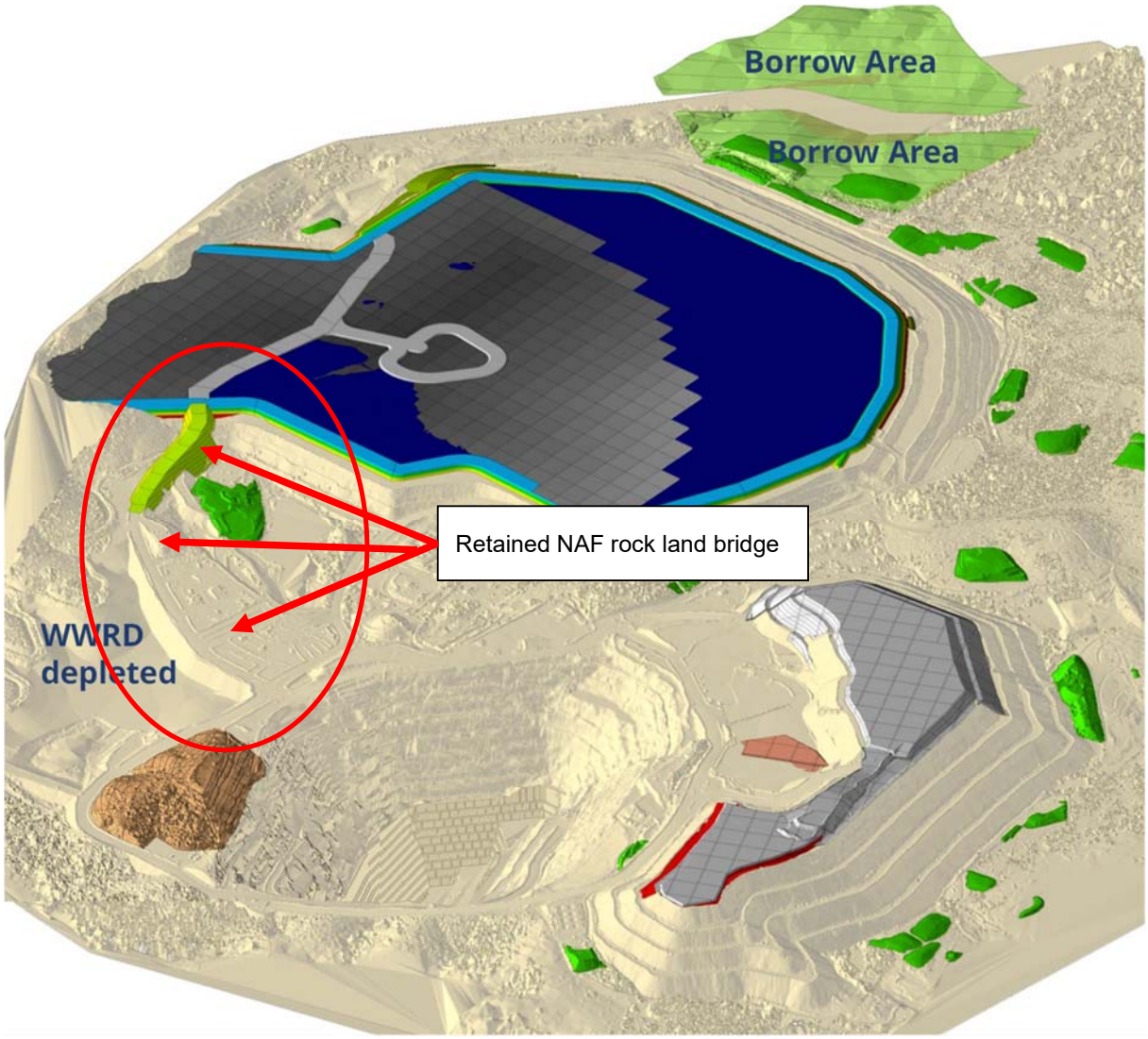


Figure 4-1: West WRD final constructed mine landform

4.2 NWRD progressive rehabilitation plan

4.2.1 Core and batters

The landform design objectives and key design criteria for the NWRD including the external batters include the following.

- The NWRD was designed and built to produce neutral pH drainage via encapsulating of PAF waste in within an outer core of neutralising rock, thereby acid runoff formed within the centre of the dump is neutralised as it passes through the outer ring of neutralising rocks.
- The NWRD was built in four lifts of up to 25 m height.
- The inner PAF core of the NWRD was covered via the construction of external NAF batters built at the angle of repose utilising competent rock comprising gravel ~ 20 mm diameter up to boulders in the range of 1 m diameter. The nominal PSD is P80 > 250 mm.
- The purpose of the NAF rock armour is to provide long term, geotechnical stability, minimise (avoid) erosion so that mineralised sediment is not moved from the NWRD into the receiving environment, avoid the need for soil cover systems on external batters that can be prone to long term failure.
- The NAF external batters utilised placement of 30 m (horizontal) and 25 m (vertical) cover over the internal waste rock in the NWRD **(Figure 2-4).**
- Each batter was underlain by compacted low permeability clay/silt/sand graded at 5% to collect batter interflow **(Figure 2-4)** and direct surface flow along contour, (**Figure 2-3**) to a drop structure that will be designed and built on the NE face of NWRD to direct surface flow to the WD1 dam. The design objective of the contour drains is to minimise the amount of water falling onto or flowing through the external batters.

4.2.2 Review of the $OPS_{PLAN.LHS}$

Before commencement of the $PRC_{PLAN.LHS}$ using Deswik.CAD and Deswik.LHS, the MRO operational plans were evaluated.

- The dump solids in MRO's operational LHS model were updated to align with the material types and extraction sequence of the mining activities in MRO's FY22 LOM plan.
- The NWRD and LTSP designs were initially too large (i.e. there was not enough of a particular material type being mined to fill the solids, but conversely, some other material types didn't have enough room within the WRD to be dumped).
- The size of the NWRD was reduced and the selective placement material types were reassigned to align with the ex-pit material quantities.
- Any overlapping solids in the dump design were repaired to ensure that the spatial extents of the dump and long-term ore stockpiles were correctly represented.
- Once that was resolved, an intermediate ~3m NAF rock cover was added beneath the Olive green LTSP (**Figure 4-3** and **Figure 4-4**) to ensure that the dumped waste would be covered when the LTSP was reclaimed, and prior to the cover system being constructed.
- An interim ~3m NAF cover was also placed over the long-term sub grade stockpile to the south, which would not be reclaimed as it was considered uneconomical.
- The NWRD landform consisted of an interim >3m NAF rock cover prior to the placement of the closure cover.
- The changes to the NWRD design are in **Figure 4-3** and **Figure 4-4**.

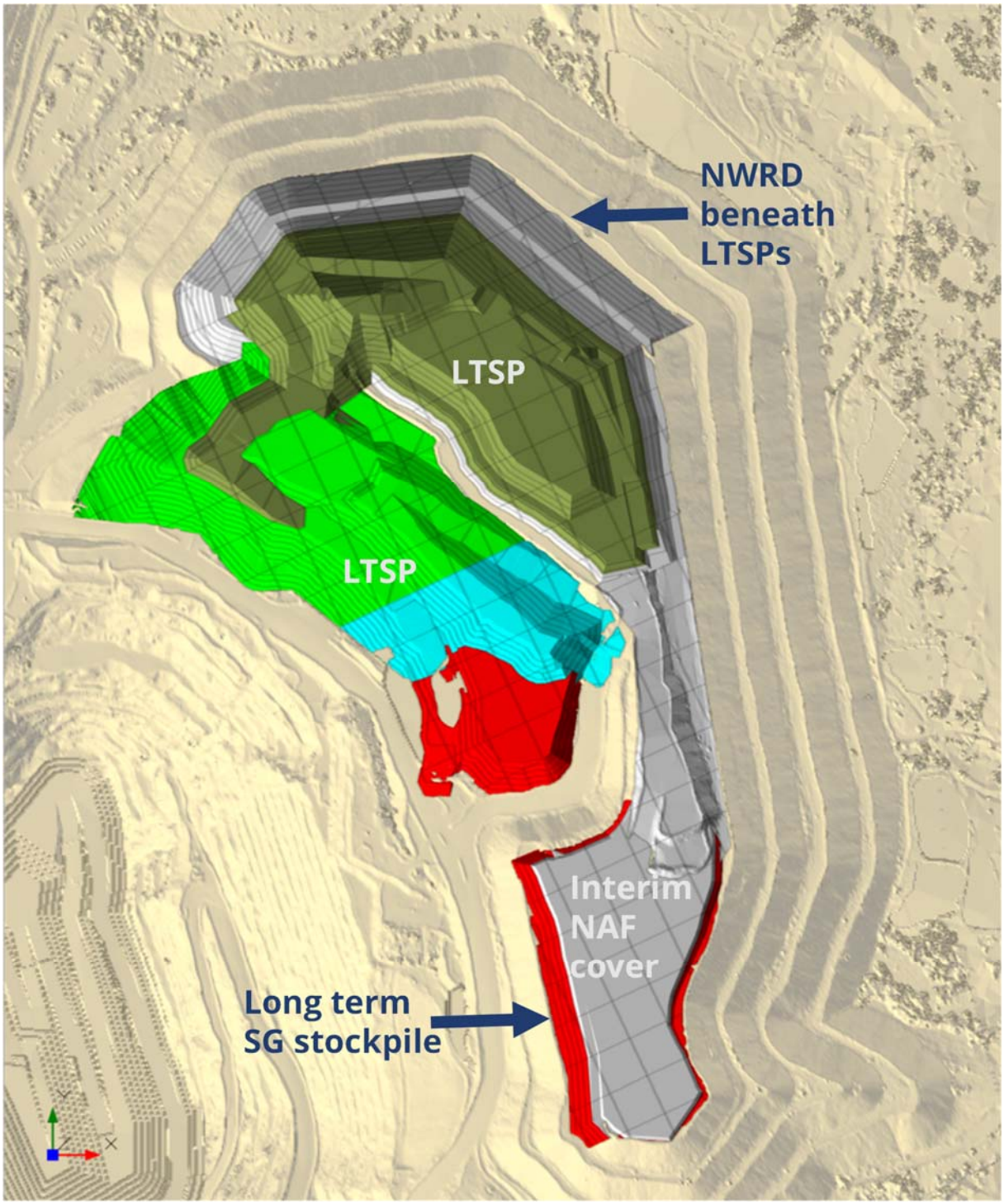


Figure 4-2: Stockpiles within the NWRD

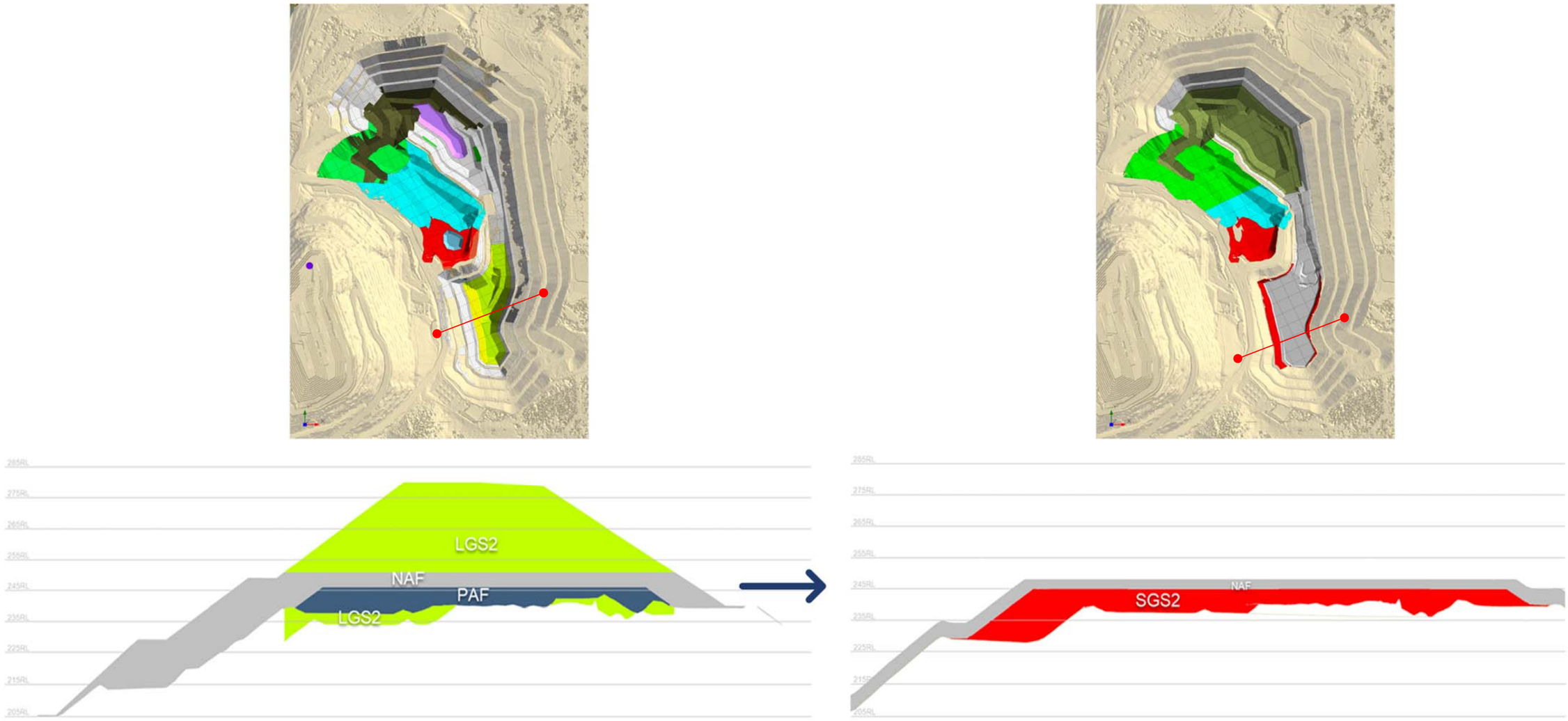


Figure 4-3: NWRD end of 2024 configuration

LEFT: This section was taken through the southern extents of the NWRD. On the left-hand side is the before picture that had capacity for a lot of LGS2, which is one of the low grade ore classes. Beneath the ore stockpile was an interim NAF rock cover, which encapsulated a PAF rock cell.

RIGHT: On the right-hand side is the modified design. The PAF rock cell wasn't required for the FY22 LOM plan, so the PAF cell was reallocated to uneconomic sub grade.

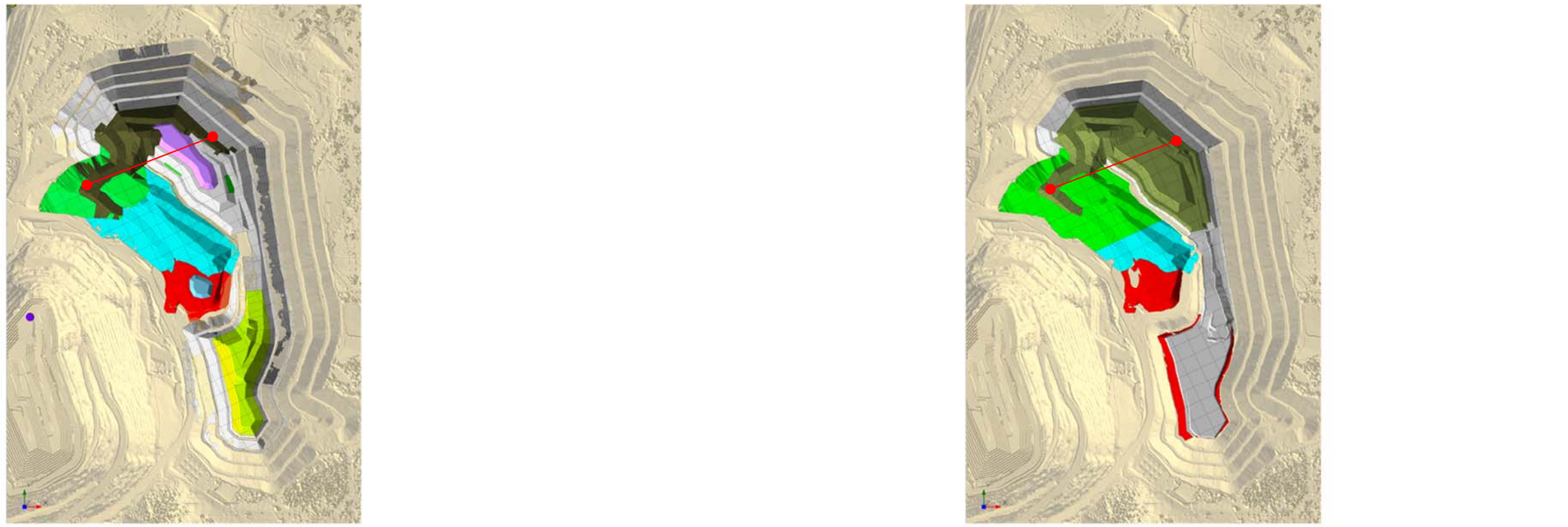


Figure 4-4: NWRD end of 2024 configuration

LEFT: This section was taken through the northern extents of the NWRD. Again, the left-hand side is the before picture with a lot of designed capacity for PAF rock, which was not required.
RIGHT: The solids on the right are the updated solids used for the WOM model. A lot of the PAF rock solids were reallocated to the Long Term Ore Stockpiles (LTOS).

The FY22 LOM sequence also had a lot of Ore Grade (OG) material being mined immediately after the PAF rock had been dumped, which meant that the design and dump sequence had to be tweaked to ensure that an intermediate NAF rock cover had been dumped prior to the Ore Grade Stockpile being filled. This would ensure that the PAF rock cells beneath the OG stockpile would be encapsulated after the LTSP had been reclaimed.

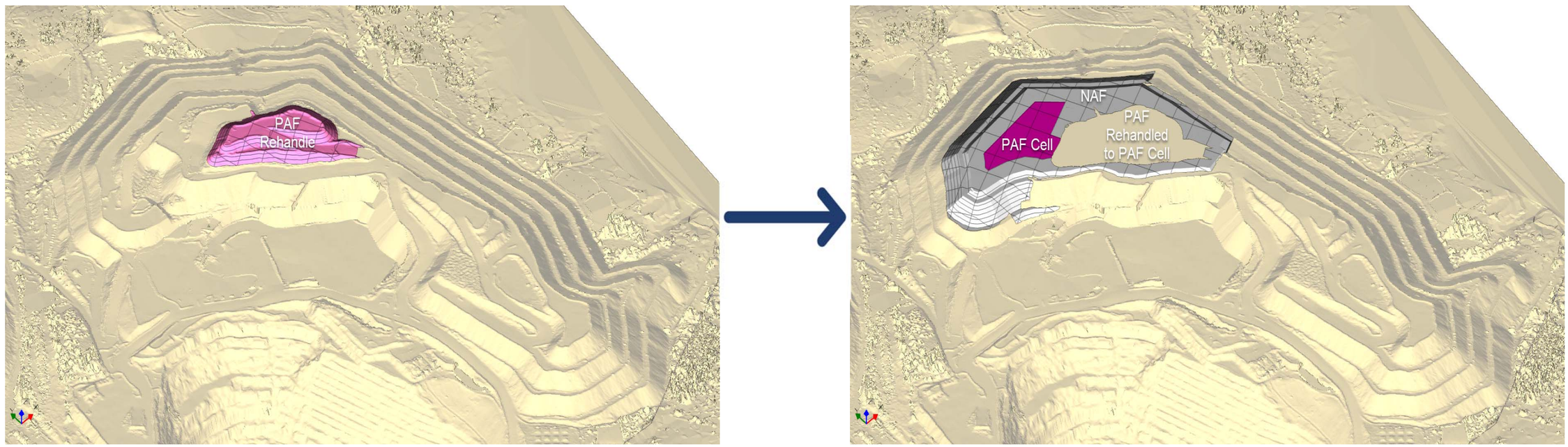


Figure 4-5: NWRD PAF rehandle

LEFT After the dump solids had been adjusted to align with the volumetric requirements of the FY22 LOM plan, it became obvious that some previously dumped PAF material would end up being above the final NWRD design, interfering with the cover system for closure.

More urgently, also it was identified that this PAF rock would need to be moved within the next few months to ensure that an interim NAF rock cover could be constructed before a large amount of ore grade material was scheduled to come out of the pit and also be placed in this area.

This information was passed back to MRO, with the recommended option of rehandling it into the adjacent PAF rock cell.

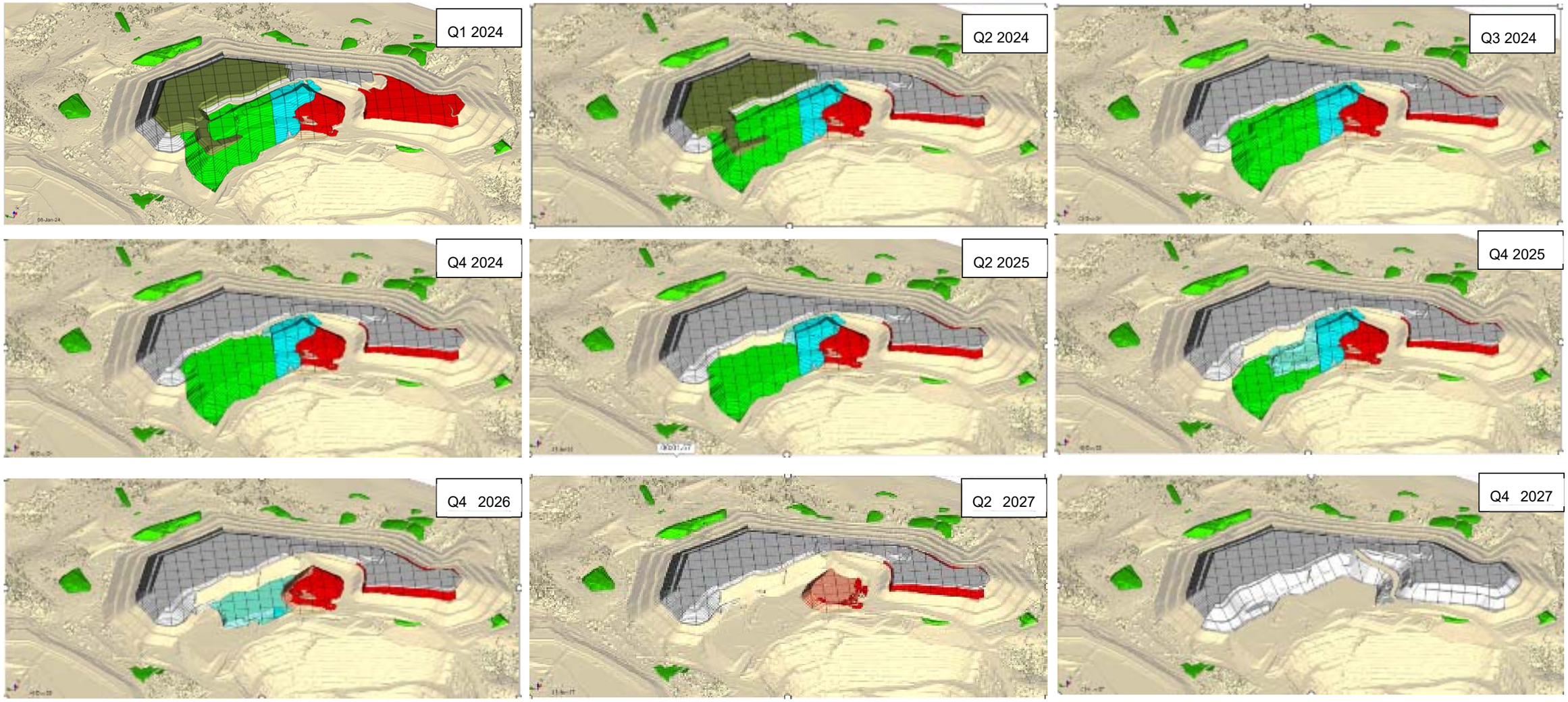


Figure 4-6: NWRD PRC$_{PLAN.LHS}$ sequence Q1 2024 to Q4 2027

4.2.3 Top tier landform design

The landform design objectives and key design criteria for the top of the NWRD include the following:

- The final NWRD landform will be profiled during the reshape to direct surface flow towards the western access ramp.
- The cover system will be built on the reshaped landform.

4.2.4 Waste rock cover system design

RGS completed unsaturated zone modelling (SEEP/W, GeoStudio, 2018) of a range of cover system options (**Figure 4-8**) that could be constructed using available material within the site material balance. The preferred cover system design was considered to be Option 1B.

The landform design objectives and key design criteria for the top of the NWRD include the following:

- The final NWRD landform will be profiled during the reshape to direct surface flow towards the western access ramp.
- After low grade ore and PAF material on the top and western side of the NWRD has been removed the NWRD final landform will be covered with an engineered cover system comprising the following:
    - NAF competent rock will be placed over the exposed waste rock to provide a basal layer (the $PRC_{PLAN.LHS}$ model allows for up to 3 m of NAF rock). This is referred to as the interim NAF rock cover.
    - Fine grained clay/silt/sand (low permeability layer) will be placed over the NAF rock interim cover layer (the $PRC_{PLAN.LHS}$ model allows for 2 x 0.25 m compacted layers). Each 0.25 m layer will be conditioned and compacted.
    - NAF oxide regolith dominated by saprolite is placed over the fine-grained clay/silt/sand low permeability layer (the $PRC_{PLAN.LHS}$ model allows for 2 m of material).
    - NAF waste rock is placed over the NAF oxide regolith (the $PRC_{PLAN.LHS}$ model allows for 1 m of > 75 mm and < 250 mm PSD.
    - Topsoil is placed over/ within the NAF waste rock to fill voids in the rock cover (the $PRC_{PLAN.LHS}$ model allows for 0.2 m of soil).
    - Surface flow from the top of the cover system will flow to the western access ramp. Part of the ramp will be retained as an access road and the remainder of the access ramp will be converted into a rock armoured drain to direct surface flow to the base of the NWRD.
    - Surface flow can then be diverted to the:
        - Open pit
        - Southern side of the NWRD toe and then into
            - WD4, or
            - into the receiving environment.

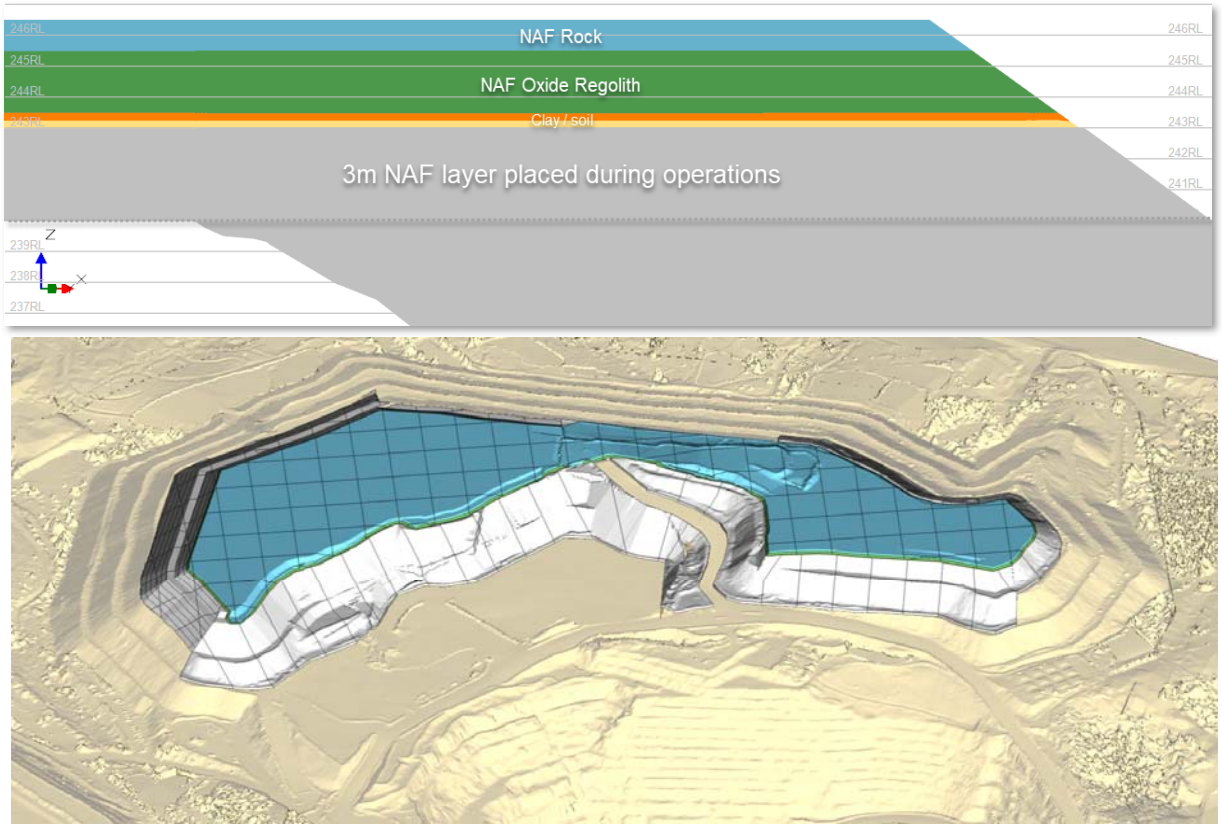


Figure 4-7: NWRD cover configuration

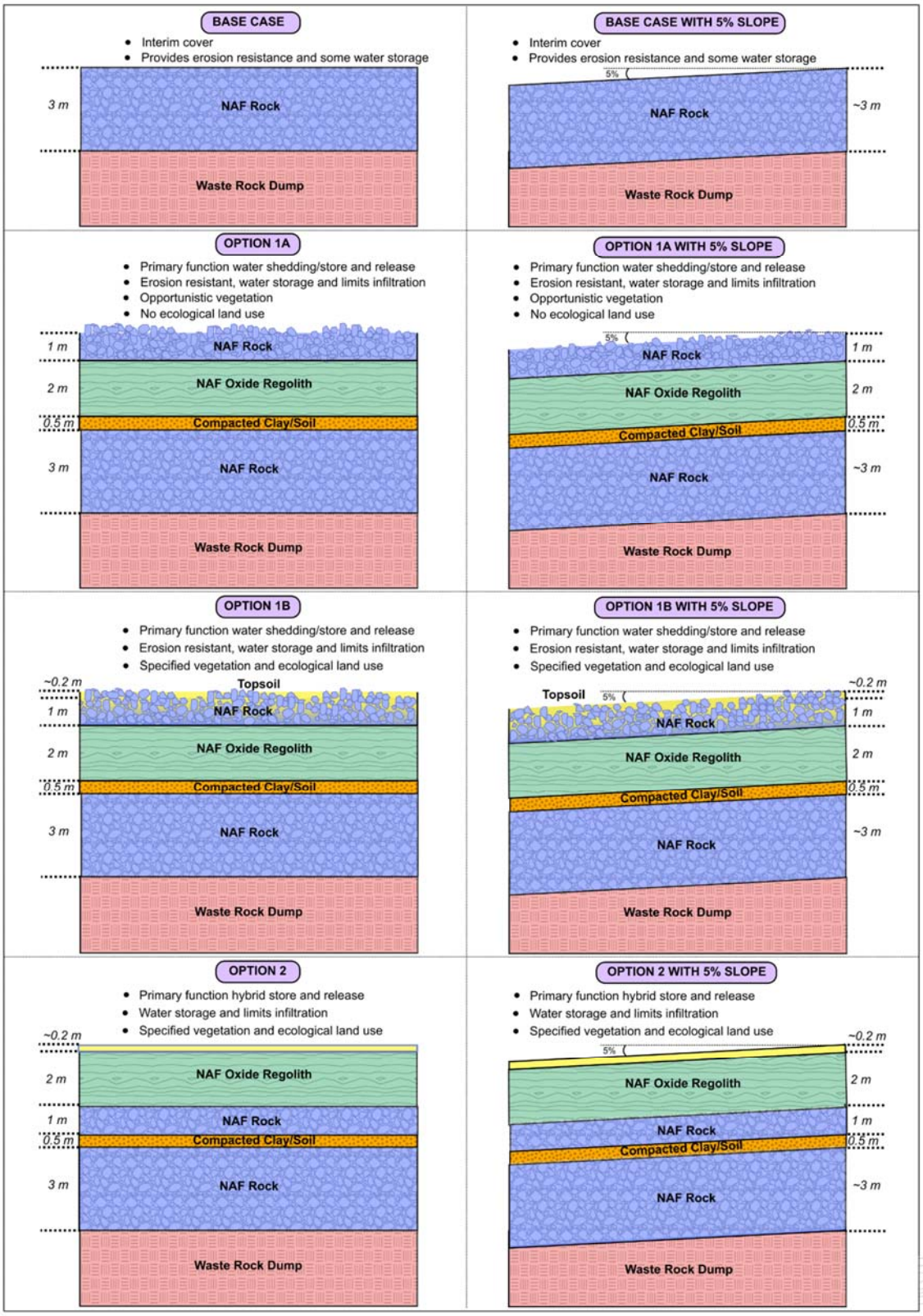


Figure 4-8: NWRD cover system concept level cover configurations

4.2.5 Water management

Rain falling on the NWRD reports as surface runoff during, and shortly following, rainfall events.

The design objective of the cover system regarding water are to collect and contain rainfall, minimising, to the extent possible, percolation of water into the WRD core, or WRD external batters. Surface runoff from the cover system should be suitable for release to the environment if this flow can be separated from mine impacted surface flows in and around the NWRD, and NWRD basal seepage.

Rain percolates into and through the cobble to boulder sized NWRD external batters to the toe of the NWRD. Some seepage may move vertically into the regolith unit below the NWRD. Basal seepage occurs from the toe, during and after rainfall events. Basal seepage can continue to seep from the toe for long periods after rainfall events.

It has not been determined if surface runoff can be separated from basal seepage. If this is not feasible then the combined surface water (stormwater) and basal seepage flow will be contained in interception dams draining (or being pumped sequentially from WD4 to WD3 to WD2 and WD1).

Water management plans are being developed to define whether passive water treatment systems can be used to treat water from WD1.

4.3 Tailings dam rehabilitation plan

4.3.1 Core and batters

ATCW will need to verify if additional NAF material will be required to be placed on external batters to buttress the TSF for perpetual management.

ATCW will also need to provide detailed designs and material specifications for the surface release points from the TSF cover system to the toe of the TSF to the north and south.

Over the LOM PAF material have been co-disposed into the TSF to the east, west and in the centre of the TSF (**Figure 4-9**).

4.3.2 Top tier landform design

The concept closure, decommissioning and rehabilitation plan for the TSF includes the following key components:

- Continued placement of PAF-HC waste rock into the decant structure(s) within the TSF to fully encapsulate this material within fine grained NAF low permeability tailings to eliminate oxygen entry into bulk PAF-HC waste rock materials and reduce/ negate sulfide oxidation.
- Placement of PAF-MC waste rock into a series of low-profile benches on the western TSF cell that will be encapsulated progressively within NAF tailings. The key design criteria for this are that PAF-MC waste rock will not be placed within 25 m horizontal of the natural ground to the west of the TSF, 50 m of the external final TSF landform, and the top of the waste rock will be covered with at least 3 m of NAF tailings.
- Consideration will be given to increasing the acid neutralising capacity of the tailings stream to maintain an ANC:MPA ratio of > 2 within the TSF from the existing to final elevation of the tailings beach.
- Utilising NAF rock crusher dust (from above) to increase the ANC of the tailings stream from 2017 to 2027.
- The PAF-MC waste rock stockpiles may require reshaping / relocating as this is the zone where surface runoff is not proposed to be directed so it can be released to the north or south of the TSF.
    - The final landform design for the TSF will require surface water flow from the hills to the west of the TSF to be directed:
        (i) via perpetual surface water diversion drains to the West Dam
        (ii) via perpetual surface water diversion drains to the West diversion drains around West Dam to the receiving environment

(iii) onto the TSF so the water can be released to the south or north via perpetual release points (drop structures) to the
   a. toe of the TSF into the receiving environment
   b. West Dam
   c. Open Pit.

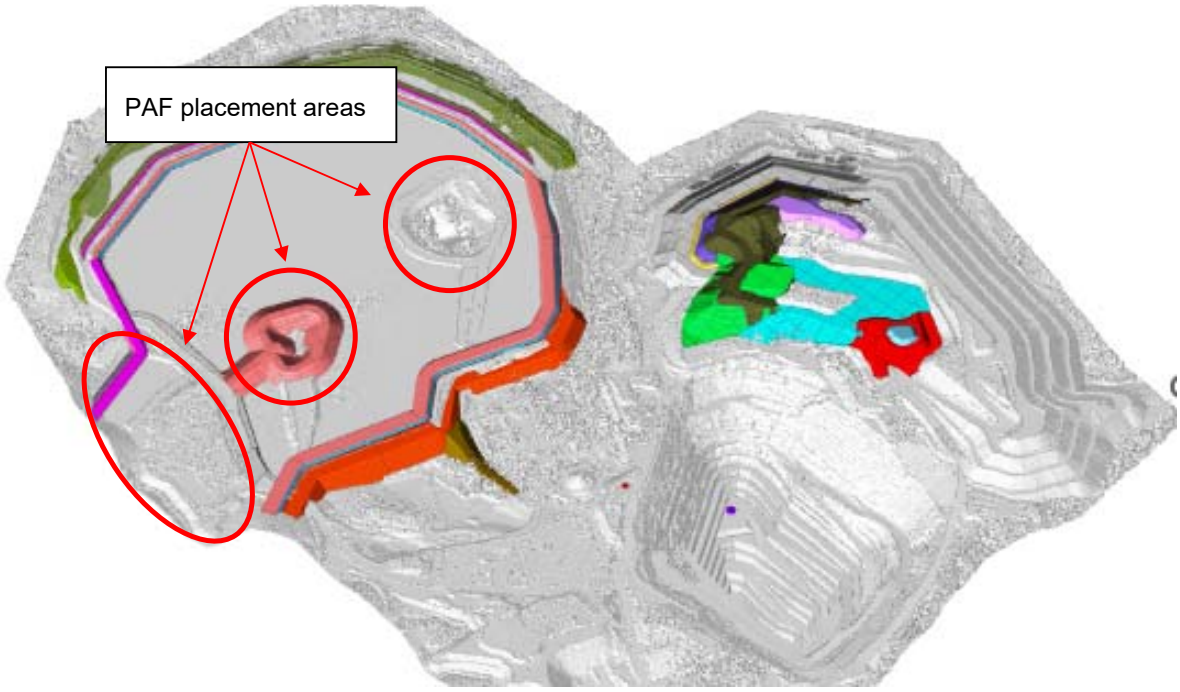


Figure 4-9: TSF PAF placement

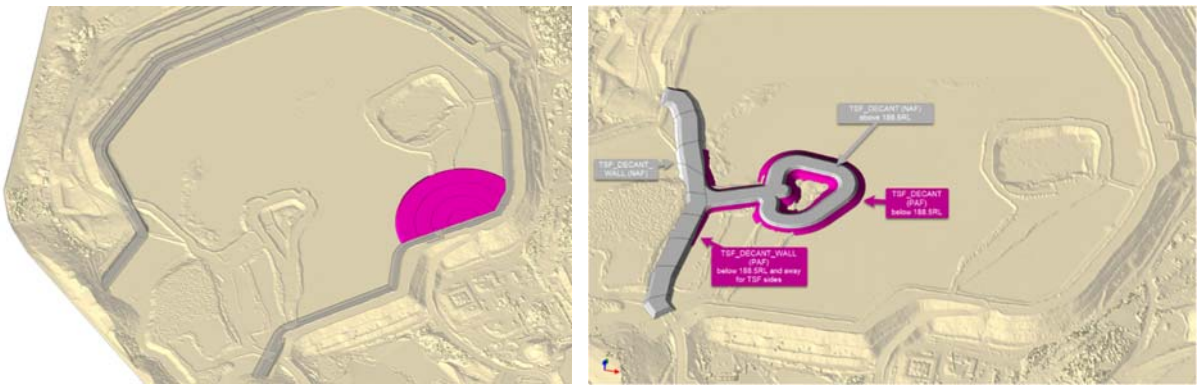


Figure 4-10: PAF closure zones post 2024.

Note PAF will not actually be allowed to be placed adjoining the TSF embankment. There will be a setback of 25 m from the embankment.

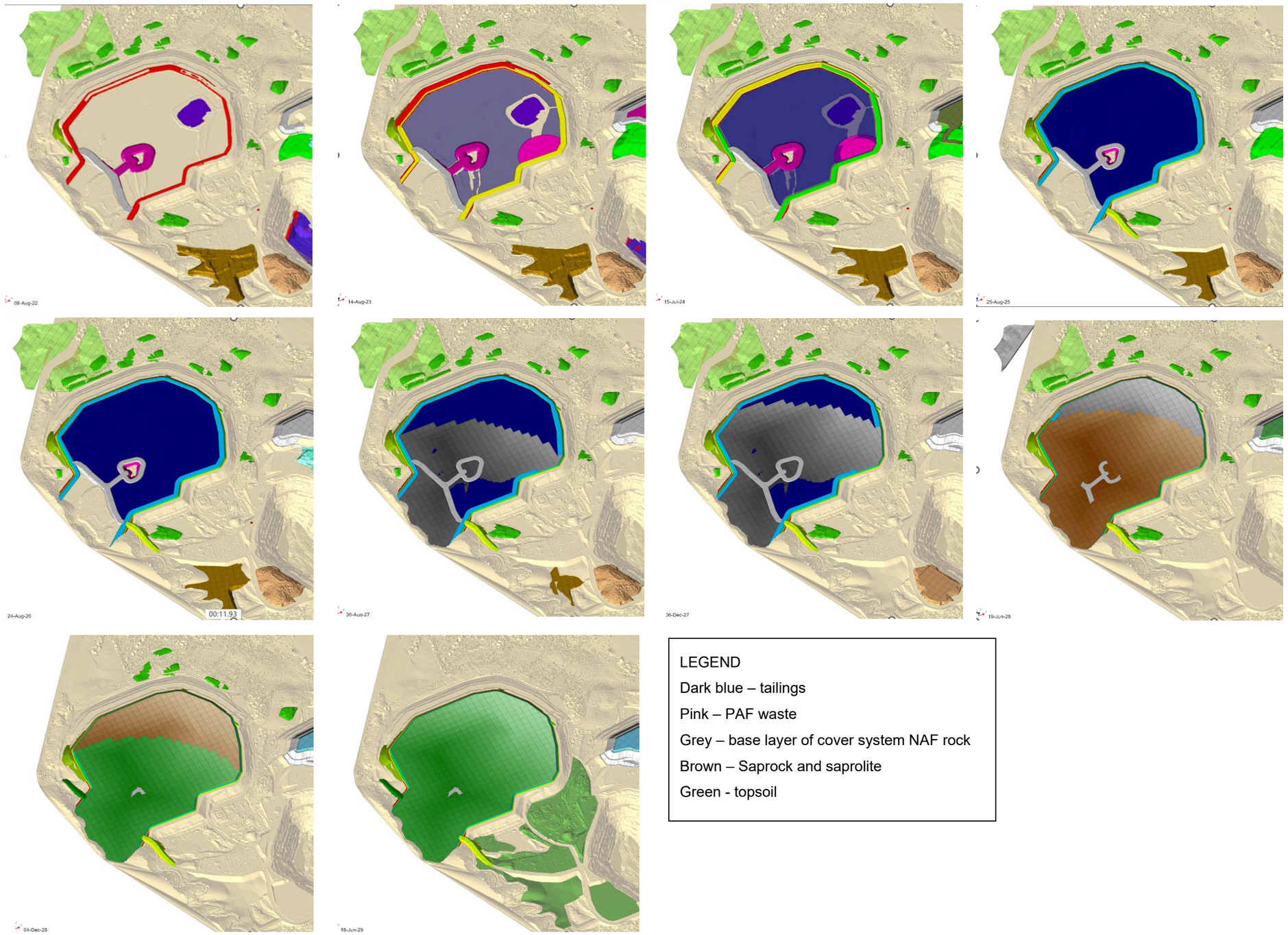


Figure 4-11: TSF PRC$_{PLAN.LHS}$ timesteps

4.3.2.1 Operational water management moving into rehabilitation phase

There are three phases of water management for the TSF as it transitions from operations to rehabilitation that will need to be developed to detailed design.

Phase 1 – Processing and mine operations

There is a requirement to move the TSF supernatant pond from the centre of the TSF to the western end of the TSF over the remaining LOM, as this is the probable location where surface water will be released to (i) the open pit, or (ii) the receiving environment. The geometry of the tailings beach profile will:

- increase the slope of the tailings beach from the TSF embankment perimeter to the tailings supernatant pond, and,
- reduce the volume of "fill" required to be placed in the basal layer on the tailings (fill could include rock, saprolite, saprock and pedolith units).

This process is likely to require changes to the TSF design and tailings deposition strategy and needs to be integrated into the TSF operations by MRO and ATCW.

Phase 2 – Cessation of tailings deposition and transition to rehabilitation

MRO will need to develop a detailed water management plan to maintain the design storage allowance (DSA) of the TSF (approx. 2 GL) as the TSF transitions through rehabilitation.

RGS understand that the TSF must maintain the DSA until rehabilitation of the cover is complete and the cover system is functioning in an as-designed manner (i.e. that the cover system can sustain the desired land use and surface runoff from the cover system can be released directly to the environment).

Phase 3 – Basal layer construction

During this phase of work the:

- water storage within the TSF is progressively reduced as it is replaced with rock, and regolith units
- the TSF needs to be kept as empty of water as possible
- DSA must be maintained within the TSF or be available in an external dam or the open pit.

If external DSA is viable then a pipe/pump/drainage system will need to be put in place during this phase of work to enable adequate transfer of water from the TSF to the open pit.

During this phase of work the following actions are required.

- A NAF basal layer will be placed over the tailings beach. ATCW will need to provide some guidance on the probable rate that the placement of NAF rock could occur.
- Careful consideration of the rate of deposition will be taken during the placement of the NAF rock layer due to previous concerns relating to deformity of the design structure from an increased rate of deposition.
- It is estimated that the final profile of the tailings and basal layer may take up to five (5) years.
- Profiling the tailings may include pushing up to 1 m of NAF waste rock into the tailings to:
  - provide a structurally competent base with low permeability, and,
  - increase the ANC in the upper profile to ensure the tailings remain NAF.

4.3.3 Tailings cover system design

During this phase of work the:

- water storage within the TSF is further reduced as it is replaced with rock, regolith units and the final cover system.
- The TSF needs to be kept as empty of water as possible.

- DSA must be maintained within the TSF or be available in an external dam or the open pit.

If external DSA is viable then a pipe/pump/drainage system will need to be put in place during this phase of work to enable adequate transfer of water from the TSF to the open pit.

4.3.3.1 Material properties and material balance

RGS completed a geochemical and physical sampling and analytical program (GaPSaAP (RGS, 2016)) to verify the properties of the soil that could be used for rehabilitation of the TSF.

- Test pit and diamond core drilling at six locations at MRO in mid-2016 verified the presence of approximately 2.5 million bulk cubic metres (BCM) of soil and weathered granitoid/schist/gneiss and gneiss/meta sediment within a borrow area to the east of the TSF.
- Chemical and physical analyses of the rehabilitation units verify they are suitable for construction of a 2.5 m deep soil cover system over the tailings.
- Analysis of the drill core using HyloggerTM has identified kaolinite, mica and chlorite group minerals: montmorillonite was identified, but is considered to be an artefact of the drilling fluid.
- The field permeability testing of the in-situ soil in Borrow Area 1 verify that it has low permeability under field conditions: under saturated conditions the tailings also have very low permeability.
- Laboratory testing of the soil and weathered overburden samples and geochemical analyses verify the materials are susceptible to compaction and very low rates of permeability. This gives MRO the flexibility of constructing a soil cover with low permeability, or higher rates of infiltration if the materials are placed in a way that compaction is minimised.

4.3.3.2 Cover configuration and construction - PFS level design

After the basal layer has been built and the tailings beach has been profiled to achieve the required slope angles and geomorphology the cover system will be placed onto the basal layer.
Design objectives of the proposed cover system include:

- reduce the movement of excess water into the tailings;
- store water during rain events;
- establish and maintain vegetation for opportunistic native fauna habitat; and,
- release water through evapotranspiration.

The cover construction sequence (**Figure 4-2)** includes sourcing, hauling, and placing:

- 1 m of saprolite.
- 1 m of subsoil form the pedolith.
- 0.5 of topsoil.

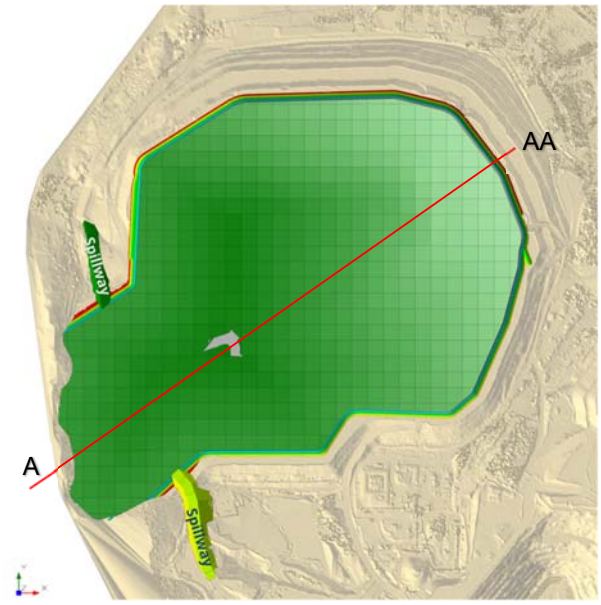


Figure 4-12: TSF plan view with surface water release points

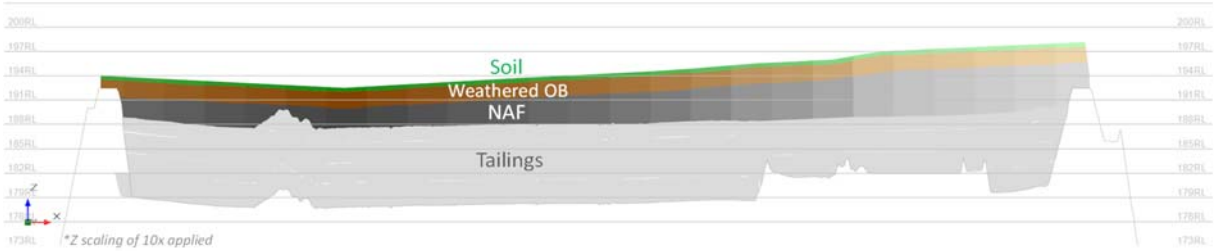


Figure 4-13: TSF cover systems cross section

4.3.3.3 Cover configuration and construction - FS and detail design

The PFS cover system design for the TSF will need to be developed to FS level and detailed design. The PFS cover system design and Deswik.LHS work enables an analysis of assumed placement of material into the TSF. However, engineered cover systems that are built to a functional design specification (FDS) are not built using coarse “mine scale – waste rock dump” construction methods; the construction method may need to be more aligned with the construction of a landfill cover system, requiring smaller plant and equipment, and compliance with a range of material and design specifications. These engineering processes will slow the rate of construction and these details will need to be revelated during the next stage of cover system design work.

This phase of work will provide all surface water drainage designs within the TSF cover system and from the TSF to the receiving environment.

4.3.3.4 Land use and perpetual water management

The performance monitoring plan provides details on how this TSF will be maintained and monitored.

5 PRC Plan environmental assessment

The technical work described in this MMM Plan complies with the intent of the PRC Plan Guideline and in the opinion of Evolution Mining, MRO, RGS and Deswik exceeds current DES expectations.

The major technical requirements of the PRC Plan guideline have been addressed in detail in this MMM Plan and associated RGS documents, and include:

- Soil capping material assessment
- Mine material characterisation
- Mine material balances and scheduling
- Landform and cover system design
- Land stability, erosion, and landform evolution
- Mine water management and final void assessment
- Performance monitoring

RGS has completed the following environmental assessments at MRO that inform the PRC Plan.

5.1 Soil capping material assessment

Soil stockpiles, and soil, saprolite and saprock borrow areas have been identified, sampled, and analysed over the LOM (**Section 2.1.1**).

The soil quality, geochemical and physical properties of the topsoil and subsoil in the pedolith, combined with the saprolite and saprock in the regolith, and the available stockpile of NAF rock in the WWRD have been measured from test pit and drilling programs over the LOM. This work includes: rehabilitation assessment of borrow areas to the east of the TSF completed by RGS in 2016; rehabilitation assessment of stockpiled topsoil and exterior waste rock material from the NWRD by RGS in 2021 (RGS, 2021); and, ongoing work in 2022 by RGS using 5 x 1m^3 samples of (i) topsoil from the borrow area to the east of the TSF (ii) a borrow area to the north of the TSF and (iii) topsoil, (iv) subsoil and (v) saprock from the West Hill between the open pit and West Dam. The soil quality, geochemical and physical properties are being verified throughout Q3 of 2022 by external laboratories including Trilab, ALS, Levay and Co and Soil Water Consultants.

5.2 Mine material characterisation

Mine material characterisation has been undertaken over the LOM and used to schedule the movement of mine materials into the constructed mine landforms (**Section 2.1.2** and **2.1.3**).

5.3 Mine material balances

The material balances within the ML have been verified and the LHS simulation also verify viable constructed mine landforms can be built to comply with the overall rehabilitation goals defined by MRO (**Section 4**).

5.4 Landform scheduling and cover system design

The MRO $OPS_{PLAN.LHS}$ leading up to cessation of mining has been integrated into, what RGS considers to be, a FS level $PRC_{PLAN.LHS}$. RGS consider the work to be at FS level as material movement is at a truck-by-truck level of resolution. The FS assessment also identified potential constructed mine landform design flaws and addressed these iteratively throughout the LHS work program.

TSF cover system assessment (RGS, 2016) and a cover system design for the TSF (ATCW, 2016) was completed in 2016; RGS consider this work to be at PFS level of assessment as additional work relating to cover performance will need to be undertaken. NWRD cover system design was undertaken by RGS in Q2 2022; RGS consider this work will be at a FS level of assessment when the cover system performance assessment of the material units is completed (**Section 5.5**). RGS will provide a cover system design memorandum for the NWRD for the PRC Plan (RGS, 2022a).

5.5 Land stability, erosion, and landform evolution

Laboratory analyses being conducted by RGS using a Rainfall and Erosion Simulator (RGS_RaE_{SIM}) on the 5 x 1m^3 samples in Q3 of 2022 include measurement of the erosion rate of each bulk sample at 5% slope and 30 mm/hr, 60 mm/hr and 90 mm/hr rainfall intensity: sample (i) above is also being measured at a 20% slope. RGS will also be collecting water samples and measuring filterable and unfiltered water quality parameters to verify probable water quality that occur from rehabilitated cover systems on the NWRD and TSF: water quality parameters will include pH, EC, acidity, alkalinity all major ions and 45 metal(loids).

The $PRC_{PLAN.LHS}$ work has verified that the material balances are sufficient to complete documented rehabilitation work at MRO.

The RGS_RaE_{SIM} results will be evaluated using MinErosion v4 to document a probable range of erosion rates for the TSF and NWRD cover systems for as-placed material and for established cover systems. This level of erosion assessment uses methods and approaches developed by the Australian Coal Association Research Program (ACARP), University of Queensland (UQ) and Griffith University over fifteen years and provides significant advantages over USA agricultural software such as the Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE) and Water Erosion Prediction Project (WEPP).

RGS will provide a soil capping and land stability report for the PRC Plan (RGS, 2022b).

5.6 Final void water assessment

The $PRC_{PLAN.LHS}$ model was used to develop a WOM and LOA (100-year post closure) water balance and water quality model developed in GoldSim by RGS (RGS, 2022b).

The assumptions within the GoldSim water assessment are depicted in terms of site layout and catchment area (**Figure 5-1)** and catchment nodes used in the model.

The focus of the GoldSim model was to evaluate WOM and LOA water management options including:

- Scenario 1: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment.
- Scenario 2: All runoff and seepage water diverted to pit during closure and post closure.
- Scenario 3: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

The GoldSim final void report includes the basis of design, modelling methods and results of the three scenarios (RGS, 2022b).

5.7 Performance monitoring plan

A cover system performance monitoring plan for the PRC Plan is included in **Attachment D**.

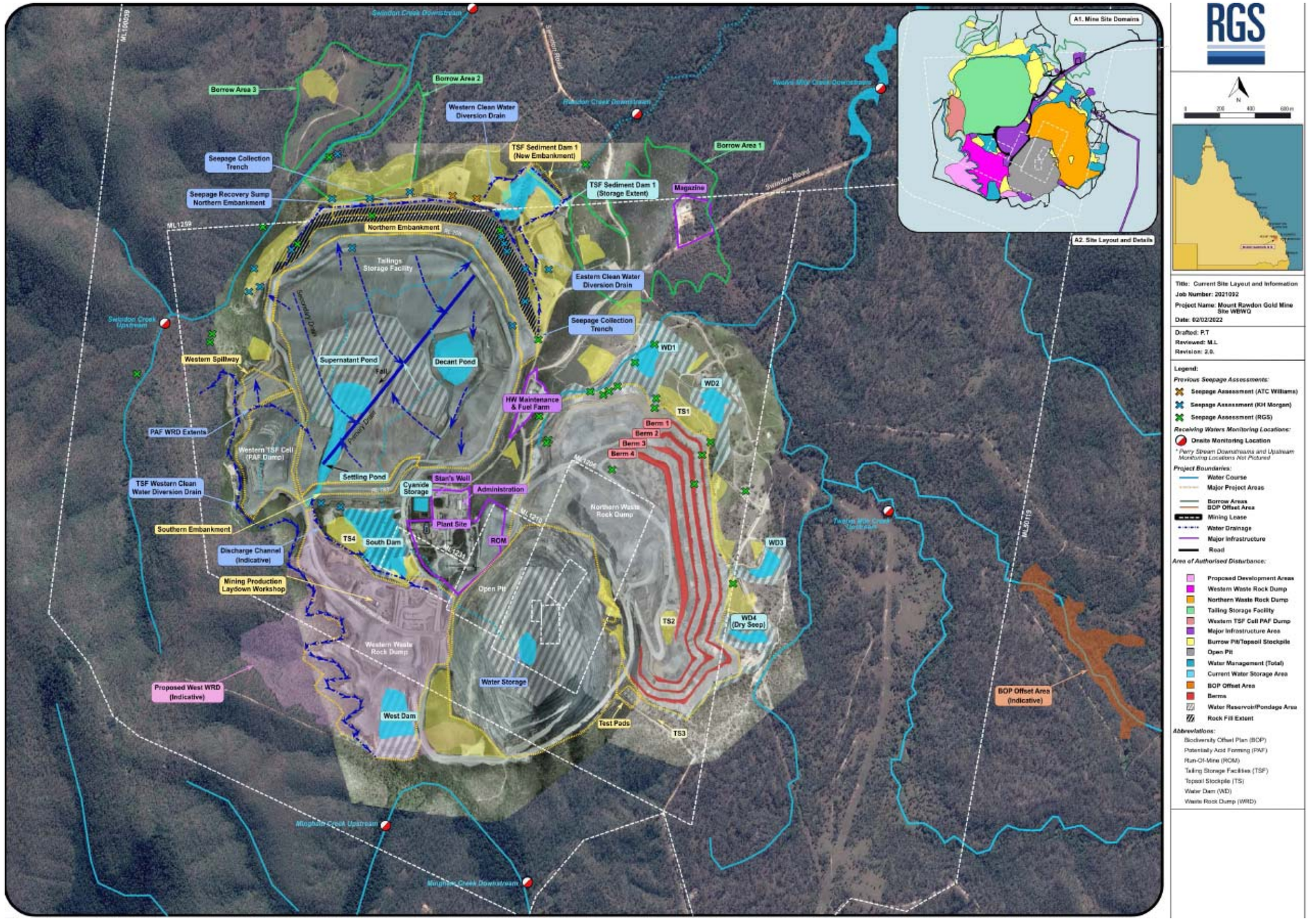
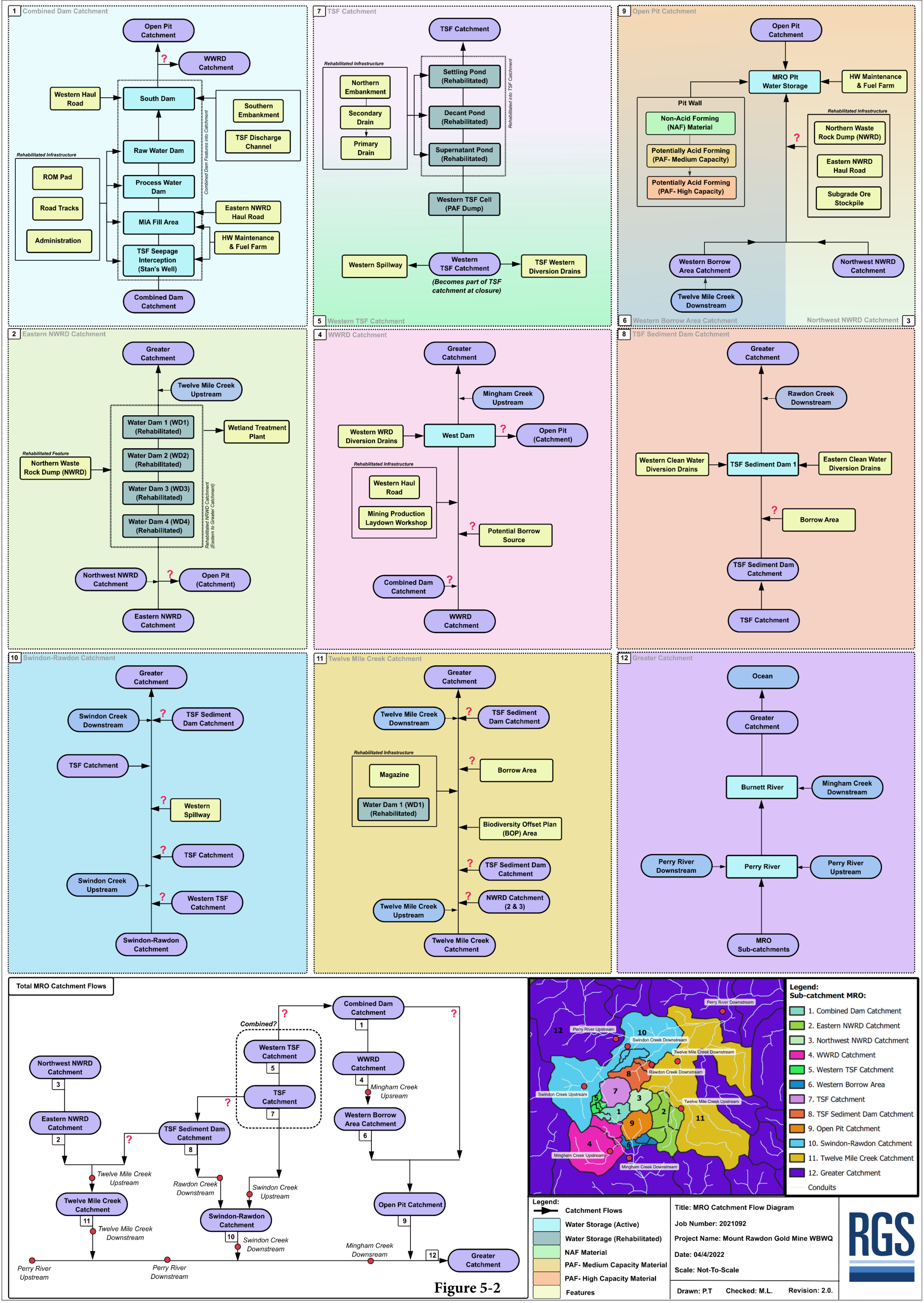


Figure 5-1: Final void water assessment - site layout


1 Combined Dam Catchment
Open Pit Catchment
?
WWRD Catchment
Western Haul Road
South Dam
Southern Embankment
TSF Discharge Channel
Combined Dam Features into Catchment
Rehabilitated Infrastructure
ROM Pad
Road Tracks
Administration
Raw Water Dam
Process Water Dam
MIA Fill Area
TSF Seepage Interception (Stan's Well)
Eastern NWRD Haul Road
HW Maintenance & Fuel Farm
Combined Dam Catchment
7 TSF Catchment
TSF Catchment
Rehabilitated Infrastructure
Northern Embankment
Secondary Drain
Primary Drain
Settling Pond (Rehabilitated)
Decant Pond (Rehabilitated)
Supernatant Pond (Rehabilitated)
Rehabilitated into TSF Catchment
Western TSF Cell (PAF Dump)
Western Spillway
Western TSF Catchment
(Becomes part of TSF catchment at closure)
TSF Western Diversion Drains
9 Open Pit Catchment
Open Pit Catchment
MRO Pit Water Storage
HW Maintenance & Fuel Farm
Pit Wall
Non-Acid Forming (NAF) Material
Potentially Acid Forming (PAF- Medium Capacity)
Potentially Acid Forming (PAF- High Capacity)
Rehabilitated Infrastructure
Northern Waste Rock Dump (NWRD)
Eastern NWRD Haul Road
Subgrade Ore Stockpile
Western Borrow Area Catchment
Northwest NWRD Catchment
Twelve Mile Creek Downstream
5 Western TSF Catchment
6 Western Borrow Area Catchment
Northwest NWRD Catchment 3
2 Eastern NWRD Catchment
Greater Catchment
Twelve Mile Creek Upstream
Water Dam 1 (WD1) (Rehabilitated)
Water Dam 2 (WD2) (Rehabilitated)
Water Dam 3 (WD3) (Rehabilitated)
Water Dam 4 (WD4) (Rehabilitated)
Rehabilitated NRWD Catchment (Eastern to Greater Catchment)
Wetland Treatment Plant
Rehabilitated Feature
Northern Waste Rock Dump (NWRD)
Northwest NWRD Catchment
Open Pit (Catchment)
Eastern NWRD Catchment
4 WWRD Catchment
Greater Catchment
Mingham Creek Upstream
Western WRD Diversion Drains
West Dam
Open Pit (Catchment)
Rehabilitated Infrastructure
Western Haul Road
Mining Production Laydown Workshop
Potential Borrow Source
Combined Dam Catchment
WWRD Catchment
8 TSF Sediment Dam Catchment
Greater Catchment
Rawdon Creek Downstream
Western Clean Water Diversion Drains
TSF Sediment Dam 1
Eastern Clean Water Diversion Drains
Borrow Area
TSF Sediment Dam Catchment
TSF Catchment
10 Swindon-Rawdon Catchment
Greater Catchment
Swindon Creek Downstream
TSF Sediment Dam Catchment
TSF Catchment
Western Spillway
TSF Catchment
Swindon Creek Upstream
Western TSF Catchment
Swindon-Rawdon Catchment
11 Twelve Mile Creek Catchment
Greater Catchment
Twelve Mile Creek Downstream
TSF Sediment Dam Catchment
Rehabilitated Infrastructure
Magazine
Water Dam 1 (WD1) (Rehabilitated)
Borrow Area
Biodiversity Offset Plan (BOP) Area
TSF Sediment Dam Catchment
Twelve Mile Creek Upstream
NWRD Catchment (2 & 3)
Twelve Mile Creek Catchment
12 Greater Catchment
Ocean
Greater Catchment
Burnett River
Mingham Creek Downstream
Perry River Downstream
Perry River
Perry River Upstream
MRO Sub-catchments
Total MRO Catchment Flows
Combined?
Combined Dam Catchment
1
Western TSF Catchment
5
WWRD Catchment
4
Mingham Creek Upsream
TSF Catchment
7
Western Borrow Area Catchment
6
Northwest NWRD Catchment
3
TSF Sediment Dam Catchment
8
Eastern NWRD Catchment
2
Twelve Mile Creek Upstream
Rawdon Creek Downstream
Swindon Creek Upstream
Twelve Mile Creek Catchment
11
Twelve Mile Creek Downstream
Swindon-Rawdon Catchment
10
Swindon Creek Downstream
Open Pit Catchment
9
Mingham Creek Downsream
12
Greater Catchment
Perry River Upstream
Perry River Downstream
Figure 5-2
Perry River Downstream
Perry River Upstream
Swindon Creek Downstream
Twelve Mile Creek Downstream
Rawdon Creek Downstream
Swindon Creek Upstream
Twelve Mile Creek Upstream
Mingham Creek Upstream
Mingham Creek Downstream
Legend:
Sub-catchment MRO:
1. Combined Dam Catchment
2. Eastern NWRD Catchment
3. Northwest NWRD Catchment
4. WWRD Catchment
5. Western TSF Catchment
6. Western Borrow Area
7. TSF Catchment
8. TSF Sediment Dam Catchment
9. Open Pit Catchment
10. Swindon-Rawdon Catchment
11. Twelve Mile Creek Catchment
12. Greater Catchment
Conduits
Legend:
Catchment Flows
Water Storage (Active)
Water Storage (Rehabilitated)
NAF Material
PAF- Medium Capacity Material
PAF- High Capacity Material
Features
Title: MRO Catchment Flow Diagram
Job Number: 2021092
Project Name: Mount Rawdon Gold Mine WBWQ
Date: 04/4/2022
Scale: Not-To-Scale
Drawn: P.T
Checked: M.L.
Revision: 2.0.
RGS

6 Forward works

The work completed for the PRC Plan attains different stages of design and levels of reliability for different aspects of the MRO landforms. Additional assessment and clarification of assumptions will be required post submission of the PRC Plan to attain detail design status for all areas of the MRO.

6.1 Planning

6.1.1 West Dam and West WRD

Additional analysis is required to address the following aspects:

- Have flow rates and water quality of surface runoff and toe seepage been adequately defined to develop a detailed design for closure?
- Will the land bridge from the TSF down to the open pit be retained into perpetuity, or will it be decommissioned?
- Will the West Dam be retained into perpetuity, or will it be decommissioned?
- What will the WOM and LOA plan be for these domains?

6.1.2 Western diversion drains

There are stormwater diversion drains around the toe of the hills that rise to the west of the West Dam and WWRD. Additional analysis is required to address the following aspects:

- Have flow rates and water quality of surface runoff been adequately defined to develop a detailed design for closure?
- Will the diversion drains be retained?
- If they are to be retained, are they built to final design for perpetual water management?
- Are additional material (NAF rock) required to develop final designs, and is this material available?
- What will the management plans be for the diversion drains?

6.1.3 NWRD

Additional analysis of the NWRD is required to address the following aspects:

- Will the NWRD proposed NE drop structure be included in the final WRD landform design to channel surface runoff from the inter batter benches and berm contour drains to the toe of the NWRD to WD1?
- Will the cover on the top of the NWRD drain to the NE (proposed drop structure), filter through the external batters, or be directed to the western access road (i) to the receiving environment or (ii) to the NWRD toe dams to WD1.
- Is there any consideration to use the top of the NWRD for other land uses such as solar power generation. If there is, then the material requirements for the NWRD cover system may not apply, and it may be optimal to cover the top of the NWRD with HDPE to ensure all seepage into the WRD is stopped.

6.1.4 Dams and drainage systems

- LOA drainage systems (drains, sumps, pipelines, pump and power requirements) are required for all domains.
- The long-term management for Stans Well will need to be developed. Will dewatering pumps be turned off, will the water level recharge to surface and if it does where will this water go?

6.1.5 TSF

Additional analysis of the TSF is required to address the following aspects:

- The $PRC_{PLAN.LHS}$ model assumes the tailings supernatant pond will transition to the western end of the TSF and that the final release point for surface water will be to the north or south of the western end of the TSF.
- Changes to the TSF construction and tailings deposition plan is likely to be required and implemented from Q3 2022 to achieve these closure plans.
- LOA surface water designs are required for the TSF, including clarification of the western diversion toe drain that collects stormwater from the hills to the west of the PAF rock dumping area and directs the surface flow around the TSF.
- It is unclear if all material requirements for the TSF construction have been accounted for in the $PRC_{PLAN.LHS}$ model. ATCW is required to verify this, e.g. will additional material be required for LOA TSF embankment buttresses, or land bridges for final water management?
- If the design objective is to direct surface runoff from the cover on the TSF to the receiving environment detailed drainage designs will need to be developed.
- TSF surface runoff from the mineralised NAF rock armoured external batters will need to collected, sampled an analysed to verify the flow rates and quality of this water. If the water quality is suitable release to the environment, drainage systems will need to be designed to accommodate this. If the water quality does not comply with release limits, designs will need to be developed to get this water to the proposed wetland system or to the open pit.
- TSF embankment toe seepage will need to collected, sampled an analysed to verify the flow rates and quality of this water. If the water quality is suitable release to the environment drainage systems will need to be designed to accommodate this. If the water quality does not comply with release limits designs will need to be developed to get this water to the proposed wetland system or to the open pit.
- Is there any consideration to use the top of the TSF for other land uses such as solar power generation. If there is, then the material requirements for the TSF cover system may not apply, and it may be optimal to cover the top of the TSF with HDPE to ensure all seepage into the TSF is stopped.

6.1.6 Open Pit

Three water management scenarios have been evaluated for the MRO final void. The PRC Plan is likely to include adoption of Scenario 1:

- *Scenario 1: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment.*
- Scenario 2: All runoff and seepage water diverted to pit during closure and post closure.
- Scenario 3: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

To ensure that the viability of Scenario 1 can be actioned, the design aspects listed above will all need to be developed to detail design and then implemented.

6.1.7 Risk and opportunity workshop

The items and aspects listed above are examples of actions that RGS has identified.

RGS recommend MRO undertake a detailed Risk and Opportunity Assessment (RaOA) to document all items and aspects that will need to be addressed to bring the PRC Planning and Scheduling in this plan to detailed design.

6.2 Scheduling

The following items are some of the key technical aspects that will need to be clarified and then developed to detail design in the next iteration of the $PRC_{PLAN.LHS}$ work program

6.2.1 Operational (short and medium term) scheduling

MRO mine planning and scheduling is done by MRO with Deswik.LHS software (referred to in this plan as the $OPS_{PLAN.LHS}$).

The $OPS_{PLAN.LHS}$ model provides truck by truck detailed and reliable material movement up to Q4 2024.

The $OPS_{PLAN.LHS}$ model is considered by RGS to be detailed and reliable because it is maintained at site by the mine planning team and is used for short and medium term planning it should align with all as-built landforms. Survey control processes will verify if this is the case.

6.2.2 PRC Plan (life of mine) scheduling

The MRO $PRC_{PLAN.LHS}$ model is a simulation of a potential mine plan.

It provides simulated “truck by truck” designation of mine materials over the WOM from end of LOM (Q4 2024) through to completion of rehabilitation work.

The $PRC_{PLAN.LHS}$ model can therefore be considered to be at detailed level of design. However, the reliability of the detailed $PRC_{PLAN.LHS}$ model can only be considered to be reliable if the as-built landforms built from Q3 2022 to the completion of site work align with the $PRC_{PLAN.LHS}$ model.

To ensure reliability of all work completed from Q3 2022 to the completion of site work the $PRC_{PLAN.LHS}$ model will need to be integrated with the $OPS_{PLAN.LHS}$ model.

6.2.3 Life of asset (post closure) scheduling

The mine plan that is adopted by MRO for implementation will be defined as LOA.LHS model ($LOA._{LHS}$ model).

The development and implementation of the $LOA._{LHS}$ model requires a clearly defined pathway to be defined by Evolution Mining and resources to be allocated by Evolution Mining to MRO to develop and implement the closure plan.

The resources may be (i) internal to Evolution Mining (corporate oversight) (ii) site based and managed by MRO or (iii) external to MRO (consultant based) with a dedicated resource, if at all feasible, to ensure the site knowledge and strategic plan is not lost.

7 References

RGS (2009). *Geochemical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials at Mt Rawdon Gold Mine – Stage 1*. Report No. R001-A (890013) prepared by RGS Environmental Pty Ltd for Mount Rawdon Gold Mine. 28 August.

RGS (2011b). Geochemical and Mineralogical Assessment of Waste Rock, Low-Grade Ore and Tailings Materials Mt Rawdon Gold Mine – Stage 2. Report prepared by RGS Environmental Pty Ltd for LGL Mt Rawdon Gold Mine, 8 November.

RGS (2016) Conceptual Closure, Decommissioning and Rehabilitation Plan. Mount Rawdon Tailings Storage Facility.

RGS (2016). 2016 geochemical (total sulfur and total carbon) database generated from tailings sampling program (3 August to 8 September 2016) using on-site Leco analyser. September.

RGS (2020). Geochemical Assessment of Waste Rock and Tailings Materials. Mt Rawdon Gold Mine. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 4 December.

RGS (2018) Mt Rawdon Operations Waste Rock Test Pile Review RGS Environmental Pty Ltd, 2018.

RGS (2021). Assessment of Long-Term Geochemical Characteristics of Mt Rawdon Tailing Materials – Final Report. Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.

RGS (2021). Geochemical Assessment of MRO Tailing Materials, Report prepared by RGS Environmental Pty Ltd for Mt Rawdon Operations, 6 January.

RGS (2022a) NWRD soil cover system design and assessment

RGS (2022b) Soil capping and land stability assessment

RGS (2022c) Final void assessment

RGS (2022d) Performance monitoring report

8 Attachment A: Landform evolution assessment

8.1 About landform evolution modelling and erosion measurement

Numerical models that can be used to quantify potential erosion rates from soil and capping materials include RUSLE v2, GeoWEPP, and MINErosion 4.5. RUSLE v2 is based on USLE and was designed to evaluate agricultural environments that are significantly different to mining conditions. RUSLE is commonly used despite its numerous deficiencies, weaknesses, and limitations. The GeoWEPP model (Watershed Erosion Prediction Project, WEPP integrated with GIS) is a physically based model produced by the U.S. department of Agriculture Natural Resources Conservation Service (NRCS and U.S. Forest Service (USFS) to replace the USLE formula. Originally WEPP was created for agricultural modelling, but it is now widely used in forestry, fisheries, rangeland and mining studies and projects. The major problem with WEPP is its over-parameterization with more than thirty-one parameters required to start running the model.

MINErosion 4, to serve the objectives of soil erosion assessment in the mining environment for the purpose of environmental rehabilitation. The laboratory scale, small field scale and large scale (catchment scale) development was undertaken predominantly at Queensland coal mines, but the approach and numerical modelling is applicable to rehabilitation of metalliferous mines as the soil physics that underpin the approaches are directly transferable.

MINErosion has four major sub-routines:

1- terrain analysis and derivation of catchment hydrological parameters,
2- derivation of rainfall erosivity and storm data,
3- derivation of soil erodibility from flume measured data and/or soil and spoil properties, and
4- environmental factors sub-routine (vegetation and consolidation effects).

MINErosion was validated against 15 years of data measured on three instrumented catchments (up to 0.91 ha in size) on the Curragh mine site in Central Queensland. The agreement between predicted (Y) and measured (X) values were very good with the regression equation of Y=0.92X and an R^2 value of 0.81 for individual storm events, and Y=1.473X and an R^2 value of 0.726 for the average annual soil loss (Khalifa, 2010).

MINErosion offers significant advancements in the ability to model erosion on mine sites over methods such USLE, RUSLE and WEPP. MINErosion accommodates slope based to catchment scale user-friendly erosion/deposition assessment.

The inputs for MINErosion and other erosion and landform evolution modelling methods are field/laboratory scale flume measured data and/or laboratory measured input parameters to successfully predict the erosional stability of the mining site.

Landform evolution modelling codes include SIBERIA and CASAR$_{LISFLOOD}$. RGS has not been required to undertake landform evolution modelling by DES on the projects we have done. We suggest that these modelling methods should be used if the erosion measurements and erosion modelling indicate that further analyses may be required, and the problems associated with erosion loss cannot be mitigated using adapted CML designs.

8.2 Purpose of this work

RGS has developed a soil capping system for the NWRD.

The purpose of the work described in this **Attachment** is to comply with PRCP requirements and provide measured and modelled data on internal layers of the cover system and the surface of the cover system. The pedolith samples were analysed under:

- loose as-placed conditions that would exist as material is being placed on the NWRD
- compacted conditions that may occur as the material is subjected to traffic compaction or settlement and consolidation.

8.3 Limitations of erosion measurement and modelling

The RaE_{SIM} process is an accelerated laboratory method that is used to quantify soil and capping material surface water quality and soil erodibility from bulk samples on a 3 m x 1 m flume that can evaluate slope angles from 0 to 45 degrees. ***Landform evolution modelling and erosion measurement is an iterative process.***

- The first stage of erosion measurement uses < 2.36 mm particle size distribution samples and static analytical methods such as cation exchange capacity, exchangeable sodium percentage, Emerson aggregate stability, and pin hole dispersion.
- The RGS RaE_{SIM} approach is the second stage of work that provides measurable data from bulk samples inclusive of < 150 mm particle size distribution materials. The data from this stage of work enables numerical modelling methods such as MinErosion, SIBERIA and $CAESAR_{LISFLOOD\ to}$ be utilised. RGS also use the RaE_{SIM} process to collect surface water samples that verify the major ion and metal(loid) chemistry from the samples.
- The third stage of assessment (referred to in the PRCP guideline) verifies the performance of a cover system using field scale trials and performance monitoring**.** At this scale the passage of time and inherent effects of climatic variability and ecological aspects are all considered in the long term performance of a cover system.
- The three stages of work are used to develop detailed constructed landform designs for waste rock and tailings storage facilities.

8.4 Objectives of the work

Use the RaE_{SIM} method to obtain the following data.

- Quantify surface water chemistry from pedolith and saprolith units that have been identified for rehabilitation of the TSF and NWRD and other MIA at MRO such as demobilised plant sites, and roads. The measured data can be used to update source terms for the Final Void water balance and water quality model in subsequent stages of the closure planning process.
- Measure and quality erosion rates and erosion mass
- Calculate the soil erodibility k-factor
- Use the k-factor in M-ULSE, WEPP and MinErosion v.4 to derive the probable range of erosion rates of as-placed soil and capping materials, compacted materials and mature soil capping profiles.

8.5 Annex Bi: Soil and capping material specification

Five pedolith and saprolith samples were identified by RGS and collected by MRO. The materials are sourced from areas identified for construction of soil cover systems on the TSF and NWRD. The movement of material from the borrow areas has been included in the Deswik.LHS scheduling.

- Sample # 1: 1 x 1 m^3 of topsoil recovered from an existing stockpile.
- Sample # 2: 1 x 1 m^3 of topsoil (0 to 1 m bgl) recovered from a potential borrow area to the northwest of the TSF.
- Sample # 3: 1 x 1 m^3 of topsoil (0 to 1 m bgl) recovered from the West Hill between West Dam and the Open Pit.
- Sample # 4: 1 x 1 m^3 of saprolite (1 to 2 m bgl) recovered from the West Hill between West Dam and the Open Pit.
- Sample # 5: 1 x 1 m^3 of saprock recovered from exposed material on the access track of West Hill between West Dam and the Open Pit.

Each as-received sample was removed from the IBC (**Figure 8-1** and **Figure 8-2**). The volume of > 150 mm PSD and > 75 mm PSD rock was estimated.

