Appendix Q - Water Management Plan

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Primary Gold Pty Ltd

Rustlers Roost and Quest 29 Water Management Plan 2022

29 July 2022

CDM Smith

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Document history & status

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Section 1 Introduction

Rustlers Roost and Quest 29 (the Project) are brownfield sites on Mineral Leases (ML) located in the Mount Bundey locality, approximately 85 kilometres (km) south-east of Darwin in the Northern Territory (NT) (Figure 2-1). The sites have a history of gold mining activity, with first gold being discovered in the 1940s and activities occurring over intermittent periods during the past 70 years (refer to Section 1.6). Primary Gold Limited (PGO) (the Proponent) is proposing to redevelop the existing mine by expanding open-cut gold mining operations and connecting the two non-contiguous sites with a haul road. Primary Gold is a fully owned subsidiary of Hanking Australia Investment Pty Ltd (Hanking).

The mine sites are located approximately 11 km apart and are connected by an existing unsealed access track, which will be upgraded to accommodate haulage of ore from the Quest 29 satellite pits to a proposed processing facility at Rustlers Roost. Ore mined at both sites will be processed at a new purpose-built processing facility located at the Rustlers Roost site to produce gold bullion which will be trucked offsite for sale. The rate of production will be up to 5 million tonnes per annum (Mtpa) over an approximately 10 year life of mine (LOM). Following completion of mining activities, the Project area will be closed and rehabilitated in accordance with an approved Mine Closure Plan (MCP).

The main Project areas of Rustlers Roost (MLN1083) and Quest 29 (ML29783) are located between 5 km and 12 km directly south-west of the Arnhem Highway on Old Mount Bundey Station, Perpetual Pastoral Lease (PPL) 1163 and McKinlay River Pastoral Station (PPL 1184). An accommodation camp for the Project workforce will be located on ML 29814 which is part of the Toms Gully Mine tenements (Figure 2-2). The proponent for Toms Gully Mine is PGO; however, that project has undergone a separate environmental assessment process and, with the exception of the camp, no additional activities or infrastructure for this Project are proposed in the Toms Gully ML. The accommodation camp will be utilised for both the construction and operational phases of the Project.

The Project includes the expansion of existing pits, waste rock landforms, water storage dams and internal roads. Two new pits will be constructed at Rustlers Roost and new infrastructure includes an onsite processing plant, a tailings storage facility, a landfill, laydown area, magazine, administration office, accommodation camp and groundwater bores for water supply. The Project includes an entire development envelope of 790.11 ha which is taken to be a maximum disturbance footprint. However, a large portion of the additional Project footprint is within historically disturbed areas and the maximum vegetation clearing extent is calculated at 389.4 ha.

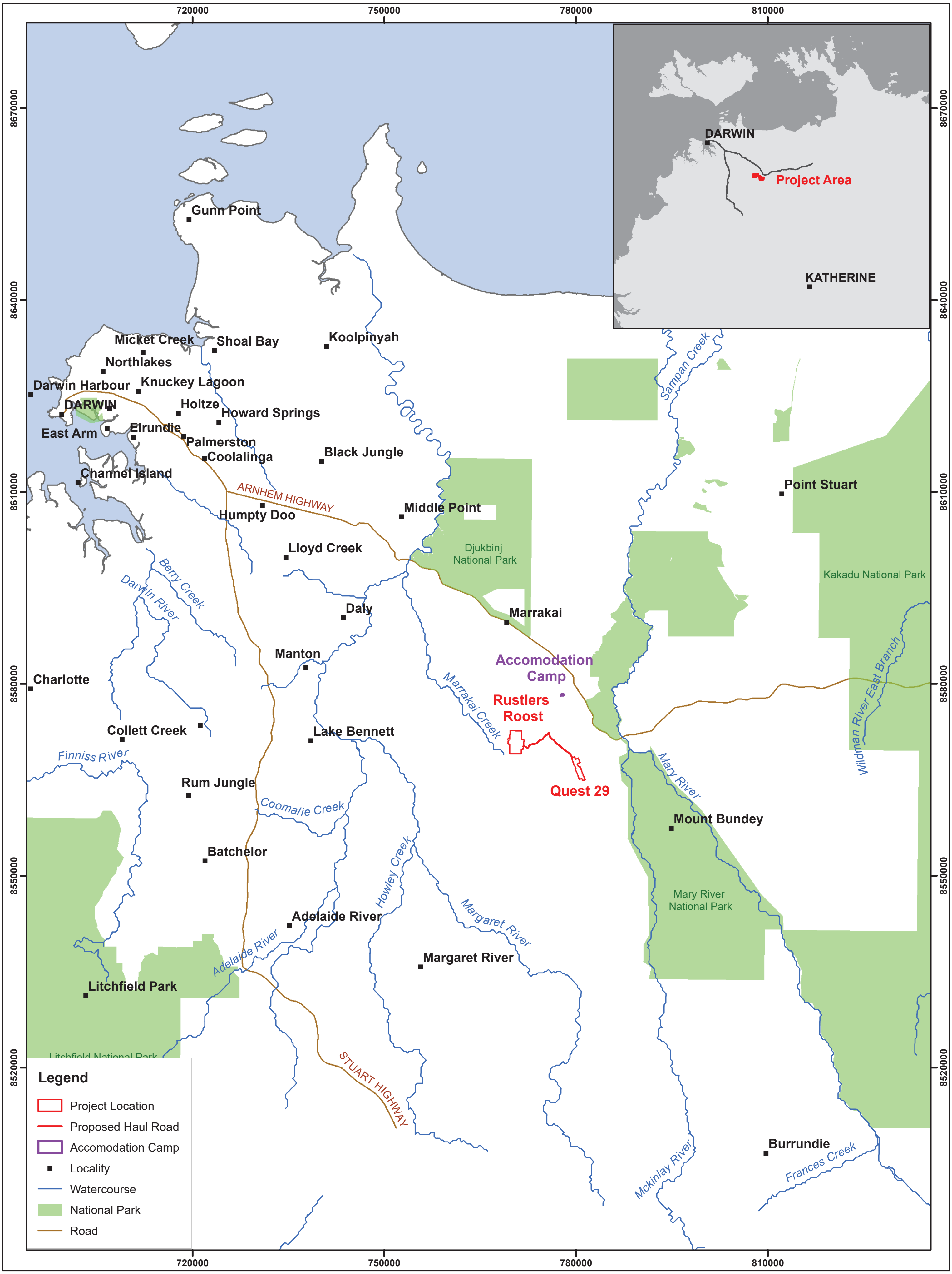
This Water Management Plan (WMP) has been prepared to address the requirements of the Mining Management Act for the Rustlers Roost project regarding maintaining and monitoring water quality during mining operations.

Section 2 Objectives of the Water Management Plan

The Water Management Plan provides a framework to assess environmental and stock water quality and manage off-site risks from the discharge of site water, dewatering and interactions with ground water. Additionally, this document describes the water types, quality and use relevant to site operations.

Specifically, the management plan has the following objectives:

- To describe baseline conditions at each site pertaining to;
  - Surface water catchments
  - Groundwater systems
  - Site surface drainage
  - Hydrogeology:
    - Environmental values of receiving environments; and
    - Seasonal rainfall and evaporation.
- Detail current information gaps;
- Detail the water balance for the site;
- Outline a management plan for pit dewatering operations and passive and active discharges. In particular, the plan will:
  - Outline the risks and management framework
  - Describe the water management process
  - Present the water quality objectives.
- Outline the water monitoring program, in particular present:
  - The method to be used to monitor surface water flows and quality to assess impacts to the downstream ephemeral water ways
  - Surface water impact assessment criteria (trigger values)
  - A response plan for the investigation of identified downstream trigger value exceedances.



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2	Final	27/07/21

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Notes:

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Meters
1 cm = 5,219 meters
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FIGURE 2-1

Project Location and Regional Setting

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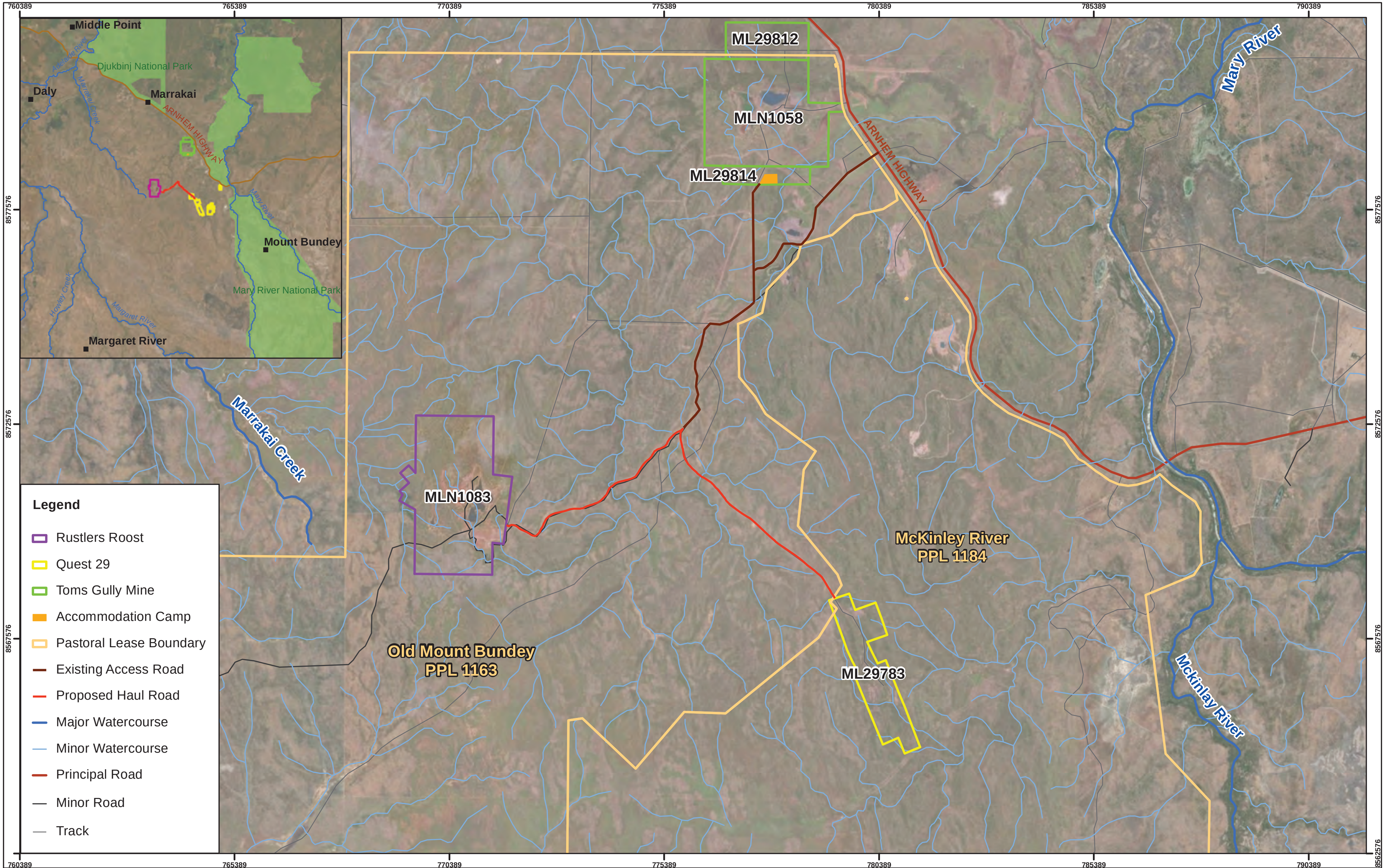

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FIGURE 2-2

Rustlers Roost and Quest 29 Project Location

DRG Ref: 1001087-EIS-01-1.4

\\bga1svr1\Projects\US DOT\AustRoads\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Chapter 1\Figure 1-4.mxd

Section 3 Current Conditions

3.1 Receiving Environment Catchment Overview

3.1.1 Climate

The climate of the Darwin Katherine region is tropical monsoonal with two distinct seasons; a dry season (May to October) and wet season (November to April). This has implications for mining planning and operations. The annual rainfall occurs predominantly in the wet season, with rainfall intensities typically being high. During the dry season there can be no rainfall for six months or more; surface water resources gradually diminish and groundwater levels drop.

There are on average 7.7 days per season when a cyclone is present. These cyclones and associated winds may affect the site. The rainfall is affected by the cyclones, with 95% of the annual rainfall arriving in the region between December and March (typical cyclone season). The wet season can deliver 1,511 mm/yr on average (as recorded at Toms Gully Mine, EcOz 2020).

Climate observations are made by the Bureau of Meteorology (BoM). The Middle Point Rangers Station (Station no. 014090) is the closest BoM weather monitoring station to the Project area, located approximately 40 km south-west of the Project area and where data have been collected since 1957. Average annual rainfall recorded at this station is 1,420.0 mm (1957 to 2021) with the highest rainfall occurring in January and the lowest in July (Figure 3-1). The average annual regional evaporation is 2,400 mm and exceeds the average annual rainfall (Figure 3-1). Evaporation is highest in October and lowest in February. The intensity frequency duration curves for the Project area are provided in Figure 3-2.

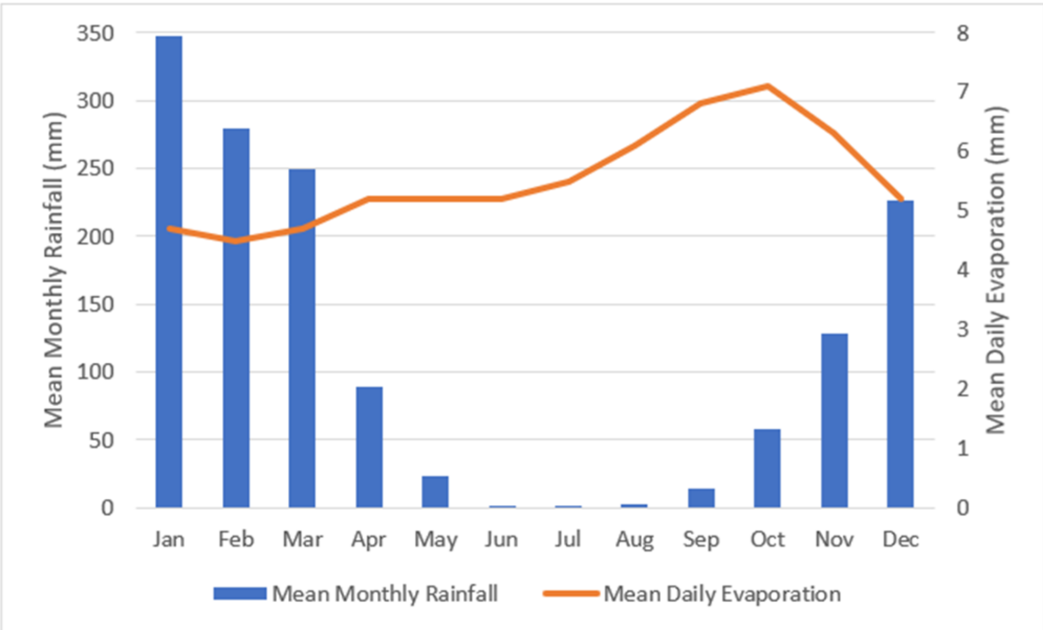

Figure 3-1 Mean Monthly Rainfall and Evaporation Data at nearest BoM Station (Middle Point Ranger station) (Source: BoM 2021)

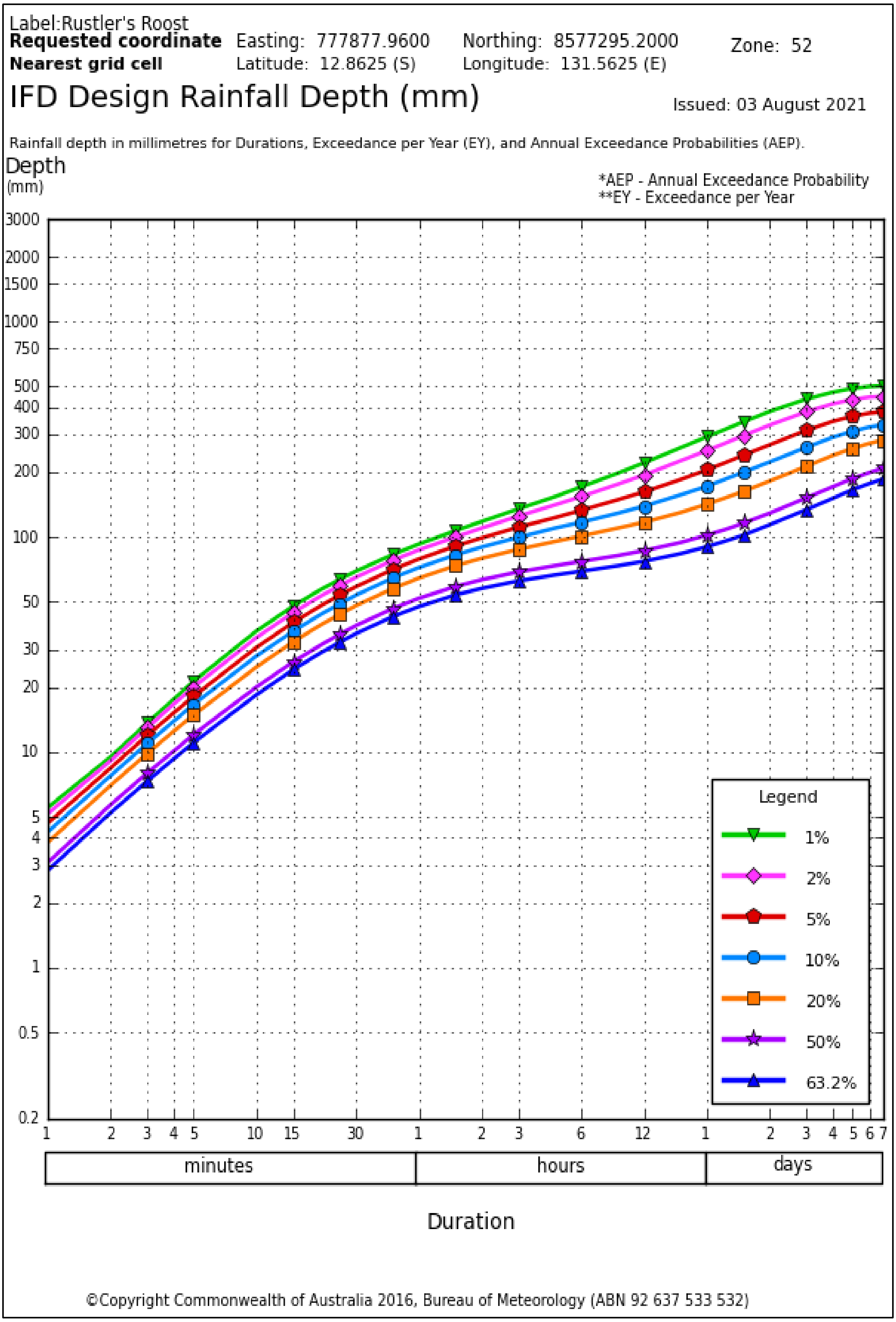

Figure 3-2 Rustlers Roost Precipitation Intensity Frequency Duration

The hot dry-wet transition occurs from October to November where humidity can be high and winds can be variable. The mean daily maximum temperature on site is reportedly 31.3°C in the cooler months and 35.6°C in the hotter months. Figure 3-3 shows the mean monthly maximum and minimum temperature data (1965 to 1998).

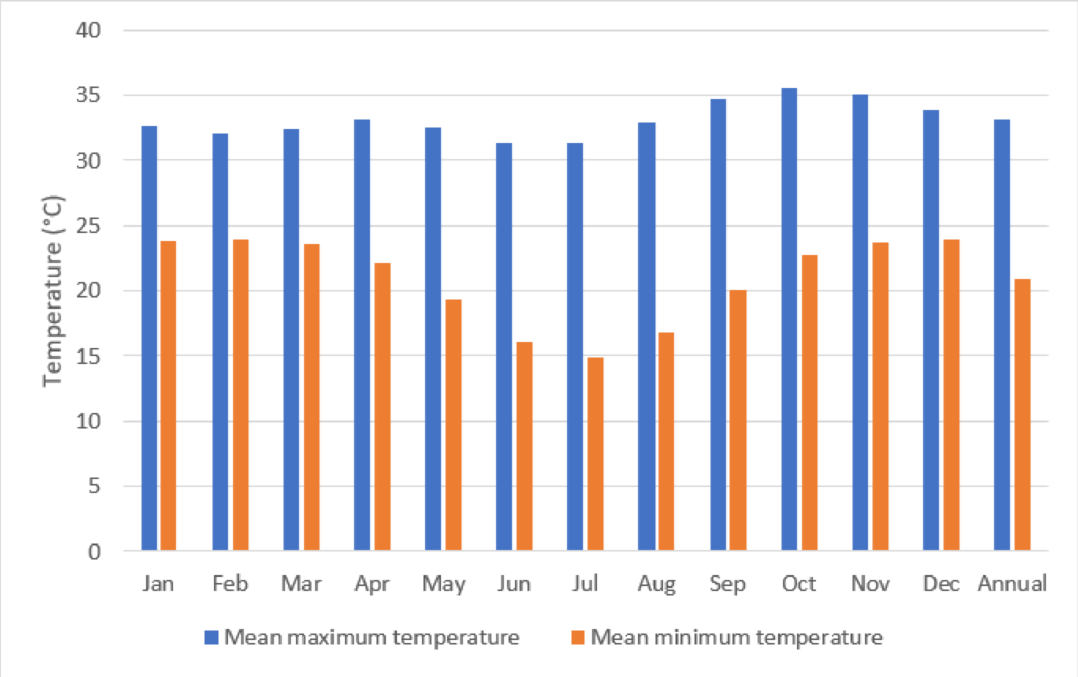

Figure 3-3 Mean Monthly Maximum and Minimum Temperature at nearest BoM Station (Middle Point Ranger station) (Source: BoM 2021)

Although some distance from the Project area, wind roses produced for the Darwin Airport BoM station[1] show that winds in the morning (9 am) are predominantly from the east and south-east, whereas in the afternoon winds (3pm) are predominantly from the north or north-west (Figure 3-4).

[1] No Wind Roses available for Middle Point Rangers station. Closest available data for Darwin Airport station (014015).

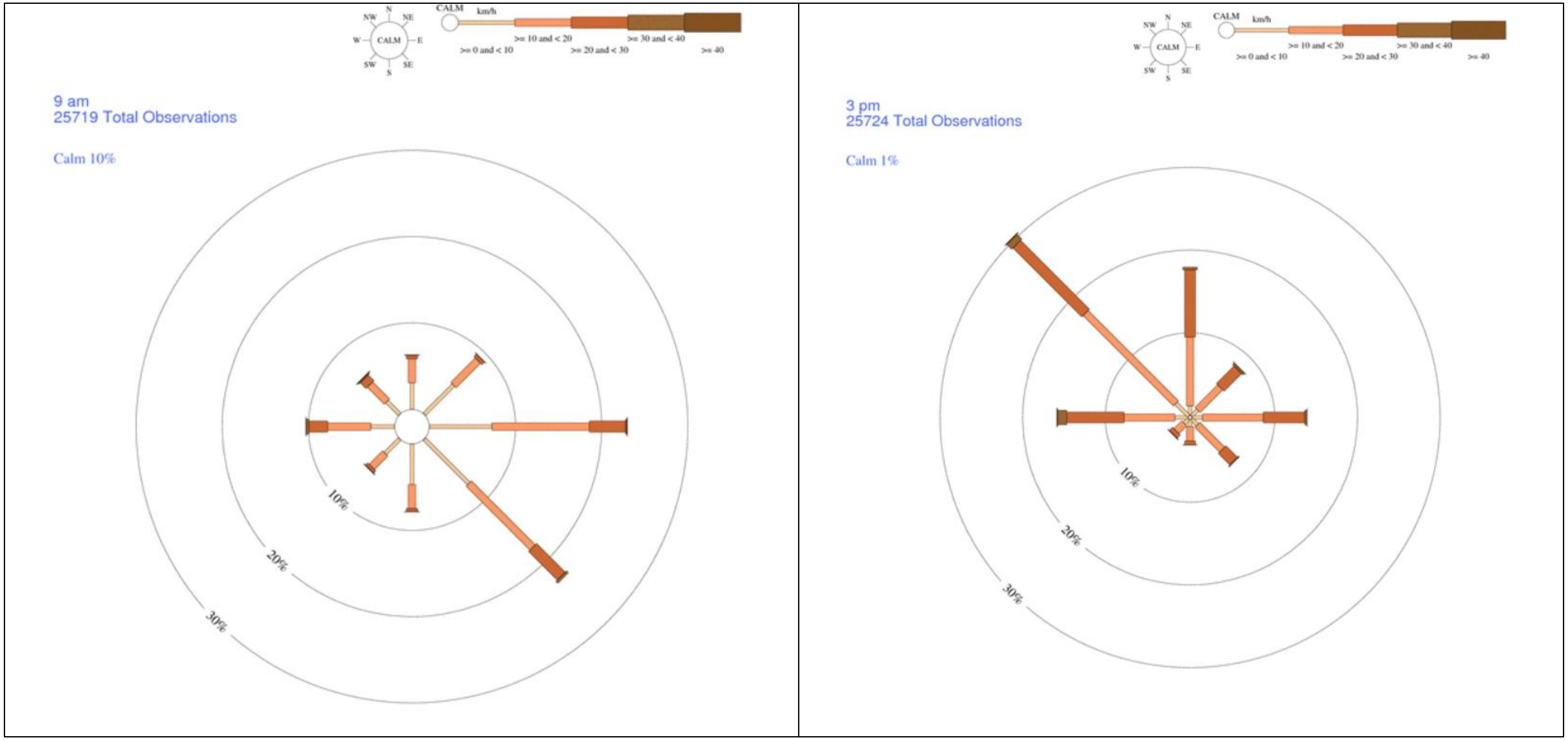

Figure 3-4 Annual morning and afternoon wind directions at Darwin Airport

3.1.2 Surface Water

The Project area traverses two river basins (Adelaide River and Mary River) and three sub-catchments. The Rustlers Roost portion of the Project area is predominantly located in the upper Mount Bundey Creek sub-catchment of the Mary River system. A portion of the western section of Rustlers Roost is located in the Marrakai Creek sub-catchment of the Adelaide River system (Figure 3-5). The Rustlers Roost portion of the Project area has only a small external catchment area, measured at approximately 2.2 km^2. This means that the Rustlers Roost area is unlikely to be affected by riverine flooding (i.e. flooding generated from further upstream), and that the dominant flooding mechanism is expected to be the rapid generation of overland flow in response to local catchment rainfall.