Splits of each sample (< 75 mm PSD) (**Figure 8-4**) have been sent to laboratories for a suite of soil quality, geochemical and physical analysis to derive measured material properties. The results are being provided iteratively by ALS, TRILAB, SWC and Levay and Co. from Q4 2022 to Q1 2023.

Table 8-1:Geochemical and soil quality analyses

ALS Code	Method Code
EA02 and EA010	APHA 4500 H+ - B and APHA 2510 B
ED002	Baumann Gully DIN 4030 Part 2
ED006	Soil Survey Test Method C5
ED007	Rayment & Lyons 2011 15A1ED005: Rayment & Lyons 2011 15G10.1
ED008	Rayment & Lyons 2011 15A1 ED005 - Rayment & Lyons 2011 15G1
EK067G	APHA 4500-P
EK074	Rayment & Lyons 2011 9E1
EP004	AS 1289.4.1.1-1997/ NEPM
AG1 (EK055, EK057G, EK058G, EK059G, EK061G)	APHA 4500-NH_3 B, APHA 4500 NO_3- B, APHA 4500 NO_3- – I/NO_2- -B, Thermo Scientific Method D08727 and NEMI: 9171, APHA 4500 Norg – D,
AG1 (EK055, EK057G, EK058G, EK059G, EK061G)	APHA 4500-NH_3 B, APHA 4500 NO_3- B, APHA 4500 NO_3- – I/NO_2- -B, Thermo Scientific Method D08727 and NEMI: 9171, APHA 4500 Norg – D,
Acid base account and geochemical analysis	pH and EC, TS, ANC, NAPP, CRS, total metals (MEMS41) and water-soluble metals (SFE).

Table 8-2: Physical analyses

Full Suite Code
Sample preparation and sample storage allowing 3 month analytical program
Grading - with Hydrometer (includes Particle Density) Fine grain material / Coarse grain material
Atterberg Limits - Standard Oven Preparation
Pinhole Dispersion (including STD compaction)
Shrink Swell Index
Emerson Class No. (Please report sub classes)
Mineralogical Analysis and Clay Mineralogy
Soil water characteristic curves
Freight, Sorting & Handling - External Testing SWCC
Sample Registration and Disposal Fee



MRO Sample # 1



MRO Sample # 2



MRO Sample # 3



MRO Sample # 4

Figure 8-1: As-received Sample # 1 to Sample # 4



Figure 8-2: As-received Sample # 5

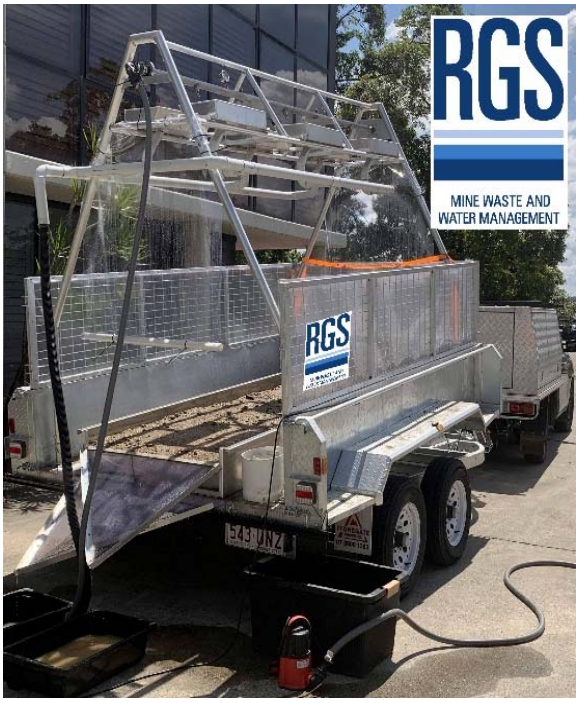


Figure 8-3: RGS trailed mounted RaE_{SIM}

MRO Sample # 1



MRO Sample # 2



MRO Sample # 3



MRO Sample # 4



Figure 8-4: < 75 mm PSD MRO RaE_{SIM} samples being analysed for ALS, TRILAB, SWC and Levay and Co.



Figure 8-5: MRO RaE$_{SIM}$ Sample # 1 to Sample # 4



Figure 8-6: MRO RaE_{SIM} Sample # 5 (West Hill saprock) + West Hill topsoil representing the proposed NWRD cover system (Figure 4-8).

8.6 Annex Bii: Soil and capping material erosion measurements

The RGS rainfall and erosion simulator (RaE_{SIM}) was used to measure the soil erodibilities for the bulk soil samples collected. The RaE_{SIM} measurements were completed on **5th November 2022.**

RGS is now awaiting analytical results from ALS, TRILAB, SWC and Levay and Co and will provide a technical report prior to Q2 2023.

8.6.1 RaE_{SIM} method

The RaE_{SIM} is a pressurised rainfall simulator that uses VEEJET nozzles. The RaE_{SIM} is calibrated for rainfall intensity, the uniformity of rainfall over the flume area (spatial distribution), drop size distribution, droplets terminal velocity, and kinetic energy.

The RaE_{SIM} measurements are used to derive the soil erodibility factor (*k-factor*). Soil erodibility is defined in M-USLE & WEPP under three different rainfall intensities (equivalent to 30, 60, and 90 mm/hr) on a 5 % slope that is the same as the slope used in landform and cover design assessment using SEEP/W numerical model.

For Sample # 1 to Sample # 4 the RaE_{SIM} process was to:

- Loose place 15 cm of < 75 mm PSD material into the 3 m x 1 m flume (**Figure 8-3**) on Day 1.
- Collect samples from the flume to measure as-placed density and measure k_{sat} using small double ring infiltration method.
- Set the RaE_{SIM} slope to 5%.
- Irrigate the sample using equivalent 90 mm/hr, 60 mm/hr and 30 mm/hr rainfall events on Day 2, 3 and 4: the sample is allowed to free drain and regain cohesive propoerties between irrigation events.
- Let the sample drain and air-dry Day 5 to Day 7.
- Hand compact the loose placed samples on Day 8. Collect samples to measure as-placed density and measure k_{sat} using small double ring infiltration method.
- Irrigate the sample using 90 mm/hr, 60 mm/hr and 30 mm/hr rainfall events on Day 9, 10 and 11.
- Dispose of the sample.

During each irrigation event surface water samples are collected in 5-minute intervals over the ½ hour rainfall event. Water samples are analysed for pH, EC, major cations and anions, acidity, alkalinity, and a full suite of 0.45 µm filtered and unfiltered meal(loids).

Some preliminary results of soil analyses showed that there are differences in texture and in other basic soil properties such as salinity and soil pH. The differences of soil texture, bulk density, infiltration rate as well as other soil properties have a great effect on soil erodibility and prospected erosional stability of the rehabilitation landform. All additional results are being provided by ALS. TRILAB, SWC and Levay and Co from Q4 2022 to Q1 2023.

Table 8-3: Preliminary results of MRO soil analyse of the samples used for RaE_{SIM} assessment

Soil Properties	MRO Sample_01	MRO Sample_02	MRO Sample_03	MRO Sample_04
pH in $1:5_{Water}$	9	5.9	8	6.7
EC in $1:5_{Water}$ µS/cm	177	50	50	36
Clay%	7	12	18	14
Silt%	10	25	35	42
Sand%	70	55	21	21
Gravel %	13	8	26	23
Texture Class	Loamy Sand	Sandy Loam	Loam	Silt Loam
Particle Density (g/cm^3)	2.71	2.5	2.47	2.4
Bulk Density (g/cm^3)	1.56	1.38	1.14	1.16
*Infiltration Rate (cm/hr)	2.5	2.7	24.3	23.4
Moisture Content (%)	5.8	9.6	11.9	10.2

The infiltration rate and bulk density for each sample were measured using a double ring infiltrometer and the bulk density cores, then a 30-minute simulated rainfall event with a predetermined rainfall intensity (30, 60, and 90 mm/hr) was applied. The rainfall erosivity values can be calculated accurately, and with an artificial and known slope length (3 meter) and slope gradient (5%), the total sediment values then can be used to calculate soil erodibilities values. During the 30-minute period of the simulated rainfall event, runoff was collected with 5-minutes interval for one minute exactly each time and then the steady state rate (Q) is calculated from the average values of the flow/minute. The amount of sediment collected in each beaker is subsequently calculated and used as an indication of the rate of soil erosion and thus soil erodibilities can be precisely calculated. Also, seepage water samples from each run were collected and analysed for the geochemical data.

The same previous steps were repeated for each sample 1, 2, 3, and 4 after subjecting it to a mechanical compression to study the effect of soil compaction (compacted layers) on the erodibility values.

9 Attachment B: NWRD Landform cover design assessment

9.1 Content

RGS has undertaken preliminary numerical modelling to evaluate several conceptual NWRD cover options and their effectiveness at achieving the determined design objectives. The conceptual cover options were developed based on the available rehabilitation materials identified in **Attachment A** and previous soil studies (RGS, 2016).

9.2 Cover design process

The design approach for the NWRD cover options is based on hydrological modelling by numerical techniques, with the relative performance of different cover options assessed by their impact on moisture storage and losses. The key model inputs have already been measured as part of a previous field/ laboratory investigation undertaken by RGS (RGS, 2016; RGS, 2021).

The process for cover design includes the following.

1. Development of conceptual models (2D) that depict the environmental process, structure and probable performance aspects of the NWRD cover.
2. Compilation of measured data from field investigations and analytical testing (e.g. PSD, SWCC, k_{sat})
3. Using the available material balance, identify possible cover configurations that can then be evaluated using numerical models.
4. Numerical modelling application of the conceptual models and measured data using SEEP/W to model how a given cover configuration might perform, mostly in terms of the soil/ water balance in the root zone of the soil cover.

9.3 Objective

The key objective of the work is to design a final cover design for the NWRD and undertake unsaturated zone modelling of several conceptual cover design options to assess cover functionality and long-term performance.

9.4 Scope of work

The scope of work developed to address the objective includes:

- Quantifying materials available for rehabilitation (site wide) and construction of the NWRD cover system.
- Develop several 2D conceptual model figures that depict the various cover configurations and associated hydro-geochemical processes.
- Design a final cover design and undertake unsaturated zone modelling of the conceptual cover designs to assess cover functionality and performance.
- Develop a Management Plan to document how the NWRD and cover system will be progressively constructed and managed over the mine life.
- Provide a work program for the establishment of field-testing programs and the long-term performance monitoring program for the NWRD.

This Attachment within the report describes the conceptual cover models and the numerical modelling to evaluate how the conceptual models may perform under site climatic conditions.

9.5 Cover Material Sources

As mentioned previously, RGS completed a test pit and drilling program in 2016 to quantify volumes and soil quality, geochemical and physical properties of pedolith units that could be used to construct the cover system on the TSF (RGS, 2016b). Similarly, in 2021 RGS undertook a physical and geochemical assessment of the NWRD and its associated berms (Berms 1-4). The program was undertaken to inform the development of the

final NWRD landform design and associated cover design through soil and waste rock sample collection and analysis (RGS, 2021). The results of both investigations have been used to generate material inputs to the numerical modelling.

The key rehabilitation materials identified within the local soil zones and borrow areas that could be used for construction of a cover system include (but not limited to) the following broad material types.

- **Soil** that includes;
    - Topsoil (nominally 0 to 50 cm depth bgl) - top layer of the native soil profile recognised by higher organic carbon content, some development of soil structure, the presence of plant roots, and typically containing the soil seed bank. A valuable resource suitable for use during the rehabilitation program.
    - Subsoil (nominally 50 to 100 cm depth bgl) - soil layer underlying the native topsoil, typically identified by a decrease in organic carbon content and fewer (and finer) roots. The characteristics of subsoil materials vary markedly depending on the soil type.
- **Overburden** that includes oxide and transition material.
    - Oxide overburden - typically highly weathered materials with minor partially-weathered rock
    - Transition overburden - weathered materials with minor partially-weathered rock and some competent fresh rock
- **Fresh competent rock** that may be suitable for armouring drains or being used as rock mulch in the soil cover e.g. NAF waste rock from the western WRD

9.6 Conceptual Cover Designs

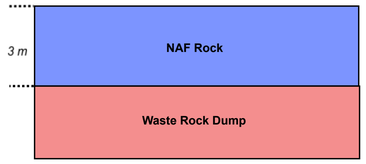
Before the commencement of numerical modelling, several detailed environmental conceptual models were constructed. The conceptual models underpin the understanding of the environmental processes associated with the NWRD. The conceptual models were then used as the basis to develop a range of numerical modelling studies to evaluate the probable environmental performance of the NWRD.

Figure 9-1 depicts the conceptual model for the design of the east and southern NWRD slopes highlighting the berm and batter design. The conceptual model highlights the ‘top tier’ of the NWRD requiring placement of a cover system and some of the potential cover configurations. The cover will be placed on an already existing > 3m NAF rock interim cover placed during operation.

A7. Preliminary Conceptual Cover Options for NWRD

BASE CASE

- Interim cover
- Provides erosion resistance and some water storage

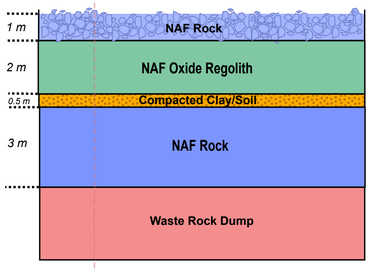


Two cover options are being evaluated as part of the RGS assesment with a range of sensitivity analysis (eg. cover thickness, vegetation, slope and climate)

**Note: based on preliminary rehabilitation material balance (i.e. available material) and various assumptions.*

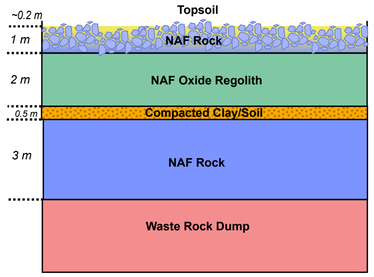
OPTION 1A

- Primary function water shedding/store and rele
- Erosion resistant, water storage and limits infiltration
- Opportunistic vegetation
- No ecological land use



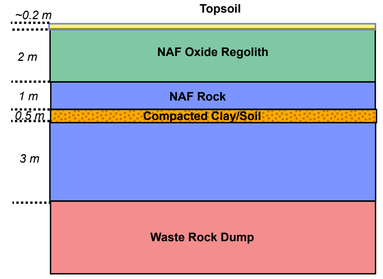
OPTION 1B

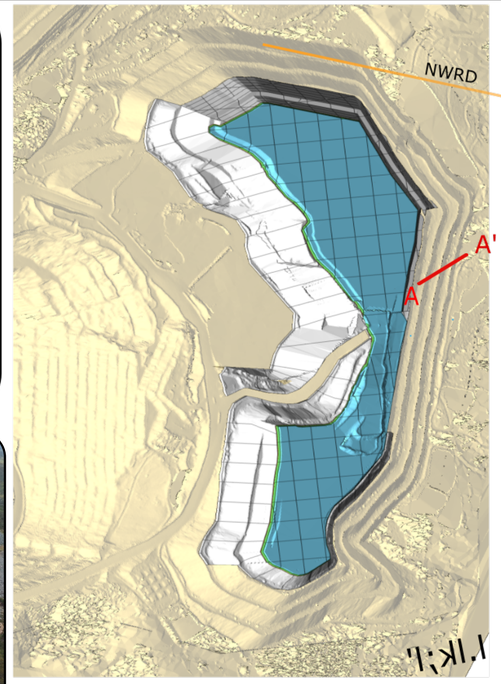
- Primary function water shedding/store and release
- Erosion resistant, water storage and limits infiltration
- Specified vegetation and ecological land use

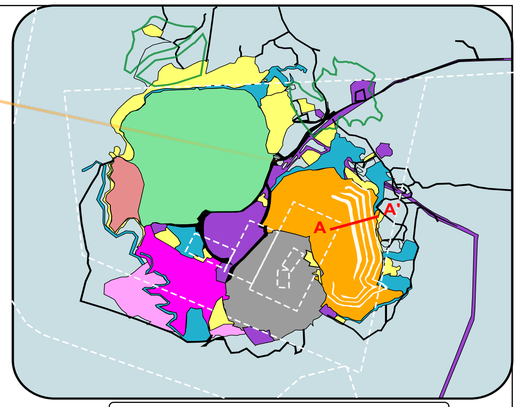


OPTION 2

- Primary function hybrid store and release
- Specified vegetation and ecological land use
- Water storage and limits infiltration



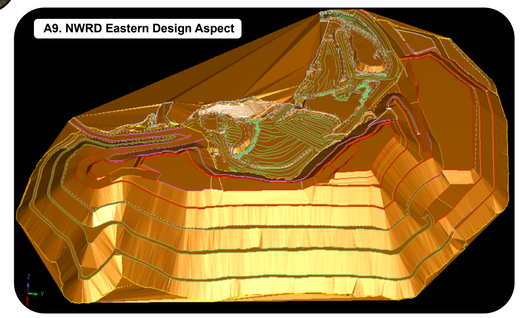




A5. Description of Key Features modifed from NRC (2013)



A8. NWRD Site Photo 2021



A9. NWRD Eastern Design Aspect

A. Design and Rehabilitation Specifications

- Segregation of Medium PAF waste rock and NAF waste rock within the dump such that it is encapsulated within NAF waste rock (High PAF waste rock is stored within the TSF)
- Development of stable slopes through the construction of competent and rocky angle of repose batter faces
- Control and segregation of surface water through suitable berm drainage which limit deep drainage and preserves water quality
- Interception of seepage through a network of interception dams
- Revegetation of berm and top surfaces using available topsoil resources and native shrub, tree and pasture species

B. Preparing Mine Waste

- Mine waste rock should be prepared such that a minimum 40 m wide berm is prepared to a smooth traffic compacted surface, material permitting
- The berm should reach from the toe of the crest bund to the toe of the batter rill.
- The berm should grade laterally across the face of the dump at a nominal 2% fall.
- The grade across the berm should be a V-section, with a 30 m section grading downwards from the toe of the North Dump rill to the bottom of the drain at a 5% slope. There should then be a 10 m section grading downwards from the toe of the crest bund to the bottom of the drain.

C. Preparing Crest Bund

- A bund, not less than 1 m in height, should be constructed at the outer edge of the berm. Armouring oxide or growth media is the most desirable material for the construction of the bund.
- All berm surfaces, even temporary surfaces, should grade away from this bund and towards the batter toe.

D. Lining the Drain

- If there is available clay from a clay stockpile or borrow, this should be used to construct a conditioned drain liner.
- If there is no clay available, the next best alternative growth media or borrow should be used.
- This material should be harvested, placed, conditioned and compacted such that after compaction the lining is at nominal 200mm thick at the shallowest point.
- The bottom of the drain area should be approximately 300 mm thick.
- These lining surfaces should be finished and trimmed to a good standard across the entire berm surface. At this point in construction, work should be checked to ensure the construction specifications and angles have been met.

E. Armouring the Drain

- A 2-3m wide section straddling the bottom of the drain should be armoured to a depth of 100mm, using well-graded, coarse NAF waste rock.
- To place this material, cut a slot from the toe of the limit of dump marker bund outwards for 2.5m, with the cut material cast up onto the 10m-berm that is adjacent to the new cut.
- This cut should be filled with select material which is well-graded but coarse.
- The fill material should not exceed 150mm in depth.
- It is essential that this material be placed below the drain batter, such that water from each side of the drain will flow onto the armoured section, and not run beside the armour, eroding the fill to the sides of the armour and causing the armour to sit proud of the base of the drain.
- If the material is placed into the drain to the level of the edge of the cut and is heavily compacted and conditioned, it should compact to the desired invert level below the drain batter

F. Marking the Limit of Dumping

- Once the drain lining is laid, a line of flagged pegs should be placed at 100m intervals to mark the placement of the limit of tipping;
- These pegs should be placed so no butt-dumped waste rock comes within 1m of the bottom of the drain;
- Smaller haul trucks would be more desirable vehicles, to minimise disturbance to the drain liner; and
- Oversized dump trucks should be avoided in these bund lines.

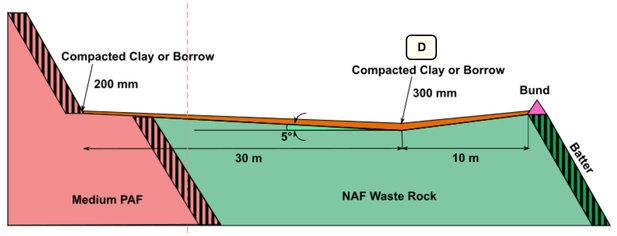
G. Revegetation of the Exposed Berm

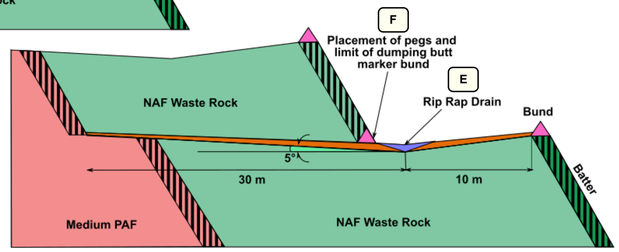
- All of the exposed berms, apart from the armoured section of the bottom of the drain, should be very lightly scarified and seeded with pasture species or couch grass.
- The crest bund can also be hand seeded.
- Once established, this vegetation will help to prevent erosion and hold the surfaces of the crest bund and the exposed berm in place.

H. Drop Structures

- The berms should be constructed to direct runoff to the closed-circuit impacted water system until the water quality is demonstrated to be appropriate for discharge into the receiving environment.
- The drop structures should be carefully designed and constructed to carry probable maximum precipitation (PMP) level flow.

A4. NWRD Berm Design (NRC, 2013)





A3. Cross-section of NWRD

North Waste Rock Dump (NWRD)

The Northern WRD (Final approved footprint of 73 ha), contains PAF waste rock encapsulated by NAF waste rock, coupled with low permeability clay/soil layers on the benches that limit the ingress of water into the NAF embankments. The NRC (2013) final landform design intent will aim to shed rainfall and channel runoff along the benches through stormwater infrastructure and drop structures to the existing interception dams. During operations, water is collected within these dams and pumped back through the processing circuit. Upon decommissioning of the processing plant and rehabilitaton of the NWRD, rainfall captured within the interception dams will be either pumped to the pit or undergo passive treatment via constructed wetlands which are currently being trialled on-site.

Figure 9-1

Legend:

- Topsoil (Stockpile/Borrow Area)
- NAF Oxide Regolith
- NAF Waste Rock
- Medium PAF Material
- Clay/Soil
- NWRD Engineered Cover
- Bund
- Engineered Berm
- Rip Rap Drain
- Batter

Title: MRO NWRD Conceptual Model
Job Number: 2021092
Project Name: Mount Rawdon Gold Mine WBWQ
Date: 02/02/22
Scale: Not-To-Scale
Drafted: P.T **Reviewed: M.L.** **Revision:2.0.**

RGS

9.7 Modelling Theory

Numerical models are commonly applied to the understanding of highly complex environmental systems by endeavouring to simulate their performance. Numerical models such as SEEP/W (Geo-Slope International, 2018) use mathematical equations to simulate environmental conditions. The mathematical equations include equations imbedded in the software and user defined inputs. The mathematical data inputs may, in some cases, be altered to reflect conditions that cannot be met by measured laboratory values and this may be done using subjective or site-specific knowledge.

The surface boundary condition is the key to accurate vadose zone modelling. The most important parameters in the model are surface infiltration and actual evapo-transpiration (the surface unit flux boundary).

The surface unit flux boundary in SEEP/W is determined by coupling the moisture and heat profiles in the soil with the climate conditions present above the ground surface. The model also incorporates the fundamental flow laws for transient flow of water, heat, vapor and gas.

The purpose of the numerical modelling in mine closure is to establish how the final cover configuration(s) are likely to perform in terms of managing the soil / water balance. For example, the regolith units that are used to construct the soil cover will store and/or or lose water (precipitation) via evaporation or transpiration. The numerical results can be used as inputs to other models. Other models may be used to evaluate the environmental system and could include surface water models (e.g. GoldSim) or groundwater models (e.g. FeFlow).

9.7.1 Modelling Methodology

Two-dimensional (2-D) modelling using SEEP/W software was used to model water movement through various WRD cover configurations.

SEEP/W is a 2-D (or 1-D) finite element model that can simulate the physical movement of water and oxygen through a soil/cover medium. The model predicts pore water pressure (suction) and temperature profiles in the soil/cover profile in response to changes in climatic conditions (e.g. rainfall and evapotranspiration). The model simultaneously deals with heat, mass and vapour flow through both saturated and unsaturated soils. Oxygen transfer is dependent on soil saturation; however, oxygen transfer does not influence the calculation of heat and water flow.

The basic governing equations for the flow and heat transport aspects of the model (after Song and Yanful, 2010), include:

$$m\frac{\partial P}{\partial t} = Q + \frac{1}{\rho_w}\frac{\partial}{\partial x}\left(D_v\frac{\partial P_v}{\partial x}\right) + \frac{1}{\rho_w}\frac{\partial}{\partial y}\left(D_v\frac{\partial P_v}{\partial x}\right) + \frac{\partial}{\partial x}\left(K_x\frac{\partial(P/P_w g+y)}{\partial x}\right) + \frac{\partial}{\partial y}(K_y\frac{\partial(P/P_w g+y}{\partial y}$$

Equation 1

$$\lambda_t\frac{\partial T}{\partial x} = Qt + L_v\frac{\partial}{\partial x}\left(D_v\frac{\partial P_v}{\partial x}\right) + L_v\frac{\partial}{\partial y}\left(D_v\frac{\partial P_v}{\partial y}\right) + \frac{\partial}{\partial x}\left(k_{tx}\frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_{ty}\frac{\partial T}{\partial y}\right) + p_w c_w V_x\frac{\partial T}{\partial x} + p_w c_w V_y\frac{\partial T}{\partial y}$$ **Equation 2**

Where P= water pressure; m= slope of the soil water characteristic curve (SWCC); Q= applied boundary flux; P_v= vapour pressure of soil moisture; D_v= vapour diffusion coefficient; K_x =hydraulic conductivity in the x direction; K_y =hydraulic conductivity in the y direction; y= elevation head; g_w= density of water; g= acceleration due to gravity; t= time; k_t= apparent volumetric heat capacity in soil; T= temperature; Q_t= thermal boundary flux; L_v= latent heat of vaporisation; k_{tx}= thermal conductivity in the x direction; k_{ty}= thermal conductivity in the y direction; c_w = mass specific heat capacity of water; V_x= Darcy water velocity in the x direction; and, V_y= Darcy water velocity in the y direction.

Water flow and heat transfer are combined via the equation:

$$P_v = P_{vs}(e^{\frac{-PW_v}{P_w RT}})$$ **Equation 3**

Where P_{vs}= saturated vapor pressure of pure free water; W_v= molecular weight of water (0.018 kg/mol); and, R= universal gas constant (8.314 J/mol K).

Actual evaporation (*AE*) is calculated from solar radiation data using the Wilson-Penman method (Wilson, 1990).

SEEP/W numerical modelling involves solving the aforementioned mathematical equations (Equations 1 - 3) simultaneously using finite element analysis (FEA) and user input data (**Section 4.0**). The key user input data includes SWCC's, hydraulic conductivity function, thermal conductivity function, volumetric specific heat function and climatic data (maximum and minimum temperature and relative humidity, wind speed, rainfall and solar radiation). The equations generate *AE*, *P*, P_v and *T*.

9.7.2 Performance Indicators

Performance Indicators are used to establish how particular cover scenarios are performing relative to one another. The proposed land cover system is configured to reduce infiltration into the WRD materials (i.e. net percolation). The typical performance indicators for soil cover systems include net percolation (NP) and oxygen flux. For this investigation, the degree of saturation, and NP will be the primary performance indicator for each model. NP refers to all water that infiltrates below the cover system and into the PAF-M waste rock. NP does not include water that may enter the cover system (infiltration of precipitation) and is removed up or laterally by either transpiration, evaporation, runoff or lateral flow (above the waste rock).

9.7.3 Model Limitations and Assumptions

- The intent of the modelling is to undertake unsaturated zone modelling of several WRD cover design options using the finite element unsaturated zone model SEEP/W for the purpose of assessing the suggested land cover functionality and hydraulic performance. The models are based on mathematical equations and user input data, with the conceptual model significantly simplified for the purpose of modelling. As such, the numerical models are limited by the accuracy and details of the user input data.
- Movement of water in the unsaturated zone occurs according to Darcy's law – which describes flow in a porous medium. Darcy's law does not account for flow through preferential pathways (cracks, non-porous flow) that can be a significant flow path in a constructed regolith soil cover, particularly if there are flaws in the construction.
- Measured parameters for K_{sat} and SWCC's were performed on the fine fraction of the materials (<2.63mm), and the actual modelling inputs were inferred (corrected) based on the laboratory results and particle size distribution. Although sound scientific basis was applied to selecting these functions, there may be some ambiguity around the appropriateness of the curves without detailed field measurements.
- The acceptable seepage volumes that may result in water qualities that meet downstream trigger vales are unknown and do not form part of this investigation. The outcomes of this modelling will provide the initial basis for surface or seepage modelling and used as input to a water balance/ water quality model developed in GoldSim.
- Constructability of the cover system is of major importance. The final cover design should take into consideration the available machinery/equipment for construction of the cover and the practical limits of the machinery. The cover constructability, including time for consolidation and trafficability, has not been incorporated in the models. The modelling has assumed that the cover is placed directly over the *in-situ* WRD (interim cover).
- Erosion due to wind (after extensive dry periods) and surface runoff (extensive wet periods) are likely to affect the cover system and are not included in this investigation. However, this will be addressed as part of a separate investigation.
- Chemical migration – the movement of dissolved chemical constituents resulting from the cover system (e.g. capillary rise of salts, dilution effects) are not considered as part of the present investigation but will be addressed as part of the cover performance trials (**Attachment C**).
- The type of vegetation that will be used later in the rehabilitation process was not specified, and it was not included as an influencing factor within the modelling processes; however, it is anticipated that the cover will be vegetated with shallow rooted shrubs.

9.8 Model Inputs

Seepage modelling inputs can be separated into four groups:

- Materials Properties – soil water characteristic curves (SWCC) & hydraulic conductivity functions (k-functions).net
- Surface Boundary Conditions – climate, vegetation, surface material.
- Lower Boundary Conditions – water table, seepage faces.
- Geometry – layering, sequencing and topography.

The following section provides the inputs for each group and the rational for their selection

9.8.1 Material Properties

9.8.1.1 Soil water characteristic curves (SWCC)

The SWCC (or water retention curve) is the relationship between soil pore water pressure (suction; kPa) and volumetric water content [m^3/m^3]. The SWCC is one of the most important input parameters for the model, as it governs the water movement in the unsaturated soil.

Partial SWCCs for the materials used in the conceptual cover designs were either measured as part of separate investigations (RGS, 2016; RGS, 2021) or estimated based on other measured material properties (e.g. PSD). The measured data were fitted with the equation by Van Genuchten (1980):

$$\Theta_w = \Theta_r \frac{\Theta_s - \Theta_r}{[1+(\frac{\psi}{a})^n]^m} \qquad \textbf{Equation 4}$$

Where Θ_w= volumetric water content; Θ_s= saturated volumetric water content; ψ= negative pore-water pressure; and, *a*, *n*, *m*= curve fitting parameters.

The curve fitting parameter *a* is the pivot point of the SWCC at which *n* changes the slope of the function; *n* controls the slope of the SWCC; and *m* affects the sharpness of the curve at the lower end of the SWCC plateau. residual water content. The fitting parameters and SWCC's are shown in **Table 9-1** and **Figure 9-2**, respectively. The fitted curves together with particle-size-distribution measurements were used to derive representative SWCC for each of the major material types (i.e. over the entire particle size range). Sensitivity modelling were undertaken on each of the representative SWCCs.

Table 9-1: Van Genuchten (1980) curve fitting parameter for SWCC's

Material	Van Genuchten (1980) Parameters					k_{sat} (90% std. compaction)
	Θ_s	Θ_R	*a*	*n*	*m*	
	(m^3/m^3)	(m^3/m^3)	-	-	-	m/day
Compacted Soil (stockpiled topsoil)	0.480	0.058	1.400	1.991	0.498	8.64E-03
NAF Oxide Regolith	0.460	0.050	0.590	2.171	0.539	3.99E-02
NAF Rock/ Waste Rock	0.290	0.010	0.574	2.440	0.590	8.64E+00
Topsoil	0.450	0.080	1.200	2.761	0.638	1.83E-04

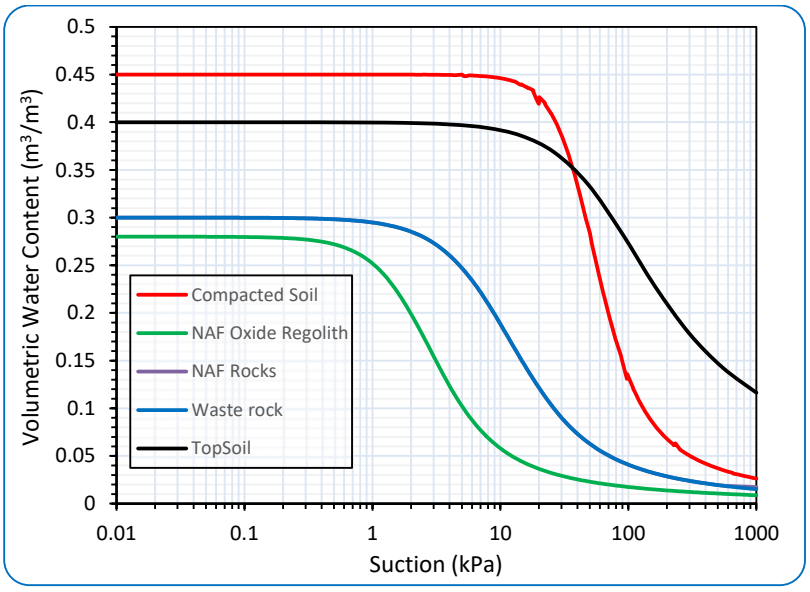


Figure 9-2: Soil Water Characteristic Curves for the examined materials. Note: NAF rock curve is the same as waste rock curve.

9.8.1.2 Hydraulic conductivity function

Permeability of representative materials was measured at Trilab Laboratory, Brisbane, and the saturated hydraulic conductivity (k_{sat}) calculated. The hydraulic conductivity function (suction [kPa] versus hydraulic conductivity [m/s]) was estimated using the measured k_{sat} and extrapolated using the Fredlund method (Fredlund et al., 1994). The Fredlund method integrates along the SWCC to develop the unsaturated hydraulic conductivity function (**Section 3.1.1**). The equation is (based on Geo-Slope International, 2018):

$$k_w = k_s \frac{\sum_{i=j}^{N} \frac{\Theta(e^y)-\Theta(\psi)}{e^{y_i}} \Theta'(e^{y_i})}{\sum_{i=1}^{N} \frac{\Theta(e^y)-\Theta_s}{e^{y_i}} \Theta'(e^{y_i})} \qquad \textbf{Equation 12}$$

Where k_w= calculated conductivity for a specific water content or negative pore-water pressure (m/s); k_s= measured saturated conductivity; Θ_s= volumetric water content; *e*= natural number (2.71828); *y*= dummy variable of integration (representing log of negative pore water pressure); *i*= interval between the range of j to N; *j*= least negative pore-water pressure (described in final function); *N*= maximum negative pore-water pressure (described by final function); ψ= suction corresponding to the j^{th} interval; and, Θ'= first derivative of the equation:

$$\Theta = C(\psi) \frac{\Theta_s}{\{ln[e+(\frac{\psi}{a})^n]\}^m} \qquad \textbf{Equation 13}$$

Where *a*= approximately air-entry value of the material; *n*= parameter that controls slope at the inflection point in the SWCC; *m*= parameter that is related to the residual water content; and, $C(\psi)$= correcting function, defined by the equation:

$$C(\psi) = 1 - \frac{\ln(1+\frac{\psi}{C_r})}{\ln(1+\frac{1{,}000{,}000}{C_r})} \qquad \textbf{Equation 14}$$

Where C_r= constant related to matric suction corresponding to residual water content.

The hydraulic conductivity functions established for the modelling, using the above-mentioned method, are shown on **Figure 6**.

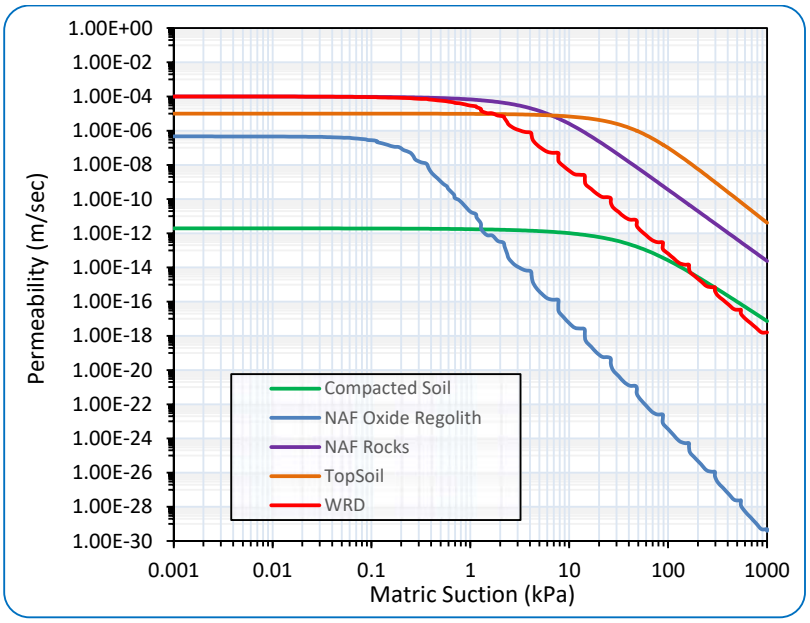


Figure 9-3: Established hydraulic conductivity functions for various material types

9.8.1.3 Thermal conductivity function

The thermal conductivity function is volumetric water content [m^3/m^3] versus thermal conductivity [kJ/days/m/°C] and describes the heat transfer through the soil. Water content and thermal behaviour of the soil influence each other because unsaturated soils consist of air, water, and solids, with air and water having different thermal properties.

The standard thermal properties for a sand, silt or clay material have been used in the modelling depending on the material type, or, estimated according to method by Johansen (1975). The thermal conductivity of dry natural soils (k_{dry}) can be estimated based on its dry density according to the equation:

$$K_{dry} = \frac{0.135\gamma_d + 64.7}{2700 - 0.947\gamma_d} \pm 20\% \qquad \textbf{Equation 15}$$

Where γ_d= dry density (kg/m^3).

For dry crushed rock material (e.g. gravel or waste rock), the thermal conductivity is estimated based on its porosity (n) using the equation:

$$K_{dry} = 0.039n^{-2.2} \pm 25\% \qquad \textbf{Equation 16}$$

For a saturated unfrozen soil, the thermal conductivity (k_{sat}) is estimated based on the thermal conductivities of its components and respective volume fractions:

$$K_{sat} = (K_s)^{1-n}(K_w)^n \qquad \textbf{Equation 17}$$

Where K_s and K_w are the thermal conductivities of soil particles and pore-water, respectively.

The ground temperature at this site does not drop below freezing and is fairly uniform so these parameters have little influence on overall results. The Ground freezing function in SEEP/W was disabled.

9.9 Boundary conditions and initial conditions

The “base case” model boundary conditions are summarised in the following sections.

9.9.1 Climatic conditions – surface boundary

The climatic conditions at MRO are applied as the upper boundary condition. There are two Bureau of Meteorology (BOM) weather stations in the vicinity of MRO:

- BOM weather station 39070: Mt Perry - The Pines, QLD (Lat: 25.17°S, Lon: 151.64°E).
- BOM weather station 39096: Wateranga, QLD (Lat: 25.36°S, Lon: 151.82°E).

The rainfall/ evaporation data from both stations were analysed, Mt Perry has a higher accumulated rainfall than Wateranga (cumulative over 122 years). The data from both stations was interpolated to create a datum point located immediately north of the TSF (Lat: -25.25 °S, Lon:151.75 °E) to give the best possible representation of the site climatic conditions.

The average climatic conditions for MRO can be summarised in the following points:

- MRO is located within a hot humid summer with a low winter rainfall climate zone (Winter, 2016, Meteorology, 2022), where the wettest months are December to March and the driest months are June to September.
- On average, the mean evaporation exceeds mean precipitation for all months of the year.
- Average annual rainfall is 767.0 mm.

The historical climatic data selected for the modelling process includes the last ten years of a total 100 years database (1/1/2012 to 31/12/2021), divided into five time periods (two years for each period) in order to provide the necessary climatic boundaries required for modelling operations using SEEP/W. The selected years include several extreme rainfall events (**Figure 9-4**) as well as a representation of the average climatic conditions over the 100 year period.

A summary of the rainfall data according to the separate 2-year blocks of time include:

1- The first period (Days: 1-730): The total accumulated amount of rain that fell during this period was 1375.2 mm of rain, noting that there were two extreme rainfall events during this period. The first one occurs from 25th to 27th January 2013, where 494.1 mm of rain fell over three days, of which 289.1 mm fell on the day 394 alone (27/01/2013). The second event was shortly after with a total of 133.6 mm of rain falling over three days (day 422-424; February 24-26, 2013) with an average of 44.5 mm/day. Based on Australian Intensity-Frequency-Duration (IFD) (BOM, 2016), the Annual Exceedance Probability (AEP) for a storm of 262 mm over 24 hours is less than 1% (**Figure 9-5**).

2- The second period (Days: 731-1460): the total accumulated amount of rain that fell during this period was 1085.5 mm. With a major event on day 1148, during that day alone 126.2 mm of rain fell.

3- The third period (Days: 1461-2190): The total accumulated amount of rain that fell during that period was 1192.7 mm. It was marked by a major event during the days of 2117-2118, during which a total of 217 mm of rain fell during these two days (112 mm and 105 mm/day, respectively).

4- The fourth period (Days: 2191-2920): This period was characterised by relative drought, as the total rainfall during these two years amounted to a total of 801.3 mm of the accumulated rain. With one major event during day 2479 where the average water precipitation during that day was 97.9 mm/day.

5- The fifth period (Days: 2921-3651): This period was characterised by the largest number of rainy days at a rate of more than 10 mm/day (48 days) compared to only 28 days during the previous period, with an average of 998.2 mm of accumulated rain.

The actual climate dataset including daily maximum and minimum values for temperature and relative humidity, and daily values for wind speed (not shown), precipitation and solar radiation are built into the model (**Figure 9-6** to **Figure 9-9**).

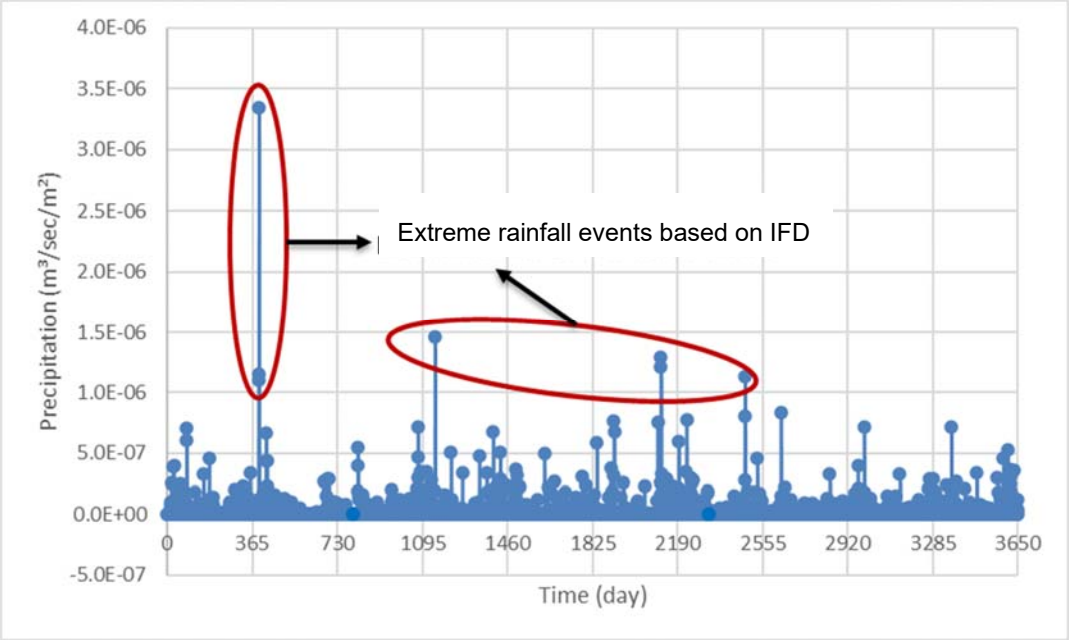


Figure 9-4: The Rainfall data for MRO from 1/1/2012 to 31/12/2021.

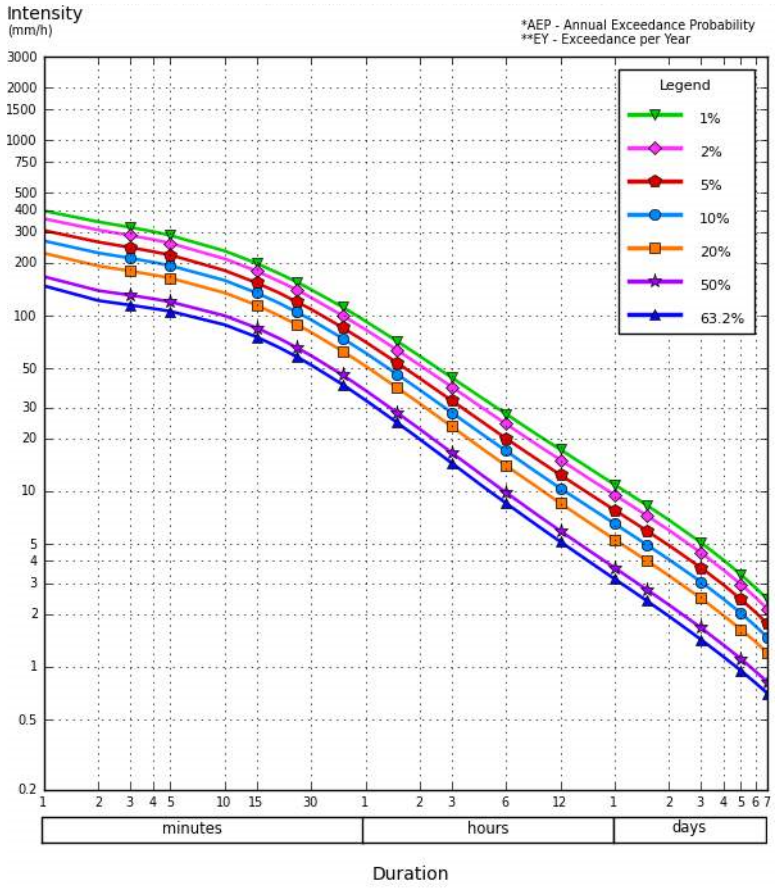


Figure 9-5: IFD Design Rainfall Intensity (mm/h) for Mt. Rawdon Minesite (BoM, 2016)

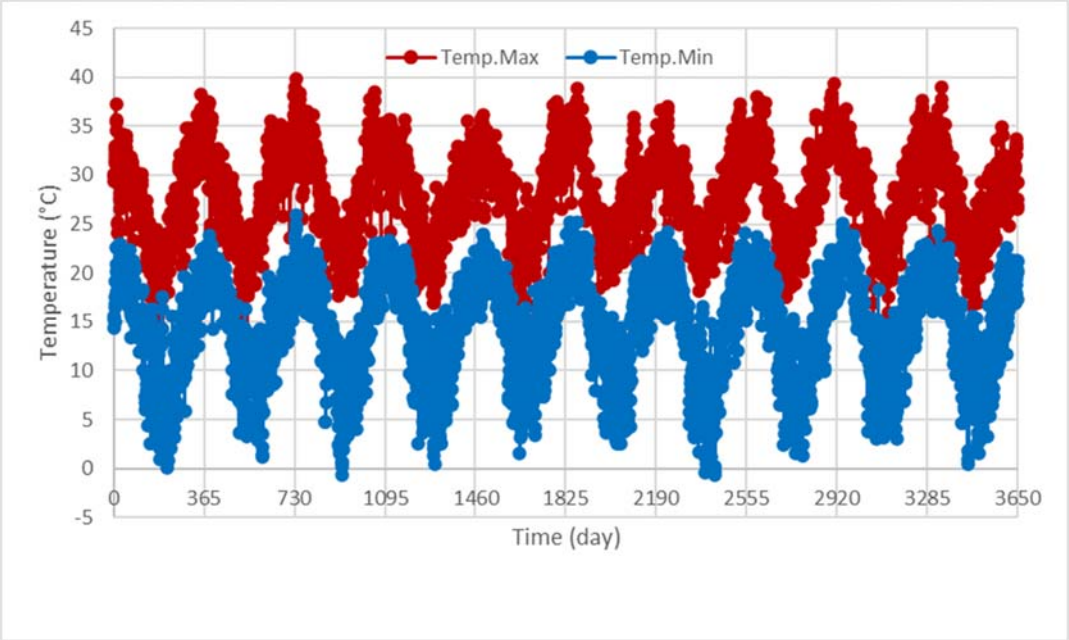


Figure 9-6: Maximum and Minimum daily temperature for MRO from 1/1/2012 to 31/12/2021 (10 Years = 3650 day).

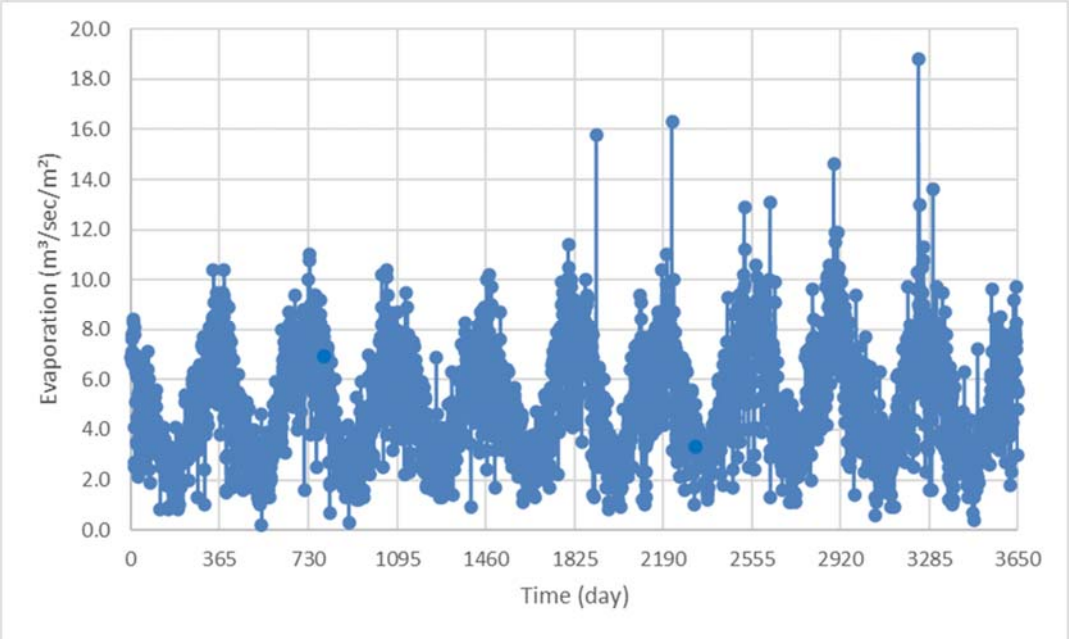


Figure 9-7: Evaporation data for MRO from 1/1/2012 to 31/12/2021 (10 Years = 3650 day).

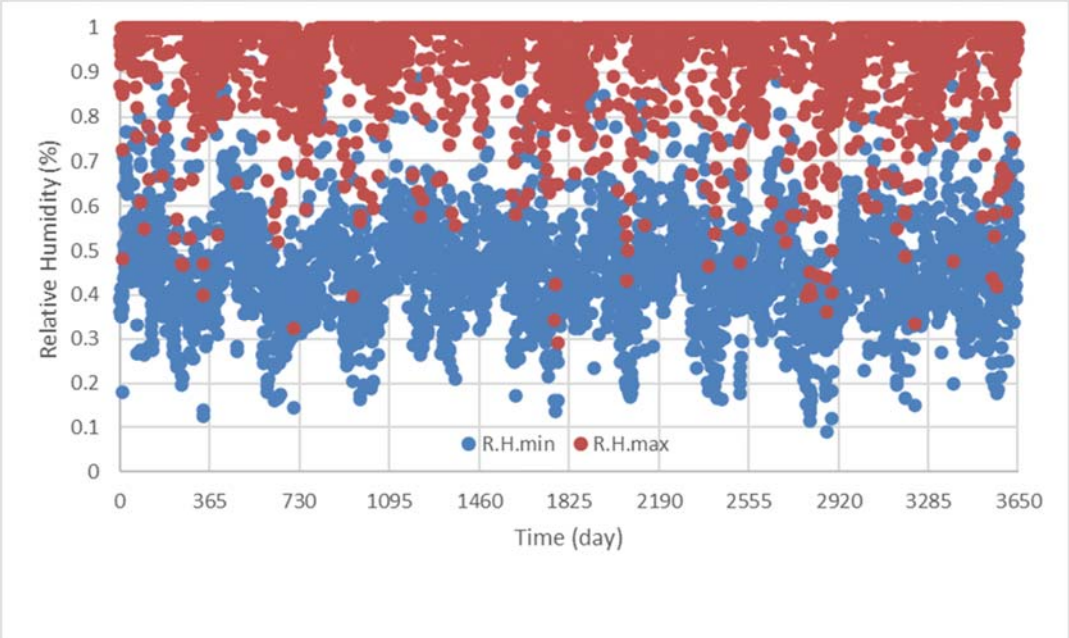


Figure 9-8: Relative Humidity data for MRO from 1/1/2012 to 31/12/2021 (10 Years = 3650 day).

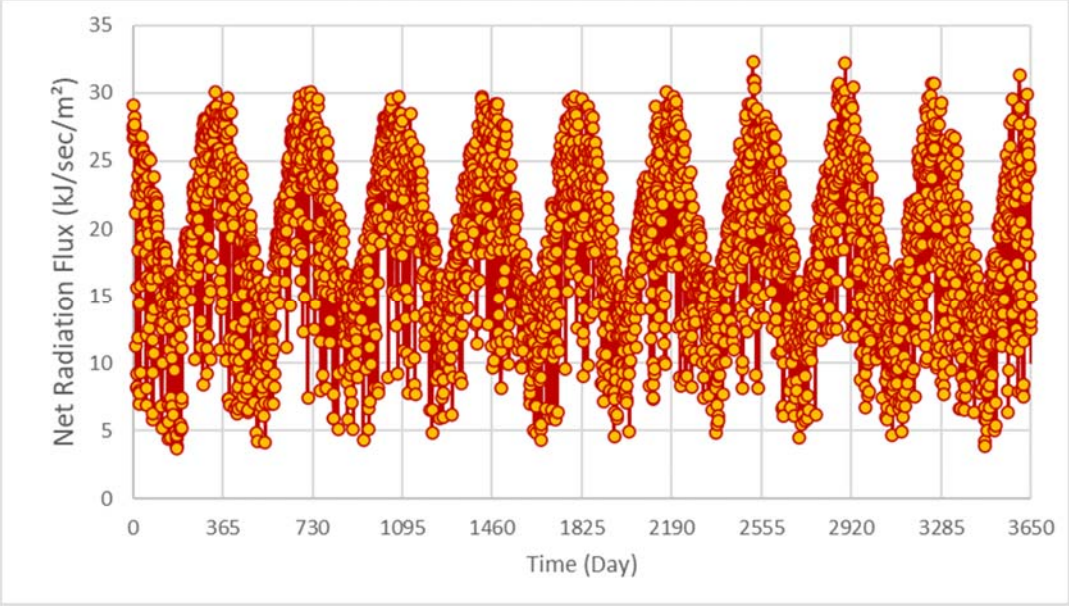


Figure 9-9: Net Solar Radiation Flux for MRO from 1/1/2012 to 31/12/2021 (10 Years = 3650 day).

9.9.2 Ground surface water

Surface water will be allowed to pond on the ground surface boundary; water is stored on the surface (nodes) and allowed to evaporate or infiltrate during later time steps. For selected models, water that ponds on the cover surface will be allowed to flow laterally out of the model once it reaches a defined pressure head (seepage face; **Section 4.2.3**). Similarly, the 5% slope on the surface of some examined land cover designs (**Section 4.2.5**) will allow surface runoff.

9.9.3 Seepage face (boundary condition)

For some selected model scenarios (flat surface profiles), it is expected that a large percentage of the interflow is likely to infiltrate into the profile due to lack of slope. Therefore, the majority of the simulations were run without a seepage face. Meanwhile, for the model scenarios with 5% slope, will have a seepage face boundary condition above the base case, which will allow the lateral flow out of the model once it reaches a defined pressure head.

9.9.4 Base condition

RGS has assumed that there is no water table within the WRD for the purpose of assessing the cover water balance. Therefore, the lower boundary condition of the models was simulated with a water unit gradient boundary with a water table placed below the WRD.

9.9.5 Model geometry

The typical model geometry and mesh used for each of the models is shown in **Figure 9-10**. The 2D SEEP/W models consist of a 10-meter-wide column which is 12 m high for the flat surface simulation, and 11.5 m high on the left boundary and 12 m high on the right boundary for the sloped surface; this provides a slope on the surface of 1:20 (5%).

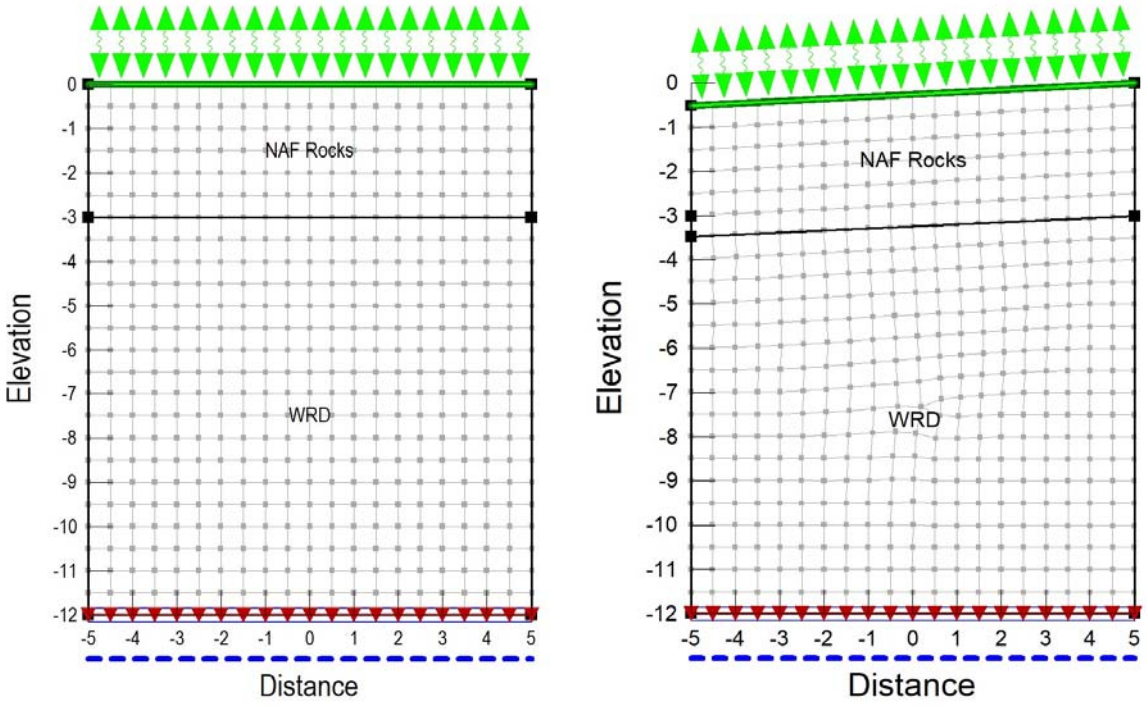


Figure 9-10: Example model geometry

9.9.6 Modelling Scenarios

RGS constructed a ‘base-case’ model and three different cover model configurations which represent three different scenarios (**Figure 9-11**). The modelling scenarios include the ‘Base Case’ model which represents the NWRD without a final cover but includes the 3m interim NAF cover that overlies the PAF-M rock. The three different scenarios include:

Option 1A:

- **Option 1A: '**Base Case' interim cover topped with a 0.5 m compacted clay/ soil layer, followed by 2 m of NAF Oxide Regolith and another 1 m of competent NAF rocks.
- **Option 1B:** replica of Option 1A with 0.2 m of topsoil (plant growth media) added to the surface.

Both Cover system 1A and 1B would be considered a hybrid water shedding/ store and release cover; the competent NAF rock placed on the surface is erosion resistant and acts, together with NAF oxide regolith, as a storage layer. Option 1B is the same, however, also has a specified vegetation and ecological land use (due to the topsoil placement). The compacted clay/soil layer plays an important role as a low permeability layer for reducing net percolation to underlying waste rock and helps store water within the plant root zone.

Option 2:

- Includes the 'Base Cover" interim cover topped with 0.5m of compacted clay/soil, followed by 1m NAF rock, 2m of NAF Oxide Regolith and then 0.2m of topsoil (plant growth media).

This cover system is a hybrid store and release cover. Infiltrated water is stored above the compacted clay/soil which is later evaporated.

For each of these scenarios, a flat surface profile and a profile with 5% slope have been simulated. All the cover systems can be constructed based on the site rehabilitation material balance.

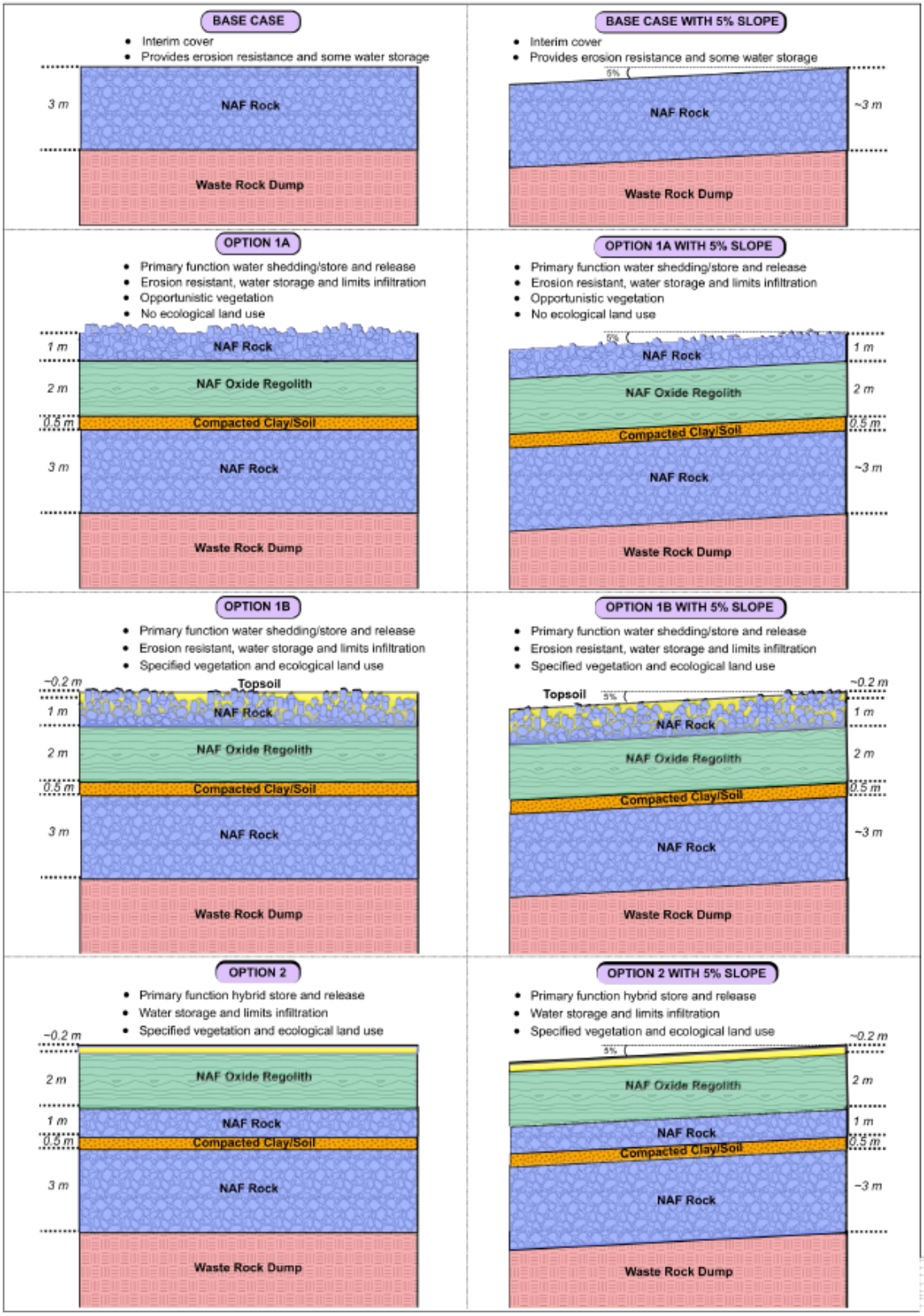


Figure 9-11: Base case and conceptual cover designs being modelled

9.10 Modelling Results

The results of the modelling simulations are summarised in the following sections. The data output from the modelling is extensive, so only relevant information has been included in the summary below.

Note: positive cumulative flux values indicate water entering the model domain while negative values indicate water being removed from the model domain.

Note: comparison of sloped and non-sloped landforms can be misleading as boundary conditions for both model types are not identical.

9.10.1 Water Balance

The cumulative water balance summary for each of the scenarios is described below. The associated graphs are generated at every time step for the whole ten-year simulation period (2012-2021). All water balance parameters are summed for each node (i.e., cumulative mesh; m^3).

Base Case Scenario – Flat surface & with 5% slope (1:20):

The cumulative water balance summary for the Base Case scenario with no slope (flat surface) and with 5% slope are shown on **Figure 9-12** and **Figure 9-13**, respectively. The water balance indicates:

- Approximately 75.6 m^3 of rain is accumulated during the simulation (10 years) which equates to 7,560 mm over 10 years (i.e., average rainfall over a ten-year period, 756 mm/year). This is applicable for each of the simulations and is therefore not repeated again below.
- There was almost no runoff over the entire 10-year period for the flat Base Case landform scenario and for the Base Case Scenario with 5% slope (1:20). No significant runoff event occurred due to high infiltration and evaporation rates as a direct result of the high hydraulic conductivity of the surface layer (i.e. coarse NAF rock).
- Approximately 40.8 m^3 (53.9 % of precipitation) and 24.7 m^3 (32.7% of precipitation) of water was removed from the model domain due to surface evaporation over the entire 10-year period for the flat Base Case landform scenario and for the Base Case Scenario with 5% slope (1:20), respectively.
- There was 35 m^3 (46.3 % of precipitation) and 51.0 m^3 (67.4 % of precipitation) of Net Infiltration over the entire 10-year period for the flat Base Case landform scenario and for the Base Case Scenario with 5% slope (1:20), respectively. A significant amount of this infiltrated water percolates through the 3m interim cover, reaching the PAF-M waste rocks dump. It is expected that any acidic leachate will be neutralised by the excess acid neutralization capacity surrounding the PAF rock.

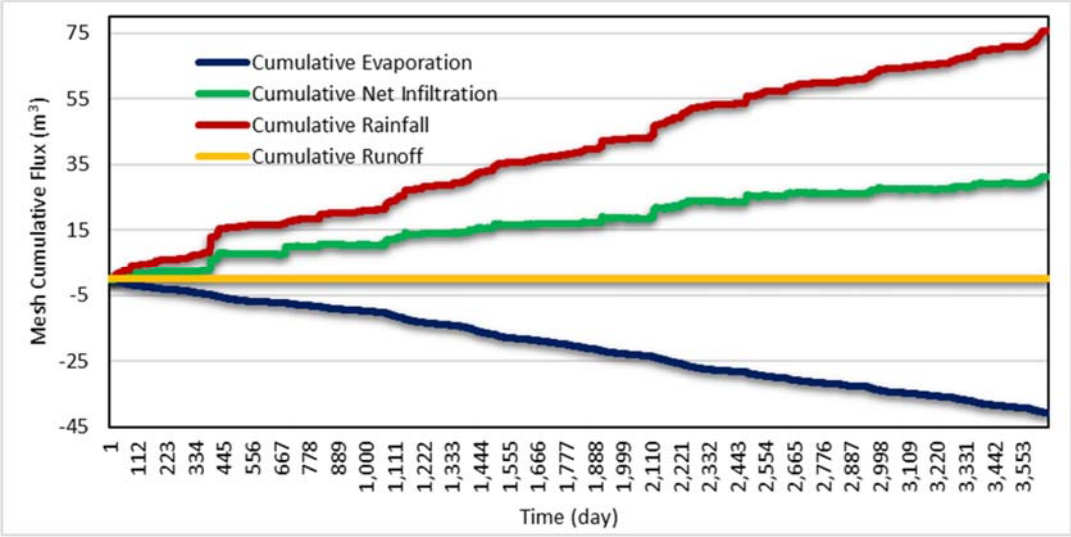


Figure 9-12: Water Balance for the "Base Case" (flat) Scenario.

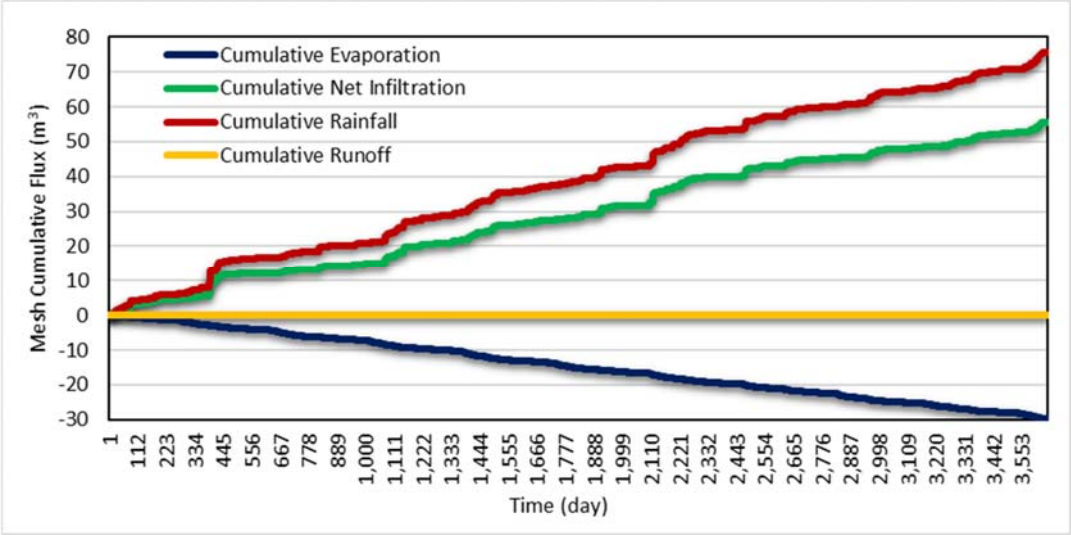


Figure 9-13: Water Balance for the "Base Case" with 5% Slope Scenario.

Option 1A Scenario – No Slope:

The water balance summary for "Option 1A" scenario with no slope (flat surface) is shown on **Figure 9-14**. The water balance indicates:

- There were no significant runoff events over the entire 10-year since the cover surface was flat which encourages ponding and infiltration.
- Approximately 65.03 m^3 (85.97 % of precipitation) of water was removed from the model domain due to surface evaporation over the entire 10-year period. Most of the water loss by evaporation usually occurs with low intensity rainfall events (up to 85% of rainfall runoff for a ≤10 mm/day rainfall event; less than 2% runoff for a rainfall events ≥ 60 mm/day).
- There were 5.64 m^3 (7.5 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolates through the 3m interim cover layer over the whole 10 years of modelling.

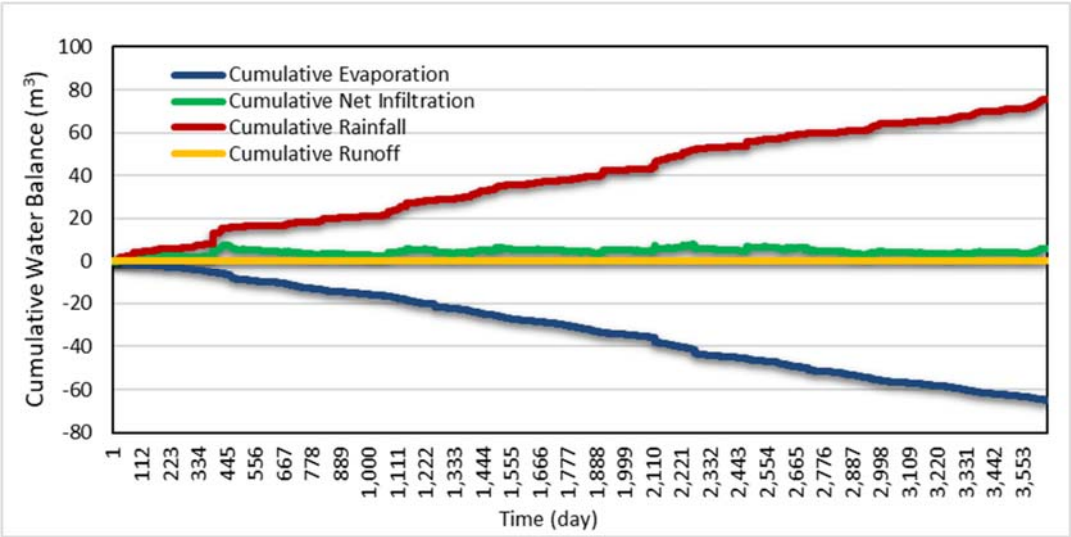


Figure 9-14: Water Balance for Option 1A Scenario.

Option 1A Scenario – 5% Slope (1:20):

The water balance summary for "Option 1A with 5% Slope (1:20)" is shown on **Figure 9-15**. The water balance indicates:

- There were 3.55 m^3 (4.70 % of precipitation) of runoff over the entire 10-year. The runoff Increased from 2.1% with the rainstorm intensity ≥ 20 mm/day gradually to approach up to 40.6% of the total water balance for the rainstorm event ≥ 200 mm/day.
- Approximately 81.03 m^3 (more than the accumulative precipitation) of water was removed from the domain due to surface evaporation over the entire 10-year period. Most of the water loss by the evaporation usually happen with the low intensity rainfall storm (up to 92 % of the received water with the storm ≤10 mm/day, less than 3% when the rainfall intensity is ≥ 60 mm/day).
- There were 31.75 m^3 (41.97 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolates through the 3m interim cover layer over the whole 10 years of modelling.

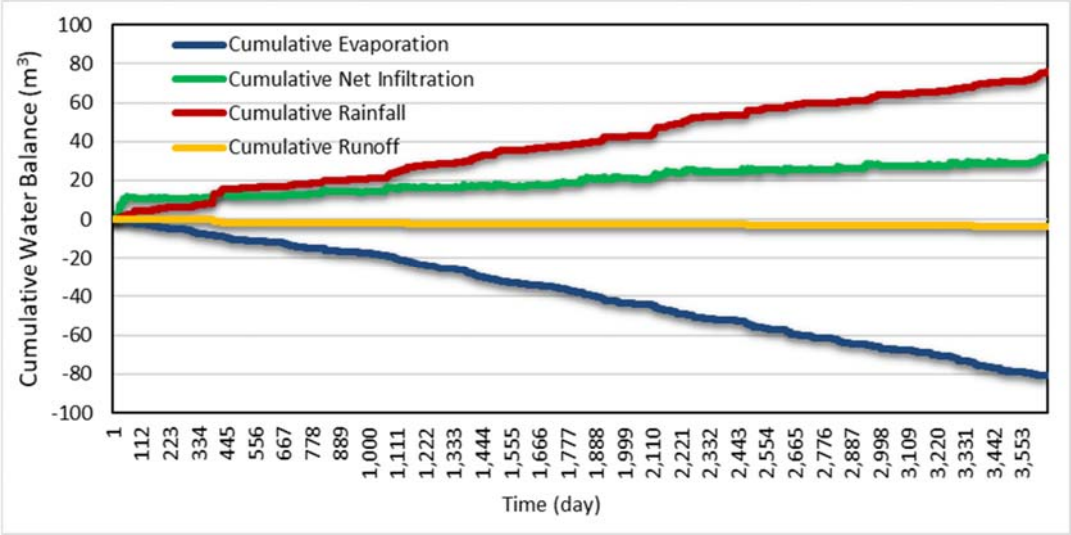


Figure 9-15: Water Balance for Option 1A with 5% Slope Scenario.

Option 1B Scenario – No Slope:

The water balance summary for "Option 1B" scenario is shown on **Figure 9-16**. The water balance indicates:

- There were 3.23 m^3 (4.27 % of precipitation) of runoff over the entire 10-year simulation. The runoff increased gradually from 1.3% with the rainstorm intensity > 0-10 mm/day to approach up to 17 % of the total water balance for the rainstorm event 60-80 mm/day.
- Approximately 52.58 m^3 (69.51 % of precipitation) of water was removed from the domain due to surface evaporation over the entire 10-year period. Most of the water loss by the evaporation usually happen with the low intensity rainfall storm (up to 73.4% of the received water with the storm ≤10 mm/day, less than 2% when the rainfall intensity is ≥ 60 mm/day).
- There were 14.32 m^3 (18.93 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolates through the 3m interim cover layer over the whole 10 years of modelling.

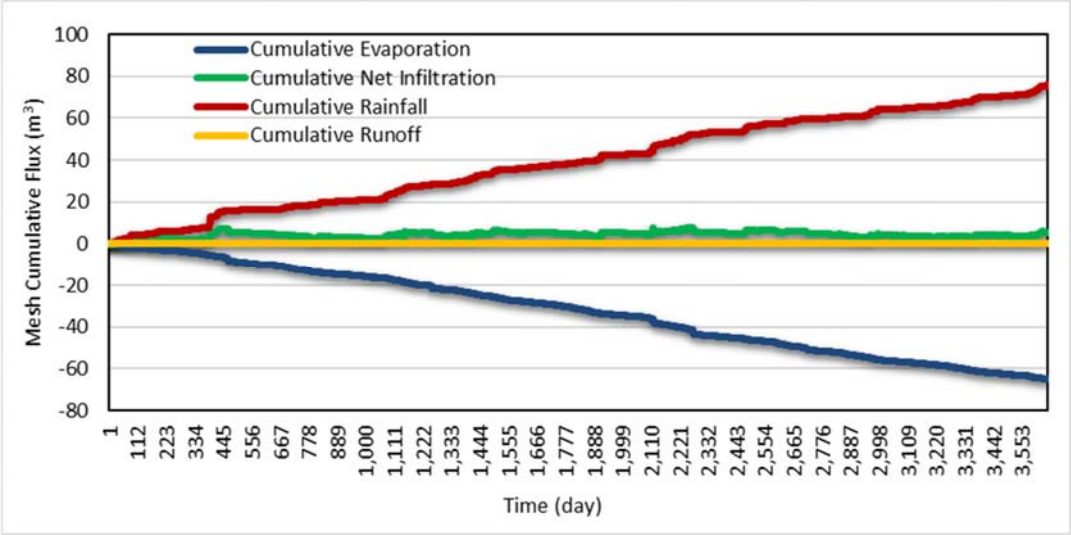


Figure 9-16: Water Balance for Option 1B Scenario.

Option 1B Scenario – 5% Slope (1:20):

The water balance summary for "Option 1B" scenario is shown on **Figure 9-17**. The water balance indicates:

- There were 2.21 m^3 (2.93 % of precipitation) of runoff over the entire 10-year.
- Approximately 82.19 m^3 (more than the accumulative precipitation) of water was removed from the domain due to surface evaporation over the entire 10-year period. Most of the water loss by the evaporation usually happen with the low intensity rainfall storm (up to 90 % of the received water with the storm ≤10 mm/day, less than 3% when the rainfall intensity is ≥ 60 mm/day).
- There were 8.43 m^3 (11.14 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolates through the 3m interim cover layer over the whole 10 years of modelling.

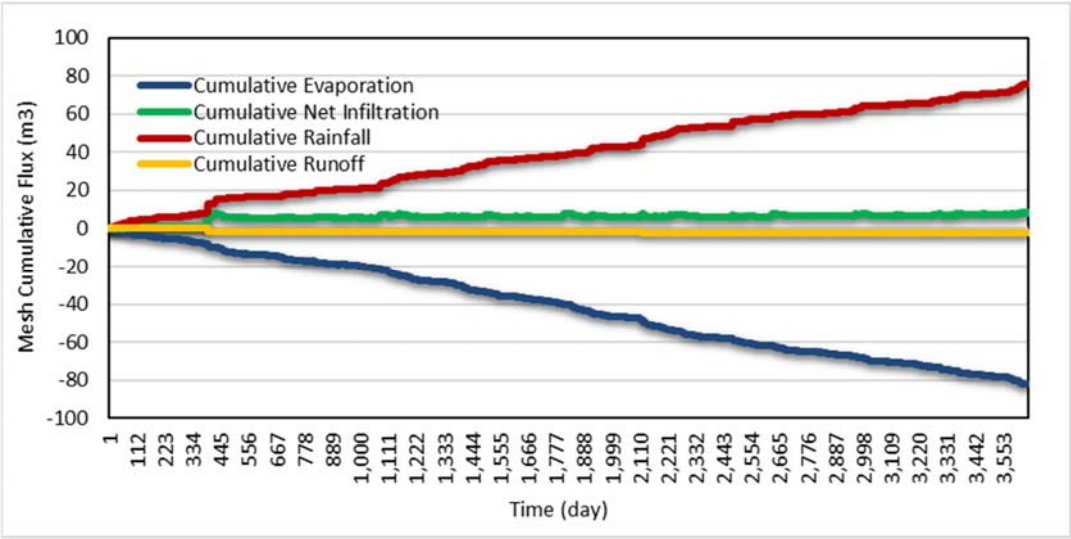


Figure 9-17: Water Balance for Option 1B with 5% Slope Scenario.

Option 2 Scenario – No Slope:

The water balance summary for "Option 2" scenario is shown on **Figure 9-18**. The water balance indicates:

- There were 10.37 m^3 (13.37 % of precipitation) of runoff over the entire 10-year simulation. The runoff Increased gradually from 2.3% with the rainstorm intensity > 0-10 mm/day to approach up an average of 46.5 % of the total water balance for the rainstorm event ≥ 60 mm/day.
- Approximately 56.08 m^3 (74.14 % of precipitation) of water was removed from the domain due to surface evaporation over the entire 10-year period. Most of the water loss by the evaporation usually happen with the low intensity rainfall storm (up to 79 % of the received water with the storm ≥10 mm/day, less than 2 % when the rainfall intensity is ≤ 60 mm/day).
- There were 4.39 m^3 (5.81 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolates through the 3m interim cover layer over the whole 10 years of modelling.

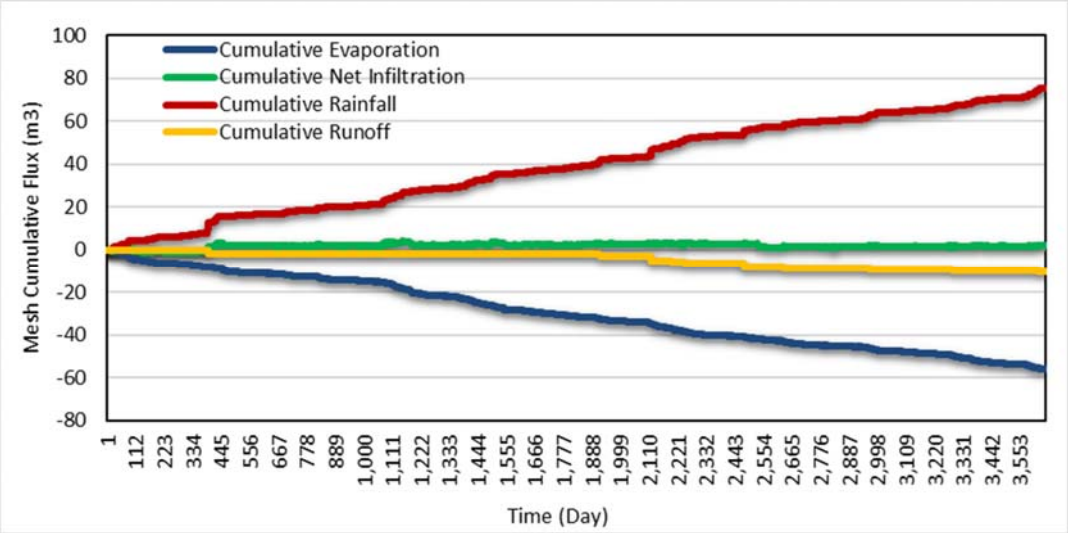


Figure 9-18: Water Balance for Option 2 Scenario.

Option 2 Scenario – 5% Slope (1:20):

The water balance summary for "Option 2 with 5% Slope (1:20)" scenario is shown on **Figure 9-19**. The water balance indicates:

- There were 15.57 m^3 (20.58 % of precipitation) of runoff over the entire 10-year. The average of runoff % for the rainstorm event ≥ 60 mm/day increased to be 72.6% of the total water balance.
- Approximately 69.62 m^3 (more than the accumulative precipitation) of water was removed from the domain due to surface evaporation over the entire 10-year period. Most of the water loss by the evaporation usually happen with the low intensity rainfall storm (up to 79 % of the received water with the storm ≤10 mm/day, less than 1.4% when the rainfall intensity is ≥ 60 mm/day).
- There were 2.08 m^3 (2.75 % of precipitation) of Net Infiltration over the entire 10-year period. No seepage/water percolate deep enough to the WRD for the whole 10 years of modelling.

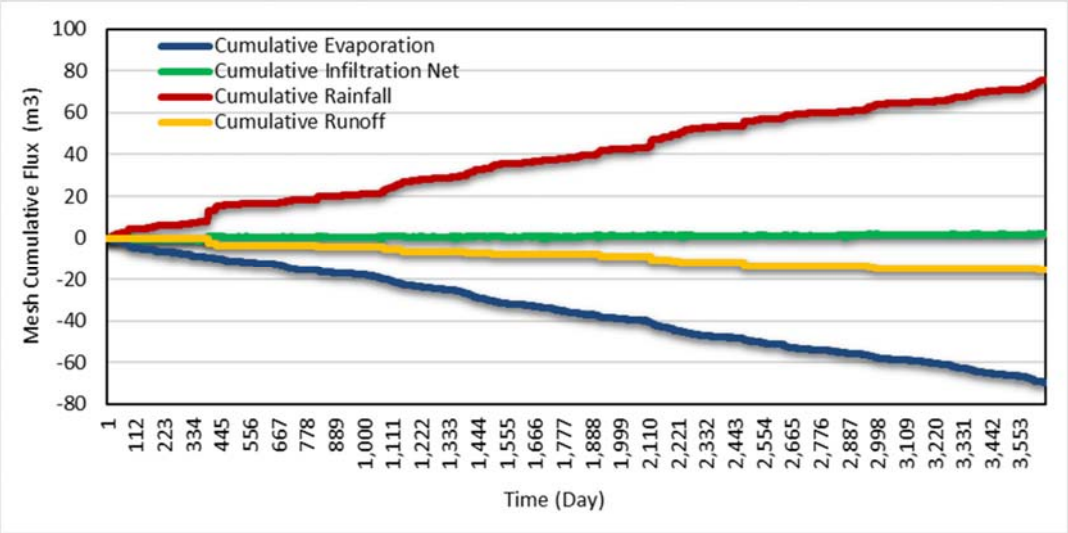


Figure 9-19: Water Balance for Option 2 with 5% Slope Scenario.

Water Balance Summary

Results of the modelling are summarised in **Table 9-2.** The results show high infiltration and NP though the interim cover (Base Case scenario) where there is no top tier cover placement. The water balance for each of the model scenarios was typically controlled by the high infiltration (albeit surficial) and evaporation rates with generally low runoff, particularly for the flat scenarios.

The results of the water balance are explored statistically for each of the simulations according to rainfall event, as the frequency and intensity of a rainfall event largely drives the water balance (**Table 9-2**). Low rainfall events (>0 to 10 mm) typically have no runoff with very high evaporation and moderate infiltration. With increasing rainfall, there is a marked increase in runoff with less evaporation and higher infiltration. However, there is a point at which the infiltration contribution decreases with increasing rainfall intensity (during extreme and long rainfall events) because most of the meteoritic water in such cases is removed by runoff.

Table 9-2: Water Balance Summary for MRO different cover options.

Scenario		Cumulative Evaporation	Cumulative Infiltration	Cumulative Runoff
Base Case Scenario	(m^3)	40.8	31.2	0.0
	%	53.9	41.3	0.0
Base Case Scenario - Slope 5%	(m^3)	24.7	51.0	0.0
	%	32.7	67.4	0.0
Option 1 A Scenario	(m^3)	65.0	5.6	0.0
	%	86.0	7.5	0.0
Option 1 A - Slope 5% Scenario	(m^3)	81.0	31.7	3.6
	%	107.1	42.0	4.7
Option 1 B Scenario	(m^3)	52.6	14.3	3.2
	%	69.5	18.9	4.3
Option 1 B - Slope 5% Scenario	(m^3)	82.2	8.4	2.2
	%	108.6	11.1	2.9
Option 2 Scenario	(m^3)	56.1	4.4	10.4
	%	74.1	5.8	13.7
Option 2 - Slope 5% Scenario	(m^3)	69.6	2.1	15.6
	%	92.0	2.7	20.6

Note: comparison of sloped and non-sloped landforms can be misleading as boundary conditions for both model types are not identical.

Table 9-3: Event Based Water Balance Statistical Distribution over ten years (2012-2021) for MRO different Land Cover Scenarios.

Average Water Balance for MRO "Base Case" Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	0	63.7	36.3
10 - 20 mm	117	0	20	80
20 - 40 mm	59	0	11.9	88.1
40 - 60 mm	13	0	3.5	96.5
60 - 80 mm	9	0	1.4	98.6
80 - 120 mm	5	0	1.5	98.5
120-200 mm	1	0	0.6	99.4
>200 mm	1	0	0.2	99.8

Average Water Balance for MRO Option 1A Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	0	85.1	14.9
10 - 20 mm	117	0	26.5	73.5
20 - 40 mm	59	0	13	87
40 - 60 mm	13	0	3.5	96.5
60 - 80 mm	9	0	1.4	98.6
80 - 120 mm	5	0	1.8	98.2
120-200 mm	1	0	0.6	99.4
>200 mm	1	0	0.2	99.8

Average Water Balance for MRO Option 1B Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	1.3	73.4	25.3
10 - 20 mm	117	4.4	29.3	66.3
20 - 40 mm	59	4.3	19.5	76.2
40 - 60 mm	13	9.6	3.5	87
60 - 80 mm	9	17	1.4	81.5
80 - 120 mm	5	5	0.4	94.6
120-200 mm	1	0	0.6	99.4
>200 mm	1	0	0.2	99.8

Average Water Balance for MRO Option 2 Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	2.3	79.9	17.8
10 - 20 mm	117	8	28.2	63.8
20 - 40 mm	59	10.8	15.1	74.1
40 - 60 mm	13	13.6	3.5	82.9
60 - 80 mm	9	34.1	1.4	64.5
80 - 120 mm	5	58.4	1.4	40.2
120-200 mm	1	39.8	0.6	59.6
>200 mm	1	53.8	0.2	45.9

Average Water Balance for MRO "Base Case" with 5% slope Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	0	48	52
10 - 20 mm	117	4.3	14.9	80.8
20 - 40 mm	59	6.3	10.7	83
40 - 60 mm	13	7.5	3.5	89
60 - 80 mm	9	7.5	1.4	91
80 - 120 mm	5	0	1	99
120-200 mm	1	0	0.6	99.4
>200 mm	1	0	0.2	99.8

Average Water Balance for MRO Option 1A with 5% slope Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	0	92	8
10 - 20 mm	117	1.9	31.1	67
20 - 40 mm	59	2.1	12	85.8
40 - 60 mm	13	6.9	3.5	89.6
60 - 80 mm	9	14.1	2.4	83.4
80 - 120 mm	5	16.8	2.7	80.5
120-200 mm	1	28.3	0.6	71.1
>200 mm	1	40.6	0.2	59.2

Average Water Balance for MRO Option 1B with 5% slope Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	4.5	90.8	4.7
10 - 20 mm	117	2.2	28.4	69.4
20 - 40 mm	59	5.1	21.6	73.3
40 - 60 mm	13	8.5	4	87.4
60 - 80 mm	9	13.4	2.2	84.4
80 - 120 mm	5	24.9	15	60.1
120-200 mm	1	30.5	0.9	68.7
>200 mm	1	58.6	0.3	41.1

Average Water Balance for MRO Option 2 with 5% slope Scenario

Rainfall event (24 hours)	Frequency (No. rainfall events)	Water outputs distribution (%)		
		Runoff %	Evaporation %	Infiltration %
> 0 - 10 mm	992	10.4	79.6	10
10 - 20 mm	117	17.4	23.5	59.1
20 - 40 mm	59	22	14.8	63.2
40 - 60 mm	13	27	3.5	69.5
60 - 80 mm	9	43.5	1.4	55.1
80 - 120 mm	5	76.6	1.2	22.2
120-200 mm	1	86.9	0.6	12.5
>200 mm	1	83.6	0.2	16.2

9.10.2 Net percolation & Volumetric Water Content

The NP and Volumetric Water Content (VWC) through the cover are used as performance indicators for the conceptual cover designs.

NP is presented as the cumulative volume of water (versus time) moving through the base of the cover (i.e., interface between compacted layer and the interim cover). A positive value of cumulative volume of water indicates flow into the sub-domain, while a negative indicates flow out of the sub-domain. The models were used to produce graphs showing NP (using nodal data of a subdomain) through the cover profile over the ten years simulation period.

The second indicator that was used is the VWC through the cover. The volumetric water content function describes the capability of the soil/ rock to store water under changes in matric pressures. In other words, VWC describes what portion or volume of the voids remain filled with water as the soil/ rock drains. SEEP/W calculate the VWC for the layer as the soil porosity multiplied by the degree of saturation; in a saturated soil/ rock, all the voids are filled with water and the VWC of the soil/ rock is equal to the porosity.

The VWC graphs were generated using nodal data with a cross section placed through the middle of the cover from surface to the bottom of the cover. Date was output for the first day of each month over the first 2 years of the model simulation (which included extreme rainfall events).

The NP and VWC graphs were generated for each conceptual cover scenario and are presented in **Annex A**. The graphs highlight that there is little or negligible net infiltration though any of the cover configurations and into the underlying interim NAF cover. The VWC plots highlight the ability of the topsoil and the compacted soil/clay layers to retain moisture over extended dry periods relative to the coarse rock layers that are susceptible to drying and thus have limited capacity to sustain vegetation.

9.11 Conclusions

All modelled cover configurations (Option 1A, 1B, and 2), under the applied climatic boundary conditions, were able to inhibit net percolation of meteoritic water from entering the underlying PAF-M waste rock. Net percolation was limited to the top 50-100 cm of the interim cover (NAF rock layer).

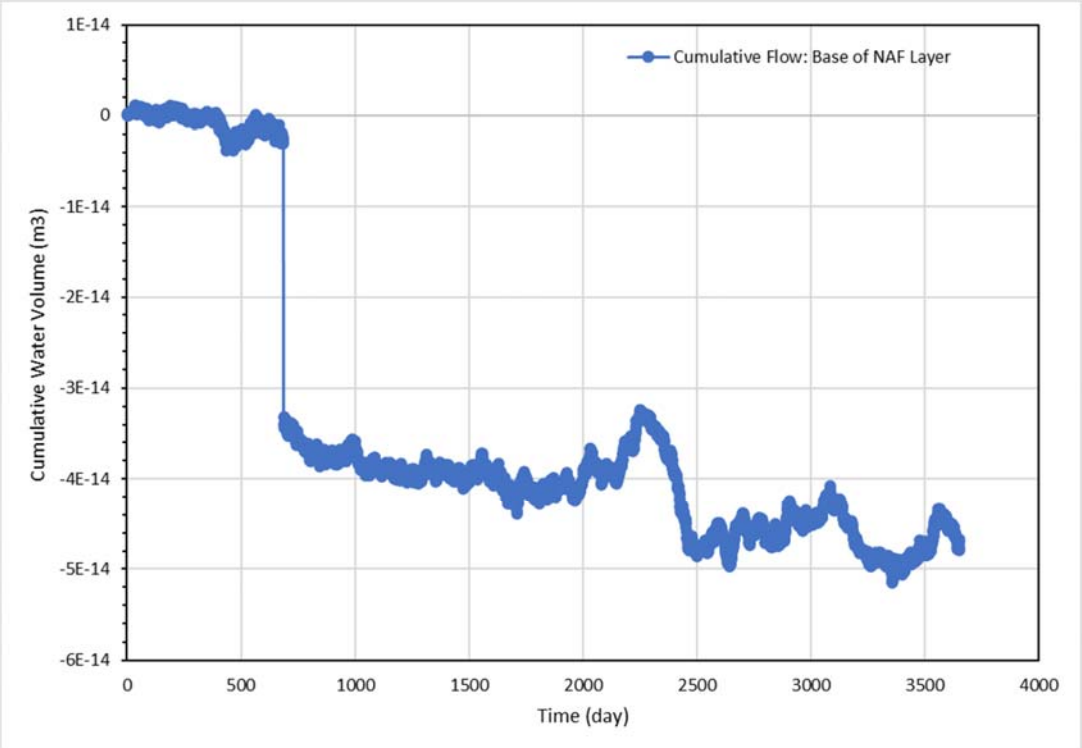
Option 1A shows a greater tendency than Option 1B and Option 2 for larger net infiltration rates through the surface layer due to the absence of the topsoil layer, while Option 2 shows a greater inclination towards encouraging surface runoff due to the succession of the topsoil layer with the NAF regolith oxide layer, both of which are less permeable compared to the coarse NAF rock layer.

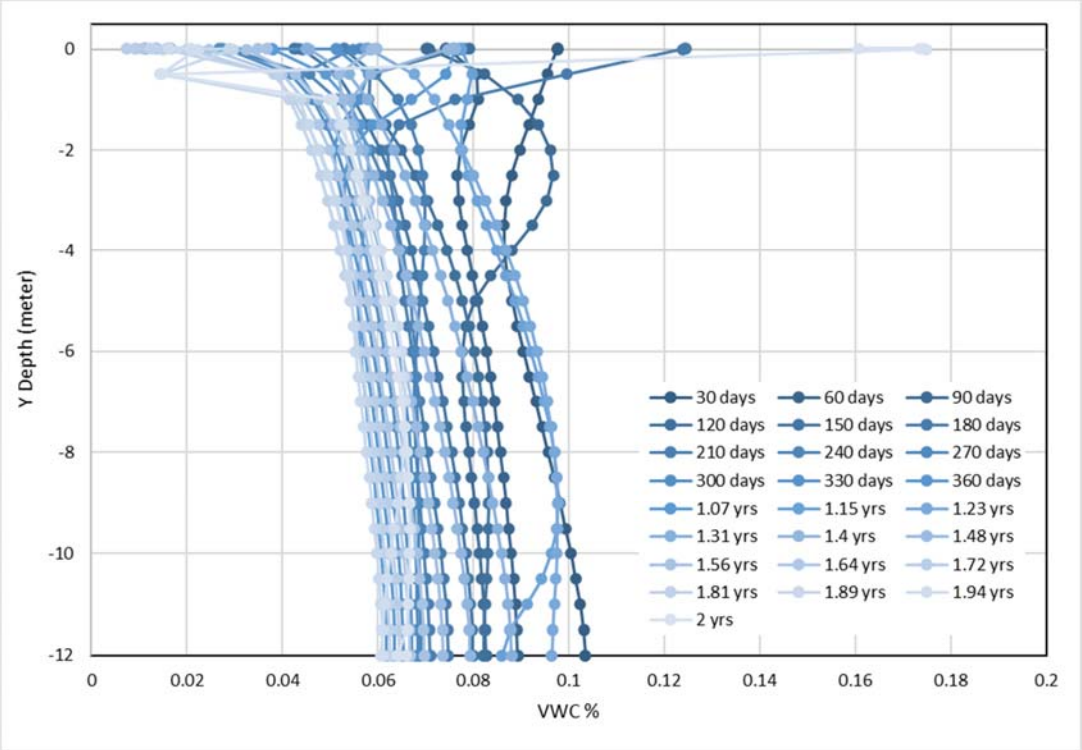
Based on the SEEP/W modelling results, RGS considers that the best option for the top tier cover for the NWRD is Option 1B, as this option (such as Option 1 A and Option 2) displays the ability to inhibit deep percolation of rainfall water even under severe rainstorm conditions. Similarly, Option 1B is distinguished from Option 1A by the presence of a topsoil layer (growing media layer) that is more capable of retaining water - especially during extended dry periods (such as the third (year 4-6) and fourth (years 6-8) time periods modelled), and therefore it is more capable of sustaining vegetation providing a specified vegetation and ecological land use and contributing to erosion resistance.

While Option 2 has the advantages related to the existence of the topsoil cover and is able to sustain vegetation, the lack of competent rock on the exterior is likely to lead to increased risk of erosion over an extended period of time.

9.12 Annex A: Modelling results

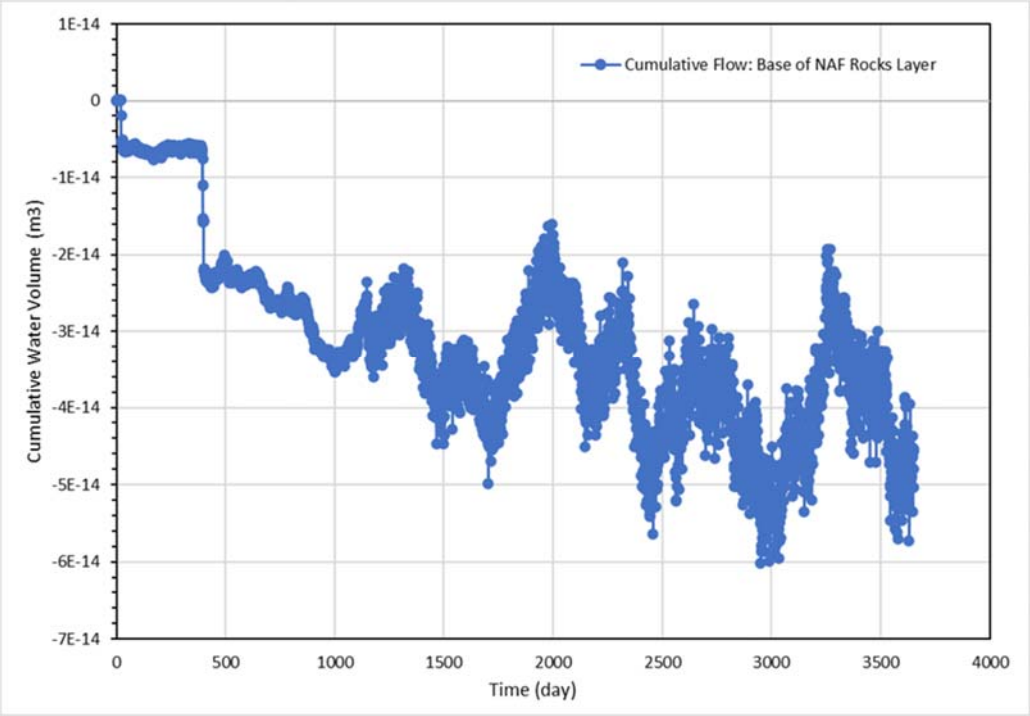
"Base Case" Scenario – No Slope:



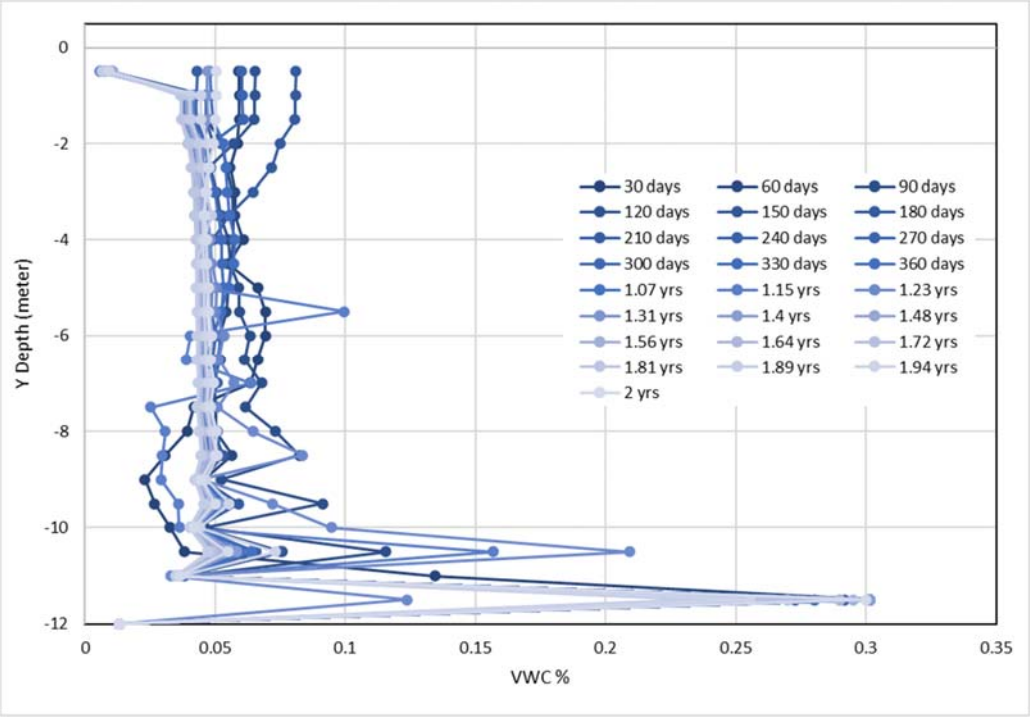


Volumetric Water Content through the cover for Base Case Scenario over a selected time window.

"Base Case" Scenario – 5% Slope:

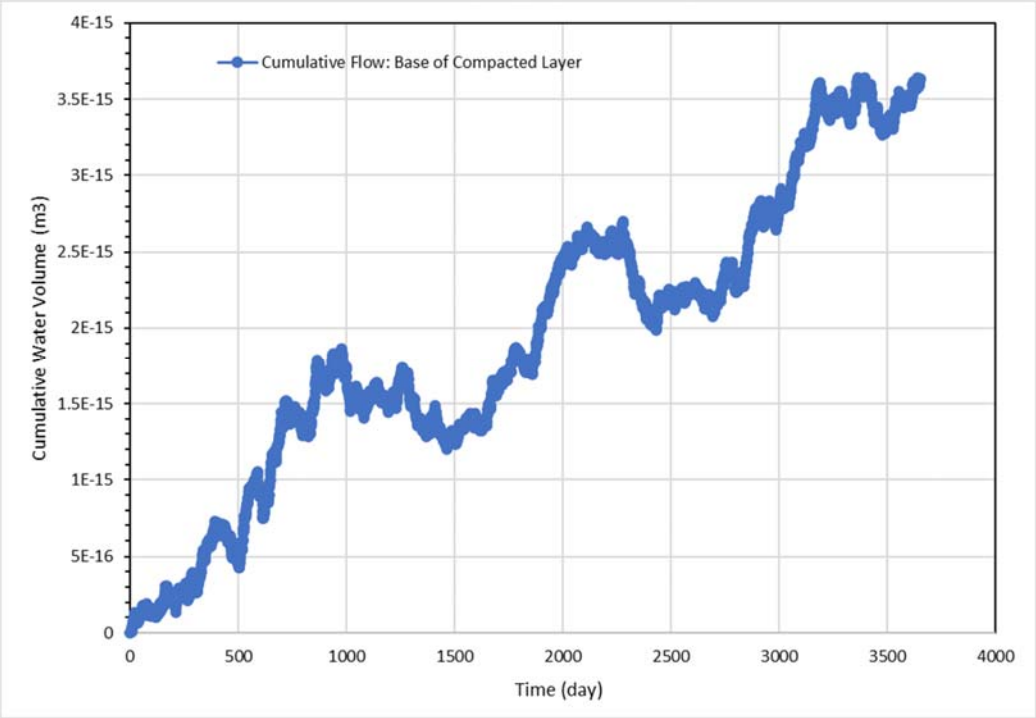


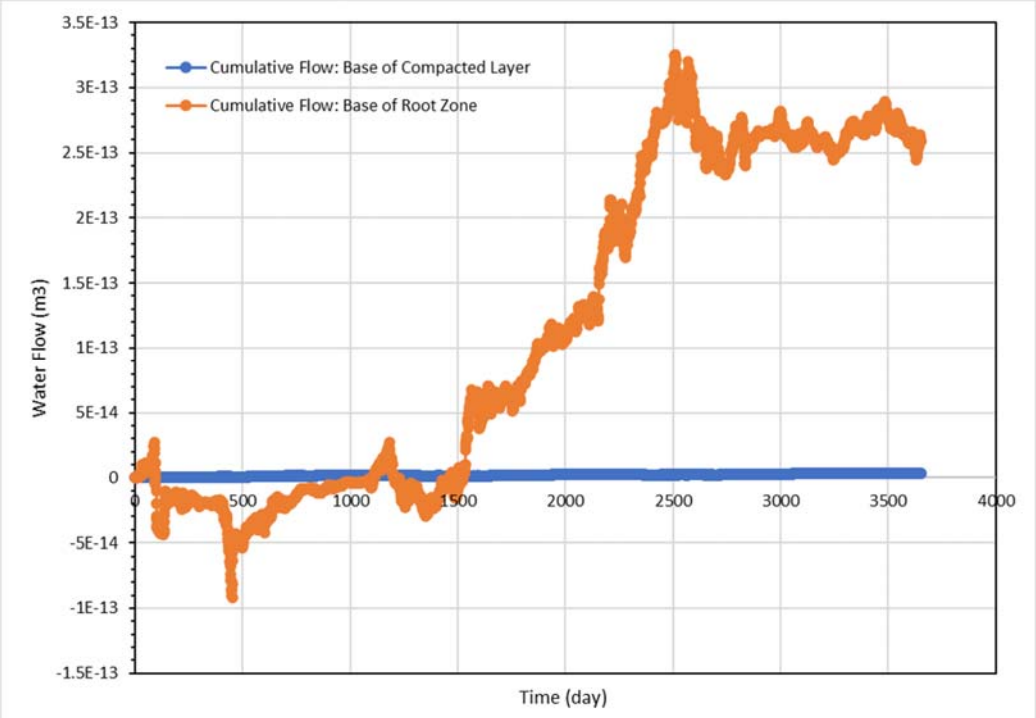
NP- Cumulative Water Volume vs Time at the base of NAF Rocks layer for MRO "Base Case with 5% Slope" scenario.



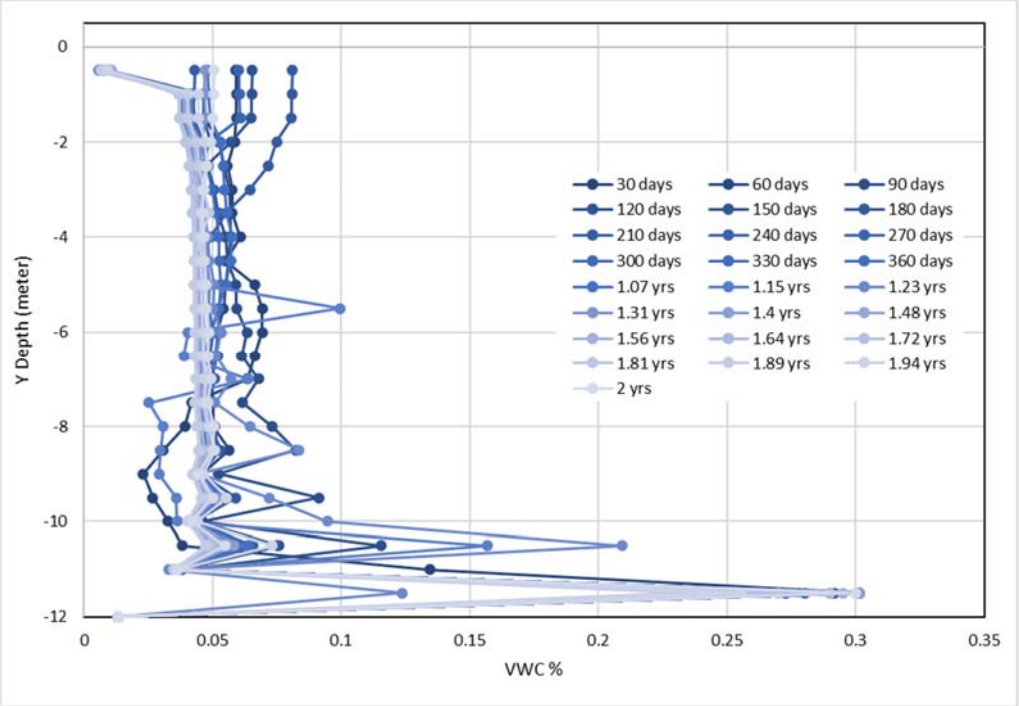
Volumetric Water Content through the cover for Base Case Scenario with 5% Slope over a selected time window.

Option 1A Scenario – No Slope:



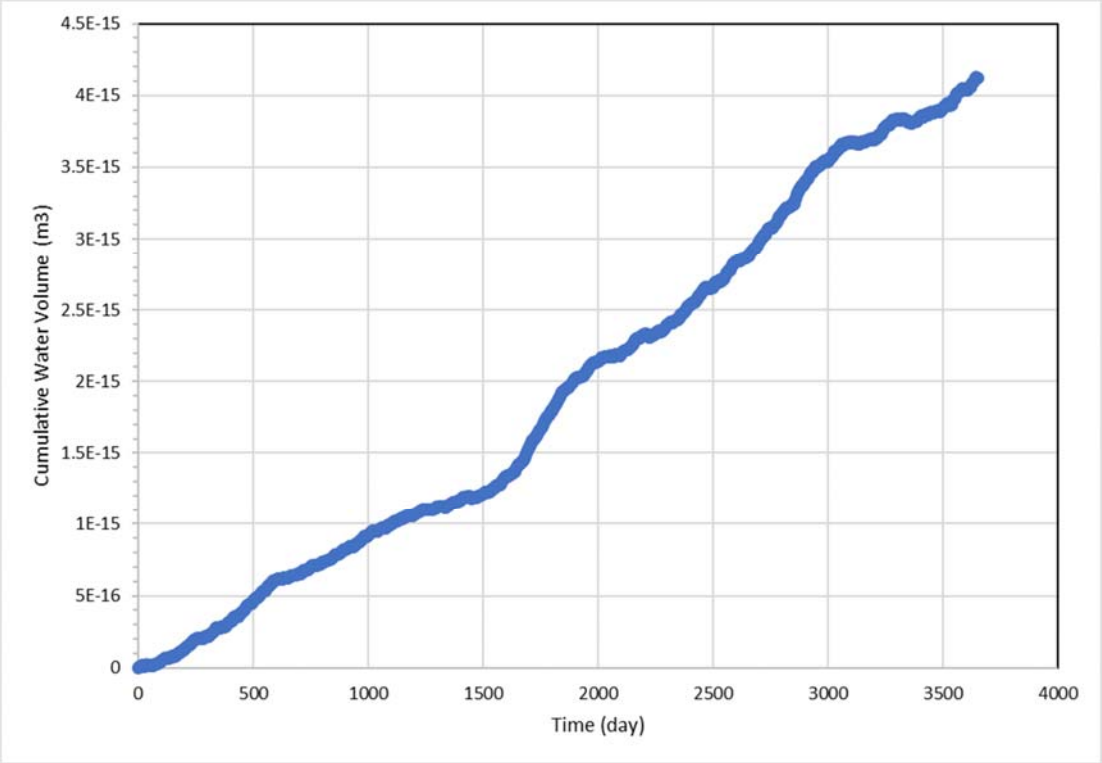


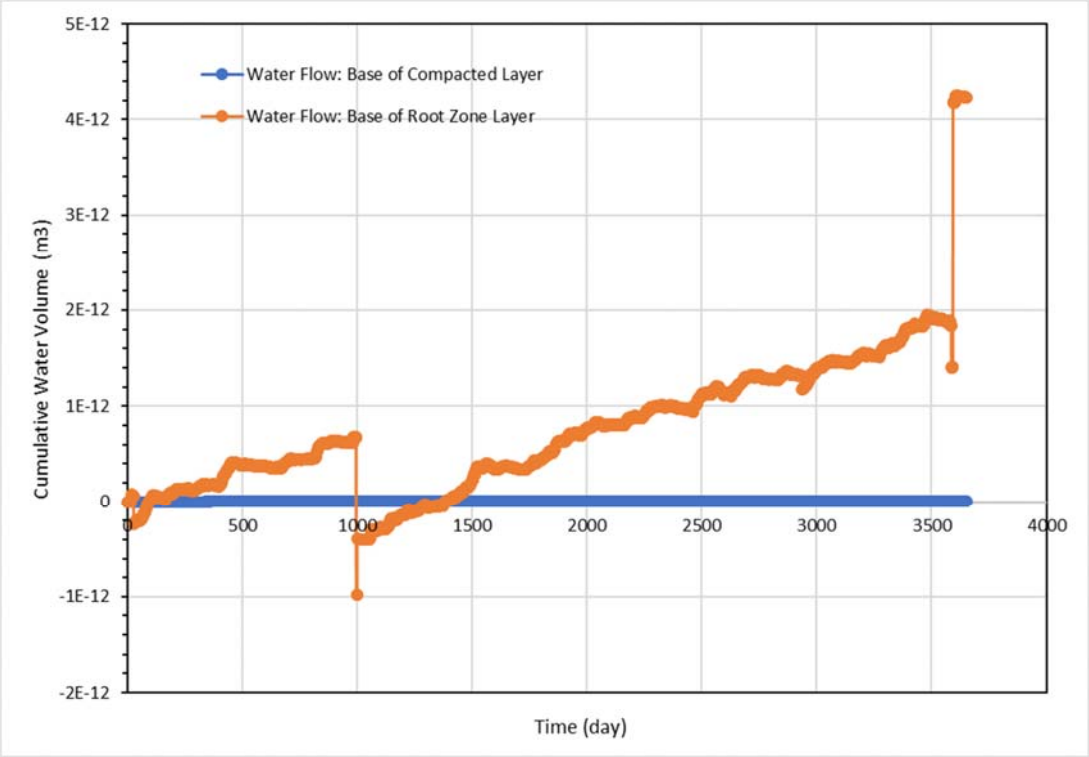
NP - Cumulative Water Volume vs Time at the base of compacted clay/soil (and root zone layer) for MRO "Option 1A" scenario.



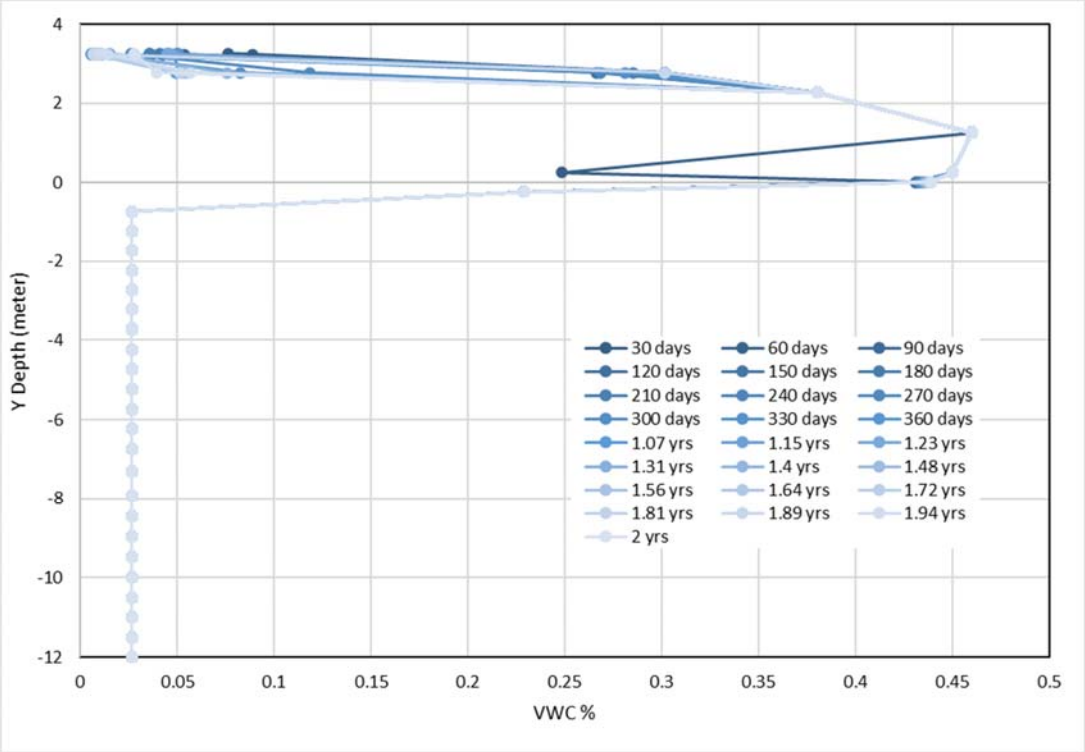
Volumetric Water Content through the cover for Option 1A Scenario over a selected time window.

Option 1A Scenario – 5% Slope (1:20):



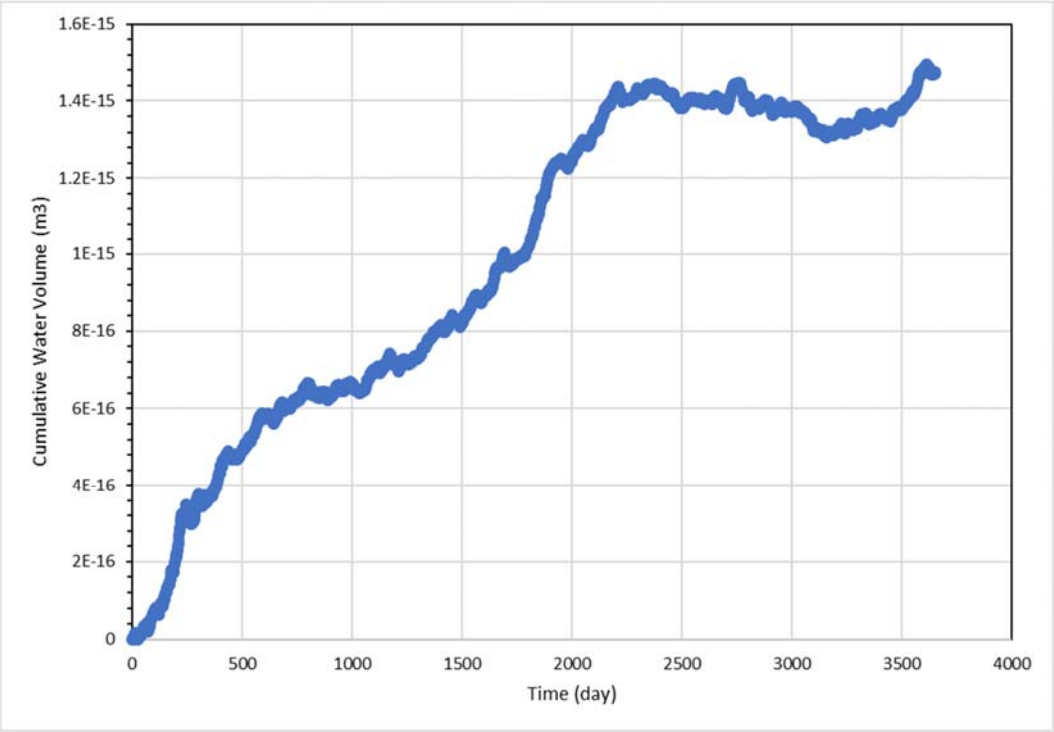


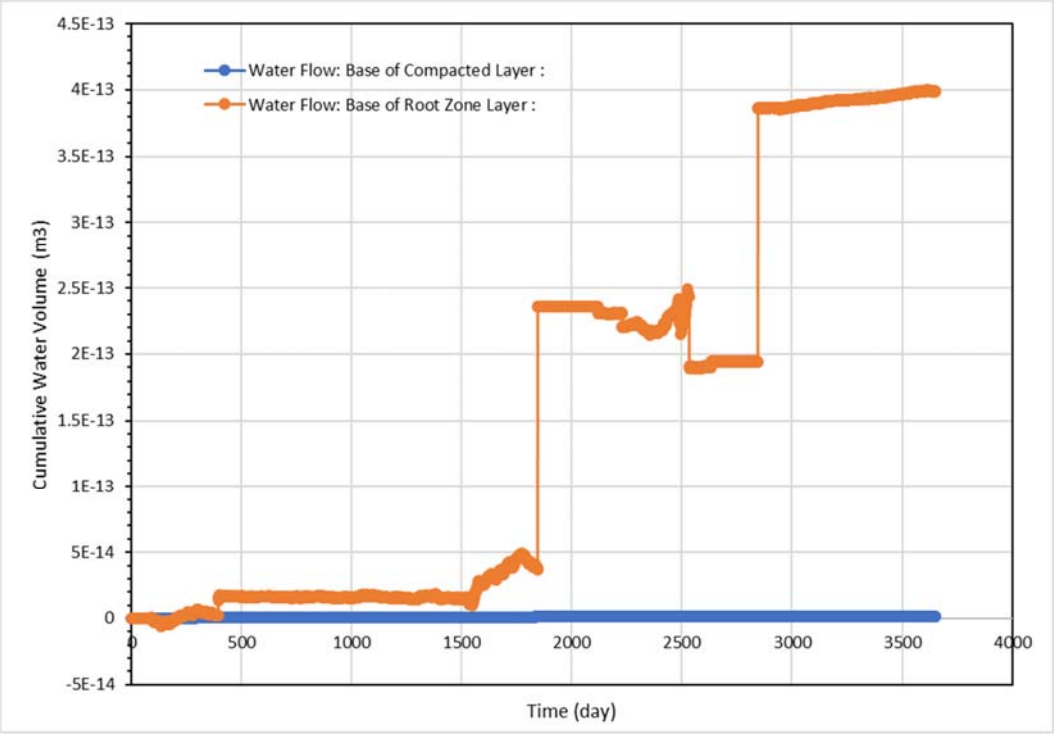
NP - Cumulative Water Volume vs Time at the base of compacted clay/soil (and root zone layer) for MRO "Option 1A with 5% Slope" scenario.



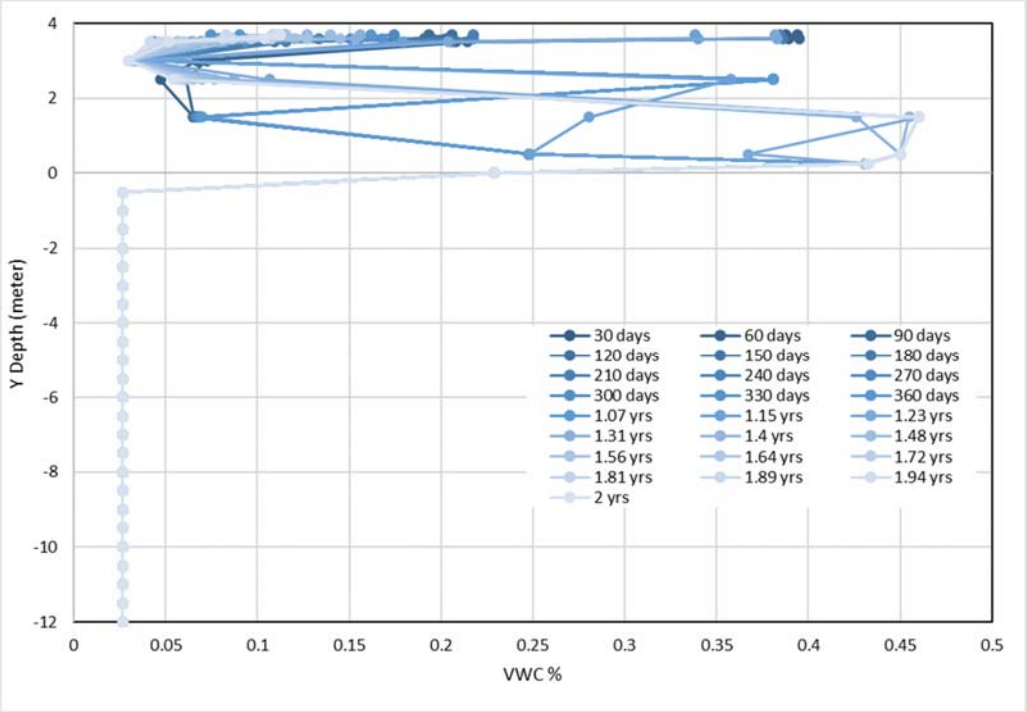
Volumetric Water Content through the cover for Option 1A Scenario with 5% Slope over a selected time window.

Option 1B Scenario – No Slope:



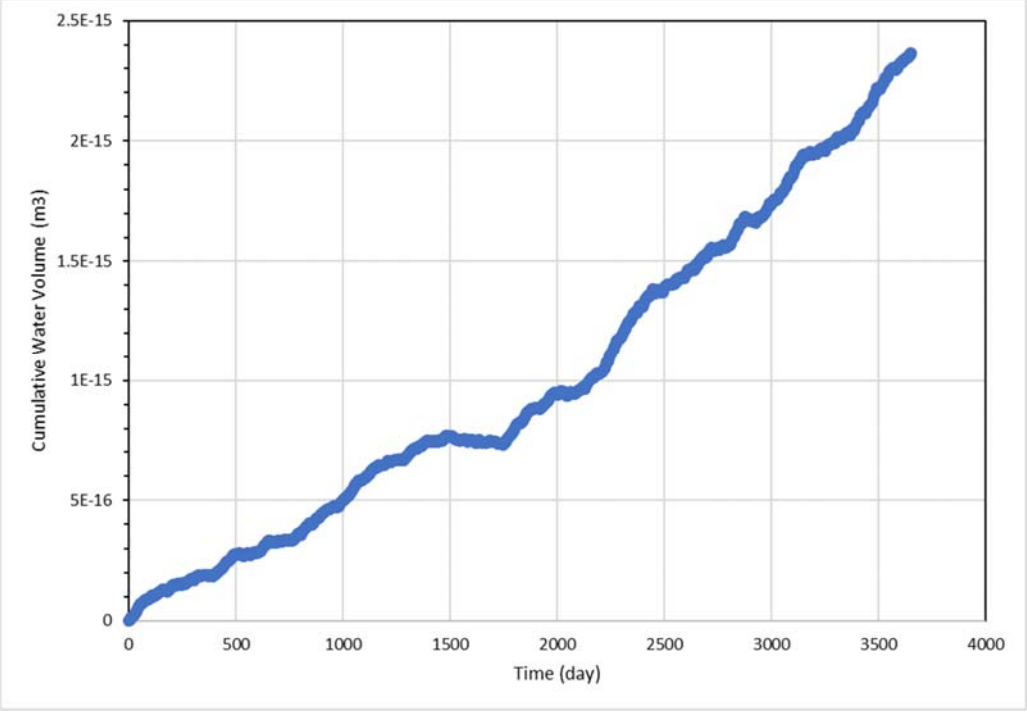


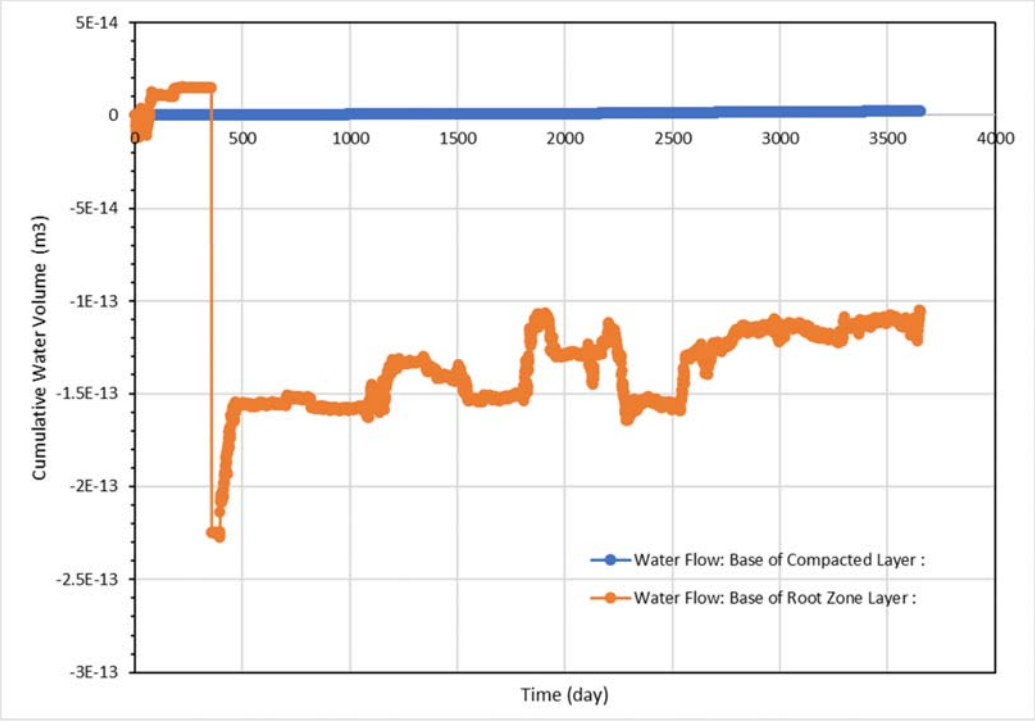
NP - Cumulative Water Volume vs Time at the base of Compacted Clay/Soil (and root zone layer) for MRO "Option 1B" scenario.



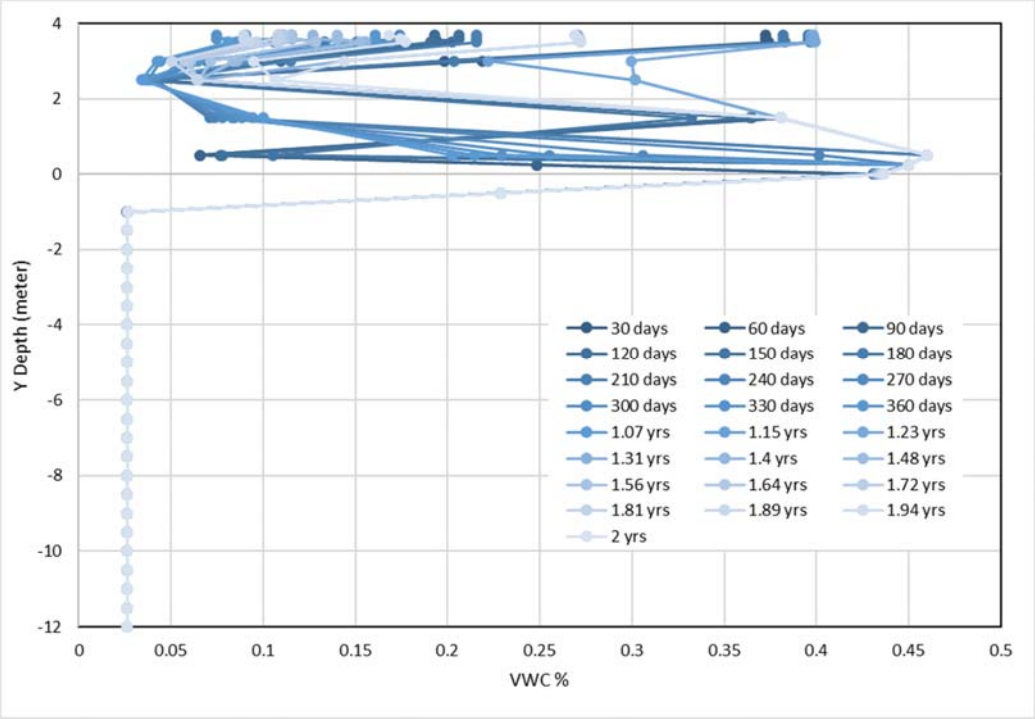
Volumetric Water Content through the cover for Option 1B Scenario over a selected time window.

Option 1B Scenario – 5% Slope (1:20):



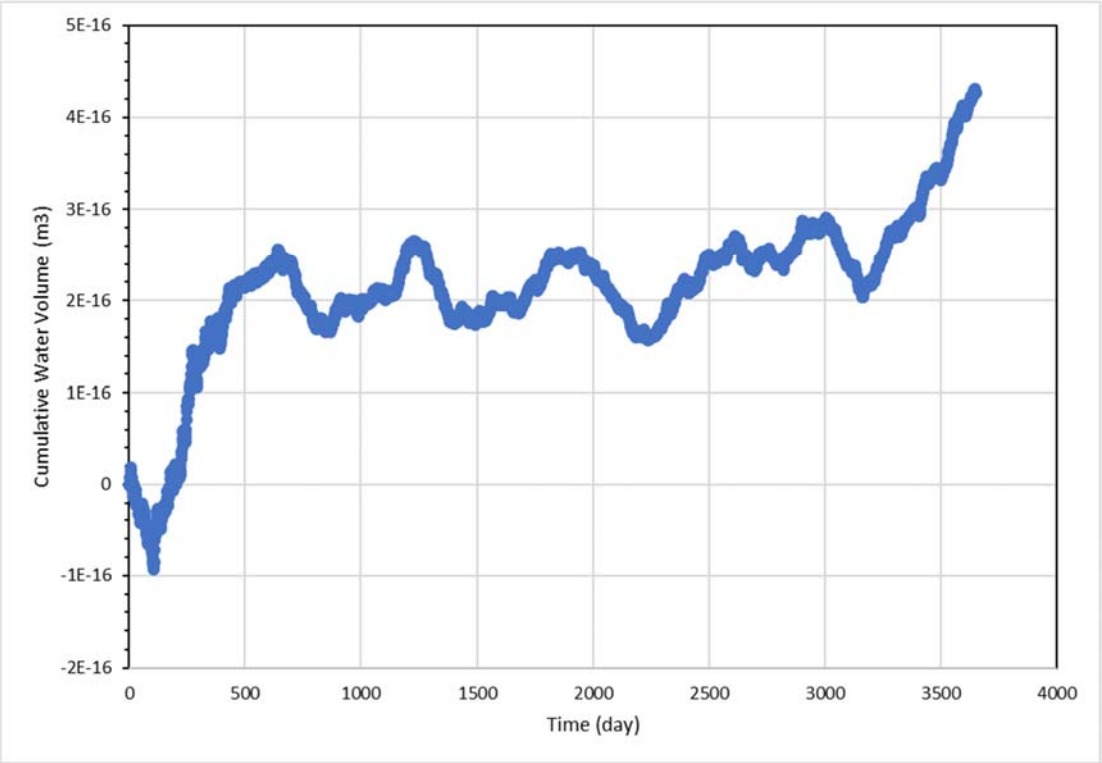


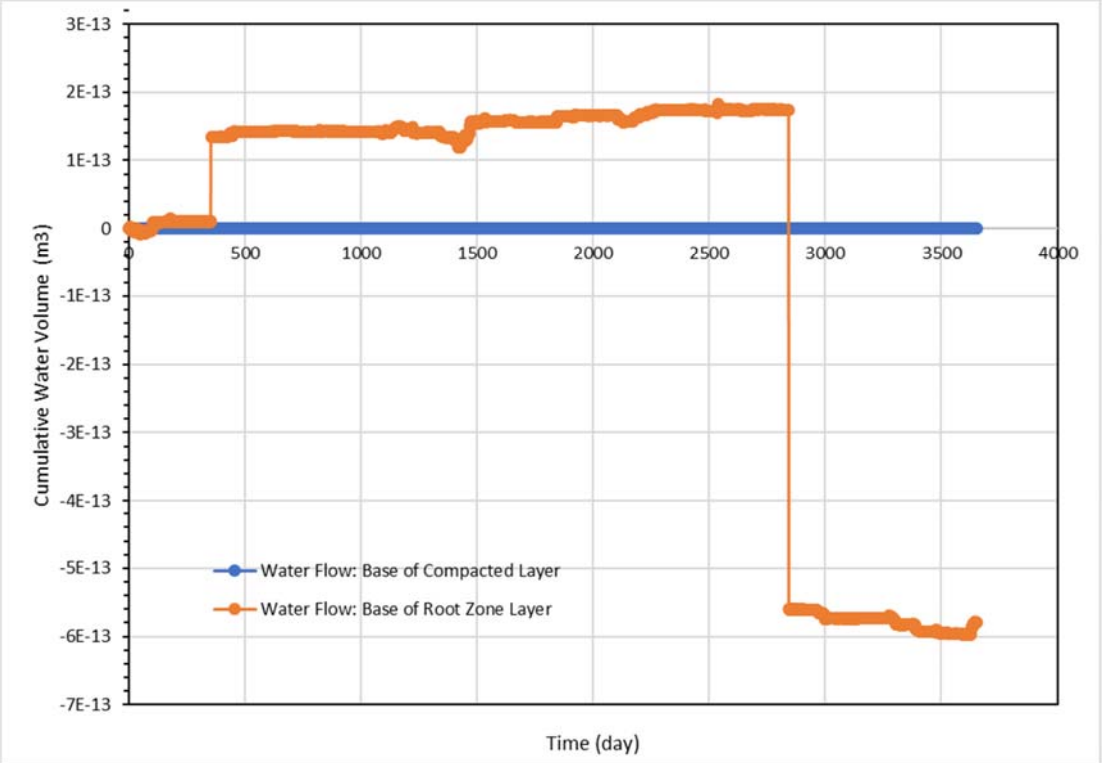
NP - Cumulative Water Volume vs Time at the base of compacted clay/soil (and root zone layer) for MRO "Option 1B with 5% Slope" scenario.



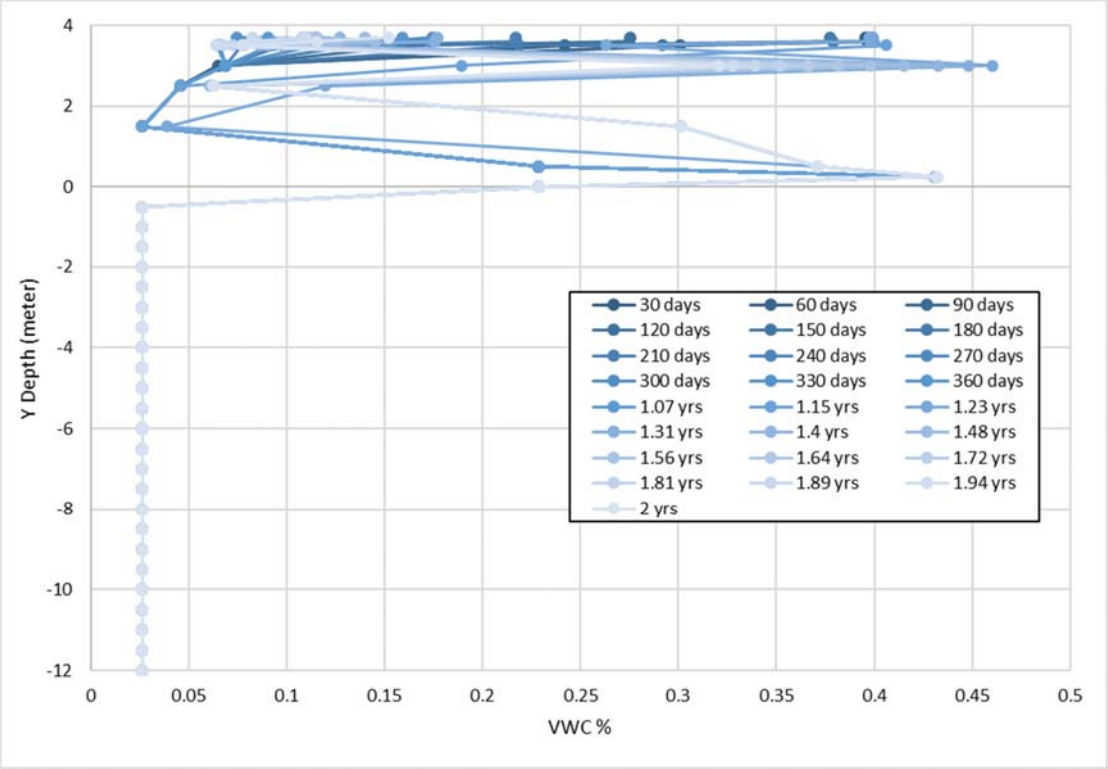
Volumetric Water Content through the cover for Option 1B Scenario with 5% Slope over a selected time window.

Option 2 Scenario – No Slope:



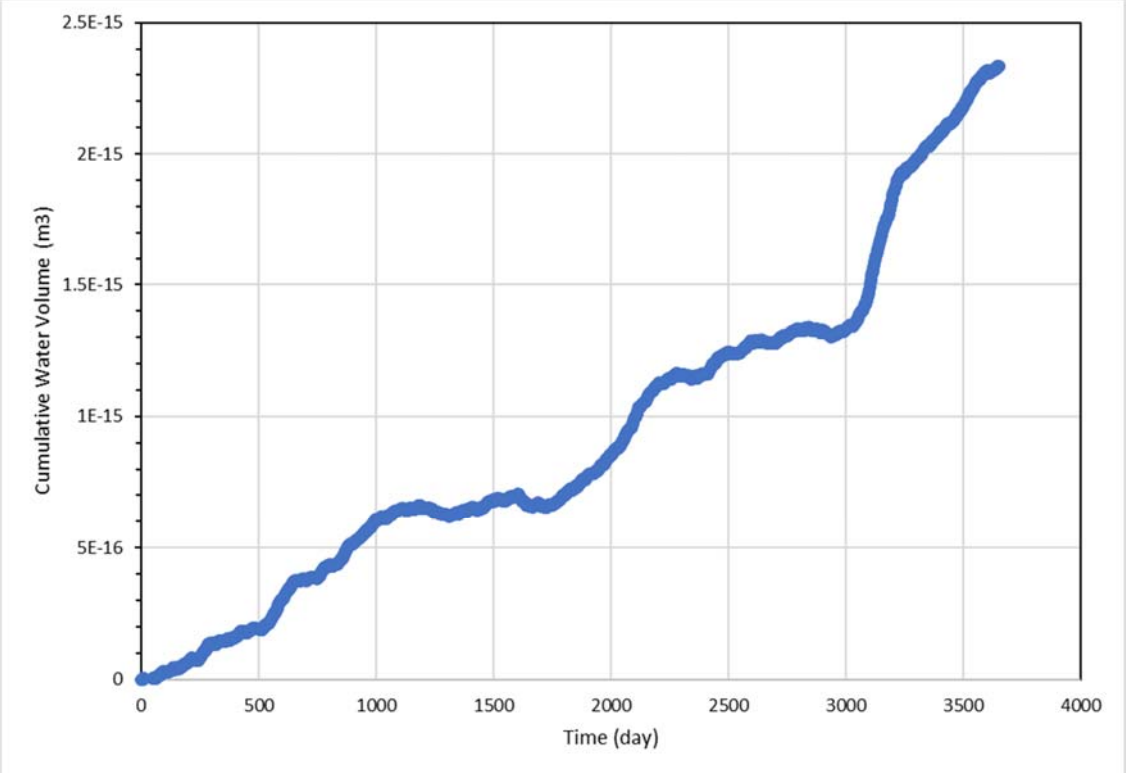


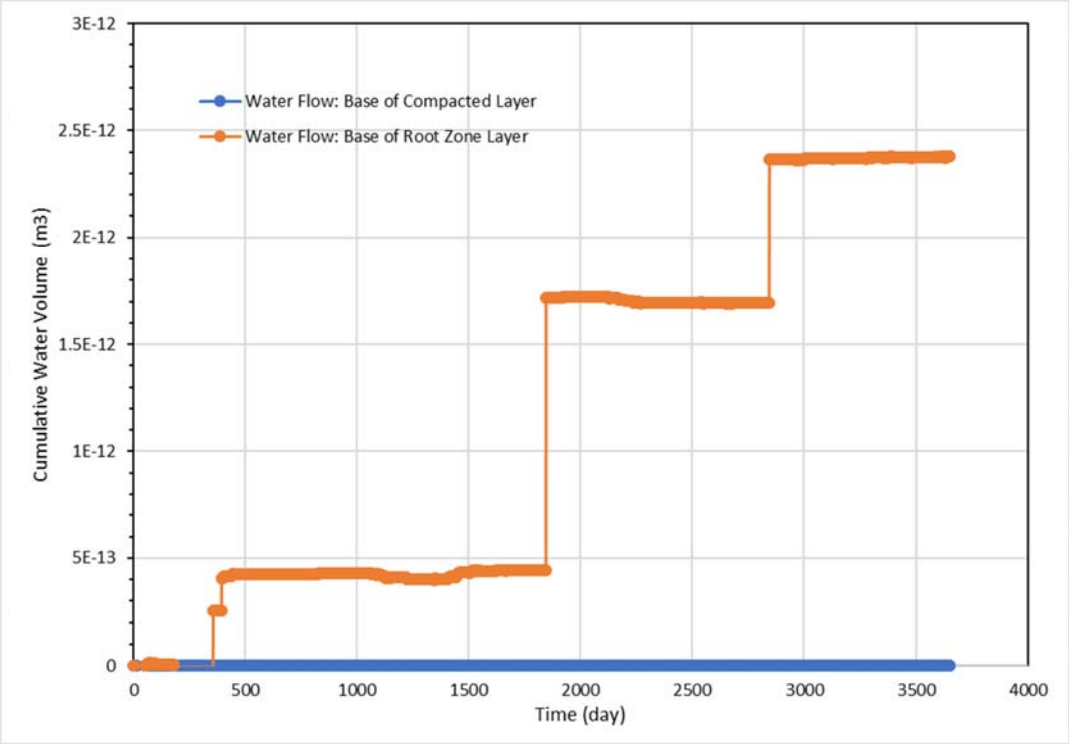
NP - Cumulative Water Volume vs Time at the base of Compacted Clay/Soil for MRO "Option 2" scenario.



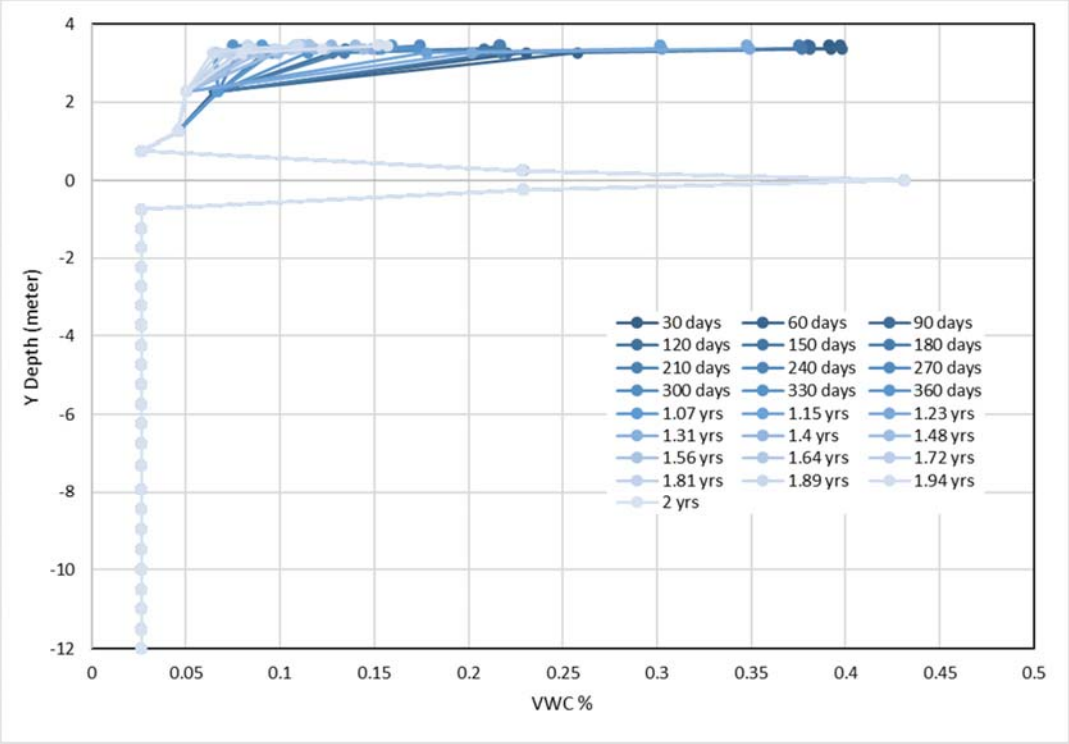
Volumetric Water Content through the cover for Option 2 Scenario over a selected time window.

Option 2 Scenario – 5% Slope (1:20):





NP - Cumulative Water Volume vs Time at the base of Compacted Clay/Soil for MRO "Option 2 with 5% Slope" scenario.



Volumetric Water Content through the cover for Option 2 Scenario with 5% Slope over a selected time window.

10 Attachment C: Cover trial and performance monitoring plan

10.1 Content

This performance monitoring plan includes sufficient information for MRO and DES to understand why cover trials are required, where they may be constructed, and how they could be built and monitored.

MRO will develop a detail design specification for the cover trials to conform with PRC Plan requirements and the needs of MRO.

10.2 Landform and cover design process

Final constructed mine landforms rely on cover systems built from pedolith (topsoil and subsoil), saprolite, saprock and fresh rock to provide overarching rehabilitation goals that enable safe, stable, and non-polluting landforms to be built:

(i) so that surface water running over, and off the surface of the landforms, will retain desired beneficial uses, and

(ii) chemical, physical, and biological weathering of the waste rock within the landforms is minimised so that mine impacted water has a low potential to enter the receiving environment.

Soil cover systems are designed to address specific design objectives e.g. reduce the movement of oxygen into underlying sulfide bearing rock to minimise the potential for AMD, reduce the movement of water into and through the underlying waste rock or provide a surface that is non-erosive and that will support a desired land use.

The design objectives are met by developing a functional design specification (that may utilise measured data or modelled outcomes) e.g. the cover placed over PAF waste will need to reduce the net annual percolation of rainfall by 90 % (for example).

To ensure the functional design specification is attained, the material specifications will need to be defined e.g. the blacksoil will need to have: > 1% TOC, pH > 6.5, EC < 1,500 µS/cm, P100 < 20 mm PSD, > P40 clay, PSD and k_{sat} < $1x10^{-7}$ m/sec.

Soil cover systems are often portrayed as discrete engineered layers of material placed on top of mine waste. Cover systems are however an integrated component of the final landform and must be considered as such. For example, consider a natural geological profile that is an integrated bio-hydro-geo-chemical system that transitions from:

- Pedolith
  - A horizon in the topsoil layer
  - B and C horizons in the subsoil layers
- Saprolith
  - Saprolite (> 20% weatherable minerals altered)
  - Saprock (< 20% weatherable minerals altered)
- Bedrock

10.2.1 Material specification

RGS is completing organic, geochemical, and physical material specification work on topsoil, subsoil, saprolite, saprock and fresh rock samples from down gradient of the TSF and West Hill at MRO. The analytical program includes measuring erosion rates and surface water quality from these material under 5%, 10% and 20% slopes and 30, 60 and 90 mm /hour rainfall events. The results from the 3 m x 1 m flume measurements will be used to model probable erosion rates for these materials for design rainfall events and long-term landform evolution.

The material specifications and erosion report will be appended to a revision of this Management Plan when the work is completed (nominally end of Q2 2023) (**Attachment A**).

10.2.2 Design objectives for the NWRD

Some of the key design objectives of the cover system on the NWRD include the following.

- Maximise surface runoff off the top of the cover system
- Store water within the cover system to support vegetation
- Minimise the ingress of air and water through the cover into the underlying waste rock to minimise sulfide oxidation rates and percolation of water into the WRD.

10.2.3 Functional design specification

A functional design specification is developed using the material specification and SEEP/W (GeoStudio, 2018) modelling included in the *Cover Design Report* (**Attachment B**).

10.2.4 Cover configuration options

RGS has used the Deswik.LHS outcomes for the WOM and LOM planning to verify the material balance that is available to complete all site rehabilitation work.

The material balance and previously measured data of site materials was used to identify five cover configurations that could be built on the NWRD (**Figure 4-8**).

10.2.5 Cover system modelling using SEEP/W

The cover water balance for the various cover configurations were evaluated using SEEP/W. The outcome of the modelling work indicates that Option 1B (**Figure 10-1**) is likely to provide the best outcome and address the design objectives for the NWRD.

The SEEP/W modelling provides a probable range of outcomes based on measured, inferred or indicated data including highly variable and uncertain climate inputs.

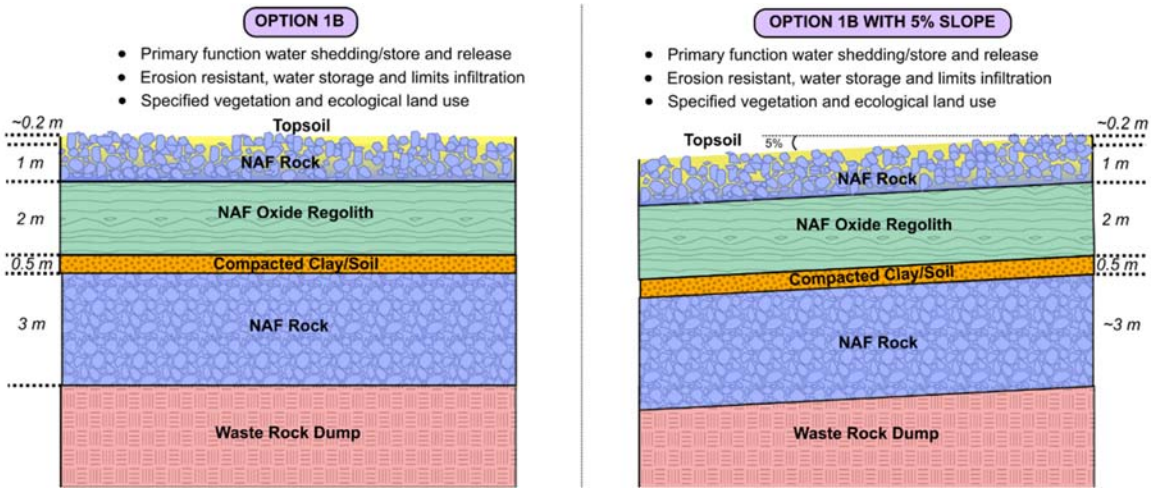


Figure 10-1: Preferred cover system outcome design for the NWRD

10.3 Performance monitoring

10.3.1 Requirement

The design process in **Section 10.1** will lead to an optimised design based on available knowledge. The performance monitoring program is used to verify the reliability of the design process.

The PRC Plan includes recommendations for rehabilitation field trials and performance monitoring to verify that proposed rehabilitation plans will be effective and address the rehabilitation goals.

Performance monitoring is done to evaluate the performance of a cover system(s) using appropriately sized and designed pads to quantify the performance of:

- cover components such as;
  - site based erosion trials to verify surface runoff and erosion rates for different soils or cover options such as the top of the cover in Option 1B;
  - field based and field scale material handling and compaction, density, and permeability measurements of discrete layers within a cover system;
- cover configurations e.g. **Option 1B** in **Figure 8-1**.

10.3.2 Components

The key components of landform design and cover system performance include the following:

- Climate
- Stability
- Material handling
- Material specification
- Surface hydrology
- Vadose hydrology
- Ecology

10.3.2.1 Climate

The project area is affected by La Nina and El Nino weather patterns that induce below average and above average climate patterns. The site is also exposed to significant rainfall intensity and duration events that can exacerbate instability and erosion.

Field trials that are seeking to verify the environmental performance of a cover system can rely on naturally occurring climate conditions or the trials can be established with engineered solutions (irrigation) that enable simulated rainfall events to be used on the field trails. Relying on natural rainfall events can pose problems for the site e.g. if the trials are set up during the commencement of an extended dry weather cycle it may take many years to collect sufficient data to verify how the cover is performing.

Establishing the field trails with an engineered irrigation system enables prescribed rainfall intensity – frequency – duration events to be evaluated and enables the duration of the performance monitoring program to be done under controlled conditions in a much shorter time frame

10.3.2.2 Sizing and stability

Any field trials need to be scaled and designed to accommodate the objectives of the trials. Geotechnical stability and assessment should be done to verify the designs will not induce failure of the landforms they are built on and will be stable in their own right.

10.3.2.3 Material handling

Key objectives of field trials should be to verify the following.

- Will the materials being sourced for the cover system be;
  - homogenous and contiguous (can be dug, hauled, and placed) without material handling; or
  - heterogeneous and disconnected that might require a borrow material to be crushed, screened and graded?
- What equipment would be used to build an engineered cover system and how will the choice of the equipment affect the build?

- Many cover studies assume mining fleet would be appropriate but building discrete compacted layers (e.g. 0.25 m) might require placement of material using small dump trucks, movement of material using GIS graders and one or more passes with specific mechanical compaction.

These aspects will have a direct (and potentially significant) effect on the haulage cycles, build time and the cost.

10.3.2.4 Material specification

Cover materials were sampled and analysed by RGS in 2016 to develop conceptual cover designs for the TSF.

Bulk ($1m^3$) samples were obtained from test pits in Q3 2022 and have been analysed for organic, geochemical and physical properties to verify the material properties. These samples are also being used to verify erosion rates and water quality under as-placed and compacted conditions.

The measured data from 2016 and 2022 will be used to document the material specification for these samples.

The measured data are however constrained by practical limitations. For example, rock > 75 mm particle size distribution (PSD) is excluded from erosion flume tests and the geotechnical labs use < 20 mm PSD fractions for some measurements (e.g. permeability) or < 2 mm PSD fractions for methods including soil water characteristics.

The field trails enable the material specification process to be scaled up to actual conditions in the field and quantify (for example); the actual PSD of material coming out of a borrow area; the density that can be achieved from as-placed material or compacted material; field permeability; and importantly the inherent variability of the materials being sourced for construction of the cover system.

These measured values from the field are used to verify actual material specifications and then enable the calibration of numerical models to be corrected.

10.3.2.5 Surface hydrology

Rain falling on the surface of the cover system has the capacity to infiltrate the surface material: this is termed **infiltration**.

Water that does not infiltrate the surface material runs over the surface material: this is termed **surface runoff**.

Field trials should be used to verify the hydraulic assumptions from (i) the laboratory scale water quality and erosion measurements and modelled forecasts, and (ii) the cover water balance outcomes from the SEEP/W numerical modelling.

Field trials verify the following.

- How much rain runs off the surface for:
  - discrete (single) rainfall IFD events after the field trial has been built, and
  - for different rainfall IFD events – over a number of years as the soil cover system settles, consolidates and evolves as a bio-geo-chemical system.
- Changes in surface water quality over time e.g. pH, EC, major ion and metal(loid) concentrations in unfiltered fractions (including suspended and bedload sediment) and 0.45µm filtered fractions.

10.3.2.6 Vadose hydrology

The infiltration of water into the surface material changes the soil moisture and when there is enough water in the solid phase it can percolate through the material to deeper layers in the cover system and the landform: this is process is termed **percolation**.

If the percolating water moves out of the cover material or the landform it becomes **seepage.** If the flow rate is sufficient for the water to flow, the seepage, then becomes **surface runoff.** The percolation of water through the vadose (unsaturated) zone may move the water to a saturated zone: this water is termed **groundwater**.

Vadose water is the water that occurs in unsaturated zones, and moves into, through and out of the regolith. The field trails are established to verify vadose functions in the cover system.

- How much of the rain is retained in the cover system over time and how much is lost via surface evaporation or transpiration.
- How much of the water falling on the cover system percolates through the cover system into the underlying waste rock / tailings.
- Changes in seepage water quality over time e.g. pH, EC, major ion and metal(loid) concentrations in unfiltered fractions (including suspended and bedload sediment) and 0.45µm filtered fractions.
- Changes in the distribution of major ions and metal(loids) in the profile over time e.g. movement of major ions (e.g. salts) upwards into the soil from capillary rise – or flushing of these elements out of cover.

Vadose hydrology is a complex technical aspect of cover system design that determines where the water inside the cover system and the underlying landform end up: key terms are defined in the following sections.

10.3.2.6.1 Porosity and permeability

Porosity is defined as the volume of open spaces, or pores, between the solid mineral components that make up a rock or unconsolidated sediment, and is expressed as a percentage. **Saturation** is the threshold at which all the pores (empty spaces between the solid soil particles) are filled with water. The volumetric water content (**VWC**) at this threshold varies from 30 percent in sandy soils to 60 percent in clay soils. The soil matric potential (**SMP**) at saturation is less dependent on soil texture and is close to zero, indicating that there is minimal restriction to water movement and plant roots can extract water from the soil with minimum energy.

Effective porosity refers to how well interconnected the pore spaces are in a block of rock or sediment; like porosity, effective porosity is expressed as a percentage of the total rock or sediment volume. Higher effective porosity results in higher permeability.

Permeability is generally understood to mean the ability of a fluid to pass through another object or substance. Permeability is an intrinsic property that is difficult to measure, and is considered as "hydraulic conductivity[1]," the more precise term that geologists use to describe the ease with which a specific fluid, such as water or petroleum, will flow through a body of rock or sediment under saturated conditions and a uniform hydraulic gradient.