The Quest 29 area of the Project is predominantly located in the McKinley River sub-catchment, which also flows into the Mary River system. A minor northern portion of Quest 29 is located in the upper Mount Bundey Creek sub-catchment of the Mary River system as is the haul road and accommodation camp (Figure 3-5).

The local catchment is comprised of ridges and dissected hills that are drained by small step rivulets (CDM Smith 2019). Stream flows in these upper areas of the catchments are ephemeral, with flows occurring for only a few weeks to months each year throughout the wet season, in response to rainfall events.

The landscape has been altered due to prior mining and processing operations at both mining sites within the Project area. There are three permanent water bodies located at the Rustlers Roost site – the pit lake, heap leach ponds and Annie's Dam, while there are six permanent waterbodies at the Quest 29 site consisting of the five historic pits and the heap leach ponds. Water stored in the pits is a combination of stormwater runoff, incident rainfall and (possibly) groundwater, whilst Annie's Dam is a combination of predominantly stormwater runoff and incident rainfall.

There are no flow data available for Mount Bundey Creek. However, average annual runoff for most small to medium-sized ephemeral creeks in the Top End usually accounts for between 10 and 30% of incident rainfall. Based on the available flow records held by the Power and Water Authority (PAWA), the average annual runoff in the Mary River catchment approximated 23% of the mean annual rainfall (310 mm).

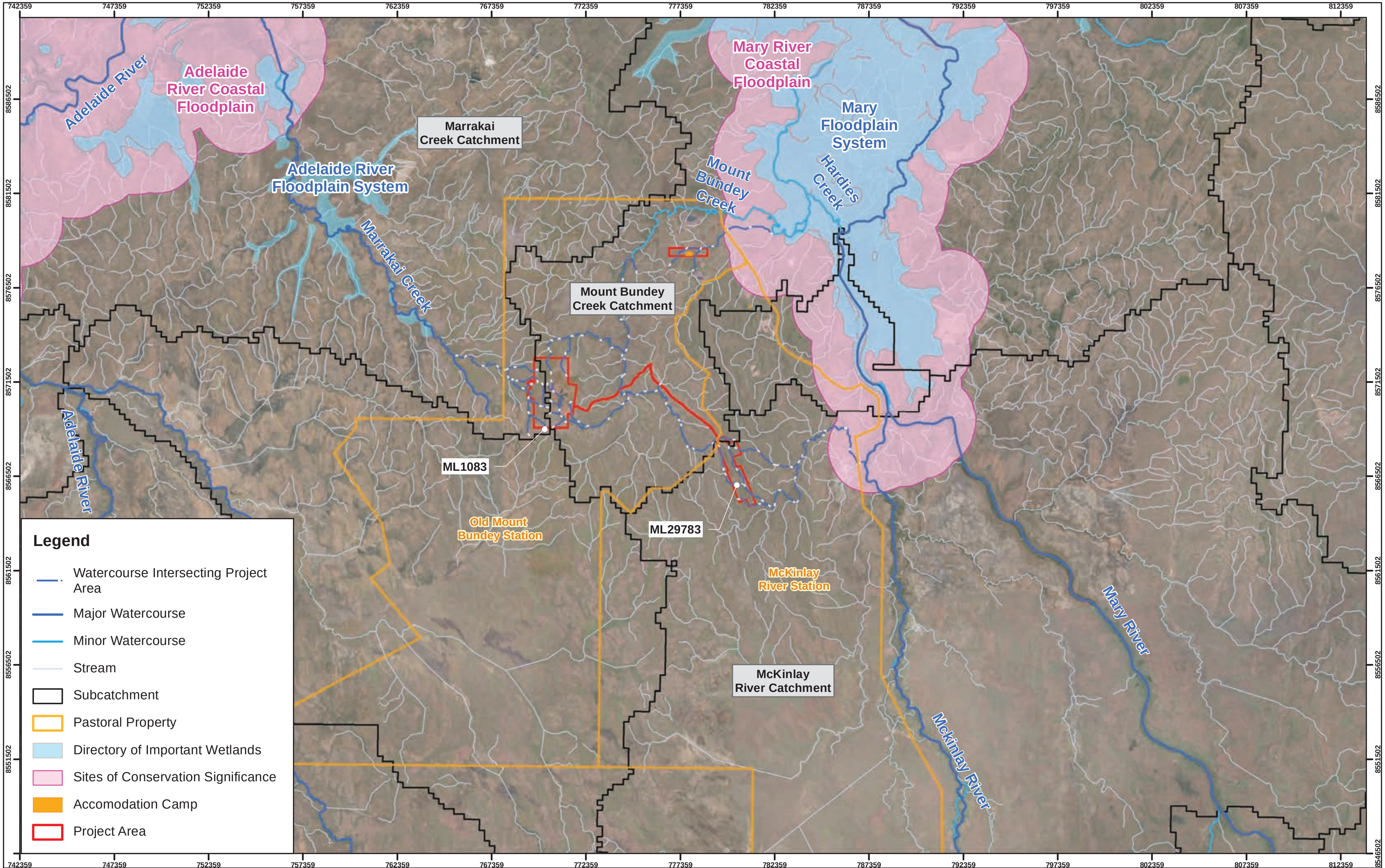

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FIGURE 3-5

Regional Catchment and Surface Water Site Map

DRG Ref:

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3.1.2.1 Mount Bundey Creek – Mary River

During the wet season, drainage lines downstream of both Rustlers Roost and Quest 29 sites discharge to the north into the receiving Mount Bundey Creek, which flows into the main branch of the Mary River approximately 35 km downstream. Mount Bundey is an ephemeral creek that has limited flow and contains isolated pools during the dry season (Primary Gold 2020). The creek flow is dependent on localised rainfall and historically the creek flows for 3-4 weeks annually (Primary Gold 2020).

Surface hydrological regimes in Mount Bundey Creek are not significantly altered by any existing land use in the catchment, which is limited to pastoral grazing and the Mary River National Park. Past mining activities are unlikely to have significantly altered flows in any of the creeks downstream because those activities affect relatively small areas of land in the upper parts of the catchment that are a relatively minor contributor to stream flows.

A total of 66% (or 4.9 km^2) of the Rustlers Roost ML1083 and all of the accommodation camp sits within the headwaters of the Mount Bundey Creek catchment. Approximately 3.5% (or 0.1 km^2) of Quest 29 ML29783 (northern area heap leach infrastructure) drains north into Charlies Creek, a tributary of the upper Mount Bundey Creek, upstream of the Rustlers Roost portion of the Project area. The Project area covers 3.5% (or 5.8 km^2) of the total ~170 km^2 catchment area of the Mount Bundey Creek.

Mount Bundey Creek is currently used as stock drinking water during the wet season, and the wet season flows and dry season pools support riparian and aquatic ecosystems. The nearest permanent billabong thought capable of providing suitable habitat for aquatic fauna is situated approximately 4 km directly north-east of the Rustlers Roost. Figure 3-6 presents an overview of the catchment and creek lines.

3.1.2.2 McKinley River – Mary River

The majority of the Quest 29 mine site (96.5% or 2.75 km^2 - eastern and southern parts) are located in the McKinley River catchment. Unnamed ephemeral drainage lines downstream of the site discharge to the east through floodplains towards the McKinley River main branch, which is approximately 15 km downstream of the Project. From this location, the McKinley River flows north and discharges to the Mary River at a location 2 km upstream from the Arnhem Highway Mary River Bridge.

3.1.2.3 Marrakai Creek – Adelaide River

A total of 34% (or 2.6 km2) of Rustlers Roost ML1083 (the western portion) sits within the headwaters of the Marrakai Creek catchment. The main ephemeral drainage line that receives surface water flows from the Project area has been dammed to create Annie's Dam, previously built as a pastoralist dam. The dam has a surface area of approximately 11 ha and without extraction and retains water throughout the dry season.

Surface water from this area flows west into minor unnamed ephemeral drainage lines, which during the wet season flow into Marrakai Creek proper approximately 6 km downstream. Marrakai Creek discharges into the upper tidal reaches of the Adelaide River approximately 35 km downstream of the Project area.

3.1.2.4 Project Area Catchment Stream Flows

There are no stream flow data for the tributaries and relevant creeks in the Project area. However, a hydrologic model was developed for each of the catchments at Rustlers Roost and Quest 29 to assess baseline environmental flows and future flows by application of climate change scenarios with changed catchment conditions resulting from mining (PG2021a, PG2021b). Overall, there was little difference between the baseline discharge and the modelled future scenario discharge, as well as the baseline peak flow (Qp) and the modelled future mean flow for all connected catchments (Table 3-1).

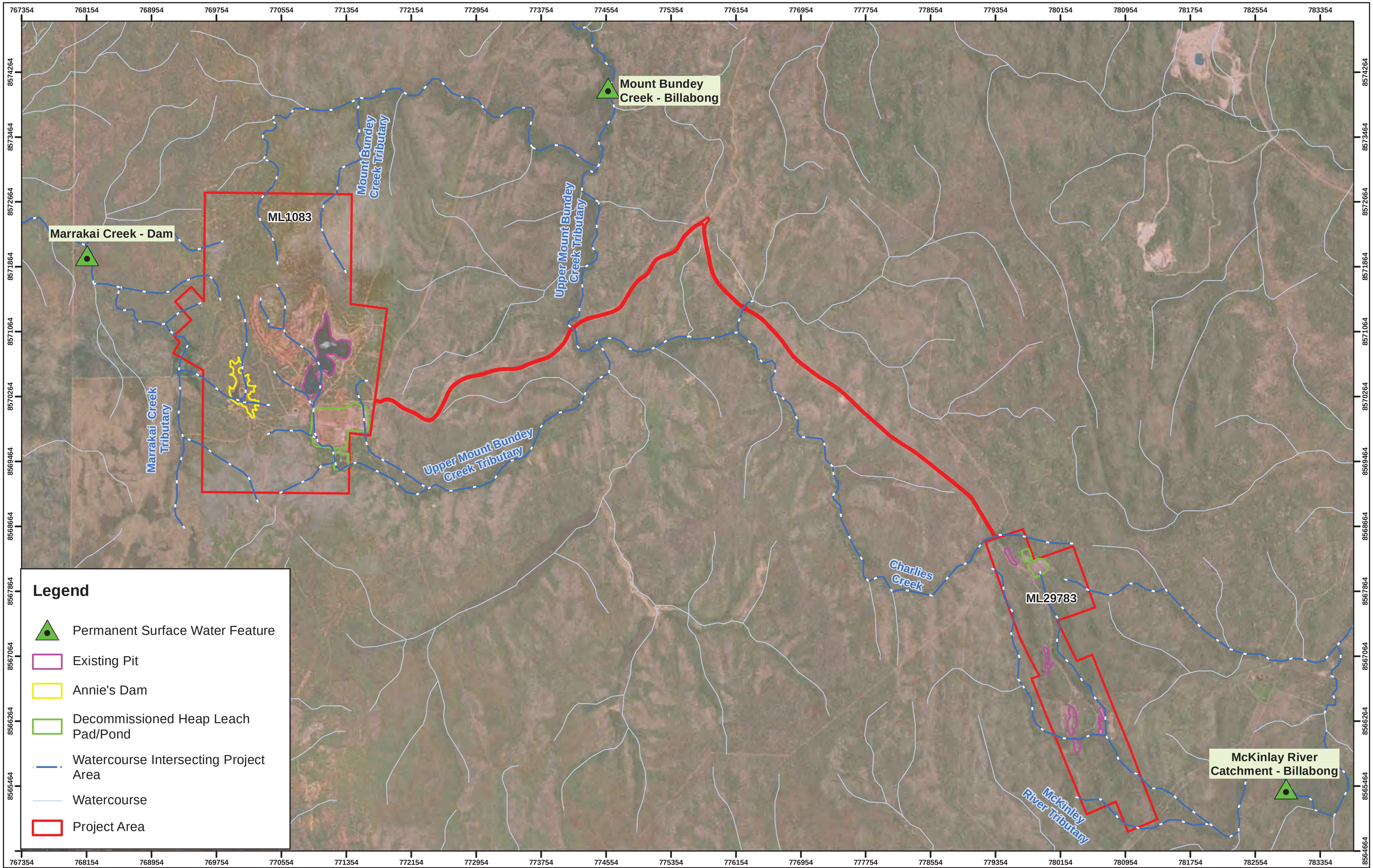

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FIGURE 3-6

Permanent Surface Water Features

DRG Ref: 1001087-EIS-07-7.23

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Table 3-1 Rustlers Roost and Quest29 Surface Water Catchments, Modelled Baseline and Future Discharge

Catchment	Mean Baseline Annual Discharge (GL)	Mean Scenario Annual Discharge (GL)	Baseline Peak Flow (Qp) (m^3s^{-1})	Scenario Peak Flow (Qp) (m^3s^{-1})
Rustlers Roost east (Mount Bundey Creek outlet)	107.0	118.1	245.7	247.1
Rustlers Roost west (Marrakai Creek outlet)	178.8	178.1	316.3	315.6
Rustlers Roost EWR at inflow point to creek	0.83	2.46	2.23	2.4
EWR confluence Mt Bundey & Mary River	98.2	99.9	130.6	130.6
Quest 29 north (Mount Bundey Creek)	0.5	0.5	1.6	1.7
Quest 29 south (Charles Creek)	2.2	2.1	7.2	7.8
Charles Creek EWR at inflow point to creek	1.97	2.9	3.75	5.3
Charles Creek EWR at McKinley River	50.0	50.7	32.1	33.1
Charles Creek (McKinley River)	41.6	41.5	106.7	107.1

3.1.2.5 Beneficial Uses

The Mary River regional catchment has declared ‘beneficial uses’ under the Water Act. The Mary River beneficial uses declaration (BUD) covers Rustlers Roost (with the exception of the western catchment encompassing Annie’s dam) and the Quest 29 Project area. The declared beneficial uses for the Mary River surface water catchment are environment, riparian and cultural. These uses rely on the maintenance of stream flows and good water quality.

The Project areas are not directly covered by the Mount Bundey Creek BUD which commences approximately 13 km downstream. The declared beneficial uses for Mount Bundey Creek are aquatic ecosystem protection (for the upper and lower creek sections), and stock water supply for the middle 7.8 km section of the creek (downstream of Toms Gully Mine east of the Arnhem Highway).

3.1.2.6 Other Surface Water Users

There are no permanent natural waterbodies or wetlands within the Project area. Existing waterbodies are the result of previous mining activities (mine pits, and leach pond) and pastoral activities (Annie’s dam). There are no known direct surface water users within the 5 km radius of the Project areas, however the existing pits and dams may be accessed by stock and fauna for drinking water. Flows in watercourses or permanent waterholes downstream of the mine sites, may also be accessed by stock and fauna.

3.1.2.7 Inundation and Flooding Occurrence

There are no records of significant flood events within the Project area. Hydrodynamic flood models have been used to assess the potential occurrence and impacts of flood and inundation events at Rustlers Roost (CDM Smith 2019 and Appendix N of the Draft EIS).

Both, the Rustlers Roost and the Quest 29 project sites are only in small upper catchment areas which are unlikely to be affected by riverine flooding (i.e. flooding generated from further upstream). The dominant flooding mechanism is expected to be the rapid generation of overland flow in response to local catchment rainfall. In addition, due to previous mining activities the catchment area has been highly disturbed. This has led to numerous areas, especially in the eastern section around the waste rock dump, being prone to shallow ponding (< 0.2m). Rainfall would likely pond at these locations for a short time before either seeping into the soil or evaporating away. Reasonable separation between disturbed and undisturbed areas of the site exists. The Rustlers Roost pit void acts as a terminal sink for a large portion of the catchment, including the waste rock dump and previous mine infrastructure area. The gullies to the west of the heap leach pad and ponds drain freely to the outlet (i.e. site boundary), separated from the disturbed areas by bunds. Overall the site is unlikely to be adversely affected by flooding, as the undisturbed sections are largely free draining, and the disturbed sections drain mostly to the pit.

3.1.3 Groundwater

Groundwater information available for the Project area is limited to regional-scale aquifer information from Tickell 2019 and historical site-specific information from previous operators of Rustlers Roost, Valdora (1994) and Greenbase (1997). The regional groundwater system is comprised of intermediate-scale aquifers associated with unconsolidated sediments and local-scale aquifers associated with fractured and weathered rocks with minor groundwater resources (Tickell 2019). In general, the Project is situated near the northern flank of the Pine Creek Geosyncline. Aquifers, where they occur, are typically associated with increased structural deformation of the metasediments and are recharged by direct infiltration of rainfall and stream run-off.

Groundwater Enterprises (2020) was commissioned to prepare a groundwater investigation plan, including aquifer hydraulic properties testing, for the Project area. A network of groundwater monitoring bores, as recommended by Groundwater Enterprises (2020), was installed during October 2020. Baseline groundwater monitoring is being undertaken on these investigation bores, which will provide site-specific data on groundwater levels, flow directions, connectivity with surface water and water quality.

3.1.3.1 Rustlers Roost

Aquifers beneath the Rustlers Roost lease are associated with fractured/structural permeability within the metasediments of the South Alligator Group and Burrell Creek Formation (refer to Appendix O in the SEIS). These aquifers are mapped at a local scale (Tickell 2019). Regional data suggests typical bore yields in the Mount Bonnie Formation range from 0.5 – 2 L/s away from major structural features and 0.5 – 5 L/s along major faults or shear zones (Valdora 1994).

A potentiometric surface developed using surveyed water levels in mineral holes pre-mining in 1993, indicates the regional groundwater flow direction is towards the east/north-east towards the Mary River and local flow directions follow the natural surface gradient (Valdora 1994). The aquifer response from a short-term (26 hour) pumping test completed prior to mining (Valdora 1994) showed confined to semi- confined conditions with a transmissivity range of 71 – 107 m^2/day and a storativity range of 2 x 10^{-3} – 10^{-5}. Further investigations at the Rustlers Roost site reported a hydraulic conductivity range from 0.8 — 12.5 m/day with a geometric mean of 4.1 m/day (refer to Appendix O of the SEIS).

NR Maps indicates seven registered bores were drilled along the eastern boundary of ML1083 for Valdora Mining during 1994. A bore search undertaken during 2016 could not locate any of the historical registered bores. Bore completion depths ranged from 61 to 86 m; SWL ranged between 11 to 23 mBGL and yield ranged from 1.5 L/s to 20 L/s. Desktop assessment of the groundwater by CDM Smith (2019) identified one existing groundwater sampling point (MB1), located downstream of the heap leach pad. The MB1 bore is not a registered bore and there is no bore development report available. There are no other bores located within 5 km of the Rustlers Roost portion of the Project area.

Available records of groundwater level monitoring conducted between 2020 and early 2021 at Rustlers Roost are summarised in Table 3-2.

Table 3-2 Rustlers Roost Groundwater Levels

Bore_ID	Lat	Long	mean RSWL [mAHD]	max RSWL [mAHD]	min RSWL [mAHD]
RRMB01	-12.926872	131.500677	54.46	55.25	52.78
RRMB02	-12.928138	131.501481	51.85	53.73	49.95
RRMB03	-12.931479	131.492211	54.48	57.05	52.18
RRMB04	-12.923166	131.487615	55.39	57.51	53.18
RRMB05	-12.918846	131.49531	57.7	59.92	55.71
RRMB06	-12.915522	131.502737	56.48	58.69	54.61
RRMB07	-12.908878	131.498342	57.31	59.76	55.33
RRMB08	-12.903331	131.492669	51.47	54.96	49.4

The groundwater flow direction inferred from observations at Rustlers Roost is consistent with topographic relief, indicating that the water table resemble a subdued representation of ground surface elevation. There are no other bores located within 5 km of the Rustlers Roost portion of the Project area.

3.1.3.2 Quest 29

Groundwater Enterprises (2020) report that there is limited groundwater information available onsite or in the immediate vicinity of the lease. Regional scale mapping suggests aquifers across the lease are local scale systems in fractured and weathered rocks with expected bore yields of 1-3 L/s in the metasediments and <0.75 L/s in the Mt Bundey Granite (Tickell 2019). Higher permeabilities are likely associated with structural deformation within the metasediments/dolerite (Sirocco 1999) and at local scale (refer to Appendix O in the SEIS). Slug testing on site undertaken by Groundwater Enterprises (2020) has shown hydraulic conductivity ranges from 0.3 — 38.8 m/day with geometric mean of 5.2 m/day.

NR Maps records show four registered bores within the Quest 29 ML were historically drilled for mining purposes. Three of these bores (drilled in 1976) were not located during a bore audit undertaken in 2016. The fourth bore, drilled during 1999 for Sirocco Resources was located immediately north-west of the existing heap leach ponds, and is monitored as part of the Quest 29 groundwater monitoring program (GWB01). Bore completion depths ranged from 17 to 27 m; SWL is artesian to 10 mBGL and yield ranged from 0.25 L/s to 10 L/s. An unregistered bore (GWB02) located to the south-west of the heap leach ponds is also included in the Quest 29 groundwater monitoring plan.

Available records of groundwater level monitoring conducted between 2020 and early 2021 at Quest 29 are summarised in Table 3-3.

Table 3-3 Quest 29 Groundwater Levels

Bore_ID	Lat	Long	mean RSWL [mAHD]	max RSWL [mAHD]	min RSWL [mAHD]
Q29MB01	-12.93731	131.577287	68.91	71.65	66.65
Q29MB02	-12.939042	131.577692	68.9	71.69	66.61
Q29MB03	-12.962217	131.587492	31.93	33.32	30.43
Q29MB04	-12.957727	131.584775	36.06	37.24	34.7
Q29MB05	-12.954557	131.585617	44.38	45.07	43.8

Bore_ID	Lat	Long	mean RSWL [mAHD]	max RSWL [mAHD]	min RSWL [mAHD]
Q29MB06	-12.952175	131.579835	46.14	48.62	44.53
Q29MB07	-12.949718	131.58156	49.09	50.61	47.48
Q29MB08	-12.940141	131.581646	78.97	82.75	76.43
Q29MB09	-12.936416	131.574607	62.81	64.17	61.55

There is no groundwater flow direction information available, however it is assumed to broadly reflect the topographic gradient and surface flows, flowing towards Charlies Creek in the north and the remainder of the site flowing south.

There are five registered bores within a 5 km radius of the Quest 29 portion of the Project area, all bores are associated with mining activities and are either historical investigation holes or monitoring sites. The closest registered bores not associated with mining is a pastoral bore (RN036401) located 6 km north-east of the lease (refer to Appendix O in the SEIS).

Groundwater monitoring provides the following observations:

- The water table typically occurs within basement rocks, and in Cainozoic sediments where they occur in topographic lows;
- Apart from the earliest field measurements of physico-chemical parameters, EC and pH remain relatively stable between wet and dry seasons;
- With the exception of aluminium, many of the dissolved metals display a seasonally reducing concentration trend that may be associated with wet season recharge;
- Groundwater quality is similar to end of dry season surface water quality, potentially indicating groundwater and surface water connectivity;
- Available site data indicates the following regarding groundwater flows:
  - Aquifer transmissivity ranges between 80 and 110 m^2/d
  - Aquifer storativity ranges between 10^{-5} and $2x10^{-3}$.

Groundwater flow beneath the site is understood to be structurally controlled, with a regional-scale flow path toward the Mary River (approximately 20 km) to the east/northeast of the Site. However, at the site level it is expected that local groundwater flow systems exist, with recharge occurring in elevated areas and discharging to small creek lines.

3.1.3.3 Beneficial Uses

The majority of the Project area lies within the declared beneficial uses and objectives area of the Mary River. The beneficial use and objectives apply to both surface water and groundwater. The beneficial uses of groundwater are for environmental, riparian and agricultural uses. The surface water is for environmental, riparian and cultural uses. This section of the region is not within a Declared Water Control District (WCD) or Management Zone.

3.1.3.4 Groundwater Dependent Ecosystem

The Bureau of Meteorology (BoM) GDE Atlas classifies the Mount Bundey, Marrakai Creek and Mary River system as having a moderate to high potential for aquatic and terrestrial GDE occurrence. The closest mapped potential GDE (an aquatic inflow dependent ecosystem) is a layer covering Mount Bundey Creek, approximately 80 m north (downstream) of the existing haul road bridge and 40 m from the Project area. There is a low-moderate potential for terrestrial GDEs, at two locations approximately 2-3 km downstream, north-east of Rustlers Roost, and one low potential terrestrial GDE, approximately 5 km downstream, north-west of Quest 29 portion of the Project area.

CDM Smith (2022) has undertaken a GDE assessment (provided as Appendix P of the SEIS) to identify and assess potential impact of the Project on GDEs and provide an ongoing approach to actively manage the potential risks to GDEs from the Project activities. A summary of the findings is provided below.

Aquifer and Cave Ecosystems (Subterranean GDEs)

At this stage no field data has been collated to assess the range of stygofauna that may be present within the impact aquifers. Given the regional nature of the groundwater system, species present are likely to be ubiquitous across the Project area, with no particular species occurring within isolation to other species with geographic boundaries.

Ecosystems Dependent on the Surface Expression of Groundwater (Aquatic GDEs)

It is unlikely aquatic GDEs exist within the area of predicted drawdown. While no future work is recommended regarding aquatic GDEs, additional monitoring with respect to Terrestrial GDEs will provide confirmation of this conclusion.

Ecosystems Dependent on the Subsurface Presence of Groundwater (Terrestrial GDEs)

Additional mapping of terrestrial GDEs has identified that there is a likelihood that riparian vegetation within the areas of drawdown exist. These are likely restricted to narrow zones of riparian vegetation, dominated by the presence of medium sized trees *Eucalyptus bigalerita*, and *Lophostemon grandifloras.*

These areas are considered likely to be using groundwater due to their persistent high Normalized Difference Vegetation Index (NDVI) trend and the presence of shallow water tables. However, it is largely unknown at this stage if these trees, present across the study area have the root structure to access deeper soil moisture from the capillary fringe above the water table, and if indeed they require groundwater as part of their annual water requirements.

Irrespective of the uncertainty regarding their groundwater use patterns, a precautionary risk assessment has been conducted. The risk assessment has identified areas of potential high risk is associated with areas of initial depth to water table of less than 5 metres and a change to that water depth due to mining of greater than 5 meters.

As a result of the risk assessment the development of a Groundwater Dependent Ecosystem Monitoring Program (GDEMP) is proposed and will be implemented during the operations of the Project. Section 5.4 provides the scope and objectives of the proposed GDEMP.