10.3.2.6.2 Water fractions

Field capacity (FC) is the threshold at which water in larger pores has been drained away by the force of gravity. An irrigation application depth that causes the soil water curve (**SWC**) to go above FC is not desirable, because the additional water will percolate to deeper layers and will not be available to plant roots. At FC, the water content of the soil is considered to be ideal for crop growth. Thus, FC is usually considered as the upper threshold for irrigation management. Most agricultural soils reach field capacity one to three days after an irrigation or rainfall event. At this threshold, typical VWC varies from 20 percent in sandy soils to 40 percent in clay soils. Typical value of SMP at field capacity varies from 10 kPa to 33 kPa. When salinity is a concern, increasing SWC to levels above FC may be appropriate to leach salts below the root zone.

[1] 1) "**Permeability**" in a qualitative sense describes a soil's capacity to transmit fluids, including water, or gases. No quantitative measure is implied. For example, sandy soils are more "permeable" than clayey soils.

2) "**Permeability**" (**k**) (Richards, 1952) (also known as intrinsic permeability) is an exclusive, quantitative porous material parameter controlled by pore geometry. In a stable porous material, (k) is independent of the fluid. Permeability (**k**) is the hydraulic conductivity (**K**) times the fluid viscosity (**n**) divided by the fluid density (**ρ**) and the gravitational constant (**g**). Permeability (**k**) has area units (e.g., m^2).

3) "**Permeability**" is short for permeability coefficient, which is **hydraulic conductivity (K)**, or in saturated soil ($\mathbf{K_{sat}}$). The Darcy equation quantitatively defines hydraulic conductivity (K) as the factor that relates flux (q) to the hydraulic gradient (Δh/l). Ksat depends upon both soil and fluid attributes. Measurement units for Ksat depend on the input units. With flux expressed as volume (cm^3), head change (Δh) as cm (cm H_2O/cm), and length as cm, the Ksat units are length/time (cm/s). Note that both variables q and K have units of length/time (cm/s), but they are distinctly different entities. Flux (q), when expressed as length/time, is an apparent rate that varies with Δh/l. Ksat is a proportionality factor that relates q to Δh/l. Ksat remains constant when the hydraulic gradient (Δh/l) varies. It is a physical parameter, not a rate.

Permanent wilting point (PWP) is the threshold where it becomes impossible for plants to extract water at a rate fast enough to keep up with their water demand. At PWP, soil particles hold the water so strongly that it becomes difficult for plant roots to extract it. At this threshold, transpiration (water use by plants) and consequently other processes vital to plant survival come to a near stop. This causes a significant reduction in vegetation growth and biomass production. If SWC remains below the PWP for an extended period, the plant will eventually die. Irrigation should be applied well before SWC starts approaching the PWP. The value of PWP varies with the type of plant, soil and climate, ranging from 7 percent in sandy soils to 24 percent in clay soils when expressed in VWC. The soil matric potential at this threshold ranges from 500 to 3,000 kPa. The value of 1,500 kPa is usually considered as the average SMP at PWP for most agricultural soils.

Total available water (TAW) is the total amount of water available to plants, estimated as the difference between soil water content at FC and PWP. Above FC, water is available to plants only for a short period of time (one to three days), then lost to drainage. Below PWP, plants cannot apply enough force to extract the remaining water. Thus, SWC outside this range is considered not available to plants. Sandy soils cannot hold a large amount of water and have the lowest amount of TAW, whereas, medium texture soils, such as silt loam and silty clay loam have the largest TAW. Therefore, sandy soils need to be irrigated more often than loam soils. Although plants can extract water in the full TAW range, stress occurs before SWC approaches PWP. Water must be applied at a SWC level above PWP to avoid water stress in plants.

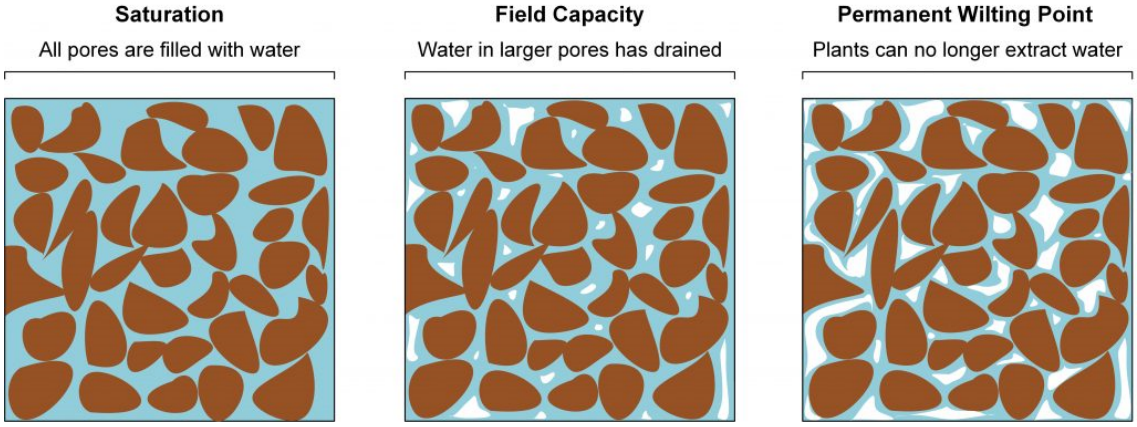


Figure 10-2: Soil water content at saturation, field capacity and permanent wilting point thresholds.

10.3.2.6.3 Water retention

Water retention is defined as the soil water content at a given soil water suction. By varying the soil suction and recording the changes in soil water content, a water retention function or soil water curve is determined.

This relationship is dependent on particle-size distribution, clay mineralogy, organic matter, and structure or physical arrangement of the particles as well as hysteresis, i.e., whether the water is absorbing into or desorbing from the soil. The data collected in these methods are from water desorption.

10.3.2.6.4 Soil water characteristic curve (SWCC)

Soil water characteristic curves (SWCC), also known as a water retention curve, are useful directly and indirectly as indicators of other soil behaviour traits, such as drainage, aeration, infiltration, plant-available water, and rooting patterns.

The SWCC contain important information regarding the amount of water contained in the pores in any soil suction situation and the pore size distribution related to the stress state in the soil-water (availability of water to the plants) as well as considered the source of the key soil information required for the analysis of seepage, shear strength and volume change problems involving unsaturated soils.

The SWCC shows the relationship between matric suction and water content. It is used to determine the hydraulic and mechanical behaviour of unsaturated soils and to help predict water storage.

A SWCC is important in terms of agriculture, soil science, geotechnical and geo-environmental engineering. Their measurement, however, is challenging, expensive, and time-consuming; therefore, many empirical models such as Gardner (1958) and van Genuchten (1980) have been developed to describe the SWCC.

10.3.2.6.5 Volumetric water content (VWC)

The volumetric water content (VWC) is the ratio of the volume of water to the unit volume of soil. Volumetric water content can be expressed as ratio, percentage or depth of water per depth of soil (assuming a unit surface area), such as inches of water per foot of soil. For example, if the volume of water is 20 percent of the unit volume of soil containing it, the VWC can be reported as 20 percent, 0.20 (ratio).

10.3.2.6.6 Soil matric potential (SMP)

Soil matric potential is sometimes referred to as tension or pressure head (ψ, hPa), is the cohesive attractive force between a soil particle and water in the pore spaces in the soil particle/water/air matrix. Typical ranges are 0 to 10,000,000 hPa where 0 is near saturation and 10,000,000 hPa is dryness. The drier the soil the more energy it takes to pull water out of it. Capillary forces are the main force moving water in soil and it typically will move water into smaller pores and into drier region of soil. This process is also called wicking.

Because of the wide pressure ranges that can be observed from very wet to very dry conditions, matric potential is often expressed as the common log of the pressure in hPa. The log of the pressure is called pF. For example 1,000,000 hPa is equal to a pF of 6. Water potential is highly texture dependent. Clay particles have a larger surface area and thus will have a higher affinity for water than that of silt or sandy soils. The most common methods for measuring or inferring the matric potential include granular matrix sensors such as gypsum electrical resistance blocks, and tensiometers which measure pressure directly. Matric potential is important for irrigation scheduling because it can represent the soil water that would be available to vegetation. Many unsaturated flow models require a soil water curve where water fraction by volume is plotted with the matric potential in a range of moisture conditions. A soil water curve can help understand the movement and distribution of water such as infiltration rates, evaporation rates and water retentions (**Figure 10-3**).

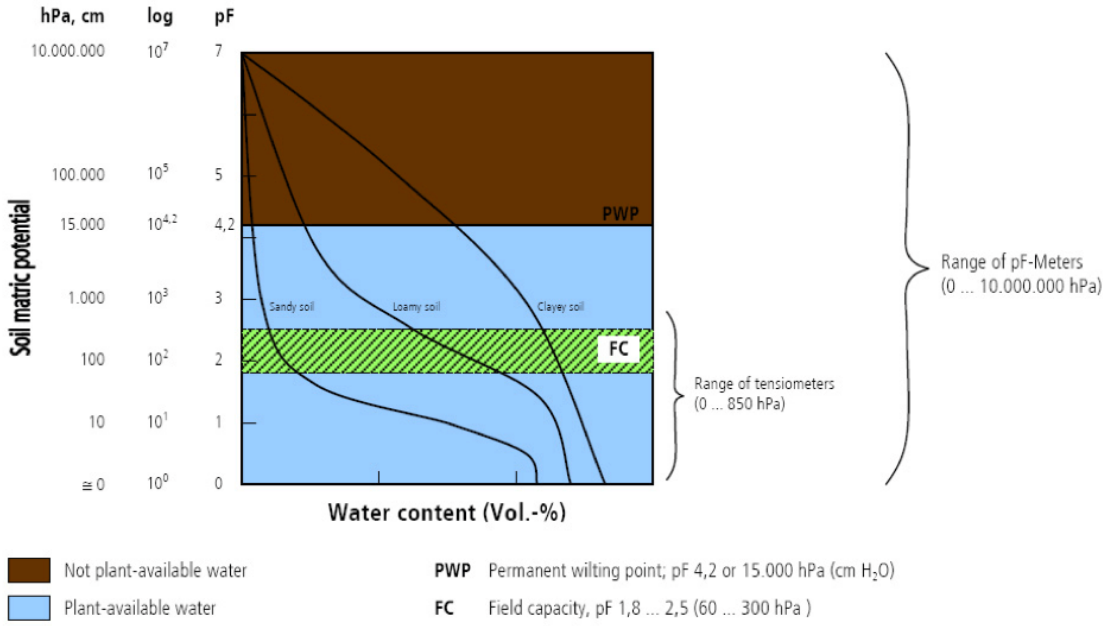


Figure 10-3: Soil water retention curve: soil matric potential verses soil moisture

10.3.2.7 Ecology

In cases when the cover system is developed to support an ecological function (e.g. managed grazing or low-moderate-high biodiversity) the vegetation itself will affect the cover design over time.

Key changes that occur over time that need to be monitored include:

- biomass production above the soil
- changes in species diversity and abundance
- root depth and root biomass in the cover system
- transpiration
- nutrient cycling into and out of the cover
- effect of bioturbation on the physical properties of the cover materials (e.g. termites, wombats).

One of the primary objectives of a cover system may be to support vegetation, but if the cover overlies reactive mine waste (AMD materials) the cover must be deep enough to (i) support the root system of the vegetation so it is not adversely affected by acid (for example) and (ii) be deep enough to support the biomass (e.g. if large trees are going to colonise the landform through successional development the cover has be deep enough to support the trees so they do not fall over and rip up the cover.

10.4 Cover trial design options and locations

10.4.1 Cover trial – level of design

The NWRD and TSF cover designs are considered by RGS to be at PFS level because:

- Material locations have been identified (but not confirmed).
- Material specifications have been determined in 2016 and more work is being done in 2022.
- Material balances required have bene quantified.
- Material scheduling has been confirmed to be viable.
- Numerical modelling has been completed on both cover systems to quantify the probable performance of 1 x configuration of the TSF and 4 x configurations for the NWRD.

The NWRD and TSF cover systems will need to developed to feasibility and then detail design.

10.4.2 Locations for cover trials

There are three viable locations for the cover trials.

- On top of the NWRD
- On the PAF cell within the TSF
- Waste rock trial pad area

10.4.2.1 NWRD

The cover trails may evaluate layers of the cover system and / or 2 or 3 cover configurations.

This site would not be able to provide long term monitoring as it would have to be decommissioned.

10.4.2.2 TSF – PAF Cell

If the TSF cell is not required for PAF storage it could be reshaped, capped with NAF tailings, and developed into a trail area.

This site would not be able to provide long term monitoring as it would have to be decommissioned.

10.4.2.3 Waste rock trial area

Waste rock trial pads were designed and built by MRO.

This site could be repurposed (i) to provide PAF mine waste for the base layer of the cover trails and (ii) to build two or three cover trail pads for the NWRD and TSF: tailings could be trucked in for the base layer of a tailings cover trial.

This site **could be used** to provide long term monitoring as it would **not** have to be decommissioned.

This site would allow for 3 or 4 x 50 m x 20 m cover trails to be established and monitored for > 5 years before major commitments are made to build covers on the MRO TSF and NWRD.

10.4.3 Potential cover trial configurations

The concept level drawing (**Figure 10-4**) provides an indication of the possible dimensions of 3 x cover trial configurations that could be built in the area shown next to the NWRD in **Figure 10-5**

1. NAF tailings base + HDPE liner + tailings + NAF rock (1 m) + saprolite (2 m) + soil (0.5 m) @ 1% slope
2. NAF tailings base + HDPE liner + PAF rock (1 m) + saprolite (2 m) + soil (0.5 m) @ 5% slope
3. NAF tailings base + HDPE liner + PAF rock (1 m) + NAF rock (2 m) + clay (0.5 m) + saprolite (2 m) + NAF rock & soil (1.0 m) @ 5% slope

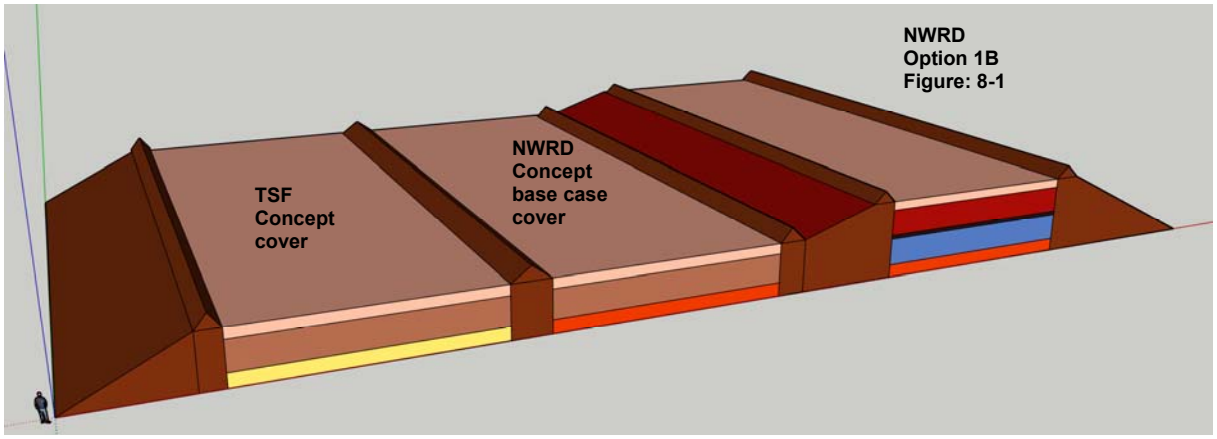


Figure 10-4: Conceptual cover trial configuration - approx. 100 m x 50 m



Figure 10-5: Potential cover trial location

10.5 Cover instrumentation monitoring

A broad suite of monitoring equipment can be used to measure the data types referred to in **Section 10.3.2.** Equipment types, and parameters that may be used for proposed field trials are in **Table 10-1.**

Table 10-1: Potential monitoring equipment

Climate	ATMOS weather station. Low cost, easy to use all-in-one weather station Measure rainfall, temperature, wind, solar, humidity, lightning, evapotranspiration, growing degree days, and more Ideal for wireless, IoT devices for researchers, growers, engineers and industry
	Class A evaporation pan. In simple terms, a Class A Evaporation Pan is a standardised measurement of water loss through Evaporation. With the characteristics of the Pan construction and installation the same between sites, the resulting observed evaporation is able to be compared across sites with a measure of confidence. The Class A Pan itself is a low, wide steel cylinder or 'Pan', with an internal diameter of 120.7cm and a depth of 25cm. The pan is filled to 20.0cm deep each morning at 9am. The depth of water the following morning prior to refill represents the evaporative loss.
	Tipping bucket rainfall. The Environdata RG50 Series tipping bucket rain gauge is built to Australian Standards, WMO Standards and is almost identical to the BoM rain gauges. Sturdily constructed from stainless steel with a powder coated cast aluminium base and copper receiving funnel. The tipping mechanism is gold plated brass for the very best in water drainage. This design incorporates Hall Effect sensing for the ultimate in accurate, rugged and reliable rainfall monitoring.
Surface runoff flow rate and volume	Wier boxes and / or used to collect and verify flow rates and total volume coming off the surface of the trial area. Flow rate measurement can range from manual systems (e.g. v-notch weir) to pressure transducer systems.
Surface runoff quality	ISCO sampler. An automated sampling system that is used to collect 1L bottles at defined intervals (e.g. every hour) over a defined period (e.g. 24 hours). Water samples can be analysed for pH, acidity, alkalinity, EC, suspended sediment, major ions and filtered (soluble) and unfiltered (total) metal(loids).
	Bedload sampler used to measure the bedload eroded for the surface of the cover system
Vadose water balance	Moisture
	Water potential / matric suction
	Temperature
	Electrical conductivity
	In-situ lysimeters. Pre-packaged units that measures the rate and volume of water passing through the soil cover layers above it.
Seepage rate, volume and quality	In-situ lysimeters. Measures the rate and volume of water passing through the soil cover layers above it.
	Leachate interception. If the trials are built on HDPE pads (not connected to the underlying landform) then seepage can be collected to evaluate how much water is moving to the base of the cover.
Field measured or surveyed data	Settlement, consolidation, and density
Ecological aspects	Biomass production - above ground
	Biomass production - below ground
	Species diversity / abundance
	Nutrient cycling & ecotoxocity

10.6 Design selection and Detail Design Specification

The concepts in this plan will need to be evaluated using multi criteria analysis to identify risks and opportunities and guide the scope of work that will be undertaken to verify cover designs that will be built on the MRO TSF and NWRD.

The MCA analysis and design process is likely to require 3 to 6 months and could be undertaken from Q1 and Q2 in 2023.

A Detailed Design Specification (DDS) would be developed at this stage. This document provides the detail required for a Tender Specification to be issued so that a Contractor(s) can be engaged to develop, implement and monitor the cover trial.

Aspects to be included in the DDS include the following.

- Cover placement QA/QC
- Monitoring program of seepage etc.
- Testing surface of interim cover (under high grade ore)
- MMP cover placement – CC layer lifts --- compaction methods

When the DDS is completed the costs will be defined and a procurement plan can be put in place for the monitoring equipment.

10.7 Procurement process

After viable cover configurations are defined in the MCA analysis, detailed design will need to be produced from the trial area. After the design is completed a procurement process would be undertaken to verify:

- what monitoring equipment would be used,
- how, where and when it would be installed and what the installation program would cost,
- who would monitor and maintain the equipment, and
- who would collect, maintain, and interpret the data.

The degree of effort and work required to design, procure, and install, this program is extensive and detailed planning will ensure that no mistakes are made.

10.8 Monitoring equipment, servicing, data management and reporting

The final equipment specification and duration of the cover trial (that should be at least 5 years) will determine how much data will need to be collected, checked, maintained, and delivered in annual technical reports.

11 Attachment D: Final void assessment

Executive Summary

Background and Objectives

RGS was commissioned to construct a WB/WQ model for the site and final void at MRO. The numerical WB/WQ model was developed for the MRO final void with the following objectives:

- To predict the pit water quality (dissolved concentrations) for a 'terminal sink'[2] at closure and understand how the water quality evolves 100 years into the future;
- To understand the demand for water to fill and maintain the pit lake based on several different closure scenarios; and,
- To understand how climate variability affect the water balance and water quality of the pit lake.

Modelling Scenarios

The WB/WQ model was developed using GoldSim and the Contaminant Transport (CT) module. The modelling includes three key closure scenarios:

- **Scenario 1**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment.
- **Scenario 2**: All runoff and seepage water diverted to pit during closure and post closure.
- **Scenario 3**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

Key Conclusions

The results discussed in this report are considered to be at an 'inferred' level of confidence. The key conclusions from the water balance are summarised in **Table** A and **Figure A.**

Table A: Summary of Water Balance Results

Scenarios	Summary
Scenario 1: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment	Pit lake water level never reaches capacity (RL + 120 m AHD) over the 100-year simulation period. The pit filled to a maximum RL of approximately +77 m AHD (mean probability) at year 2123 (100 years) and approximately +113 m AHD (maximum probability) at year 2034 (11 years).
Scenario 2: All runoff/ seepage water diverted to pit during closure and post closure.	Pit lake water level reaches capacity for the maximum probability and 95th percentile probabilities at years 2032 (9 years) and 2045 (22 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity).
Scenario 3: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit	Pit lake water level reaches capacity for the maximum probability and 95th percentile probability at years 2032 (9 years) and 2057 (34 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity).

[2] A 'terminal sink' for MRO is not considered a true terminal sink as there is likely to be some groundwater flux from the pit lake; however, there is no interconnection with external water bodies.

Scenarios	Summary
	The water balance results are very similar to Scenario 2, albeit the fill and overflow times are longer due to the TSF runoff being release to the environment post closure.

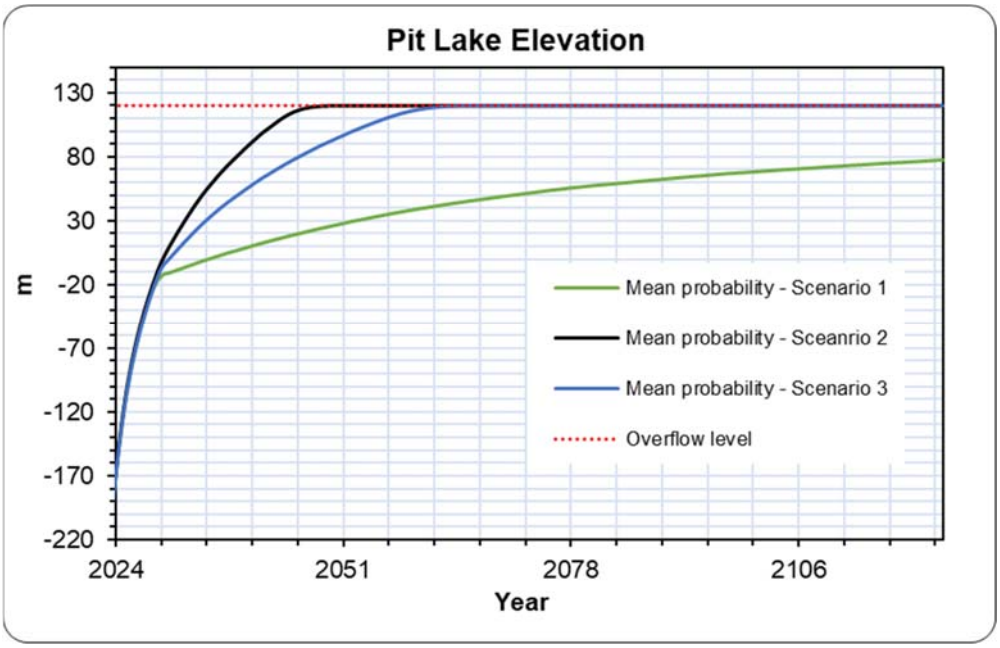


Figure A: Pit lake water level versus time. Note: overflow height is RL +120m AHD.

The key conclusions from the pit void water quality modelling are summarised in the following points.

- The modelling results for each of the scenarios and sensitivities indicate that pH is near neutral over the simulation period with a pH of ~pH 6.5.
- The TDS ranged from around 2,280 mg/L to 250 mg/L (mean probability) for each of the scenarios and sensitivities over the assessment period.
- The general water quality concentration trends vary slightly for different modelled species and reflect the water balance inputs and geochemical source terms. The general water quality concentration trends can be separated into different phases: i) initial sump water quality phase, where the first-time step in the model reflects the pit sump water quality which is present in the pit void before the commencement of the simulation; ii) pre-closure phase, where runoff and seepage water from the non-rehabilitated landforms is directed to the pit and generally results in a gradual increase in concentration of a particular species within the pit lake over this time; and, iii) post closure phase, which shows some variation between chemical species and the scenarios due to either of the following: evapoconcentration effects on pit lake water quality, runoff water from the rehabilitated landforms dilute pit lake water quality, or overflow of the pit lake releases solute from the pit lake stabilising concertation increases.
- The longer-term post closure phase for Scenario 1 (which simulates a 'terminal sink' since it does not overflow) generally shows a steady increase in concentration of solutes over the simulation period reflecting the effects of. evapoconcentration. In reality, bio-geochemical processes (e.g. nutrient cycle, carbon cycling, etc.) would be expected to supress increasing concentrations and some form of equilibrium would be attained.

- The water qualities for each of the scenarios and sensitivities are dominated by the major ions (namely SO_4, Cl and Na), with metals and metalloid concentrations relatively low in comparison.
- The modelled mass balance results for Al, As, Cd, Cr, Cu, Pb (Scenario 3) and Zn concentrations are slightly elevated when compared to ANZG (2018) (freshwater ecosystem; 90% species protection) (**Table B**). Similarly, comparison of the modelled water qualities to site release limits (for WD3, WD4 and spillway of Sediment Dam 3) indicate that TDS (occasionally) and particularly SO_4 are above the release limits.
- Atmospheric equilibration and consideration of thermodynamic constraints on the water quality through geochemical modelling typically had very little effect on the mass balance results due to the generally low concentration of salts and metal(loid)s in the pit lake.

Table B: Summary of select model predicted (inferred) water qualities for each scenario.

Scenario		Scenario 1				Scenario 2				Scenario 3			
Time (years)		0	25	50	100	0	25	50	100	0	25	50	100
TDS (mg/l)	Me	228	524.	584.	662.	228	269.	228.	205.	228	389.	377.	369.
	Min	292.	355.	392.	485.	284.	239.	210.	198.	292.	322.	330.	350.
	Ma	285	691.	707.	754.	285	302.	246.	214.	285	456.	409.	388.
Sulfate (mg/l)	Me	628.	252.	233.	223.	625.	195.	179.	170.	628.	209.	193.	180.
	Min	201.	229.	210.	203.	194.	187.	170.	164.	201.	198.	180.	171.
	Ma	731.	284.	258.	250.	731.	204.	188.	176.	731.	222.	204.	190.
Aluminium (mg/l)	Me	0.01	0.06	0.06	0.08	0.01	0.33	0.41	0.45	0.01	0.46	0.64	0.82
	Min	0.00	0.04	0.05	0.06	0.00	0.29	0.39	0.44	0.00	0.36	0.57	0.79
	Ma	0.11	0.12	0.13	0.16	0.11	0.35	0.42	0.47	0.11	0.50	0.67	0.84
Arsenic (mg/l)	Me	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.00
	Min	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.01	0.01	0.01	0.00
	Ma	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.01	0.01
Cadmium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (mg/l)	Me	0.07	0.24	0.19	0.15	0.07	0.09	0.04	0.01	0.07	0.14	0.08	0.04
	Min	0.00	0.20	0.14	0.10	0.00	0.07	0.02	0.00	0.00	0.11	0.06	0.03
	Ma	0.35	0.30	0.29	0.30	0.34	0.13	0.06	0.01	0.35	0.19	0.13	0.05
Lead (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc (mg/l)	Me	0.08	0.13	0.11	0.09	0.08	0.23	0.25	0.27	0.08	0.33	0.41	0.49
	Min	0.05	0.10	0.08	0.06	0.05	0.22	0.25	0.26	0.05	0.28	0.38	0.48
	Ma	0.21	0.17	0.18	0.19	0.20	0.24	0.26	0.28	0.21	0.34	0.42	0.51

Note: Highlighted orange cells represent those values that exceed ANZG (2018) – freshwater aquatic ecosystem (90%), while those in shaded blue exceed site release limits (for WD3, WD4 and spillway of Sediment Dam 3)

11.1 Introduction

RGS Environmental Pty Ltd (RGS) was commissioned by Evolution Mining Pty Ltd (Evolution) to assist with technical studies to support the development of the Progressive Rehabilitation and Closure Plan (PRCP) for Mount Rawdon Operations Pty Ltd (MRO) in south-east Queensland. The technical studies include i) the development of a waste rock dump (WRD) final landform and cover design, ii) and construction of a site-wide water balance and water quality (WB/ WQ) model for MRO. This report summarises the results of site WB/WQ model for MRO.

The results discussed in this report are considered to be at an 'inferred' level of confidence. An "Inferred water balance and water quality model" is that part of an environmental and engineering assessment for which quantity and quality can be estimated on the basis of hydrogeological, hydrological, and geochemical 'evidence' and reasonably assumed, but not verified, from geological, geochemical and hydro-geological data. The model estimate is based on limited information and sampling gathered through appropriate standard industry practices for sampling and analysis methodology, and conformance to the Australian Groundwater Modelling Guideline.

The results of the inferred model provide an acceptable level of confidence and reliability to forecast likely future environmental outcomes. It is assumed to be suitable for environmental approval level of investigation and suitable for pre-feasibility engineering.

11.1.1 Project Scope of Work

RGS has developed the scope of work based on discussions with MRO and comments provided by the Department of Environment and Science (DES). The RGS scope of work includes:

Task 1: Material Balance Evaluation

- Quantify materials available for rehabilitation (site wide).
- Undertake a site-wide Risk and Opportunity Assessment.

Task 2: WRD Final Landform Design and Cover Design

- RGS will assist MRO in constructing a 3D DTM of the as-built WRD.
- RGS will design a WRD final cover design and undertake unsaturated zone modelling of several WRD cover design options to assess cover functionality and performance.
- RGS will develop a Management Plan to document how the WRD and cover system will be progressively constructed and managed over the mine life.
- RGS will provide a detailed work program for the establishment of field-testing programs and the long-term performance monitoring program for the WRD.

Task 3: Mine Closure Water Quality Model

- RGS will construct a predictive GoldSim model to simulation the site-wide water balance and hydrogeochemical properties of seepage and reservoirs at MRO upon closure. The focus of this model will be the final void.
- The site-wide WB/ WQ closure model will be used as a tool to assess closure options.

11.1.2 Objective of this report

The key objectives of the site-wide WB/WQ model for MRO included:

- To predict the pit water quality (dissolved concentrations) for a 'terminal sink'[3] at closure and understand how the water quality evolves 100 years into the future;
- To understand the demand for water to fill and maintain the pit lake based on several different closure scenarios; and,
- To understand how climate variability affect the water balance and water quality of the pit lake.

11.1.3 Scope of this report

The scope of work associated with this report includes:

- Construct a predictive GoldSim model to simulation the site-wide water balance and hydrogeochemical properties of seepage and reservoirs at MRO upon closure. The focus of this model is on the final void.
- The site-wide WB/ WQ closure model will be used as a tool to assess closure options.
- Provide a standalone technical report summarizing the results of the WB/ WQ modelling (this report).

11.1.4 Background

Refer to main report for background information.

[3] A 'terminal sink' for MRO is not considered a true terminal sink as there is likely to be some groundwater flux from the pit lake; however, there is no interconnection with external water bodies.

11.2 Hydrogeochemical Conceptual Model Summary

A summary of the hydrogeochemical conceptual model for the site and pit lake is provided below.

11.2.1 Conceptual cross sections

The term open pit applies to the mining phase. After the open pit is decommissioned the open pit is considered a mined void. When the mined void fills with water a pit lake will develop and inundate the pit walls.

The MCO conceptual model is a 2D cross section of a mined void and pit lake system that shows the processes influencing pore water quality in the NWRD and TSF, changes to groundwater as it rebounds towards pre-mine conditions and the resulting water quality in the pit lake as it evolves over time (**Figure 11-2**). The MRO conceptual model assist in defining the relevant biogeochemical processes of the pit lake that will be modelled using numerical methods to predict the quality of the pit lake.

11.2.2 Hydrological Impact on Pit Lake Quality

The water quality of the pit lake is a result of many factors including but not limited to geology and minerology of the host formations, surface water and groundwater quality entering the mined void, concentrating effects of evaporation, geochemical, biological, and limnological processes with the pit lake and anthropogenic impacts. The key water quality inputs to the final void/ pit lake are summarised in the cross section **(Figure 11-2)**.

The hydrology of the pit lake affects the water quality of the pit lake by changing the chemical mass balance associated with the pit lake.

General statements regarding the impacts of hydrological processes on water quality can be made and these are applicable to MRO:

- Groundwater inflows carry dissolved constituents at background concentrations into the mined void/ pit lake. Natural, upgradient groundwater will have a certain water quality and will contribute to the mined void/ pit lake. Inflowing groundwater can also pick up constituents from weathered rockl immediately surrounding the mined void/ pit lake or from recharging meteoric water passing through the dewatered zone.
- Surface water runoff from pit walls may transport constituents and sediments that will affect the chemistry of the mined void/ pit lake.
- NWRD and TSF seepage may carry dissolved constituents into the pit lake.
- Direct precipitation generally is a diluting factor on mined void/ pit lake quality.
- Since evaporation takes out the water and leaves behind any dissolved constituents evaporation tends to have a concentrating effect on mined void/ pit lake quality.
- Ground- and surface water outflows from the pit lake typically have the effect of removing constituents from the pit lake. However, if the pit lake is stratified, these outflows may remove water of different quality, which may result in either improved or worsened water quality in the pit lake.
- Redox reactions within the pit lake will result in the chemistry of the pit lake water evolving towards thermodynamic equilibrium. Dissolved solutes will react with each other in order to form new chemical species.
- Mineral phases that are supersaturated in the pit lake water can precipitate out of solution. The removal of the solutes involved with precipitation can change the pH of the remaining water and will also cause the concentration of the solutes remaining in the pit lake water to decrease.
- Dissolution and oxidation of minerals also has a significant impact on the chemistry of the pit lake water. Dissolution of minerals can result in the release of acidity into the system and is an important factor in the chemistry of runoff input into the pit lake. The dissolution of soluble secondary minerals that may have formed on the exposed pit walls over the life-of-mine can be “flushed” into the pit lake

with run-off and as the pit lake levels rise. The oxidation of sulfide minerals (particularly pyrite) results in the release of sulfate, creating sulfuric acid.

11.2.3 Pit Lake – Groundwater Interaction

Before mining commenced at MRO the unsaturated (vadose) zone was limited to the shallow regolith near the surface. Mining lowered the standing groundwater table through dewatering thereby increasing the extent of the vadose zone, moving (generally) laterally down through the underlying strata in a broad cone of depression. As the groundwater table dropped in response to dewatering air can be drawn into the underlying strata and this is likely to have led to the (partial) oxidation of the rock, including oxidation of sulfide minerals that may be present within the surrounding rock. The extent of oxidation and weathering in the cone of depression is uncertain and it is possible that the pore voids in the vadose zone may be dominated by either oxygen or nitrogen.

When the dewatering ceases and the groundwater level rebounds, the rebound could occur ahead, in equilibrium, or lag behind the pit lake level. In each of these situations the soluble weathering products in the pore voids in the vadose zone may be leached out and mobilised to the pit lake or to groundwater. Groundwater will seep in and out of the pit lake through permeable units exposed in the pit walls.

Within the land around the pit lake rim, there is the NWRD and TSF which are a new feature of the surface topography dominated by vadose zone hydrology i.e. they are present above the current and future post mine standing groundwater table.

From a conceptual perspective, rain falling on these areas will report as surface runoff, or percolate through the dump/tailings where it will report as resurgent seepage and drain into surface features or it will percolate down into the groundwater system.

11.3 Surface Water Inflows

After closure, there will be various potential surface water inflows to the mined void, that will create a pit lake. Each inflow will need to be accounted for within the numerical model to allow simulation and comparison of different closure scenarios. The conceptual model for the different closure scenarios identified the key surface water flows into the mined void as:

- Runoff from exposed pit walls (NAF, M-PAF and H-PAF).
- Runoff and seepage from the TSF and NWRD.
- Direct rainfall onto the mined void/ pit lake surface.
- Local runoff from the catchment within the mining lease (various land use types depending on the scenario).

11.4 NWRD Contact Water

Sulfide rich material is assumed to only occur within the interior of the NWRD while the WWRD (which will be repurposed for rehabilitation), is assumed to contain only NAF material; for this reason, the focus of this section is largely around the NWRD.

Oxidation of sulfide-rich (e.g. pyrite/ marcasite (FeS_2)) materials within the NWRD is currently producing seepage water quality that is net neutral, although elevated in some salts and metals/ metalloids. Kinetic leach column (KLC) testing has indicated that the NWRD is likely to continue to generate neutral, saline and metalliferous drainage through the life-of-mine and beyond mine closure without intervention (e.g. lime dosing).

Runoff and seepage from the NWRD could be directed to the pit.

11.4.1 Summary Historical Kinetic Testing (waste rock)

The kinetic testing results for NAF, medium PAF and High PAF waste rock indicate circum neutral leachate water quality over the 2-year testing period (2016-2018) (**Figure 11-1**).

The sulfate results from the KLC test was used to derive acid production rates for each of the samples. The calculations are considered conservative since the main assumption is that all sulfate is generated

from pyrite oxidation, when in fact there are other sulfate bearing minerals present (e.g. sphalerite and galena).

The calculated acid production rates were then used together with measured acid neutralisation capacity (ANC) and the acid buffering characteristic curves (ABCC) to estimate the time (in years) for ANC to be consumed to the point at which pH 7 and pH 4.5 (acid conditions) is reached.

The results from the KLC testing, so far, indicates the following:

- The time for all ANC to be consumed for PAF waste rock samples is ~650 to 850 years; however, a large portion of the ANC is consumed under acidic conditions. This is likely to be due to the presence of aluminosilicates.
- The time for PAF waste rock samples to acidify (pH < 4.5) is ~170 to 190 years. This assumes optimal conditions for pyrite oxidation which is emulated in the columns (e.g. wetting/drying cycles, exposure to oxygen and fine particle size of waste rock).
- Under field conditions is would be expected that the time for PAF waste rock samples to acidify would be significantly longer.
- NAF waste rock reports the longest time to acidification range (~1,500 years); however, it is important to note that these materials will never acidify. The sulfate released from the samples is mainly due to sphalerite and galena reactions.

While the potential for acid mine drainage is expected to low assuming proper management of waste rock materials, there is evidence to suggest saline (sulfate) and metalliferous (metals and metalloids) drainage could be considered moderate/high risk for the NWRD. The following sections describe the nature of seepage water quality monitored historically and as part of the RGS site investigation.

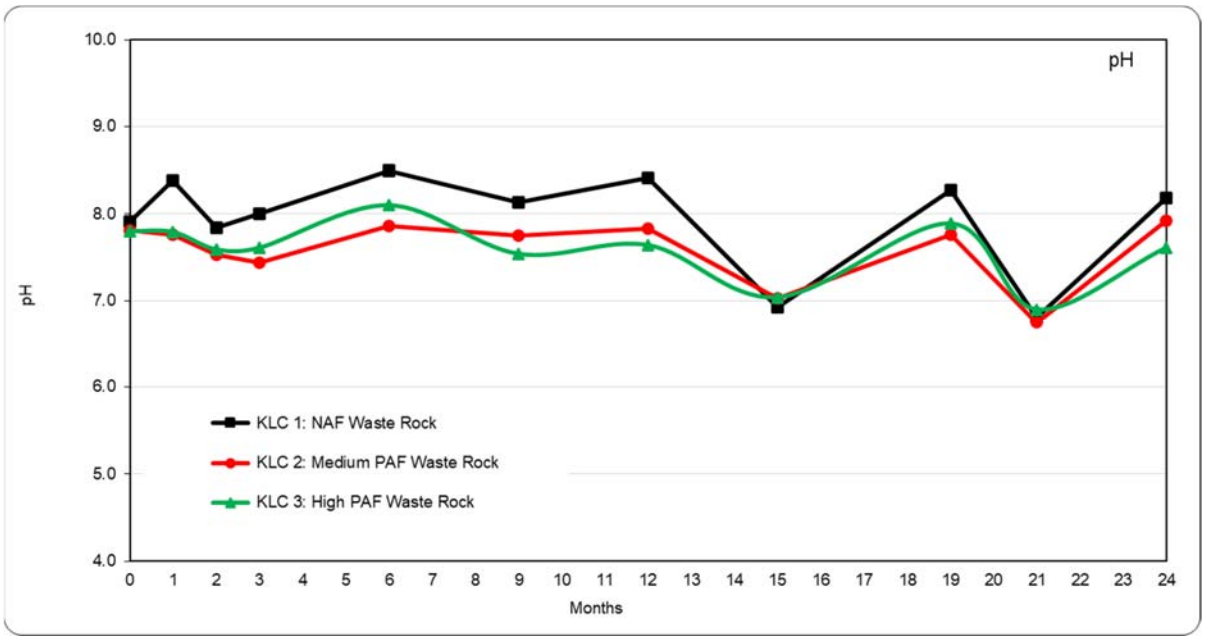


Figure 11-1: pH versus time graph for waste rock materials

11.4.2 NWRD Historical Seepage Water Quality

Toe seepage water from eleven locations on the NWRD was collected and analysed in June/ December 2010, March/ August 2012 and 2021.

The seepage water qualities range from slightly acidic to neutral (pH 5.0 to 7.84) with a TDS ranging from 468 to 3,310 mg/L. The water qualities are dominated by sulfate (441 to 2,800 mg/L) with lesser calcium, sodium, magnesium, chloride, nitrite and alkalinity (as bicarbonate under neutral conditions). Some metal(loid)s are elevated in the NWRD seepage water, including (amongst others): aluminium, cadmium, copper, manganese and zinc.

Dissolved metal(loid) concentrations in the seepage samples were spatially variable with some exceedances of aquatic freshwater ecosystem (95% species protection) and livestock drinking water criteria. Criteria exceedances were recorded for cadmium, copper, manganese, nickel and zinc. Concentrations of cadmium were almost thirty times higher than the livestock drinking water criteria (0.01 mg/L). Concentrations of molybdenum (0.004-0.017 mg/L), rubidium (0.006-0.011 mg/L), strontium (2.01-3.68 mg/L) and uranium (0.004-0.018 mg/L) were relatively consistent.

To understand the solubility constraints of some minerals on metal(loid) concentrations in the NWRD, simplified geochemical modelling was undertaken using PHREEQC (Parkhurst and Appelo, 1999). PHREEQC modelling compares measured seepage water quality data with theoretical solubility limits of a number of minerals under different geochemical conditions. The saturation states of a number of minerals (depending on the database used) are calculated from the saturation index (SI). The SI value of a particular mineral is indicative of a mineral's potential to precipitate or dissolve out of solution. If the SI value is negative, then the mineral is undersaturated in solution. However, if the SI of a mineral is positive, then the mineral is supersaturated and may precipitate out of solution. If the SI value is equal to zero, then the minerals and solution are at equilibrium. The PHREEQC modelling indicated that some supersaturated (may precipitate) minerals include alunite, aluminium and iron (oxy)hydroxides (e.g. boehmite, gibbsite, goethite, hematite, etc.) and some copper bearing minerals like tenorite and cuprite. Gypsum SI was close to zero, indicating at that gypsum is likely at equilibrium and possibly a constraint on dissolved sulfate concentrations.

11.4.3 TSF Contact Water

The tailings are classified as non-acid forming; however, contain a sulfide sulfur content of approximately 1% with sulfide minerals consisting of pyrite with minor sphalerite, galena and chalcopyrite. The sulfide minerals oxidise at the surface of the TSF and are subsequently neutralised by residual acid neutralising minerals producing neutral pH drainage in the TSF. In the western TSF cell, where surface tailings have been exposed for seven years, tailings samples were subjected to KLC testing. The leachate data from the kinetic tests show that the tailings had initially high concentrations of salts and metal(loid)s due to evapo-concentration of supernatant and runoff in the (isolated) cell over several years. Leach testing of the tailings verified (1) that the soluble major ions that had accumulated in the surface profile of the TSF would be leached from the tailings under a closure scenario whereby surface runoff was directed from the surface of the TSF and (2) that subsequent leachate from the tailings would remain pH neutral; static analyses suggest the drainage will always be neutral but will leach salts and metal(loid)s over time as the tailings oxdise and weather.

11.5 Biological Processes

Biogeochemical reactions can affect pit lake water quality. Microbial processes can influence the redox conditions present in the pit lake. Concentrations of dissolved metals can be impacted by the precipitation of sulfide minerals and uptake of dissolved metals by microorganisms. Microbial processes can also be responsible for the removal of organic carbon from the pit lake water.

Biological reactions such as photosynthesis and respiration can alter the concentration of dissolved CO_2 and O_2 in the pit lake waters. Stratification in the pit lake can result in the depletion of O_2 at the base of the pit lake, which will affect any organisms present.

Studying the microbial communities in pit lakes is an important part of understanding element cycling. Element cycling occurs from chemical, geological, and biological factors. Microbes can increase chemical reaction rates and water-rock interactions by metabolising both organic and inorganic components in a system. In effect, these interactions affect the speciation of elements in an environment, which can lead to either an increase or reduction of dissolved metals in water. In mine

waters, microbes can act as catalysts in redox reactions, alter mineral compositions, sequester or release toxic metals, and change net pH as a product of their metabolism.

The chemical, physical and biological processes that contribute to the production and neutralisation of acid and the presence of salts and metal(loids) particularly in anoxic and reducing water in the pit lake are extremely complex.

The interaction between biota (bacteria) and oxygen, carbon, sulfate, iron and manganese need to be understood as they have a direct effect on element cycling.

11.6 Limnology

In mine pit lake studies, the term limnology is used to refer to vertical stratification and vertical changes in water body density. The primary factors influencing vertical stratification are temperature (heat exchange with the atmosphere) and chemistry (gradients of dissolved substances), as these parameters affect the density of water.

The degree of circulation is also influenced by (i) pit lake morphology and (ii) wind speed, although observations of permanently stratified water bodies have found little correlation between pit morphology and circulation patterns. The density of water from various sources and the volumetric contribution of each source appear to have a greater influence on stratification (Castendyk and Webster-Brown, 2007).

Most pit lakes show a vertical stratification of their water masses, at least for some extended time periods. Several studies on existing acidic mine pit water bodies indicate permanent stratified conditions occur (e.g. Castendyk and Webster-Brown, 2007; Delgado-Martin et al., 2013; Knoller et al., 2004).

However, a few studies on mine pit lakes and crater lakes (similar morphology) with near-neutral pH demonstrate that these water bodies are holomictic (Larson et al., 2007; Gammons et al., 2013). This suggests that, although it might be reasonable to assume permanently stratified conditions (meromixis) will occur over time in acidic mine pit lakes, caution must be taken with this assumption when pit lakes exhibit near-neutral pH.

Pit lakes can remain permanently stratified (meromixis) due to, but not limited to, the following processes:

- inflows of different salinity (e.g. from external sources or groundwater);
- inflows of high turbidity;
- salt exclusion and ice formation during winter; or,
- organic matter degradation in the deep water.

A10. Site Timeline Progress



A11. Site Cross-section

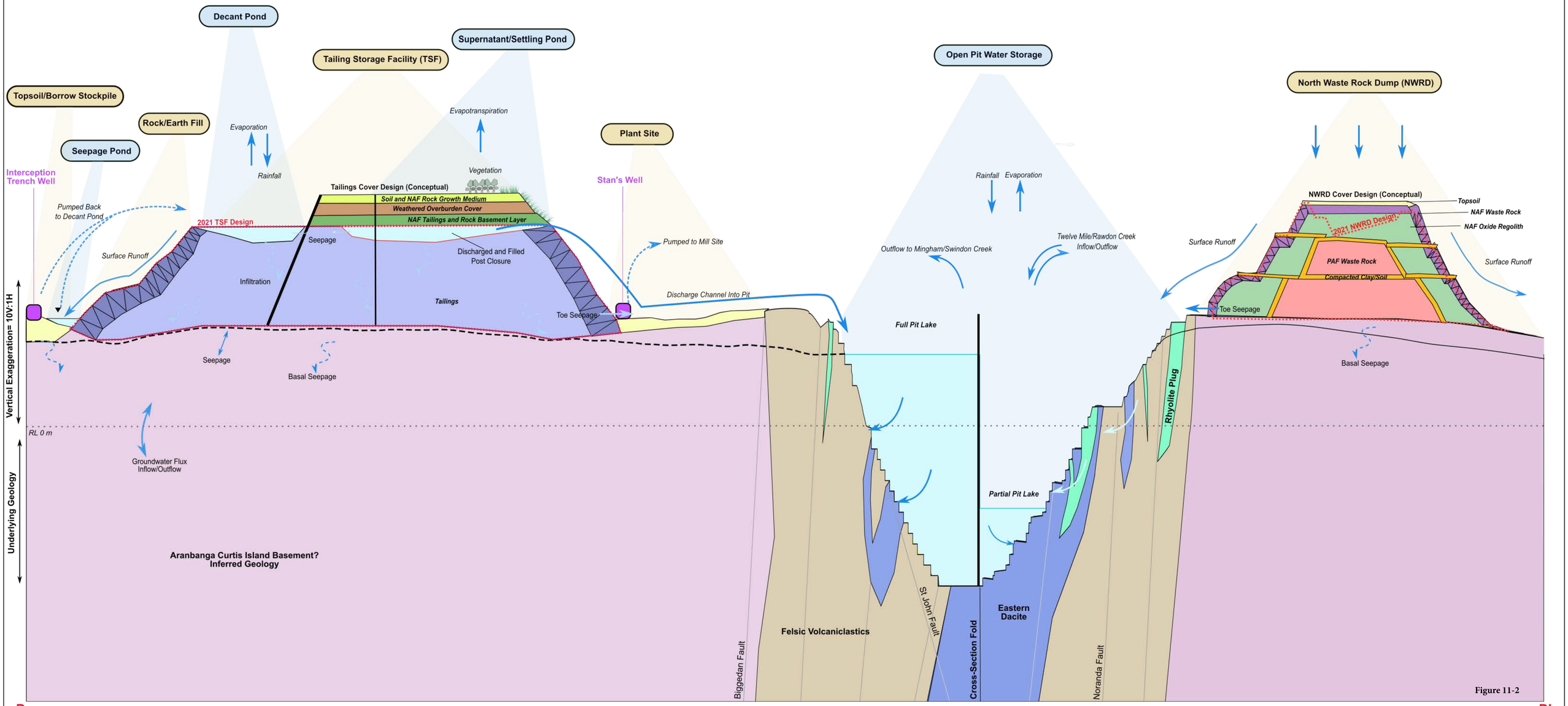


Figure 11-2

Conceptual Site Layout

Conceptual site cross-section shows the progressive rehabilitation conceptual models in TSF, NWRD and Pit Lake.
- TSF rehabilitation and conceptual closure design (RGS (2017), Evolution Mining (2020, 2021)) currently lean towards analogue cover system comprising of 3 layers of low permeable soil, weathered overburden and NAF Tailings and Rock.
- NWRD cover design is currently discussed further in A3-A9 within MRO NWRD Conceptual Model.
- Open Pit will be designed as water storage filled from ongoing dewatering from supernatant/settling pond TSF and surrounding areas that are shaped to allow rainfall and surface runoff into pit lake.

Source:

Model Earth Global Geological Services. (2016). Mt. Rawdon Geological Review and 3D Model (Memorandum). Prepared for Evolution Mining (Mt. Rawdon). 16th October 2016
Evolution Mining (2020). Mount Rawdon Environmental Evaluation. Stage 3: Final Report. Prepared by Dr. Graeme Esslemont for Evolution Mining. November 2020.
Evolution Mining (2021). Mount Rawdon Operation. Progressive Rehabilitation and Closure Plan. Version 1. Submitted 30th June 2021.
RGS (2017). Conceptual Closure, Decommissioning and Rehabilitation Plan for Mt. Rawdon TSF. Report by RGS Environmental Consultants Pty Ltd prepared for Evolution Mining (Mt Rawdon Operations Pty Ltd). Job No. 2016014 - 003 RevH. 31st December 2017

Legend:

- Soil and NAF Rock Growth Medium
- Weathered Overburden Cover
- NAF Tailings and Rock Basement Layer
- Tailings
- Rock/Earth Fill
- Topsoil/Borrow Stockpile
- Compacted Clay/Soil
- PAF Waste Rock
- NAF Oxide Regolith
- NAF Waste Rock
- Felsic Volcaniclastics
- Aranbanga Curtis Island Basement? Inferred Geology
- Eastern Dacite
- Rhyolite Plug
- Batter
- Biggedan Fault
- Noranda Fault
- St. John Fault
- Groundwater
- Water Flowpath
- Current Design

Title: MRO Conceptual Hydrogeological Model
Job Number: 2021092
Project Name: Mount Rawdon Gold Mine WBWQ
Date:04/02/2022
Scale: Not-To-Scale
Drawn: P.T Checked: M.L. Revision: 1.0.

RGS

11.7 Model Development

The numerical model, including the water balance and water quality components, has been developed using GoldSim Software. The model has been developed as a decision support tool for assessing closure options. For this reason, it has been developed with flexibility to allow the user to run a series of different "what-if" scenarios and sensitivity analyses, by varying different inputs and model switches. The model has been developed on a daily time-step, to run for periods of up to 100 years.

The sub-sections below describe the numerical model development including input data, model structure and logic, and key assumptions and limitations. Some of the model development sections describe functions that are not required as part of the PRCP modelling scenarios but may be utilised in future iterations of the model (e.g. 95th percentile geochemistry source terms).

11.8 GoldSim

GoldSim is a dynamic, probabilistic simulation software developed by GoldSim Technology Group. It is a graphical, object-orientated coding platform. This means that it is a flexible platform in which the user can program the software to represent any system (such as a mine site) within a graphical user interface. This makes it user-friendly to lay out equations, code logic and system influences, whilst reducing the risk of hidden error that may be experienced in spreadsheets.

GoldSim has been selected for the numerical model development as:

- It is particularly well suited for stochastic or probabilistic simulations with its Monte Carlo simulation framework.
- Its ability to run dynamic simulations of complex systems using a tailored development approach
- Its ability to simulate both water balance and water quality (using the Contaminant Transport (CT) module)
- It is very well suited to environmental and engineering risk analysis, with applications in the areas of water resource management, mining and water quality assessments.
- Its ability to run a series of different "what-if" scenarios and sensitivity analyses in which input parameters can be varied to understand the impact to the system. This makes it a very useful decision support tool.
- Its dashboard function in which the model can be packaged with a front-end including input and results dashboard. This allows users who are not model developers to run different scenarios in the model to better understand the system and support the decision-making process.

11.9 Modelling Scenarios

The modelling scenarios and sensitivities undertaken as part of the PRCP modelling are outlined in **Figure 11-3** to **Figure 11-5**. The modelling includes three closure scenarios using average geochemistry source term inputs.

The focus of the GoldSim model was to evaluate whole of mine (WOM) and life of asset (LOA) water management options including:

- **Scenario 1**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment.
- **Scenario 2**: All runoff and seepage water diverted to pit during closure and post closure.
- **Scenario 3**: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

Several sensitivities of the modelling scenarios were also run, including:

- Sensitivity 1 – run model with a no-closure option (i.e. model run without any rehabilitation).

- Sensitivity 2 – run model with Catchment 2 and 4 concentrations multiplied by 10 to check the model propagates mass transfer correctly (hence two sub cases – scenario 1 and scenario 3).
- Sensitivity 3 – run model with inflow to the pit limited to direct rainfall, pit walls runoff and groundwater (i.e. all site water diverted away from the pit as though it was bunded).

The results of the modelling sensitivities are not discussed in this report.

11.10 Assessment Period

The model has been developed on a daily time-step to run for a period of 100 years.

It should be noted that there are some risks involved in longer simulation periods (e.g. 500 years). The longer the model simulation period, the greater the bounds of uncertainty in the modelled WB/WQ results that are likely to be observed. For example:

- the uncertainty of some of the key input parameters such as climate, hydrology and chemistry. When the model run time is extended, these uncertainties are magnified.
- the uncertainty in groundwater inflows, particularly after 100 years.
- uncertainty in chemistry and reactions e.g. precipitation of materials as concentration increases.

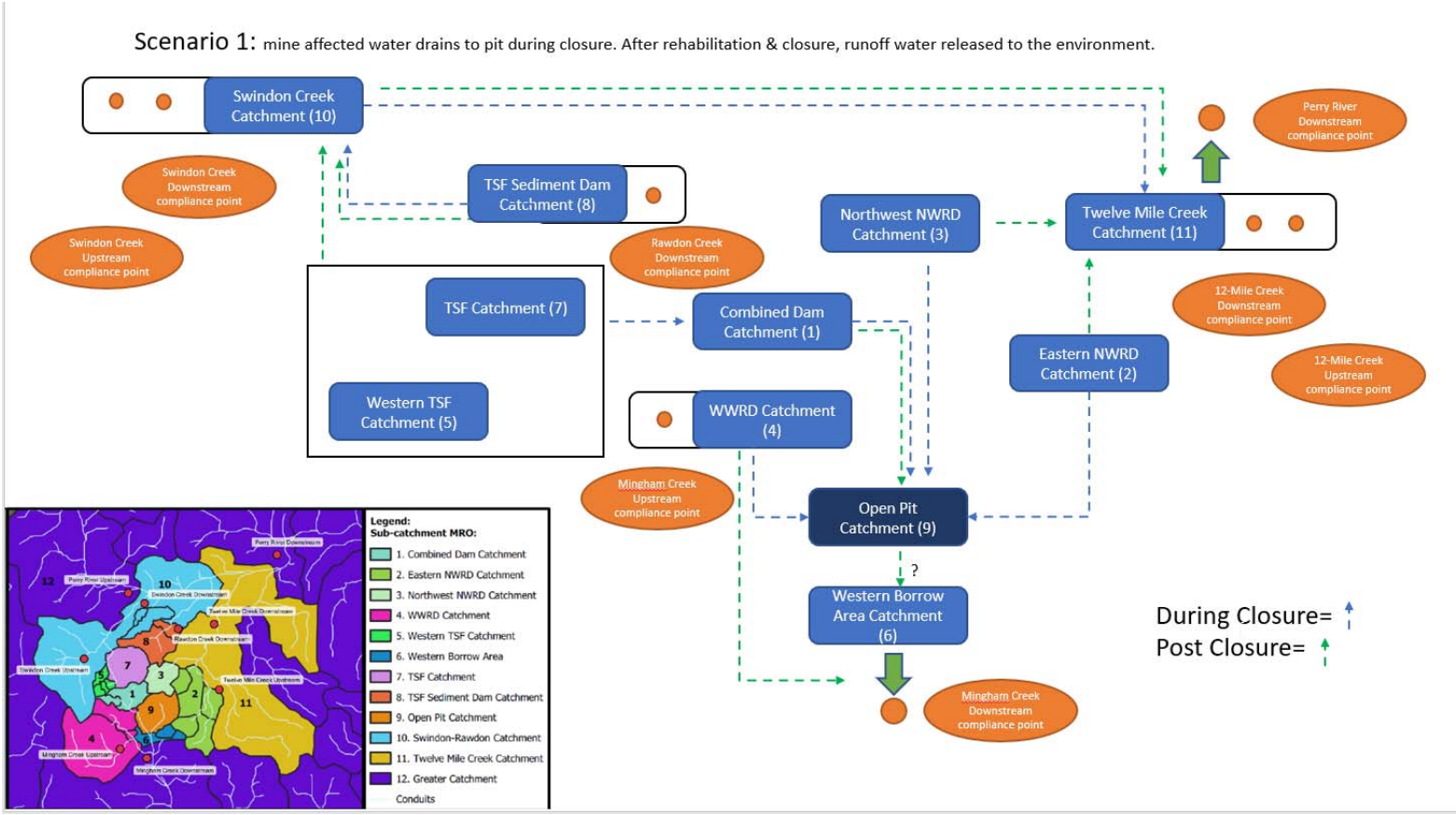


Figure 11-3: Scenario 1: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment

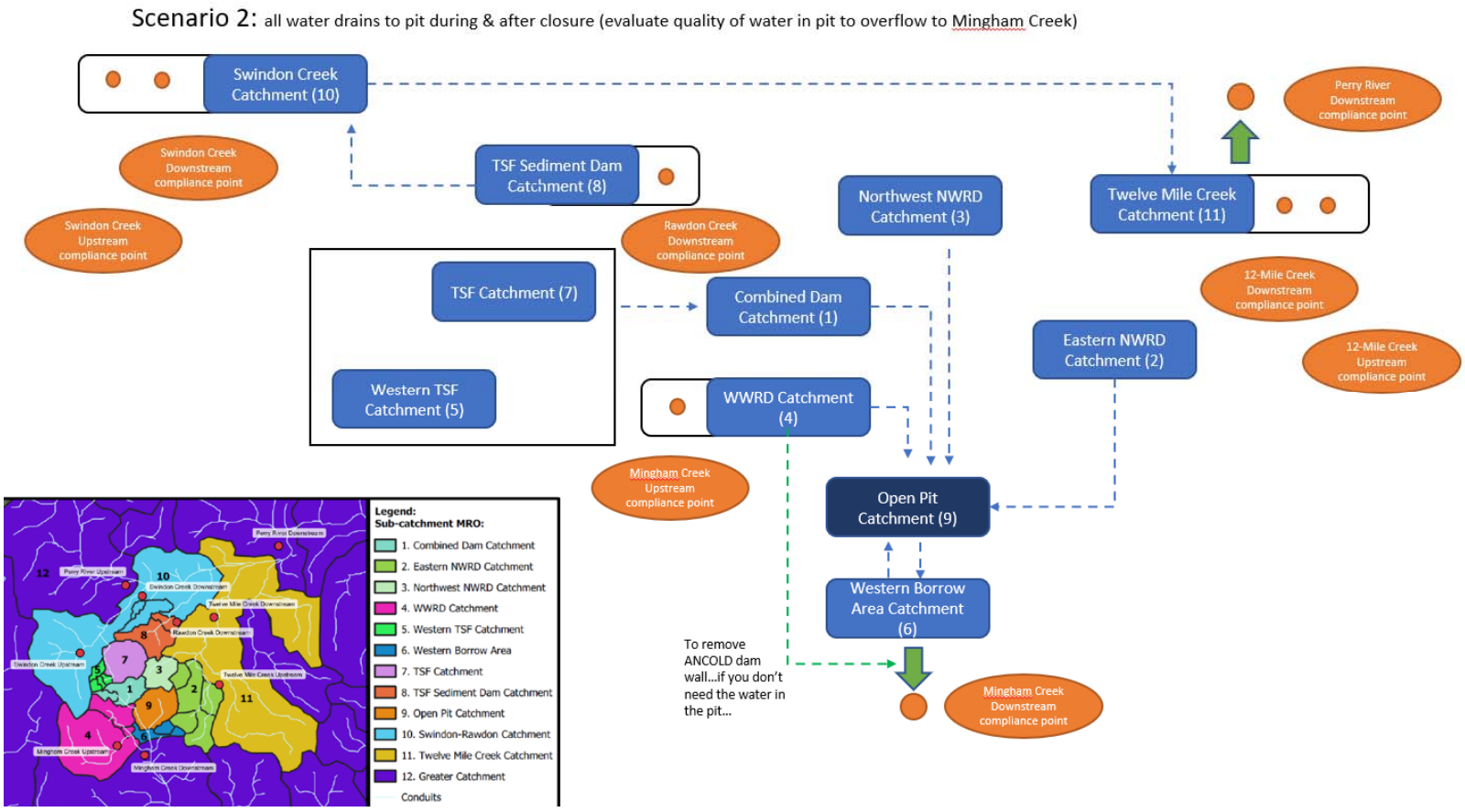


Figure 11-4: Scenario 2: All runoff and seepage water diverted to pit during closure and post closure.

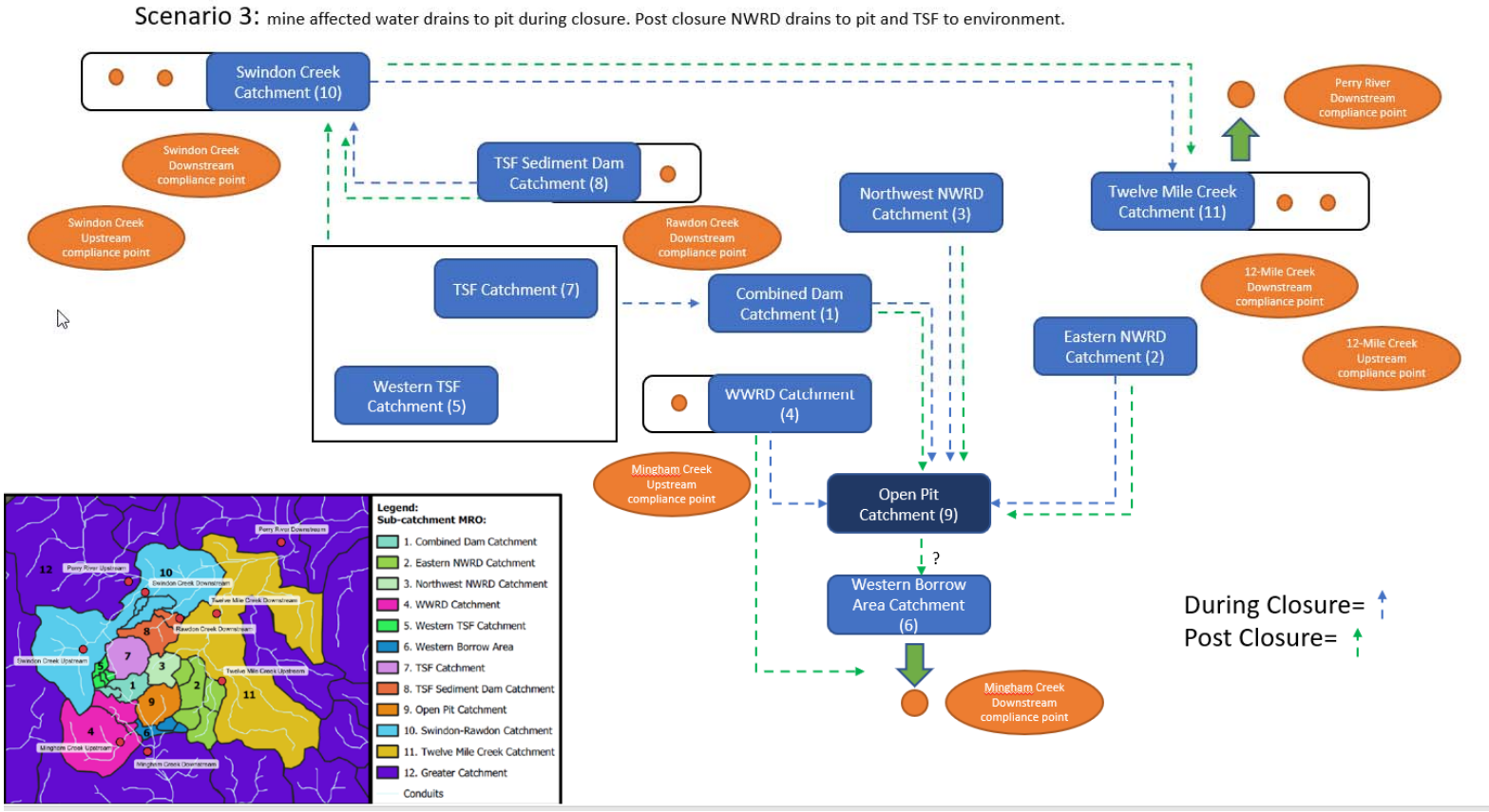


Figure 11-5: Scenario 3: All runoff and seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit.

11.11 Climate

The climate simulated in the numerical model includes rainfall, evaporation and evapotranspiration. The base climate for the model is derived from the Bureau of Meteorology (BoM) point data for Lat: -25.25 Lon: 151.75 – the closest point to the site (**Figure 11-6**). Scientific Information for Land Owners (SILO) Patched Point Data (PPD) was obtained for the location, which has infilled any gaps in the data, based on the neighbouring stations and their data availability. The SILO data available for the location included daily historic rainfall, evaporation and evapotranspiration data.

The approach to generating climate data sets for the modelling is to use the complete available SILO climate record. This is approximately 122 years of record, between start of year 1900 and the end of 2021. From this historical climate sequence, one hundred of stochastic (probabilistic) sequences, of 100 years in length were generated for use in the GoldSim model. The probabilistic climate replicates are generated in Stochastic Climate Library in a way that the average of all 100 climate replicates matches the historical data statistics.



Figure 11-6: BoM climate location

11.11.1 Evaporation

Two different sets of modelled evaporation datasets are used in the model:

- **Morton's Shallow Lake Evaporation** (Morton, 1983) is used in the model to represent the evaporation loss from the pit water body and sediment dams water body surface. The shallow water body dataset is calculated using Moreton's method which converts observed pan evaporation to the evaporation that would likely be observed on a larger body of water.
- **Potential evapotranspiration (PET)** represents the combined loss of water from a given catchment area, by evaporation from the soil surface and by transpiration from plants. Being the potential evapotranspiration, it represents the maximum evapotranspiration which could occur. However, if the soil stores and plants are dry on any given day, this amount could be reduced, and would be referred to as the *Actual Evapotranspiration*. The PET dataset provided in the SILO data is calculated using Moreton's method (Morton, 1983). The PET dataset is an input to the hydrological modelling (AWBM model) of greater size catchments (compare section 1.7 – Catchments no. 4, 10, 11 and 12)), to calculate surface runoff..

Figure 11-7 below shows average daily rates of both the lake surface evaporation and the potential evapotranspiration, together with average daily rainfall in any given month.

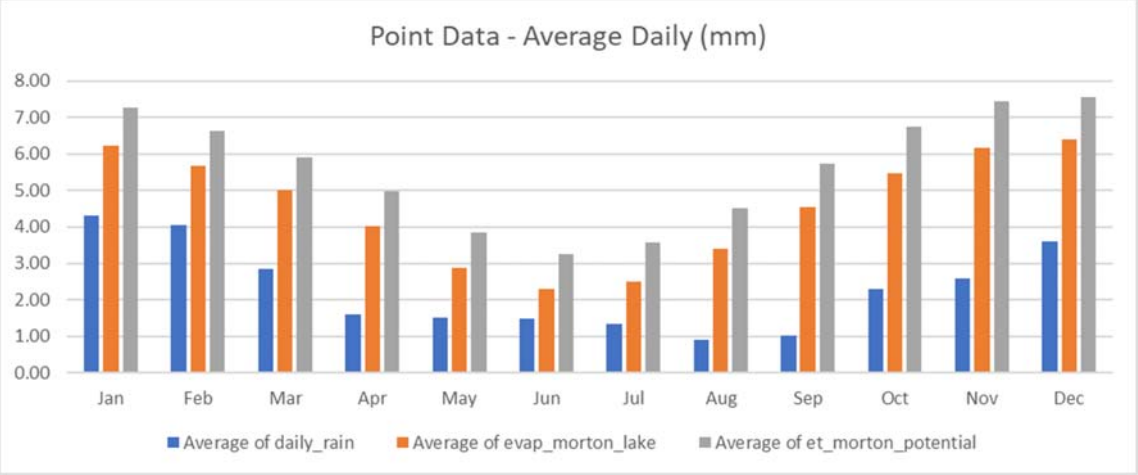


Figure 11-7: Average daily rates of evaporation.

11.11.2 Rainfall

The base climate datasets (rainfall and evaporation) are based on SILO data from for the period from 1 January 1900 to 31 December 2021. **Figure Y below** shows the historical annual rainfall record. The average annual rainfall for the 122-year sequence is 835 mm, with the highest rainfall occurring in summer months (**Figure 11-8**).

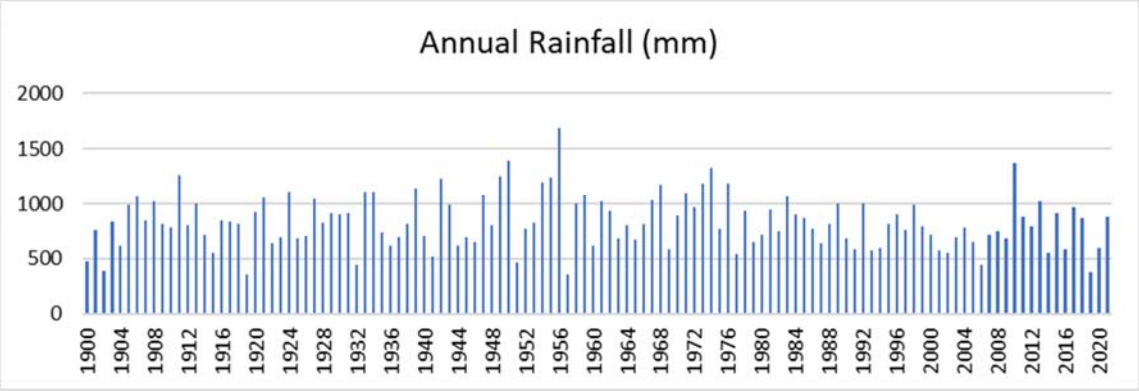


Figure 11-8: Annual rainfall

11.11.3 Probabilistic (stochastic) Rainfall

For the rainfall only, stochastic rainfall data was generated to represent climatic uncertainty in the model.

Each probabilistic dataset has been generated using the eWater Stochastic Climate Library Software (SCL), applying the 122-year daily historical sequence as the base climate. The stochastic sequences are designed in a way that the average of all of the generated future rainfall records, closely resembles the statistics of the historical data that it is based on. Many of the individual stochastic rainfall sequences will contain both rainfall events which exceed those experienced in the historical record, and drought periods more extreme than previously experienced. This allows the model to simulate how the pit water balance and water quality may respond to climatic uncertainty.

11.11.4 Probabilistic rainfall stacking approach

In addition to previously applied stochastic rainfall routines, an additional probabilistic routine was introduced. In the probabilistic rainfall stacking approach, the model randomly picks up daily rainfall data from years available in the 122 years rainfall record and arranges them in random 100-year sequences (for example – *run 1* – rainfall records from: 2011, 1950, 2019, 1905…. etc (100 years in total), *run 2*: 1988, 2005, 1939, 1956, etc)).

This option has a potential to generate a more severe rainfall sequences in cases when unusually wet or dry years are selected back-to-back in the full 100 years rainfall sequence. This option does not honor the overall statistics of the historical data but it allows for a quick model runs of any time length if required (100 years, 300 years, 1000 years etc).

This option was implemented in the model but not used to generate the model results at this stage.

11.12 Final landform Modelling

Computer aided design/modelling software Deswik.CAD was used to merge designs depicting changes to the mine area landform proposed to occur as the mine progresses toward closure (e.g., increasing pit depth, TSF lifts, infrastructure removal, and stockpiled material reclamation) with a recent digital elevation model (DEM) of the mine area to form a final landform model. The final landform surface was used to model stage area/storage data and catchment boundaries for the final landform. Two landform models were used to establish model inputs: the landform surface prior to site rehabilitation and closure (i.e. site surface at the completion of mining and prior to rehabilitation) (

Figure 11-9); and, the final landform surface after complete rehabilitation and closure (**Figure 11-10**).

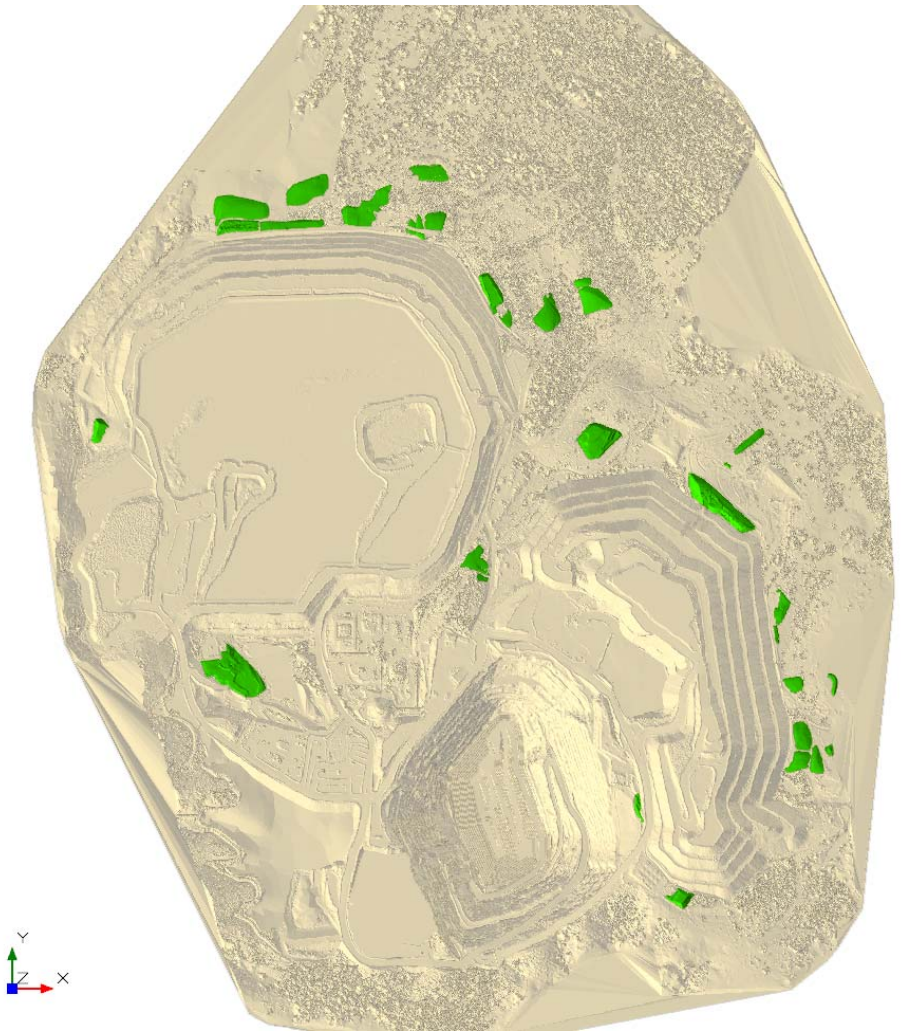


Figure 11-9: Final landform surface for MRO before closure (topsoil stockpiles highlighted in green).



Figure 11-10: Final landform surface for MRO post closure.

11.13 Pit Physical Characteristics (Stage Curves)

The numerical model incorporates input data to describe the pit void geometry and its final landform, as well as the geometry of the various site dams and water storages (South Dam, West Dam and Sediment Dam 3).

Final landform features with the capacity to store water (e.g., dams and the pit void) were split into vertical stages 1 m in height. The surface areas, plan areas, and storage volumes of each stage of the pit and dam walls/floors were then reported to generate stage area/storage curves.

A summary of the pit geometry inputs is provided in **Table 11-1**.

Table 11-1: **Pit Void Geometry Summary**

Pit Geometry Dataset	Description	Value
Pit maximum elevation	The elevation at which the pit is considered as “full”.	RL +120 m
Pit maximum volume	Volume corresponding to the pit maximum elevation. This is the volume at which the pit is considered as “full”.	62,186,014 m^3

Details of each dam and pit void geometry input which is incorporated in the model, and their application in the water balance is provided in **Table 11-2**. Each of these geometries was extracted from the final landform surface in Deswik, at 1m intervals.

Table 11-2: **Geometry data and application to water balance in the WB/WQ body model**

No.	Pit Geometry Dataset	Application in Water Balance
1	Storage volume vs water surface Area curve	Relates the pit/ dam water volume to the pit/ dam water surface area at each timestep. This is used to calculate the evaporation volume loss from and direct rainfall volume into the dams and pit lake.
2	Elevation vs volume curve	Relates the pit/ dam water volume to the pit/ dam water surface elevation at each timestep. Essentially a lookup table which returns the volume for a given elevation. This is used to calculate the pit/ dam water elevation at each timestep.
3	Volume vs Elevation curve	This is the same as the Elevation volume curve but simply in the opposite order. As such, it provides a lookup table to return pit water surface elevation for a given water volume.
4	Elevation vs pit wall area curve for each material type (H-PAF, M-PAF, NAF)	Relates the pit elevation to the pit wall surface area for each material type at each timestep. This dataset considers the pit wall surface areas for each material type individually (i.e. there are three curves for H-PA, M-PAF and NAF rock). It should be noted that this curve is different to the volume vs water surface area curve (Item 1) in that the water surface area is the 2-dimensional area measured in plan view of the pit, for each elevation, that would contribute to rainfall & evaporation loss. In contrast, the pit wall area at each elevation is measured as a 3-dimensional surface area, taking into account the vertical pit wall areas which would contribute a loading rate. This is used to calculate the loading rates coming from the exposed pit wall surface area during rain events for each rock type.

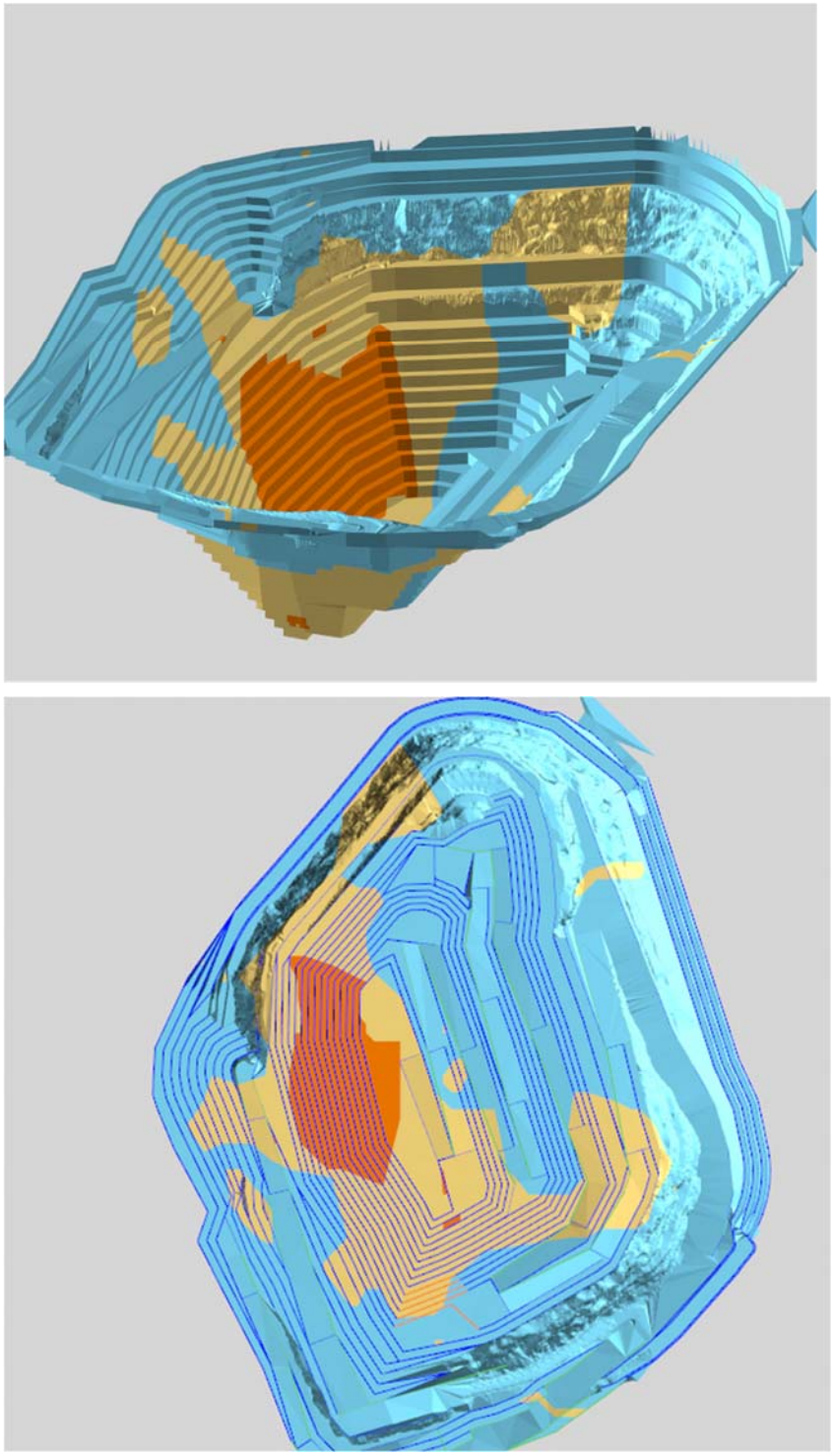


Figure 11-11 highlights the rock types exposed in the final pit shell at closure which correspond to input geometry data in the WB/WQ model.

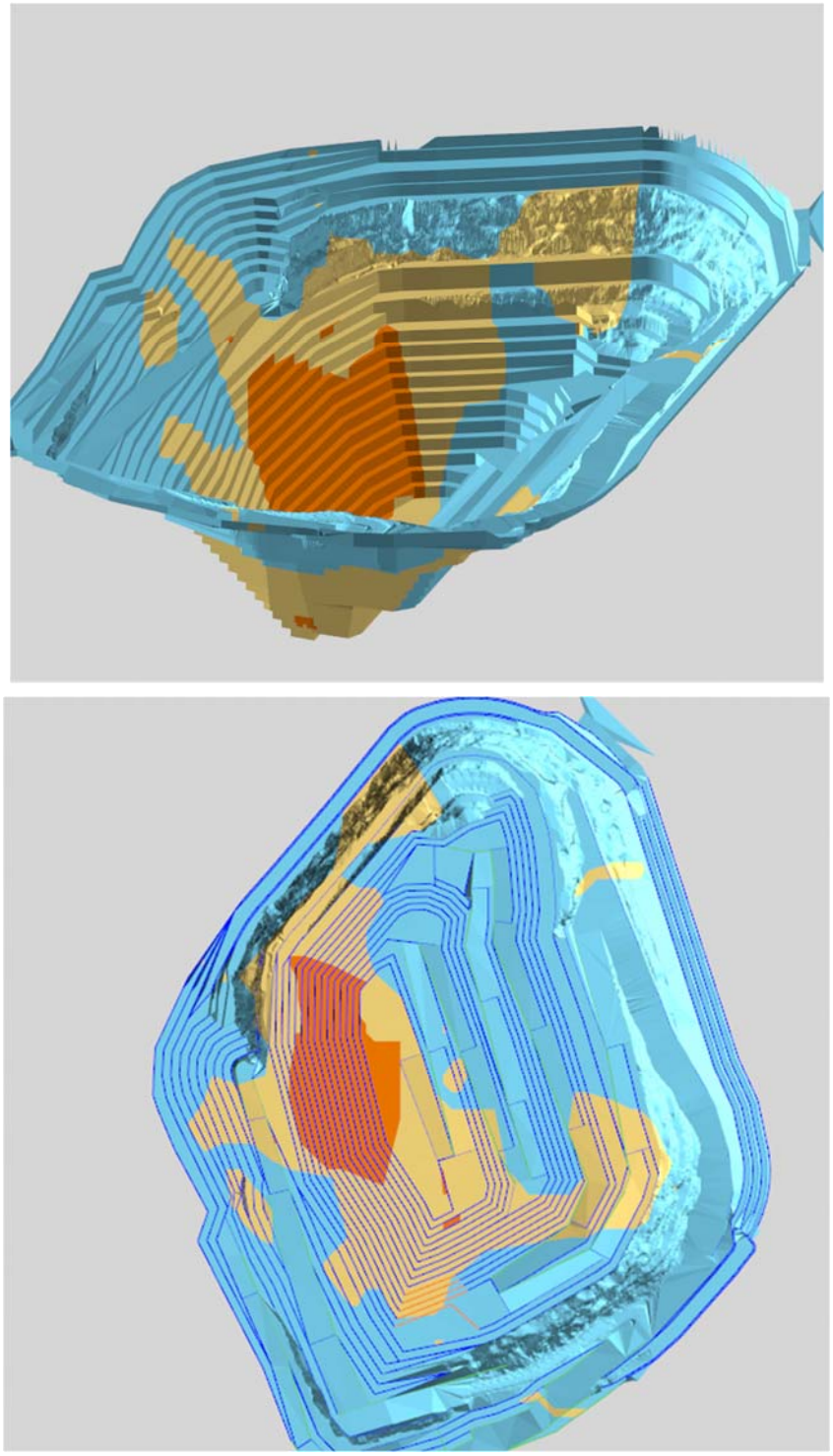


Figure 11-11: MRO final pit shell and expose wall it wall rock types (Blue = NAF, yellow = PAF-LC, orange = PAF-HC)

11.14 Catchment modelling

The Deswik.Water Catchment tool were used to model drainage paths, and catchment boundaries (**Figure 11-12**), connections, spill points, areas, and capacities. To model the catchment in the greater mine area (i.e., outside the bounds of the provided mine area DEM) Shuttle Radar Topography Mission elevation data was sourced from Geoscience Australia and appended to the final landform surface. A 5 x 5 m gridded DEM derived from these merged elevation data was then used as the input for the WaterCatchment tool.

The catchments were then subdivided based on land use type by identifying different landform features to represent different land types (e.g. mine impacted versus natural). Separation of sub-catchments based on land use type was important in the model construction for two reasons:

- to align with the geochemistry domains and source term data. Different land use types will be assigned with different source terms in the model and therefore must be separated.
- Different land use types have different hydrology behaviour and different runoff volumes will be expected.

Table 11-3 describes each of the different sub catchment types and the key mine domains within each catchment and their corresponding sizes. **Figure 11-12** shows the corresponding catchment boundaries.

Table 11-3: Sub Catchment Area Descriptions

Sub-catchment (number)	Domain (within catchment)	Area (m2)	% Contribution
Combined Dam Catchment (1)	Total catchment	484,069	94.49%
	South Dam	28,238	5.51%
Eastern NWRD Catchment (2)	Total catchment	2,284,637	79.63%
	NWRD	584,527	20.37%
Northwest NWRD Catchment (3)	Total catchment	703,578	70.89%
	NWRD	288,897	29.11%
WWRD Catchment (4) (during closure)	WWRD (pre closure)	177,019	4.31%
	West Dam	46,348	1.13%
	Total catchment	3,887,551	94.57%
Western TSF Catchment (5) (combine with catchment 7)		-	-
Western Borrow Area Catchment (6)	Total catchment	408,930	100.00%
TSF Catchment (7)	Total catchment	2,249,673	53.85%
	TSF	1,927,713	46.15%
TSF Sediment Dam Catchment (8)	Total catchment	1,110,496	99.62%
	Sediment dam 3	4,269	0.38%
Open Pit Catchment (9)	Total catchment	968,286	100.00%
Swindon-Rawdon Catchment (10)	Total catchment	8,867,523	100.00%

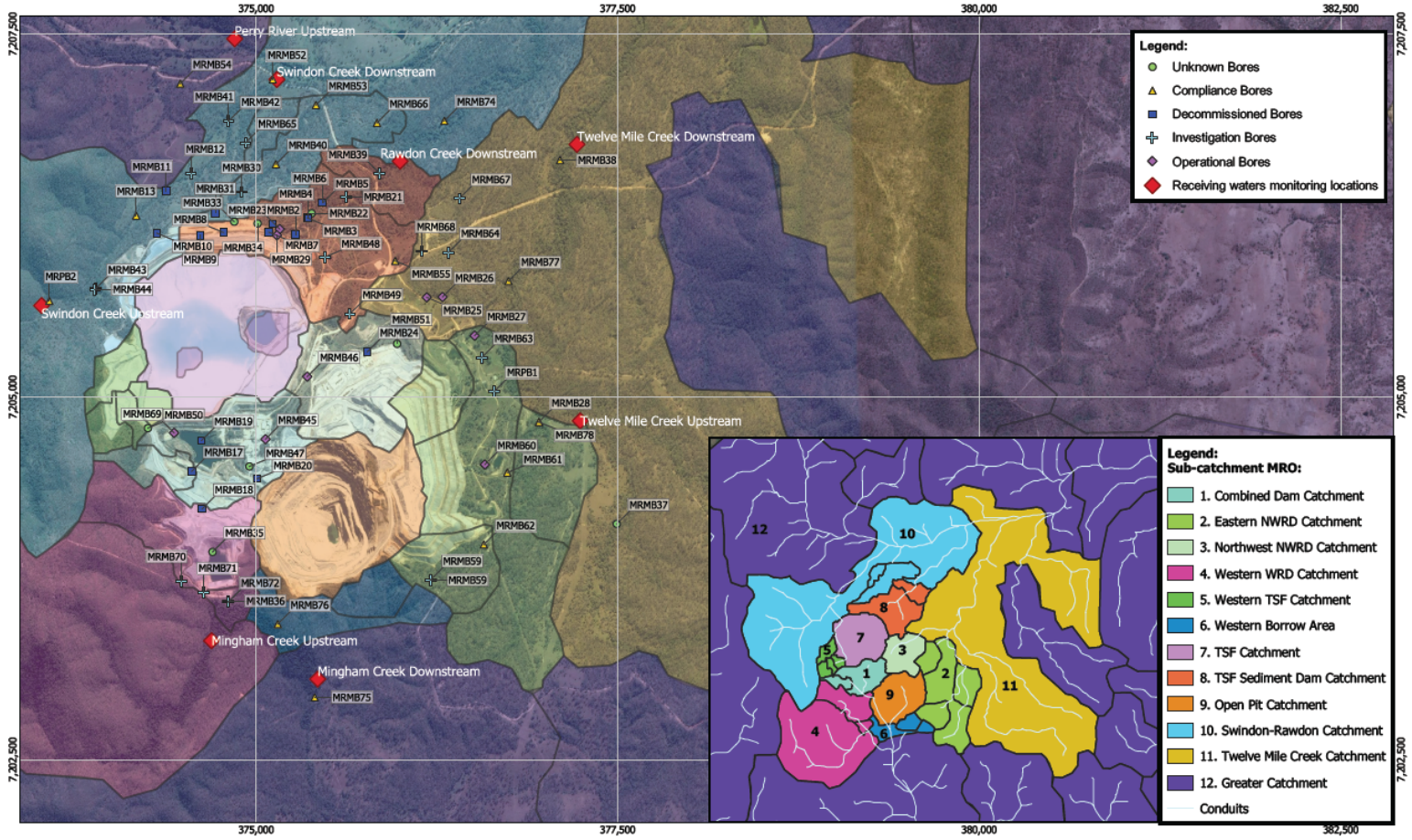


Figure 11-12: **Sub Catchment boundaries**

11.15 Surface Water

After closure, there will be various potential surface water inflows to the pit void from the catchments and each of these has been accounted for within the model to allow simulation and comparison of different closure scenarios. This section describes the approach to the surface water and hydrology components in the model development.

The key surface water flows incorporated in the model are:

- Local rainfall and runoff
  - direct rainfall onto the pit lake surface
  - runoff from pit walls;
  - runoff and seepage from the NWRD, WWRD and TSF;
  - overflow from sediment dams; and,
  - local runoff from the surrounding catchments (various land use types);

All surface water flows generated from sizeable and undisturbed catchments are be simulated within the GoldSim model itself, using the Australian Water Balance Model (AWBM) as a module.

Runoff and seepage generated from the smaller catchments is generated in the model using runoff and seepage coefficients.

11.15.1 The Australian Water Balance Model

AWBM is a daily timestep hydrology model which takes in rainfall (stochastic rainfall datasets) and evapotranspiration data, then simulates the infiltration, soil storage based on antecedent rainfall conditions, and the hydrological lag response in the catchment and produces runoff as a daily timestep. **Figure 11-13** shows a schematic of the model logic. The model is able to simulate both surface runoff and shallow baseflow runoff, which together make up the total runoff.

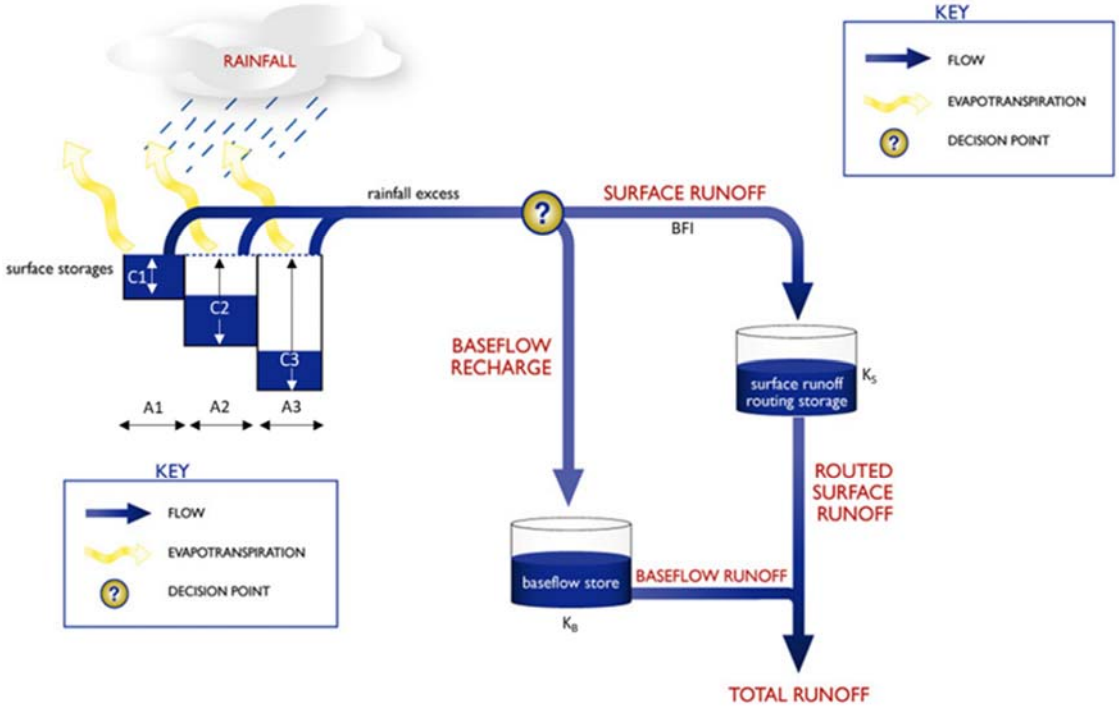


Figure 11-13: Schematic of the Australian Water Balance Model

The parameters in the AWBM model are summarised in **Table 11-4**.

Table 11-4: AWBM parameters

Parameter	Symbol	Description
Surface Area Stores	A_1, A_2, A_3	Proportion of the modelled catchment for each of the surface storages. i.e. storage per square meter of surface area. $A_1 + A_2 + A_3 = 1$
Soil Storage Capacities	C_1, C_2, C_3	Storage capacity for each surface store. Each storage is a depth measured in mm.
Baseflow Index	BFI	Fraction of runoff which reports to baseflow (ranges from 0 to 1)
Surface runoff recession constant	K_s	Fraction of surface runoff recession at each timestep (ranges from 0 to 1)
Baseflow runoff recession constant	K_b	Fraction of baseflow runoff recession at each timestep (ranges from 0 to 1)

A separate hydrology module has been developed for each of the land use types represented in the pit water balance. Each module will produce two hydrology outputs:

- surface runoff; and,
- shallow baseflow.

A summary of the different modules to represent each land-use type, and the proposed hydrology approach is provided in **Table 11-5**. RGS expects that some of the input parameters will be updated with measured data when/if it becomes available from other ongoing assessments

Table 11-5: Hydrology approach for various landforms

Landform Area	Hydrology module	Simulation approach
direct rainfall onto the pit lake/ dam surface;	**Water surface**	The pit lake/ dam surface area at each timestep Direct rainfall volumes are calculated at each timestep with the dynamic water surface area and 100% Runoff assumed. i.e. runoff (t) = rainfall (mm/d) * surface area (t)
Undisturbed area within the mining lease	**Undisturbed**	Any area that remains in it's natural, pre-mining project state and has not been disturbed by the mining operations. The undisturbed AWBM module for catchments 4,10,11 uses generic AWBM parameters.
Perry river catchment.		AWBM model used for Perry River Catchment has been calibrated to river gauging station 136019A downstream from Twelve Mile Creek Catchment . This calibrated modules represent land which is not disturbed by mining activities.

Landform Area	Hydrology module	Simulation approach
Pit walls (including NAF, PAF-H and PAF-L wall material)	**Pit and disturbed areas**	Pit wall and pit floors which are characteristically highly compacted. In the absence of recorded pit runoff data for calibration, the runoff and seepage from the remaining landforms have been generated by the model using runoff and seepage coefficients..
Disturbed areas within the mining lease		

11.15.2 Undisturbed AWBM Hydrology Module Calibration

The undisturbed module for Perry River was calibrated to observed streamflow data for the Perry River at Mt Rawdon gauge - BOM ID 136019A. This gauge is downstream from Twelve Mile Creek Catchment outlet into Perry River.

In the calibration, SILO historical rainfall and potential evapotranspiration point data for the location was used. The model was calibrated within GoldSim using the available data from 1995 to 2014. A visual assessment was applied to assess the accuracy of the calibration.

It should be noted that there are only two gauging stations on Perry River in the vicinity of the mine site. One located at Evolution Dam Headwater (not useful for calibration of natural flows as it exhibits flow buffering characteristics being located in the dam pool) and one downstream (used for calibration) in which natural flow is somehow obscured to some extent by upstream dam water releases.

Figure 11-14 presents the observed flow timeseries plotted against the calibrated simulated flow timeseries. The figure shows that the calibration achieved a reasonable fit between the observed and modelled streamflow data considering the gauging station location.

In summary, in the absence of measured data a generic AWBM module was used for all of the sizeable and undisturbed catchments within the mining lease, and calibrated (to available data and considering the unfortunate location of the gauging station) AWBM module was used for Perry River flows upstream and downstream from the mine site. The resultant applied parameters for the undisturbed AWBM modules are summarised in **Table 11-6**.

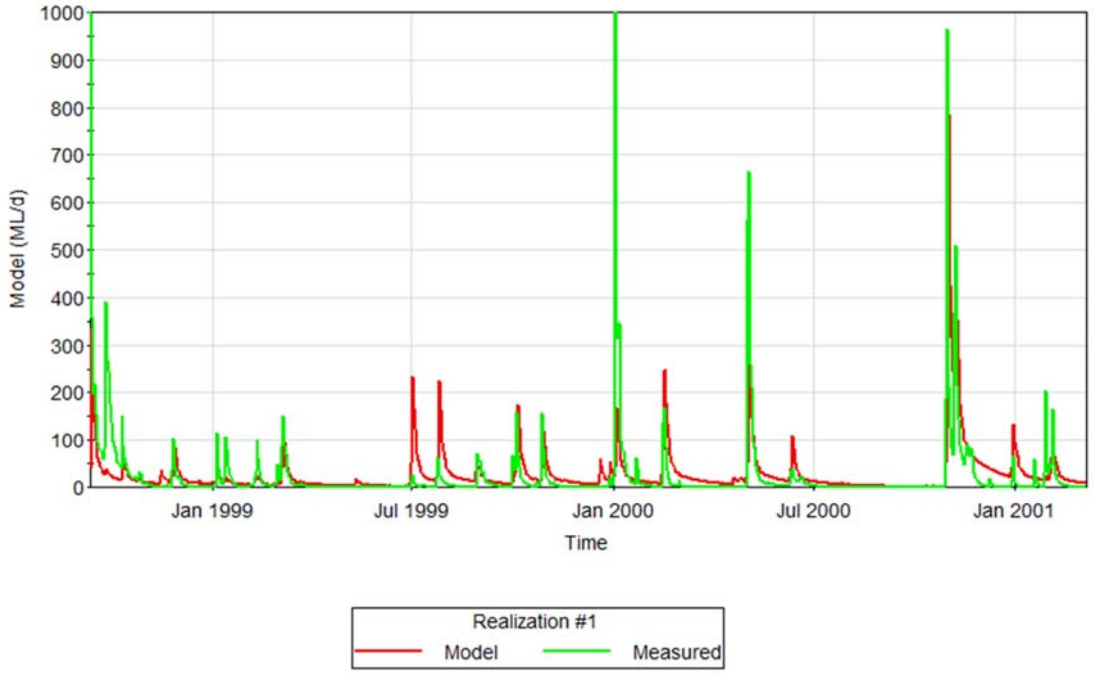


Figure 11-14: Observed versus simulated stream flow data.

Table 11-6: Calibrated parameters for natural undisturbed catchments

Parameter	A_1	A_2	A_3	C_1	C_2	C_3	BFI	K_b	K_s
Generic module	0.134	0.433	0.433	10	20	60	0.5	0.697	0.969
Perry River Module	0.134	0.695	0.17	10	35.11	196.6	0.5	0.697	0.969

11.16 Groundwater

Groundwater inflow into the pit and outflow from the pit were simulated using an analytical approach coded directly in GoldSim model.

A large water well inflow equation was used to estimate groundwater inflows and outflows from the pit:

Q = 2.73*k*h*d/ln(R/r)

Where:

k – hydraulic conductivity

h – aquifer thickness

d – drawdown

R – radius of pit cone of depression

r – radius of well (radius of pit base)

In essence, based on daily data, the equation calculates inflows into the pit while pit lake level is below the estimated regional groundwater level, and outflows from the pit lake in case when pit lake level is higher than the assumed regional groundwater level.

The model results for one of the simulated cases are presented below (**Figure 11-15** and **Figure 11-16**).

Overall, the groundwater inflows / outflows to and from the pit are likely to be insignificant contributions compared to all of the other water sources, there is however a considerable uncertainty in groundwater inflow prediction, mostly due to the complexity of the groundwater system.

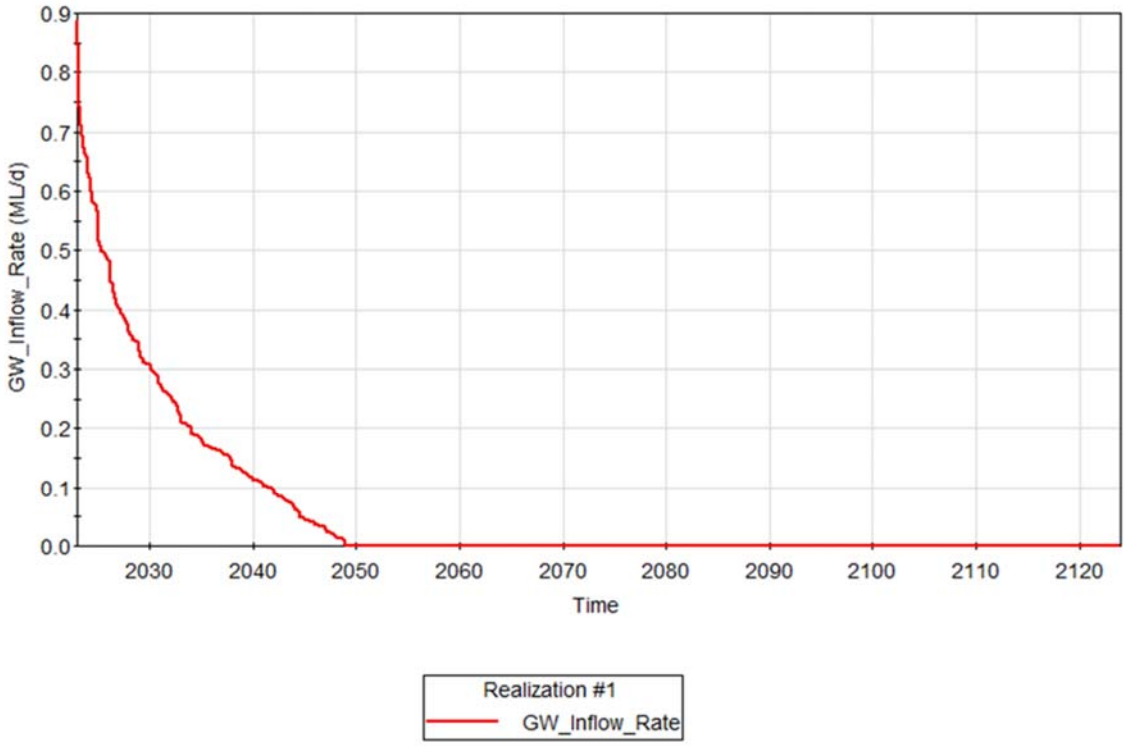


Figure 11-15: Groundwater inflow to the pit rate versus time

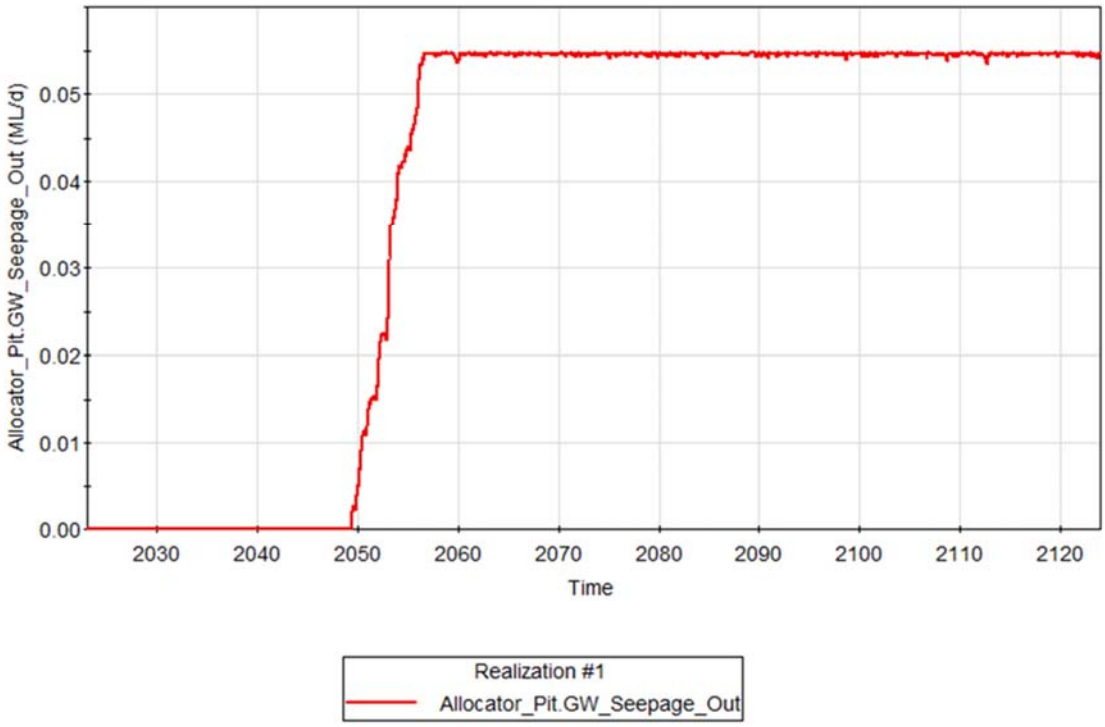


Figure 11-16: Groundwater outflow from the pit versus time.

11.17 Water quality components of model

11.17.1 General Approach

The general approach to simulating water quality within the model for each scenario includes:

- Determination of the exposed/ saturated pit wall (by waste type: NAF rock, M-PAF rock and H-PAF rock) and water volumes in each (daily) time step of the simulation;
- Addition of dissolved loads added to the system through groundwater inflows, surface water runoff and pit wall reactions (runoff);
- Mixing of loads and volumes to determine mass balance concentrations;
- Calculation of water losses via evaporation, groundwater and other losses with distributed dissolved mass loss; subsequent mass additions and water balance considerations;
- Recalculation of mine pit water body quality progressively (daily) over the duration of model simulation (100 years).
- Selectively apply geochemical controls (e.g. mineral solubility, atmospheric equilibrium).

11.17.2 Geochemical Source Terms

The source terms (geochemical inputs) are used in the WB/WQ model to evaluate how the catchment and pit water quality may evolve over time. The source terms have been generated from a combination of inferred, assumed and measured data. The data used to derive the source terms is provided in **Table 11-7**.

Surface water and groundwater quality source terms were generally developed from historical site monitoring data. If there was sufficient data, median and 95th percentile values of water quality data were applied to the model. When water quality data were below instrumental detection limits,

concentrations equal to half the detection limit were applied to the source terms or for some source terms the detection limits were applied to be conservative. As part of the QA/QC process unit errors were corrected, and in some cases spurious results were deleted.

Since pH is on a logarithmic scale, pH was converted to H^+ so that median and 95th percentile could be calculated for source term inputs.

The source terms for the pit walls were inferred using results of laboratory KLC testing and data from other sites; a detailed description of this process is described in following sections. Where no suitable data was available, the source terms were inferred from measured data.

Table 11-7 Geochemical data to derive source terms

Catchment (during/ post closure)	Water Quality Inputs	Model Input	Description
Combined Dam Catchment (1) (during closure)	Starting South Dam WQ	Measured	South Dam water quality measurements (Median and 95th percentile). Four measurement 6/08/2020 - 6/05/2021.
	Mine affected Runoff	Measured	Rawdon Creek Downstream water quality measurements (Median and 95th percentile). 137 measurements 4/01/2000 - 07/04/2021.
Combined Dam Catchment (1) (post closure)	South Dam WQ	Modelled	Pick-up water quality from during closure modelling.
	Rehab Runoff	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Eastern NWRD Catchment (2) (during closure)	NWRD Runoff	Measured	Measured water quality from Waste Rock Dam 2, 3 and 4 (WD2, WD3 & WD4) (10th percentile). 818 measurements 01/12/2003 - 5/08/2021.
	NWRD Seepage	Measured	NWRD seepage measurements from 11 sites (Median and 95th percentile). 24 measurements from 3/06/2010 - 23/08/2012.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Eastern NWRD Catchment (2) (post closure)	NWRD Runoff	Measured	Measured water quality from Waste Rock Dam 2, 3 and 4 (WD2, WD3 & WD4) (10th percentile). 818 measurements 01/12/2003 - 5/08/2021.
	NWRD Seepage	Measured	NWRD seepage measurements from 11 sites (Median and 95th percentile). 24 measurements from 3/06/2010 - 23/08/2012.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Northwest NWRD Catchment (3) (during closure)	NWRD Runoff	Measured	Measured water quality from Waste Rock Dam 2, 3 and 4 (WD2, WD3 & WD4) (10th percentile). 818 measurements 01/12/2003 - 5/08/2021.
	NWRD Seepage	Measured	NWRD seepage measurements from 11 sites (Median and 95th percentile). 24 measurements from 3/06/2010 - 23/08/2012.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Northwest NWRD	NWRD Runoff	Measured	Measured water quality from Waste Rock Dam 2, 3 and 4 (WD2, WD3 & WD4) (10th percentile). 818 measurements 01/12/2003 - 5/08/2021.

Catchment (during/ post closure)	Water Quality Inputs	Model Input	Description
Catchment (3) (post closure)	NWRD Seepage	Measured	NWRD seepage measurements from 11 sites (Median and 95th percentile). 24 measurements from 3/06/2010 - 23/08/2012.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
WWRD Catchment (4) (during closure)	WWRD Runoff	Measured	West Waste Rock Dump Dam water quality monitoring data (10th percentile). 147 measurements 26/03/2014 - 6/08/2021.
	WWRD seepage	Measured	West Waste Rock Dump Dam water quality monitoring data (Median & 95th percentile). 147 measurements 26/03/2014 - 6/08/2021.
	West Dam starting	Measured	West Waste Rock Dump Dam water quality monitoring data (Median & 95th percentile). 147 measurements 26/03/2014 - 6/08/2021.
	Mine affected Runoff	Measured	Rawdon Creek Downstream water quality measurements (Median and 95th percentile). 137 measurements 4/01/2000 - 07/04/2021.
WWRD Catchment (4) (post closure)	West Dam	Modelled	Pick-up water quality from during closure modelling.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Western Borrow Area Catchment (6) (during/post closure)	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
TSF Catchment (7) (during closure)	TSF Runoff current	Measured	TSF decant water quality measurements (Median and 95th percentile). 86 measurements 3/11/2011 - 10/12/2019
	TSF Seepage	Measured	Measured TSF seepage water quality (Median and 95th percentile).
TSF Catchment (7) (post closure)	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
	TSF Seepage	Measured	Pick-up water quality from closure modelling. 12 measurements 18/12/2020 - 07/05/2021.
TSF Sediment Dam Catchment (8) (during closure)	Starting sediment dam 3	Measured	Measured Sediment Dam #3 water quality (Median and 95th percentile). 33 measurements 18/10/2017 - 5/08/2021
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
TSF Sediment Dam Catchment (8) (post closure)	Sediment dam 3	Modelled	Pick-up water quality from during closure modelling.
	Natural land	Inferred	Inferred from measured water quality data for Burnett River (Figtree) (Min. & 10th percentile). 6 measurements.
Open Pit Catchment (9)	Open pit start	Measured	Pit sump water quality measurement. 234 measurements from 21/07/2004 to 25/05/2016. (more recent results available for model calibration)
	Pit wall: NAF (mg/m2/day)	KLC tests (Inferred)	Kinetic leach testing results (2016 - 2022) of NAF rock. Calculate loading rate. Median and 95th percentile of last for leach events. Apply scaling factors.

Catchment (during/ post closure)	Water Quality Inputs	Model Input	Description
	Pit wall: M-PAF (mg/m2/day)	KLC tests (Inferred)	Kinetic leach testing results (2016 - 2022) of M-PAF rock. Median and 95th percentile of last for leach events. Apply scaling factors.
	Pit wall: H-PAF (mg/m2/day)	KLC tests (Inferred)	Kinetic leach testing results (2016 - 2022) of H-PAF rock. Median and 95th percentile of last for leach events. Apply scaling factors.
Groundwater	Groundwater	Measured	Groundwater bore monitoring data: MRMB76; MRMB20; MRMB35; MRMB36; MRMB45 (Median & 95th percentile). 319 measurements

11.17.3 Geochemical Loading Rates

The rate of production of dissolved mass has been calculated for the model using the results of KLC tests conducted in the laboratory. These tests are conducted to establish the long-term behaviour of geological materials (Price 2009; Morin and Hutt 1999). These rates are based on kinetic tests conducted under fully oxidative conditions (free leaching).

The geochemical solute release rates (loading rates) have been calculated by interpretation of leachate water quality from the KLC tests and the volume of representative materials within the columns and converting the time lapse data into release rates. Additional factors are considered in these calculations, such as “flushing”.

The process for converting individual KLC test results into a loading rate is as follows:

- Leached concentrations and volumes from the KLC tests are compiled into a single large file.
- Concentrations and cumulative volumes are converted into loading rates.
- Analyses are excluded if a flushing event was evident (i.e. first flush phenomenon).
- Concentrations are assessed statistically to determine the median and 95th percentile. In this case the median and 95th percentile are calculated from the last four leaches.

Time and mass dependent loading rates are calculated by multiplying the effluent concentrations by the effluent volume and dividing by the sample mass and the sample interval to produce a mg/kg/month value, Equation 1.

$$\boldsymbol{LoadRate} = \frac{[X]v}{\frac{m}{t}}$$

where:

X = the concentration in the effluent.
v = the volume of effluent.
m = the mass of source term used (rock mass).
t = the period of time since the last measurement was taken (i.e. monthly).

Two loading rates are calculated for each parameter for each of the waste material types (NAF rock, M-PAF rock and H-PAF rock) for free leaching conditions. The Base Case is taken from the median values of the loading rates and the Upper Bound from the 95th percentile (P95) of the loadings rates.

Scaling factors are also employed (**Section 4.10.4**) to the laboratory rates to derive release rates applicable to field conditions at MRO.

11.17.4 Scaling Factors

For the pit wall materials, scaling factors are applied to the calculated loading rates (solute release rates) to scale the laboratory derived release rates to field conditions at MRO. The scaling factors account for (amongst other things): particle size effects, water-rock contact and oxygen availability (e.g. saturated versus un-saturated) and are consistent with reported values elsewhere (Kempton, 2012; Linklater et al., 2017). A description of how the scaling factors were derived and the key assumptions are provided in **Annex A**.

11.17.5 Pit Wall Solute Reservoir

Distribution of pit wall materials (NAF rock, M-PAF rock and H-PAF rock) were derived from the mining pit shell and geological information for these pit shells. To reflect the interaction of the pit wall materials with rainfall and runoff, the model implements specific logic around the release of solutes from the pit wall to the pit water body. The logic is as follows:

- The daily loading rate is accumulated in a “reservoir” for each timestep where no rain occurs.
- The daily loading rate is linked to the pit wall surface area for a material type that is either exposed or inundated by the pit water body.
- When there is a rain day of greater than 10 mm/day, the cumulated solute mass within the reservoir is released to the pit water body on that day.
- If there is a dry day (i.e. rainfall less than 10 mm/day) following the rain day, then the accumulation starts again.
- If there are subsequent rain days (i.e. greater than 10 mm/day) after an accumulated mass is released from the reservoir, then the loading rate keeps releasing a daily load.

For example, a sustained dry period (i.e. consecutive days without rain greater than10 mm/day) for 100 days followed by a rainfall event greater than 10 mm/day would result in release of a solute load that has accumulated in the reservoir for 100 days (i.e. 100 days of load), consecutive rainfall days (greater than 10 mm/day) after the initial release would results in a daily release. This reflects the accumulation of soluble species in the pit walls with time which dissolves during rainfall events and enters the pit lake.

11.17.6 Contaminant Transport Module

The water quality components of the model are simulated using the contaminant transport module in GoldSim. For each water source (including local rainfall and runoff sources, external fill sources and groundwater flux sources), a cell pathway was used to simulate the loading rates. All Cell pathways were constructed as vectors referencing the array of species. This means that for each input source, one cell pathway element was used to simulate the transport of all modelled species.

Loading rates in the Cell pathways were calculated as follows:

Source terms (Vector of 28 species) [mg/l] x inflow rate [l/d]

11.18 Model Structure and Logic

This section describes the GoldSim model structure. A number of different containers (yellow boxes) are used to represent each of the different aspects to the pit water balance (**Figure 11-17**).

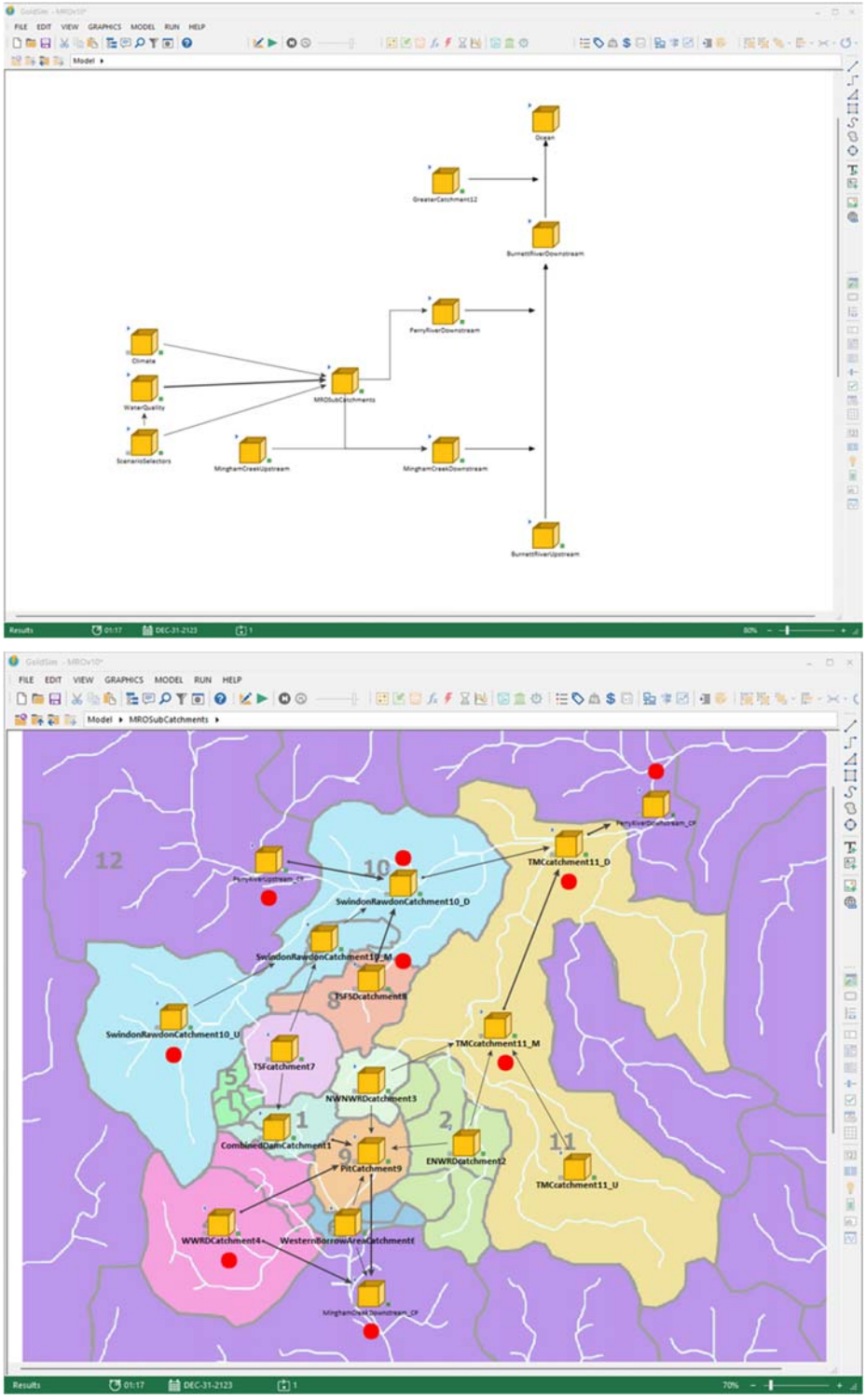


Figure 11-17: GoldSim model structure

11.18.1 Model Switches

A number of switches have been programmed into the model to allow it so to simulate different scenarios and sensitivities. The switches are summarised in **Table 11-8**.

Table 11-8: Summary of Model Switches

Switch	Description	Value	Function
Climate	Selects whether a historical or forecast climate will be applied in the simulation	1	Historical
		2	Forecast
Forecast climate	Selects which climate forecast will be applied (e.g. SCL generated Monte Carlo Series or Random Year Series)	1	Historical
		2	Random Year Series
		3	SCL Monte Carlo Series
Scenario	Selects the scenario to be simulated	1	Scenario 1
		2	Scenario 2
		3	Scenario 3
Closure Dates	Allows to modify closure dates for all of the project sub-catchments	Date input - manual	
Geochemistry	Selects which geochemistry source terms will be applied (average or 95th percentile source terms)	1	Average
		2	95th percentile (Extreme)

11.18.2 Climate and Hydrology

The model is structured with a 'global' climate and hydrology section, containing the climate and the hydrology modules. This section contains a timeseries data element for the rainfall, shallow lake evaporation, and evapotranspiration data. It also contains a look up table for the stochastic rainfall inputs for each of the climate scenarios. The lookup table contains 100 rainfall timeseries replicates or 100 years.

The global runoff and climate data then feed into a number of other containers representing each different catchment or inflow to the pit void (**Figure 11-18**).

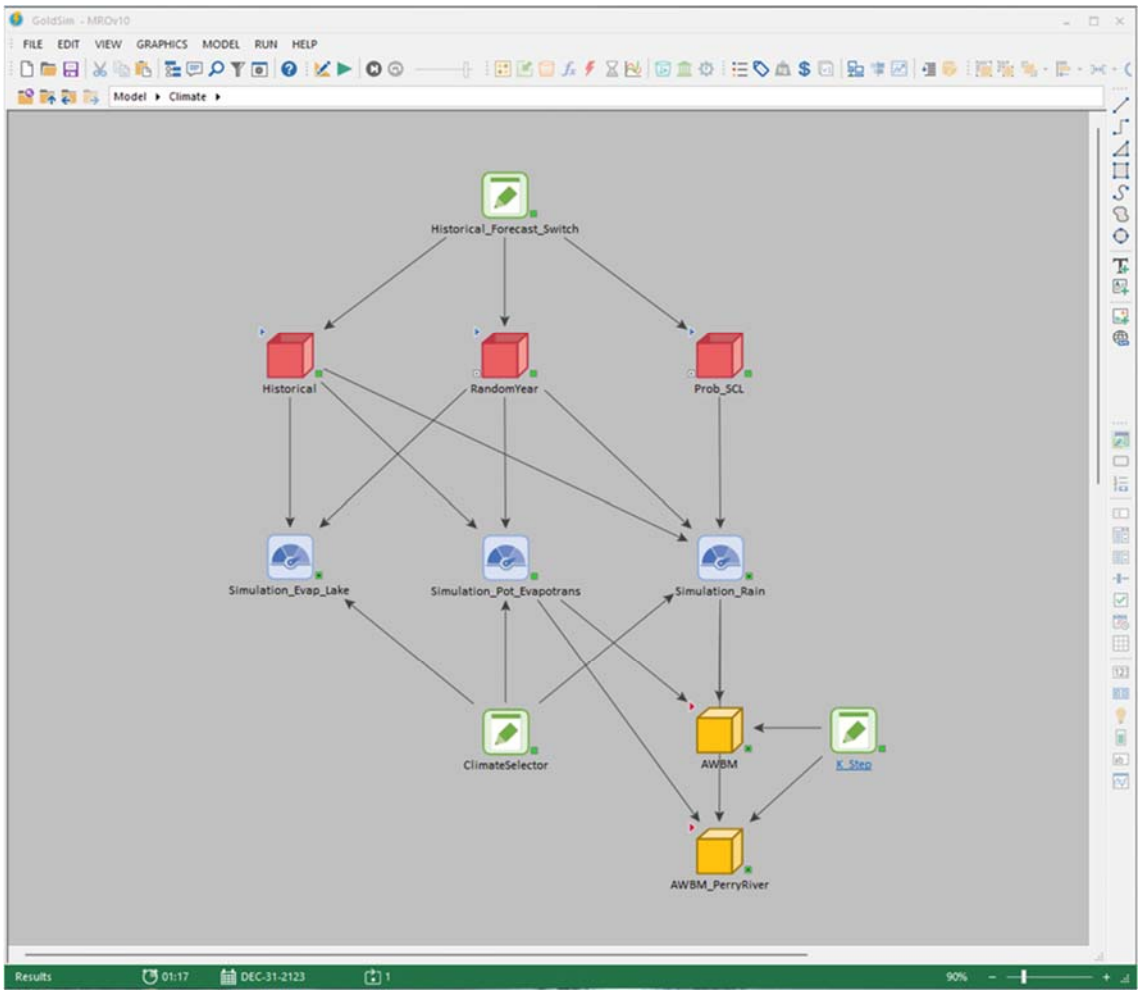


Figure 11-18: Climate Data within GoldSim Model

11.18.3 Geochemistry Inputs

The model has the capacity to simulate 28 species which are defined within the materials container of the model, in the species element. The list of species which has been programmed into the GoldSim model is summarised in **Table 11-9**.

Geochemistry source term data for each of these species is then imported into the model directly from a spreadsheet file. This file must be located with the same folder directory as the GoldSim model file in order for the model to run. This means that the geochemistry source terms can be easily updated in subsequent stages of work and read straight into the model whilst minimising additional programming within the GoldSim model.

Source terms are read into a spreadsheet element in the GoldSim model, which translates the data into a GoldSim element. A number of selectors are then used to determine which source term datasets will be used based on which geochemistry scenarios have been selected (i.e. average or 95th percentile).

Table 11-9: List of Water Quality Species simulated in GoldSim model

Array number	Parameter
1	H+ (pH)
2	TDS
3	Alkalinity (total)
4	Acidity

Array number	Parameter
5	Calcium
6	Chloride
7	Sulfate
8	Magnesium
9	Sodium
10	Potassium
11	Aluminium
12	Arsenic
13	Boron
14	Cadmium
15	Chromium
16	Copper
17	Fluoride
18	Iron
19	Lead
20	Manganese
21	Molybdenum
22	Selenium
23	Zinc
24	cyanide (WAD)
25	placeholder
26	placeholder
27	placeholder
28	placeholder

11.18.4 MRO Pit

MRO pit is programmed into the model as a reservoir element with the applicable physical characteristics. A sum of the inflows is applied to the Pit_Void reservoir, and a sum of the outflows is applied to the reservoir.

The GoldSim model has been designed such that the MRO pit is a closed system. This has been done by implementing a maximum volume of water that the pit can hold. If that volume is exceeded the pit overflows.

The maximum volume is set at an elevation of RL +120.0 m and represents the volume at which the pit is considered as “full” – 62.2 GL. Inflows

The model simulates the pit water body inflows based on the selected Scenario.

11.18.4.1 Local rainfall runoff and seepage

The model has separate containers to represent each of the sub-catchments which may contribute surface water runoff. Sub-catchments are divided based on location and proposed closure dates to represent different pit fill scenarios. This allows the model to attribute different hydrology modules and geochemistry source terms to each sub-catchment.

The different sub-catchments in the model include:

- Combined Dam Catchment (1)
- Eastern NWRD Catchment (2)
- Northwest NWRD Catchment (3)
- WWRD Catchment (4)
- Western TSF Catchment (5) (combine with catchment 7)

- Western Borrow Area Catchment (6)
- TSF Catchment (7)
- TSF Sediment Dam Catchment (8)
- Open Pit Catchment (9)
- Swindon-Rawdon Catchment (10)
- Twelve Mile Creek Catchment (11)

The runoff inflow rates for each of these areas is calculated in the model using the rainfall and the hydrology approach described in previous sections. The dry pit area and the water surface area are calculated dynamically in the model. This is because these areas change at each timestep as the pit void fills with water.

Cumulative inflow volumes are calculated and tracked. Each source is then linked to its relevant geochemical source term, and a loading rate calculated based on the flow and concentration.

11.18.4.2 Groundwater Inflow

The groundwater section incorporates the estimated groundwater inflow rates based on the approach explained above.

Cumulative inflow volumes are calculated and tracked. The groundwater inflow source is then linked to its geochemical source term (as described in **Section 11.17.2**), and a loading rate is calculated based on the flow and concentration.

11.18.5 Outflows

A description of the model structure and logic for outflows is provided below.

11.18.5.1 Evaporation

Evaporation losses are calculated at each timestep using the SILO Moreton's shallow lake evaporation, applied over the water surface area calculated at each timestep.

Evaporation leaving the MRO pit (and site sediment dams) does not carry any dissolved species mass with it, meaning that when the pit water body experiences significant evaporation over time, the dissolved species within the pit may concentrate over the duration of the model simulation.

11.18.5.2 Groundwater outflow

As the pit water level increases and the groundwater table reaches an equilibrium with the pit water body, some groundwater outflows are expected.

The groundwater outflow source is then linked to the MRO pit via a coupled flux link, which facilitates flow of water and mass from the MRO pit back to groundwater aquifer. As such, the loading rate reporting to the aquifer is then calculated based on the relevant outflow flux rate and applying the concentrations of each species in the MRO pit.

11.18.5.3 Overflow/ outflow

The model will calculate any surplus inflow which exceeds the pit's maximum volume based on its physical storage characteristics, and track this as overflow, calculating pit discharge rates and mass load leaving the pit over time.

11.18.5.1 Pit lake quality

The resulting water quality of the pit water body is simulated with CT cell pathway element (**Figure 11-19**).

The “Pit_Void” represents MRO pit water body volume and Pit_Void_Q represents CT cell calculating pit water quality. The GW_Sink cell in **Figure 11-19** represents mass load lost to aquifer, associated with groundwater seepage out of the pit.

The Pit_Void_Q cell pathway has a volume specified by linking to the element Pit_Void". "Pit_Void" is the reservoir element which tracks and accumulates water volume in the pit. This means that the Pit_Void_Q cell pathway's volume is equal to the dynamic volume of water in the Pit water body at each timestep.

The Pit_Void_Q cell pathway receives various inputs, depending on which Scenario is being modelled.

Pit_Void_Q cell pathway has the following outflows (regardless of the Scenario modelled):

- Mass flux transfer to cell pathways attached to groundwater flux sources (advective flux).
- Mass flux transfer to cell pathway attached to overflow (advective flux).

Since the Pit_Void_Q cell pathway is linked to the " Pit_Void" element, it takes into account evaporation losses which influence the MRO pit water body volume but do not result in subsequent loss of mass for each species.

The pH is then calculated for the pit and sediment dams initial volumes, and the Pit_Void_Q as:

pH = -log[H^+]

with the concentration of H^+ being in moles per litre.

Acidity in the model is calculated as (Kirby and Cravotta, 2005):

Acidity (mg/L as $CaCO_3$) $\approx 50 \times \left[\left(3 \times \frac{Fe_{total}}{55.85}\right) + \left(3 \times \frac{Al}{26.98}\right) + \left(2 \times \frac{Mn}{54.94}\right) + (1000 \times 10^{-pH})\right]$

With the concentrations of Iron, Aluminium and Manganese linked to the concentrations calculated in the Pit_Void_Q cell pathway.

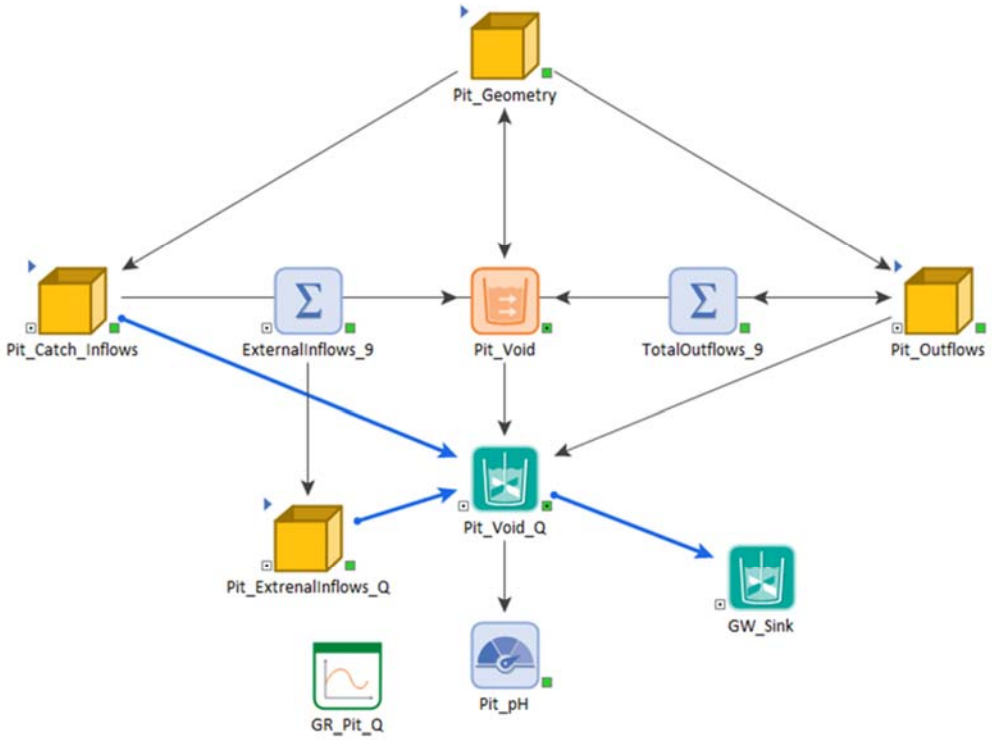


Figure 11-19: Pit volume tracking in GoldSim Model

11.19 WB/WQ Modelling Results

The MRO water balance and water quality (WB/WQ) model is a tool for assessing closure options with respect to the MRO site and pit lake. This report focuses on the scenarios and sensitives outlined in **Section 11.9**; however, the model has been developed so that a range of scenarios and sensitivities can be modelled, which are outside of the scope of this report, but may form key components of future stages of modelling. The following sections only summarise the key findings of specific scenarios and sensitivity analysis for the final void/ pit lake. It is noted that water qualities could be reported for each of the site dams, catchments, and compliance points. The broader results are in the Attachments. These results are of an inferred level of reliability.

11.20 Water Balance – pit lake water level

The water balance results are discussed below in terms of the pit lake water levels. For each of the scenarios, multiple climate sensitivity analysis was undertaken to examine the impacts of climate variability. The probabilistic scenarios applied 200 stochastic climate timeseries replicates over 200 realisations (model runs) to understand how the pit lake responded under climatic uncertainty.

The results in **Table 11-10** show the maximum pit lake level reached over the model run (100 yeas) for mean, maximum and minimum probabilities. The key results for each of the scenarios are summarised in the following points.

- **Scenario 1** showed that the pit water level never reaches capacity (RL + 120 m AHD) over the 100-year simulation period (**Figure 11-20**). The pit filled to a maximum RL of approximately +77 m AHD (mean probability) at year 2123 (100 years) and approximately +113 m AHD (maximum probability) at year 2034 (11 years). The pit initially fills quick during the pre-closure phase where all water is directed to the pit; however, post closure water levels stabilise and there is only a gradual increase since NWRD and TSF runoff water is release to the environment. Water levels appear to be close to stabilising (reaching equilibrium) towards the end of the 100 year simulations period.
- **Scenario 2** showed that the pit water level reaches capacity for the maximum probability and 95th percentile probabilities at years 2032 (9 years) and 2045 (22 years), respectively (**Figure 11-21**). The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity). Since all runoff and seepage water from the various site catchments are directed to the pit during and post closure there is a relatively seamless and rapid filling of the pit. Water levels appear to have stabilised (reaching equilibrium) within approximately 25 years for each of the sensitivities.
- **Scenario 3** showed that the pit water level reaches capacity for the maximum probability and 95th percentile probability at years 2032 (9 years) and 2057 (34 years), respectively (**Figure 11-22**). The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity). Since all runoff and seepage water from the various site catchments are directed to the pit during and post closure (excluding the TSF post closure) there is a relatively seamless and rapid filling of the pit. Water levels appear to have stabilised (reaching equilibrium) within approximately 40 years for each of the sensitivities. The water balance results are very similar to Scenario 2, albeit the fill and overflow times are longer due to the TSF runoff being release to the environment post closure.

Overall, the results show that the pit fill date (and associated number of years to fill), or time to reach maximum pit lake water level are sensitive to climatic uncertainty.

Table 11-10: Pit lake water levels

Scenarios	Max water level (year) (Mean probability)	Max water level (year) (Max probability)	Max water level (year) (Min probability)
Scenario 1: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment	RL +77 m AHD (2123)	RL +113 m AHD (2034)	RL +68 m AHD (2123)
Scenario 2: All runoff/ seepage water diverted to pit during closure and post closure.	RL +119.9 m AHD (first in 2048)	RL +120 m AHD (first in 2032)	RL +119.8 m AHD (first in 2051)
Scenario 3: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit	RL +119.9 m AHD (first in 2066)	RL +120 m AHD (first in 2032)	RL +119.8 m AHD (first in 2078)

Note: water levels have not stabilised for all scenarios and sensitivities over the 100-year simulation period.

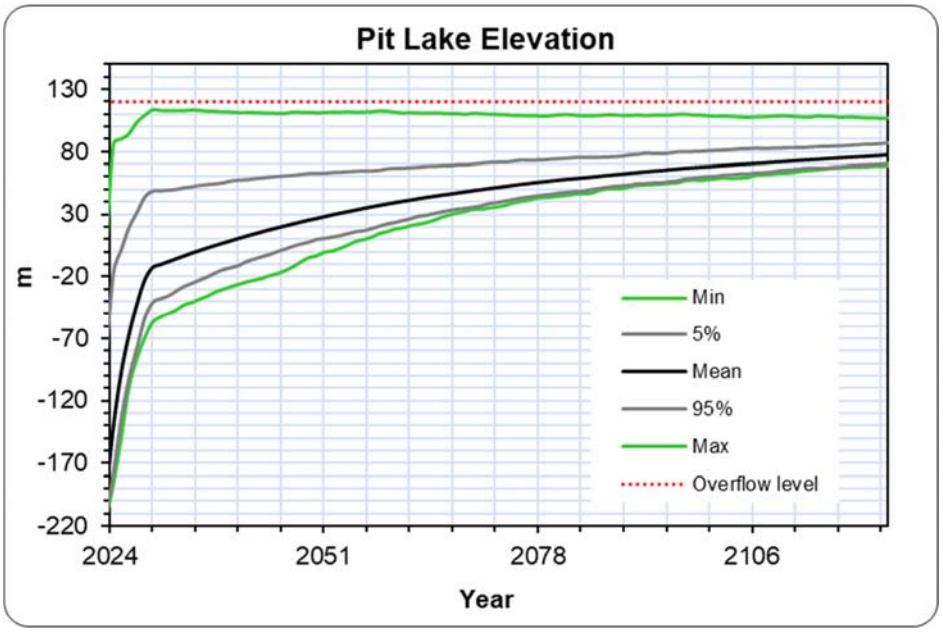


Figure 11-20: Scenario 1 – Pit lake elevation versus time

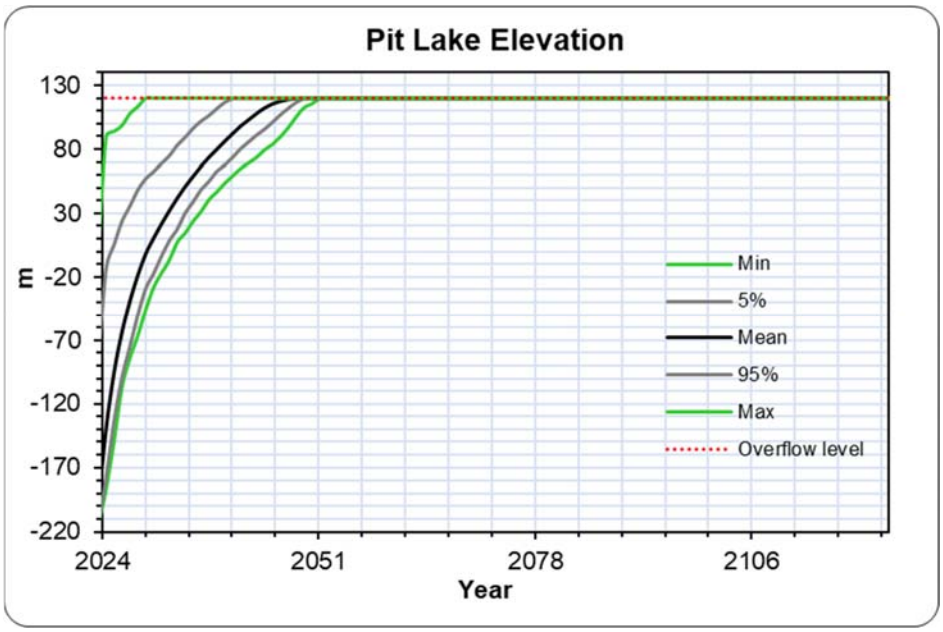


Figure 11-21: Scenario 2 – Pit lake elevation versus time

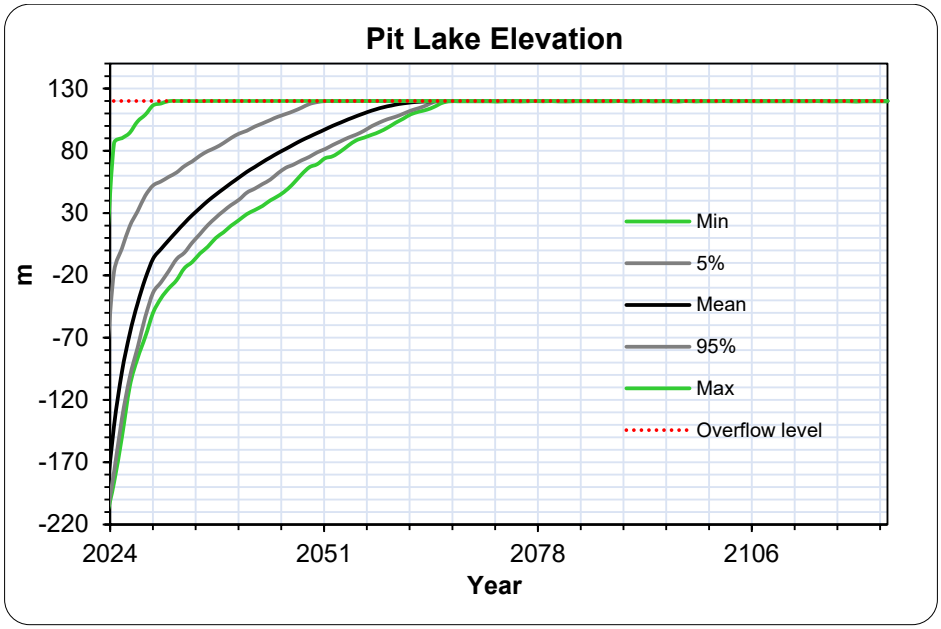


Figure 11-22: Scenario 3 – Pit lake elevation versus time

11.21 Water Quality

Hydrogeochemical modelling of the pit water quality is an iterative process similar to the water balance modelling, with results for daily time steps available for each of the modelled scenarios and sensitivities. A selected sample of results were exported from the model to summarise the key water quality results. A full summary of the water quality results for each of the modelled probabilistic scenarios for select years (years 0, 5, 10, 25, 50, 75 and 100) are shown in **Annex B**. Corresponding water quality versus time graphs are shown for each of the scenarios for each modelled water quality parameter in **Annex C**.

11.21.1 General water quality trend

The general water quality concentration trends vary slightly for different modelled species and reflect the water balance inputs and geochemical source terms. The general water quality concentration trends can be separated into different phases as outlined below:

Initial sump water quality

The first-time step in the model reflects the pit sump water quality which is present in the pit void before the commencement of the simulation. The pit sump water quality is generally concentrated (due to evapoconcetration) for most chemical species, resulting in an initial spike in the concentration versus time graphs (**Annex C**).

Arsenic (As) concentration versus time graphs for Scenario 1 (**Figure 11-23**) and Scenario 2 (**Figure 11-24**) are used to display the different water quality trends through the phases.

Pre-closure phase

The water quality results indicate that during the pre-closure phase all scenarios show the same general trend for a particular chemical species (e.g. **Figure 11-23** and **Figure 11-24**). This is because during the pre-closure phase, runoff and seepage water from the non-rehabilitated landforms is directed to the pit for each of the scenarios. This generally results in a gradual increase in concentration of a particular species within the pit lake over this time. This is exacerbated by evapoconcetration.

Post closure phase

The post closure phase shows some variation between chemical species and the scenarios with three general trends observed:

i) there can be a decrease in concentrations for some chemical species during the start of the post closure phase whereby runoff water from the rehabilitated landforms and direct rainfall dilutes the pit lake water quality (i.e. seepage and runoff water qualities pre-closure are far more concentrated than runoff and seepage from the rehabilitated landforms assuming constructed and functioning as planned). This is even more pronounced for Scenario 1 (**Figure 11-23**), where all TSF and NWRD seepage and water quality is released to the environment.

ii) the concentrations may remain relatively consistent over the post closure phase (e.g. (**Figure 11-24**) for those scenarios that the pit fills and overflows (Scenario 1 and Scenario 2) allowing release of chemical load.

iii) there may be a slight increase in the pit lake water concentration due mainly to the effects of evaporation (i.e. evapoconcentration).

The longer-term post closure phase for Scenario 1 (which does not overflow) generally shows a steady increase in concentration of solutes over the simulation period reflecting the effects of. evapoconcentration. Since the model simulates a ‘terminal sink’, the only means for removal of solutes (in the model) is via groundwater flux (or overflow). However, in reality, bio-geochemical processes (e.g. nutrient cycle, carbon cycling, etc.) would be expected to supress increasing concentrations and some form of equilibrium would be attained.

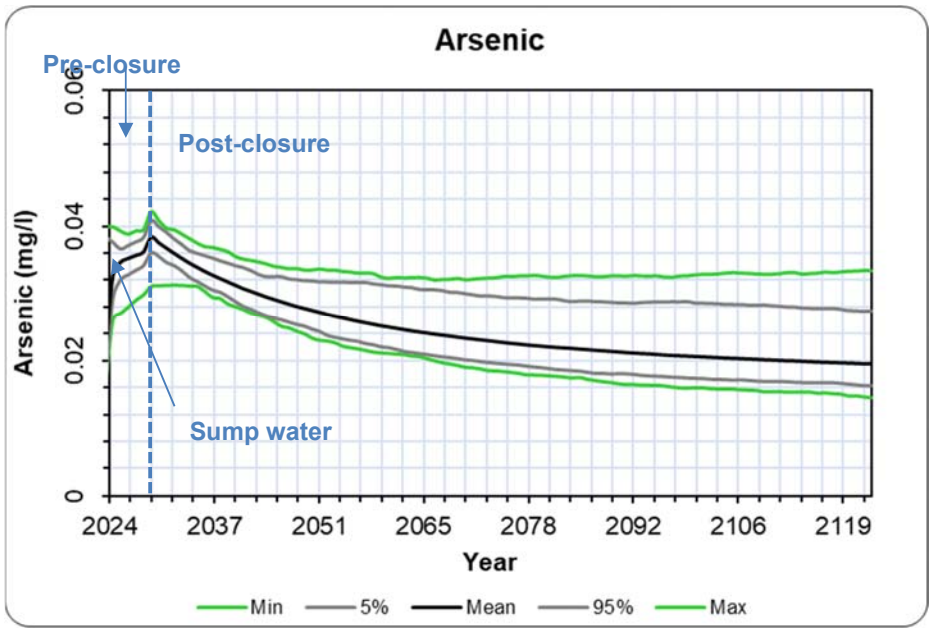


Figure 11-23: Arsenic concentration versus time for Scenario 1

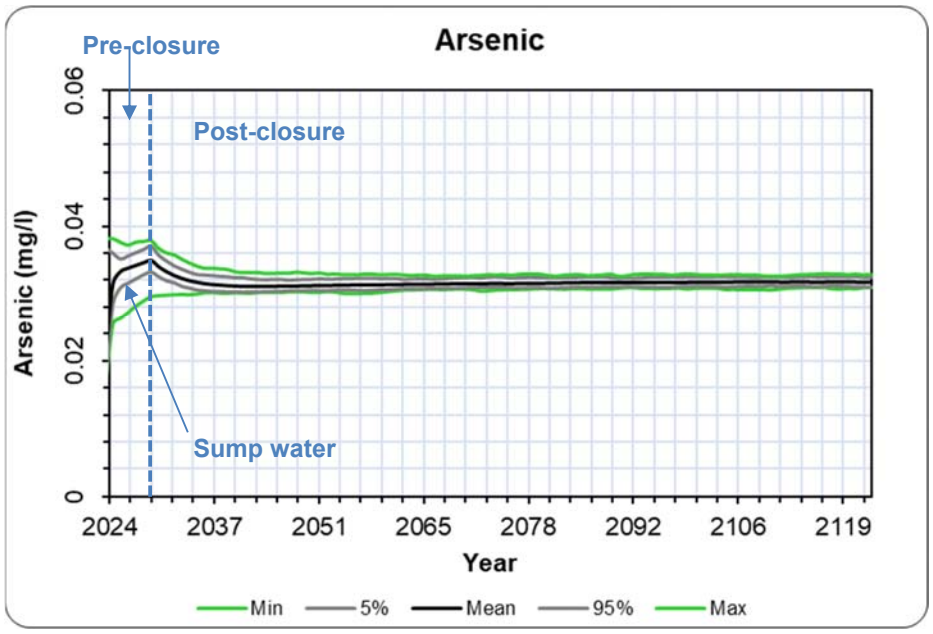


Figure 11-24: Arsenic concentration versus time for Scenario 2

11.21.2 Hydrogen ion concentration (pH) and alkalinity

The geochemical modelling simulated pH using the mass balance approach for H^+, which converts modelled H^+ to pH using pH = -log [H^+]. The results for each of the modelling scenarios and sensitivities indicate that pH is neutral over the simulation period with a pH range of ~ pH 7 to pH 6.3 (mean probability climate) (e.g. **Figure 11-25**).

The modelled pH values are consistent with what may be expected under field conditions in the pit lake, even when alkalinity and atmospheric equilibration is initially excluded from the model.

For example, as groundwater flux in the pit lake equilibrates with atmospheric concentrations of $CO_{2(g)}$ and $O_{2(g)}$, excess dissolved CO_2 from groundwater (for example) is vented to the atmosphere and diffusion of atmospheric oxygen into the pit lake. The loss of CO_2 results in a slight increase in pH due to a decrease in carbonic acid. This has been shown simplistically for the average groundwater composition using Geochemist's Workbench (GWB; Bethke and Yeakel, 2009); **Figure 11-26** shows the resultant pH and alkalinity of the groundwater after equilibration with atmospheric CO_2 (i.e. $PCO_2 = 10^{-3.5}$). The model indicated that pH is driven from pH 6.8 to pH 7.9 and alkalinity (HCO_3^-) from ~160 mg/L to ~40 mg/L.

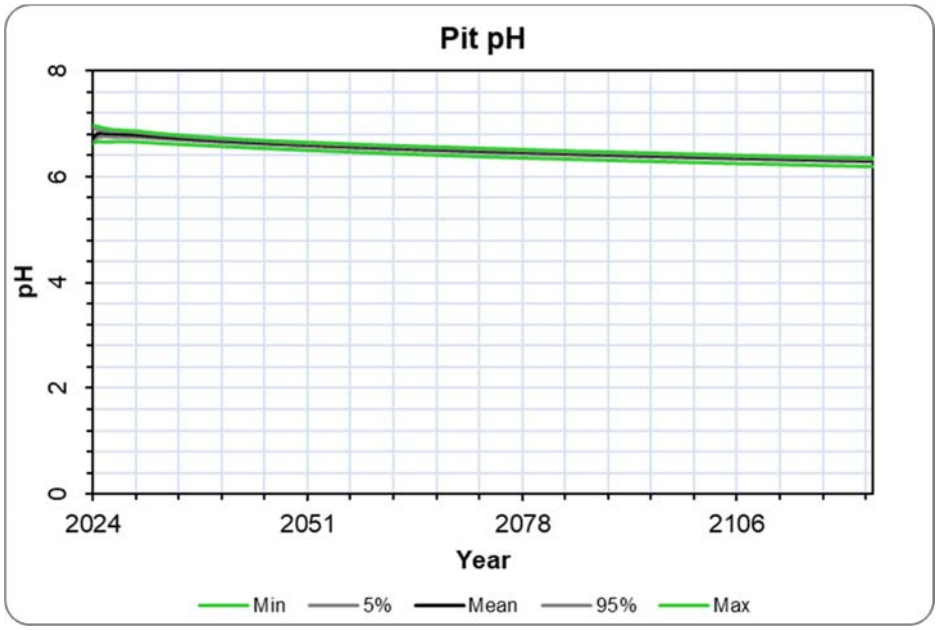


Figure 11-25: Modelling results for pH for Scenario (Note: results for Scenario 2 and Scenario 3 are very similar).

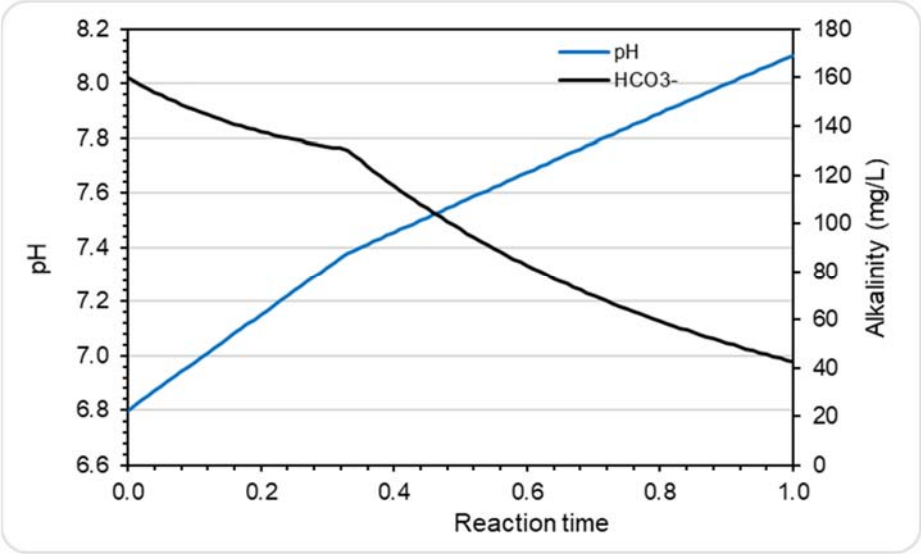


Figure 11-26: Adjustment of pH for average groundwater equilibrating with atmospheric $CO_{2(g)}$

11.21.2.1 Salinity

The water qualities for each of the scenarios and sensitivities are dominated by the major ions, with metals and metalloid concentrations relatively low in comparison.

The total dissolved solids (TDS) for each of the scenarios and sensitivities range from approximately 2,280 mg/L to 250 mg/L (mean probability) assuming that post closure rehabilitated landforms produce low concentration runoff water qualities. It also needs to be highlighted that the modelled concentrations are all dissolved, and total concentrations are likely to be far more concentrated, especially for rehabilitated landforms. TDS concentrations are typically dominated by sulfate (SO_4), sodium (Na) and chloride (Cl).

The gradual increase in TDS with time for Scenario 1 is due to evapoconcentration which is influenced by climate uncertainty (**Figure 11-27**). Scenario 2 and Scenarios 3 show lower TDS values due to pit lake overflow which releases solutes to the receiving environment.

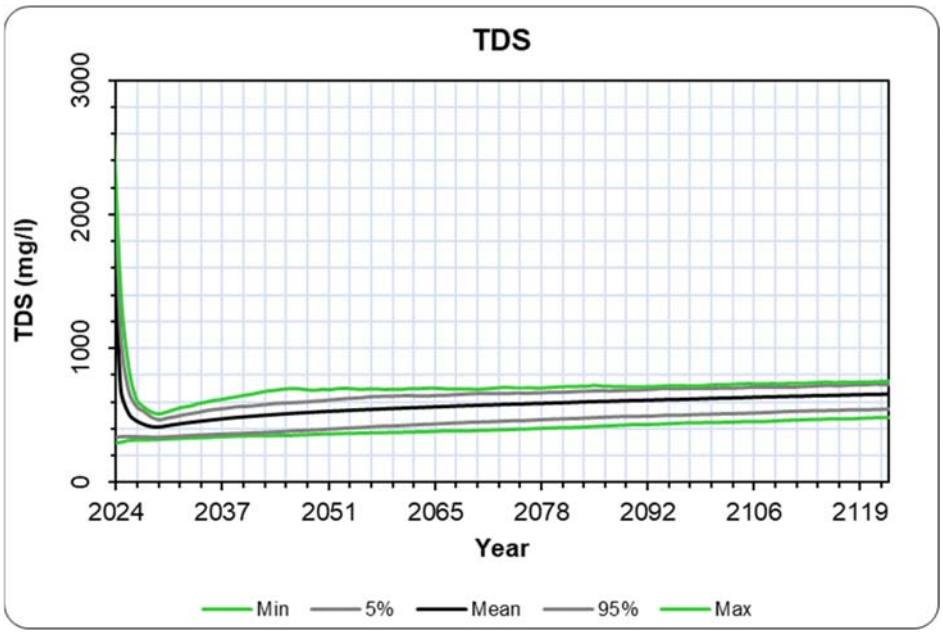


Figure 11-27: Modelling results for total dissolved solids (TDS) for Scenario 1.

11.21.2.2 Metal(loids)

The inferred modelling results statistics for each of the scenarios and sensitivities are provided in **Annex B** and **Annex C**. The mean, minimum and maximum statistics are summarised in **Table 11-11**.

The water qualities for each of the scenarios and sensitivities are dominated by the major ions. The mean probability water qualities at the end of the assessment period (100 years) for the major ion concentrations are: SO_4 (180 – 223 mg/L) >chloride (Cl; 63 – 243 mg/L) > sodium (Na; 61 - 143 mg/L) > bicarbonate alkalinity (HCO_3^-; 65 – 142 mg/L) > calcium (Ca; 51 – 69 mg/L) > magnesium (Mg; 21 – 39 mg/L) > potassium (K; 8.6 – 11 mg/L), with metal(loid) concentrations relatively low in comparison.

The mean, minimum and maximum statistics (at 0, 25, 50 and 100 years) were compared with the revised Australian and New Zealand Guidelines for fresh and marine water quality guidelines – freshwater ecosystem (90% species protection) (ANZG, 2018) (**Table 11-11**). These guidelines are provided for context only as the modelling excludes key bio-geochemical processes which may affect solute concentration results, and the key assumption in the modelling is that the rehabilitated landforms are producing low concertation runoff water qualities.

Modelled aluminium (Al), As, cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb) (Scenario 3) and zinc (Zn) concentrations are considered elevated when compared to ANZG (2018) (freshwater ecosystem; 90% species protection). Similarly, comparison of the modelled water qualities to site release limits (for WD3, WD4 and spillway of Sediment Dam 3) indicate that TDS (occasionally) and particularly SO_4 are above the release limits.

These concentrations are likely to increase through evapoconcentration beyond the model simulation time, particularly for Scenario 1.

Table 11-11: Summary of model predicted (inferred) water qualities for each scenario.