3.1.3.5 Other Groundwater Users

The nearest identified groundwater users include the Old Mount Bundey Station/Quarry, Goanna Park and McKinlay River Station. All of these users are located greater than 5 km in distance from the Project areas and therefore their groundwater supplies are unlikely to be affected by the Project activities.

3.1.4 Conceptual Hydrogeological Model for the Rustlers Roost Site

While there is limited available data from which to develop a detailed conceptual hydrogeological model, a conceptual site model for Rustlers Roost has been developed to illustrate potential surface and groundwater interaction for the Project area (Figure 3-7).

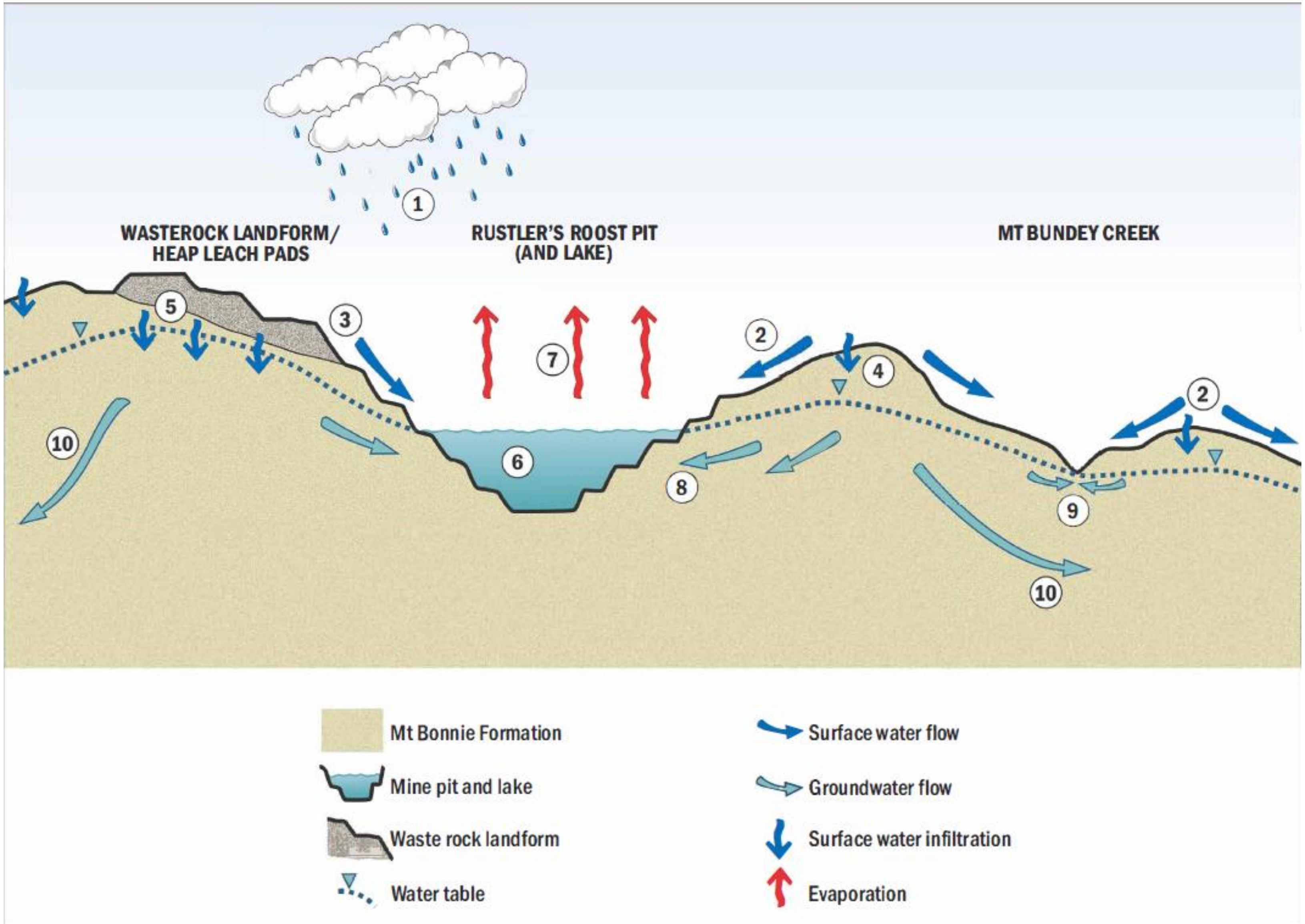


Figure 3-7 Conceptual hydrogeological model for the Rustlers Roost site

The following describes the essential elements of the preliminary conceptualisation:

① - Wet season rainfall generates surface water runoff (sheet and stream flow) and groundwater recharge

② - Runoff to local catchments, the Rustler's Roost pit lake and Annie's Dam[2].

③ - Seasonal runoff from waste rock[3] (to northern creek and mine pit) and heap leach pads[4] (to Mt Bonny Creek/ Mount Bundey Creek).

④ - Rainfall infiltration and recharge.

⑤ - Infiltration of water from waste materials and leach pads to underlying groundwater system.

⑥ - Pit lake formed from groundwater discharge to former mine pit, incident rainfall and seasonal runoff.

⑦ - Evaporative losses from pit lake maintain a dynamic steady state pit lake level (seasonal fluctuations).

⑧ - Groundwater discharge to pit lake.

⑨ - Possible seasonal groundwater discharge to creeks (reliant on water table rise due to seasonal recharge).

⑩ - Deep regional groundwater flow toward Mary River (Rustler's Roost catchment) and the catchment to the northeast of the Site (Marrakai Creek – Adelaide River).

3.2 Surface and Groundwater Quality and Monitoring

Surface and groundwater quality monitoring has been undertaken over several years within the scope of the existing Mine Management Plan for care and maintenance activities at the Rustlers Roost and Quest 29 sites. Figure 3-8 provides an overview of the existing surface water and groundwater monitoring locations within the 'upstream' Project area and Figure 3-9 provides the 'downstream' reach of Mount Bundey Creek, where regular monitoring has been undertaken for several years for the Toms Gully Mine. The proposed 'downstream' monitoring locations is shown in Figure 3-10.

3.2.1 Surface Water Quality Monitoring Sites

Rustlers Roost Marrakai Creek Catchment – Adelaide River

Table 3-4 identifies the two surface water monitoring sites within the Marrakai Creek catchment. Both sites are located in the Project area (Figure 3-8).

Table 3-4 Rustlers Roost – Marrakai Creek Catchment – Surface Water Monitoring Locations

Site Name	Latitude	Longitude	Location Description
SW6	-12.923545	131.489554	Spill way proximal to Annie's Dam

[2] Annie's Dam is located in a separate catchment (Marrakai Creek) to the pit lake and Mt Bonny Creek (Mount Bundey Creek)
[3] Northern side of waste rock landform drains to separate catchment (Mount Bundey Creek)
[4] Waste rock landform and heap leach pads are not integrated as shown on schematic

Site Name	Latitude	Longitude	Location Description
SW7	-12.922619	131.48726	Downstream from Annie's Dam nearby lower pond in an unnamed tributary of the Marrakai Creek

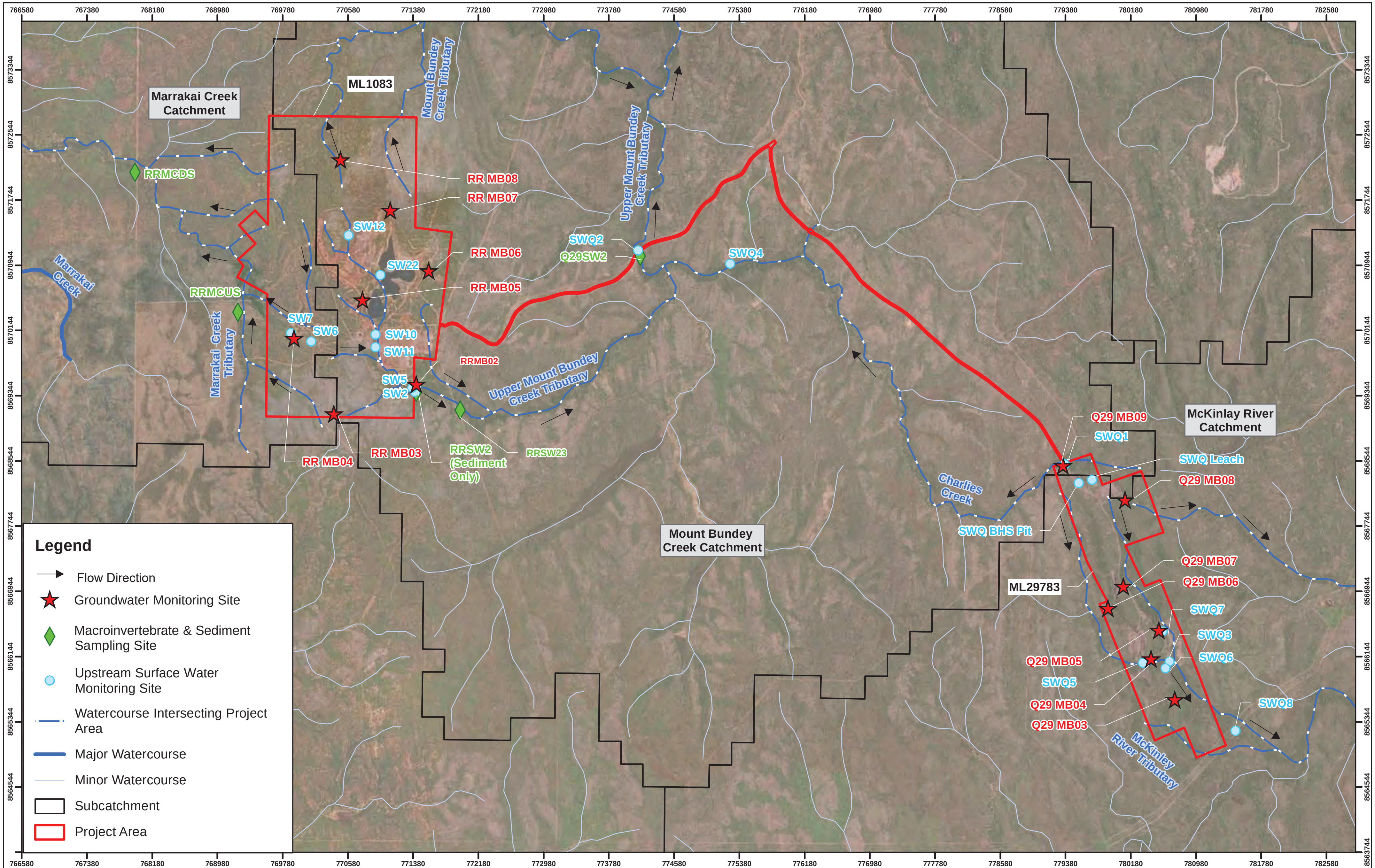
Rustlers Roost Mount Bundey Creek Catchment – Mary River

Table 3-5 identifies the seven surface water monitoring sites within the upper Mount Bundey Creek catchment in proximity to the Rustlers Roost portion of the Project. One site is outside the Project area approximately 7 km down-stream from the mining lease boundary. Most of the other sites are within the Project area with some being just outside on pastoral land (Figure 3-8).

Table 3-5 Rustlers Roost Mount Bundey Creek Catchment Surface Water Sampling Locations

Site name	Latitude	Longitude	Location description
SW2	-12.928670	131.501560	Creek line to the east of southern heap leach pond
SW5	-12.928539	131.501017	Southern heap leach pond
SW10	-12.922680	131.496812	ROM drainage before influence from heap leach
SW11	-12.924117	131.496836	Downstream from SW10 in drainage line at base of heap leach pad
SW12	-12.911724	131.493673	Northern drainage of WRD
SW22	-12.915881	131.497434	Pit lake western side
SWQ2	-12.913087	131.526381	Mount Bundey Creek culvert crossing, approximately 500m downstream of confluence with Quest29 drainage line

Surface water monitoring sites have been sampled with changing frequency and intensity since at least 2011.



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-	-	-
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DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	26/08/21

Notes:

N

0 455 910 1,820
Meters
1 cm = 419 meters
GCS GDA 1994 MGA Zone 52

DISCLAIMER
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DATA SOURCE
QLD Government Open Source Data

DESIGNER
CDM Smith

CLIENT
PRIMARY GOLD

FIGURE 3-8

Existing and Proposed Upstream Surface Water and Groundwater Monitoring Sites

DRG Ref: 1001087-EIS-07-7.31

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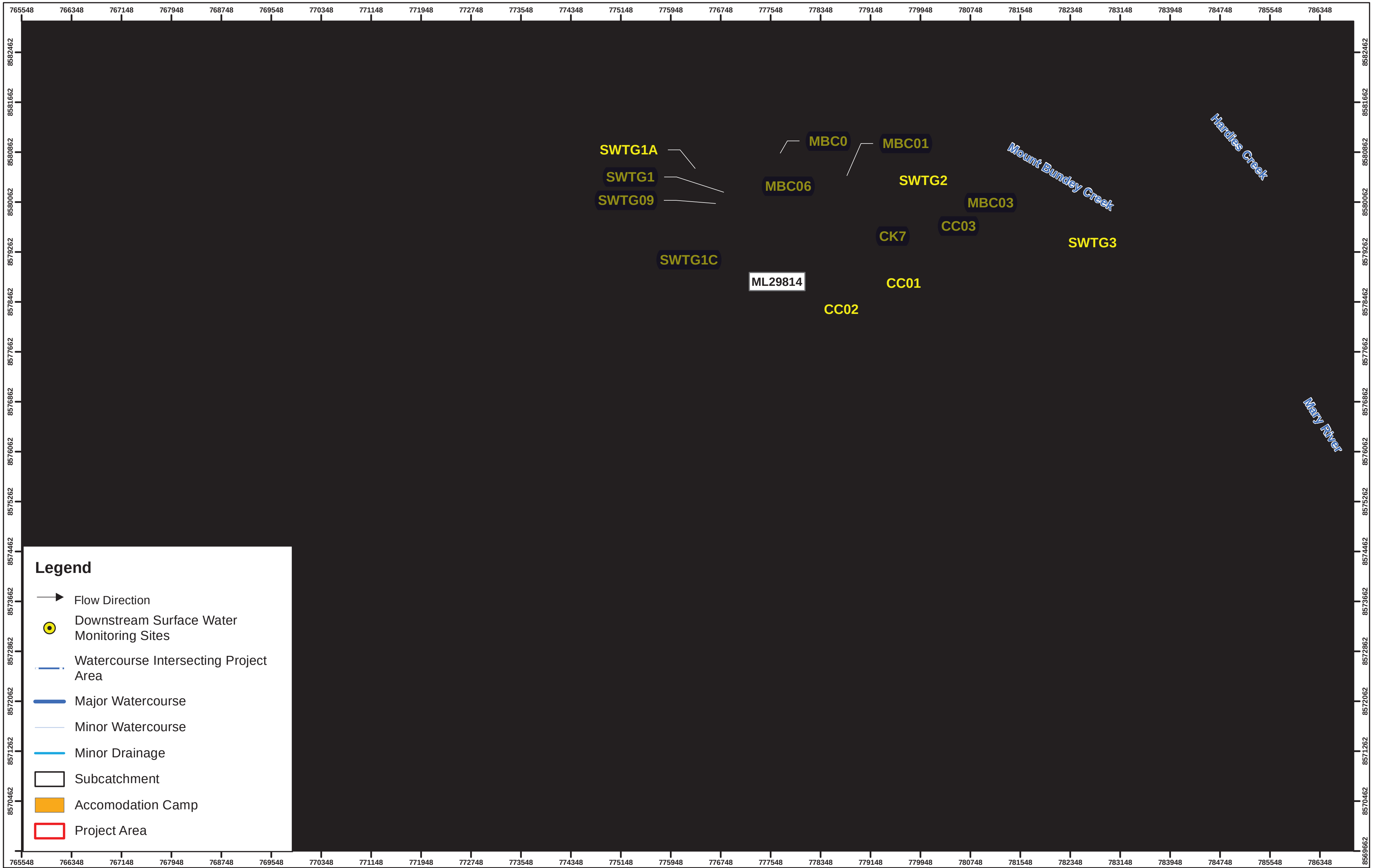

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DATA SOURCE
QLD Government Open Source Data

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FIGURE 3-9

Existing Downstream Surface Water Monitoring Sites

DRG Ref: 1001087-EIS-07-7.32

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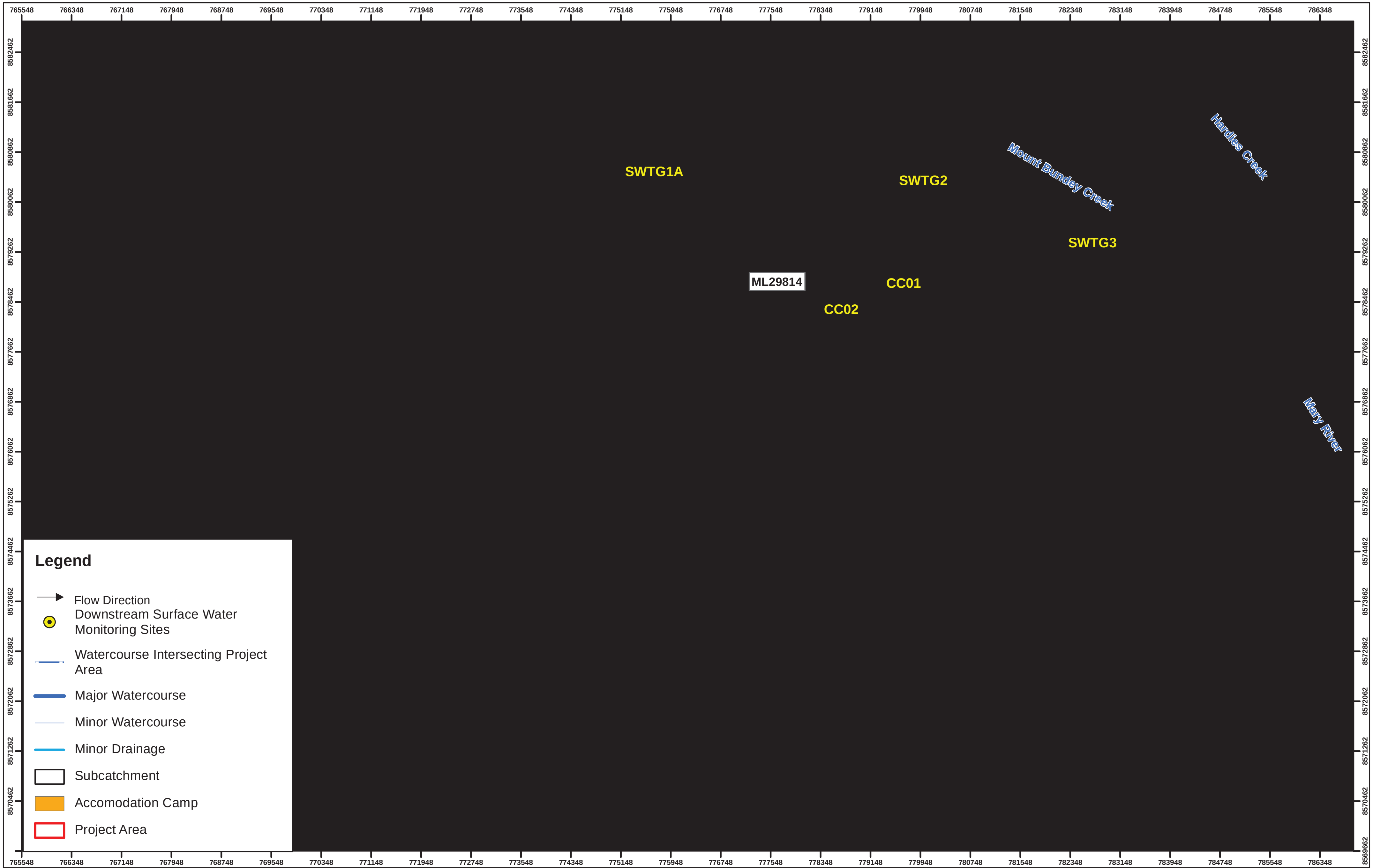

R	Details	Date
1	Final	27/09/21
-	-	-
-	-	
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-	-	
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DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	27/09/21

Notes:

DISCLAIMER
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DATA SOURCE
NT Government Open Source Data

DESIGNER
CDM Smith

CLIENT
PRIMARY GOLD

FIGURE 3-10

Proposed Downstream Surface Water Monitoring Sites

DRG Ref:

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Quest 29 – Mount Bundey Creek Catchment – Mary River

Table 3-6 identifies the five surface water monitoring sites within the Mount Bundey Creek catchment relevant to the Quest 29 portion off the Project. Three sites are located within the Project area and two are outside, with one site (SWQ4) approximately 6 km downstream in Mount Bundey Creek. The second surface water sampling site (SWQ2) is further downstream at the haul road crossing of Mount Bundey Creek (Figure 3-8).

Table 3-6 Quest 29 Mount Bundey Creek Catchment – Surface Water Monitoring Locations

Site name	Latitude	Longitude	Location description
SWQ1	-12.936324	131.574809	Charlies Creek, north of BHS pit at culvert crossing
SWQ2	-12.913087	131.526381	Mount Bundey Creek culvert crossing, approximately 500m downstream of confluence with Rustlers Roost creek line
SWQ4	-12.914471	131.536777	Mount Bundey Creek, approximately 6 km downstream from Quest 29 lease, upstream from Rustlers Roost creek line confluence
SWQ Leach	-12.938021	131.577894	Quest 29 lower leach pond
SWQ BHS Pit	-12.938386	131.576396	BHS pit lake

Surface water monitoring sites have been sampled with changing frequency and intensity since at least 2011.

Quest 29 – McKinlay River Catchment – Mary River

Table 3-7 identifies the five surface water monitoring sites within the McKinlay River catchment. Four sites are located within the Project area and one site (SWQ8) is roughly 170 m south-east of the Project area (Figure 3-8).

Table 3-7 Quest 29 McKinlay River Catchment – Surface Water Monitoring Locations

Site name	Latitude	Longitude	Location description
SWQ3	-12.958068	131.586851	Zamu pit
SWQ5	-12.958234	131.583856	Northern Taipan pit bund
SWQ6	-12.958795	131.586416	Small drain downstream of Zamu pit after confluence from SWQ3 and SWQ5
SWQ7	-12.954703	131.586032	Small drainage line upstream of Zamu pit
SWQ8	-12.965656	131.594375	Further downstream from SWQ6, approx. 200 m outside of Quest 29 lease boundary

Surface water monitoring sites have been sampled with changing frequency and intensity since at least 2011.

Proposed Accommodation Camp – Coulter Creek – Mary River Catchment

Table 3-8 identifies two surface water quality monitoring sites downstream of the proposed accommodation camp location in Coulter Creek, a tributary to Mount Bundey Creek (Figure 3-9).

Table 3-8 Proposed accommodation camp – Coulter Creek surface water monitoring sites

Site name	Latitude	Longitude	Location description
CC02	-12.847370	131.563955	Coulter Creek approximately 500 m downstream from accommodation camp boundary
CC01	-12.843499	131.573087	Coulter Creek approximately 1.5 km downstream form CC02 outside of mining lease

Surface water monitoring sites have been sampled with changing frequency and intensity since at least 2016.

Tom's Gully mine – Lower Mount Bundey Creek – Mary River Catchment

Table 3-9 identifies the three surface water monitoring sites within the lower Mount Bundey Creek. While more sites have been sampled for aquatic ecosystem monitoring requirements at Tom's Gully mine project, only these three sites provided Project relevant baseline data for current Mount Bundey Creek water quality in this area (SWTG1A, SWTG2 and SWTG3). Therefore, these sites are in close proximity and downstream from the mine. The furthest upstream site (SWTG1A) is also approximately 20 km downstream from the Rustlers Roost and Quest 29 Project area (Figure 3-9).

Table 3-9 Tom's Gully Mine – Relevant Lower Mount Bundey Creek Surface Water Monitoring Sites

Site name	Latitude	Longitude	Location description
SWTG1A	-12.828336	131.545764	Mount Bundey Creek upstream of mine at lease boundary.
SWTG2	-12.828622	131.574529	Mount Bundey Creek at Arnhem Highway Crossing.
SWTG3	-12.837374	131.599889	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek.

Surface water monitoring sites have been sampled with changing frequency and intensity since at least 2016.

3.2.2 Groundwater Quality Monitoring Sites

Three historical monitoring bores exist within the Project area, with one at Rustlers Roost and two at Quest 29. Bore MB01 at Rustlers Roost is to the south of the heap leach pad, between the pad and the leach ponds (Figure 3-8). The Quest 29 bores are located in the northern section of the Project area between the DHS pit and the leach pad and leach ponds (Q29MB01 and Q29MB02) (Figure 3-8). Due to the lack of historic groundwater monitoring bores in the Project area, knowledge of historic groundwater quality is deficient.

For future monitoring and to improve understanding of current groundwater quality, additional monitoring bores were constructed in 2020 in the Rustlers Roost and Quest 29 portions of the Project area. The relevant technical data for these bores are presented in Table 3-10 and the location of these is shown in Figure 3-8.

Table 3-10 Current Groundwater Monitoring Bores

Bore Name	Latitude	Longitude	Depth (m)	Screened Interval (m)	Yield (l/s)
Rustlers Roost					
RR MB02	-12.928138	131.501481	39	27-36	1
RR MB03	-12.931479	131.492211	70	44-56	1
RR MB04	-12.923166	131.487615	70	41-47	1
RR MB05	-12.918846	131.49531	70	55-67	1

Bore Name	Latitude	Longitude	Depth (m)	Screened Interval (m)	Yield (l/s)
RR MB06	-12.915522	131.502737	70	55-67	1
RR MB07	-12.908878	131.498342	68	56-65	1
RR MB08	-12.903331	131.492669	70	61-67	1
Quest 29					
Q29 MB03	-12.962217	131.587492	52	24-51	1
Q29 MB04	-12.957727	131.584775	54	40-52	1
Q29 MB05	-12.954557	131.585617	54	24-36	1
Q29 MB06	-12.952175	131.579835	54	19-37	1
Q29 MB07	-12.949718	131.58156	54	25-31	0.5
Q29 MB08	-12.940141	131.581646	53	46-52	0.5
Q29 MB09	-12.936416	131.574607	58	22-31	1

The water quality at the new groundwater monitoring bores has been sampled monthly over a six month period in 2020/2021.

3.2.3 Surface Water Quality

Surface water quality has been influenced by previous land uses such as pastoral uses and mining activities with legacy related water quality issues arising from pit lakes, WRD, and heap leach pads and ponds. The water quality results from data collected between 2011 and 2021 were compared to the ANZG (2018) guidelines default trigger values for physical and chemical stressors in tropical Australia in slightly disturbed ecosystems and the CSIRO Review of Site-Specific Trigger Values (SSTV) for Tom's Gully Mine (Stauber and Batley 2018) (refer to Appendix A). The ANZG (2018) water quality guidelines outline the process for using SSTV based on circumstances where background concentrations cannot be measured at a site due to existing disturbance, or where measurement at an equivalent reference site is deemed to match closely the geology or natural water quality of the site of interest. If the background concentration has been clearly established and it exceeds the 95% trigger value, the 80th percentile of the background concentration as described in the ANZG (2018) guidelines can be accepted as the SSTV for the relevant WQ sites.

This section outlines the water quality from the relevant surface water monitoring sites for Upstream (Rustlers Roost and Quest 29) and downstream (Toms Gully) sites. Baseline monitoring has been conducted throughout all seasons over a 10 year period. However, not all of the sites were sampled with the same intensity. Water sampling sites included water bodies associated with mining activities, like pit lakes and leach ponds and in creek & drainage lines. The different hydrological properties of the sampling sites may present large value variations for individual parameters between sites. For example, water quality in creek and drainage lines is highly dependent from flow caused by rainfall, whereas some of the permanent water structures may also be affected by accumulation of contaminants from runoff and evaporation during dry season.

3.2.3.1 Rustlers Roost Site Specific Analytes Results

Relevant surface water quality parameters compared against ANZG (2018) 95% species protection, Toms Gully (TG) SSTV 80% and stock water quality guidelines for each of the monitoring sites for Rustlers Roost are shown in Table 3-11 to Table 3-19.

The surface water quality summary of the main water bodies and downstream sites within each receiving catchment are shown in Table 3-20 and Table 3-21 below.

Table 3-11 Analytes summary Rustlers Roost Site SW2

RRSW2	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	19	5.5	11	51	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.05	0.20	0.01
Max	160	7.4	899	115	0.44	0.073	0.0001	0.004	0.007	0.002	0.001	0.207	0.002	0.01	0.001	1	0.03	1.5	2.30	0.32
Mean	90	6.5	107	75	0.116	0.022	0.0001	0.002	0.0028	0.0013	0.001	0.0534	0.001	0.01	0.001	0.75	0.007	0.38	0.68	0.08
Median	91	6.5	23	71.6	0.11	0.011	0.0001	0.001	0.002	0.001	0.001	0.0355	0.001	0.01	0.001	0.75	0.005	0.28	0.40	0.04
SD	45	0.48	264	23	0.1201	0.025	0	0.0012	0.0022	0.0005	0	0.0535	0.001	0	0	0.2611	0.008	0.43	0.80	0.12
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 12
Data Collected between: 28-Nov-2016 and 14-May-2021

Table 3-12 Analytes summary Rustlers Roost Site SW5

RRSW5	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	13	6.3	3.5	55.6	0.01	0.002	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.5	0.001	0.01	0.6	0.01
Max	313.3	8.2	720	75	0.09	0.024	0.0001	0.001	0.001	0.004	0.002	0.18	0.002	0.01	0.001	1	0.19	0.47	1.7	0.04
Mean	160.11	7.379	83.274	65.8667	0.0243	0.0109	0.0001	0.001	0.001	0.0014	0.0011	0.0643	0.0012	0.0064	0.001	0.625	0.0254	0.1359	1.2667	0.03
Median	150	7.56	13.9	67	0.01	0.0105	0.0001	0.001	0.001	0.001	0.001	0.0055	0.001	0.01	0.001	0.5	0.005	0.076	1.5	0.04
SD	99.8601	0.6544	223.8078	9.7495	0.0273	0.0077	0	0	0	0.001	0.0003	0.0773	0.0004	0.0049	0	0.2261	0.054	0.1404	0.5859	0.0173
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 12
Data Collected between: 22-Aug-2012 and 29-Apr-2021

Table 3-13 Analytes summary Rustlers Roost Site SW6

RRSW6	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	10	5.46	4	63.5	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.5	0.001	0.14	0.4	0.01
Max	25	6	46.8	63.5	0.22	0.002	0.0001	0.001	0.001	0.002	0.001	0.023	0.001	0.01	0.001	1	0.026	0.21	0.4	0.01
Mean	14.7	5.74	22.7	63.5	0.0846	0.0014	0.0001	0.001	0.001	0.0014	0.001	0.0168	0.001	0.0055	0.001	0.6	0.0092	0.178	0.4	0.01
Median	11.9	5.75	20	63.5	0.05	0.001	0.0001	0.001	0.001	0.001	0.001	0.018	0.001	0.0055	0.001	0.5	0.003	0.19	0.4	0.01
SD	7.0965	0.2525	19.537		0.0843	0.0005	0	0	0	0.0005	0	0.0074	0	0.0064		0.2236	0.0111	0.0277		
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 5
Data Collected between: 09-Dec-2012 and 03-Feb-2021

Table 3-14 Analytes summary Rustlers Roost Site SW7

RRSW7	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	11	4.3	2.2	55.5	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.05	1	0.01
Max	49	6.43	28	62.8	0.12	0.001	0.0001	0.001	0.003	0.001	0.001	0.794	0.001	0.01	0.001	1	0.006	0.41	1.2	0.01
Mean	25.7	5.9727	10.8818	58.5333	0.0364	0.001	0.0001	0.001	0.0015	0.001	0.001	0.4169	0.001	0.01	0.001	0.6364	0.0026	0.1227	1.1333	0.01
Median	26	6.2	4.8	57.3	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.47	0.001	0.01	0.001	0.5	0.001	0.08	1.2	0.01
SD	12.0478	0.5876	10.6203	3.8031	0.042	0	0	0	0.0007	0	0	0.2626	0	0	0	0.2335	0.0021	0.1085	0.1155	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 11
Data Collected between: 20-Dec-2016 and 29-Apr-2021

Table 3-15 Analytes summary Rustlers Roost Site SW10

RRSW10	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	8	5.77	12.7	47.6	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.05	0.4	0.01
Max	55	7.1	860	66	0.05	0.008	0.0001	0.001	0.001	0.002	0.001	0.095	0.002	0.01	0.001	1	0.006	0.52	0.4	0.02
Mean	30.08	6.312	200.68	56.8	0.026	0.0028	0.0001	0.001	0.001	0.0012	0.001	0.0338	0.0012	0.01	0.001	0.7	0.0036	0.212	0.4	0.015
Median	30.2	6.1	44	56.8	0.02	0.002	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.005	0.21	0.4	0.015
SD	16.9945	0.5353	369.4089	13.0108	0.0182	0.0029	0	0	0	0.0004	0	0.0414	0.0004	0	0	0.2739	0.0024	0.1899	0	0.0071
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 5
Data Collected between: 20-Dec-2016 and 29-Apr-2021

Table 3-16 Analytes summary Rustlers Roost Site SW11

RRSW11	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	21	5.32	2.8	19.7	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.04	0.2	0.01
Max	82	7.3	610	50.9	0.08	0.014	0.0001	0.001	0.004	0.002	0.001	0.65	0.001	0.01	0.001	1	0.005	1.01	0.3	0.01
Mean	45.0636	6.2073	124.5027	34.68	0.0218	0.0043	0.0001	0.001	0.0022	0.0013	0.001	0.2543	0.001	0.01	0.001	0.7273	0.0031	0.2655	0.22	0.01
Median	42.6	6.2	11	33.9	0.01	0.003	0.0001	0.001	0.002	0.001	0.001	0.283	0.001	0.01	0.001	0.5	0.003	0.12	0.2	0.01
SD	19.762	0.5767	196.0246	13.9518	0.0218	0.0039	0	0	0.0013	0.0005	0	0.2459	0	0	0	0.2611	0.0019	0.3264	0.0447	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 11
Data Collected between: 28-Nov-2016 and 14-May-2021

Table 3-17 Analytes summary Rustlers Roost Site SW12

RRSW12	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	10	4.46	4.98	65	0.05	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.05	0.1	0.01
Max	17.3	6.1	47	85.5	0.14	0.001	0.0001	0.001	0.001	0.001	0.001	0.018	0.001	0.01	0.001	1	0.005	0.15	0.3	0.01
Mean	13.78	5.342	24.99	75.25	0.09	0.001	0.0001	0.001	0.001	0.001	0.001	0.0112	0.001	0.01	0.001	0.7	0.003	0.102	0.2	0.01
Median	14	5.4	24	75.25	0.07	0.001	0.0001	0.001	0.001	0.001	0.001	0.008	0.001	0.01	0.001	0.5	0.002	0.12	0.2	0.01
SD	2.6461	0.604	19.3641	14.4957	0.0464	0	0	0	0	0	0	0.0063	0	0	0	0.2739	0.0019	0.0444	0.1414	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 5
Data Collected between: 20-Dec-2016 and 08-Mar-2021

Table 3-18 Analytes summary Rustlers Roost Site SW22

RRSW22	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	21	6.4	0.7	73	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.5	0.001	0.01	0.1	0.01
Max	27.3	7.59	9.6	95.8	0.02	0.001	0.0001	0.001	0.001	0.001	0.001	0.014	0.001	0.01	0.001	1	0.027	0.05	0.7	0.01
Mean	24.0556	6.9533	3.0862	85.9667	0.0109	0.001	0.0001	0.001	0.001	0.001	0.001	0.0054	0.001	0.0064	0.001	0.6364	0.0077	0.022	0.3	0.01
Median	24	7	2.35	89.1	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.005	0.01	0.1	0.01
SD	2.1119	0.3867	2.82	11.7185	0.003	0	0	0	0	0	0	0.0032	0	0.0049	0	0.2335	0.0085	0.0182	0.3464	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 11
Data Collected between: 22-Aug-2012 and 29-Apr-2021

Table 3-19 Analytes summary Rustlers Roost Site SWQ2

SWQ2	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	16	5.91	9.1	60.5	0.06	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.11	0.2	0.01
Max	46.1	7.44	1500	91	0.52	0.002	0.0001	0.002	0.001	0.0016	0.001	0.06	0.001	0.01	0.001	1	0.01	1.39	0.8	0.1
Mean	32.2875	6.585	167.2933	75.35	0.1713	0.0011	0.0001	0.0012	0.001	0.001	0.001	0.0158	0.001	0.01	0.001	0.6875	0.0039	0.3757	0.3833	0.0317
Median	33.5	6.6	52	77.65	0.125	0.001	0.0001	0.001	0.001	0.001	0.001	0.0095	0.001	0.01	0.001	0.5	0.005	0.32	0.35	0.02
SD	8.725	0.4218	379.0283	11.4089	0.1233	0.0003	0	0.0004	0	0.0001	0	0.0154	0	0	0	0.25	0.0029	0.3105	0.2229	0.0349
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 16
Data Collected between: 29-Mar-2016 and 06-May-2021

Baseline Water Quality Summary at Rustlers Roost for Marrakai Creek Catchment

Table 3-20 Baseline Marrakai Creek Catchment Water Quality Parameters

Parameter	Water quality summary
Electrical Conductivity (EC)	Low EC average (20 µS/cm) has been recorded for times with significant flow. The range was between 10 to 49 µS/cm for the recorded sampling occasions at both sites, indicating very fresh-water quality, with water quality well below the ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm.
pH Dissolved Oxygen (DO)	pH was on average 5.91 for both sides for all sampling occasions with a range of 4.3 to 6.4. There was also a low mean DO of 60 % recorded with a range of 56 to 63 %. These mean values are below ANZG (2018)) trigger values with a pH between 6-8 and a DO between 80-120 %.
Turbidity (NTU)	Turbidity levels were on average 14.0 NTU with a range between 2.7 and 46.8 NTU. The range indicates variability in turbidity in response to rainfall events. The mean NTU value is below the ANZG (2018) water quality objective of 15 NTU.
Dissolved metals	Overall, there was exceedance of the ecosystem protection guideline values (GV) for dissolved metals for some of the sampling occasions (Aluminium (Al), Zinc (Zn), Copper (Cu)), with a maximum measured value of 0.22 mg/L for dissolved Al, 0.026 mg/L for Zn and 0.002 mg/L for Cu. ANZG (2018) default trigger values for these metals are 0.055 mg/L for Al, 0.008 mg/L for Zn and 0.0014 mg/L for Cu.[5]
Nutrients	In general, total nitrogen levels (TN) had a mean value of 0.95 mg/L with a range between 0.4 mg/L and 1.2 mg/L. The results show an exceedance of the trigger values for TN set by the ANZG (2018) guidelines (0.2 mg /L). Total phosphorus (TP) levels have been consistently below the ANZG (2018) trigger values of 0.001 mg/L.

Overall, the water quality at the Annie's dam spillway (SW6) and downstream of the spillway within Marrakai Creek (SW7) has been within ANZG (2018) guidelines for most of the water quality parameters, with pH and DO readings below ANZG (2018) trigger values and occasional exceedance of ecosystem protection GVs for some dissolved metals (Al, Zn, Cu). It is expected that the sub-neutral pH conditions in streams and rainfall facilitate the mobilisation of metals from minerals in natural and mine impacted soils and rocks. Elevated concentrations of aluminium in the region is known and currently assumed to reflect influences from the natural geology. The acidic pH value of 4.3 was recorded during December 2016 and may be attributed to a first flush event. This indicates that water quality may be influenced by past mining activities. The elevated Total Nitrogen levels may be connected to the existing pastoral use and free roaming cattle within the Project area and surrounding lands that drain into the watercourse.

[5] Aluminium toxicity to aquatic organisms in freshwater may be dependent from co-factors like pH, water hardness and water temperature. pH appears to have the greatest effect, as aluminum is more toxic in both acidic and alkaline waters. Therefore, the ANZG (2018) guidelines apply different aluminum default values for protecting aquatic ecosystems. A freshwater moderate reliability trigger value of 0.055mg/L was derived for aluminium at pH >6.5 using with 95% protection. A freshwater low reliability trigger value of 0.0008 mg/L was derived for aluminium at pH <6.5. The low reliability figures should only be used as indicative interim working levels. For the purpose of consistency and due to the recorded fluctuation of pH in the collected water samples the default trigger value of 0.055 mg/l for a pH >6.5 was chosen for this report across all locations.

Baseline Water Quality at Rustlers Roost for Mount Bundey Creek Catchment

Table 3-21 Baseline Mount Bundey Creek Catchment Water Quality Parameters - Upstream

Parameter	Water quality summary
Electrical Conductivity (EC)	Low EC average (71 µS/cm) has been recorded in the permanent water bodies and during times of flow. The range was between 8 to 313 µS/cm for the recorded 46 sampling occasions at all six sites. SW5 exceeded the ANZG (2018) trigger value for aquatic ecosystems of 250 µS/cm on two sampling occasions (300 and 313 µS/cm). The SW5 location is at the southern heap leach pond. The high EC values were recorded during the dry season and may be related to evapoconcentration and lack of freshwater inflow into the pond.
pH Dissolved Oxygen (DO)	pH was on average 6.5 for all sites and all 46 occasions with a large range of 4.5 to 8.0. SW12 consistently showed pH levels below the ANZG (2018) trigger values between 6-8. SW12 receives runoff from the existing WRD. A low mean DO of 71 % was recorded with a range of 20 to 115 %. The mean value is below the ANZG (2018) trigger values for DO between 80-120%. The lowest DO levels were measured at SW11 with a range between 20 and 51 %.
Turbidity (NTU)	Turbidity levels were on average 102.8 NTU with a range between 0.7 and 899.0 NTU with SW2 showing the highest turbidity values. The range indicates the variability in turbidity may depend on rainfall events prior to sampling. The mean NTU values are above the ANZG (2018) water quality objective of 15 NTU.
Dissolved metals	Overall, there are occasional exceedances of the ecosystem protection GVs for dissolved metals, with a maximum measured value of 0.44 mg/L for Al at SW2, 0.073 mg/L for Arsenic (As) at SW2, 0.004 mg/L for Chromium (Cr) at SW2 and 0.15 mg/L Zn at SW5. ANZG (2018) trigger values for these metals are 0.055 mg/L for Al, 0.013 mg/L for As, 0.001 mg/L for Cr and 0.008 mg/L for Zn.
Nutrients	In general, TN levels had a mean value of 0.62 mg/L, with a range between 0.1 and 2.3 mg/L with the maximum at SW2. TP was 0.07 mg/L, with a range between < 0.01 and 0.32 mg/L with the maximum recorded also at SW2. Mean TN and TP was in exceedance of the ANZG (2018) trigger values (TN 0.2 mg/L, TP 0.01 mg/L).

Overall, the water quality in the upstream section of Mount Bundey Creek tributaries has been within ANZG (2018) limits for most of the parameters, sites and sampling. However, exceedance for some values (e.g. pH, turbidity, dissolved metals and nutrients) indicates that influences on water quality are likely to come from a range of sources including storm events, natural geology as well as previous mining activities and current pastoral land use.

3.2.3.2 Quest 29 Site Specific Analytes Results

Relevant surface water quality parameters compared against ANZG (2018) 80% and 95% species protection and stock water guidelines for each of the monitoring sites for Quest29 are shown in Table 3-22 to Table 3-31.

The surface water quality summary of the main water bodies and downstream sites within each receiving catchment are shown in Table 3-32 and Table 3-33 below.

Table 3-22 Analytes Summary Quest29 Site QSW1

QSW1	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	78	5.26	2.7	38.4	0.01	0.002	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.5	0.001	0.01	0.1	0.01
Max	456	7.4	478	116	0.21	0.006	0.0001	0.001	0.0027	0.005	0.025	0.25	0.0016	0.01	0.001	1	0.0229	0.48	1.8	0.04
Mean	192.4944	6.5583	40.6441	82.6167	0.0711	0.0031	0.0001	0.001	0.0012	0.0023	0.0023	0.0612	0.001	0.01	0.001	0.6667	0.0055	0.1104	0.45	0.015
Median	161	6.6	6.4	85.25	0.0464	0.003	0.0001	0.001	0.001	0.002	0.001	0.042	0.001	0.01	0.001	0.5	0.005	0.095	0.2	0.01
SD	87.2963	0.4775	113.9467	25.4072	0.0666	0.001	0	0	0.0005	0.001	0.0057	0.0701	0.0001	0	0	0.2425	0.0052	0.1068	0.6656	0.0122
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 18

Data Collected between: 29-Mar-2016 and 27-Apr-2021

Table 3-23 Analytes summary Quest29 Site QSW2

QSW2	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	16	5.91	9.1	60.5	0.06	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.11	0.2	0.01
Max	46.1	7.44	1500	91	0.52	0.002	0.0001	0.002	0.001	0.0016	0.001	0.06	0.001	0.01	0.001	1	0.01	1.39	0.8	0.1
Mean	32.2875	6.585	167.2933	75.35	0.1713	0.0011	0.0001	0.0012	0.001	0.001	0.001	0.0158	0.001	0.01	0.001	0.6875	0.0039	0.3757	0.3833	0.0317
Median	33.5	6.6	52	77.65	0.125	0.001	0.0001	0.001	0.001	0.001	0.001	0.0095	0.001	0.01	0.001	0.5	0.005	0.32	0.35	0.02
SD	8.725	0.4218	379.0283	11.4089	0.1233	0.0003	0	0.0004	0	0.0001	0	0.0154	0	0	0	0.25	0.0029	0.3105	0.2229	0.0349
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 16

Data Collected between: 29-Mar-2016 and 06-May-2021

Table 3-24 Analytes summary Quest29 Site QSW3

QSW3	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	29	4.4	3.2		0.02	0.0078	0.0001		0.001	0.001	0.001	0.001	0.001			0.5	0.001	0.05		
Max	74	7.37	120		0.38	0.28	0.0001		0.001	0.002	0.021	0.0221	0.0012			0.5	0.0085	0.224		
Mean	58	6.7733	35.24		0.1583	0.1661	0.0001		0.001	0.0017	0.0043	0.0069	0.001			0.5	0.0028	0.119		
Median	63	7.2	18		0.14	0.199	0.0001		0.001	0.002	0.001	0.005	0.001			0.5	0.0015	0.115		
SD	15.4402	1.1692	47.7963		0.1309	0.1288	0		0	0.0005	0.0082	0.0076	0.0001			0	0.0029	0.0598		
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 6

Data Collected between: 29-Mar-2016 and 06-Apr-2020

Table 3-25 Analytes summary Quest29 Site QSW4

QSW4	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	12	5.7	13.8	78.5	0.04	0.001	0.0001	0.001	0.001	0.001	0.001	0.004	0.001	0.01	0.001	0.5	0.001	0.1	0.1	0.01
Max	64	7.07	1300	105.9	0.34	0.002	0.0001	0.001	0.001	0.001	0.008	0.042	0.001	0.01	0.001	1	0.006	1.16	0.6	0.07
Mean	34.4769	6.3046	154.0846	92.75	0.16	0.0011	0.0001	0.001	0.001	0.001	0.0015	0.0162	0.001	0.01	0.001	0.7308	0.0032	0.3062	0.2833	0.025
Median	34.7	6.6	54	96.55	0.17	0.001	0.0001	0.001	0.001	0.001	0.001	0.015	0.001	0.01	0.001	0.5	0.005	0.25	0.25	0.01
SD	12.5408	0.5073	348.4979	10.6393	0.1069	0.0003	0	0	0	0	0.0019	0.012	0	0	0	0.2594	0.0022	0.269	0.1722	0.0251
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 13

Data Collected between: 20-Dec-2016 and 29-Apr-2021

Table 3-26 Analytes summary Quest29 Site QSW5

QSW5	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	24	6.3	1.3	54.7	0.02	0.002	0.0001	0.001	0.001	0.001	0.001	0.0039	0.001	0.01	0.001	0.5	0.001	0.03	0.1	0.01
Max	52.1	8.11	46	95.8	0.38	0.03	0.0001	0.001	0.001	0.007	0.001	0.035	0.001	0.01	0.001	1	0.023	0.23	0.3	0.05
Mean	37.4364	7.0345	14.3455	76.5667	0.0947	0.0131	0.0001	0.001	0.001	0.002	0.001	0.0091	0.001	0.01	0.001	0.6364	0.0066	0.1155	0.2	0.03
Median	37	7	8	79.2	0.07	0.009	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.005	0.09	0.2	0.03
SD	10.8941	0.5145	13.2707	20.6762	0.1045	0.0097	0	0	0	0.0018	0	0.0092	0	0	0	0.2335	0.0064	0.0641	0.1	0.02
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 11
Data Collected between: 07-Jul-2016 and 27-Apr-2021

Table 3-27 Analytes summary Quest29 Site QSW6

QSW6	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	27.4	6.08	3.3	66.5	0.01	0.003	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.5	0.001	0.03	0.1	0.01
Max	53.7	6.8	44	89.7	0.49	0.015	0.0001	0.001	0.001	0.004	0.001	0.089	0.002	0.01	0.001	1	0.024	0.22	0.3	0.02
Mean	36.6364	6.5218	19.054	77.68	0.1409	0.0085	0.0001	0.001	0.001	0.0014	0.001	0.0185	0.0011	0.01	0.001	0.7273	0.0056	0.1155	0.2	0.012
Median	32	6.53	18	77.2	0.11	0.008	0.0001	0.001	0.001	0.001	0.001	0.008	0.001	0.01	0.001	0.5	0.005	0.1	0.2	0.01
SD	9.8843	0.2214	11.6408	10.5651	0.1274	0.0037	0	0	0	0.0009	0	0.027	0.0003	0	0	0.2611	0.0064	0.0534	0.0707	0.0045
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 11
Data Collected between: 20-Dec-2016 and 27-Apr-2021

Table 3-28 Analytes summary Quest29 Site QSW7

QSW7	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	19	6	2.7	112.6	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.5	0.001	0.05	0.3	0.01
Max	80.9	7.75	66	167.2	0.47	0.014	0.0001	0.001	0.001	0.003	0.001	0.23	0.001	0.01	0.001	1	0.005	0.32	0.3	0.03
Mean	58.875	6.9875	26	139.9	0.1212	0.0075	0.0001	0.001	0.001	0.0014	0.001	0.0351	0.001	0.01	0.001	0.625	0.0026	0.16	0.3	0.02
Median	65.05	7.15	17.9	139.9	0.08	0.006	0.0001	0.001	0.001	0.001	0.001	0.0065	0.001	0.01	0.001	0.5	0.0015	0.13	0.3	0.02
SD	18.4542	0.5489	21.7901	38.608	0.1466	0.0042	0	0	0	0.0007	0	0.0789	0	0	0	0.2315	0.002	0.084	0	0.0141
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 8
Data Collected between: 20-Dec-2016 and 03-Feb-2021

Table 3-29 Analytes summary Quest29 Site QSW8

QSW8	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	20	4.1	9.41	45.7	0.02	0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.001	0.01	0.001	0.5	0.001	0.08	0.1	0.01
Max	124	7.12	67	102.4	0.41	0.008	0.0001	0.001	0.001	0.001	0.001	0.083	0.001	0.01	0.001	1	0.007	0.26	0.4	0.01
Mean	60.0143	6.24	26.7683	75.7	0.1286	0.0059	0.0001	0.001	0.001	0.001	0.001	0.0356	0.001	0.01	0.001	0.8571	0.0047	0.18	0.22	0.01
Median	34	6.51	16.15	77	0.05	0.007	0.0001	0.001	0.001	0.001	0.001	0.023	0.001	0.01	0.001	1	0.005	0.19	0.1	0.01
SD	44.4559	0.9875	22.5489	21.48	0.1402	0.0025	0	0	0	0	0	0.0302	0	0	0	0.244	0.0018	0.0668	0.1643	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 7
Data Collected between: 20-Dec-2016 and 27-Apr-2021

Table 3-30 Analytes summary Quest29 Site QSW BHS pit

QSW BHS Pit	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	220	6.34	0.5	71.4	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.0007	0.01	0.001	0.5	0.001	0.006	0.1	0.01
Max	510	8.31	35	90.1	0.15	0.007	0.0003	0.001	0.001	0.0052	0.001	0.02	0.006	0.01	0.001	1	0.0452	0.07	0.6	0.01
Mean	367.4467	7.5047	8.045	83.4	0.0349	0.0029	0.0001	0.001	0.001	0.0025	0.001	0.0061	0.0016	0.01	0.001	0.6	0.0102	0.0245	0.3	0.01
Median	370	7.54	3.25	88.7	0.01	0.002	0.0001	0.001	0.001	0.002	0.001	0.005	0.001	0.01	0.001	0.5	0.005	0.01	0.2	0.01
SD	80.5013	0.4503	10.7835	10.4159	0.0407	0.0018	0.0001	0	0	0.0012	0	0.0045	0.0013	0	0	0.207	0.012	0.0206	0.2646	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 15
Data Collected between: 06-Jun-2015 and 27-Apr-2021