Scenario		Scenario 1				Scenario 2				Scenario 3			
Time (years)		0	25	50	100	0	25	50	100	0	25	50	100
TDS (mg/l)	Me	228	524.	584.	662.	228	269.	228.	205.	228	389.	377.	369.
	Min	292.	355.	392.	485.	284.	239.	210.	198.	292.	322.	330.	350.
	Ma	285	691.	707.	754.	285	302.	246.	214.	285	456.	409.	388.
Calcium (mg/l)	Me	280.	62.1	65.2	68.7	280.	46.6	45.1	44.3	280.	52.3	51.5	51.3
	Min	30.5	34.3	36.4	40.1	29.8	38.0	41.7	42.9	30.5	38.2	43.0	48.1
	Ma	348.	85.1	81.5	80.4	348.	52.6	48.0	45.8	348.	62.5	56.5	54.0
Chloride (mg/l)	Me	102	202.	223.	243.	102	95.4	77.2	67.1	102	109.	85.5	63.3
	Min	88.3	97.8	107.	125.	86.6	75.4	67.5	64.5	88.3	76.9	64.0	55.5
	Ma	129	290.	288.	291.	129	115.	85.8	70.1	129	143.	101.	69.8
Sulfate (mg/l)	Me	628.	252.	233.	223.	625.	195.	179.	170.	628.	209.	193.	180.
	Min	201.	229.	210.	203.	194.	187.	170.	164.	201.	198.	180.	171.
	Ma	731.	284.	258.	250.	731.	204.	188.	176.	731.	222.	204.	190.
Magnesium (mg/l)	Me	141.	35.8	37.1	39.3	140.	24.2	22.3	21.3	141.	25.5	23.0	21.0
	Min	22.0	24.5	25.8	28.7	21.5	21.6	20.9	20.6	22.0	21.9	20.5	19.8
	Ma	173.	46.2	44.2	44.4	173.	26.6	23.7	22.1	173.	29.6	25.3	22.3
Sodium (mg/l)	Me	411.	141.	139.	143.	410.	90.1	78.3	71.8	411.	91.8	75.5	61.1
	Min	108.	122.	124.	131.	105.	86.0	73.8	69.3	108.	85.7	68.7	56.9
	Ma	493.	166.	156.	155.	493.	95.5	83.0	74.6	493.	99.6	81.8	65.8
Potassium (mg/l)	Me	10.0	9.4	8.6	8.6	9.9	7.8	7.3	6.9	10.0	10.0	10.3	10.8
	Min	9.3	8.5	7.5	7.2	9.1	7.4	6.9	6.7	9.3	9.5	9.8	10.4
	Ma	11.3	10.9	11.6	12.9	10.9	8.5	7.7	7.2	11.3	10.7	11.0	11.3
Aluminium (mg/l)	Me	0.01	0.06	0.06	0.08	0.01	0.33	0.41	0.45	0.01	0.46	0.64	0.82
	Min	0.00	0.04	0.05	0.06	0.00	0.29	0.39	0.44	0.00	0.36	0.57	0.79
	Ma	0.11	0.12	0.13	0.16	0.11	0.35	0.42	0.47	0.11	0.50	0.67	0.84
Arsenic (mg/l)	Me	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.02	0.01	0.01	0.00
	Min	0.01	0.02	0.01	0.01	0.01	0.03	0.03	0.03	0.01	0.01	0.01	0.00
	Ma	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.02	0.01	0.01
Boron (mg/l)	Me	0.02	0.03	0.03	0.03	0.02	0.03	0.04	0.04	0.02	0.04	0.05	0.05
	Min	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.02	0.04	0.05	0.05
	Ma	0.03	0.04	0.04	0.05	0.03	0.04	0.04	0.04	0.03	0.04	0.05	0.06
Cadmium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper (mg/l)	Me	0.07	0.24	0.19	0.15	0.07	0.09	0.04	0.01	0.07	0.14	0.08	0.04
	Min	0.00	0.20	0.14	0.10	0.00	0.07	0.02	0.00	0.00	0.11	0.06	0.03
	Ma	0.35	0.30	0.29	0.30	0.34	0.13	0.06	0.01	0.35	0.19	0.13	0.05
Fluoride (mg/l)	Me	0.45	0.20	0.20	0.21	0.45	0.12	0.11	0.10	0.45	0.13	0.12	0.10
	Min	0.18	0.19	0.18	0.20	0.17	0.11	0.10	0.09	0.18	0.12	0.11	0.10
	Ma	0.53	0.21	0.22	0.26	0.53	0.14	0.11	0.10	0.53	0.16	0.13	0.11
Iron (mg/l)	Me	0.18	0.15	0.17	0.21	0.18	0.12	0.12	0.12	0.18	0.17	0.19	0.22

Scenario		Scenario 1				Scenario 2				Scenario 3			
Time (years)		0	25	50	100	0	25	50	100	0	25	50	100
	Min	0.06	0.13	0.15	0.18	0.05	0.11	0.11	0.12	0.06	0.15	0.18	0.21
	Ma	0.25	0.26	0.29	0.35	0.24	0.17	0.14	0.12	0.25	0.23	0.23	0.23
Lead (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manganese (mg/l)	Me	1.12	0.42	0.42	0.44	1.11	0.38	0.38	0.38	1.12	0.44	0.47	0.50
	Min	0.37	0.39	0.38	0.40	0.36	0.36	0.36	0.36	0.37	0.43	0.45	0.48
	Ma	1.33	0.46	0.46	0.51	1.33	0.39	0.39	0.39	1.33	0.46	0.49	0.52
Molybdenum (mg/l)	Me	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
	Min	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.02	0.02	0.02
	Ma	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Selenium (mg/l)	Me	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Ma	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zinc (mg/l)	Me	0.08	0.13	0.11	0.09	0.08	0.23	0.25	0.27	0.08	0.33	0.41	0.49
	Min	0.05	0.10	0.08	0.06	0.05	0.22	0.25	0.26	0.05	0.28	0.38	0.48
	Ma	0.21	0.17	0.18	0.19	0.20	0.24	0.26	0.28	0.21	0.34	0.42	0.51

Note: Highlighted orange cells represent those values that exceed ANZG (2018) – freshwater aquatic ecosystem (90%), while those in shaded blue exceed site release limits (for WD3, WD4 and spillway of Sediment Dam 3)

11.22 Limitations

The WB/WQ modelling aimed to simulate the pit water body system to an inferred level of certainty. At this stage in the modelling, there are a number of areas in which reliable data is not yet available and hence there are some key limitations of this modelling study that include the following:

- Geochemical inputs to the model for final rehabilitated landforms were not available at the time of reporting. Therefore, estimated runoff water qualities for rehabilitated land (e.g.. soil covers) were established based on natural land runoff water qualities.
- The WB/WQ models dissolved chemical concentration. The site release limits for some chemical parameters considered total concentration.
- It should be recognised that the climate forecasting into the future will always have an associated risk. The method adopted by RGS attempts to capture the full extent of climatic variability or uncertainty (i.e. through stochastic modelling); however, climate change should be considered in future iterations.
- The water quality approach applied in the study considered mass balance only, based on mass loading rates and water volumes. It did not consider chemical reactions or mineral precipitation which may change the water quality outcomes. Similarly, atmospheric equilibrium of waters is not considered in the study.
- Pit water body stratification has not been considered as part of the modelling.
- Some of the AWBM modelling has been limited to the use of parameters adopted based on experience and literature. RGS recommended that the AWBM parameters be reviewed and revised in future modelling stages, as more data becomes available for these land use types.
- No bio-geochemical processes (e.g. nutrient cycle) are considered as part of the modelling.
- This water balance water quality model was not coupled with the groundwater model for an iterative simulation (i.e. results were not passed between each model dynamically at each timestep). This means that the simulation of the pit lake elevation and hydrology was undertaken separately in both the WB/WQ model and the Groundwater model. This represented some duplication and overlap of a key driver of the pit lake groundwater flux estimates. Whilst best efforts were undertaken by RGS to align hydrology estimates, it is acknowledged that the model does not integrate with the groundwater modelling dynamically and iterate calculations and this may have impacted the groundwater flux estimates as well as the direct rainfall and evaporation estimates.

11.23 Conclusions

RGS was commissioned to construct a WB/WQ model for the site and final void at MRO. The numerical WB/WQ model was developed for the MRO final void with the following objectives:

- To predict the pit water quality (dissolved concentrations) for a 'terminal sink'[4] at closure and understand how the water quality evolves 100 years into the future;
- To understand the demand for water to fill and maintain the pit lake based on several different closure scenarios; and,
- To understand how climate variability affect the water balance and water quality of the pit lake.

The results discussed in this report are considered to be at an 'inferred' level of confidence. The key conclusions from the pit void water balance based on scenario are provided in Table 11-12.

Table 11-12: Pit lake water levels

Scenarios	Summary
Scenario 1: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated NWRD and TSF water (from cover) released to environment	Pit lake water level never reaches capacity (RL + 120 m AHD) over the 100-year simulation period. The pit filled to a maximum RL of approximately +77 m AHD (mean probability) at year 2123 (100 years) and approximately +113 m AHD (maximum probability) at year 2034 (11 years).
Scenario 2: All runoff/ seepage water diverted to pit during closure and post closure.	Pit lake water level reaches capacity for the maximum probability and 95th percentile probabilities at years 2032 (9 years) and 2045 (22 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity).
Scenario 3: All runoff/ seepage water diverted to pit during closure. Post closure, rehabilitated TSF water (from cover) released to environment; NWRD water diverted to pit	Pit lake water level reaches capacity for the maximum probability and 95th percentile probability at years 2032 (9 years) and 2057 (34 years), respectively. The maximum water level for mean probability stabilises on a level of approximately RL + 119.9 m AHD (i.e. at approximate capacity). The water balance results are very similar to Scenario 2, albeit the fill and overflow times are longer due to the TSF runoff being release to the environment post closure.

Note: water levels have not stabilised for all scenarios and sensitivities over the 100-year simulation period.

The key conclusions from the pit void water quality modelling are summarised in the following points.

- The modelling results for each of the scenarios and sensitivities indicate that pH is near neutral over the simulation period with a pH of ~pH 6.5.
- The TDS ranged from around 2,280 mg/L to 250 mg/L (mean probability) for each of the scenarios and sensitivities over the assessment period.
- The general water quality concentration trends vary slightly for different modelled species and reflect the water balance inputs and geochemical source terms. The general water quality concentration trends can be separated into different phases: i) initial sump water quality phase, where the first-time step in the model reflects the pit sump water quality which is present in the pit void before the commencement of the simulation; ii) pre-closure phase, where runoff and

[4] A 'terminal sink' for MRO is not considered a true terminal sink as there is likely to be some groundwater flux from the pit lake; however, there is no interconnection with external water bodies.

seepage water from the non-rehabilitated landforms is directed to the pit and generally results in a gradual increase in concentration of a particular species within the pit lake over this time; and, iii) post closure phase, which shows some variation between chemical species and the scenarios due to either of the following: evapoconcentration effects on pit lake water quality, runoff water from the rehabilitated landforms dilute pit lake water quality, or overflow of the pit lake releases solute from the pit lake stabilising concertation increases.

- The longer-term post closure phase for Scenario 1 (which simulates a 'terminal sink' since it does not overflow) generally shows a steady increase in concentration of solutes over the simulation period reflecting the effects of. evapoconcentration. In reality, bio-geochemical processes (e.g. nutrient cycle, carbon cycling, etc.) would be expected to supress increasing concentrations and some form of equilibrium would be attained.
- The water qualities for each of the scenarios and sensitivities are dominated by the major ions (namely SO_4, Cl and Na), with metals and metalloid concentrations relatively low in comparison.
- The modelled mass balance results for Al, As, Cd, Cr, Cu, Pb (Scenario 3) and Zn concentrations are slightly elevated when compared to ANZG (2018) (freshwater ecosystem; 90% species protection). Similarly, comparison of the modelled water qualities to site release limits (for WD3, WD4 and spillway of Sediment Dam 3) indicate that TDS (occasionally) and particularly SO_4 are above the release limits.
- Atmospheric equilibration and consideration of thermodynamic constraints on the water quality through geochemical modelling typically had very little effect on the mass balance results due to the generally low concentration of salts and metal(loid)s in the pit lake.

11.24 References

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11.25 Annex A

11.25.1 Scaling Factor Derivation

Density

A density of 2,000 kg/m^3 was adopted for the rock material.

Infiltration depth (m)

Kinetic Leach Column (KLC) data can be converted to loading rates as shown in equation (1) and (2). To apply these data to pit wall runoff the loading rates need to be converted to loading rate per square meter of wall rock (exposed versus inundated for each rock type), as the exposed pit wall area will vary according to the water balance and modelled pit filling rate.

$$Loading\ rate\ \left(\frac{\frac{mg}{kg}}{time}\right) = leached\ conentration\ \left(\frac{mg}{L}\right) \times \frac{Volume\ of\ leachate\ (L)}{Column\ weight\ (kg)} \quad (1)$$

$$Loading\ rate\ \left(\frac{\frac{mg}{kg}}{time}\right) \times density\ \left(\frac{kg}{m^3}\right) \times infiltration\ depth\ (m) =$$

$$Loading\ rate\ per\ square\ meter\ of\ wall\ rock\ \left(\frac{\frac{mg}{m^2}}{time}\right) \quad (2)$$

The infiltration depth is defined as the thickness of the outer pit wall that interacts with water and produces loads that will contribute to the pit lake water quality.

When the pit wall is exposed, it is assumed that the outer 1-1.5 cm of the pit wall will interact with rainfall/ runoff. When the pit wall is submerged (i.e. below the water table of the pit lake), physiochemical processes (solubility and diffusion associated with anoxic/ reducing conditions) will be the main driving forces that determine the load contributing to the pit. As such, the infiltration depth is assumed to be smaller and estimated to be 5 mm.

The exposed pit wall will only contribute loads to the pit water quality during a rainfall event (of ≥ 10mm in 24-hours). As historic rainfall data is available on a daily timestep, daily loading rates are accumulated ('banked') in GoldSim and only report to the pit water body during a rainfall event of ≥ 10mm in 24-hours. After the banked load is released to the pit, the cumulative load reverts back to one day of load (i.e. there is always at least one day of load able to be released in case there are consecutives days of rainfall).

Erosion

RGS have assumed that a few mm of pit wall material is eroded after each rainfall event, exposing fresh material and replenishing total potential load (i.e. there is no need to consider depletion rates).

Surface area correction

The KLC tests are performed with crushed material, of which the surface area will be significantly larger than in the field. Oxidation and dissolution rates are subsequently higher in the laboratory. To account for this a surface area correction is employed. The scaling factor for surface area is taken to be 0.2 due based on literature values and RGS experience with similar systems (Linklater et al., 2017; Kempton (2012).

Temperature correction

The KLC testing temperature can fluctuate according to laboratory conditions. Field temperatures will also vary daily, affecting geochemical reaction rates. The lab testing is being undertaken in Brisbane Queensland which is typically similar to Mount Rawdon.

It has been suggested that temperature scaling factors should be considered if field temperatures are expected to be around 10 °C higher than in the laboratory (Eary, 2015).

Kempton (2012) has proposed the following scaling factor to be applied for temperature.

$$Scaling\ Factor\ (Temperature) = \exp\left(-\frac{Ea}{R}\left(\frac{1}{T_{lab}} - \frac{1}{T_{field}}\right)\right.$$

In this case, the scaling factor is taken as 1 due to:

- temperature differences between lab and field are generally <10°C. The lab temperatures are likely to be greater than field so is therefore considered a conservative assumption since elevated temperatures are likely to results in increased solute production rates.
- No limited oxygen availability due to fractured rock and wall being highly oxidised.
- Relatively low sulfide S concentrations.

Oxygen availability

The scaling factor for the exposed pit walls are taken as 1. Oxygen availability in the wall materials are not considered to be constrained in the laboratory or field under exposed conditions. However, under saturated conditions (pit water body inundation), a scaling factor of 0.1 has been applied. In reality, oxygen availability is likely to be closer to zero; therefore, applying a scaling factor of 0.1 is considered conservative.

Fraction flushed

In the KLC free leach tests, the volume of water that is added onto the column is larger than the water leached out of the column, and a fraction is retained within the material pore space. The fraction flushed is calculated from the leachates and used to calculate the loading rate (in this case from the last four leaches).

The fraction flushed by contact water is the equivalent of how much water is leached from the column (fraction between volume on and volume off; if 1L is placed on column, then 0.6L will leach out; i.e. 40% storage within pit walls).

11.26 Annex B

11.26.1 Water quality results summary tables

Scenario 1: Select water quality results

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
TwelveMileCreekD_CP_Q																						
0	2023	37	0	157	0.8	0.0	3.2	0.0001	0.0000	0.0003	0.000003	0.000000	0.000013	0.00009	0.00000	0.00040	0.00003	0.00000	0.00013	1.96	0.00	6.91
5	2028	150	121	159	3.1	2.5	3.2	0.0003	0.0002	0.0003	0.000013	0.000010	0.000013	0.00038	0.00031	0.00040	0.00013	0.00010	0.00013	6.67	6.65	6.76
10	2033	149	121	164	3.0	2.5	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.67	6.63	6.76
25	2048	147	119	162	3.0	2.4	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.68	6.64	6.77
50	2073	149	120	163	3.0	2.4	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.67	6.63	6.77
75	2098	148	120	158	3.0	2.4	3.2	0.0003	0.0002	0.0003	0.000012	0.000010	0.000013	0.00037	0.00030	0.00040	0.00012	0.00010	0.00013	6.68	6.65	6.77
100	2123	149	119	158	3.0	2.4	3.2	0.0003	0.0002	0.0003	0.000012	0.000010	0.000013	0.00037	0.00030	0.00040	0.00012	0.00010	0.00013	6.67	6.65	6.77
SwindonRawdonD_CP_Q																						
0	2023	39	0	182	0.8	0.0	3.7	0.0001	0.0000	0.0003	0.000003	0.000000	0.000015	0.00010	0.00000	0.00046	0.00003	0.00000	0.00015	1.95	0.00	6.91
5	2028	172	121	185	3.5	2.5	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00043	0.00031	0.00047	0.00014	0.00010	0.00016	6.61	6.58	6.76
10	2033	170	121	190	3.5	2.5	3.9	0.0003	0.0002	0.0004	0.000014	0.000010	0.000016	0.00043	0.00030	0.00048	0.00014	0.00010	0.00016	6.62	6.57	6.76
25	2048	168	119	187	3.4	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00042	0.00030	0.00047	0.00014	0.00010	0.00016	6.62	6.57	6.77
50	2073	170	120	190	3.5	2.4	3.9	0.0003	0.0002	0.0004	0.000014	0.000010	0.000016	0.00043	0.00030	0.00048	0.00014	0.00010	0.00016	6.62	6.57	6.77
75	2098	169	120	185	3.4	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00043	0.00030	0.00047	0.00014	0.00010	0.00016	6.62	6.58	6.77
100	2123	169	119	184	3.5	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000015	0.00043	0.00030	0.00046	0.00014	0.00010	0.00015	6.62	6.58	6.77
SedimentDam3_Q																						
0	2023	7,412	53	10,067	4,135.5	6.9	5,643.7	0.0122	0.0005	0.0164	0.002416	0.000045	0.003288	0.02419	0.00019	0.03288	0.10845	0.00024	0.14798	6.63	6.29	6.69
5	2028	591	363	1,750	46.6	26.2	134.8	0.0026	0.0015	0.0084	0.000218	0.000123	0.000724	0.00171	0.00107	0.00516	0.00152	0.00089	0.00449	5.67	5.12	5.89
10	2033	1,146	404	2,083	64.6	22.6	117.9	0.0053	0.0020	0.0093	0.000441	0.000167	0.000797	0.00332	0.00118	0.00589	0.00231	0.00082	0.00411	5.34	5.07	5.74
25	2048	2,696	1,304	6,180	112.8	54.4	265.1	0.0131	0.0062	0.0314	0.001085	0.000511	0.002622	0.00783	0.00377	0.01810	0.00450	0.00216	0.01060	4.94	4.54	5.24
50	2073	5,573	2,835	11,147	204.5	106.1	405.3	0.0274	0.0144	0.0529	0.002261	0.001174	0.004315	0.01617	0.00831	0.03211	0.00860	0.00448	0.01691	4.61	4.31	4.88
75	2098	8,351	4,033	17,951	292.3	137.3	629.1	0.0414	0.0187	0.0887	0.003406	0.001509	0.007293	0.02425	0.01155	0.05209	0.01254	0.00584	0.02695	4.43	4.09	4.77
100	2123	10,939	5,868	23,674	373.1	201.7	798.4	0.0542	0.0295	0.1141	0.004457	0.002433	0.009314	0.03175	0.01708	0.06831	0.01617	0.00875	0.03448	4.32	3.98	4.56
RawdonCreekDownstream_CP_Q																						
0	2023	34	0	119	0.7	0.0	2.8	0.0001	0.0000	0.0002	0.000003	0.000000	0.000013	0.00009	0.00000	0.00030	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SouthDam_Q																						
0	2023	18,991	61	26,220	10,065.5	6.7	13,929.9	0.0533	0.0005	0.0736	0.024997	0.000057	0.034586	0.17026	0.00025	0.23548	1.18034	0.00062	1.63362	6.52	6.29	6.58
5	2028	1,113	404	4,285	84.0	31.2	315.8	0.0053	0.0024	0.0227	0.000545	0.000238	0.002284	0.00383	0.00152	0.01480	0.00754	0.00253	0.02759	5.38	4.69	5.68
10	2033	2,248	463	6,238	121.8	24.5	345.8	0.0110	0.0023	0.0321	0.001013	0.000216	0.002986	0.00714	0.00147	0.02005	0.00940	0.00185	0.02662	5.05	4.53	5.67
25	2048	5,355	1,635	17,435	219.5	67.0	731.5	0.0269	0.0081	0.0914	0.002327	0.000701	0.007973	0.01619	0.00493	0.05323	0.01367	0.00419	0.04563	4.65	4.07	5.13
50	2073	11,612	3,781	48,270	421.8	140.9	1,743.4	0.0584	0.0200	0.2365	0.004925	0.001702	0.019857	0.03444	0.01134	0.14255	0.02310	0.00771	0.09632	4.32	3.66	4.73
75	2098	16,708	5,553	38,898	582.4	188.3	1,359.0	0.0845	0.0263	0.2052	0.007084	0.002174	0.017236	0.04929	0.01618	0.11478	0.03014	0.00981	0.07057	4.15	3.72	4.62
100	2123	22,591	8,163	65,149	769.9	280.0	2,196.3	0.1141	0.0418	0.3212	0.009522	0.003495	0.026642	0.06641	0.02406	0.19059	0.03867	0.01407	0.11059	4.02	3.53	4.41
WestDam_Q																						
0	2023	5,968	164	8,052	3,888.3	25.0	5,320.7	0.0255	0.0008	0.0345	0.001396	0.000228	0.001723	0.01494	0.00347	0.01723	0.04455	0.01439	0.05098	6.78	6.24	6.94
5	2028	2,711	439	8,863	405.8	63.0	1,313.8	0.0121	0.0023	0.0425	0.003680	0.000621	0.012230	0.05876	0.00940	0.19066	0.24512	0.03899	0.79332	5.34	4.70	5.92
10	2033	1,328	427	5,429	144.3	41.9	604.9	0.0058	0.0019	0.0232	0.001360	0.000400	0.005617	0.02069	0.00591	0.08664	0.08180	0.02280	0.34444	5.53	4.89	5.93
25	2048	1,581	776	3,169	104.9	49.8	209.3	0.0072	0.0037	0.0139	0.001071	0.000520	0.002091	0.01376	0.00639	0.02761	0.04585	0.02074	0.09490	5.27	4.98	5.53
50	2073	3,043	1,591	6,591	151.8	74.6	326.9	0.0143	0.0073	0.0299	0.001663	0.000808	0.003501	0.01823	0.00878	0.03966	0.04909	0.02219	0.10759	4.94	4.60	5.21
75	2098	4,837	2,489	25,927	213.3	106.4	1,163.8	0.0231	0.0113	0.1245	0.002430	0.001164	0.013261	0.02434	0.01220	0.13381	0.05595	0.02701	0.31550	4.74	3.97	5.01

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
100	2123	5,814	3,036	14,985	236.9	119.6	601.0	0.0278	0.0145	0.0676	0.002752	0.001395	0.006717	0.02610	0.01289	0.06750	0.05232	0.02378	0.13755	4.63	4.23	4.89
MinghamCreekUpstream_CP_Q																						
0	2023	103	0	369	36.5	0.0	151.0	0.0006	0.0000	0.0023	0.000044	0.000000	0.000389	0.00064	0.00000	0.00678	0.00264	0.00000	0.02859	2.15	0.00	7.62
5	2028	312	305	367	53.8	42.0	146.7	0.0011	0.0010	0.0023	0.000365	0.000088	0.000400	0.00633	0.00100	0.00700	0.02664	0.00404	0.02950	6.78	6.72	7.51
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
Pit_Q																						
0	2023	2,280	285	2,855	625.1	194.9	731.4	0.0205	0.0161	0.0381	0.000761	0.000136	0.003019	0.07335	0.00056	0.34166	0.08577	0.05434	0.20169	6.65	6.57	6.97
5	2028	405	307	503	272.0	211.8	313.9	0.0347	0.0289	0.0377	0.002821	0.002548	0.003040	0.30906	0.26355	0.33898	0.18955	0.16996	0.20306	6.80	6.66	6.86
10	2033	342	288	391	231.6	207.9	248.4	0.0323	0.0298	0.0350	0.002945	0.002746	0.003102	0.20504	0.16303	0.25480	0.20557	0.18689	0.21403	6.81	6.66	6.86
25	2048	270	239	303	195.3	187.3	204.7	0.0312	0.0302	0.0331	0.003259	0.003157	0.003366	0.09761	0.07621	0.13740	0.23477	0.22357	0.23975	6.76	6.67	6.80
50	2073	228	211	246	179.1	170.1	188.2	0.0316	0.0304	0.0328	0.003541	0.003438	0.003634	0.04136	0.02872	0.06226	0.25853	0.25149	0.26480	6.72	6.68	6.73
75	2098	212	202	220	172.8	166.5	179.7	0.0317	0.0308	0.0328	0.003655	0.003554	0.003756	0.01916	0.01339	0.02813	0.26806	0.26076	0.27511	6.70	6.68	6.71
100	2123	206	198	214	170.3	164.7	176.6	0.0318	0.0308	0.0328	0.003700	0.003596	0.003811	0.01030	0.00821	0.01366	0.27187	0.26426	0.27991	6.69	6.68	6.70
TwelveMileCreek_M_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SwindonRawdU_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
MinghamCreekDownstream_CP_Q																						
0	2023	0	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00
5	2028	0	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00
10	2033	239	238	312	6.8	4.9	202.1	0.0007	0.0004	0.0290	0.000046	0.000020	0.002669	0.00285	0.00060	0.22548	0.00201	0.00020	0.18157	6.47	6.47	6.65
25	2048	242	238	283	27.9	4.9	199.8	0.0042	0.0004	0.0316	0.000411	0.000020	0.003268	0.01279	0.00060	0.13322	0.02847	0.00020	0.23524	6.50	6.47	6.78
50	2073	237	211	238	26.6	4.9	179.6	0.0043	0.0004	0.0316	0.000459	0.000020	0.003562	0.00567	0.00060	0.05480	0.03241	0.00020	0.26049	6.50	6.47	6.72
75	2098	235	204	238	25.9	4.9	175.9	0.0044	0.0004	0.0323	0.000476	0.000020	0.003716	0.00294	0.00060	0.02288	0.03377	0.00020	0.27241	6.50	6.47	6.69
100	2123	234	200	238	26.1	4.9	173.1	0.0045	0.0004	0.0323	0.000493	0.000020	0.003757	0.00183	0.00060	0.01186	0.03510	0.00020	0.27598	6.50	6.47	6.69
PerryR_D_CP_Q																						
0	2023	35	0	136	0.7	0.0	2.8	0.0001	0.0000	0.0003	0.000003	0.000000	0.000011	0.00009	0.00000	0.00034	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	134	121	136	2.7	2.5	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.76
10	2033	134	121	137	2.7	2.5	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000012	0.00034	0.00030	0.00035	0.00011	0.00010	0.00012	6.72	6.71	6.76
25	2048	133	119	137	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77
50	2073	134	120	137	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000012	0.00034	0.00030	0.00035	0.00011	0.00010	0.00012	6.72	6.71	6.77
75	2098	133	120	136	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77
100	2123	133	119	136	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
PerryRiver_U_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77

Notes: U= upstream; DS= downstream; CP=compliance point

Scenario 2: Select water quality results

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
TwelveMileCreekD_CP_Q																						
0	2023	37	0	157	0.8	0.0	3.2	0.0001	0.0000	0.0003	0.000003	0.000000	0.000013	0.00009	0.00000	0.00040	0.00003	0.00000	0.00013	1.96	0.00	6.91
5	2028	150	121	159	3.1	2.5	3.2	0.0003	0.0002	0.0003	0.000013	0.000010	0.000013	0.00038	0.00031	0.00040	0.00013	0.00010	0.00013	6.67	6.65	6.76
10	2033	149	121	164	3.0	2.5	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.67	6.63	6.76
25	2048	147	119	162	3.0	2.4	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.68	6.64	6.77
50	2073	149	120	163	3.0	2.4	3.3	0.0003	0.0002	0.0003	0.000012	0.000010	0.000014	0.00037	0.00030	0.00041	0.00012	0.00010	0.00014	6.67	6.63	6.77
75	2098	148	120	158	3.0	2.4	3.2	0.0003	0.0002	0.0003	0.000012	0.000010	0.000013	0.00037	0.00030	0.00040	0.00012	0.00010	0.00013	6.68	6.65	6.77
100	2123	149	119	158	3.0	2.4	3.2	0.0003	0.0002	0.0003	0.000012	0.000010	0.000013	0.00037	0.00030	0.00040	0.00012	0.00010	0.00013	6.67	6.65	6.77
SwindonRawdonD_CP_Q																						
0	2023	39	0	182	0.8	0.0	3.7	0.0001	0.0000	0.0003	0.000003	0.000000	0.000015	0.00010	0.00000	0.00046	0.00003	0.00000	0.00015	1.95	0.00	6.91
5	2028	172	121	185	3.5	2.5	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00043	0.00031	0.00047	0.00014	0.00010	0.00016	6.61	6.58	6.76
10	2033	170	121	190	3.5	2.5	3.9	0.0003	0.0002	0.0004	0.000014	0.000010	0.000016	0.00043	0.00030	0.00048	0.00014	0.00010	0.00016	6.62	6.57	6.76
25	2048	168	119	187	3.4	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00042	0.00030	0.00047	0.00014	0.00010	0.00016	6.62	6.57	6.77
50	2073	170	120	190	3.5	2.4	3.9	0.0003	0.0002	0.0004	0.000014	0.000010	0.000016	0.00043	0.00030	0.00048	0.00014	0.00010	0.00016	6.62	6.57	6.77
75	2098	169	120	185	3.4	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00043	0.00030	0.00047	0.00014	0.00010	0.00016	6.62	6.58	6.77
100	2123	169	119	184	3.5	2.4	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000015	0.00043	0.00030	0.00046	0.00014	0.00010	0.00015	6.62	6.58	6.77
SedimentDam3_Q																						
0	2023	7,412	53	10,067	4,135.5	6.9	5,643.7	0.0122	0.0005	0.0164	0.002416	0.000045	0.003288	0.02419	0.00019	0.03288	0.10845	0.00024	0.14798	6.63	6.29	6.69
5	2028	591	363	1,750	46.6	26.2	134.8	0.0026	0.0015	0.0084	0.000218	0.000123	0.000724	0.00171	0.00107	0.00516	0.00152	0.00089	0.00449	5.67	5.12	5.89
10	2033	1,146	404	2,083	64.6	22.6	117.9	0.0053	0.0020	0.0093	0.000441	0.000167	0.000797	0.00332	0.00118	0.00589	0.00231	0.00082	0.00411	5.34	5.07	5.74
25	2048	2,696	1,304	6,180	112.8	54.4	265.1	0.0131	0.0062	0.0314	0.001085	0.000511	0.002622	0.00783	0.00377	0.01810	0.00450	0.00216	0.01060	4.94	4.54	5.24
50	2073	5,573	2,835	11,147	204.5	106.1	405.3	0.0274	0.0144	0.0529	0.002261	0.001174	0.004315	0.01617	0.00831	0.03211	0.00860	0.00448	0.01691	4.61	4.31	4.88
75	2098	8,351	4,033	17,951	292.3	137.3	629.1	0.0414	0.0187	0.0887	0.003406	0.001509	0.007293	0.02425	0.01155	0.05209	0.01254	0.00584	0.02695	4.43	4.09	4.77
100	2123	10,939	5,868	23,674	373.1	201.7	798.4	0.0542	0.0295	0.1141	0.004457	0.002433	0.009314	0.03175	0.01708	0.06831	0.01617	0.00875	0.03448	4.32	3.98	4.56
RawdonCreekDownstream_CP_Q																						
0	2023	34	0	119	0.7	0.0	2.8	0.0001	0.0000	0.0002	0.000003	0.000000	0.000013	0.00009	0.00000	0.00030	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SouthDam_Q																						
0	2023	18,991	61	26,220	10,065.5	6.7	13,929.9	0.0533	0.0005	0.0736	0.024997	0.000057	0.034586	0.17026	0.00025	0.23548	1.18034	0.00062	1.63362	6.52	6.29	6.58
5	2028	1,113	404	4,285	84.0	31.2	315.8	0.0053	0.0024	0.0227	0.000545	0.000238	0.002284	0.00383	0.00152	0.01480	0.00754	0.00253	0.02759	5.38	4.69	5.68
10	2033	2,248	463	6,238	121.8	24.5	345.8	0.0110	0.0023	0.0321	0.001013	0.000216	0.002986	0.00714	0.00147	0.02005	0.00940	0.00185	0.02662	5.05	4.53	5.67
25	2048	5,355	1,635	17,435	219.5	67.0	731.5	0.0269	0.0081	0.0914	0.002327	0.000701	0.007973	0.01619	0.00493	0.05323	0.01367	0.00419	0.04563	4.65	4.07	5.13
50	2073	11,612	3,781	48,270	421.8	140.9	1,743.4	0.0584	0.0200	0.2365	0.004925	0.001702	0.019857	0.03444	0.01134	0.14255	0.02310	0.00771	0.09632	4.32	3.66	4.73
75	2098	16,708	5,553	38,898	582.4	188.3	1,359.0	0.0845	0.0263	0.2052	0.007084	0.002174	0.017236	0.04929	0.01618	0.11478	0.03014	0.00981	0.07057	4.15	3.72	4.62
100	2123	22,591	8,163	65,149	769.9	280.0	2,196.3	0.1141	0.0418	0.3212	0.009522	0.003495	0.026642	0.06641	0.02406	0.19059	0.03867	0.01407	0.11059	4.02	3.53	4.41
WestDam_Q																						
0	2023	5,968	164	8,052	3,888.3	25.0	5,320.7	0.0255	0.0008	0.0345	0.001396	0.000228	0.001723	0.01494	0.00347	0.01723	0.04455	0.01439	0.05098	6.78	6.24	6.94
5	2028	2,711	439	8,863	405.8	63.0	1,313.8	0.0121	0.0023	0.0425	0.003680	0.000621	0.012230	0.05876	0.00940	0.19066	0.24512	0.03899	0.79332	5.34	4.70	5.92
10	2033	1,328	427	5,429	144.3	41.9	604.9	0.0058	0.0019	0.0232	0.001360	0.000400	0.005617	0.02069	0.00591	0.08664	0.08180	0.02280	0.34444	5.53	4.89	5.93
25	2048	1,581	776	3,169	104.9	49.8	209.3	0.0072	0.0037	0.0139	0.001071	0.000520	0.002091	0.01376	0.00639	0.02761	0.04585	0.02074	0.09490	5.27	4.98	5.53
50	2073	3,043	1,591	6,591	151.8	74.6	326.9	0.0143	0.0073	0.0299	0.001663	0.000808	0.003501	0.01823	0.00878	0.03966	0.04909	0.02219	0.10759	4.94	4.60	5.21

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
75	2098	4,837	2,489	25,927	213.3	106.4	1,163.8	0.0231	0.0113	0.1245	0.002430	0.001164	0.013261	0.02434	0.01220	0.13381	0.05595	0.02701	0.31550	4.74	3.97	5.01
100	2123	5,814	3,036	14,985	236.9	119.6	601.0	0.0278	0.0145	0.0676	0.002752	0.001395	0.006717	0.02610	0.01289	0.06750	0.05232	0.02378	0.13755	4.63	4.23	4.89
MinghamCreekUpstream_CP_Q																						
0	2023	103	0	369	36.5	0.0	151.0	0.0006	0.0000	0.0023	0.000044	0.000000	0.000389	0.00064	0.00000	0.00678	0.00264	0.00000	0.02859	2.15	0.00	7.62
5	2028	312	305	367	53.8	42.0	146.7	0.0011	0.0010	0.0023	0.000365	0.000088	0.000400	0.00633	0.00100	0.00700	0.02664	0.00404	0.02950	6.78	6.72	7.51
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
Pit_Q																						
0	2023	2,280	285	2,855	625.1	194.9	731.4	0.0205	0.0161	0.0381	0.000761	0.000136	0.003019	0.07335	0.00056	0.34166	0.08577	0.05434	0.20169	6.65	6.57	6.97
5	2028	405	307	503	272.0	211.8	313.9	0.0347	0.0289	0.0377	0.002821	0.002548	0.003040	0.30906	0.26355	0.33898	0.18955	0.16996	0.20306	6.80	6.66	6.86
10	2033	342	288	391	231.6	207.9	248.4	0.0323	0.0298	0.0350	0.002945	0.002746	0.003102	0.20504	0.16303	0.25480	0.20557	0.18689	0.21403	6.81	6.66	6.86
25	2048	270	239	303	195.3	187.3	204.7	0.0312	0.0302	0.0331	0.003259	0.003157	0.003366	0.09761	0.07621	0.13740	0.23477	0.22357	0.23975	6.76	6.67	6.80
50	2073	228	211	246	179.1	170.1	188.2	0.0316	0.0304	0.0328	0.003541	0.003438	0.003634	0.04136	0.02872	0.06226	0.25853	0.25149	0.26480	6.72	6.68	6.73
75	2098	212	202	220	172.8	166.5	179.7	0.0317	0.0308	0.0328	0.003655	0.003554	0.003756	0.01916	0.01339	0.02813	0.26806	0.26076	0.27511	6.70	6.68	6.71
100	2123	206	198	214	170.3	164.7	176.6	0.0318	0.0308	0.0328	0.003700	0.003596	0.003811	0.01030	0.00821	0.01366	0.27187	0.26426	0.27991	6.69	6.68	6.70
TwelveMileCreek_M_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SwindonRawdU_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
MinghamCreekDownstream_CP_Q																						
0	2023	0	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00
5	2028	0	0	0	0.0	0.0	0.0	0.0000	0.0000	0.0000	0.000000	0.000000	0.000000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00	0.00	0.00
10	2033	239	238	312	6.8	4.9	202.1	0.0007	0.0004	0.0290	0.000046	0.000020	0.002669	0.00285	0.00060	0.22548	0.00201	0.00020	0.18157	6.47	6.47	6.65
25	2048	242	238	283	27.9	4.9	199.8	0.0042	0.0004	0.0316	0.000411	0.000020	0.003268	0.01279	0.00060	0.13322	0.02847	0.00020	0.23524	6.50	6.47	6.78
50	2073	237	211	238	26.6	4.9	179.6	0.0043	0.0004	0.0316	0.000459	0.000020	0.003562	0.00567	0.00060	0.05480	0.03241	0.00020	0.26049	6.50	6.47	6.72
75	2098	235	204	238	25.9	4.9	175.9	0.0044	0.0004	0.0323	0.000476	0.000020	0.003716	0.00294	0.00060	0.02288	0.03377	0.00020	0.27241	6.50	6.47	6.69
100	2123	234	200	238	26.1	4.9	173.1	0.0045	0.0004	0.0323	0.000493	0.000020	0.003757	0.00183	0.00060	0.01186	0.03510	0.00020	0.27598	6.50	6.47	6.69
PerryR_D_CP_Q																						
0	2023	35	0	136	0.7	0.0	2.8	0.0001	0.0000	0.0003	0.000003	0.000000	0.000011	0.00009	0.00000	0.00034	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	134	121	136	2.7	2.5	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.76
10	2033	134	121	137	2.7	2.5	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000012	0.00034	0.00030	0.00035	0.00011	0.00010	0.00012	6.72	6.71	6.76
25	2048	133	119	137	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77

Analyte		TDS	TDS	TDS	Sulfate	Sulfate	Sulfate	Arsenic	Arsenic	Arsenic	Cadmium	Cadmium	Cadmium	Copper	Copper	Copper	Zinc	Zinc	Zinc	pH	pH	pH
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
50	2073	134	120	137	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000012	0.00034	0.00030	0.00035	0.00011	0.00010	0.00012	6.72	6.71	6.77
75	2098	133	120	136	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77
100	2123	133	119	136	2.7	2.4	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.77
PerryRiver_U_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77

Notes: U= upstream; DS= downstream; CP=compliance point

Scenario 3: Select water quality results

Analyte		TDS			Sulfate			Arsenic			Cadmium			Copper			Zinc			pH		
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	-	-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
TwelveMileCreekD_CP_Q																						
0	2023	37	0	157	0.8	0.0	3.2	0.0001	0.0000	0.0003	0.000003	0.000000	0.000013	0.00009	0.00000	0.00040	0.00003	0.00000	0.00013	1.96	0.00	6.91
5	2028	150	121	159	3.1	2.5	3.2	0.0003	0.0002	0.0003	0.000013	0.000010	0.000013	0.00038	0.00031	0.00040	0.00013	0.00010	0.00013	6.67	6.65	6.76
10	2033	139	58	164	20.8	2.8	132.2	0.0066	0.0003	0.0461	0.000014	0.000011	0.000025	0.00039	0.00034	0.00045	0.00031	0.00011	0.00146	6.71	6.63	7.08
25	2048	136	56	159	23.7	2.7	134.9	0.0076	0.0002	0.0470	0.000015	0.000011	0.000025	0.00039	0.00034	0.00045	0.00034	0.00011	0.00149	6.72	6.64	7.09
50	2073	137	56	163	24.0	2.8	134.3	0.0077	0.0003	0.0468	0.000015	0.000012	0.000025	0.00039	0.00035	0.00045	0.00034	0.00012	0.00148	6.72	6.63	7.09
75	2098	139	56	158	20.0	2.8	134.5	0.0063	0.0003	0.0469	0.000014	0.000011	0.000025	0.00039	0.00034	0.00045	0.00030	0.00011	0.00148	6.71	6.65	7.09
100	2123	136	56	159	24.8	2.8	135.0	0.0080	0.0003	0.0471	0.000015	0.000012	0.000025	0.00039	0.00035	0.00045	0.00035	0.00012	0.00149	6.73	6.64	7.09
SwindonRawdonD_CP_Q																						
0	2023	39	0	182	0.8	0.0	3.7	0.0001	0.0000	0.0003	0.000003	0.000000	0.000015	0.00010	0.00000	0.00046	0.00003	0.00000	0.00015	1.95	0.00	6.91
5	2028	172	121	185	3.5	2.5	3.8	0.0003	0.0002	0.0003	0.000014	0.000010	0.000016	0.00043	0.00031	0.00047	0.00014	0.00010	0.00016	6.61	6.58	6.76
10	2033	157	57	190	24.0	3.1	133.5	0.0076	0.0003	0.0465	0.000016	0.000013	0.000025	0.00044	0.00039	0.00048	0.00036	0.00013	0.00147	6.67	6.57	7.08
25	2048	153	56	185	27.8	3.1	135.0	0.0089	0.0003	0.0471	0.000017	0.000013	0.000025	0.00044	0.00038	0.00047	0.00039	0.00013	0.00149	6.68	6.58	7.09
50	2073	155	56	190	27.6	3.2	134.7	0.0089	0.0003	0.0469	0.000017	0.000013	0.000025	0.00045	0.00039	0.00048	0.00039	0.00013	0.00148	6.68	6.57	7.09
75	2098	157	56	184	23.6	3.1	134.8	0.0074	0.0003	0.0470	0.000016	0.000013	0.000025	0.00044	0.00039	0.00046	0.00035	0.00013	0.00149	6.67	6.58	7.09
100	2123	154	56	185	27.7	3.2	135.1	0.0089	0.0003	0.0471	0.000017	0.000013	0.000025	0.00045	0.00039	0.00047	0.00039	0.00013	0.00149	6.68	6.58	7.09
SedimentDam3_Q																						
0	2023	7,412	53	10,067	4,135.5	6.9	5,643.7	0.0122	0.0005	0.0164	0.002416	0.000045	0.003288	0.02419	0.00019	0.03288	0.10845	0.00024	0.14798	6.63	6.29	6.69
5	2028	591	363	1,750	46.6	26.2	134.8	0.0026	0.0015	0.0084	0.000218	0.000123	0.000724	0.00171	0.00107	0.00516	0.00152	0.00089	0.00449	5.67	5.12	5.89
10	2033	1,146	404	2,083	64.6	22.6	117.9	0.0053	0.0020	0.0093	0.000441	0.000167	0.000797	0.00332	0.00118	0.00589	0.00232	0.00082	0.00411	5.34	5.07	5.74
25	2048	2,686	1,289	5,944	112.3	53.8	255.0	0.0131	0.0061	0.0302	0.001081	0.000506	0.002524	0.00780	0.00373	0.01741	0.00448	0.00214	0.01020	4.94	4.55	5.25
50	2073	5,595	2,770	10,799	205.3	104.2	392.8	0.0276	0.0144	0.0513	0.002269	0.001196	0.004191	0.01624	0.00813	0.03112	0.00863	0.00440	0.01640	4.61	4.33	4.88
75	2098	8,351	4,033	17,840	292.1	137.4	625.5	0.0413	0.0187	0.0882	0.003403	0.001512	0.007260	0.02424	0.01155	0.05178	0.01253	0.00584	0.02680	4.43	4.09	4.77
100	2123	10,966	5,923	23,505	373.8	203.6	790.8	0.0543	0.0298	0.1127	0.004461	0.002455	0.009189	0.03181	0.01724	0.06776	0.01620	0.00883	0.03413	4.31	3.98	4.56
RawdonCreekDownstream_CP_Q																						
0	2023	34	0	119	0.7	0.0	2.8	0.0001	0.0000	0.0002	0.000003	0.000000	0.000013	0.00009	0.00000	0.00030	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SouthDam_Q																						
0	2023	18,991	61	26,220	10,065.5	6.7	13,929.9	0.0533	0.0005	0.0736	0.024997	0.000057	0.034586	0.17026	0.00025	0.23548	1.18034	0.00062	1.63362	6.52	6.29	6.58
5	2028	1,113	404	4,285	84.0	31.2	315.8	0.0053	0.0024	0.0227	0.000545	0.000238	0.002284	0.00383	0.00152	0.01480	0.00754	0.00253	0.02759	5.38	4.69	5.68
10	2033	2,248	463	6,238	121.8	24.5	345.8	0.0110	0.0023	0.0321	0.001013	0.000216	0.002986	0.00714	0.00147	0.02005	0.00940	0.00185	0.02662	5.05	4.53	5.67
25	2048	5,320	1,609	16,757	218.0	65.9	703.0	0.0267	0.0080	0.0879	0.002312	0.000690	0.007668	0.01609	0.00486	0.05116	0.01358	0.00413	0.04384	4.65	4.09	5.13
50	2073	11,655	3,663	46,599	423.2	136.6	1,683.4	0.0586	0.0195	0.2286	0.004940	0.001661	0.019205	0.03456	0.01099	0.13765	0.02317	0.00747	0.09295	4.32	3.68	4.74
75	2098	16,731	5,553	38,362	582.8	188.3	1,338.3	0.0846	0.0264	0.2061	0.007084	0.002175	0.017288	0.04934	0.01618	0.11339	0.03016	0.00981	0.06949	4.15	3.72	4.62
100	2123	22,709	8,263	65,511	773.2	283.4	2,202.0	0.1145	0.0423	0.3211	0.009551	0.003536	0.026597	0.06673	0.02435	0.19142	0.03884	0.01424	0.11088	4.02	3.53	4.41
WestDam_Q																						
0	2023	5,968	164	8,052	3,888.3	25.0	5,320.7	0.0255	0.0008	0.0345	0.001396	0.000228	0.001723	0.01494	0.00347	0.01723	0.04455	0.01439	0.05098	6.78	6.24	6.94
5	2028	2,711	439	8,863	405.8	63.0	1,313.8	0.0121	0.0023	0.0425	0.003680	0.000621	0.012230	0.05876	0.00940	0.19066	0.24512	0.03899	0.79332	5.34	4.70	5.92
10	2033	1,328	427	5,429	144.3	41.9	604.9	0.0058	0.0019	0.0232	0.001360	0.000400	0.005617	0.02069	0.00591	0.08664	0.08182	0.02280	0.34444	5.53	4.89	5.93
25	2048	1,571	777	3,263	104.2	49.8	215.6	0.0072	0.0037	0.0143	0.001065	0.000521	0.002154	0.01367	0.00640	0.02844	0.04556	0.02077	0.09642	5.27	4.96	5.53
50	2073	3,057	1,648	6,535	152.5	77.3	324.1	0.0144	0.0075	0.0309	0.001671	0.000836	0.003562	0.01832	0.00909	0.03872	0.04931	0.02300	0.10333	4.93	4.58	5.19
75	2098	4,794	2,527	24,988	211.4	106.7	1,122.1	0.0229	0.0113	0.1201	0.002408	0.001169	0.012798	0.02412	0.01222	0.12896	0.05546	0.02705	0.30395	4.74	3.98	5.01

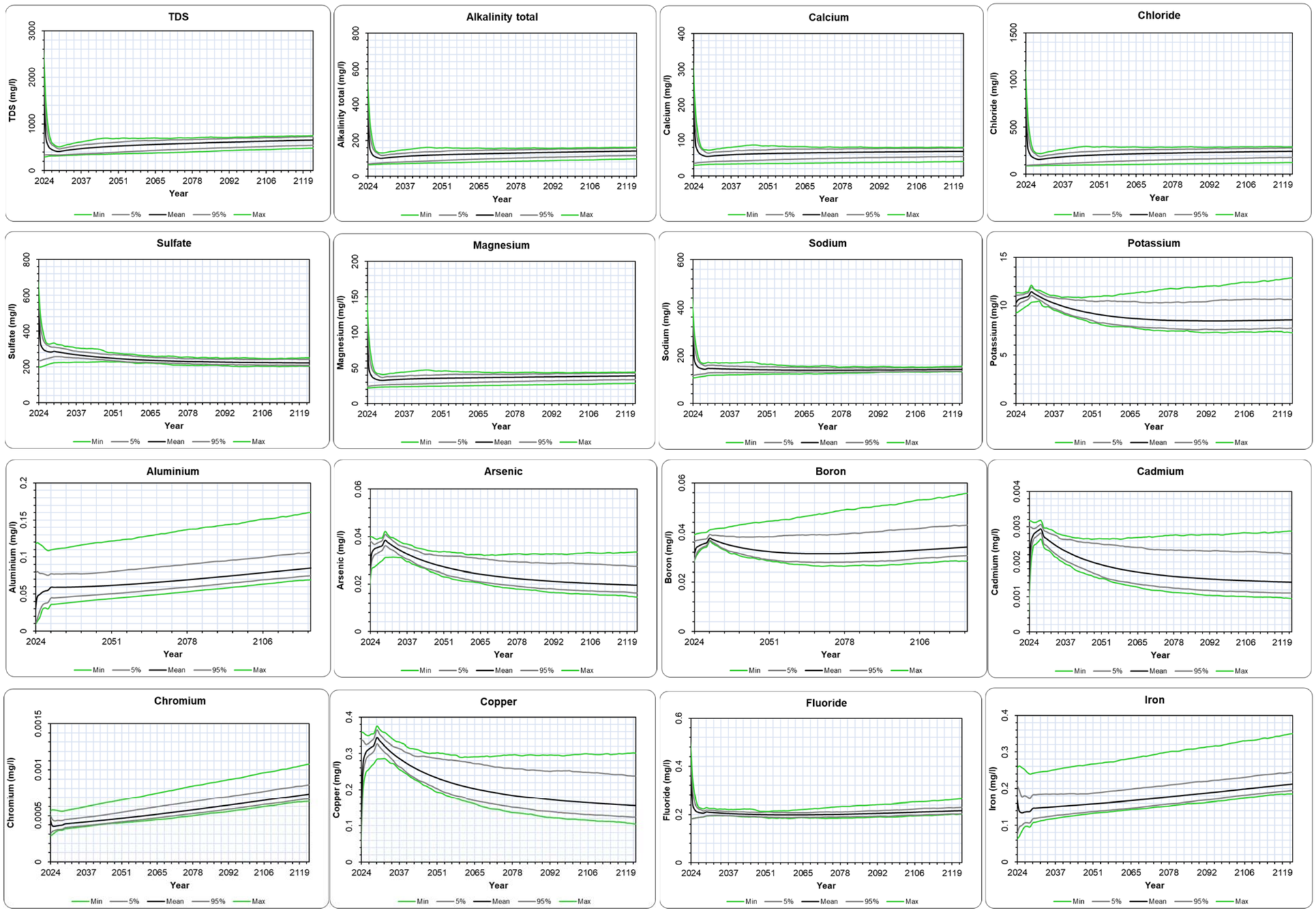
Analyte		TDS			Sulfate			Arsenic			Cadmium			Copper			Zinc			pH		
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	-	-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
100	2123	5,815	3,038	14,338	236.8	121.2	575.4	0.0278	0.0147	0.0678	0.002751	0.001411	0.006675	0.02609	0.01308	0.06457	0.05231	0.02414	0.13149	4.63	4.22	4.89
MinghamCreekUpstream_CP_Q																						
0	2023	103	0	369	36.5	0.0	151.0	0.0006	0.0000	0.0023	0.000044	0.000000	0.000389	0.00064	0.00000	0.00678	0.00264	0.00000	0.02859	2.15	0.00	7.62
5	2028	312	305	367	53.8	42.0	146.7	0.0011	0.0010	0.0023	0.000365	0.000088	0.000400	0.00633	0.00100	0.00700	0.02664	0.00404	0.02950	6.78	6.72	7.51
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
Pit_Q																						
0	2023	3,330	1,335	3,905	1,423.2	993.1	1,529.5	0.0294	0.0249	0.0469	0.013637	0.013012	0.015895	0.10232	0.02953	0.37062	0.82590	0.79447	0.94182	6.65	6.57	6.99
5	2028	1,455	1,357	1,554	1,070.1	1,010.0	1,112.1	0.0435	0.0377	0.0465	0.015696	0.015424	0.015916	0.33802	0.29252	0.36794	0.92967	0.91008	0.94319	6.81	6.65	6.87
10	2033	1,393	1,338	1,441	1,029.7	1,006.0	1,046.6	0.0411	0.0386	0.0439	0.015821	0.015622	0.015978	0.23401	0.19199	0.28376	0.94570	0.92701	0.95416	6.77	6.64	6.81
25	2048	1,320	1,290	1,353	993.4	985.5	1,002.8	0.0400	0.0390	0.0420	0.016135	0.016033	0.016242	0.12657	0.10517	0.16637	0.97489	0.96369	0.97988	6.68	6.58	6.72
50	2073	1,279	1,261	1,296	977.3	968.3	986.3	0.0404	0.0392	0.0416	0.016417	0.016314	0.016510	0.07033	0.05769	0.09122	0.99865	0.99162	1.00492	6.58	6.53	6.60
75	2098	1,262	1,253	1,270	971.0	964.6	977.9	0.0405	0.0396	0.0416	0.016530	0.016430	0.016632	0.04812	0.04235	0.05710	1.00819	1.00089	1.01523	6.53	6.50	6.55
100	2123	1,256	1,248	1,265	968.5	962.9	974.8	0.0406	0.0396	0.0416	0.016576	0.016471	0.016687	0.03926	0.03717	0.04263	1.01199	1.00438	1.02004	6.50	6.48	6.51
TwelveMileCreek_M_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
SwindonRawdU_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
MinghamCreekDownstream_CP_Q																						
0	2023	35	0	119	0.7	0.0	2.4	0.0001	0.0000	0.0002	0.000003	0.000000	0.000010	0.00009	0.00000	0.00030	0.00003	0.00000	0.00010	1.96	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	225	123	321	6.5	2.5	193.2	0.0007	0.0002	0.0255	0.000045	0.000010	0.002668	0.00285	0.00031	0.22896	0.00200	0.00010	0.18127	6.50	6.47	6.76
25	2048	223	119	323	7.2	2.4	186.6	0.0007	0.0002	0.0208	0.000074	0.000010	0.003730	0.00311	0.00030	0.17745	0.00409	0.00010	0.26309	6.51	6.47	6.77
50	2073	238	120	372	19.3	2.5	178.4	0.0014	0.0002	0.0148	0.000462	0.000010	0.005232	0.00741	0.00030	0.11456	0.03254	0.00010	0.38231	6.50	6.47	6.77
75	2098	239	120	353	20.1	2.4	166.5	0.0013	0.0002	0.0110	0.000561	0.000010	0.005635	0.00575	0.00030	0.07206	0.03991	0.00010	0.41232	6.50	6.47	6.77
100	2123	239	120	356	20.5	2.4	168.8	0.0011	0.0002	0.0083	0.000629	0.000010	0.006286	0.00422	0.00030	0.04204	0.04503	0.00010	0.46114	6.50	6.47	6.77
PerryR_D_CP_Q																						
0	2023	35	0	136	0.7	0.0	2.8	0.0001	0.0000	0.0003	0.000003	0.000000	0.000011	0.00009	0.00000	0.00034	0.00003	0.00000	0.00011	1.96	0.00	6.91
5	2028	134	121	136	2.7	2.5	2.8	0.0002	0.0002	0.0003	0.000011	0.000010	0.000011	0.00034	0.00030	0.00034	0.00011	0.00010	0.00011	6.72	6.71	6.76
10	2033	126	59	137	16.7	2.6	129.8	0.0052	0.0002	0.0452	0.000013	0.000011	0.000025	0.00035	0.00033	0.00044	0.00026	0.00011	0.00143	6.75	6.71	7.07
25	2048	125	56	136	19.2	2.6	134.8	0.0061	0.0002	0.0470	0.000013	0.000011	0.000025	0.00035	0.00033	0.00045	0.00028	0.00011	0.00149	6.76	6.71	7.09
50	2073	125	57	137	19.5	2.7	133.6	0.0062	0.0002	0.0466	0.000013	0.000011	0.000025	0.00035	0.00033	0.00045	0.00029	0.00011	0.00147	6.76	6.71	7.09
75	2098	127	56	136	16.0	2.7	133.9	0.0049	0.0002	0.0467	0.000013	0.000011	0.000025	0.00035	0.00033	0.00045	0.00025	0.00011	0.00148	6.75	6.71	7.09
100	2123	124	56	136	20.7	2.7	135.0	0.0066	0.0002	0.0471	0.000013	0.000011	0.000025	0.00035	0.00033	0.00045	0.00030	0.00011	0.00149	6.76	6.71	7.09

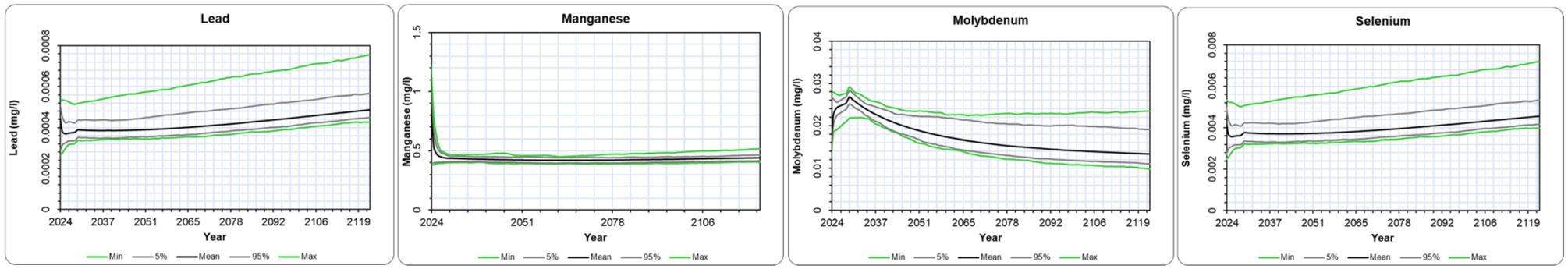
Analyte		TDS			Sulfate			Arsenic			Cadmium			Copper			Zinc			pH		
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	-	-	-
Year	Statistics	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
PerryRiver_U_CP_Q																						
0	2023	8	0	119	0.2	0.0	2.4	0.0000	0.0000	0.0002	0.000001	0.000000	0.000010	0.00002	0.00000	0.00030	0.00001	0.00000	0.00010	0.47	0.00	6.77
5	2028	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
10	2033	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
25	2048	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
50	2073	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
75	2098	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77
100	2123	119	119	119	2.4	2.4	2.4	0.0002	0.0002	0.0002	0.000010	0.000010	0.000010	0.00030	0.00030	0.00030	0.00010	0.00010	0.00010	6.77	6.77	6.77

11.27 Annex C

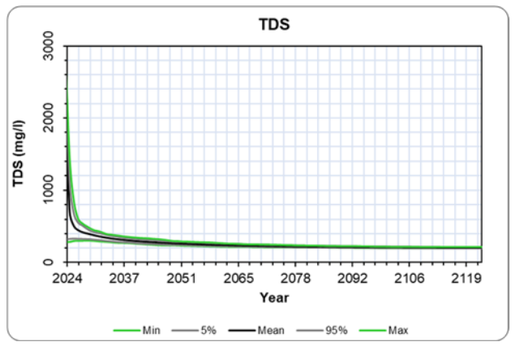
11.27.1 Pit lake concentration versus time for each parameter

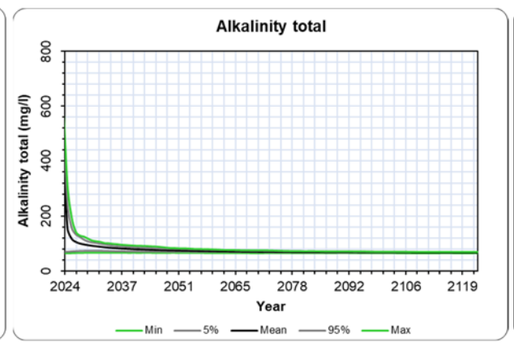
Scenario 1: Select water quality versus time results for the pit lake

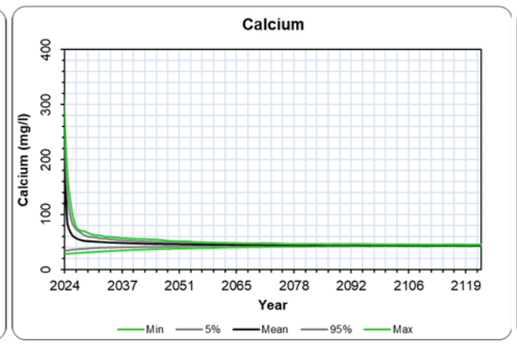


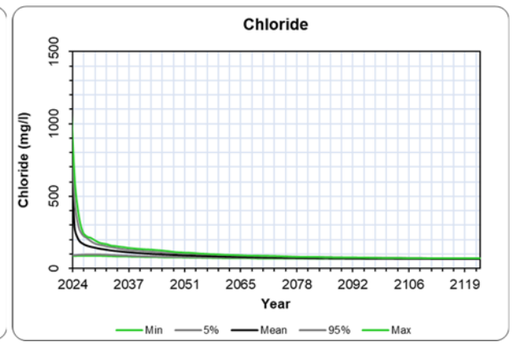

Lead
Lead (mg/l)
0
0.0002
0.0004
0.0006
0.0008
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max
Manganese
Manganese (mg/l)
0
0.5
1
1.5
2024
2051
2078
2106
Year
Min
5%
Mean
95%
Max
Molybdenum
Molybdenum (mg/l)
0
0.01
0.02
0.03
0.04
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max
Selenium
Selenium (mg/l)
0
0.002
0.004
0.006
0.008
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max
Zinc
Zinc (mg/l)
0
0.1
0.2
0.3
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max
Cyanide WAD
Cyanide WAD (mg/l)
0
0.002
0.004
0.006
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max
Pit pH
pH
0
2
4
6
8
2024
2051
2078
2106
Year
Min
5%
Mean
95%
Max

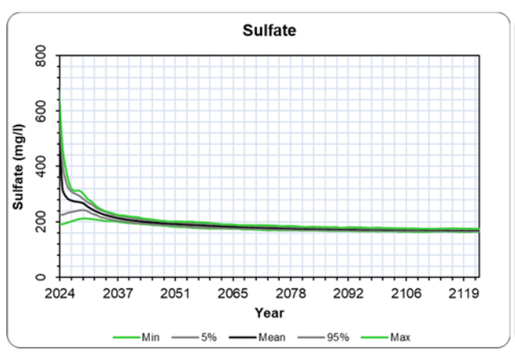
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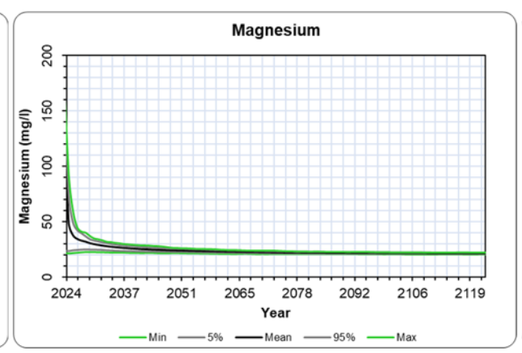


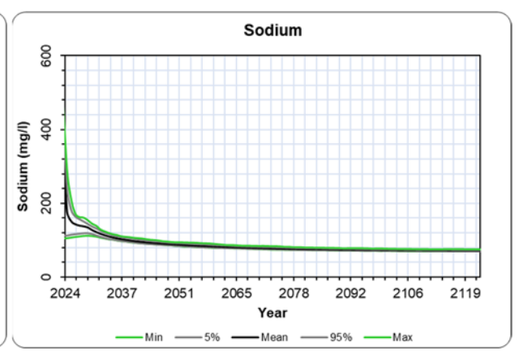


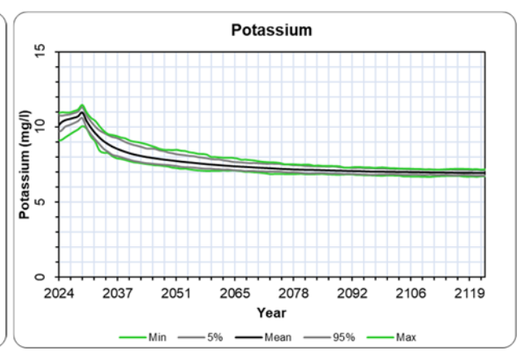


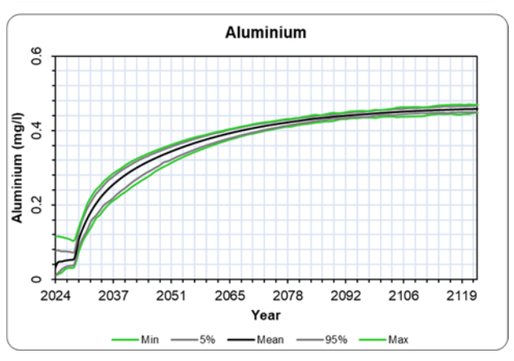


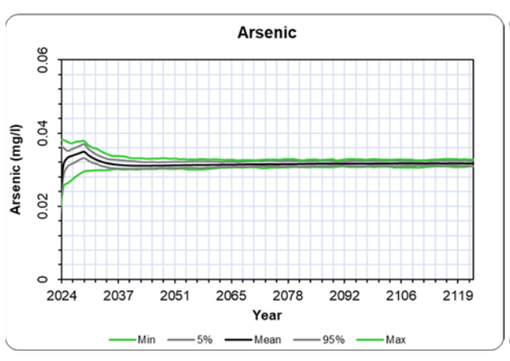


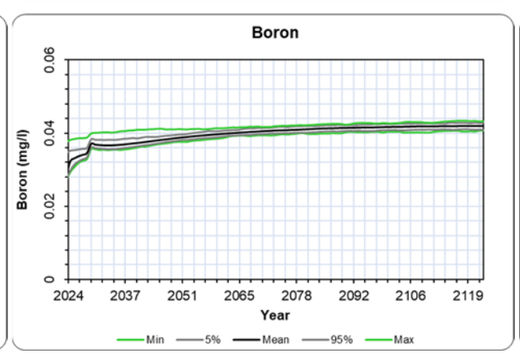


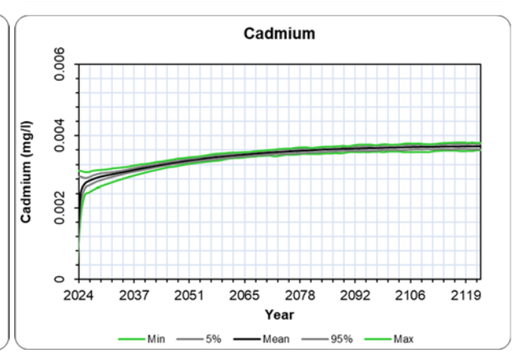


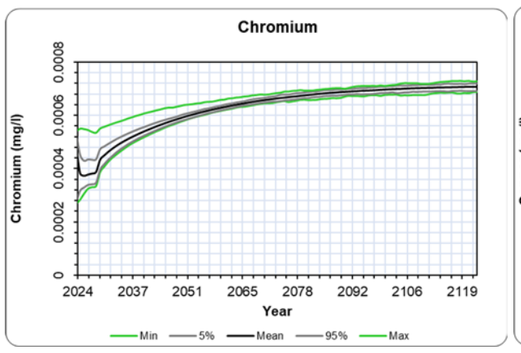


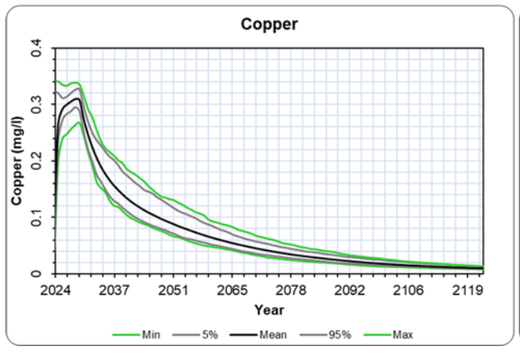


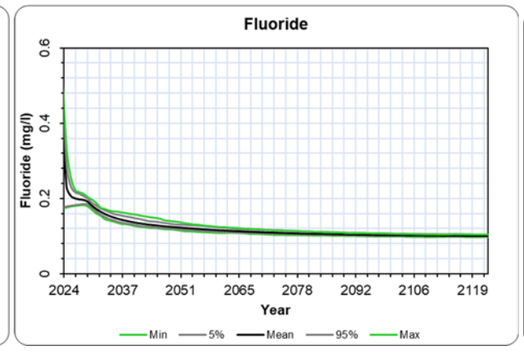


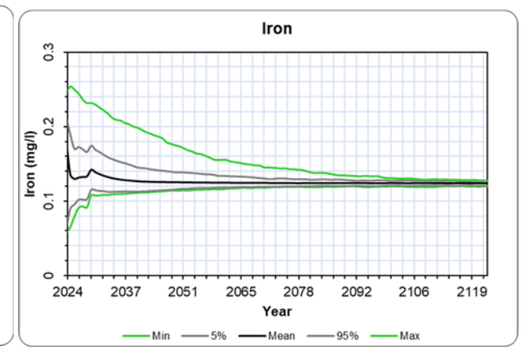


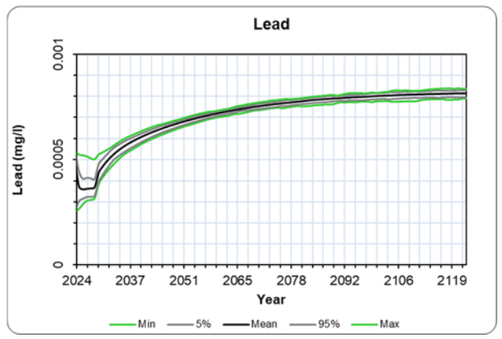


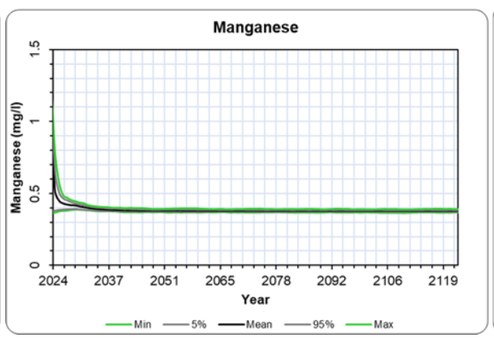


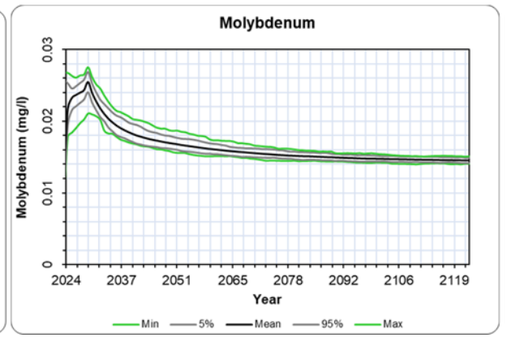


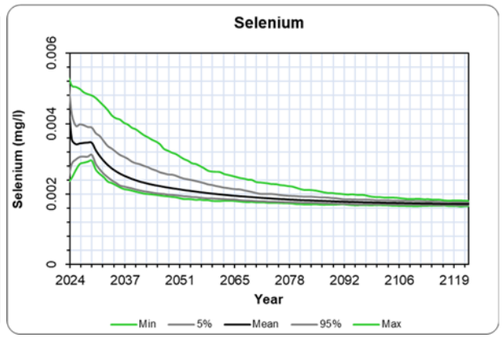


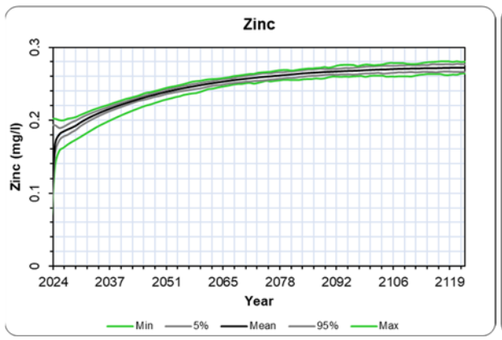


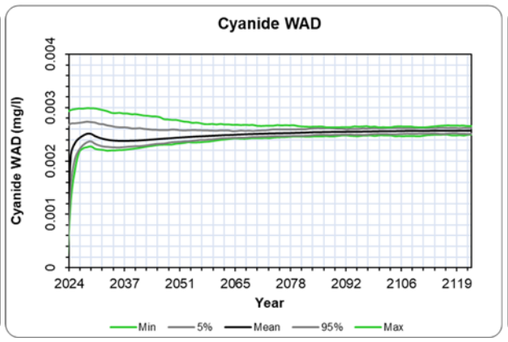

Lead
Lead (mg/l)
0
0.0005
0.001
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

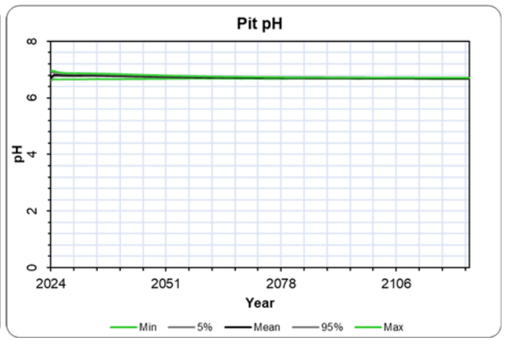

Manganese
Manganese (mg/l)
0
0.5
1
1.5
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Molybdenum
Molybdenum (mg/l)
0
0.01
0.02
0.03
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

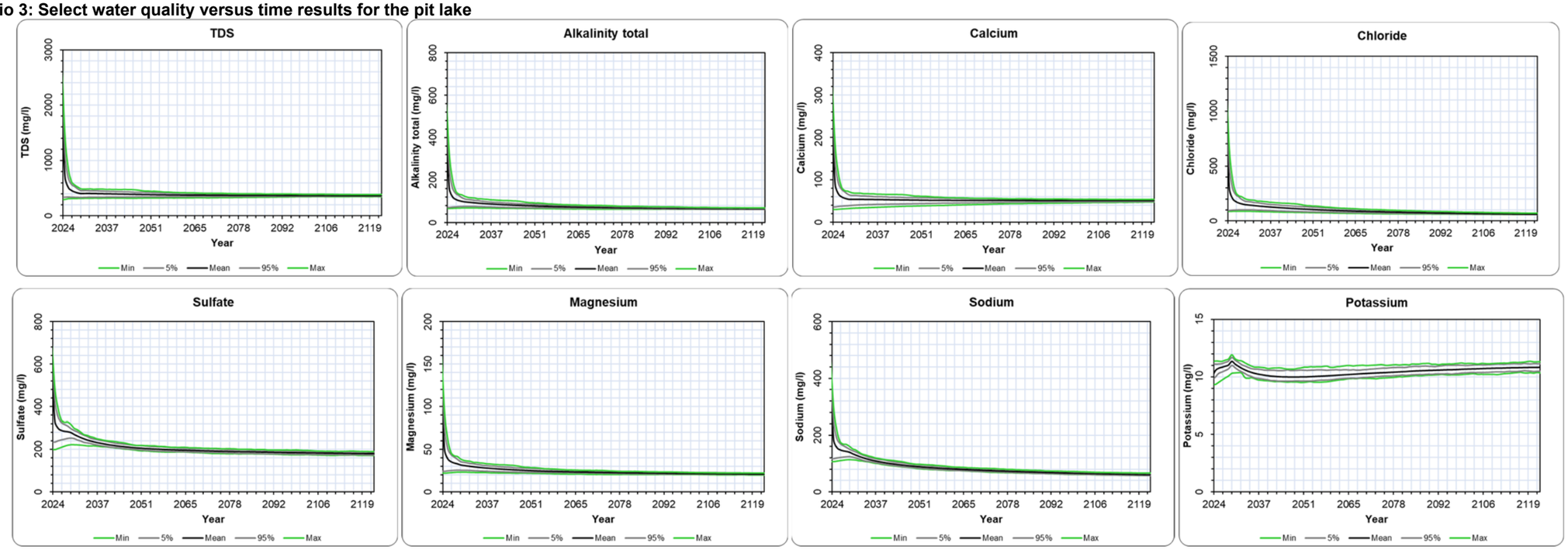

Selenium
Selenium (mg/l)
0
0.002
0.004
0.006
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

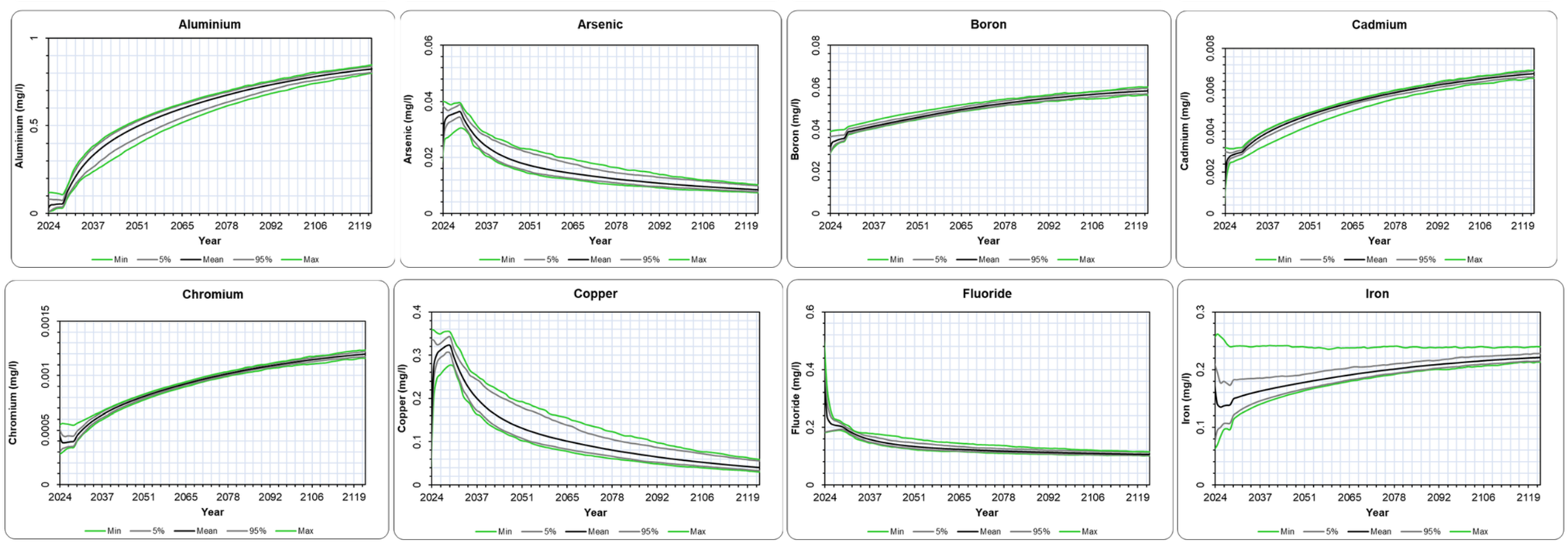

Zinc
Zinc (mg/l)
0
0.1
0.2
0.3
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

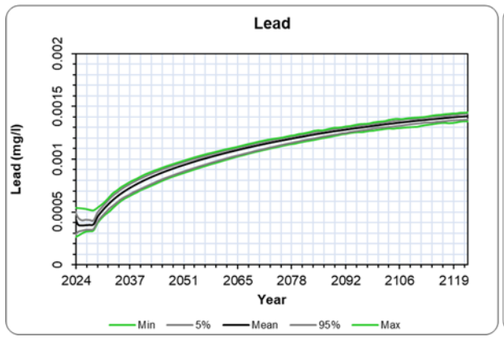

Cyanide WAD
Cyanide WAD (mg/l)
0
0.001
0.002
0.003
0.004
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

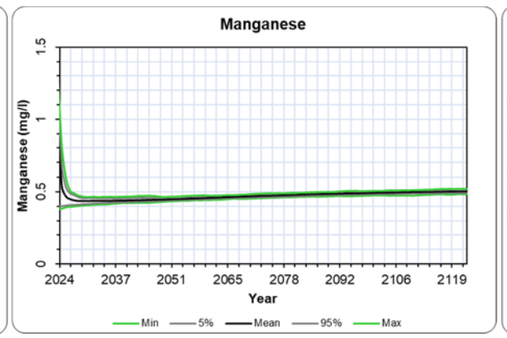

Pit pH
pH
0
2
4
6
8
2024
2051
2078
2106
Year
Min
5%
Mean
95%
Max

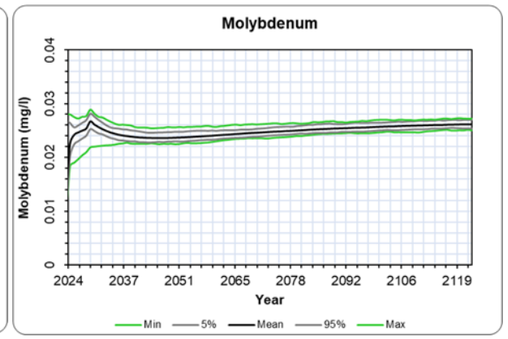
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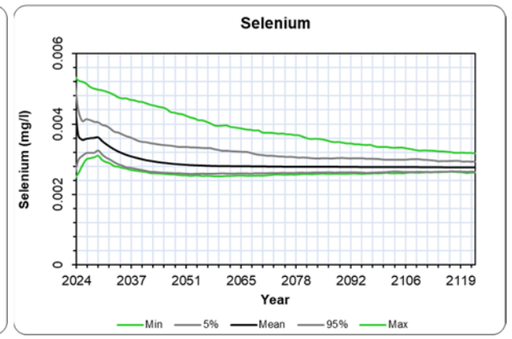


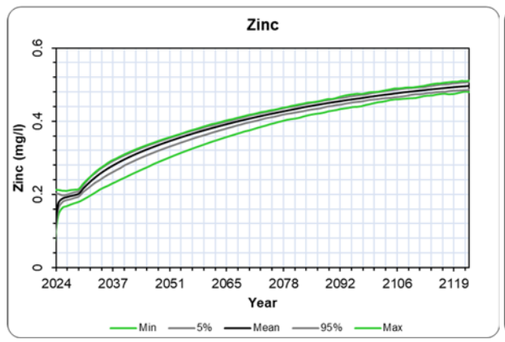


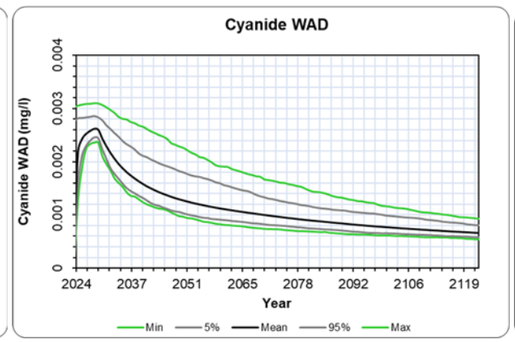

Lead
Lead (mg/l)
0
0.0005
0.001
0.0015
0.002
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max

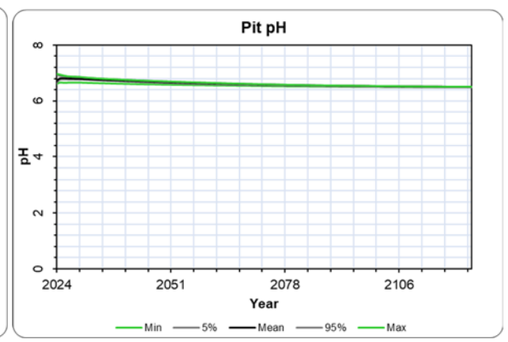

Manganese
Manganese (mg/l)
0
0.5
1
1.5
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Molybdenum
Molybdenum (mg/l)
0
0.01
0.02
0.03
0.04
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Selenium
Selenium (mg/l)
0
0.002
0.004
0.006
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Zinc
Zinc (mg/l)
0
0.2
0.4
0.6
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Cyanide WAD
Cyanide WAD (mg/l)
0
0.001
0.002
0.003
0.004
2024
2037
2051
2065
2078
2092
2106
2119
Year
Min
5%
Mean
95%
Max


Pit pH
pH
0
2
4
6
8
2024
2051
2078
2106
Year
Min
5%
Mean
95%
Max



MINE WASTE AND
WATER MANAGEMENT

TECHNICAL REPORT

Mt Rawdon Operations Waste Rock Test Pile Review

Evolution Mining Pty Ltd

LEADERS IN MINING GEOCHEMISTRY

TECHNICAL REPORT

Mt Rawdon Operations Waste Rock Test Pile Review

Evolution Mining Pty Ltd

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1 Introduction

RGS Environmental Pty Ltd (RGS) was commissioned by Evolution Mining Pty Ltd (Evolution) to undertake a review of the large-scale kinetic field experiment (test piles) being undertaken at Mt Rawdon Operations (MRO). This report provides recommendations for improving the construction and operation of the tests pile experiments, and summarises the test pile water quality results available against specific measured site water quality (eg. waste rock dump seepage and pit void sump water quality).