Table 3-31 Analytes summary Quest29 Site QSW Leach

QSW Leach	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	428.9	3.9	0.6	77.1	0.03	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.5	0.001	0.006	0.2	0.01
Max	1574	8.8	15	110.2	1.6	0.018	0.0069	0.001	0.026	0.0654	0.31	0.37	0.11	0.01	0.001	2	0.38	0.06	0.7	0.02
Mean	764.348	6.7716	3.5517	96.8	0.4892	0.0056	0.0022	0.001	0.0079	0.0192	0.0229	0.1003	0.0288	0.01	0.001	0.804	0.1198	0.0269	0.4444	0.0122
Median	737	7.21	2.465	98.4	0.11	0.004	0.0001	0.001	0.001	0.003	0.001	0.017	0.001	0.01	0.001	0.7	0.005	0.01	0.4	0.01
SD	279.5607	1.4192	3.3414	12.0346	0.5948	0.0052	0.0027	0	0.0092	0.025	0.0765	0.1334	0.0425	0	0	0.3539	0.1525	0.0204	0.1667	0.0044
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 25
Data Collected between: 06-Jun-2015 and 27-Apr-2022

Baseline Water Quality at Quest 29 for Mount Bundey Creek Catchment

Table 3-32 Baseline Mount Bundey Creek Catchment Water Quality Parameters at Quest 29

Parameter	Water quality summary
Electrical Conductivity	Low EC average (313 µS/cm) has been recorded for times with significant flow. The range was between 12 to 1,574 µS/cm for the 85 sampling occasions at all 5 sites. The mean value was above the quality objective for ANZG (2018) for aquatic ecosystems of 250 µS/cm. Water samples from the leach pond showed the highest EC values with a range between 427 and 1,574 µS/cm potentially associated with evapoconcentration and ongoing leaching from the leach pad.
pH Dissolved Oxygen (DO)	pH was on average 6.7 for all sites and all sampling occasions with a large pH range of 3.9 to 8.8 with the lowest recorded at the leach pond. There was also a low mean DO of 85 % recorded with a range of 38 to 116 %. Lowest DO was recorded for SWQ1. These mean values are within ANZG (2018) trigger values for pH (6-8) and DO (80-120 %).
Turbidity	Turbidity levels were on average 67.3 NTU with a range between 2.7 and 1,500.0 NTU. The range indicates the variability in turbidity and influence by rainfall events prior to sampling. The mean NTU values are above the ANZG (2018) water quality objective of 15 NTU. One sampling occasion on the 20/12/2016 recorded NTU in excess of 1,200 at two sites (SWQ2 and SWQ4), potentially due to significant rainfalls, skewing the mean calculation.
Dissolved metals	Overall, there was exceedance of the ecosystem protection GVs for some of the dissolved metals (Al, As, Cd, Cu, Pb, Ni, Zn) for some of the sampling occasions, with a maximum measured value of 1.6 mg/L for Al, 0.018 mg/L for As, 0.0069 mg/L for Cadmium (Cd), 0.065 mg/L for Cu, 0.31 mg/L for Lead (Pb), 0.11 mg/L for Nickel (Ni), and 0.38 mg/L for Zn. All maximum values have been recorded from the leach pond. ANZG (2018) trigger values for these metals are 0.055 mg/L for Al, 0.013 mg/L for As, 0.0002 mg/L for Cd, 0.0014 mg/L for Cu, 0.0014 mg/L for Pb, 0.011 mg/L for Ni, and 0.008 mg/L for Zn.
Nutrients	In general, TN levels had a mean value of 0.52 mg/L with a range between <0.1 mg/L and 3.8 mg/L. TP was 0.07 mg/L, with a range between < 0.01 and 0.53 mg/L. Mean TN and TP was in exceedance of the ANZG (2018) trigger values (TN 0.2 mg/L, TP 0.01 mg/L).

Seasonal influences of first-flush, storm events, residual flow and evapoconcentration are expected to result in a broad range of water quality conditions observed. High turbidity readings reflect ongoing erosion from existing disturbance on site. Elevated levels Most of the elevated dissolved metal readings have been associated with water samples taken from the SWQ Leach point between 2016 and 2018, which is the historic heap leach ponds. Overall, the water quality results in are consistent with previous mining and current pastoral activities in and surrounding the Project area.

Baseline Water Quality at Quest 29 for McKinlay River Catchment

Table 3-33 Baseline McKinlay River Catchment Water Quality Parameters at Quest 29

Parameter	Water quality summary
Electrical Conductivity (EC)	Low EC average (47 µS/cm) has been recorded for times with significant flow. The range was between 19 to 124 µS/cm for the 45 sampling occasions at all 5 sites with the recorded high at SWQ8. The mean value was below the quality objective for ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm, indicating freshwater conditions.
pH Dissolved Oxygen (DO)	pH was on average 6.8 for all sites and all sampling occasions with a large pH range of 4.4 to 8.3. A mean DO of 84 % was recorded with a range of 54 to 167 %. The mean values were within ANZG (2018) trigger values for pH (6-8) and DO (80-120 %). Lowest pH and DO values were recorded at SWQ8, a location within a tributary to McKinlay River outside of the mining lease.
Turbidity (NTU)	Turbidity levels were on average 22.0 NTU with a range between 1.2 and 120.0 NTU with the lowest recorded at SWQ3. The mean NTU values are above the ANZG (2018) water quality objective of 15 NTU.
Dissolved metals	Overall, there was exceedance of the ecosystem protection GVs for some of the dissolved metals (Al, As, Cd, Cu, Pb, Ni, Zn) for some of the sampling occasions, with a maximum measured value of 0.49 mg/L for Al at SWQ6, 0.28 mg/L for As at SWQ3, 0.07 mg/L for Cu at SWQ5, and 0.024 mg/L for Zn at SWQ6. ANZG (2018) trigger values for these metals are 0.055 mg/L for Al, 0.013 mg/L for As, 0.0014 mg/L for Cu, and 0.008 mg/L for Zn.
Nutrients	In general, TN values had a mean value of 0.45 mg/L with a range between <0.1 mg/L and 2.8 mg/L. Mean TP was 0.21 mg/L, with a range between < 0.01 and 1.54 mg/L. Mean TN and TP was in exceedance of the ANZG (2018) trigger values (TN 0.2 mg/L, TP 0.01 mg/L). Both maximum values for TN and TP were recorded at SWQ7.

The low pH and DO recorded for SWQ8 appears as an outlier in the data. The sampling location is in a creek bed outside of the Quest 29 lease but receives runoff from previously disturbed areas. Overall, the water quality results in the pit lakes, leach ponds and creeks are reflecting the hydrological properties of each sampling site. They are consistent with the ephemeral character of the creek flows, including first flush and storm events and residual flows and with impacts on water quality from disturbance due to previous mining and current pastoral lease activities in the Project area.

3.2.3.3 Accommodation Camp and Relevant Tom's Gully Water Quality Summaries

Baseline Water Quality at Tom's Gully for Lower Mount Bundey Creek Catchment

Site specific trigger values for Tom's Gully mine have been developed and are outlined in (Stauber and Batley 2018). These values represent the 80^{th} percentile related to the freshwater species protection as outlined in the ANZG (2018) guidelines for dissolved metals, EC, pH and turbidity.

Table 3-34 Baseline Water Quality at Tom's Gully for lower Mount Bundey Creek Catchment

Parameter	Water quality summary
Electrical Conductivity (EC)	Low EC average (71 µS/cm) has been recorded for times with significant flow. The range was between 11 to 385 µS/cm for the recorded sampling occasions at all three sites, indicating very fresh-water quality, with water quality well below the ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm but above the relevant Toms Gully SSTV of 41 µS/cm. SWTG2 was the only site that had readings significant exceedance of the relevant trigger values during recorded low flow periods.
pH Dissolved Oxygen (DO)	pH was on average 6.3 for both sides for all sampling occasions with a range of 4.5 to 7.4. These mean values are within the ANZG (2018) trigger value for pH (between 6-8). SWTG2 had the lowest mean pH value of all sites (5.9) and was the only side that had pH values lower than the SSTV threshold for Tom's Gully mine of 5.8-8. No readings above pH 8.0 were recorded. There were no available data for dissolved oxygen for the sites.
Turbidity (NTU)	Turbidity levels were on average 104.7 NTU with a range between 1.7 and 1600.0 NTU. The range indicates large variability in turbidity in response to rainfall events. The mean value was in exceedance of the ANZG (2018) of 15 NTU and relevant SSTV 87 NTU. SWTG3 had the highest recorded turbidity vale (1600.0 NTU).
Dissolved metals	Overall, there was exceedance of the ANZEG (2018) and SSTV ecosystem protection GVs for dissolved metals (Al, Cd, Cr, Cu, Mn, Ni, Zn) for some of the sampling occasions, with a maximum measured value of 6.4 mg/L for Al, 0.083 mg/L for Cd, 0.017 mg/L for Cr, 0.036 mg/L for Cu, 3.62 mg/L for Mn, 0.096 mg/L for Ni, and 0.37 mg/L for Zn. All exceedances and maximum values were recorded at site SWTG2. ANZG (2018) and site-specific trigger values for these metals are 0.055 / 0.295 mg/L for Al, 0.0002 / 0.0004 mg/L for Cd, 0.001 / 0.006 mg/L for Cr, 0.0014 / 0.0018 mg/L for Cu, 1.9 / 2.5 mg/L for Mn, 0.011 / 0.013 for Ni, and 0.008 / 0.015 mg/L for Zn.
Nutrients	TN and TP values have not been sampled regularly at the sites. However, some available data for site SWTG2 from 2009 has shown elevated TN readings (0.47 and 1.36 mg/L). These readings were in exceedance of the ANZG (2018) trigger values (TN 0.2 mg/L). Concurrent TP levels were below the ANZG (2018) trigger value (TP 0.01mg/L). SSTV were not set for nutrients.

Overall, exceedance of dissolved metals was recorded at site SWTG2. This site appears to be most directly influenced by the mining activities from Tom's Gully mine as it is about 1 km downstream from mine related infrastructure (TSF). However, there was no significant dissolved metal exceedance recorded at SWTG3, a site that is site that is further 5.5 km downstream from SWTG2. This indicates that the potential influence on water quality from dissolved metals associated with mining does not extend further downstream.

Baseline Water Quality Proposed Accommodation Camp for Coulter Creek

Site specific trigger values for Tom's Gully mine that shares the same mining lease with the proposed accommodation camp have been developed and are outlined in Stauber and Batley (2018). These values represent the 80th percentile related to the freshwater species protection as outlined in the ANZG (2018) guidelines for dissolved metals, EC, pH and turbidity.

Table 3-35 Baseline Water Quality Proposed Accommodation Camp for Coulter Creek

Parameter	Water quality summary
Electrical Conductivity (EC)	EC average for both sites was 117 µS/cm. The range was between 23 to 290 µS/cm for the recorded sampling occasions, indicating fresh-water quality, with water quality well below the ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm but above the relevant Toms Gully SSTV of 41 µS/cm.

Parameter	Water quality summary
pH Dissolved Oxygen (DO)	pH was on average 6.5 for both sides with a range of 5.0 to 8.4. The mean value was within the ANZG (2018) trigger value for pH (between 6-8). However, CK7 recorded pH below (5.0) and above (8.4) the ANZG 2018 and the Tom's Gully site-specific trigger values (5.8 -8.0). There were no available data for dissolved oxygen for the sites.
Turbidity (NTU)	Turbidity levels were on average 17.9 NTU with a range between 2.6 and 66.0 NTU. The mean value was just above exceedance of the ANZG (2018) of 15 NTU and relevant SSTV 87 NTU.
Dissolved metals	Overall, there was exceedance of the ANZG (2018) and SSTV ecosystem protection GVs for dissolved metals (Al, Cd, Cu, Mn, Ni, Zn) for some of the sampling occasions, with a maximum measured value of 0.76 mg/L for Al, 0.014 mg/L for Cd, 0.007 mg/L for Cu, 2.6 mg/L for Mn, 0.043 mg/L for Ni, and 0.16 mg/L for Zn. Most of the maximum values have been recorded at CK7. ANZG (2018) and site-specific trigger values for these metals are 0.055 / 0.295 mg/L for Al, 0.0002 / 0.0004 mg/L for Cd, 0.0014 / 0.0018 mg/L for Cu, 1.9 / 2.5 mg/L for Mn, 0.011 / 0.013 for Ni, and 0.008 / 0.015 mg/L for Zn.
Nutrients	There were no nutrient data available for the Coulter Creek sites.

Most of the exceedance records for dissolved metals are associated with CK7. This site is outside of the Tom's Gully mining lease area downstream of CCO2 where Coulter Creek may have been affected by disturbance from pastoral activities.

None of the samples for all water quality sites in upper and lower Mount Bundey Creek, Marrakai, McKinlay River and Coulter Creek catchment showed any exceedance with the default ANZG (2008) stock drinking water guidelines for all sampling occasions.

Piper Diagram for Surface Water Samples at Rustlers Roost and Quest 29

A Piper Diagram for the surface water at Rustlers Roost and Quest 29 has been produced to present the dissolved constituent of the water samples and to better understand seasonal and mining influence on surface water chemistry (Figure 3-11).

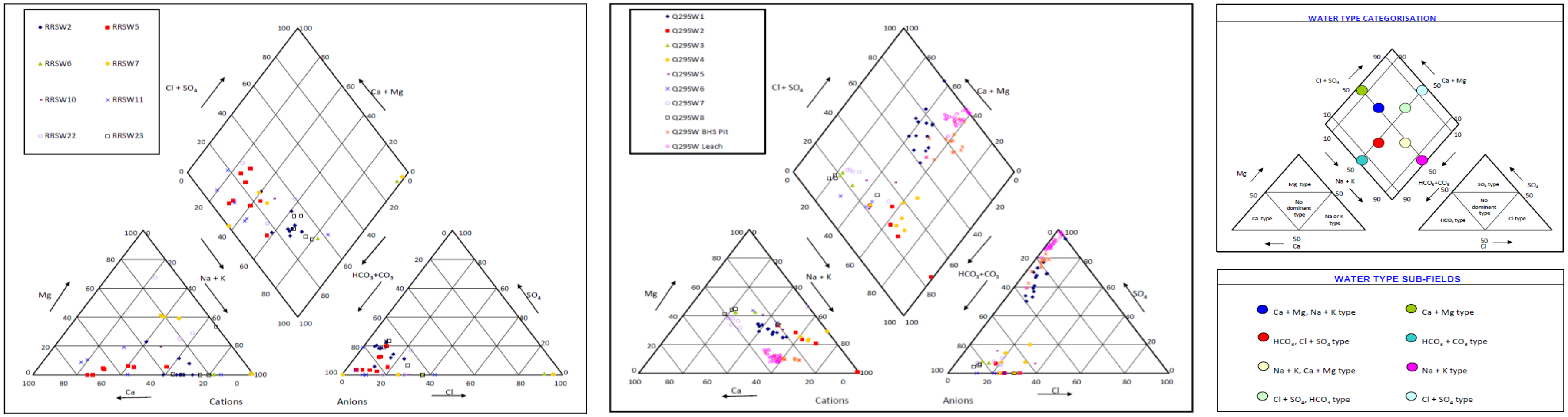


Figure 3-11 Piper Diagram for Rustlers Roost and Quest 29 Surface Water Ionic Composition

Rustlers Roost

The distribution of the values for each sampling occasion and location indicates that surface water monitoring sites at Rustlers Roost have not so much been affected by leaching of waste rock solutes, rather by seasonal variations. Furthermore, the plot supports geochemical assessments of low AMD potential of previously mined material at the Rustlers Roost location (refer to Appendix D in the Draft EIS).

Quest29

Surface water quality at the BHS pit (Q29SW BHS pit) and the nearby leach ponds (Q29SW Leach) presented with signals for potential influence from waste ore leachate. Furthermore, the plot shows some connectivity between the leach ponds and the creek associated with Q29SW1. The spread of the values for Q29SW1 shows greater variation then the pit and the leach ponds, potentially representing seasonal influences on water quality. The values for site Q29SW4 (about 5 ½ km further downstream from Q29SW1) indicate that the influence from mine site leachate do not extend further.

3.2.3.4 Stock Drinking Water Quality

The majority of surrounding land use comprises pastoral leases used for cattle farming with the likely future land use the continuation of pastoral activities. PGO acknowledges good water quality is essential for successful livestock production with poor water quality likely to reduce animal production and impair fertility. High contaminant loads may produce residues within animal products and adversely affect saleability and/or create human health risks (ANZG 2018). Therefore, the existing groundwater and surface water sampling results for have been assessed against the relevant ANZG Stock water metal trigger values. A total of 294 surface and groundwater samples were taken between 2011 and 2021 with occasional exceedance of ANZG Stock water trigger values for metals (Table 3-36). None of the surface monitoring sites at Rustlers Roost and none of the groundwater monitoring bores at both locations showed exceedance of SWG values for metals.

Table 3-36 ANZG Stock Drinking Water Quality

Site	Date	Al mg/L	As mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Pb mg/L	Ni mg/L	U mg/L	Zn mg/L	No of Samples
SWQ1	12/11/2020	9.03	-	-	-	-	-	0.435	-	-	-	18
SWQ2	4/12/2020	6.68	-	-	-	-	-	-	-	-	-	15
	20/12/2016	6.9	-	-	-	-	-	0.26	-	-	-	
SWQ4	20/12/2016	-	-	-	-	-	-	0.17	-	-	-	13
SWQ6	20/12/2016	-	-	-	-	-	-	0.11	-	-	-	10
SWQ7	12/11/2020	9.9	-	-	-	-	-	-	-	-	-	8
SWQ8	20/12/2016	-	-	-	-	-	-	0.12	-	-	-	6
SWQ Leach	20/12/2016	-	-	-	-	-	-	0.31	-	-	-	24
	26/01/2017	-	-	-	-	-	-	0.24	-	-	-	
ANZG SWG		5	0.5	0.01	1	1	1	0.1	1	200	20	

3.2.4 Surface Water Sediment Quality

A targeted sediment sampling survey was conducted to obtain a contemporary baseline of existing sediment quality and to characterise potential impacts on surface water quality from previous mining activities at the RR site.

The sediment sampling sites with coordinates and description are shown in Table 3-37.

Table 3-37 Sediment Sampling Locations and Descriptions

Site ID	Latitude	Longitude	Description	Purpose
RRMCUS	- 12.9196239	131.4809763	Marrakai creek upstream site	Control
RRMCDS	- 12.9049505	131.4695765	Marrakai creek downstream Site	Impact
RRSW2	- 12.92867	131.50156	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad	Impact
RRSW23	- 12.930765	131.50637	Upper Mount Bunt Creek tributary downstream from RRSW2	Impact

Water quality measurements on site were taken for pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), and Temperature using a pre-calibrated Pro DSS instrument. The sediment samples were taken in accordance with guidance provided in *Sediment Quality Assessment – A Practical Guide* (Simpson and Batley 2016), and the macroinvertebrate samples were collected following the method from the *User Manual* *for the Darwin-Daly Regional AUSRIVAS Models – Northern Territory* (Lamche 2007). The detailed methodology has been outlined in the relevant report (refer to Appendix Q in the Draft EIS).

Weak acid extraction was used by the laboratory for quantification of bioavailable metals in the sediment. All analytes with a ANZG (2018) default guideline value (DGV) recorded concentrations far below those guidelines with the large majority of results being below the laboratory's limit of reporting (LOR). Laboratory results for extractable metals covered by sediment toxicity DGV are provided in Table 3-38 and Table 3-39 below. The concentrations for extractable metals were generally greatest at RRSW2 and RRSW23. This was largely for metals without a DGV, such as aluminium, which recorded the highest concentration of 400 mg/kg at RRMCUS, and iron, with a concentration recorded at RRSW2 and RRSW23 of 1,830 mg/kg and 1,120 mg/kg respectively (Table 3-38 and Table 3-39). The concentrations of cyanide were below LOR at all sites.

The sediment concentrations for iron were highest at the downstream locations from the heap leach pad (RRSW2 and RRSW23). Other metals where concentrations were higher at these sites compared to RRMDCS and RRMCUS were Arsenic, Barium, Cobalt, Copper, Lead, Manganese, Vanadium and to a lesser extent Zinc and Nickel (only recorded at RRSW2). While these analytes have no applicable DGVs, the concentrations indicate a potential impact from the pre-existing mine site. Aluminium recorded a maximum concentration of 400 mg/kg at RRMCDS, the only occurrence of a site recording a greater concentration than that found at RRSW2 and RRSW23. All metals not discussed in this section recorded concentrations below the laboratory's limit of reporting (LOR). No exceedances as per the DGV and the fact that cyanide was below LOR indicate that there are no concerns regarding sediment toxicity at present.

Table 3-38 Laboratory Result Summary for Sediment Toxicant DGV* Assessment

Site ID	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Silver	Zinc	Mercury
Sediment Toxicant DGV* (mg/kg)	2-25	20-70	1.5-10	80-130	65-270	50-220	21-52	1-4	200-410	0.15-1
RRMCUS	<1.0	<1.0	<0.1	<1.0	<1.0	1.4	<1.0	<1.0	<1.0	<0.01
RRMCDS	<1.0	<1.0	<0.1	<1.0	<1.0	1.6	<1.0	<1.0	<1.0	<0.01
RRSW2	<1.0	5.8	<0.1	1.1	9.9	2.7	1.2	<1.0	1.8	0.01
RRSW23	<1.0	2.4	<0.1	<1.0	3.1	3	<1.0	<1.0	1	0.01

*Sediment Toxicant DGV: Toxicant default guideline values for sediment quality (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants)

Table 3-39 Laboratory Result Summary for Dissolved Metals (Without Toxicant default guideline values)

Site ID	Aluminium	Barium	Beryllium	Boron	Cobalt	Iron	Manganese	Molybdenum	Selenium	Strontium	Uranium	Vanadium
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
RRMCDS	190	18.7	<1.0	<50	0.7	960	62	<5	<0.5	<5	<1.0	<2.0
RRMCUS	400	15.6	<1.0	<50	1.4	750	38	<5	<0.5	<5	<1.0	<2.0
RRWS2	290	30.4	<1.0	<50	2.2	1830	88	<5	<0.5	<5	<1.0	4.7
RRSW23	310	30.5	<1.0	<50	2.4	1120	91	<5	<0.5	<5	<1.0	2.5

3.2.5 Groundwater Quality

Groundwater quality has been influenced by previous land uses such as pastoral uses and mining activities with legacy related water quality issues arising from seepage of pit lakes, WRD, and heap leach pads and ponds. The water quality results from data collected between 2011 and 2021 were compared to the ANZG (2018) guidelines default trigger values for physical and chemical stressors in tropical Australia in slightly disturbed ecosystems and the CSIRO Review of Site-Specific Trigger Values (SSTV) for Tom's Gully Mine (Stauber and Batley 2018). The ANZG (2018) water quality guidelines outline the process for using SSTV based on circumstances where background concentrations cannot be measured at a site due to existing disturbance, or where measurement at an equivalent reference site is deemed to match closely the geology or natural water quality of the site of interest. If the background concentration has been clearly established and it exceeds the 95% trigger value, the 80th percentile of the background concentration as described in the ANZG (2018) guidelines can be accepted as the SSTV for the relevant WQ sites.

While the relevant ANZG (2018) guideline trigger values provide guidance on water quality standards for tropical lowlands surface waters in slightly disturbed areas the guidelines should apply to the quality both of surface water and of groundwater, since the environmental values which they protect relate to above-ground uses (e.g. irrigation, drinking water, stock watering and maintenance of aquatic ecosystems). Hence guideline thresholds similar to surface water SSTV (ANZG 2018) 95%, Tom's Gully SSTV 80% and Stock Watering Guidelines) have been applied to report on groundwater quality for this WMP.

3.2.5.1 Rustlers Roost Site Specific Analytes Results

Relevant groundwater quality parameters compared against ANZG (2018) 95%, Toms Gully (TG) SSTV 80% and stock water guidelines for each of the monitoring bores for Rustlers Roost are shown in Table 3-40 to Table 3-47

The groundwater quality summary for all relevant bore associated with Rustlers Roost is shown in Table 3-48 below.