1.1 Project Background

Mount Rawdon Operations Pty Ltd (MRO) is owned by Evolution Mining and is located in south-east Queensland, approximately 80 km south-west of Bundaberg, and 300 km north-north west of Brisbane. MRO is an open cut gold mine with facilities for gold recovery by ore processing at a Carbon-in-Leach (CIL) treatment plant, and the tailing retained in an engineered tailing storage facility (TSF). Mining, processing of ore, and tailings deposition commenced in 2001. Waste rock generated through mining activities is stored within the TSF, Northern waste rock dump (NWRD) and Western Waste Rock Dump (WWRD). The current anticipated life-of-the mine is approximately ten years. MRO carries out its operations in accordance with the current Permit (DEHP, 2017), which requires tailings materials to be geochemically characterised and placed at the TSF.

1.2 Geology and Geochemistry

MRO has completed several studies over the past few years to confirm the geology and geochemical nature of waste rock (and tailings) materials produced and stored on site through mining and processing ore (RGS, 2009; 2011; 2016a, b; and 2017a, b). The geology of the waste rock is variable however waste rock materials are generally classified into three material types on site:

- Non-Acid Forming (NAF);
- Potentially Acid Forming – Medium Capacity (PAF-MC); and,
- PAF - High Capacity (PAF-HC).

In contrast, tailings are generally uniformly classified on site as NAF or Uncertain and additional studies are continuing to confirm that the predicted classification remains valid in the longer term and that the geochemical nature of tailings will not change significantly over time (eg. if ore is being processed from deeper elevations and/or different locations within the open pit).

1.3 Waste Rock Classification Criteria

As mentioned above, MRO classifies waste rock types according to acid potential (ie. NAF, PAF-MC; and PAF-HC). The classification criteria utilise measured total sulfur and carbon according to the relationship highlighted in **Figure 1-1**. A total sulfur cut off value of ≤1 %S is used to delineate NAF materials, provided that the total carbon content is ≥ 0.38 %C. If the total carbon content is < 0.38 %C, then the maximum stoichiometric relationship between total sulfur and total carbon is 1:1 (S:C) and is applied to identify NAF materials in the lower left-hand side of the figure. The relationship between total sulfur and total carbon with respect to conversion to equivalent units of kg H_2SO_4/t is %S = 2.6 x %C.

Mineralogical studies on MRO waste rock indicate that high sulfur waste rock materials contained unevenly distributed carbonates and elevated levels of sphalerite in contact with pyrites. Conversely, low sulfur waste rock contains carbonates as rims around the pyrite grains and generally less sphalerite in contact with pyrite. (Ewington, 1996). Therefore, with respect to potential for acid generation at MRO, it is important to ensure that the stoichiometric ratio of total sulfur to total carbon is 1:2 for higher sulfur waste rock materials (i.e. greater than 1 %S) and less important to achieve this ratio for lower sulfur waste rock materials (ie. less than 1 %S). The total sulfur/total carbon relationship displayed in **Figure 1-1** acknowledges and addresses this fact and is likely to reduce the risk of acidity and metals being liberated from higher sulfur waste rock materials.

The PAF-HC waste rock materials are identified using a total sulfur cut off value of ≥ 1.5 %S, provided that the total carbon content is ≥ ~0.38 %C (**Figure 1-1**). If the total carbon content is < 0.38 %C, then a linear relationship between total sulfur and total carbon applies to identify PAF-HC materials, which ranges from 1.5 % S to 0.5 % S. Similarly, PAF-MC waste rock materials are identified using a total sulfur/total carbon relationship that is essentially in between that used for identifying NAF materials and that used for identifying PAF-HC materials. Materials are classified accordingly and manged separately by MRO.

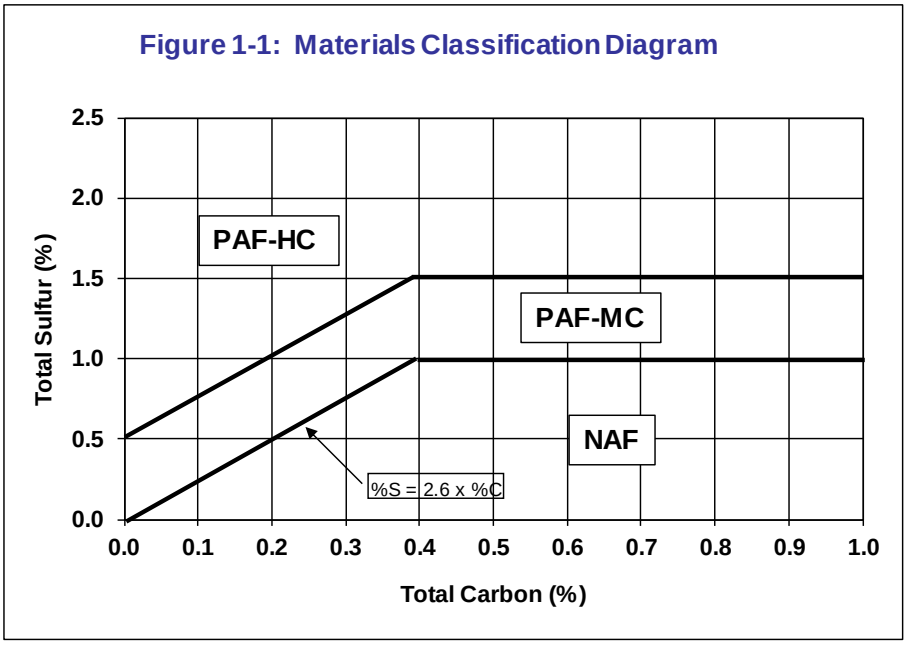


Figure 1-1: MRO Waste Rock Classification Criteria

1.4 Waste Rock Test Piles

As part of MROs ongoing commitment to understanding waste rock geochemical characteristics and to assist with the development of rehabilitation and closure strategies for waste rock facilities, MRO has designed and constructed a field test pile project (**Figure 1-2**). The aim of the project is to *"determine how specific waste rock dump design types will affect water quality characteristics of leachate produced from rainfall events"*.



Figure 1-2: Field pad trials for waste rock materials currently being operated at MRO

1.5 Scope of Work

The scope of work involved completing a review of all available information on the waste rock field trials, interpretation of the acquired data, and provision of relevant conclusions and recommendations in a technical report.

The review was completed by RGS to align with technical guidelines associated with the management of sulfidic waste rock materials in Queensland (DME, 1995, DEHP, 2013), Australia (COA, 2016) and internationally (INAP, 2009).

2 Methodology

2.1 Site Visit

A site visit was undertaken by Alan Robertson (Principal Geochemist), Matt Landers (Senior Geochemist) and Peter Long (Geoscientist) of RGS in March 2018. The site visit included meeting with Sven Sewell and Graeme Esslemont of MRO and inspection of the waste rock field trial area. Key relevant site data associated with the field trial (eg. water quality monitoring data) was collected.

2.2 Data

RGS was provided with the following data and information:

- Field test pile water quality results (.xls file);
- North waste rock dump seepage water quality data (.xls file);
- Pit sump water quality data (.xls file);
- 2017 annual water quality review (NRC, 2017);
- Dam and decant water quality data (.xls file); and
- MRO WRD Leachate Experiment presentation (.ppt file).

RGS has completed a high-level review of all the aforementioned data/ information in light of the large-scale field test pile experiment for waste rock.

3 Large Scale Field Kinetic Leach Experiment Preview

3.1 Background

MRO has implemented a large-scale field kinetic leach experiment (test piles). The experiment includes nine control test pads, representing the three waste rock classes (**Section 1.3**), and three treatment test pads. A summary of the test piles and the first recorded (measured) leachate event is provided in **Table 3-1**. According to documents provided to RGS, the objective of the test piles is to:

- "*Assist with the development of rehabilitation and closure designs for waste rock dumps*"; and,
- *"determine how specific waste rock dump design types will affect water quality characteristics of leachate produced from rainfall events"*.

In general, test pile experiments are typically designed to:

- Assess the sulfide oxidation/metal leaching rates and weathering rates of waste rock materials under site-specific field conditions;
- Assess leachate quality generated under site-specific field conditions;
- Provide information that can be used to understand and scale sulfide oxidation, weathering reaction rates from laboratory tests to site-specific field conditions;
- Provide information that can be used for water quality estimation; and,
- Evaluate the effectiveness of various treatments (eg. cover design; alkaline dosing, etc.) on oxygen ingress and water infiltration as an engineered strategy to minimise/mitigate acid and metalliferous drainage (AMD) [including metalliferous leaching (ML) and saline drainage (SD)].

Table 3-1: Large Scale Field Kinetic Test Pads

Waste Class	Code	Replicate	First Leach	Description
Control: Non-Acid	C-N	R1	4/06/2016	NAF Waste Rock
	C-N	R2	4/06/2016	NAF Waste Rock
	C-N	R3	4/06/2016	NAF Waste Rock
Control: Medium-Acid	C-M	R1	4/06/2016	PAF-MC Waste Rock
	C-M	R2	4/06/2016	PAF-MC Waste Rock
	C-M	R3	4/06/2016	PAF-MC Waste Rock
Control: High-Acid	C-H	R1	20/03/2017	PAF-HC Waste Rock
	C-H	R2	4/06/2016	PAF-HC Waste Rock
	C-H	R3	4/06/2016	PAF-HC Waste Rock
Treatment	T1	R1	31/03/2017	PAF-MC encapsulated with NAF Waste Rock
	T1	R2	19/07/2016	PAF-MC encapsulated with NAF Waste Rock
	T1	R3	19/07/2016	PAF-MC encapsulated with NAF Waste Rock

3.2 Site selection

The field test pile site location needs to take into consideration the following logistical and experimental considerations:

- Sufficient available space for the test piles with the opportunity to expand the experiment;
- The location needs to be compatible with future mine development (eg. pit void expansion);

- Ideally, the location is within short haulage distance from the mine pit and haul road;
- The location should be away from mining operations; particularly any operations which may impact on the results of the testing (eg. dust from run-of-mine pad etc.); and,
- The location should be above the 1:50 year flood levee or appropriate flood protection should be built into the design.

The MRO test piles are located in relatively close proximity to the southern base of the Northern Waste Rock Dump (N-WRD) and to the SE of the pit void. There is sufficient open space to accommodate twelve test piles (**Figure 1-2**) and possibly more. The location appears to be sufficiently elevated to avoid any potential flooding and any negative impacts from mining operations. However, the test piles, particularly those to the north, may receive surface water runoff from the NWRD bund.

At the time of the site visit, the test piles were surrounded by grass and an invasive weed (**Figure 3-1**), which should be removed.



Figure 3-1: Invasive weed surrounding the test pile experiments and sampling containers.

3.3 Test Pile Construction

The construction sequence photos of the test piles are shown in **Attachment A**. RGS has not received test pile construction drawings or any information regarding design criteria (if they exist); therefore, RGS has summarised common procedures for test pile construction and used site observations of the MRO test piles together with the construction photos supplied by MRO.

The foundations for the test piles are typically surveyed and levelled by an excavator prior to construction. The construction photos for MRO test piles indicate the surface conditions were well prepared; it is not clear if the foundations were surveyed prior to test pile construction. Depending on the original foundation material, a foundation layer may be required to be placed on top of the original foundation. The MRO test piles appear to be constructed on clay-like material.

The test piles at MRO are essentially a large lysimeter. The intent of the lysimeter is to capture all water infiltrating into the waste rock. The infiltrated water is directed by gravity to a drainage pipe, which transports the water to a sampling catchment barrel.

The lysimeters are approximately 15m x 15 m, with a 300 mm bund constructed around the perimeter with top soil/ growth medium or crushed waste rock (**Figure 1-2** and **Figure 1A**; **Attachment A**). The base of the lysimeters and bund was then lined with an impermeable geomembrane (Enviro Liner 6040 HD 40mil; 1mm thickness). It is not clear to RGS if the base of the lysimeter was sloped towards a drainage point; however, the base would typically have a ~10% gradient directing flow towards the drainage point. The geomembrane is typically placed and 'rolled-out' using an excavator and measured/cut to specification. Once sized to specification, the edge of the geomembrane is folded in to accommodate the construction of a berm from granular material. The placement of the geomembrane

is usually undertaken by specialised contractors, due to the risk of piercing or damaging the liner. Since the geomembrane is placed in separate rows, the seams are sealed using an extrusion welder. After placement and extrusion welding of the seams, field tests (ie. air pressure testing) are conducted on the liner to verify that the condition of the welded seams are satisfactory. It is not clear if the MRO seams were welded and pressure tested, or simply overlapped which may result in leakage. During placement of the geomembrane, consideration of thermal effects needs to be considered; the geomembrane is prone to contraction during cooler weather.

The geomembrane was then lined with a “sand blanket”, presumably inert, as a protective layer to prevent puncture during placement of waste rock. It is not uncommon to test the vertical hydraulic conductivity of the sand blanket (double ring infiltrometer test) to ensure immediate drainage. The test piles were placed directly on top of the lysimeters to a height of ~2m (refer to **Section 3.7**).

3.4 Drainage

The drainage of the lysimeter/ test piles is one of the most important aspects of the test pile design, as inadequate drainage will result in ponding of water at the base of the lysimeter which affects the leachate sample chemistry/concentration and geochemical characteristics of the saturated waste rock within the ponded water.

As mentioned earlier, it is not clear if the base of the lysimeters was sloped towards a drainage point. An image provided to RGS during the construction phase (**Figure 2A; Attachment A**) indicates that water drains to a certain point and then ponds within the lysimeter (not that water was not flowing at the time the photo was taken). Leachate is supposed to percolate through the sand blanket and be directed to a PVC drainage pipe through the HDPE lined bund (**Figure 3A and Figure 4A**; **Attachment A**). Poly pipe is then used to deliver leachate to collection tanks.

The site visit undertaken by RGS showed evidence of ponding of leachate at the base of the drainage pipes (**Figure 3-2**), which is open and not covered. Typically, a ‘pipe boot’ is welded to a low point of the geomembrane to accommodate the drainage pipe(s) which drains from the test pile, through the boot and into the catchment barrel. The drainage network continues into the lysimeter to ensure all leachate is collected and removed.

RGS agrees that the drainage attachment is acceptable; however, drainage from the lysimeter is not optimised, with ponding of water occurring at the drainage outlet and the outlet is open to influence from the surrounding environment. This may result in (amongst other things):

- dilution of leachate water quality at the drainage outlet with direct precipitation;
- contamination of leachate water quality at the drainage outlet; and,
- saturation of the base of the waste rock affecting mineral solubility and dissolution;

Each of the test pile drainage outlets is directed to a separate collection tank.



Figure 3-2 Ponding of water and weed at the drainage outlet.

3.5 Waste Rock Placement

The placement of waste rock is an important step in the construction process because the placement technique will have an impact on the internal structure of the test pile (eg. particle sizing, chimney effect, preferential flow-paths, etc.) and may affect water infiltration and oxygen diffusion.

According to the construction photos supplied by MRO, waste rock was place on the lysimeters by relatively light machinery from the exterior perimeter of the test piles; this placement strategy reduces the possibility of creating preferential pathways or the chimney effect which is more commonly associated with end-dumping techniques.

3.6 Test Material Sample

The waste rock (test material) placed on the lysimeters is summarised in **Table 3-1**. Nine of the twelve test piles are dedicated to understanding the three waste rock classes, while the other three test piles include PAF-MC material encapsulated with NAF waste rock. RGS agrees with the inclusion of the waste rock classed in the test piles; however, is not in favor of the treatment test piles. The leachate results from the treatment test piles will not be able to be interpreted because of the combination of material types with unknown volumes for each. The idea behind the treatment test piles is to understand how a potential WRD cover may perform; however, this cannot be achieved at the test piles scale. Cover design trials, of this nature, are best performed on the active WRD with instrumentation and key performance indicators.

The MRO presentation of the test piles indicates that a historical equation (RSG, 2003), was used for classifying the waste rock as the more current classification criteria (**Section 1.3**, RGS; 2016) was not available at the time of the test pile construction. RGS was not provided with any corresponding static data (acid base accounting) or total sulfur/total carbon data for the test pile materials.

As mentioned above, the mass of the material placed on the lysimeters was not measured. To calculated depletion rates of chemical parameters (eg. depletion of ANC and total sulfur with time), an understanding of the starting mass of chemical constituents in the test pile materials is required, and this cannot be achieved without the starting mass.

3.7 Sample Collection and Analysis

The MRO test piles are designed for leachate to drain from the drainage outlet to a collection tank via poly pipe (**Figure 3-3**). The collection ponds are located ~25 to 100m down slope of the test piles. Rising stage samplers are fitted to the inside of each collection tank (**Figure 4a; Attachment A**), used to collect the "first-flush" and steady state leachate events.

At the time of the field trip, the collections tanks were contained a thick layer of sediment at the base of the tank (**Figure 3-3**). It is not clear if the sediment was leached from the test piles or through wind blown processes. The sediment could add significant contamination to the water quality samples and will need to be rectified (refer to **Section 3.8**).

RGS is not aware of the current MRO protocol/procedure for sampling leachate from the collection tanks. The leachate water samples are currently analysed in the field for pH, EC and DO. The commercial laboratory analysis suite is summarised in **Table 3-2**.



Figure 3-3: Sample collection tanks (left). Sediment inside sample collection tank (right).

Table 3-2: Leachate water quality analysis suite

Chemical Parameter	Chemical Parameter
Alkalinity Bicarbonate	Lead Dissolved
Alkalinity Carbonate	Magnesium Dissolved
Alkalinity Total	Manganese Dissolved
Aluminium Dissolved	Molybdenum Dissolved
Arsenic Dissolved	Nitrate
Boron Dissolved	Nitrite + Nitrate
Cadmium Dissolved	Nitrite
Calcium Dissolved	pH
Chloride Total	Potassium Dissolved
Chloride Dissolved	Selenium Dissolved
Chromium Dissolved	Sodium Dissolved
Copper Dissolved	Sulphate
Electrical Conductivity	Total Anions
Fluoride	Total Cations
Hardness Total as $CaCO_3$	Total Dissolved Solids
Alkalinity Hydroxide as $CaCO_3$	Zinc Dissolved
Ionic Balance	Electrical Conductivity
Iron Dissolved	Acidity as $CaCO_3$

3.8 Recommendations for Improvement

RGS has reviewed the information provided and developed some recommendations to improve the operation of the current test piles. RGS has considered the costs that would be incurred from starting again, which are extensive, so have made recommendations to improve the current set-up. Option 1 considers removing the waste rock and improving the drainage, while Option 2 allows for the drainage system to be improved without having to remove waste rock.

Test Material

RGS recommends decommissioning the treatment test piles (T1) because leachate results are unlikely to be representative of seepage results from a covered (1m NAF layer) WRD as intended. Similarly, the treatment test piles are essentially a mixture of both PAF-HC and NAF waste rock which are already well represented by separate test piles.

Cover design trials are best performed on an active WRD. The trial should have key performance indicators with the field trials well instrumented and designed (eg. lysimeters) to measure the performance indicators. The cover design options should be well investigated (eg. unsaturated zone modelling) before commencing such a trial.

MRO has indicated the possibility of test pile C-H-R2 leaking. This should be confirmed by measuring seepage and rainfall volumes over time. If test pile C-H-R2 is confirmed to be leaking, then it should also be decommissioned.

The test pile materials have been classified according to the historical RSG (2003) classification criteria. The revised RGS (2016) classification criteria should be applied to the data set (if available) to align with the mine operations.

Drainage Improvements

Resolving the drainage issues is a high-priority. There are several options MRO may undertake to optimise the test pile drainage; however, the majority are extensive and involve removing the as-placed waste rock material and upgrading the drainage system which is an expensive operation. RGS has therefore provided two options; Option 1 involves removing the waste rock, while Option 2 allows for the drainage system to be improved without having to remove waste rock. A summary of the options is provided below:

Option 1:

- Remove waste rock material, sand blanket and pull back geomembrane to expose the lysimeter base.
- The basic specification of the base preparation includes a drainage trench, which runs through the centre of the test pile with a 2% gradient towards the current outlet. The drainage trench is required to accommodate at least one 10 cm drainage pipe. The base should also slope towards the drainage trench with a 2% gradient; the 2% gradient is expected to be sufficient to direct infiltrating water at the base of the test pile towards the drainage pipe within a time frame that allows correlation of the pile response to rainfall events.
- The 300 mm bund will remain around the test piles, with a slot cut-out for the drainage pipe. There may need to be minor modification (see points below).
- The base of each test pile will then be re-covered with the geomembrane. Since the base has been reshaped and there is now inclusion of a central drainage trench, the geomembrane may be fall short of covering the base and bund walls. If this is the case, then the bund will have to be pushed in slightly (and compacted) until the goemembrane covers the base and bund wall.
- The geomembrane should be inspected and tested to ensure there are no punctures and the seams are intact.
- A perforated 10 cm diameter PVC pipe wrapped in geotextile fabric is placed in the central trench. The purpose is for collecting basal drainage which diverts all of the test pile rainfall infiltration to the collection tank.

- A 10 cm diameter pipe boot is welded (extrusion welder) to the outlet of the geomembrane to accommodate the drainage pipe(s) which drains from the test pile, through the boot and then to the collection tank. A hole should be cut in the geomembrane to allow the drainage pipe to pass through. The drainage pipe is sealed to the pipe boot using silicon sealer and a stainless-steel hose clamp. Alternatively, the pipe is connected to the geomembrane the same way it currently is (**Figure 3-2**).
- Separate flexible piping is used to connect the drainage pipe (from the test pile) to the collection tank (ie. re-use piping that already exists).
- The lysimeter is then backfilled with a thin layer of washed benign sand (sand blanket) which should completely cover the geomembrane and the drainage trench (and perforated drainage pipe) so that the base is essentially flat. The protective layer should not inhibit infiltration to the geomembrane.
- Waste rock is then placed over the lysimeter to a height of 2m. The outlet will be completely covered so that there is no influence from the outside environment (eg. direct rainfall dilution or dust contamination, etc.). The mass/volume of waste rock should be recorded for each test pile.

Option 2:

- Option 2 allows for the drainage system to be improved without having to remove waste rock from the test pile.
- Images provide by MRO indicate that ponding may only be occurring around the drainage outlet (**Figure 2A; Attachment A**) and possibly due to the drainage outlet being too elevated (**Figure 3-2**). RGS recommends lowering the drainage outlet to the lowest point so that all the water is allowed to drain.
- Remove the waste rock and the sand blanket directly around the drainage outlet and disconnect the drainage pipe.
- Excavate a trench through the bund and below the current placement of the drainage pipe. The geomembrane will need to be folded back of the bund. The trench should be deep enough so that when the drainage pipe is placed back in position it will be the lowest point in the lysimeter and still be able to drain to the collection tanks (ie. no ponding within the pipe works).
- This may involve having to patch and weld (extrusion welder) the current drainage hole though the geomembrane and placement of a new hole depending on the current positioning.
- Place the drainage pipe back in position (now lower in position) using the same connection method. Depending on the new location, an elbow may need to be added to the drainage pipe to ensure drainage is maintained to the collection ponds. RGS advise that a porous geofabric is placed over the drainage connection to prevent sediment from entering the collection tanks.
- The sand blanket is then placed back in position, including over the drainage connection; the sand should be coarse enough so that the drainage connection (porous geofabric) is not blocked by fine sediment. Waste rock test material is then placed back in position ensuring that the entire lysimeter surface is covered including the drainage connection.
- Since there is no known recorded volumes/ mass of the as-placed waste rock material, the test piles should be surveyed, and the volume/mass of waste rock estimate based on assumption of the materials specific density. This allows for the calculation of chemical depletion rates (eg. for Acid Neutralising Capacity (ANC) and total sulfur) with time.

Collection Tanks

There are several improvements which can be made to the collection tanks. The sediment that has accumulated in the collection tanks is either due to wind driven processes or is leaching from the test piles; either way, the sediment may be affecting the water quality and will need to be removed, and measures put in place to prevent from reoccurring. The collection tank lids that are currently in place are sufficient to prevent contamination from the environment and dilution from rainfall events; these need to remain in place at all times except when sampling or undertaking maintenance checks.

Inclusion of porous geofabric over the drainage pipe and use of coarse benign sand around the drainage outlet should prevent fines from being transported form the test pits to the collections ponds.

Whilst in theory, the rising stage samplers are good, they may add another layer of complication to the sampling procedure. RGS is not aware if calculations have been undertaken to determine the height at which the storage containers should sit within the collection tank to represent first-flush and steady state samples; if the rising stage samplers are to remain, then these calculations should be made and the containers placed accordingly. Similarly, calculations should be undertaken to determine the waste rock pore volumes that are flushed during a rainfall event and the associated collection tank water height.

Sample analysis/ Data Collection

One of the most important requirements for data collection from the test piles is the involvement of site personnel to undertake the recording of key parameters. MRO require someone from site to "champion" the project, which requires someone to regularly visit the site, maintain the site/ test piles (eg. weeds, drainage, collection tanks) and undertake the routine sampling/recording.

At each sampling event (sufficient rainfall event), the leachate collection tanks should be sub-sampled using the rising stage samplers, and water should be completely emptied from the tank prior to re-attaching new samplers. There will be occasions in the dry season when only small samples can be obtained. However, if leachate volumes are ~100 mL or greater, then these should be able to be analysed for (at least) the major parameters (e.g. pH, EC, acidity/alkalinity and SO_4^{2-}). This should be dependent on the capabilities of the commissioned laboratory service. Small, concentrated volumes maybe diluted with deionised water to make-up to a volume sufficient enough to be analysed (depending on instrumental detection limits). Routine rainfall events that provide sufficient water samples should be according to the current analysis suite (**Table 3-2**).

There are currently key parameters that are not being measured. Seepage water volume (ie. water which exits the drainage pipe) should be recorded with time (rate) and correlated to rainfall (intensity and duration). There is currently no site-specific measurement of rainfall intensity and duration, which are also important parameters to consider when interpreting the water quality results. The seepage water volumes versus time are used together with the leachate data to calculate (amongst other things) solute loading rates (eg. mg/kg/week) to understand the chemical load of a particular element entering the receiving environment (as opposed to concentration; mg/L). Similarly, the time for sufide and ANC depletion can be inferred from the initial total sulfur and ANC concentrations and the sulfate/ carbonate production rates.

A tipping bucket flow meter is a device which measures the flow rate of water discharging from the lysimeters. This is an optional devise which could be included if site personnel are not available for routinely measuring seepage.

It is necessary to collect site-specific climate data to quantify the external processes specific to the field test piles. Infiltration and water flow as well as oxygen transport within the waste rock pile are all strongly dependent on climate conditions. Seasonal temperature variations are important to understand as the temperature of the air entering the pile can result in a drying or wetting effect. Barometric pressure changes can affect the oxygen supply within the field test piles. The weather station should be installed within close proximity of the field test piles, at the least a rain gauge should be installed and routinely recorded. Parameters that should be monitored include precipitation (duration and intensity), temperature, barometric pressure and wind speed/direction.

4 Waste Rock Geochemistry

4.1 Test Pile Results Summary

The test pile kinetic testing results are summarised graphically in **Attachment B** for select parameters for each of the test piles according to waste rock class. Measured results reported as below instrumental detection limits (<) are shown graphically as zero.

Some comparisons of the leached water qualities are compared to containment dam contaminant release limits and regional ground water contaminant limits outlined in the Environmental Authority (EA; EPML00712113). These comparisons are only used as context and to framework the discussion, as waste rock seepage water quality is likely to be significantly diluted by catchment runoff and direct precipitation. The results are, however, directly comparable to the WRD seepage water quality (**Section 4.2**) and, to an extent, the pit sump water quality (**Section 4.3**); for this reason, a comparison to these water qualities is made in following section.

It needs to be highlighted that field kinetic results are typically interpreted considering rainfall data, or at least leachate volume, which were not reported or measured. RGS has used rainfall data from neighbouring Mt Perry BOM SILO data drill; Station number 39070 over the testing period

The key results are summarised below.

pH/ Acidity/ Alkalinity

- Almost all pH values reported in leachates from all waste rock types are circum neutral over the duration of the testing. These pH values are within the release limits specified for the contaminant dams and for regional groundwater tolerable limits (i.e. pH 6.0 – 9.0). The pH values typically ranged from pH 7.0 to 7.5, with slightly higher pH values evident for the NAF (C–N) and PAF-MC (C–M) test piles.
- On two occasions the PAF-HC (C–H: R3) test piles reported acidic pH values (pH < 4.5); however, later leach events reported circum neutral pH values. This is likely to reflect the depletion of available ANC at these times, with the particle size of pyrite and carbonates likely to paly an important role in the balance of weathering of these minerals.
- The acidity generation from the tests piles was negligible, except for when the leachate pH dropped below ~pH 6 (ie. for the PAF-HC test pile on two occasions), in which case up to 41 mg/L (as $CaCO_3$) of acidity was produced. The leachates generally produced alkalinity in the form of bicarbonate, with measured total alkalinity typically ranging between ~15 to 70 mg/L (as $CaCO_3$). Total alkalinity was below instrumental detection limits for C–H: R3, for the two acidic leachate events.

Salinity/ Metal(loid)s

The key metal(loid) concentrations corresponding to the receiving water monitoring requirements (Schedule E - Table 4 of the EA: SO_4^{2-}, TDS, Cu, Zn, As, Cd and WAD CN) are discussed below – excluding CN (not measured)

- Generally, the concentrations of each of the chemical parameters are sporadic and reflect rainfall intensity and frequency. The low rainfall events, which are sufficient enough to produce leachate, are more concentrated, particularly after extended dry periods where soluble oxidation products accumulate within the waste material and are flushed (ie. first-flush) (eg. 19/07/2016). In contrast, high rainfall events are generally associated with dilution of chemical constituents, even after time of extended dry periods (eg. 24/10/2017).
- The seasonality and variation of leached metal(loid)/salinity concentrations relative to rainfall intensity and frequency are highlighted in **Figure 4-1** where leached TDS concentration for each of the test piles is compared to cumulative rainfall (from the Mt Perry BOM SILO data drill; Station number 39070) over the test period. The figure highlights the elevated TDS concentrations after low rainfall events relative to low TDS concentrations after large rainfall events due to dilution.

- The leached TDS concentrations varied considerably for leachate from a particular test pile (from ~30 mg/L to 2,500 mg/L), reflecting seasonal variations in rainfall and intensity. Higher concentration leachates are most evident towards the start of each wet season, particularly after the test piles commenced. This reflects the flushing of soluble oxidation products (secondary mineral precipitates) that accumulate over the dry season.
- The leached sulfate concentrations essentially mirror leached TDS concentrations. The leached sulfate concentrations ranged from ~50 – 1,400 mg/L for the test piles. The leached sulfate concentrations were generally lower for the NAF test piles (~100 to 900mg/L) than the PAF-MC (~100 – 1,400 mg/L) and PAF-HC (~50 – 1,100 mg/L) test piles reflecting the total sulfur content of the waste rock samples. Although there is sufficient ANC in the waste rock test piles to typically inhibit (currently) the onset of acidification, the sulfides present are reacting and, although being neutralised, are producing sulfate. The sulfate concentrations also reflect the seasonal variations in rainfall with concertation and dilution effects.
- Ideally the sulfate production rates could be calculated, to show that sulfate production is likely to be similar for each of the test piles regardless of starting sulfur content and waste rock type. This would suggest that sulfide oxidation rates are approximately the same regardless of the starting total sulfur concentration, and/or, sulfate loading may be controlled by secondary mineral precipitates (eg. gypsum [$CaSO_4.2H_2O$)] precipitation).

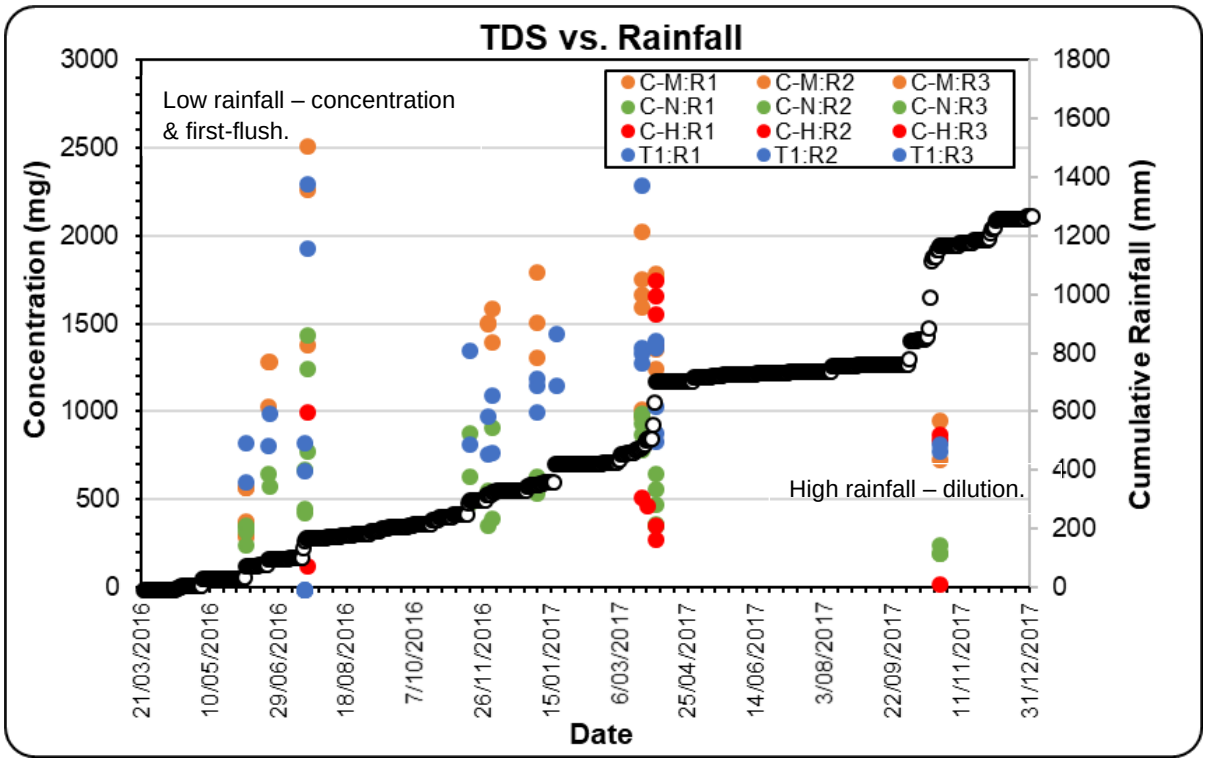


Figure 4-1 Test pile TDS (mg/L) data versus cumulative rainfall data (BOM SILO drill; Station number 39070).

- Higher leached metal(loid) concentrations are associated with the two acidic leach events for test pile C-H: R3. This is particularly evident for elements such as (amongst others): Al, Cd, Cu, Mn and Zn. This highlights the need to maintain neutral leachate conditions.
- The Cu leach concentrations are generally elevated for the majority of test piles relative to the contaminant release limits (Schedule E – Table 2) which is either < 0.04 mg/L Cu or <0.0025 mg/L Cu depending on the dam. However, there are only two measurements that exceed the regional ground water contaminant limits (Schedule E – Table 10), which are associated with the acidic leaches from the PAF-HC test piles.

- The leached Cu concentrations were more elevated in the initial flush events for the NAF (up to 0.012 mg/L Cu), PAF-MC (up to 0.01 mg/L Cu) and trial (up to 0.017 mg/L Cu) test piles, which reflects the flushing of oxidation products accumulating in the test piles; this is enhanced during the excavation and stockpiling of waste rock followed by construction phases of the test piles.
- Generally, the NAF, PAF-MC and trial test piles leached Cu concentrations below 0.004 mg/L after the initial first flush. The exception was for the PAF-HC test pile when acidic leachates occurred.
- The leached Zn concentrations are relatively low for the majority of test piles (excluding the PAF-HC test piles) relative to the contaminant release limits (Schedule E – Table 2), which is either < 0.15 mg/L Zn or <0.031 mg/L Zn, depending on the dam. All leached Zn concentrations from the NAF, PAF-MC and trial test piles are well below 0.1 mg/L Zn. However, the PAF-HC test pile concentrations are orders of magnitude higher than the other test piles, particularly during the acidic leach events, with the majority of values above 0.1 mg/L Zn. This may reflect the total Zn concentrations of the waste rock material in the PAF-HC test piles (not available), or the mineralogy/ speciation of Zn in the test piles.
- The leached Zn concentrations show a somewhat inverse trend compared to the Cu concentrations, with a generally lower first flush concentration, followed by a general increase in leached Cu concentrations over the testing period.
- The leached As concentrations are generally below instrumental detection limits for each of the test piles, including for the acidic leach events associated with PAF-HC test pile.
- The leached Cd concentrations are relatively low for the majority of test piles (excluding the PAF-HC test piles) relative to the contaminant release limits (Schedule E – Table 2), which is either < 0.005 mg/L Cd or <0.0008 mg/L Cd, depending on the dam. All leached Cd concentrations from the NAF, PAF-MC and trial test piles is well below 0.05 mg/L Cd, and the majority below 0.0008 mg/L Cd (the few exceptions are from the trial test pile).
- However, once again, the PAF-HC test pile concentrations are orders of magnitude higher than the other test piles, particularly during the acidic leach events, with several values above 0.01 mg/L Cd. This may reflect the total Cd concentrations of the waste rock material in the PAF-HC test piles (not available), or the mineralogy/ speciation of Cd in the test piles.
- The leached Mn concentrations are generally elevated for the PAF-HC test piles relative to ANZECC & ARMCANZ (2000) guideline values for Livestock Drinking Water Levels. The elevated values typically correspond to the acidic leachates.
- The test pile concentration (mg/L) results can be misleading as the actual amount (mass) of chemical constituents released to the receiving environment is likely to be higher during the larger rainfall events, albeit more dilute. Industry practice for interpreting test pile leachate results would involve conversion of concentrations to load (mg/kg/time) and interpretation of cumulative load versus time.

4.2 Comparison to Waste Rock Dump Seepage

Toe seepage water from eleven locations on the north waste rock dump (NWRD) was collected and analysed in June/December 2010, and March/ August 2012 (**Figure 4-2**). The water quality results are summarised in **Table 4-1**. The sampling dates were compared to rainfall data obtained from the BOM SILO data drill for Mt Perry station number 39070; there is no correlation between rainfall events and seepage, with seepage samples collected after dry periods. RGS understands that the WRD toe seepage is steady throughout the year and there is no corresponding flow data for these measurements to estimate chemical loads.

The seepage water qualities range from slightly acidic to neutral (pH 4.96 to 7.84) with a TDS ranging from 468 to 3,310 mg/L. The water qualities are dominated by sulfate (441 to 2,800 mg/L) with lesser calcium, sodium, magnesium, chloride, nitrite and alkalinity (as bicarbonate under neutral conditions). Some metal(loid)s concentrations are elevated compared to background concentrations in the WRD seepage water, including (amongst others): Al, Cd, Cu, Mn and Zn.

The measured seepage water TDS concentrations are generally in the same range as those reported for the test piles (~30 mg/L to 2,500 mg/L). Similarly, the dominant ions leached from the test piles are similar to the measured seepage water qualities, with the leached water qualities dominated by sulfate (~50 – 1,400 mg/L) with lesser calcium, sodium, magnesium, alkalinity and chloride.

There is, however, minor differences in trace metal(loid) concentrations between NWRD seepage and test pile leachates. This is likely to reflect such thing as, i) water:rock ratios, ii) dilution and concentration effects, iii) lag times, iv) the fact that some of the seepage water qualities were slightly acidic, and v) mineral solubility constraints.

To understand the solubility constraints of some minerals on metal(loid) concentrations in the NWRD, simplified geochemical modelling was undertaken using PHREEQC (Parkhurst and Appelo, 1999). PHREEQC modelling compares measured seepage water quality data with theoretical solubility limits of a number of minerals under different geochemical conditions. The saturation states of a number of minerals (depending on the database used) are calculated from the saturation index (SI). The SI value of a particular mineral is indicative of a mineral's potential to precipitate or dissolve out of solution. If the SI value is negative, then the mineral is undersaturated in solution. However, if the SI of a mineral is positive, then the mineral is supersaturated and may precipitate out of solution. If the SI value is equal to zero, then the minerals and solution are at equilibrium. The PHREEQC modelling indicated that some supersaturated (may precipitate) minerals include alunite, aluminium and iron (oxy)hydroxides (eg. boehmite, gibbsite, goethite, hematite, etc.) and some copper bearing minerals like tenorite and cuprite. The SI for gypsum was close to zero, indicating at that gypsum is likely at equilibrium and possibly a constraint on dissolved sulfate concentrations.

Table 4-1: North Waste Rock Dump Seepage Water Quality Summary

Parameter (mg/L)*	WRD1	WRD2	WRD3	WRD4	WRD5	WRD6	WRD7	WRD8	WRD9	WRD10	WRD11	WRD12
pH	7.7	4.96	7.59	4.86	6.43	6.67	5.52	5.73	7.84	8.53	6.82	7
EC (µS/cm)	6000	3180	2960	4810	3820	3660	4910	4900	3210	3590	966	4650
TDS	3310	1630	1510	2500	2030	1940	2630	2630	1690	1890	468	3024
TSS		29	22	56	<5	<5	28	19	<5	118	8	<5
Alkalinity Total as $CaCO_3$		<1	66	<1	30	29	3	3	45	27	52	182
Aluminium	<0.01	5.04	0.02	14	<0.01	<0.01	0.5	0.35	<0.01	<0.01	0.03	0.08
Arsenic	0.001	0.001	0.003	0.003	0.002	<0.001	0.002	0.001	0.001	0.001	0.002	0.001
Boron					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	0.001	0.589	0.0151	1.7	0.232	0.0204	1.15	1.13	0.0005	0.001	0.0014	0.476
Calcium	0.004	493	430	443	498	480	462	458	208	258	125	266
Chloride		12	12	152	56	69	187	182	78	69	13	305
Chromium					<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	2.05	0.072	6.76	0.15	0.005	3.48	3.36	0.004	0.006	0.002	0.666
Cyanide Total	<0.004	<0.004	<0.004	<0.004	0.006	<0.004	0.011	0.014	<0.004	<0.004	<0.004	0.006
Cyanide WAD	<0.004	<0.004	<0.004	<0.004	<0.004	1	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Fluoride					0.6	0.4	1	1	0.6	0.4	0.4	0.8
Iron	<0.05	<0.05	0.07	<0.05	0.16	0.18	0.15	0.18	0.08	0.08	0.09	<0.05
Lead	<0.001	0.009	<0.001	0.027	0.005	<0.001	0.017	0.015	<0.001	<0.001	<0.001	<0.001
Magnesium		177	90	332	200	157	316	313	169	245	23	236
Manganese		26.1	0.027	79.5	7.48	0.021	47.1	46	0.004	0.029	0.114	25.2
Molybdenum	0.005	0.021	0.041	0.004	0.004	0.005	0.003	0.003	0.007	0.006	0.015	0.005
Nitrate as N					65.4	65.2	64	74.6	151	111	4.03	28
Nitrite as N					<0.01	0.02	<0.01	<0.01	0.26	0.04	<0.01	<0.01
Potassium		10	11	12	13	12	11	11	4	4	6	8
Sodium		121	150	352	274	289	430	430	366	388	48	570
Sulphate	2160	2080	1500	2950	2040	1960	2740	2800	1170	1800	441	2060
Zinc	0.046	50.1	0.699	131	16.5	1.67	74.3	72.2	0.021	0.026	0.095	30

*All results are for dissolved species and reported in mg/L unless otherwise stated. Shaded cells highlight key parameter contributions to water quality.



Figure 4-2: North Waste Rock Dump Seepage Water Collection Points.

4.3 Comparison to Pit Sump Water Quality

RGS was provided with pit sump water quality data which was collected and analysed several times a year since 2004. The database included 117 water quality measurements and the summary statistics are provided in **Table 4-2**.

The pit water sump quality is circum neutral (pH 6.35 to 8.10) with a TDS ranging from 351 to 2,400 mg/L. The water qualities are dominated by sulfate (250 to 1,570 mg/L) with lesser calcium, sodium, alkalinity (bicarbonate), chloride, magnesium and nitrate. Some metal(loid) concentrations are elevated in the NWRD seepage water, including (amongst others): Cd, Cu, Mn and Zn. Once again, the measured pit sump water quality is in the same range as those reported for the test piles and NWRD seepage water qualities, albeit minor difference in some metal(loid) concentrations.

Table 4-2: Pit Sump Water Quality Summary Statistics

Parameter (mg/L)*	Average	Median	Maximum	Minimum	Count
Aluminium	0.011	0.005	0.16	0.0005	105
Arsenic	0.009	0.007	0.03	0.002	113
Boron	0.027	0.025	0.09	0.013	51
Cadmium	0.013	0.0044	0.754	0.0001	111
Chloride	57	29	267	7	64
Chromium	0.002	0.0005	0.025	0.0005	54
Copper	0.028	0.004	0.691	0.0005	111
Cyanide Total	0.010	0.002	0.104	0.002	102
Cyanide WAD	0.007	0.002	0.086	0	103
EC (µS/cm)	1851	1809	3510	539	114
Fluoride	0.288	0.3	0.4	0.1	56
Iron	0.085	0.025	3.5	0.005	105
Lead	0.003	0.0005	0.053	0.0005	109
Manganese	0.835	0.27	30.8	0.01	116
Nitrate as N	14.68	10.60	82.80	4.39	56.00
pH	7.25	7.32	8.10	6.35	116
Sodium	133	106	402	36	64
Sulphate	796	769	1570	250	118
Zinc	0.743	0.281	30.2	0.012	118
Alkalinity Bicarbonate as $CaCO_3$	121	107	338	49	62
Alkalinity Carbonate as $CaCO_3$	0.532	0.5	2.5	0.5	62
Alkalinity Hydroxide as $CaCO_3$	0.532	0.5	2.5	0.5	62
Alkalinity Total as $CaCO_3$	121	107	338	49	62
Calcium	209	232	332	71	62
Magnesium	42.9	41.0	99.0	14.0	62.0
Molybdenum	0.044	0.044	0.09	0.024	101
Nitrite + Nitrate as N	15.42	10.95	85.5	4.67	56
Nitrite as N	0.738	0.535	3.04	0.005	56
Potassium	10.8	9.5	31.0	5.0	62.0
TDS	1050	993	2400	351	115
TSS	2.5	2.5	2.5	2.5	43
Selenium	0.005	0.005	0.005	0.005	1

*All results are for dissolved species and reported in mg/L unless otherwise stated. Shaded cells highlight key parameter contributions to water quality.

5 Conclusions

RGS has completed a review of the large-scale kinetic field experiment (test piles) being undertaken at MRO. It should be noted the waste rock material type classified as PAF-HC included in the test pile experiments reports to the Tailings Storage Facility (TSF) during operations and does not report to on-site WRD facilities.

This report provides recommendations regarding the most cost-effective option for improving the construction and operation of the tests pile experiments, and summarises the test pile water quality results available against specific measured site water quality (ie. NWRD seepage and pit void sump water quality).

It is concluded that the test pile experiments currently provide useful data with respect to understanding the likely quality of seepage from waste rock materials at MRO during operations and if recommendations for improvements are implemented, will continue following rehabilitation and closure. The recommended improvements and preferred option (Option 2) are described in detail **Section 3.8**.

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Attachment A: Test Pile Construction Sequence

Pad Construction



Figure 1A: Test pile construction (photos from MRO).

Waste Rock Placement





Figure 2A: Waste rock placement (photos from MRO).

Drainage Construction





Figure 3A: Drainage construction (photos from MRO).

Sample Collection

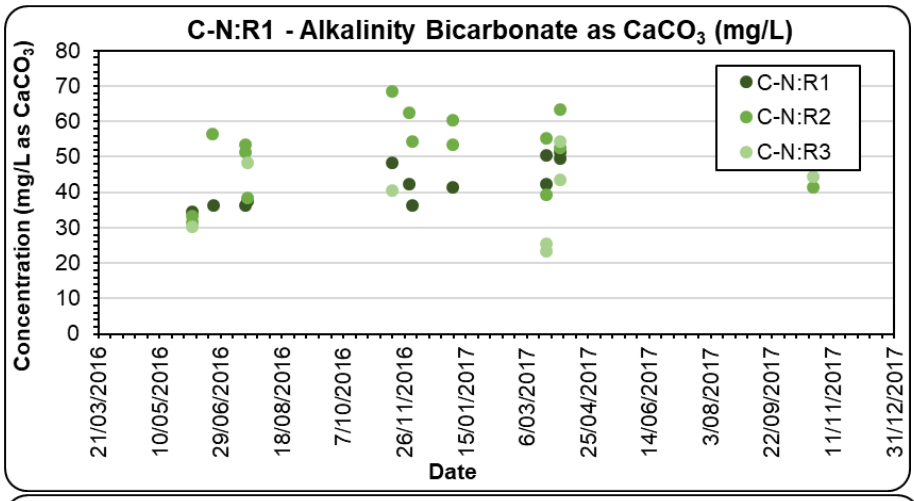


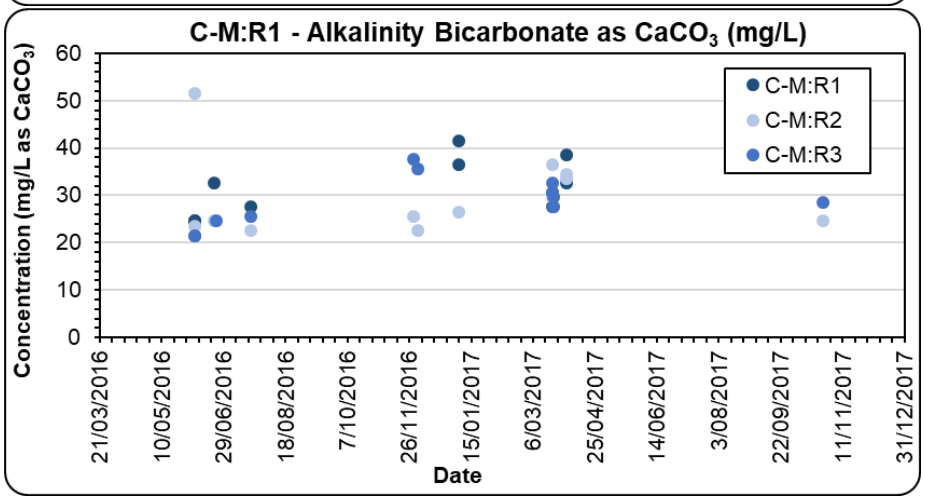


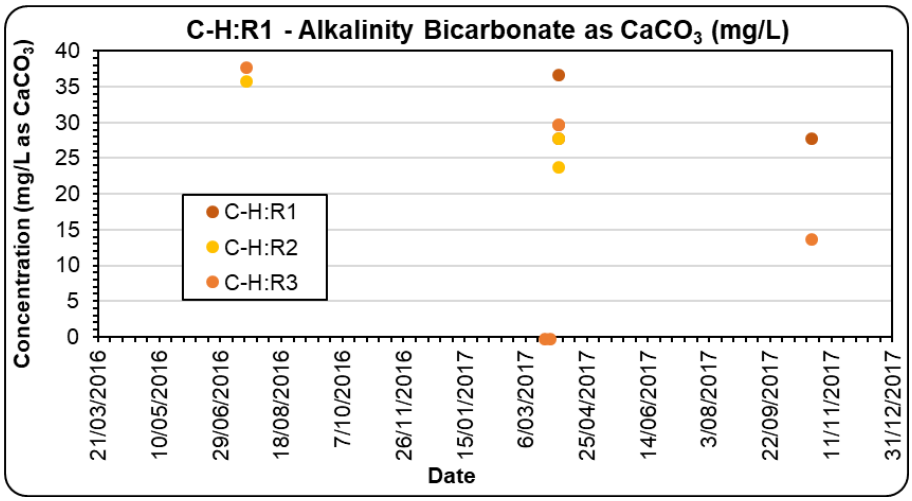


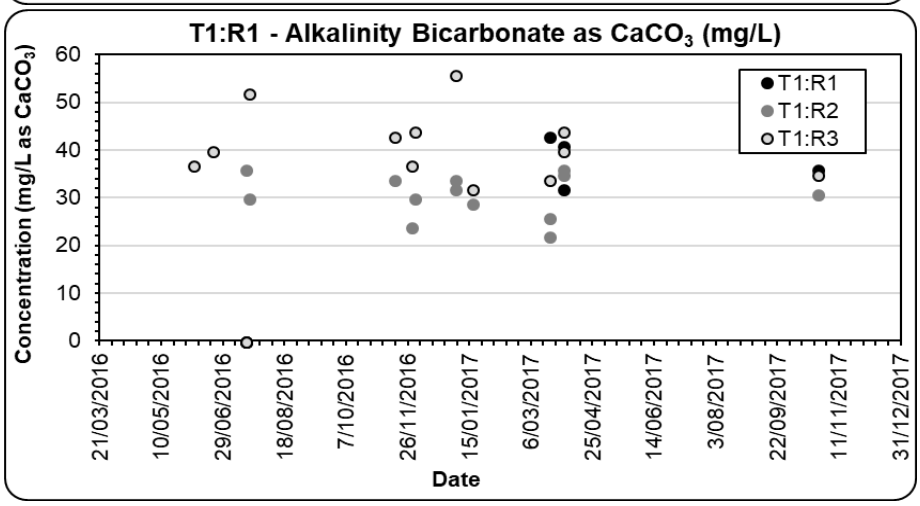
Figure 4A: Sample collection tanks and stage sampling (photos from MRO).

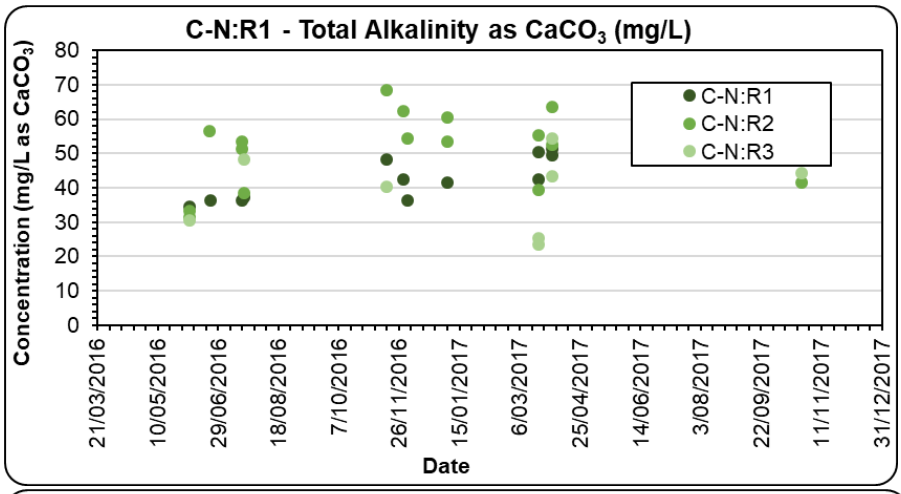
Attachment B: Test Pile Leachate Results

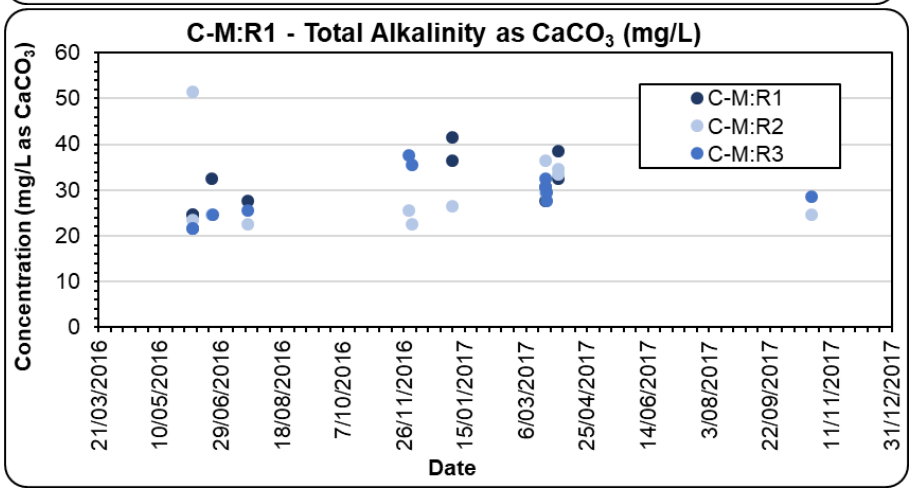

C-N:R1 - Alkalinity Bicarbonate as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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70
60
50
40
30
20
10
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

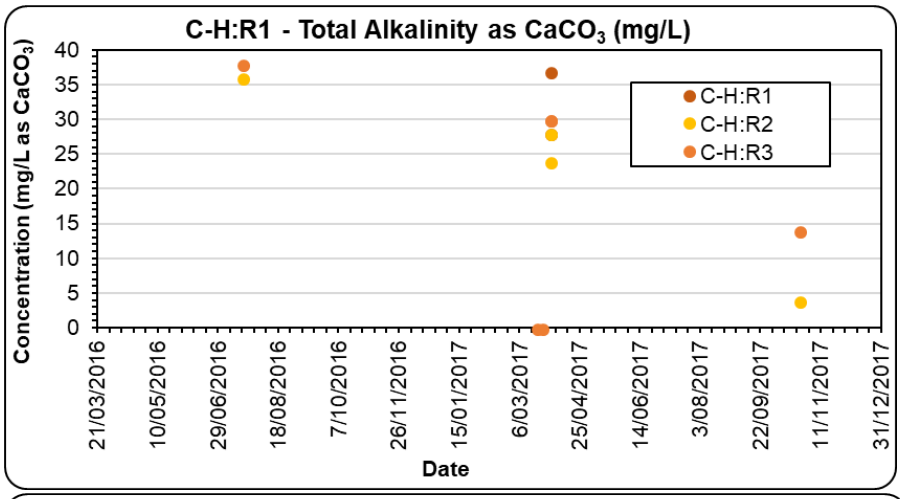

C-M:R1 - Alkalinity Bicarbonate as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
60
50
40
30
20
10
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
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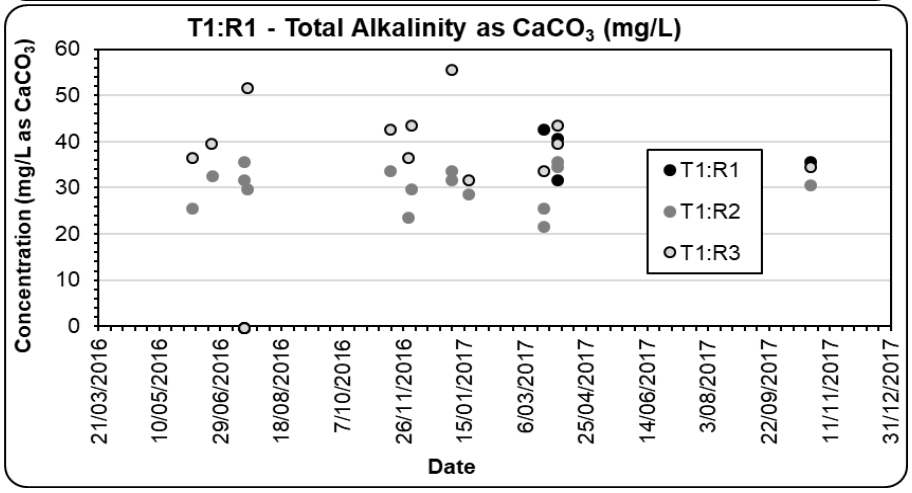

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Concentration (mg/L as CaCO3)
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20
25
30
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C-H:R2
C-H:R3
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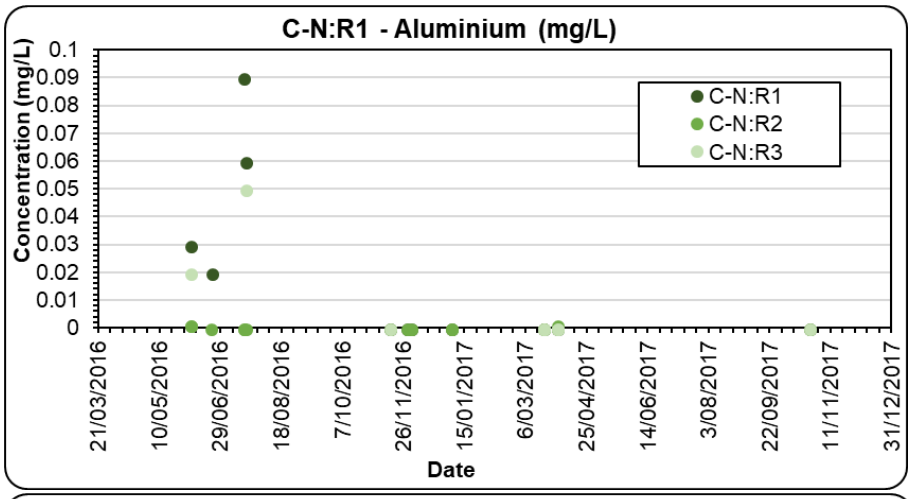

T1:R1 - Alkalinity Bicarbonate as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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10
20
30
40
50
60
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
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26/11/2016
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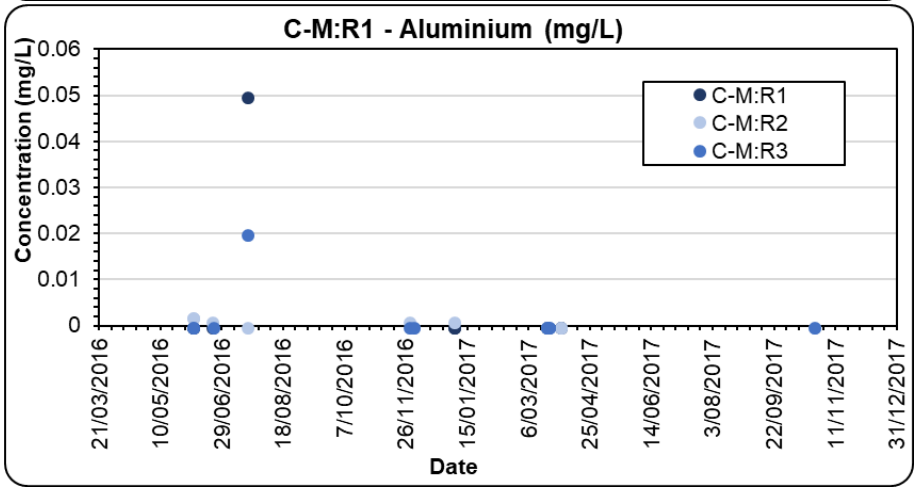

C-N:R1 - Total Alkalinity as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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60
50
40
30
20
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10/05/2016
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26/11/2016
15/01/2017
6/03/2017
25/04/2017
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22/09/2017
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31/12/2017
Date
C-N:R1
C-N:R2
C-N:R3

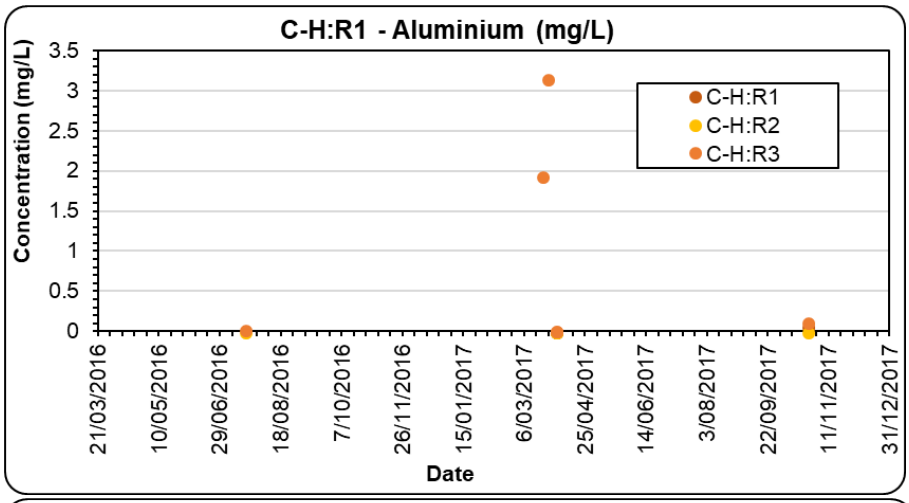

C-M:R1 - Total Alkalinity as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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50
40
30
20
10
0
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10/05/2016
29/06/2016
18/08/2016
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26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
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31/12/2017
Date
C-M:R1
C-M:R2
C-M:R3

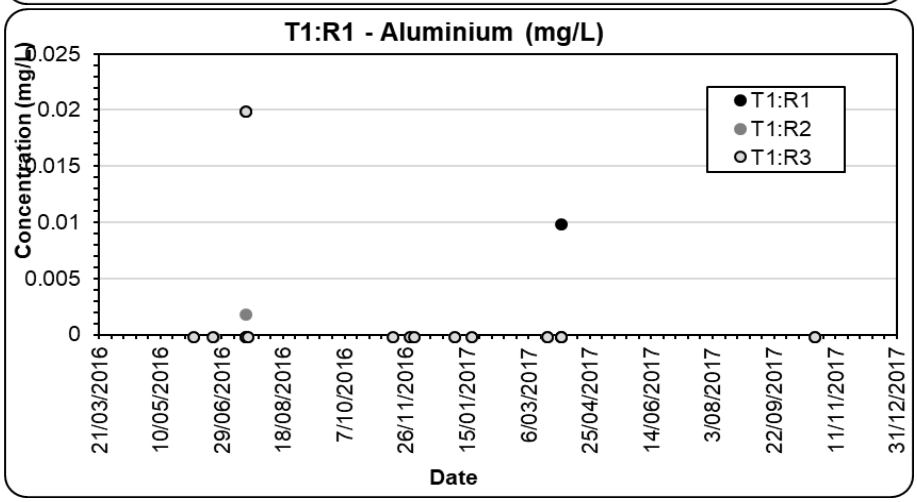

C-H:R1 - Total Alkalinity as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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35
30
25
20
15
10
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C-H:R1
C-H:R2
C-H:R3

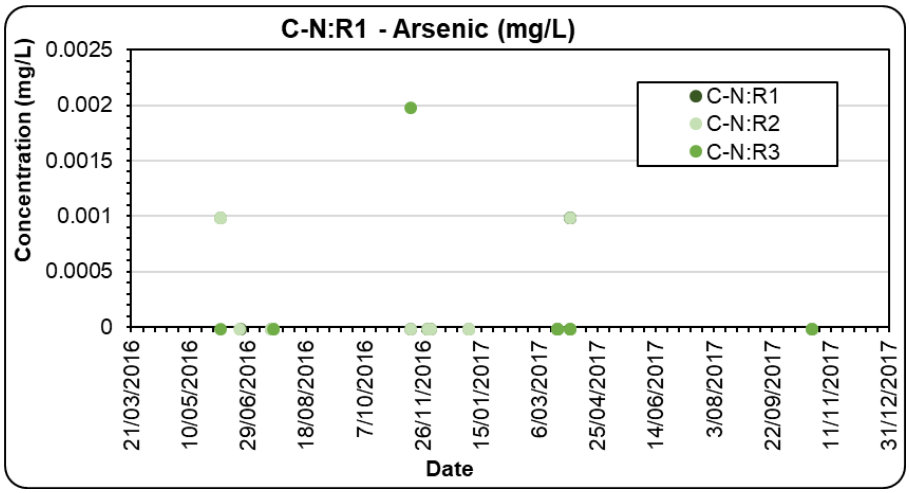

T1:R1 - Total Alkalinity as CaCO3 (mg/L)
Concentration (mg/L as CaCO3)
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20
10
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29/06/2016
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26/11/2016
15/01/2017
6/03/2017
25/04/2017
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Date
T1:R1
T1:R2
T1:R3

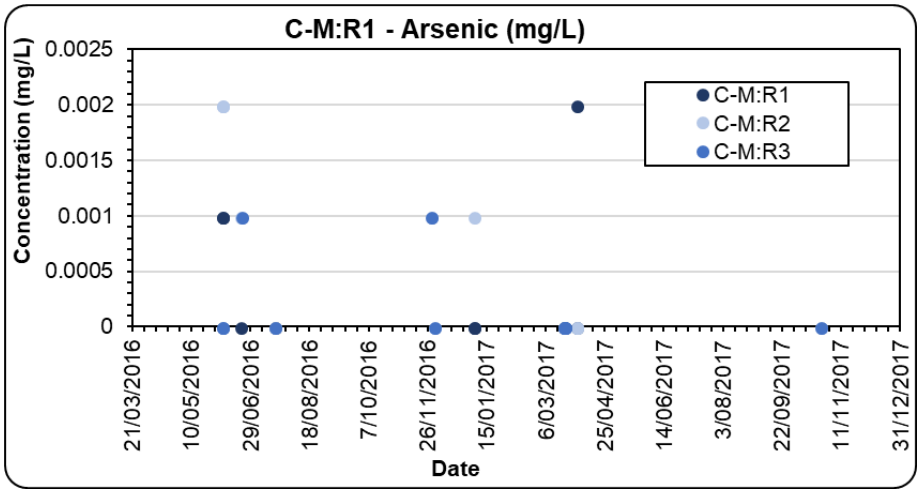

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0.04
0.03
0.02
0.01
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
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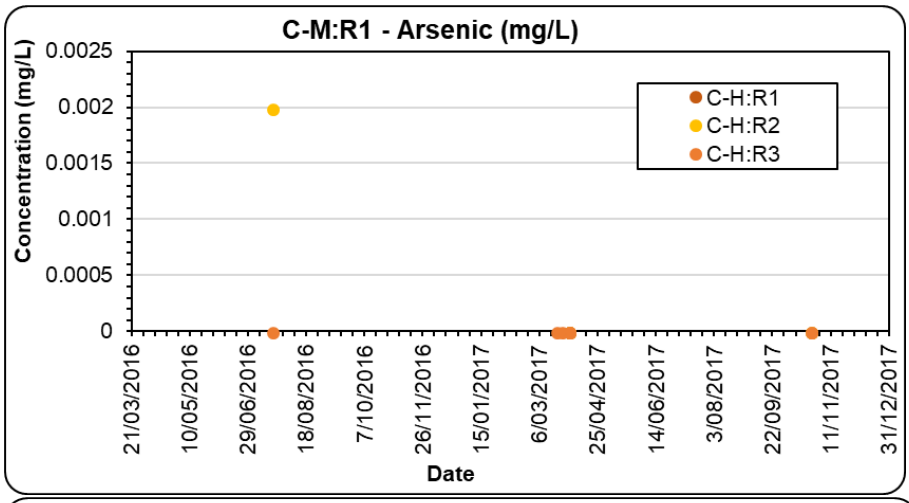

C-M:R1 - Aluminium (mg/L)
Concentration (mg/L)
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C-M:R3
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31/12/2017
Date

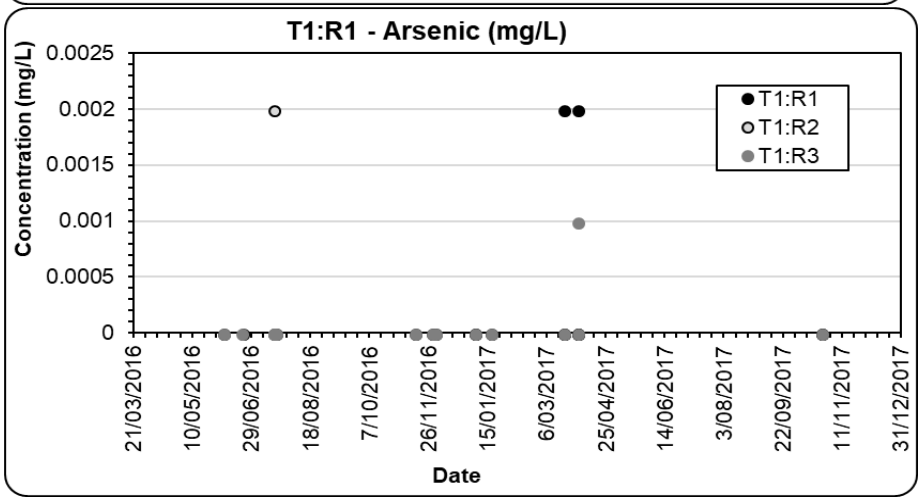

C-H:R1 - Aluminium (mg/L)
Concentration (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

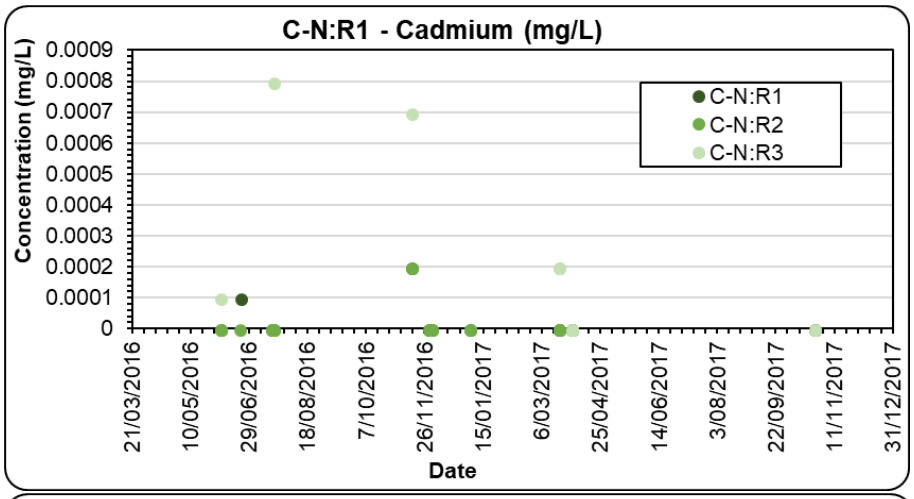

T1:R1 - Aluminium (mg/L)
Concentration (mg/L)
0.025
0.02
0.015
0.01
0.005
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

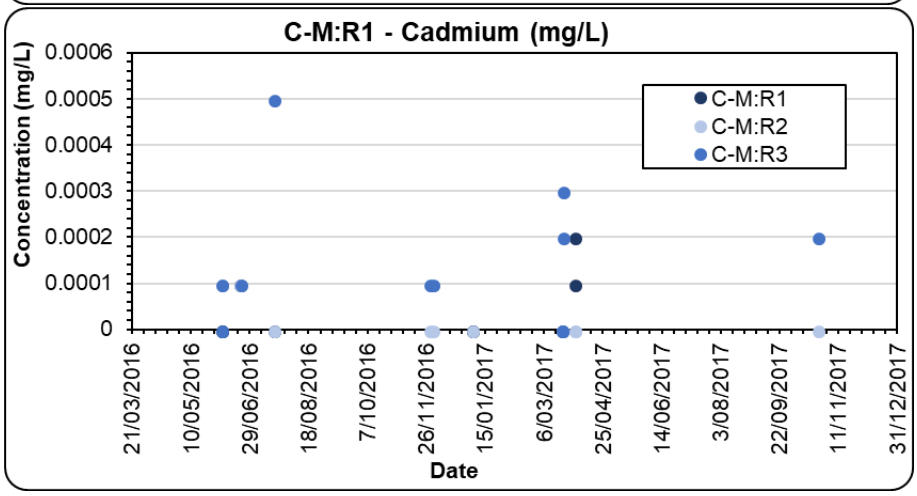

C-N:R1 - Arsenic (mg/L)
Concentration (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

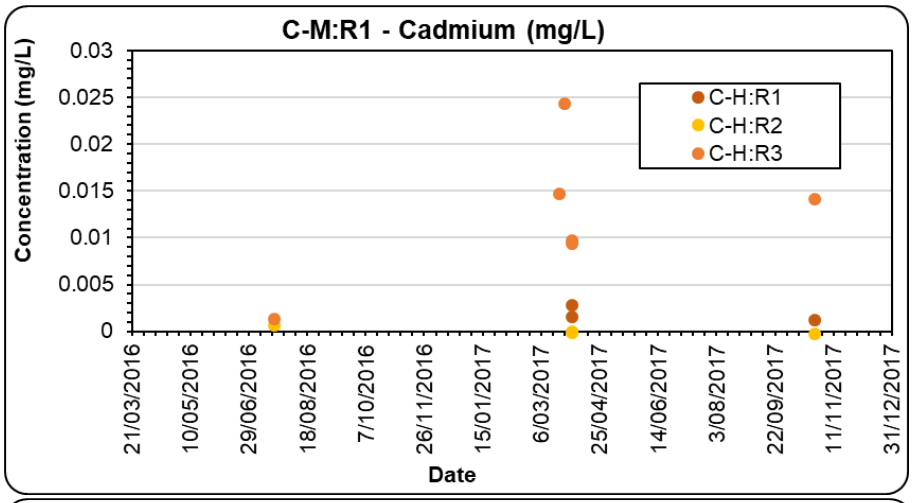

C-M:R1 - Arsenic (mg/L)
Concentration (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

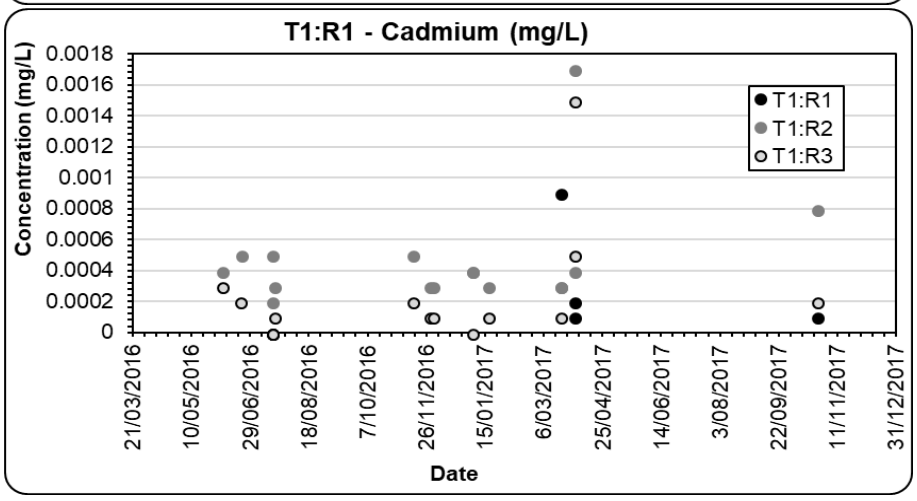

C-M:R1 - Arsenic (mg/L)
Concentration (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

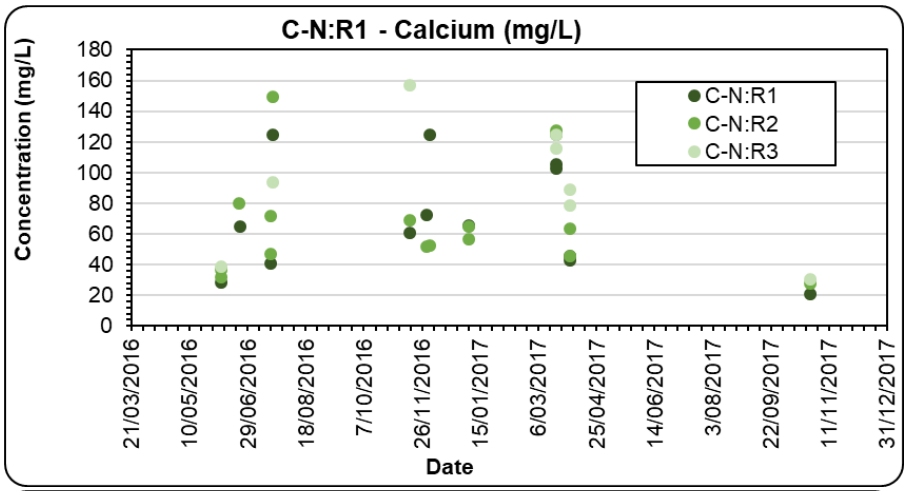

T1:R1 - Arsenic (mg/L)
Concentration (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