Table 3-40 Analytes summary Rustlers Roost monitoring bore RRMB01

RRMB01	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	130	5.35	36.7	4.1	0.01	0.001	0.0001	0.001	0.004	0.001	0.001	0.015	0.002	0.01	0.001	1	0.006	0.05	0.4	0.03
Max	199.3	6.14	576	39.7	0.19	0.009	0.0001	0.001	0.015	0.003	0.001	0.045	0.006	0.01	0.001	1	0.048	0.51	3.7	0.21
Mean	162.15	5.7925	234.475	20.4	0.0625	0.0035	0.0001	0.001	0.0078	0.0018	0.001	0.0265	0.0043	0.01	0.001	1	0.0213	0.18	1.3	0.0975
Median	159.65	5.84	162.6	18.9	0.025	0.002	0.0001	0.001	0.006	0.0015	0.001	0.023	0.0045	0.01	0.001	1	0.0155	0.08	0.55	0.075
SD	29.5317	0.3372	256.2792	18.3228	0.0862	0.0037	0	0	0.005	0.001	0	0.0138	0.0021	0	0	0	0.0184	0.2218	1.6021	0.0862
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4

Data Collected between: 09-Nov-2020 and 29-Apr-2021

Table 3-41 Analytes summary Rustlers Roost monitoring bore RRMB02

RRMB02	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	199	6.01	0.84	2.6	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	1	0.005	0.05	0.1	0.2
Max	215.3	6.22	9.41	9.1	0.01	0.002	0.0001	0.001	0.001	0.01	0.001	0.003	0.001	0.01	0.001	1	0.018	0.05	0.1	0.24
Mean	205.7	6.1325	3.0975	4.725	0.01	0.0018	0.0001	0.001	0.001	0.0035	0.001	0.002	0.001	0.01	0.001	1	0.0092	0.05	0.1	0.2225
Median	204.25	6.15	1.07	3.6	0.01	0.002	0.0001	0.001	0.001	0.0015	0.001	0.002	0.001	0.01	0.001	1	0.007	0.05	0.1	0.225
SD	6.8649	0.1008	4.2113	3.0259	0	0.0005	0	0	0	0.0044	0	0.0008	0	0	0	0	0.006	0	0	0.0171
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4

Data Collected between: 09-Nov-2020 and 29-Apr-2021

Table 3-42 Analytes summary Rustlers Roost monitoring bore RRMB03

RRMB03	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	123.9	5.54	0.71	4.9	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	1	0.011	0.05	0.1	0.02
Max	130.7	5.8	8.68	21	0.01	0.002	0.0001	0.001	0.001	0.011	0.006	0.005	0.002	0.01	0.001	1	0.078	0.05	0.1	0.05
Mean	126.225	5.68	4.7375	10.95	0.01	0.0013	0.0001	0.001	0.001	0.0043	0.0023	0.003	0.0015	0.01	0.001	1	0.0318	0.05	0.1	0.0325
Median	125.15	5.69	4.78	8.95	0.01	0.001	0.0001	0.001	0.001	0.0025	0.001	0.003	0.0015	0.01	0.001	1	0.019	0.05	0.1	0.03
SD	3.1595	0.1296	3.3758	7.3196	0	0.0005	0	0	0	0.0046	0.0025	0.0023	0.0006	0	0	0	0.0312	0	0	0.0126
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 09-Nov-2020 and 06-May-2021

Table 3-43 Analytes summary Rustlers Roost monitoring bore RRMB04

RRMB04	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	260.8	6.48	2.79	3.3	0.08	0.001	0.0001	0.001	0.001	0.001	0.001	0.031	0.001	0.01	0.001	1	0.005	0.05	0.1	0.02
Max	293.4	6.78	15.7	25.9	0.1	0.003	0.0001	0.002	0.001	0.001	0.001	0.402	0.001	0.01	0.001	1	0.006	0.18	0.1	0.04
Mean	275.45	6.63	6.445	14.55	0.0875	0.002	0.0001	0.0013	0.001	0.001	0.001	0.2065	0.001	0.01	0.001	1	0.0053	0.0825	0.1	0.03
Median	273.8	6.63	3.645	14.5	0.085	0.002	0.0001	0.001	0.001	0.001	0.001	0.1965	0.001	0.01	0.001	1	0.005	0.05	0.1	0.03
SD	17.0289	0.1621	6.1929	10.8106	0.0096	0.0008	0	0.0005	0	0	0	0.156	0	0	0	0	0.0005	0.065	0	0.0115
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 10-Nov-2020 and 06-May-2021

Table 3-44 Analytes summary Rustlers Roost monitoring bore RRMB05

RRMB05	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	269.9	6.36	1.32	1	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.11	0.001	0.01	0.001	1	0.005	0.22	0.1	0.02
Max	305.4	6.58	3.98	2.9	0.05	0.004	0.0001	0.001	0.001	0.001	0.001	0.218	0.001	0.01	0.001	1	0.008	0.65	0.1	0.14
Mean	287.525	6.5	2.075	2.05	0.025	0.0023	0.0001	0.001	0.001	0.001	0.001	0.1518	0.001	0.01	0.001	1	0.0058	0.415	0.1	0.0725
Median	287.4	6.53	1.5	2.15	0.02	0.002	0.0001	0.001	0.001	0.001	0.001	0.1395	0.001	0.01	0.001	1	0.005	0.395	0.1	0.065
SD	15.4068	0.0966	1.2729	0.7937	0.0191	0.0013	0	0	0	0	0	0.0467	0	0	0	0	0.0015	0.213	0	0.0512
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 10-Nov-2020 and 29-Apr-2021

Table 3-45 Analytes summary Rustlers Roost monitoring bore RRMB06

RRMB06	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	78.5	5.64	0.63	2.5	0.01	0.032	0.0001	0.001	0.001	0.001	0.001	0.441	0.001	0.01	0.001	1	0.008	1.71	0.1	0.56
Max	84.9	5.97	3.1	10.4	0.01	0.035	0.0001	0.001	0.001	0.007	0.001	0.501	0.002	0.01	0.001	1	0.027	2.23	0.1	0.74
Mean	82.2	5.7925	1.785	5.05	0.01	0.034	0.0001	0.001	0.001	0.0025	0.001	0.47	0.0018	0.01	0.001	1	0.0155	1.985	0.1	0.6525
Median	82.7	5.78	1.705	3.65	0.01	0.0345	0.0001	0.001	0.001	0.001	0.001	0.469	0.002	0.01	0.001	1	0.0135	2	0.1	0.655
SD	3.0144	0.1672	1.2487	3.6592	0	0.0014	0	0	0	0.003	0	0.0252	0.0005	0	0	0	0.0081	0.2499	0	0.0789
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 09-Nov-2020 and 06-May-2021

Table 3-46 Analytes summary Rustlers Roost monitoring bore RRMB07

RRMB07	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	37.1	3.77	0.84	20.9	0.08	0.001	0.0001	0.001	0.006	0.022	0.001	0.166	0.002	0.01	0.001	1	0.01	0.05	0.2	0.01
Max	40.5	4.4	2.14	39.9	0.11	0.001	0.0001	0.001	0.008	0.033	0.005	0.221	0.003	0.01	0.001	1	0.07	0.05	0.2	0.01
Mean	38.3	4.1325	1.415	29.35	0.09	0.001	0.0001	0.001	0.0073	0.0267	0.0025	0.1998	0.0023	0.01	0.001	1	0.036	0.05	0.2	0.01
Median	37.8	4.18	1.34	28.3	0.085	0.001	0.0001	0.001	0.0075	0.026	0.002	0.206	0.002	0.01	0.001	1	0.032	0.05	0.2	0.01
SD	1.5033	0.2731	0.5575	7.8852	0.0141	0	0	0	0.001	0.0046	0.0019	0.0237	0.0005	0	0	0	0.0271	0	0	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 10-Nov-2020 and 06-May-2021

Table 3-47 Analytes summary Rustlers Roost monitoring bore RRMB08

RRMB08	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	72.7	5.08	0.45	18.9	0.01	0.001	0.0001	0.001	0.001	0.002	0.001	0.002	0.001	0.01	0.001	1	0.007	0.05	0.1	0.01
Max	89.7	5.53	4.32	33.6	0.01	0.001	0.0001	0.001	0.001	0.008	0.001	0.004	0.002	0.01	0.001	1	0.036	0.05	0.1	0.04
Mean	78.425	5.3225	1.83	24.875	0.01	0.001	0.0001	0.001	0.001	0.005	0.001	0.0035	0.0013	0.01	0.001	1	0.0205	0.05	0.1	0.0225
Median	75.65	5.34	1.275	23.5	0.01	0.001	0.0001	0.001	0.001	0.005	0.001	0.004	0.001	0.01	0.001	1	0.0195	0.05	0.1	0.02
SD	7.6626	0.2055	1.7176	7.2136	0	0	0	0	0	0.0029	0	0.001	0.0005	0	0	0	0.0134	0	0	0.015
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 10-Nov-2020 and 06-May-2021

Water Quality at the Rustlers Roost Groundwater Monitoring Bores

Table 3-48 provides a summary of selected water quality parameters for the new monitoring bores at the Rustlers Roost site. The aquatic ecosystem protection GVs as ANZG (2018) trigger values are only relevant in case of abstraction of groundwater and discharge to surface water (i.e. pit dewatering).

Table 3-48 Baseline Groundwater Quality Parameters at Rustlers Roost

Parameter	Water quality summary
Electrical Conductivity	An EC average of 157 µS/cm for a total of 32 sampling occasions across all 8 sites has been recorded over the 6-month period. The range was between 37.1 to 305.4 µS/cm with highest at RR MB05. The mean value was below the quality objective for ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm, indicating freshwater conditions.
pH and Dissolved Oxygen (DO)	pH was on average 5.7 for all sites and all sampling occasions with a pH range of 3.8 to 6.8 indicating slightly acidic groundwater with lowest at RR MB07. Typical for groundwater conditions, there were low DO levels recorded over the monitoring period with a mean value of 14% and a range of 1% to 40%. The mean values were within ANZG (2018) trigger values for pH (6-8) and DO (80-120 %).
Bicarbonate alkalinity as $CaCO_3$	Bicarbonate alkalinity was continuously measured below <1 mg/L for all samples. The low levels are reflected by the measured pH <7 and indicate the reduced buffering capacity, hence reduced acid neutralising ability of the groundwater.
Hardness as $CaCO_3$	Mean total hardness (48.1 mg/L) with a range between <1 to 117 mg/L from all samples indicates general 'soft' water. Furthermore, Magnesium and Calcium ion levels were low throughout most of the samples with a maximum of 13 mg/L for Mg and 31 mg/L for Ca.
Dissolved metals	Overall, there was occasional exceedance of the aquatic ecosystem protection GVs for some of the dissolved metals (Al, As, Cu, Zn), with a maximum measured value of 0.11 mg/L for Al at RR MB07, 0.035 mg/L for As at RR MB06, 0.033 mg/L for Cu at RR MB07, and 0.078 mg/L for Zn at RR MB03. ANZG (2018) trigger values for these metals are 0.055 mg/L for Al, 0.013 mg/L for As, 0.0014 mg/L for Cu, and 0.008 mg/L for Zn. While these maximum levels were observed, most of the samples at all locations recorded metals below detection levels.
Nutrients	Total nitrogen levels (TN) had a mean value of 0.16 mg/L with a range between <0.1 mg/L and 0.2 mg/L with maximum at RR MB07. Mean total phosphorus (TP) was 0.16 mg/L, with a range between < 0.01 and 0.74 mg/L with maximum TP detected at RR MB06. Mean TP was in exceedance of the ANZG (2018) trigger value (TN 0.2 mg/L, TP 0.01 mg/L).

Overall, the groundwater quality monitoring at Rustlers Roost has shown groundwater that is typically fresh with exceedance of aquatic ecosystems GVs for some metals and nutrients at some sampling occasions and locations. The elevated phosphorus and metal concentrations may be associated with underlying mineralogical deposits entailing weathered zones.

3.2.5.2 Quest29 Site Specific Analytes Results

Relevant groundwater quality parameters compared against ANZG (2018) 95%, Toms Gully (TG) SSTV 80% and stock water guidelines for each of the monitoring bores for Quest29 are shown in Table 3-49 to Table 3-57.

The groundwater quality summary for all relevant bore associated with Quest29 is shown in Table 3-58 below.

Table 3-49 Analytes Summary Quest29 Monitoring Bore Q29 MB01

Q29MB01	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	210.4	5.96	3	1.7	0.01	0.0019	0.0001	0.001	0.001	0.001	0.001	0.12	0.001	0.01	0.001	0.5	0.001	0.01	0.1	0.06
Max	1174	7.33	290	6.4	0.31	0.106	0.0011	0.011	0.001	0.006	0.001	1.5	0.009	0.01	0.001	1	0.0846	19	0.1	0.09
Mean	949.6267	6.6462	92.356	3.45	0.0305	0.0405	0.0002	0.0034	0.001	0.0017	0.001	0.7798	0.0016	0.01	0.001	0.7222	0.0169	6.9322	0.1	0.0825
Median	988	6.55	4.835	2.85	0.01	0.025	0.0001	0.0022	0.001	0.001	0.001	0.74	0.001	0.01	0.001	0.5	0.005	4.035	0.1	0.09
SD	229.0926	0.3957	132.6649	2.2457	0.0746	0.0368	0.0003	0.0031	0	0.0016	0	0.4003	0.002	0	0	0.2635	0.0239	7.2611	0	0.015
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 17
Data Collected between: 03-Dec-2010 and 28-Apr-2021

Table 3-50 Analytes summary Quest29 monitoring bore Q29 MB02

Q29MB02	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	210	5.54	0.32	1.6	0.01	0.0019	0.0001	0.001	0.001	0.001	0.001	0.134	0.001	0.01	0.001	0.5	0.003	0.01	0.1	0.09
Max	337	7.6	400	4.9	0.018	0.036	0.0001	0.006	0.005	0.001	0.005	1.31	0.003	0.01	0.001	1	0.028	17	0.3	0.13
Mean	295.2909	6.7129	92.1136	2.95	0.0109	0.0161	0.0001	0.0018	0.0015	0.001	0.0013	0.5063	0.0012	0.01	0.001	0.6818	0.0089	3.2337	0.2	0.1075
Median	285.8	6.67	7	2.65	0.01	0.016	0.0001	0.001	0.001	0.001	0.001	0.2495	0.001	0.01	0.001	0.5	0.0055	0.94	0.2	0.105
SD	42.5621	0.5735	151.6187	1.4387	0.0023	0.0093	0	0.0017	0.0012	0	0.0011	0.4496	0.0006	0	0	0.2523	0.0074	5.7373	0.0816	0.0171
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 15
Data Collected between: 22-Nov-2011 and 28-Apr-2021

Table 3-51 Analytes summary Quest29 monitoring bore Q29 MB02

Q29MB03	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	42.4	4.69	1.83	33.1	0.01	0.001	0.0001	0.001	0.001	0.001	0.001	0.013	0.006	0.01	0.001	1	0.022	0.05	0.1	0.01
Max	83.5	5.86	5.4	59.9	0.01	0.001	0.0001	0.001	0.001	0.007	0.001	0.137	0.013	0.01	0.001	1	0.074	0.17	0.3	0.01
Mean	62.675	5.0225	3.295	44.125	0.01	0.001	0.0001	0.001	0.001	0.0043	0.001	0.0558	0.01	0.01	0.001	1	0.0432	0.09	0.15	0.01
Median	62.4	4.77	2.975	41.75	0.01	0.001	0.0001	0.001	0.001	0.0045	0.001	0.0365	0.0105	0.01	0.001	1	0.0385	0.07	0.1	0.01
SD	20.0335	0.5625	1.5986	11.5875	0	0	0	0	0	0.0028	0	0.0578	0.0032	0	0	0	0.0257	0.0566	0.1	0
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4

Data Collected between: 16-Nov-2020 and 29-Apr-2021

Table 3-52 Analytes summary Quest29 monitoring bore Q29 MB04

Q29MB04	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	391.7	6.56	0.39	1.1	0.01	0.157	0.0001	0.001	0.001	0.001	0.001	0.24	0.005	0.01	0.001	1	0.027	0.05	0.1	0.05
Max	446	6.77	12.3	9.9	0.01	0.2	0.0001	0.001	0.003	0.001	0.001	0.296	0.02	0.01	0.001	1	0.062	0.46	0.1	0.1
Mean	410.325	6.6525	4.1725	5	0.01	0.1743	0.0001	0.001	0.0015	0.001	0.001	0.2768	0.0098	0.01	0.001	1	0.0388	0.295	0.1	0.0675
Median	401.8	6.64	2	4.5	0.01	0.17	0.0001	0.001	0.001	0.001	0.001	0.2855	0.007	0.01	0.001	1	0.033	0.335	0.1	0.06
SD	24.4964	0.0929	5.5894	3.6469	0	0.0183	0	0	0.001	0	0	0.025	0.0069	0	0	0	0.0165	0.1902	0	0.0236
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4

Data Collected between: 16-Nov-2020 and 28-Apr-2021

Table 3-53 Analytes summary Quest29 monitoring bore Q29 MB05

Q29MB05	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	4.29	6.39	0.6	1.7	0.01	0.076	0.0001	0.001	0.001	0.001	0.001	0.198	0.001	0.01	0.001	1	0.006	0.73	0.1	0.02
Max	463	6.89	3.94	11.9	0.01	0.083	0.0001	0.001	0.001	0.001	0.001	0.237	0.001	0.01	0.001	1	0.012	0.93	0.1	0.05
Mean	329.7225	6.7275	2.03	6.025	0.01	0.08	0.0001	0.001	0.001	0.001	0.001	0.22	0.001	0.01	0.001	1	0.009	0.815	0.1	0.035
Median	425.8	6.815	1.79	5.25	0.01	0.0805	0.0001	0.001	0.001	0.001	0.001	0.2225	0.001	0.01	0.001	1	0.009	0.8	0.1	0.035
SD	217.7233	0.2307	1.4157	4.303	0	0.0032	0	0	0	0	0	0.0164	0	0	0	0	0.0029	0.0896	0	0.0129
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 17-Nov-2020 and 28-Apr-2021

Table 3-54 Analytes summary Quest29 monitoring bore Q29 MB06

Q29MB06	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	166	4.73	0.68	1.4	0.01	0.009	0.0001	0.001	0.001	0.001	0.001	0.167	0.001	0.01	0.001	1	0.005	0.25	0.1	0.02
Max	212	6.2	3.32	12.4	0.01	0.012	0.0001	0.001	0.001	0.001	0.001	0.204	0.001	0.01	0.001	1	0.027	0.94	0.1	0.08
Mean	185.35	5.6975	1.6775	4.925	0.01	0.0112	0.0001	0.001	0.001	0.001	0.001	0.1878	0.001	0.01	0.001	1	0.0138	0.585	0.1	0.05
Median	181.7	5.93	1.355	2.95	0.01	0.012	0.0001	0.001	0.001	0.001	0.001	0.19	0.001	0.01	0.001	1	0.0115	0.575	0.1	0.05
SD	19.255	0.6574	1.2018	5.096	0	0.0015	0	0	0	0	0	0.0167	0	0	0	0	0.0098	0.2903	0	0.0245
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 16-Nov-2020 and 28-Apr-2021

Table 3-55 Analytes summary Quest29 monitoring bore Q29 MB07

Q29MB07	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	382	6.44	0.95	1	0.01	0.028	0.0001	0.001	0.001	0.001	0.001	0.478	0.001	0.01	0.001	1	0.005	1.63	0.1	0.01
Max	437	6.58	2.67	4.7	0.01	0.055	0.0001	0.001	0.002	0.001	0.001	0.78	0.001	0.01	0.001	1	0.014	4.35	0.2	0.05
Mean	407.05	6.5125	1.4875	2.8	0.01	0.0412	0.0001	0.001	0.0015	0.001	0.001	0.565	0.001	0.01	0.001	1	0.0073	2.5675	0.125	0.0275
Median	404.6	6.515	1.165	2.75	0.01	0.041	0.0001	0.001	0.0015	0.001	0.001	0.501	0.001	0.01	0.001	1	0.005	2.145	0.1	0.025
SD	22.7305	0.0585	0.809	1.8708	0	0.0118	0	0	0.0006	0	0	0.1443	0	0	0	0	0.0045	1.2267	0.05	0.0171
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 16-Nov-2020 and 28-Apr-2021

Table 3-56 Analytes summary Quest29 monitoring bore Q29 MB08

Q29MB08	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	415.8	6.36	1.09	1.2	0.01	0.013	0.0001	0.001	0.002	0.001	0.001	0.552	0.001	0.01	0.001	1	0.005	0.82	0.1	0.01
Max	447	6.47	2.46	6	0.01	0.018	0.0001	0.001	0.003	0.001	0.001	0.905	0.005	0.01	0.001	1	0.024	1.67	0.2	0.02
Mean	432.55	6.4225	1.6625	3	0.01	0.0158	0.0001	0.001	0.0025	0.001	0.001	0.7722	0.0025	0.01	0.001	1	0.0107	1.3025	0.15	0.0125
Median	433.7	6.43	1.55	2.4	0.01	0.016	0.0001	0.001	0.0025	0.001	0.001	0.816	0.002	0.01	0.001	1	0.007	1.36	0.15	0.01
SD	13.5178	0.0519	0.673	2.1556	0	0.0026	0	0	0.0006	0	0	0.1583	0.0017	0	0	0	0.009	0.3533	0.0577	0.005
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4
Data Collected between: 16-Nov-2020 and 29-Apr-2021

Table 3-57 Analytes summary Quest29 monitoring bore Q29 MB09

Q29MB09	EC uS/cm	Field pH	Turbidity NTU	DO %Sat	Dis. Al mg/L	Dis. As mg/L	Dis. Cd mg/L	Dis. Cr mg/L	Dis. Co mg/L	Dis. Cu mg/L	Dis. Pb mg/L	Dis. Mg mg/L	Dis. Ni mg/L	Dis. Se mg/L	Dis. Sn mg/L	Dis. U µg/L	Dis. Zn mg/L	Dis. Fe mg/L	Total N mg/L	Total P mg/L
Min	211.3	5.82	0.35	1.4	0.01	0.01	0.0001	0.001	0.001	0.001	0.001	0.192	0.002	0.01	0.001	1	0.018	0.76	0.1	0.04
Max	259.7	6.13	11.1	13.7	0.01	0.013	0.0001	0.001	0.001	0.004	0.001	0.299	0.004	0.01	0.001	1	0.052	1.45	0.1	0.13
Mean	235.625	5.955	3.705	6.975	0.01	0.0115	0.0001	0.001	0.001	0.0018	0.001	0.2502	0.0033	0.01	0.001	1	0.0277	1.1775	0.1	0.08
Median	235.75	5.935	1.685	6.4	0.01	0.0115	0.0001	0.001	0.001	0.001	0.001	0.255	0.0035	0.01	0.001	1	0.0205	1.25	0.1	0.075
SD	19.9161	0.1392	4.9945	6.2575	0	0.0013	0	0	0	0.0015	0	0.0441	0.001	0	0	0	0.0163	0.3216	0	0.0392
ANZG 95%	250	6-8	15	90-120	0.055	0.013	0.0002	0.001		0.0014	0.0034	1.9	0.011				0.008		0.15	0.01
TG SSTV 80%	41	5.8-8	87		0.295	0.042	0.0004	0.006		0.0018	0.0056	2.5	0.013				0.015	2.7		
SWG	3000				5	0.5	0.01	1	1	1	0.1		1			200	20			

Total number of samples: 4

Data Collected between: 16-Nov-2020 and 06-May-2021

Baseline Water Quality at the Quest 29 Groundwater Monitoring Bores

Table 3-58 provides a summary of the selected groundwater quality parameters for the new monitoring bores at the Quest 29 site.

Table 3-58 Baseline Groundwater Quality Parameters at Quest 29

Parameter	Water quality summary
Electrical Conductivity	An EC average of 293 µS/cm for a total of 28 sampling occasions across all 7 sites has been recorded over the 6-month period. The range was between 4.3 to 463 µS/cm with highest at Q29 MB05. The mean value was above the quality objective for ANZG (2018) trigger values for aquatic ecosystems of 250 µS/cm, however still classified as freshwater.
pH Dissolved Oxygen (DO)	pH was on average 6.1 for all sites and all sampling occasions with a pH range of 4.7 to 6.6 indicating slightly acidic groundwater with lowest at Q29 MB03. Typical for groundwater, there were low DO levels recorded over the monitoring period with a mean value of 10% and a range of 1 to 33%. The mean values were within ANZG (2018) trigger values for pH (6-8), but below DO (80-120%).
Bicarbonate alkalinity as $CaCO_3$	Bicarbonate alkalinity was continuously measured below <1mg/L for all samples. The low levels are reflected by the measured pH <7 and indicates the reduced buffer capacity, hence reduced acid neutralising ability of the groundwater.
Hardness as $CaCO_3$	Mean total hardness (121.9 mg/L) with a range between 7 to 200 mg/L from all samples indicating moderately hard water. This is also reflected by the Magnesium and Calcium ion levels with a maximum of 19 mg/L for Mg and 50 mg/L for Ca.
Dissolved metals	Overall, there was occasional exceedance of the aquatic ecosystem protection GVs for some of the dissolved metals (As, Cu, Zn), with a maximum measured value of 0.2 mg/L for As at Q29 MB04, 0.007 mg/L for Cu at Q29 MB03, and 0.074 mg/L for Zn at Q29 MB03. ANZG (2018) trigger values for these metals are 0.055 mg/L for Al, 0.0014 mg/L for Cu, and 0.008 mg/L for Zn. While these maximum levels were observed, most of the samples at all locations recorded metals below detection levels.
Nutrients	In general, total nitrogen levels (TN) had a mean value of 0.1 mg/L with a range between <0.1 mg/L and 0.3 mg/L with the maximum at Q29 MB03. Mean total phosphorus (TP) was 0.05 mg/L, with a range between < 0.01 and 0.13 mg/L with maximum at Q29 MB09. Mean TP was in exceedance of the aquatic ecosystems ANZG (2018) trigger values (TN 0.2 mg/L, TP 0.01 mg/L).

Overall, the groundwater quality monitoring has shown exceedance of water quality parameters at some sampling occasions and locations. The elevated phosphorus and metal concentrations may be associated with underlying mineralogical deposits entailing weathered zones.

Piper Diagram for Groundwater Samples at Rustlers Roost and Quest 29

A Piper Diagram for the groundwater at Rustlers Roost and Quest 29 has been produced to present the dissolved constituent of the water samples and to better understand seasonal and mining influence on groundwater chemistry (Figure 3-12).

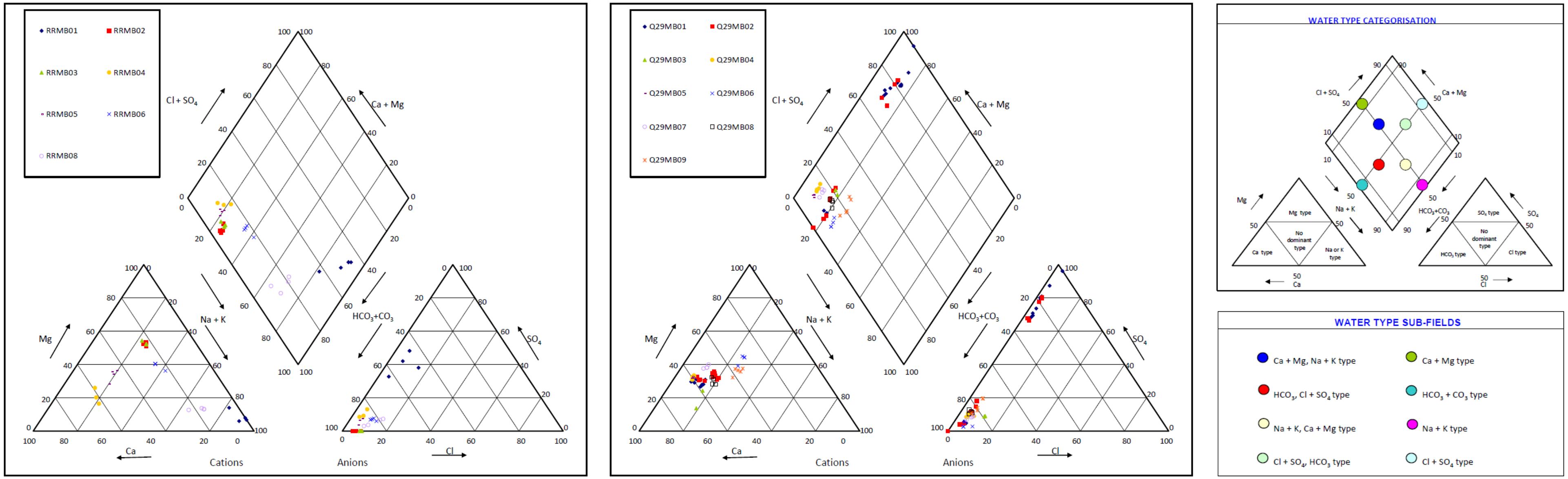


Figure 3-12 Piper Diagram for Rustlers Roost and Quest 29 Groundwater Ionic Composition

Rustlers Roost

The plot indicates that the groundwater monitoring bores show limited impacts from previous mining activities. Only RRMB01 which is located next to the heap leach pad shows signals of influence from potential waste rock leachate.

Quest29

Most of the monitoring bores showed similar water chemistry with small variations indicating limited impacts from previous mining activities. Only MB01 and MB02 may have been affected at times by waste rock solutes with elevated sulfate levels from the BHS heap leach pad as both bores are in proximity to it.

Section 4 Project Water Management

This section will outline how the projected water balance will inform the site water management. This includes measures to minimise water use and discharge, including modelled discharge volumes and timing and how these will be managed to minimise changes to hydrological regimes and to protect environmental values. Furthermore, relevant structures will be outlined to divert, capture, retain and/or treat surface runoff and to prevent discharge of contaminated water from the site post-closure in accordance with industry best practice standards.

The water management of the Rustlers Roost and Quest 29 sites consists initially of dewatering historical pit lakes, then maintaining a dry working environment by continuously dewatering pit inflows during mining operation while supplying enough water to respond to the demand of the ore processing, dust suppression activities and other site water demands (potable water).

4.1 Existing Surface Water Infrastructure

The existing water management infrastructure in the Project area is listed in Table 4-1.

Table 4-1 Existing surface water storage and infrastructure

Infrastructure	Surface Area (ha)	Total Capacity (ML)
Rustlers Roost		
RR pit lake	23	3,160
Annie dam	11.4	200
Leach ponds	3.4	75.8
Quest 29		
Pit lakes	8	367
Leach ponds	1.3	28

4.1.1 Pit Dewatering and Discharge Requirements

Both the Rustlers Roost and Quest 29 sites contain previously mined pits that have filled with water over time. The base of the pits are below the groundwater table and groundwater flows into the pits. Dewatering will be required prior to mining at Rustlers Roost and during mining at both sites.

4.1.1.1 Rustlers Roost Dewatering

Prior to commencement of mining, the calculated 3.16 GL (volume at water level 56.90 mAHD) of water accumulated in the pit will need to be removed. It is proposed that this water will be pumped out of the pit and discharged during the wet season into the drainage lines that flow to Mount Bundey Creek and/or Marrakai Creek. It is expected that it will take two wet seasons to empty the pit. A Waste Discharge Licence (WDL) application has been submitted to DEPWS and an amendment to the Care and Maintenance MMP for Rustlers Roost to DITT.

Discharge Locations

The proposed discharge plan is to dewater the Pit lake into both the upper Mount Bundey Creek catchment and the Marrakai Creek catchment (prior to operational phase). The objective of utilising both catchments allows the discharge volume to be spread over two receiving creeks. Thus, reducing the requirement for increased flow rates / velocity into one creek system, and allowing the Pit lake to be emptied over a shorter period. The Marrakai Creek catchment has previously been relatively unimpacted from mining activities, with the exception of overflow from Annie's Dam. However, given the clean water quality available for discharge, the discharge activities and managed flows over the coming wet seasons is not expected to adversely impact the receiving waterways. Water will be pumped from the Pit lake into two rock-lined discharge basins. Benign rock is available onsite to line the discharge basins at the discharge outlets to dissipate flows and to reduce turbidity before flowing into the receiving creeks. The proposed location of Discharge Basin A is south of the pit and west of the historic heap leach pads in an existing sediment trap/drainage line (Figure 4-1).

Analysis of flows and velocity changes for dewatering discharges during the operational phase indicate the discharge point can be limited to Mount Bundey Creek. Thus, it is not proposed to discharge into Marrakai Creek post completion of the initial dewatering phase (i.e. beyond 2023).

The sediment trap will be cleaned out if required, prior to being rock lined as a suitable discharge basin. Flows from Discharge Basin A will be directed through an existing drain into a tributary of the Mount Bundey Creek flowing in an easterly direction around the existing heap leach ponds. The discharge point will be on Mount Bundey Creek at the eastern lease boundary. The existing basin at the base of Annie's Dam wall will be reconditioned as Discharge Basin B (Figure 4-1), with rock lining at the discharge pipe outlet prior to flows entering the Marrakai Creek tributary. This discharge basin will be decommissioned once the Project becomes operational and only Discharge Basin A utilised thereafter.

Discharge Management and Timing

The current volume of water in the pit was calculated at 3.16 GL. A nominated pump optimal rate of 300 L/s has been selected to release flows into the Mount Bundey and Marrakai creeks. As there is no flow data available from these creeks, and the fact that these creeks are highly seasonal, the peak flows adopted are conservative for minimising the impact of additional flows into the system. In comparison to the peak flow rate at the confluence of Mt Bundey Creek and Mary River (245,700 L/s Mount Bundey Creek over 91 year-period, 700 L/s Marrakai Creek), the maximum discharge rate of 300 L/s (accounting for discharge pipe length and friction) is considered minor. Discharge basins consisting of energy dissipation infrastructure and placement of erosion and sediment control measures will be installed at the outlet of the drainage infrastructure prior to entering the creek systems. The discharge rate of the pumps will be variable throughout the wet season. The variability in the rate of flow will be determined based on analysis of wet season rainfall recorded at Old Mount Bundey Station and available forecasts. Rainfall data will be recorded in the discharge record sheet as outlined in the WDL.

For Quest 29 the pit dewatering requirements comprise the groundwater seepage and any rainfall and runoff (less evaporation) that falls within the pit catchments. For the five Quest 29 pits, the average dewatering rate is less than 52 L/s and hence a single 125 L/s capacity sump pump would be sufficient to maintain dry pit environment.

Discharge will be possible during periods of stream flow only, to reduce possible impacts on sensitive receptors from an altered flow regime downstream of the receiving waters. Strong flow in the headwaters of both creeks have been observed for 3-4 weeks only during the wet season. However, it is assumed that low flow occurs for approximately 3-4 months, during which discharge of pit water will be possible. The amount and timing of rainfall in the wet season may impact on the discharge schedule: It is considered to be important to commence seasonal discharge after natural creek flow has begun and cease when natural creek flow ends. This will likely commence in December and end during recessional creek flows in April. During times of low to no rainfall in the wet season, the pump discharge rate may be reduced to a minimum of 50 L/s, ensuring that the creek systems are not overwhelmed by the influx of water. As the rainfall volume increases, so does the rate of discharge up to a nominal rate of 200 L/s. On occasions where the rainfall is expected to be large (i.e. monsoon or cyclone events), the pump is to be turned on to its optimal rate of approximately 300 L/s.

The Water Management Plan includes a provision for water to be released from the site during the wet season into the surrounding creeks, while during the dry season the water is stored on site (predominately in the northern TSF WSD at Rustlers Roost and in non-worked pits at Quest 29). During the wet season the storages are emptied so that there is maximum storage capacity available at the beginning of each dry season.

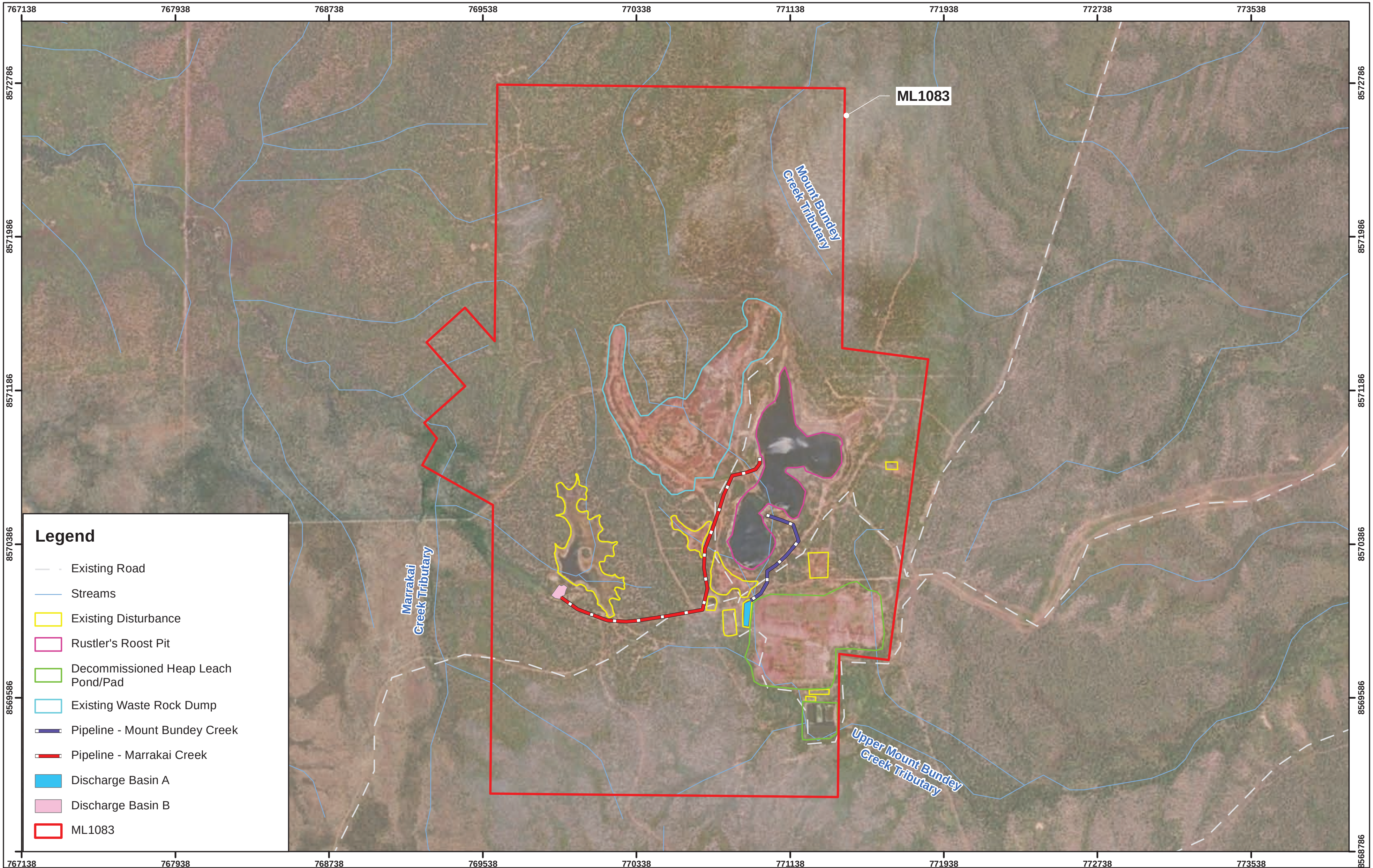
Table 4-2 shows the average release rates for each month for Rustlers Roost and Quest 29. For 95% of model runs there is no uncontrolled release during the dry season (i.e. there is sufficient storage on site). For the 95th percentile and maximum scenarios (i.e. high hydraulic conductivity and high runoff) there is some dry season release. The model is set up to maintain 5% storage in the storages to allow for water reuse in the dry season and lowering this threshold may negate the requirement for dry season release in these unlikely scenarios. The cumulative amount of environmental water release is approximately 36 GL of water (with an uncertainty range from 17 GL to 78 GL).

Table 4-2 Average pumping rates during environmental releases per month

Month	Rustlers Roost site monthly average release rate (L/s)							Q29 site monthly average release rate (L/s)						
	Min	5%	25%	50%	75%	95%	Max	Min	5%	25%	50%	75%	95%	Max
Jan	154	174	199	213	229	241	270	17	26	52	73	94	142	163
Feb	83	99	120	134	150	190	228	20	28	51	76	96	148	165
Mar	-	-	-	-	-	-	77	18	27	46	75	96	154	179
Apr	-	-	-	-	-	6	109	-	-	-	-	-	1	14
May	-	-	-	-	-	93	157	-	-	-	-	-	6	84
Jun	-	-	-	-	-	128	174	-	-	-	-	-	28	139
Jul	-	-	-	-	-	158	190	-	-	-	-	-	37	67
Aug	-	-	-	-	-	256	288	82	103	129	142	155	180	197
Sep	-	-	-	-	212	284	302	34	57	79	111	131	158	185
Oct	-	-	-	161	240	276	287	20	46	80	98	139	169	212
Nov	-	-	151	237	279	300	297	18	39	78	95	119	164	178
Dec	87	117	192	202	217	251	242	18	27	59	76	97	144	185

Pit Water Quality

The water quality in the Pit lake was assessed in November 2020, through the collection of water quality depth profile samples at four locations, resulting in a total of 17 samples. These four sampling locations were selected to measure the deepest sections within the Pit lake, with the objective to capture stratification of water quality from surface to depth. From north to south the locations according to the former pit names are: Sweat Ridge, Dolly Pot, Beef Bucket and Backhoe. Most metals were below their respective detection limits or recorded at low concentrations only (see Appendix O in the Draft EIS for all 18 November 2020 sampling results). However, there were two samples that exceeded total metals values as outlined in the ANZG (2018) guidelines for 95% species protection in freshwater: Copper was present at 0.002 mg/L, which is slightly above the guideline of 0.0014 mg/L and zinc was measured at 0.01 mg/L, slightly above the guideline value of 0.008 mg/L. There was no exceedance of the respective ANZG (2018) guideline values for dissolved metals. According to the ANZG (2018) 'Should a 'low risk' outcome result after continuous monitoring, there is scope to refine the guideline trigger value'. Note that in the consideration of guideline values for metals, total metals concentrations are used, however, acid-soluble metals, are more representative of a bioavailable fraction and it is envisaged that ultimately trigger value compliance will be based on the dissolved metals measurement. Thus, the dissolved metal concentrations, dealing with the bioavailable fraction of the metals, are the important parameter with regards to compliance with 95% species protection. As all dissolved metals and also the physico-chemistry of the pit lake were below the 95% species protection guidelines, it is concluded that the pit water is suitable to be directly discharged into the receiving environment without further treatment. Refer to Section 4.5 for post-mining pit lake water quality predictions and management approaches.



R	Details	Date
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DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	27/09/21

Notes:

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0 195 390 780

Meters

1 cm = 178 meters

GCS GDA 1994 MGA Zone 52

DISCLAIMER

CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE

NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 4-1

Rustlers Roost Proposed Dewatering and Existing Infrastructure

DRG Ref:

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\WMP\Figure 4-1.mxd

Dewatering of groundwater and surface water inflows will be required during mining activities. A dewatering bore may be installed to actively reduce the groundwater level adjacent to the pit. The rates of dewatering are currently being investigated. Water may also be pumped from within the pit sump to a turkey's nest dam for re-use as dust suppression and/or raw water for processing. This is accommodated in the water use and supply summarised in Section 4.10 of the Draft EIS. Any excess water during the wet season will be discharged into the drainage line that flow to Mount Bundey Creek under an approved operational WDL.

Quest 29

The existing pits are shallow and contain only small volumes of water. Bunding surrounding existing pit crests will be improved to reduce surface water ingress. Immediately prior to and during mining, each pit will be dewatered into other existing pits. No water will be discharged into creek and drainage lines, hence no WDL is required for this activity.

4.1.2 Pit Dewatering Schedule

The initial dewatering of the pits prior commencement of the mining activities is subject to a Wastewater Discharge Licence (WDL) currently under application. In addition, wastewater discharges as required for operations will be also undertaken in accordance with the conditions of the WDL. In general, discharges will be controlled and timed to ensure that the volumes released do not significantly alter stream flows to a point that causes scouring or overtopping of the banks. For example, discharge from dewatering of the mining pits will occur progressively and intermittently with changing volumes. The planned dewatering activities for each individual pit are outlined in Table 4-3. Note that dewatering of the pits will be required until at least to the start date of phase 3 – post-mining. After this date the pits that have not been backfilled will be progressively flooded over time.

Table 4-3 Overview of Pit Dewatering and Mining Phases

	Phase 1: Pre-mining Dewatering			Phase 2: Mining	Phase 3: Post-mining	
	Start Date	End date	Note	Start Date	Start Date	note
Rustlers Roost pit	1/12/2021	30/04/2023	With a pause between 30/04/2022 and 1/12/2022)	1/03/2023	31/10/2031	
Annie Oakley pit	n/a	n/a	Not Applicable	1/02/2024	31/05/2024	Backfilled pit
Annie Dam pit	n/a	n/a	Not Applicable	1/03/2023	31/01/2024	Backfilled pit
Zamu pit	15/12/2024	30/04/2025	Maintain empty pit until start of operation	1/07/2025	30/06/2030	Backfilled pit
South Koolpin pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/06/2031	
North Koolpin pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/06/2031	
Taipan pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/11/2031	
BHS pit	15/03/2030	30/04/2031	Maintain empty pit until start of operation	1/08/2031	30/11/2031	

Each pit mining operations can be divided into 3 stages as follow:

- Phase 1: pre-mining dewatering of the historical pits;
- Phase 2: mining operation; and

- Phase 3: post-mining pit lake recovery for the pits that are not fully backfilled including Rustlers Roost pit, South and North Koolpin pits, Taipan pit and BHS pit. Zamu pit, Annie Okley and Annie Dam pit are to be fully backfilled after operations.

4.1.3 Water Demand

The Project requires approximately 175 ML/yr of non-potable water, which will be sourced from the turkey's nest dam during the mining operation. The water is assumed to be suitable for dust suppression (pit, road and other site infrastructures).

The processing plant (operating from February 2024 to April 2032) has a water demand of 3,656.6 ML/year. The demand is to be covered by recirculation of 2,485.4 ML/yr from the TSF, and the remaining to be provided by the water produced on site from pits dewatering. When the pit dewatering is not able to satisfy the ore processing water demand, make-up water is to be sourced from the bore field. The conceptual water management including the total demand water for the Rustlers Roost operations is shown in Figure 4-2.

4.2 Water Balance Modelling

A water balance model has been prepared (refer to Appendix H in the Draft EIS) to reflect Project mine site during dewatering and operations. This water balance model has been updated as part of further groundwater investigation and it is included in Appendix O of the SEIS. The model was developed to estimate:

- the capacity of the water management plan to prevent uncontrolled spill to the environment, and to keep a dry working environment during the mining phases;
- the Rustlers Roost and Quest 29 respective pits lake water balance and stabilisation level post-mining;
- evaluate the overflowing likelihood of all the pit lakes;
- the overall site water balance; and
- the bore field production requirement to respond to the site water demand.

The water management system is conceptualised as a network of surface water storages (pit lakes, dams, turkey's nest storages), operational processes (pumping) and natural processes (rainfall, runoff, groundwater seepage, evaporation). Each water storage balances its inflows and outflows and is connected to other water storages by transfer of water (pumping). The water management schematic for Rustler Roost is illustrated on Figure 4-2 and in Figure 4-3 for Quest 29. The updated water balance model (refer to Appendix O in the SEIS) provides detailed information on the water management system at Rustlers Roost and Quest 29. The following section provides a summary of the water management system for the Project.

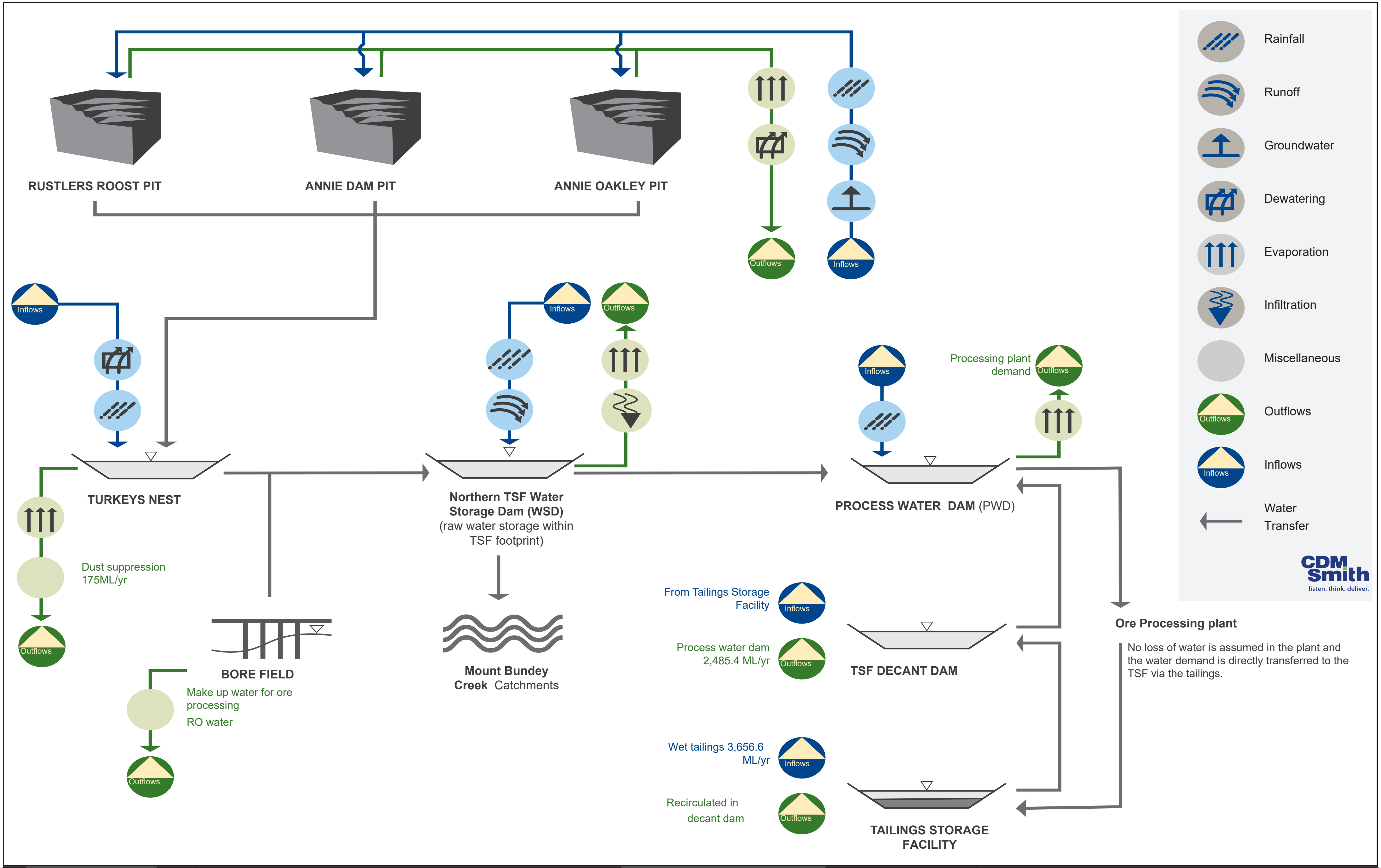
4.2.1 Rustlers Roost Water Management System

Surface water management systems proposed at Rustlers Roost include the existing Annie's Dam (raw water dam), Rustlers Roost pit, process water pond, turkey's nest, northern TSF water storage dam (NTSF WSD), TSF and TSF decant pond and storm water runoff pond (Figure 4-2). It is noted that Annie's Dam and the existing leach ponds at Rustlers Roost will be decommissioned early in the Project as they will be consumed by the expanded TSF and are not discussed further as a source of supply. Table 4-4 provides the Project's proposed surface water infrastructure and conceptual storage capacity. Processing facility water requirements include reagent mixing, gravity concentrators and elution circuit.

Important features of the site water management consist of the following:

- Northern TSF water storage dam (NTSF WSD) is a 6,998 ML storage facility (This feature is within the footprint of the TSF and will eventually become filled with tailings). The NTSF WSD footprint includes the historical Annie's Dam. The NTSF WSD collects the water from the pit's dewatering (after transiting through the Turkey's nest) and the make-up water from the bore field. This make-up water is only to be sourced to maintain the demand of the ore processing plant. The NTSF WSD then feeds the process water dam. Excess water from the NTSF WSD is diverted into the Mount Bundey Creek during the wet season. The NTSF WSD is located within the TSF footprint, and its bathymetry will evolve as tailings are progressively disposed during operations;

- The Turkeys nest storage facility. The Turkeys nest is a 50 ML water storage facility, collecting water from the Rustlers Roost pit dewatering. A portion of the water collected in the Turkey's nest is used for dust suppression on the site and the remainder is transferred to the Annie's Dam raw water storage facility;
- The process water dam. The process water dam has a capacity of 100 ML and receives the water from the decant dam and from the Annie's Dam water storage facility to maintain the capacity to feed the ore processing plant at the required water demand rate;
- The decant dam. The decant dam collects desorbed water from the TSF. The water of the decant dam is recirculated in the ore processing circuit; and
- A bore field is to be used to supply all the site potable water after a reverse osmosis treatment. It will also provide make-up water when the pit's dewatering rate is unable to sustain the ore processing water demand.