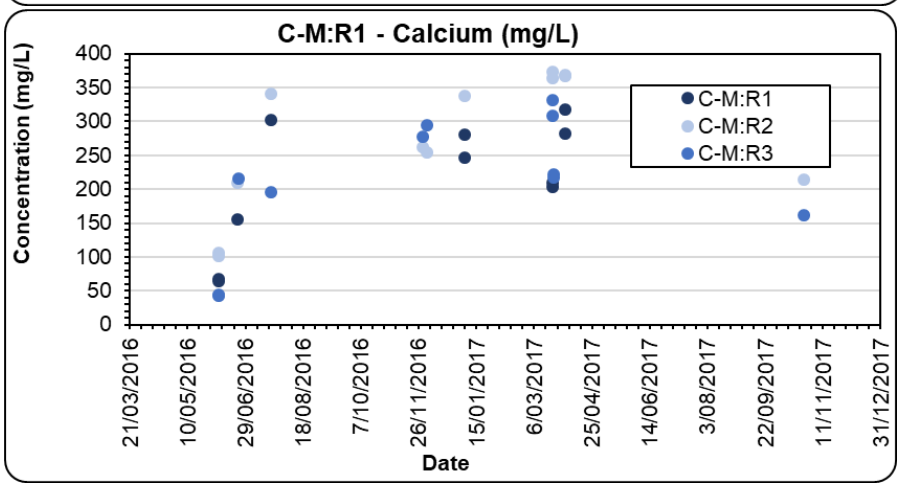

C-N:R1 - Cadmium (mg/L)
Concentration (mg/L)
0.0009
0.0008
0.0007
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

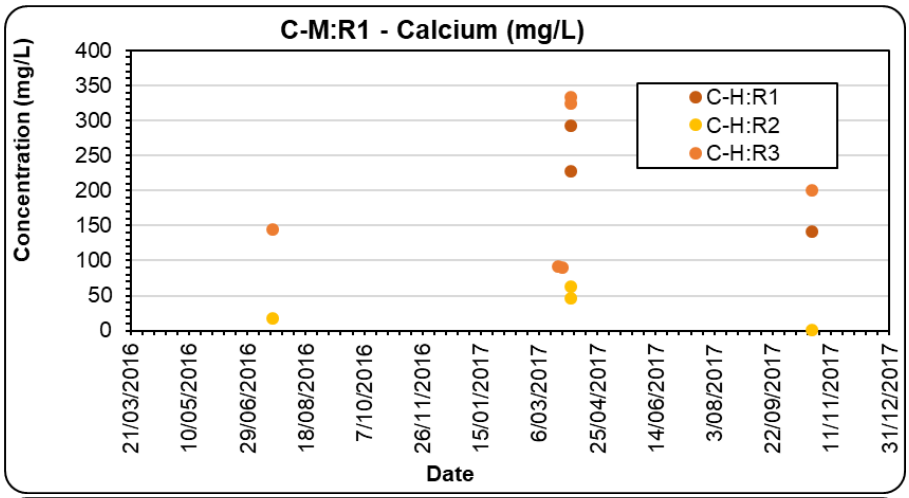

C-M:R1 - Cadmium (mg/L)
Concentration (mg/L)
0.0006
0.0005
0.0004
0.0003
0.0002
0.0001
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

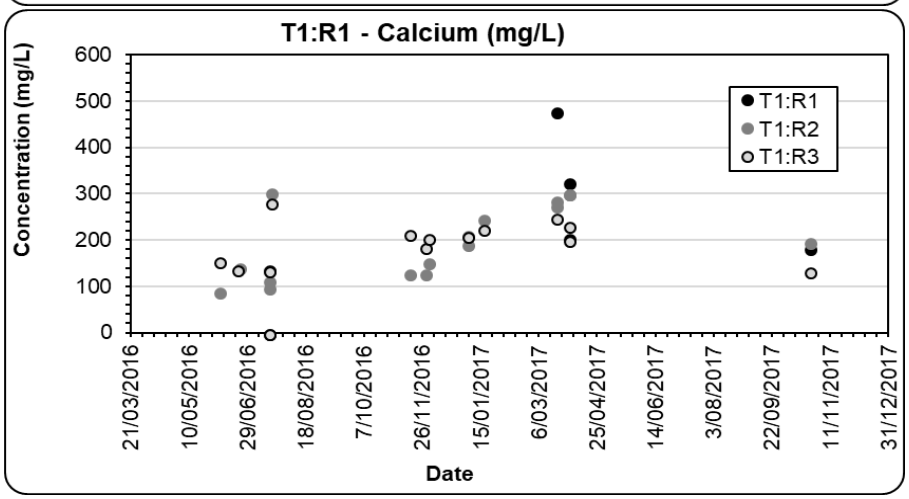

C-M:R1 - Cadmium (mg/L)
Concentration (mg/L)
0.03
0.025
0.02
0.015
0.01
0.005
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

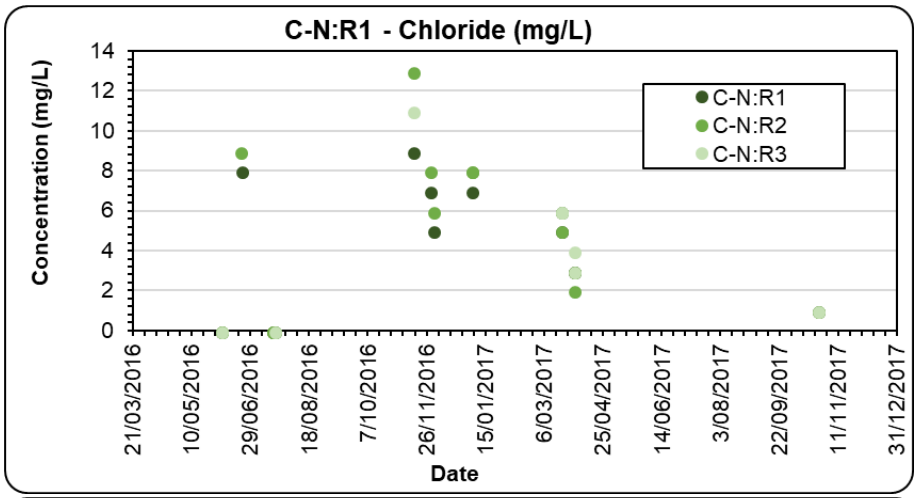

T1:R1 - Cadmium (mg/L)
Concentration (mg/L)
0.0018
0.0016
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

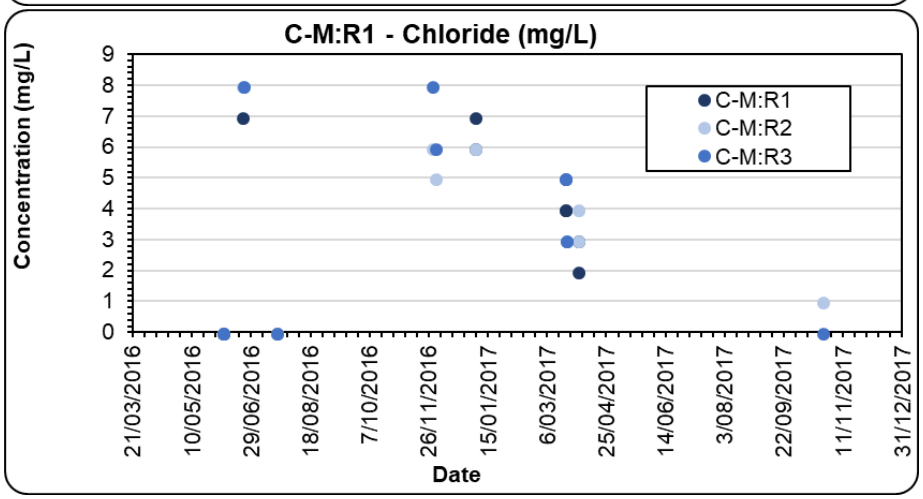

C-N:R1 - Calcium (mg/L)
Concentration (mg/L)
180
160
140
120
100
80
60
40
20
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

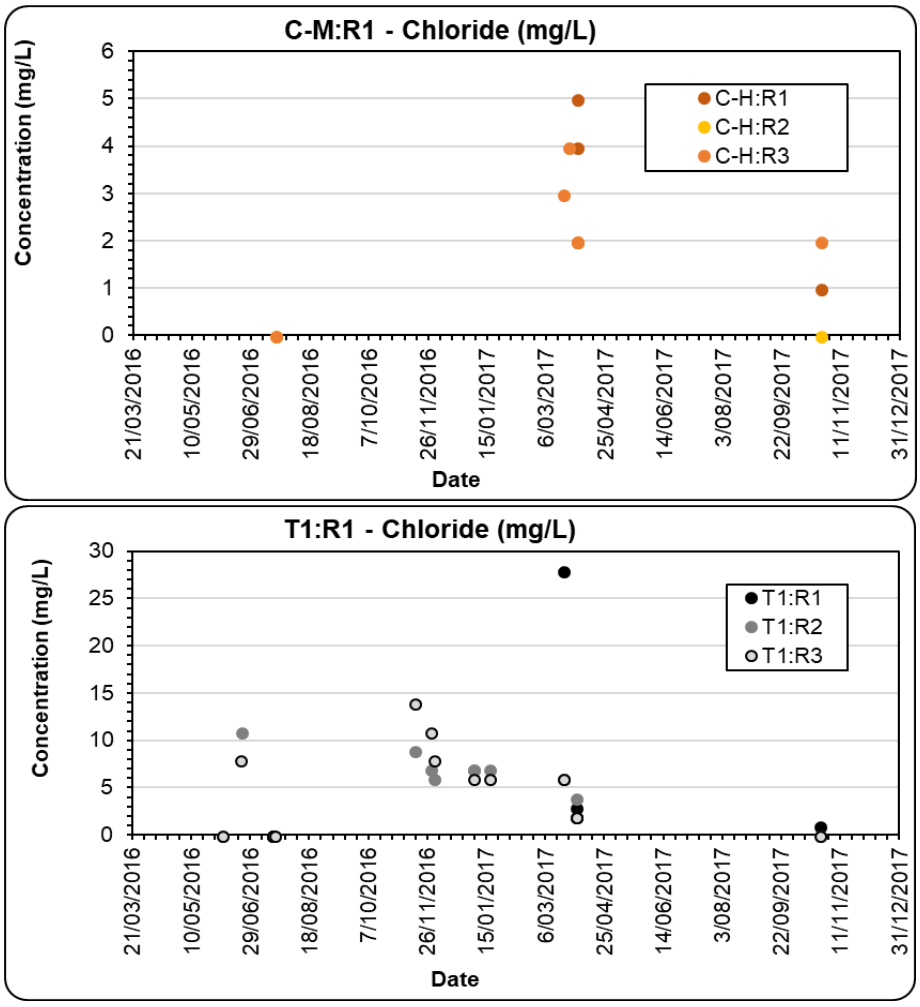

C-M:R1 - Calcium (mg/L)
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

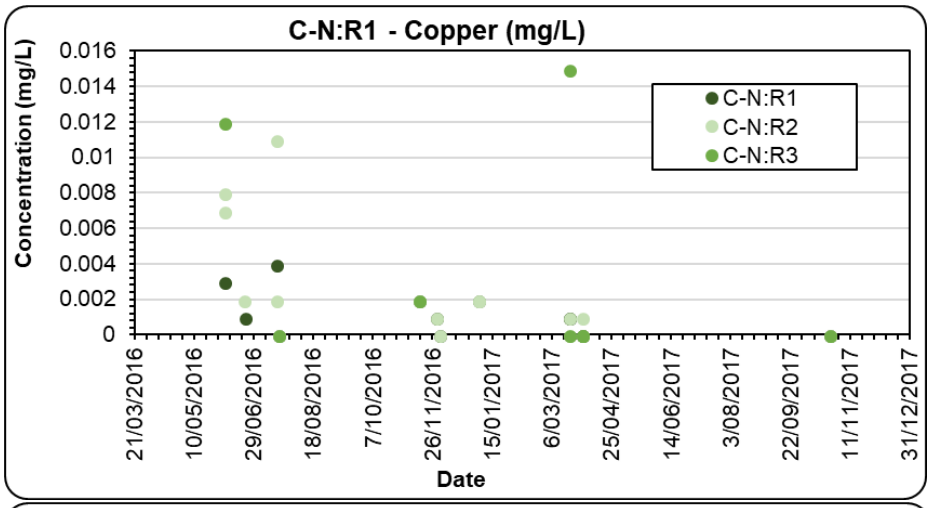

C-M:R1 - Calcium (mg/L)
Concentration (mg/L)
400
350
300
250
200
150
100
50
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

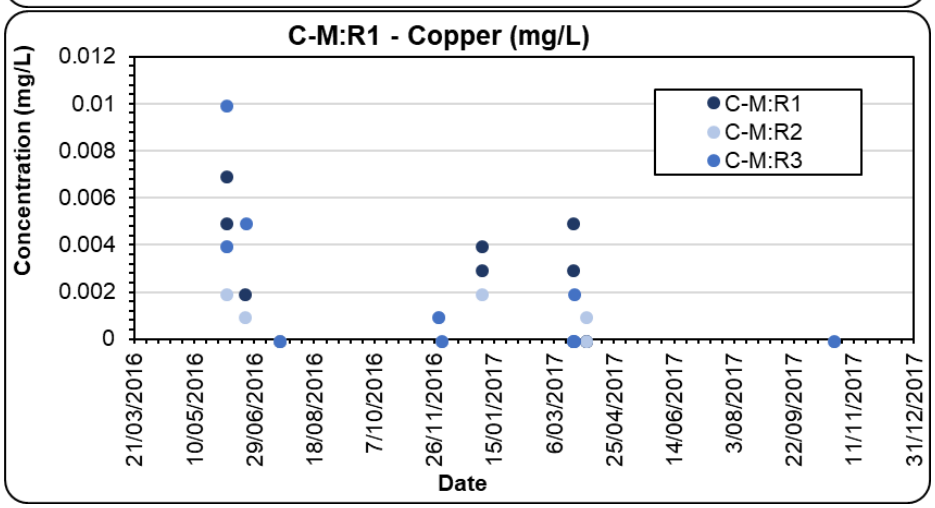

T1:R1 - Calcium (mg/L)
Concentration (mg/L)
600
500
400
300
200
100
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

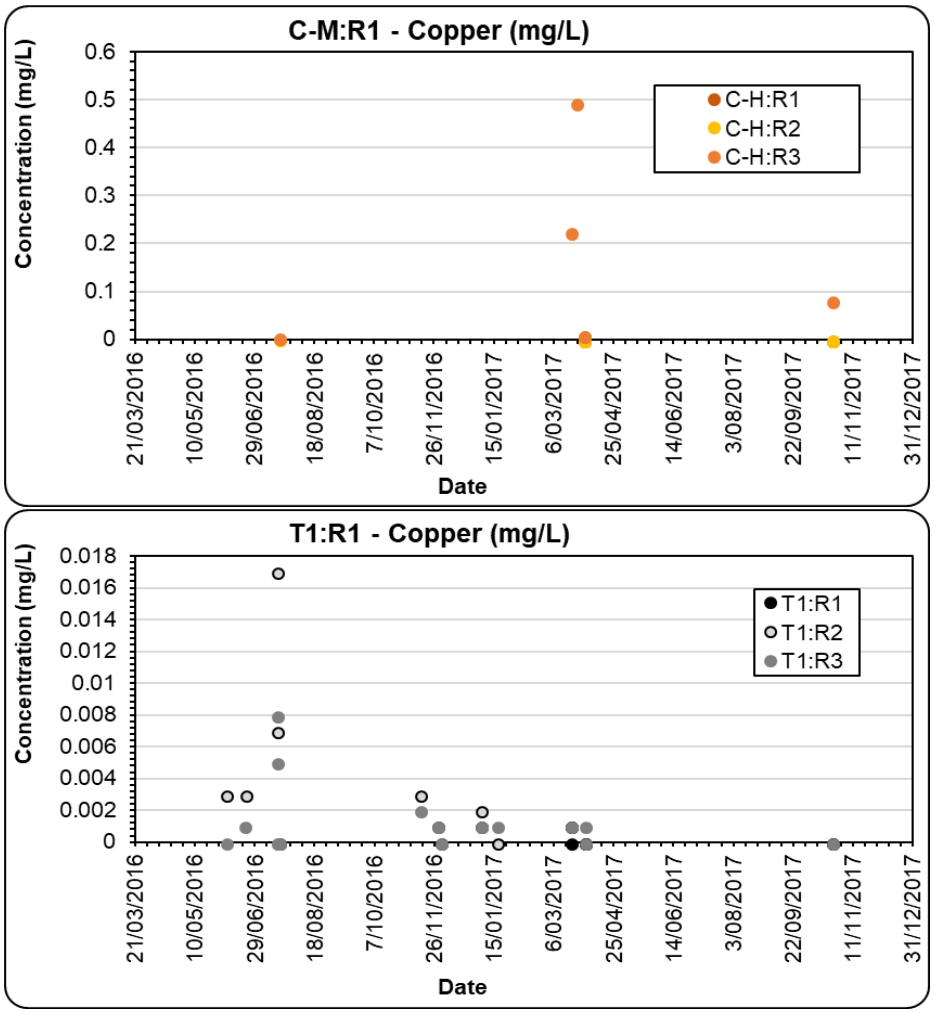

C-N:R1 - Chloride (mg/L)
Concentration (mg/L)
14
12
10
8
6
4
2
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

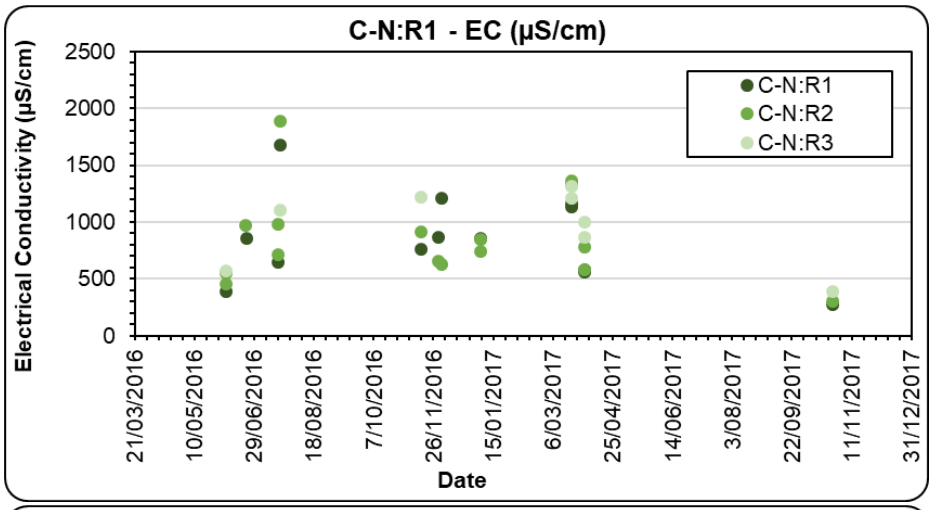

C-M:R1 - Chloride (mg/L)
Concentration (mg/L)
9
8
7
6
5
4
3
2
1
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

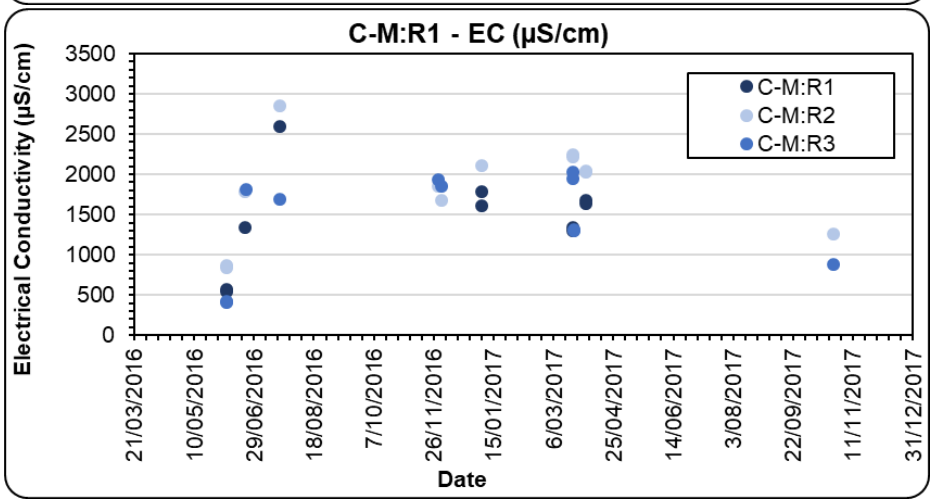

C-M:R1 - Chloride (mg/L)
Concentration (mg/L)
0
1
2
3
4
5
6
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - Chloride (mg/L)
Concentration (mg/L)
0
5
10
15
20
25
30
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

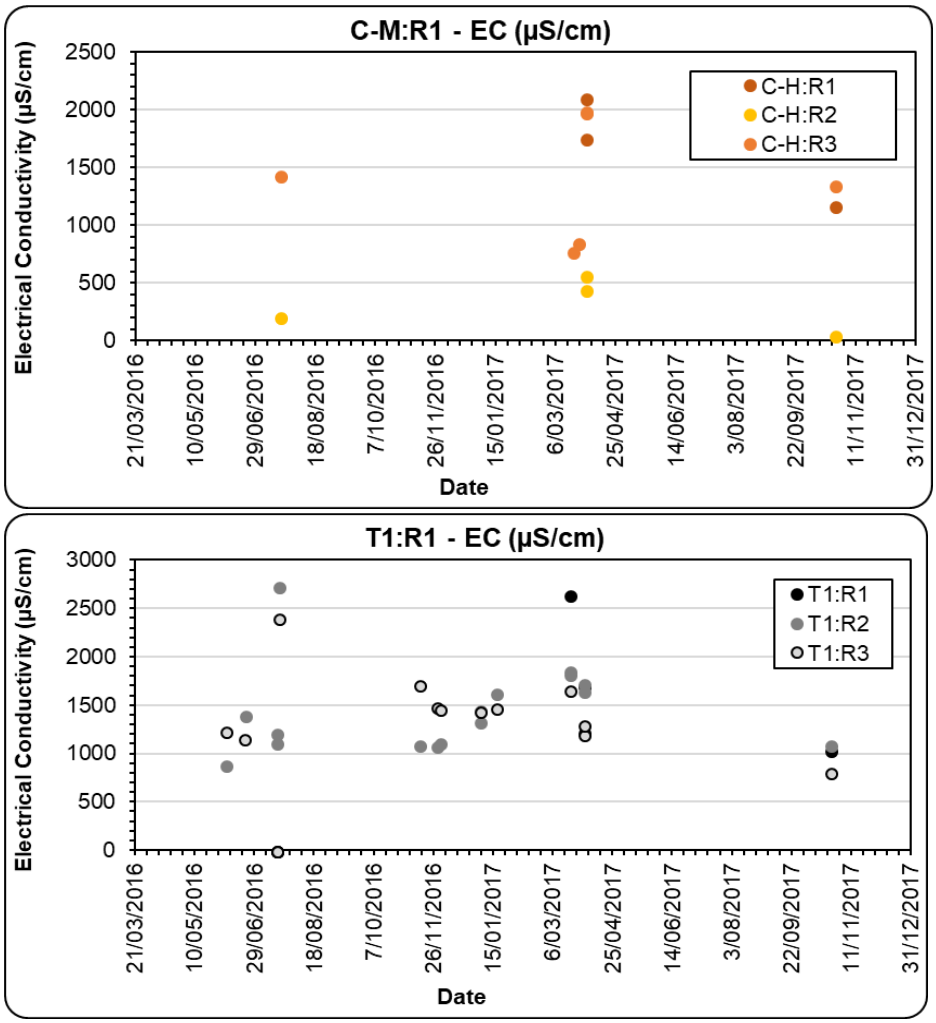

C-N:R1 - Copper (mg/L)
Concentration (mg/L)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-N:R1
C-N:R2
C-N:R3

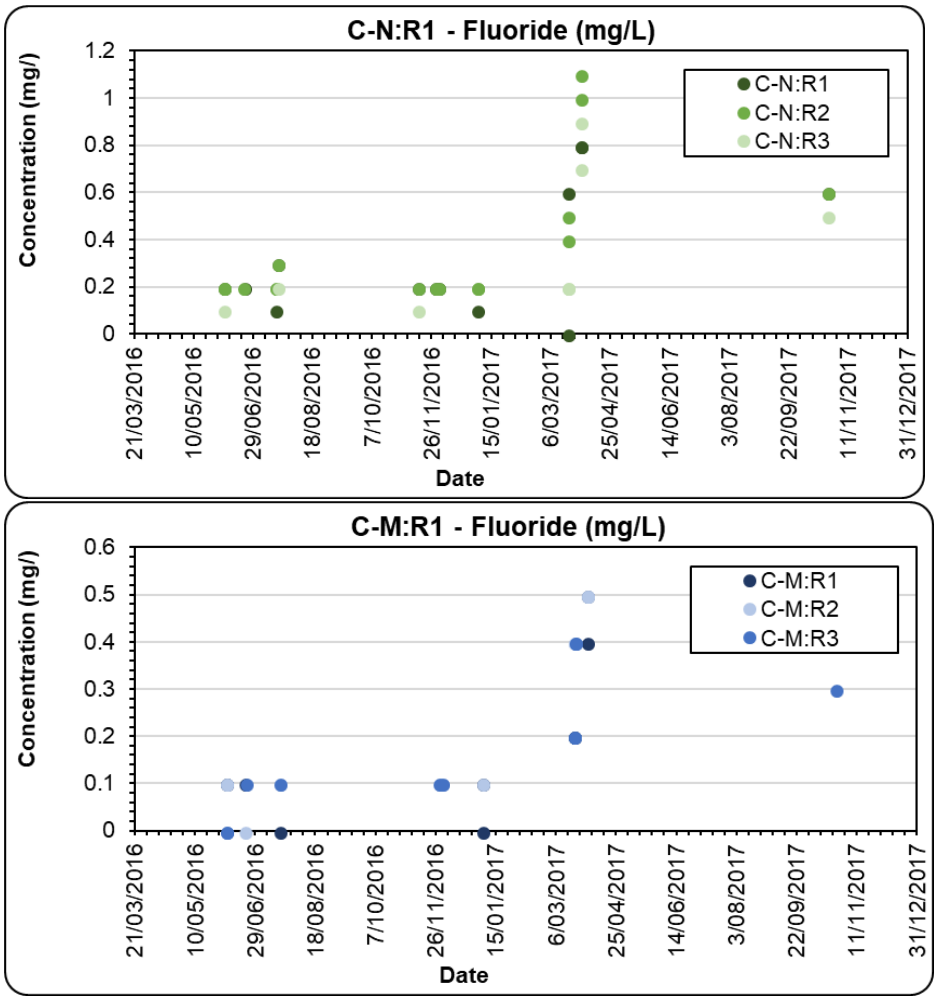

C-M:R1 - Copper (mg/L)
Concentration (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-M:R1
C-M:R2
C-M:R3

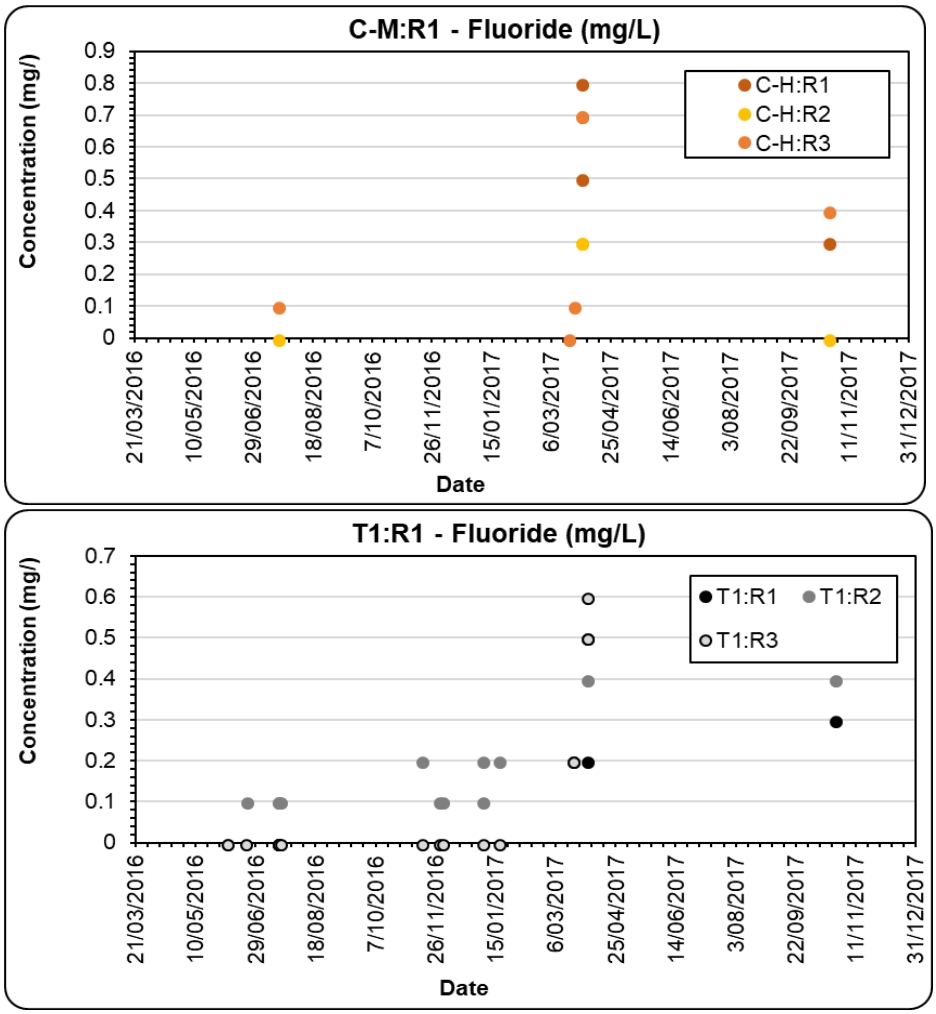

C-M:R1 - Copper (mg/L)
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - Copper (mg/L)
Concentration (mg/L)
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-N:R1 - EC (µS/cm)
Electrical Conductivity (µS/cm)
2500
2000
1500
1000
500
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

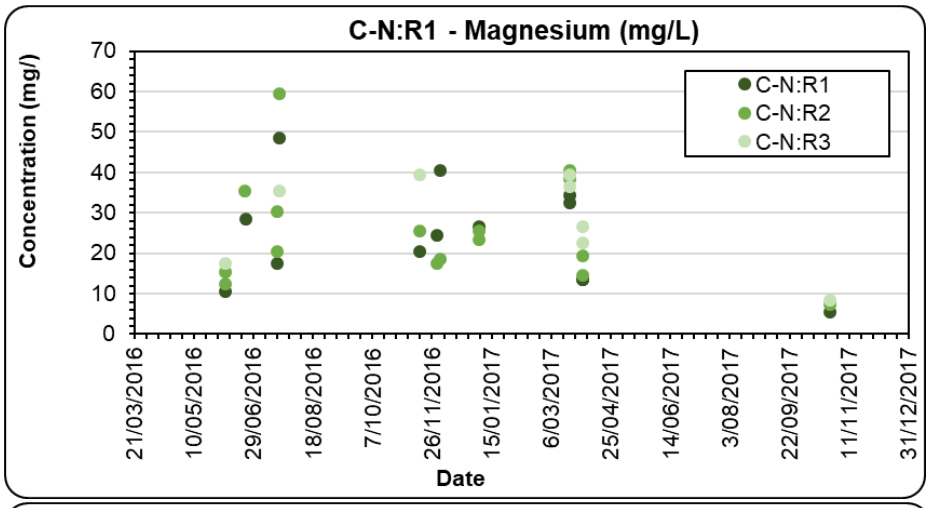

C-M:R1 - EC (µS/cm)
Electrical Conductivity (µS/cm)
3500
3000
2500
2000
1500
1000
500
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

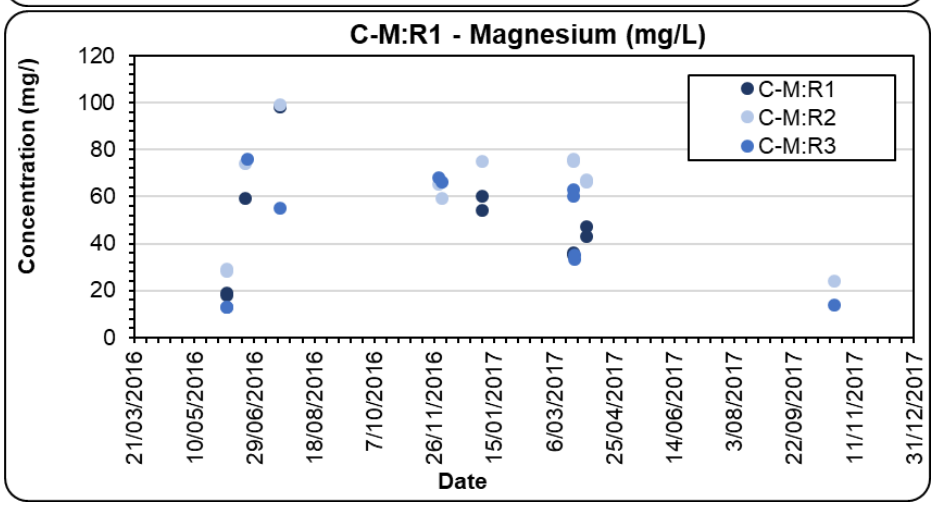

C-M:R1 - EC (µS/cm)
Electrical Conductivity (µS/cm)
2500
2000
1500
1000
500
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - EC (µS/cm)
Electrical Conductivity (µS/cm)
3000
2500
2000
1500
1000
500
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

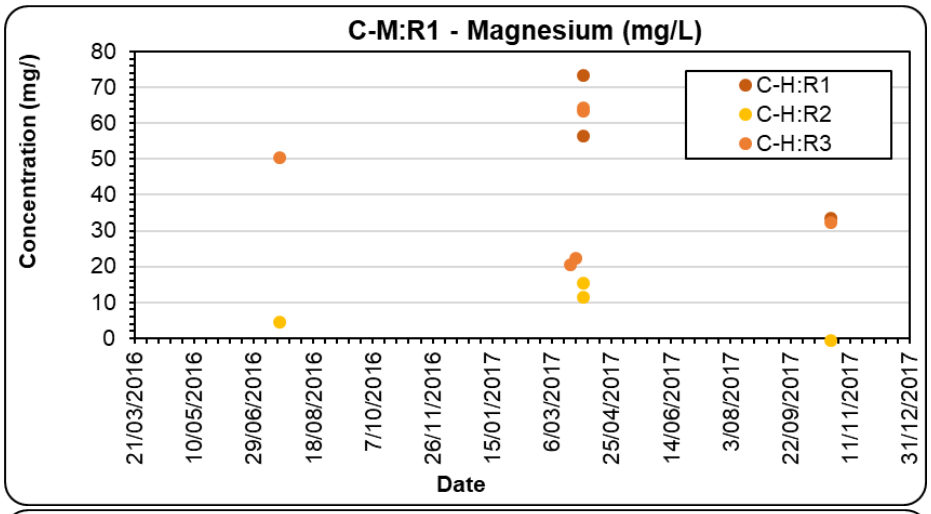

C-N:R1 - Fluoride (mg/L)
Concentration (mg/)
1.2
1
0.8
0.6
0.4
0.2
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-M:R1 - Fluoride (mg/L)
Concentration (mg/)
0.6
0.5
0.4
0.3
0.2
0.1
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

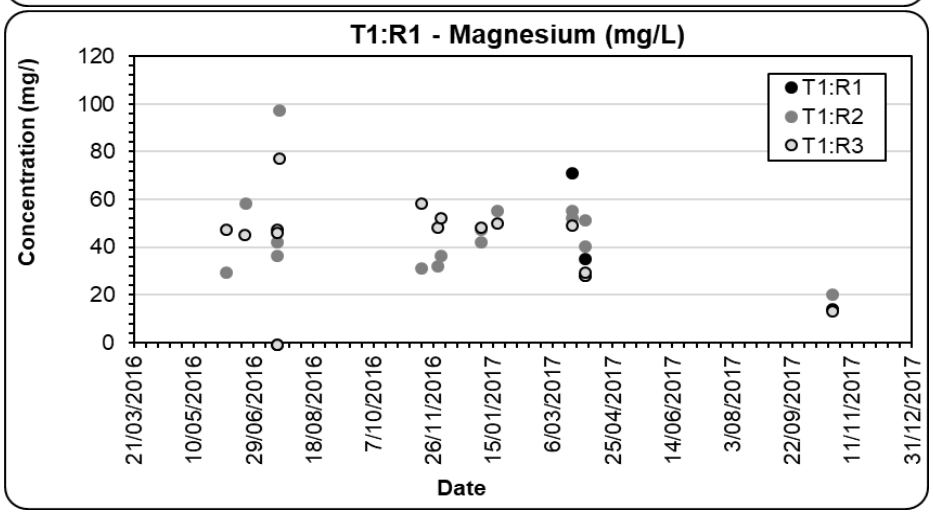

C-M:R1 - Fluoride (mg/L)
Concentration (mg/)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

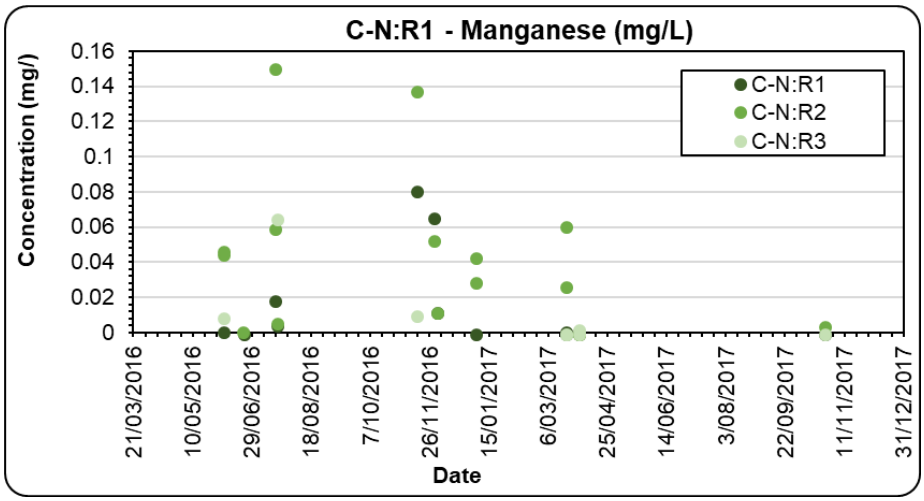
T1:R1 - Fluoride (mg/L)
Concentration (mg/)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

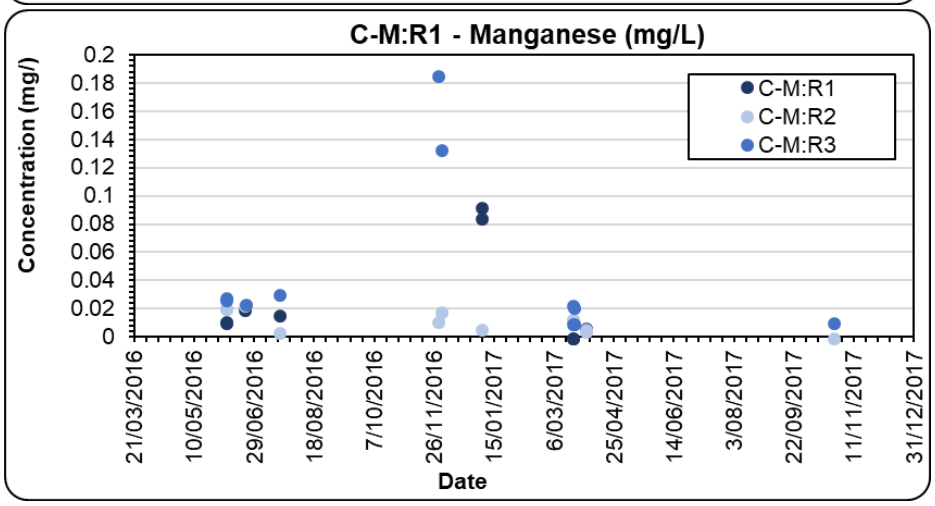

C-N:R1 - Magnesium (mg/L)
Concentration (mg/)
70
60
50
40
30
20
10
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

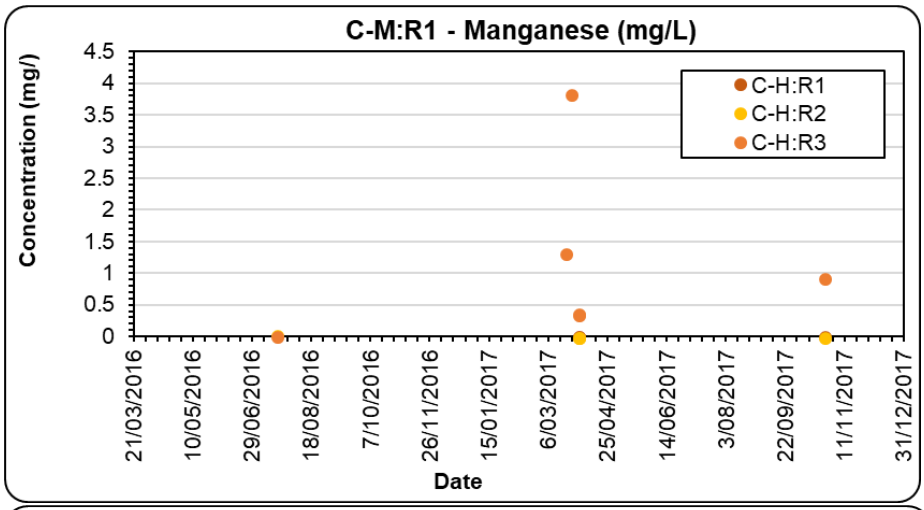

C-M:R1 - Magnesium (mg/L)
Concentration (mg/)
120
100
80
60
40
20
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

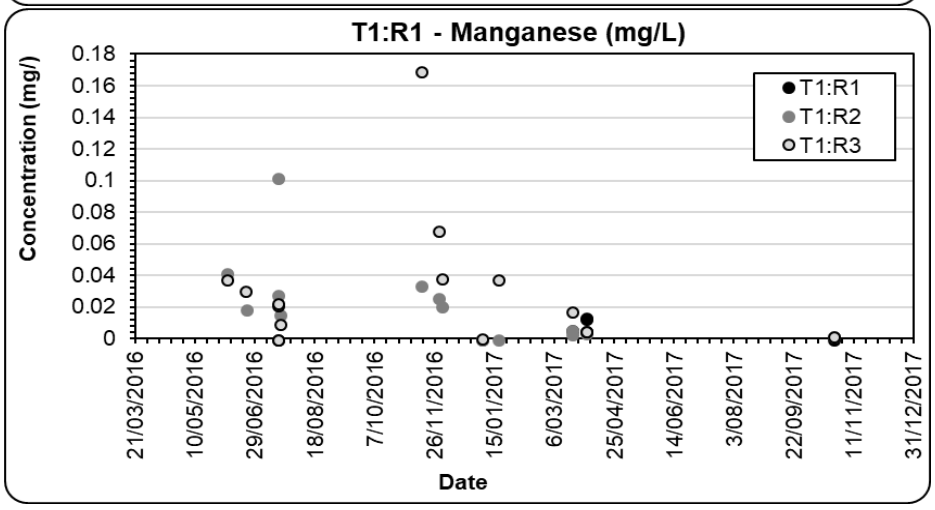

C-M:R1 - Magnesium (mg/L)
Concentration (mg/)
80
70
60
50
40
30
20
10
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

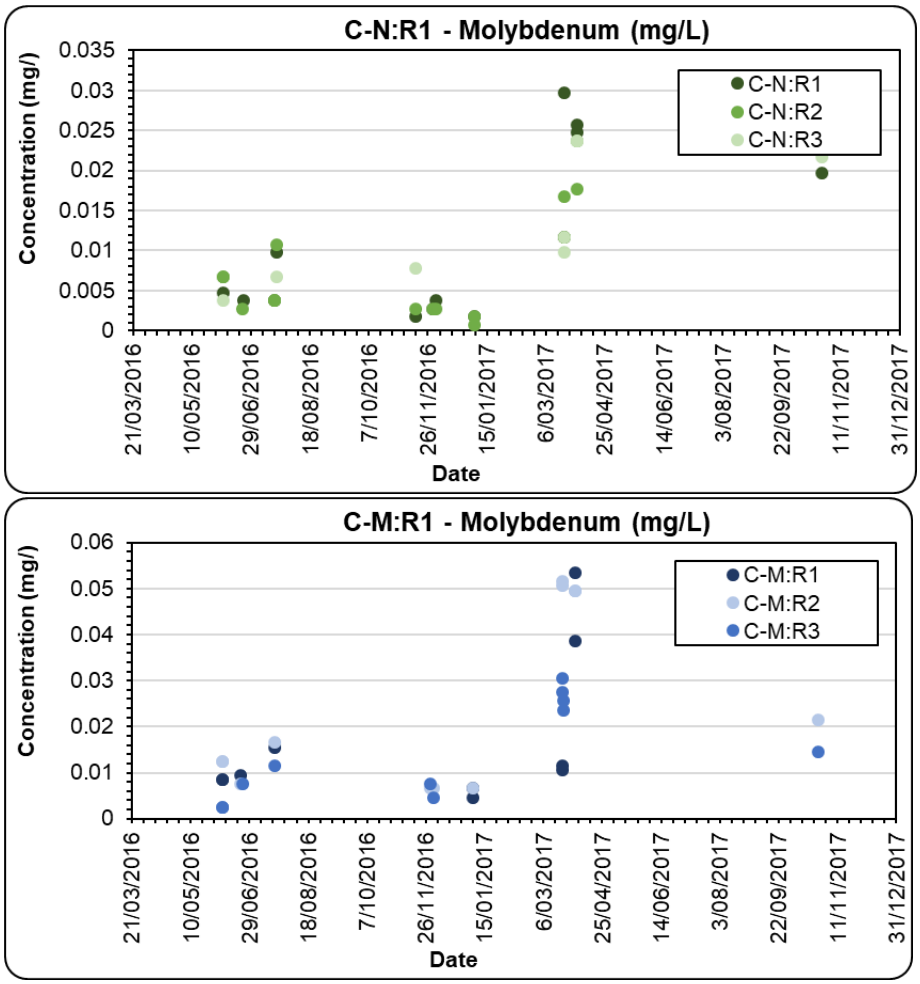

T1:R1 - Magnesium (mg/L)
Concentration (mg/)
120
100
80
60
40
20
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

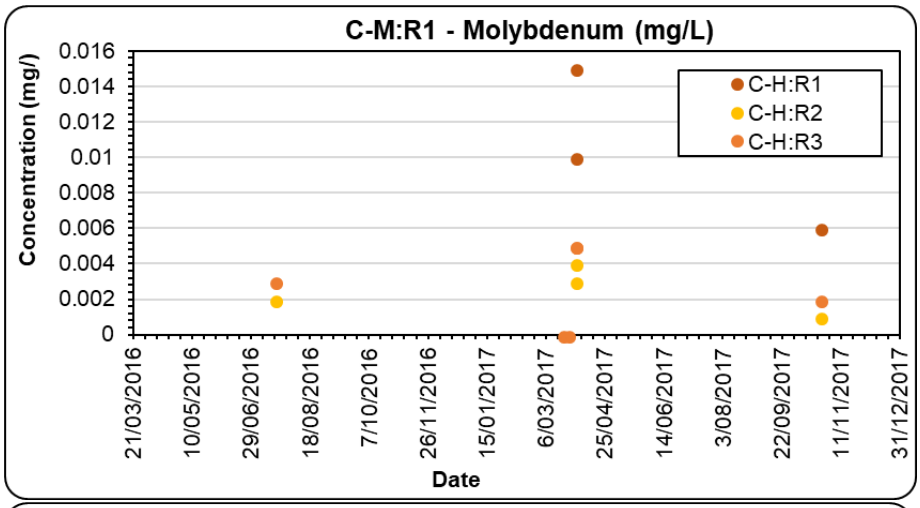

C-N:R1 - Manganese (mg/L)
Concentration (mg/)
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

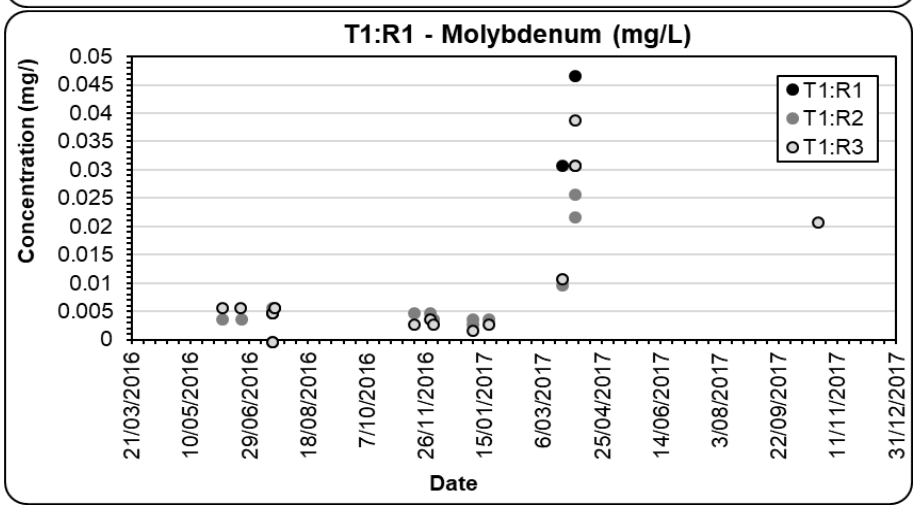

C-M:R1 - Manganese (mg/L)
Concentration (mg/)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

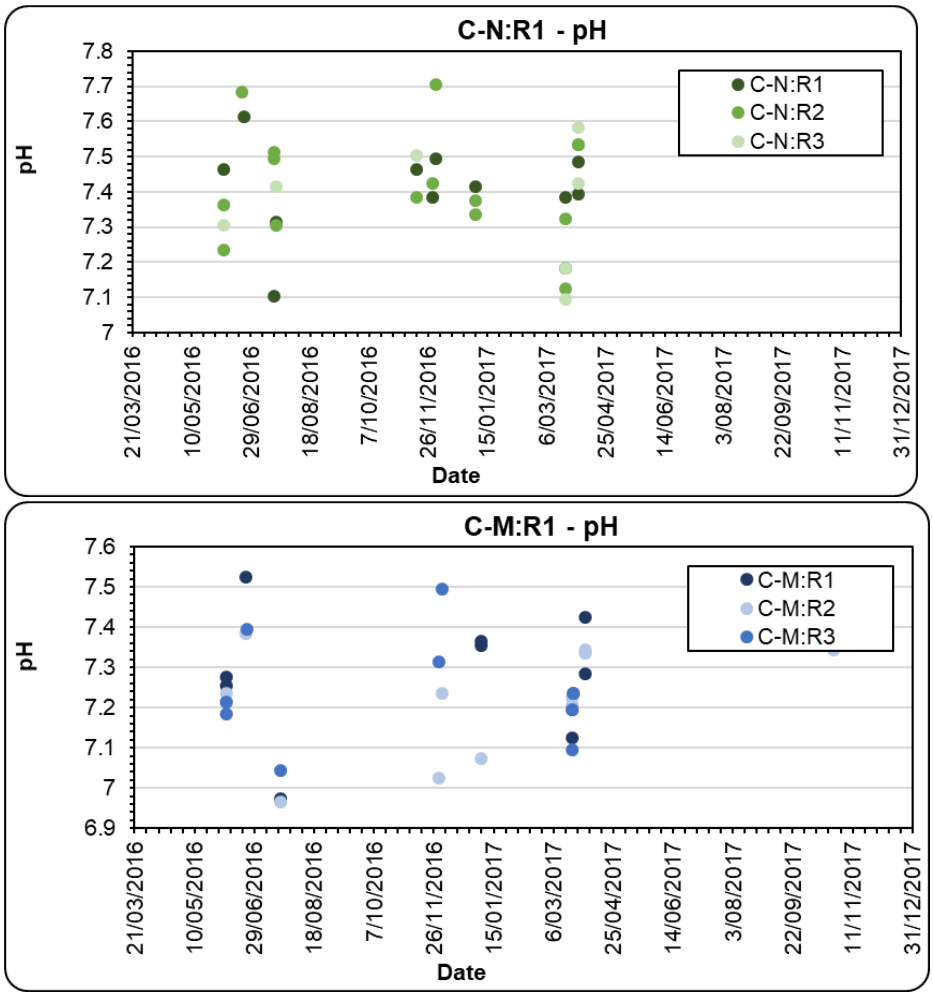

C-M:R1 - Manganese (mg/L)
Concentration (mg/)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

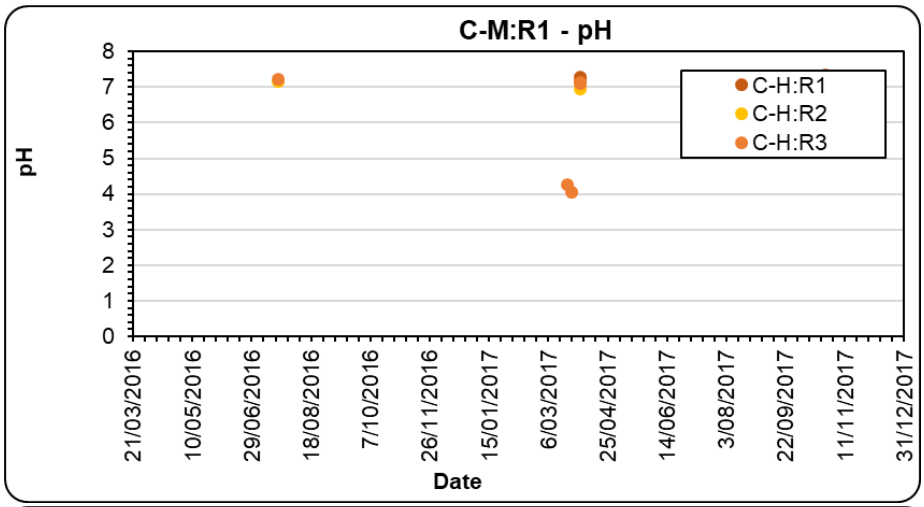

T1:R1 - Manganese (mg/L)
Concentration (mg/)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

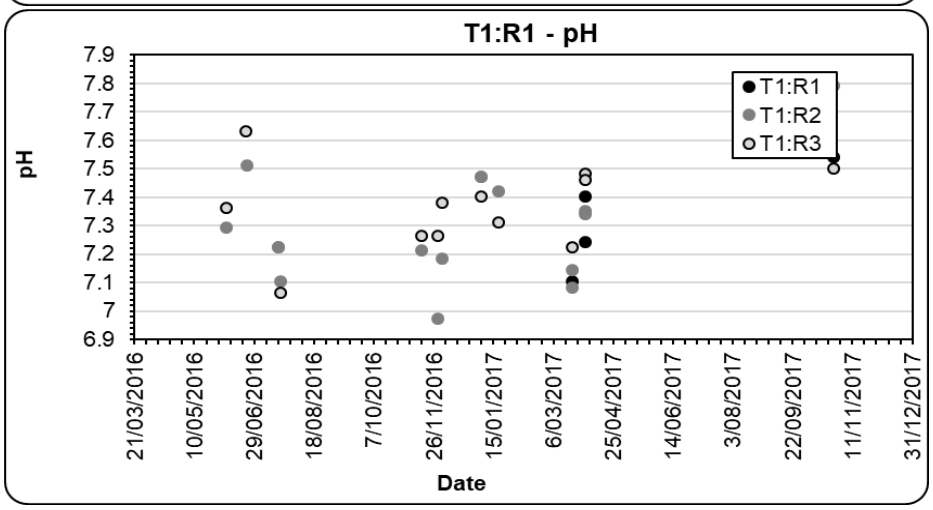

C-N:R1 - Molybdenum (mg/L)
Concentration (mg/l)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-M:R1 - Molybdenum (mg/L)
Concentration (mg/l)
0.06
0.05
0.04
0.03
0.02
0.01
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

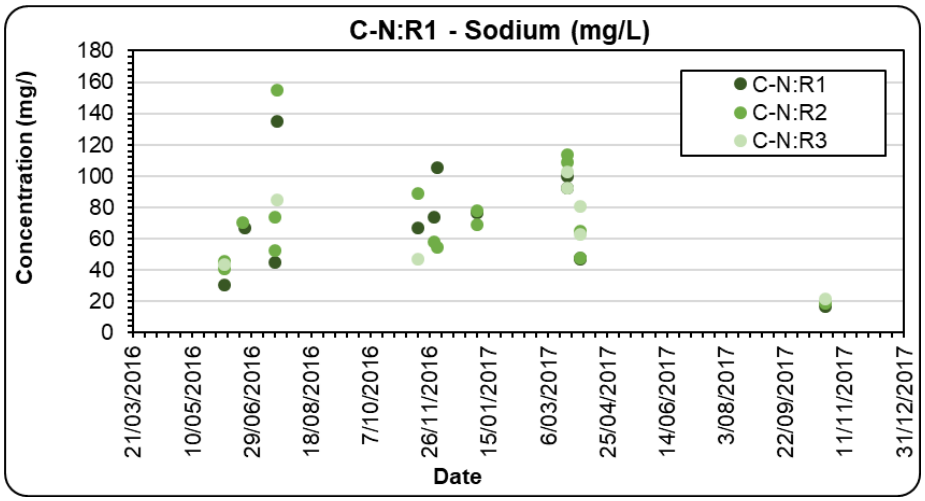

C-M:R1 - Molybdenum (mg/L)
Concentration (mg/)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

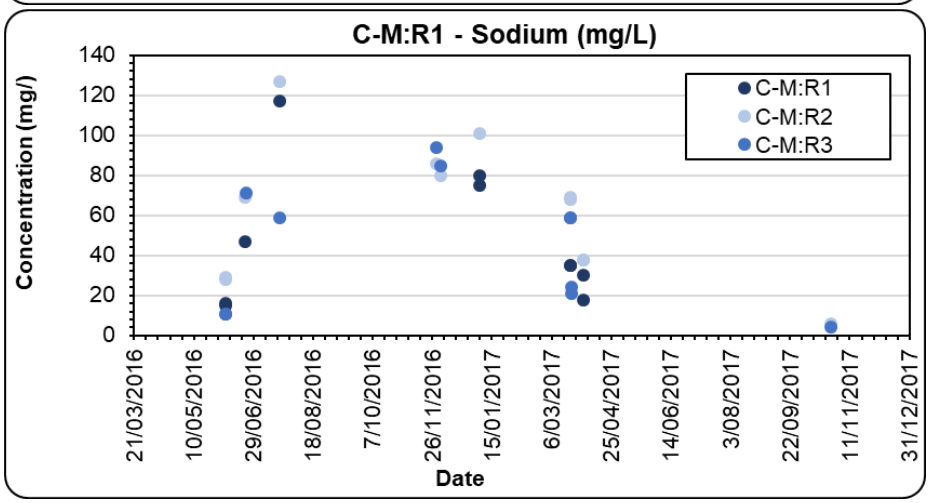

T1:R1 - Molybdenum (mg/L)
Concentration (mg/)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

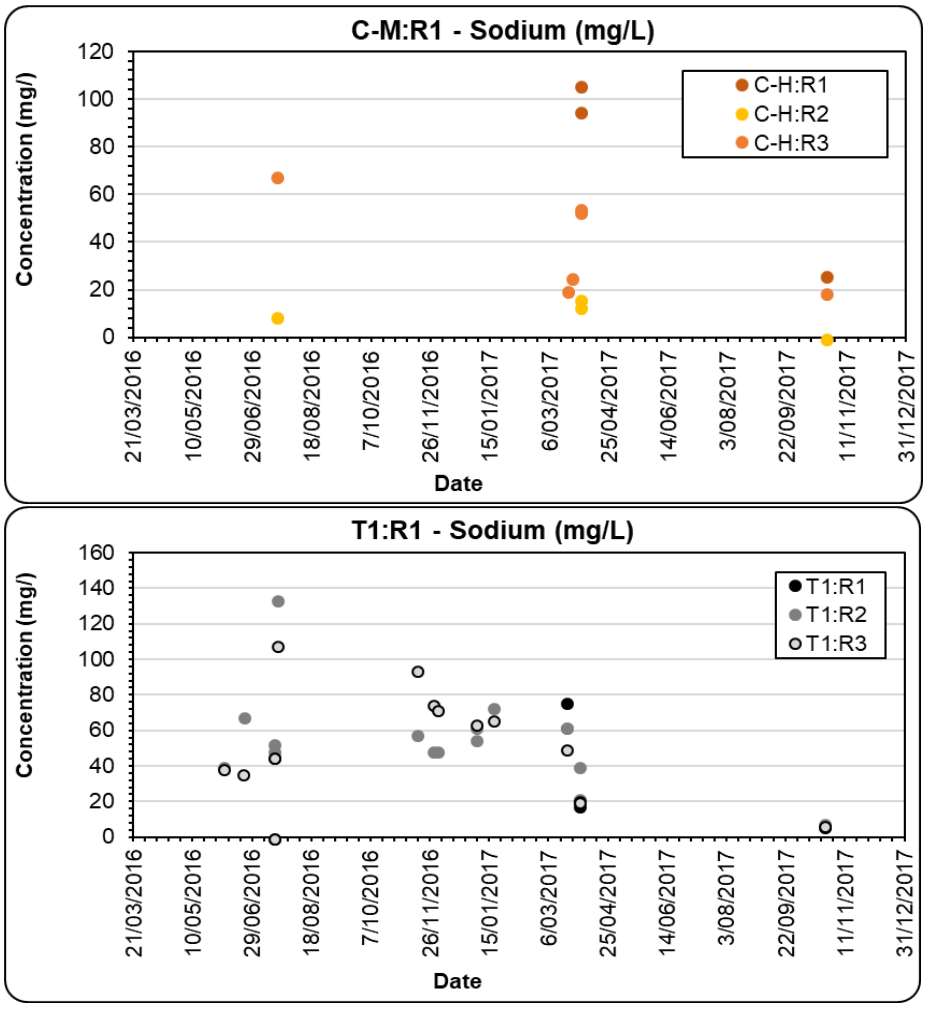

C-N:R1 - pH
pH
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-M:R1 - pH
pH
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

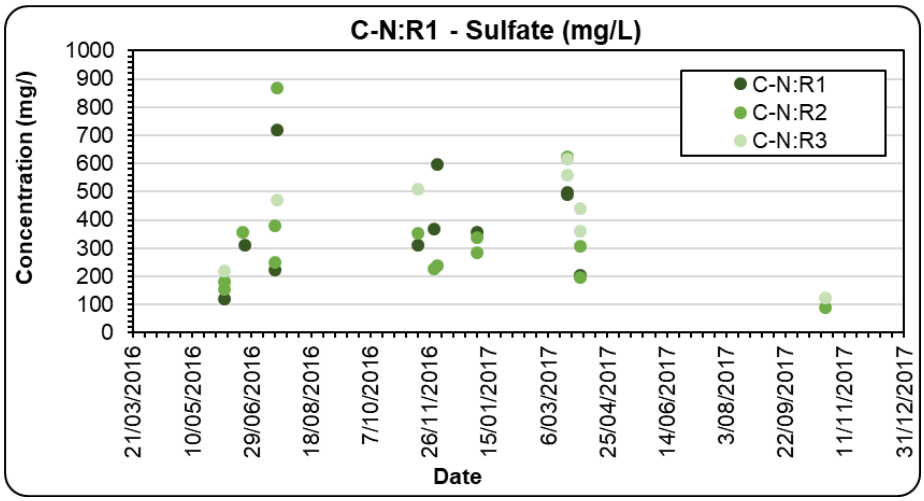

C-M:R1 - pH
pH
8
7
6
5
4
3
2
1
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

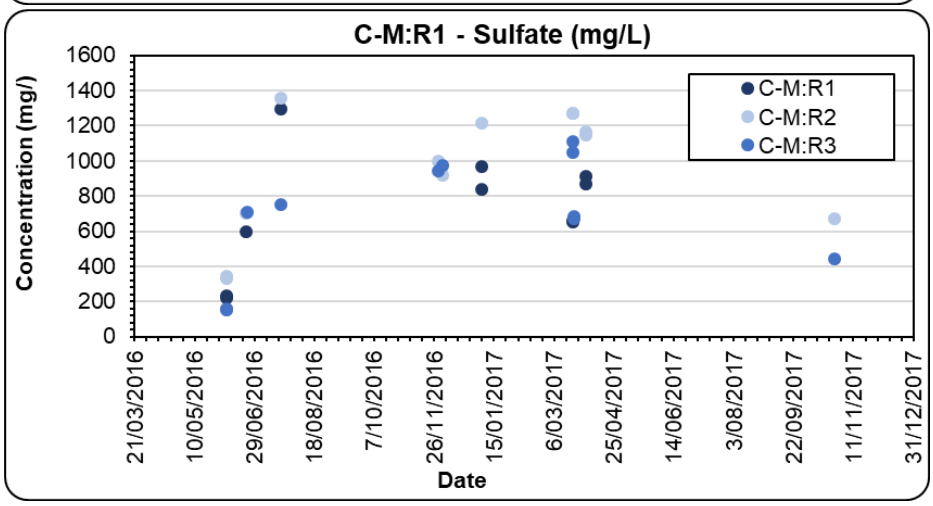

T1:R1 - pH
pH
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
7
6.9
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

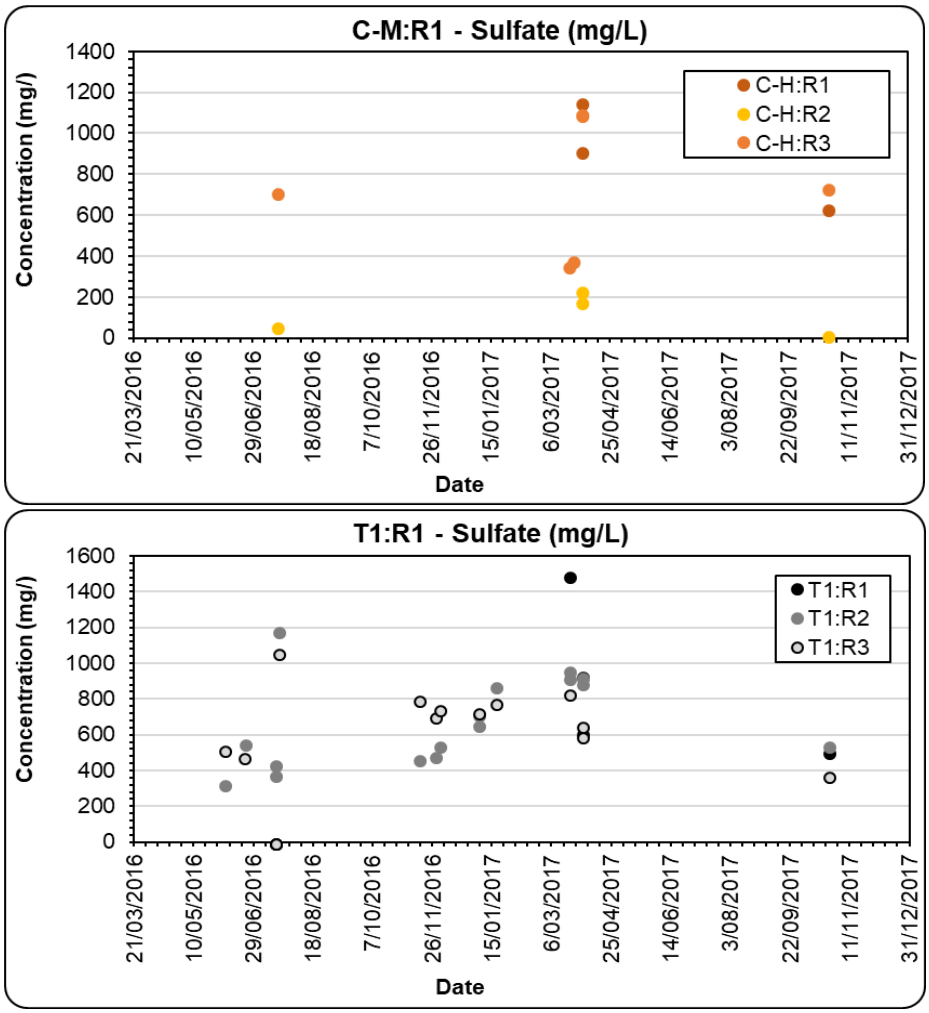

C-N:R1 - Sodium (mg/L)
Concentration (mg/l)
180
160
140
120
100
80
60
40
20
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

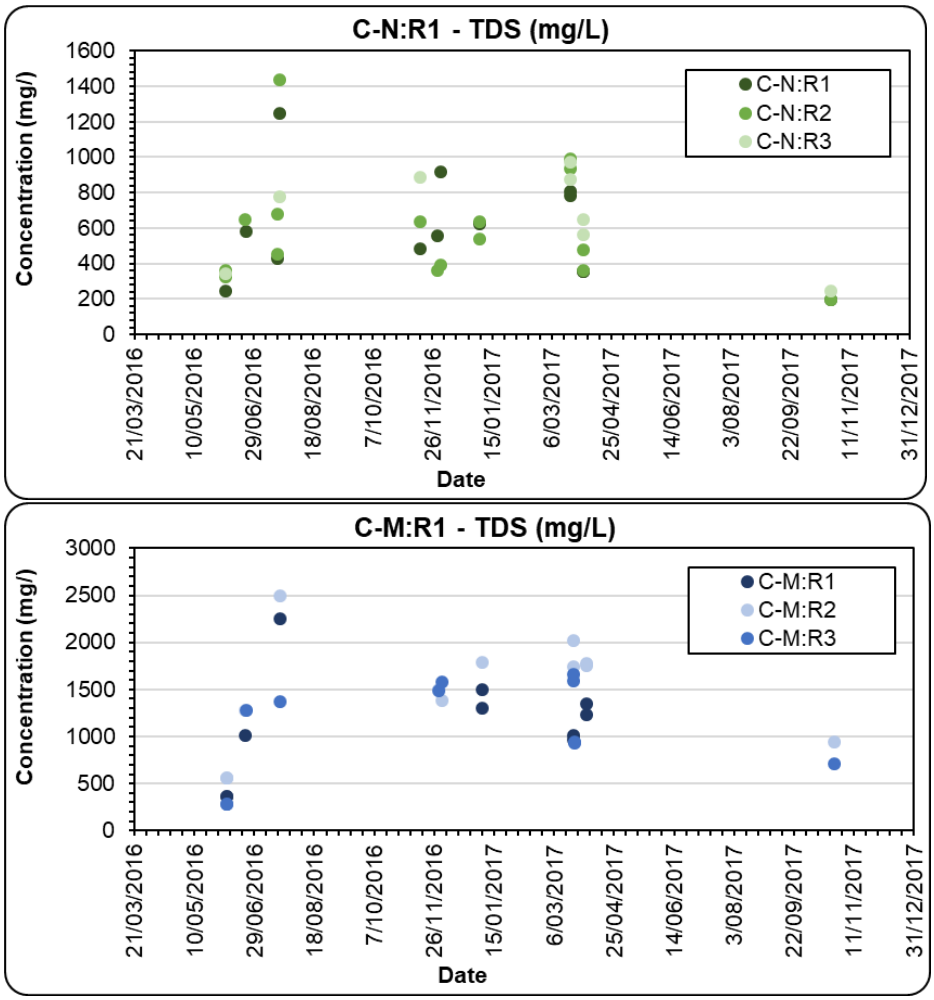

C-M:R1 - Sodium (mg/L)
Concentration (mg/l)
140
120
100
80
60
40
20
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

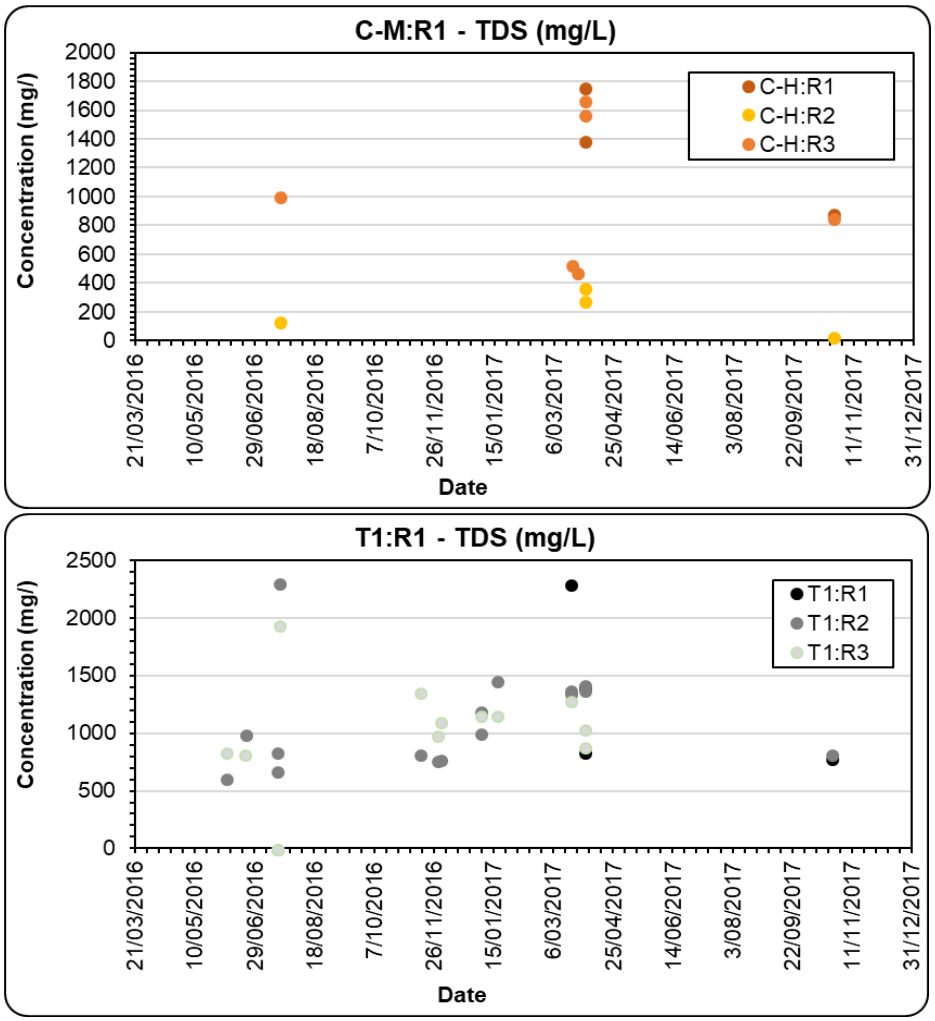

C-M:R1 - Sodium (mg/L)
Concentration (mg/)
120
100
80
60
40
20
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - Sodium (mg/L)
Concentration (mg/)
160
140
120
100
80
60
40
20
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

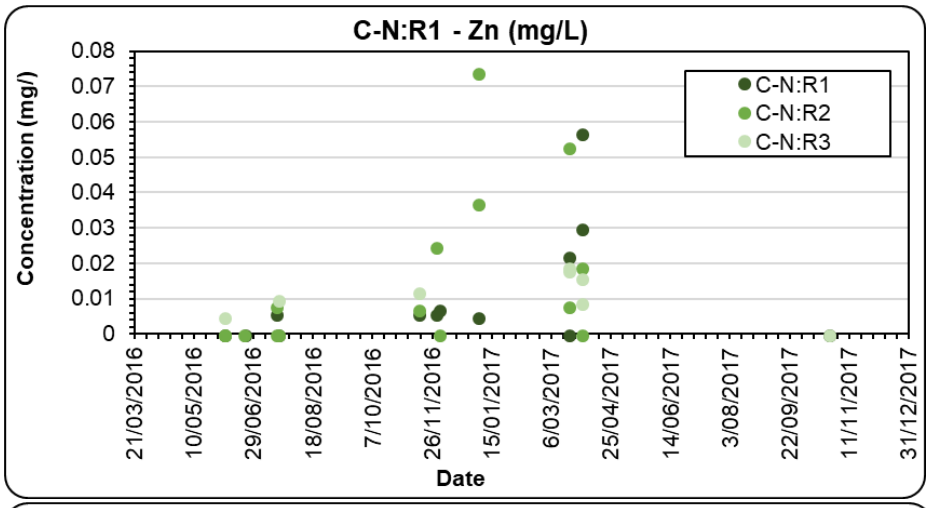

C-N:R1 - Sulfate (mg/L)
Concentration (mg/l)
1000
900
800
700
600
500
400
300
200
100
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

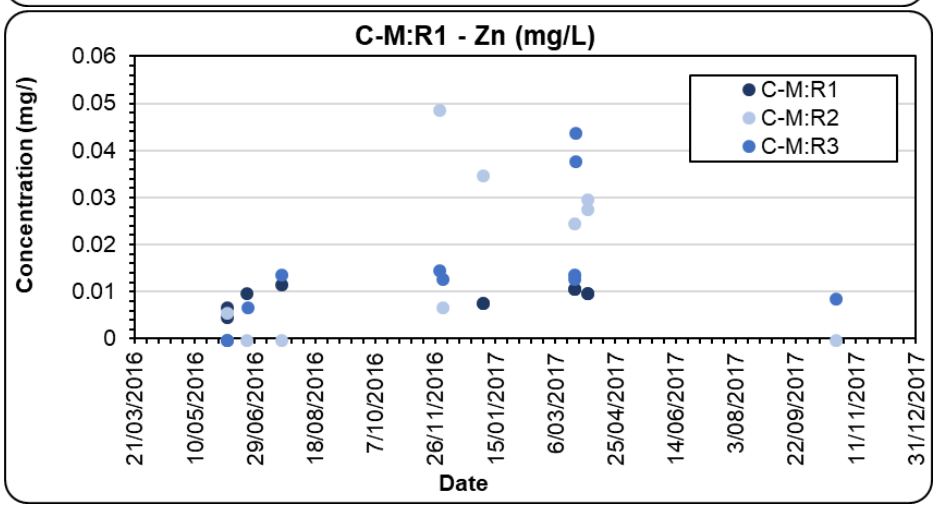

C-M:R1 - Sulfate (mg/L)
Concentration (mg/l)
1600
1400
1200
1000
800
600
400
200
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date

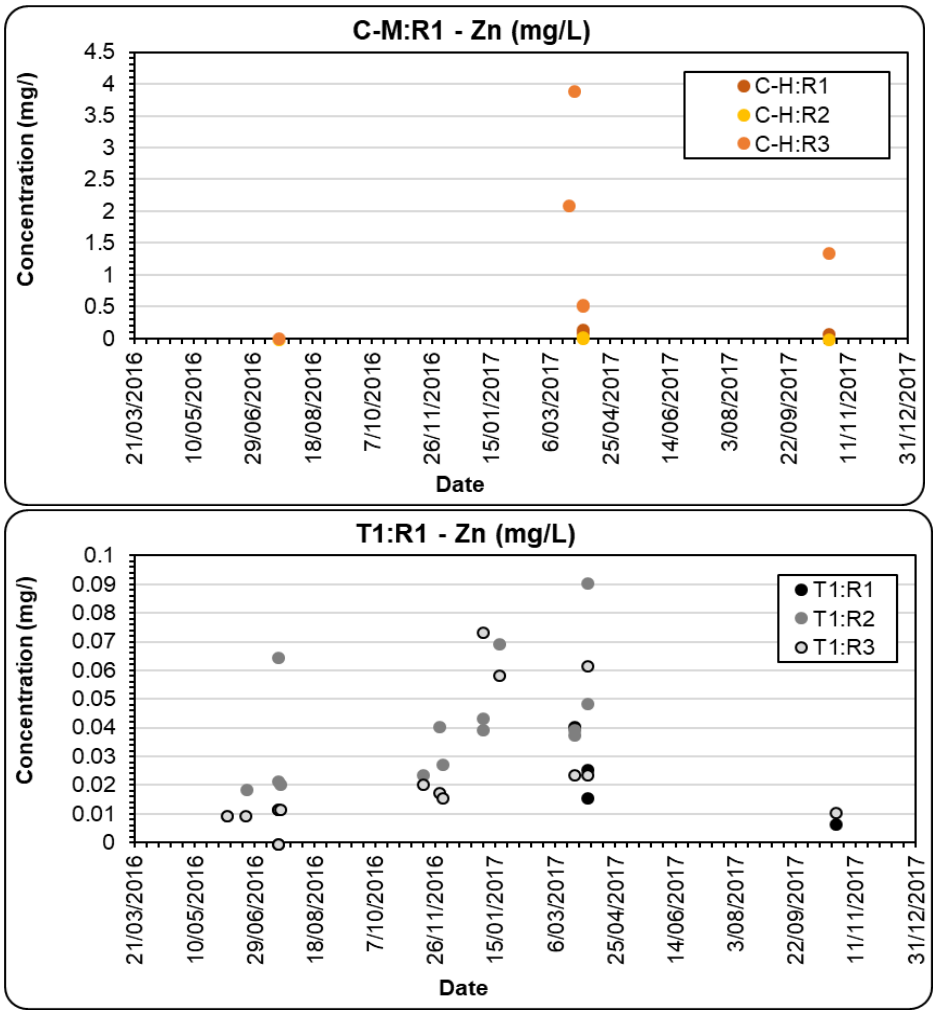

C-M:R1 - Sulfate (mg/L)
Concentration (mg/l)
1400
1200
1000
800
600
400
200
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - Sulfate (mg/L)
Concentration (mg/l)
1600
1400
1200
1000
800
600
400
200
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-N:R1 - TDS (mg/L)
Concentration (mg/l)
1600
1400
1200
1000
800
600
400
200
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
C-M:R1 - TDS (mg/L)
Concentration (mg/l)
3000
2500
2000
1500
1000
500
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-M:R1 - TDS (mg/L)
Concentration (mg/l)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - TDS (mg/L)
Concentration (mg/l)
2500
2000
1500
1000
500
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-N:R1 - Zn (mg/L)
Concentration (mg/)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
C-N:R1
C-N:R2
C-N:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-M:R1 - Zn (mg/L)
Concentration (mg/)
0.06
0.05
0.04
0.03
0.02
0.01
0
C-M:R1
C-M:R2
C-M:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date


C-M:R1 - Zn (mg/L)
Concentration (mg/l)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
C-H:R1
C-H:R2
C-H:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date
T1:R1 - Zn (mg/L)
Concentration (mg/l)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
T1:R1
T1:R2
T1:R3
21/03/2016
10/05/2016
29/06/2016
18/08/2016
7/10/2016
26/11/2016
15/01/2017
6/03/2017
25/04/2017
14/06/2017
3/08/2017
22/09/2017
11/11/2017
31/12/2017
Date



LEADERS IN MINING
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