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DRAWN	MM	CHECKED	VP
APPROVED	TK	DATE	24/08/21

Notes:

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Meters
1 cm = 644 meters
GCS GDA 1994 MGA Zone 56

DATA SOURCE
NT Government Open Source Data

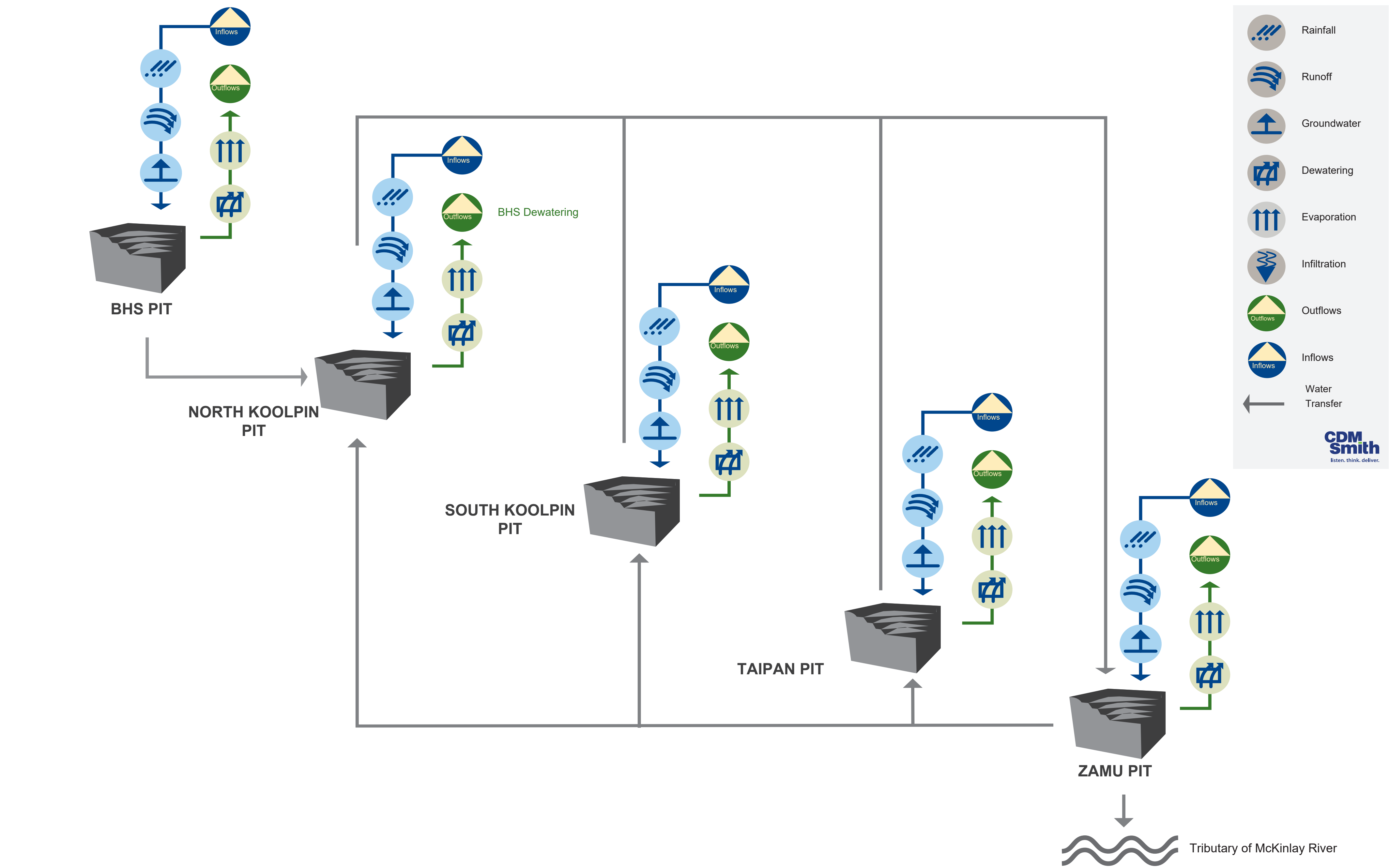
DESIGNER
CDM Smith
cdmsmith.com

CLIENT
PRIMARY GOLD

FIGURE 4-2

Rustlers Roost Water Management Schematic

DRG Ref: 1001087-EIS-04-4.14



R	Details	Date
1	Final	24/08/21
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DESIGNED	VP	CHECKED	JM
DRAWN	MM	CHECKED	VP
APPROVED	TK	DATE	24/08/21

Notes:

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0 700 1,400 2,800

Meters

1 cm = 644 meters

GCS GDA 1994 MGA Zone 56

DATA SOURCE
QLD Government Open Source Data

DESIGNER

cdmsmith.com

CLIENT

FIGURE 4-3

Quest 29 Water Management Schematic

DRG Ref: **1001087-EIS-04-4.15**

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Table 4-4 Proposed Surface Water Infrastructure and Conceptual Storage Capacity

Infrastructure	Purpose	Capacity (m^3)
Northern TSF WSD	Receives water from Turkey's nest and from the bore field. Used for water system balancing.	466,560
Open-cut pit	Dewatering during mining activities	-
Turkey's nest	Dust suppression activities and/or raw water for processing, estimated to be 175,000 m^3/yr.	50,000
Process water dam	Process water supply dam (receives return water from decant pond, raw water from Annie's dam and stormwater runoff from processing plant.	100,000
Tailings dam	Receives tailings from processing plant and catchment rainfall.	100,000
Decant dam	Receives decant water from tailings dam and tailings dam seepage. Decant water returned to process water dam for reuse in processing plant.	50,000
Stormwater pond	Capture process plant stormwater runoff. Water transferred to process pond for reuse.	50,000

A conceptual water balance for the proposed operations and water management systems is illustrated in Figure 6, based on up to 5 Mtpa production rate.

4.2.2 Quest 29 Water Management System

Current water management systems at Quest 29 comprise of the five existing pits and the decommissioned heap leach ponds. The heap leach ponds and pad are proposed to be rehabilitated at the commencement of mining Quest 29. Active management of pit water during mining operations will involve the pumping of water from one pit into another in accordance with mine scheduling. Existing pit water will be used for dust suppression activities. As material will only be mined and hauled from Quest 29 to Rustlers Roost, a site specific raw or potable water supply for Quest 29 is not required. The water management system at Quest 29 is illustrated in Figure 4-3.

Groundwater may be sourced from a bore field. The bore field will supply potable water and raw water as required. Potable water supply will be required for the accommodation village, offices, ablutions and safety showers. A camp water supply bore is within proximity to the accommodation village at Toms Gully which will be on a separate MMP. The bore will supply fresh water and will be treated by reverse osmosis (RO) water treatment plant. Total potable water requirements are estimated at 394,200 m^3/yr.

4.2.3 Water Balance Modelling

The water balance model structure consists of the numerical translation of the water management schematic provided in Figure 4-2 and Figure 4-3. The model simulates in a single platform the water management from the start of operations, commencing with the dewatering of the historical Rustlers Roost pit, until stable steady state conditions are re-established post-mining (Phase 3). The water balance model concurrently simulated all the pits and site water stores to allow for a seamless transfer of water from all the model sub-systems.

The model used daily time step to progress through the simulation. All inflows, outflows and water transfer between the various features were calculated with a daily time step. Further information on the water balance approach and methodology has been provided in Appendix O of the SEIS.

4.2.3.1 Model Results

The model results explored the following aspects associated with surface and groundwater interaction for the Project area:

- the site water balance summing up the inflows into the water management system comprising rainfall, runoff, bore field production and pit groundwater seepage (groundwater discharge), and the outflows of the system through evaporation, infiltration, or disposal into the Mount Bundey and Quest 29 Creek;
- the groundwater seepage into the open pits;
- the water disposal to creeks;
- the borefield production requirements;
- the pits' lake stabilisation level and volume post-mining due to the balancing of the pits' lake inflows and outflows; and
- the evolution of the concentration of chemical of potential concern into each of the final pits' lake.

While the model was run for a period of 300 years from beginning of operations, the lakes forming in all the open pits will stabilise within 60 years post-mining.

4.2.3.2 Site Water Balance

The site water balance during mining operations (from beginning of pit dewatering in December 2021 to the end of the stock-piled ore processing in December 2032) is summarised in Table 4-5.

Table 4-5 Water Management Site Inflows and Outflows During Operation (from beginning of operation in 2021 to end of ore processing in December 2032)

	Median Value	Minimum	Maximum	Portion of Total Inflows/Outflows
Inflow	**ML/yr**	**ML/yr**	**ML/yr**	**%**
Groundwater seepage	3,950	1970	8,190	77.3
Runoff	610	403	910	12
Bore Field production	365	367	380	7
Direct rainfall	185	165	240	3.7
TOTAL INFLOW	5,110	2,905	9,720	100
Outflow				
Disposal	3,360	1,550	6,960	69
TSF loss (TSF evaporation, infiltration and adsorption combined)	905	905	905	18.5
Potable water (reverse osmosis water)	370	370	370	7.5
Infiltration	0	0	0	0
Evaporation	70	55	90	1.5
Dust Suppression	175	175	175	3.5
TOTAL OUTFLOW	4,880	3,055	8,500	100
Change in storage				
All pit and feature storage (negative values indicates that the final volume stored is smaller than the initial and vice versa).	230	-150	1,220	

Median inflows to be managed amounts to about 5,100 ML/yr for the 11 years of operations. About 4,000 ML/yr are predicted to be generated from groundwater seepage into the open pits (i.e. 77% of all inflow into the water management system). The second largest contributor to the pit inflows is runoff with an average of 610 ML/yr (i.e. 12% of all inflow). Direct rainfall into the pits' lake and the water storage facilities (Turkey's nest, processed water dam and the NTSFD WSD) accounts for 4% (185 ML/L) and the bore field production accounts for about 7% (365 ML/yr).

Around 3,400 ML/yr (or 69%) of the water produced on site is expected to be disposed into the Mount Bundey or Marrakai Creeks or creeks/surface water drainages at Quest 29. A total of 19% of the water produced (or 905 ML/yr) is expected to be consumed by the TSF (portion that is not recovered by the decant dam). The production of potable water (treated by reverse osmosis) represents 7.5% of the outflows (370 ML/yr), and water used for dust suppression amount to 175 ML/yr (3.5%). The evaporation of surface water within pit lakes and water storage facilities are predicted to be 70 ML/yr or 1.5% of all outflows.

The minor imbalance between the total inflows and total outflows can be attributed to two reasons. The first reason is that the median values of the water balance components within the Monte Carlo approach are not from the same simulation but the median value for each component across all simulations. The second reason is due to the change of storage in the water balances features (mainly the pits' lake).

Considering the current uncertainties in the model controlling parameters, the sum of all inflows is anticipated to range somewhere between 5,000 ML/yr to 10,000 ML/yr. Most of the uncertainty arises from range of hydraulic conductivity assigned for the aquifer, which given the heterogeneity implicit in fractured rock aquifers, is difficult to constrain.

4.2.3.3 Groundwater Seepage

The groundwater seepage into the open pits is the most significant contributor to the water balance as it amounts for about 77% of all inflows. Figure 4-4 shows the groundwater seepage from the combined Rustlers Roost pits (Rustlers Roost pit, Annie Oakley pit, Annie Dam pit), and Figure 4-6 shows groundwater seepage from the combined Quest 29 pits (Zamu pit, Southern Koolpin pit, North Koolpin pit, Taipan pit and BHS pit).

The groundwater seepage is expected to increase as the pits deepen during mining operation. At the Rustlers Roost mine site there are three pits with deepening works happening at different times; Rustlers Roost pit begins operation in March 2023 and is active for the rest of the operation period whereas deepening of Annie Oakley pit and Annie Dam pit only occurs for 4 months and 10 months respectively, in 2023 and 2024. At the end of the mining operations, groundwater inflow into the Rustlers Roost pits would be 100 L/s. However, uncertainty analysis suggests that this inflow could vary between 30 L/s and 270 L/s.

For the Quest 29 pits operations start in July 2025 at Zamu pit which is mined until end of June 2030, followed by operations in South Koolpin, North Koolpin and Taipan pits from July 2030 and BHS pit from August 2032. This means that the maximum groundwater seepage rate occurs around April 2031 where an estimated inflows of 200 L/s for all Quest 29 pits is expected, although with an uncertainty range from 60 L/s to 370 L/s.

Total combined pit inflows are expected to be at their maximum in April 2031 at 290 L/s, with an uncertainty range from 90 L/s to 360 L/s. Monitoring of pit seepage during the initial phase of mining operation would greatly reduce the uncertainty.

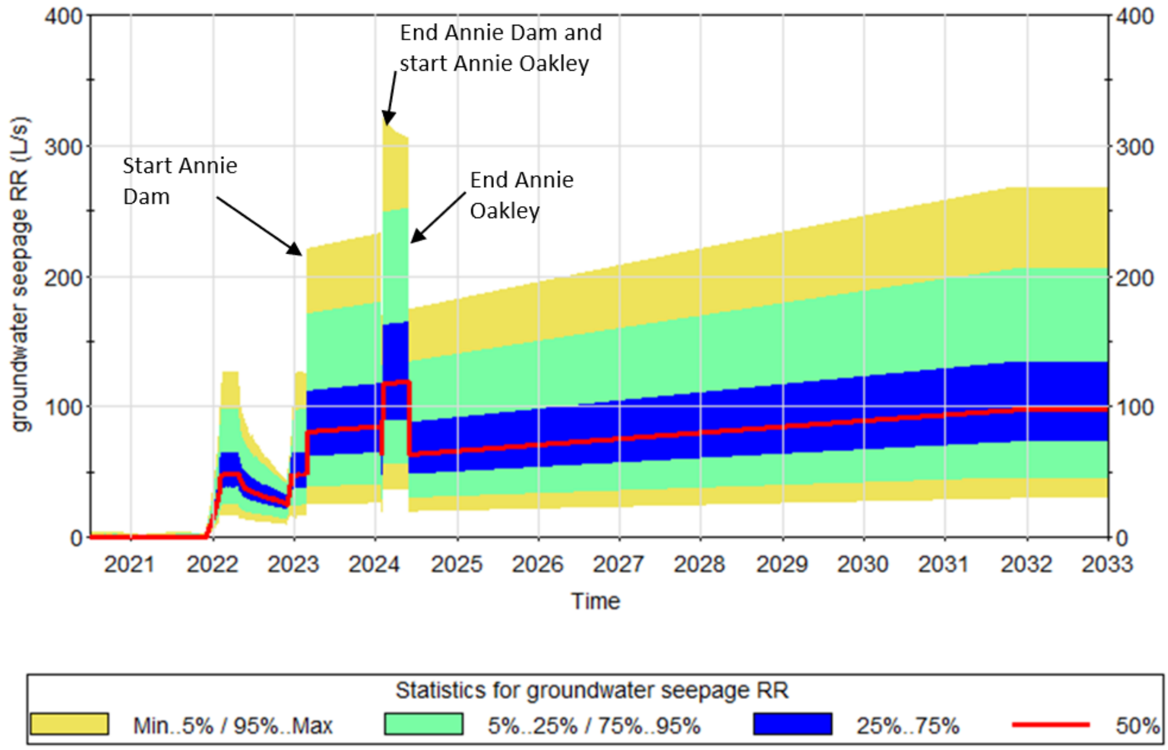

Figure 4-4 **Predicted Total Amount of Groundwater Seepage from the Rustlers Roost Pits combined over Time**

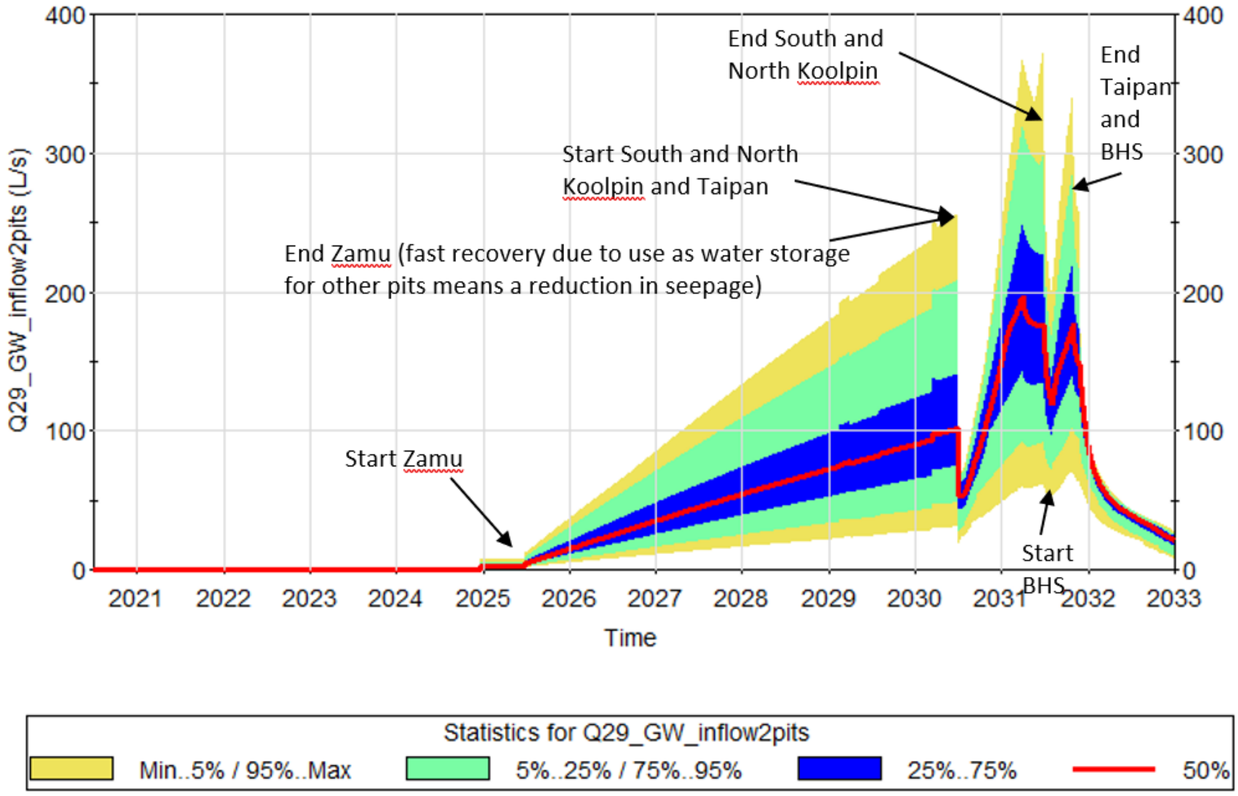

Figure 4-5 **Predicted Total Amount of Groundwater Seepage from the Quest 29 Pits Combined over Time**

Figure 4-6 illustrates the cumulative groundwater seepage volume into the pits. According to the model, at the end of the mining operations (in October 2031) about 46 GL of water is estimated to have seeped into the open pits.. Based on the uncertainty analysis, this amount ranges from 23 GL (for a lower end hydraulic conductivity range) to 95 GL (for a higher end hydraulic conductivity range).

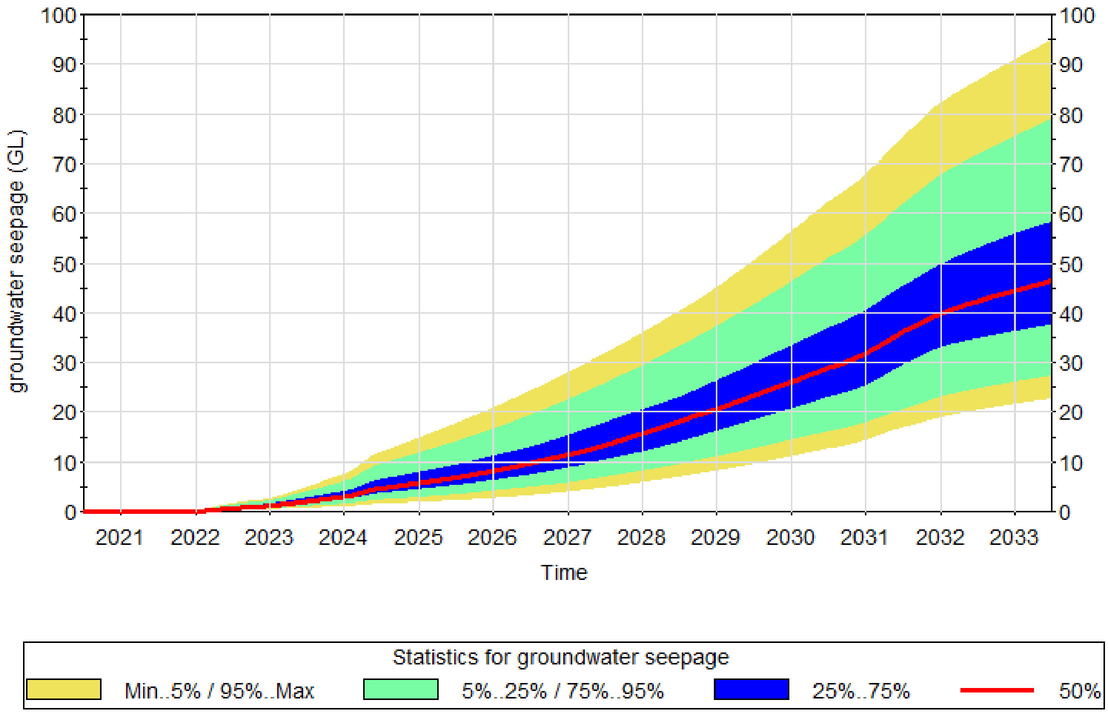

Figure 4-6 Cumulative Groundwater Seepage Volume into all Pits over Time

4.2.3.4 Water Discharge to Creeks

Water is to be released in the environment when it cannot be stored on site and is not required for mining operations. As previously discussed, the first environmental release occurs in 2022 during the Rustlers Roost dewatering phase. There is then a period between 2023 and 2027, when environmental releases are mandated because of saturation of the site water storage. From 2027, when the groundwater seepage into the Rustlers Roost pit is expected to increase due to the pit depth, environmental release of pit water may be necessary, as the groundwater intrusion may exceed the demand of the ore processing plant. It is expected that no discharge into creeks from dewatering the Quest 29 pits (Taipan, South and North Koolpin) will occur as pits will be dewatered into other unused pits.

Figure 4-7 and Figure 4-8 illustrate the controlled release during the wet season and potential uncontrolled release during the dry season if there is insufficient storage on site. During the wet season the storages are emptied so that there is maximum storage capacity available at the beginning of each dry season. Figure 4-7 and Figure 4-8 show the water released to the environment at Rustlers Roost and Quest 29 over the life of mine. The median (red line) represents the most likely of the 100 models. At the end of mining operations, no more releases are expected (Figure 4-7 and Figure 4-8).

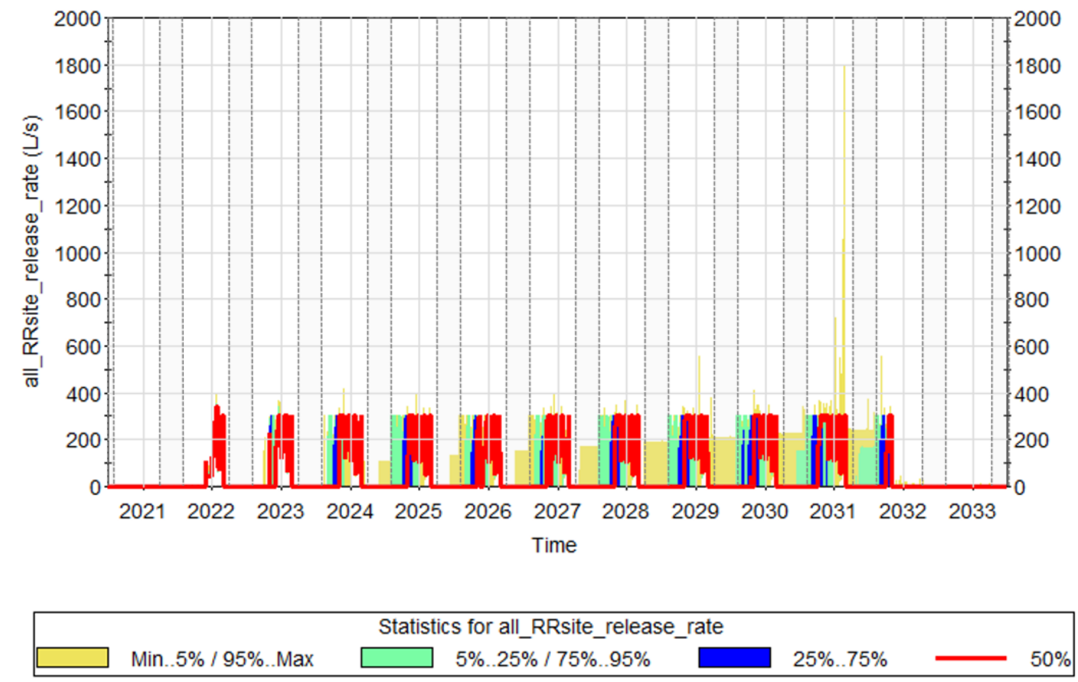

Figure 4-7 Planned Pit Dewatering Discharge Rates

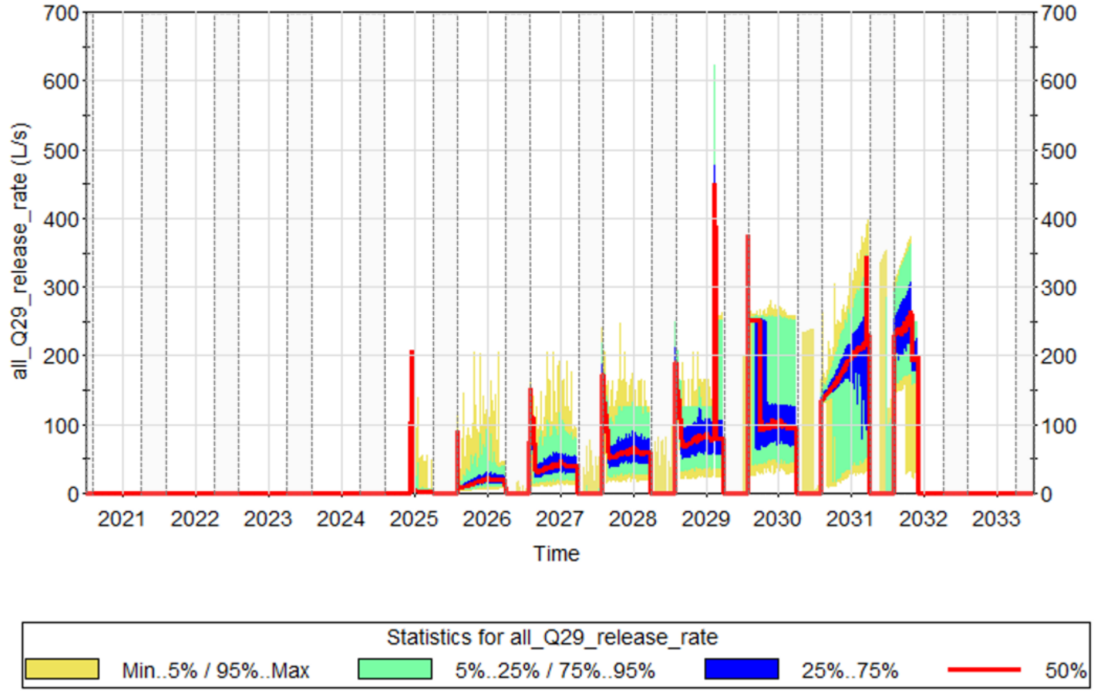

Figure 4-8 Water release to the environment from the Quest 29 site (shaded periods represent dry season)

The cumulative volume of environmental water release is illustrated on Figure 4-9. About 36 GL of water is required to be released (with an uncertainty range from 17 GL to 78 GL). Any water that requires discharge into the environment will be subject to the relevant WDL.

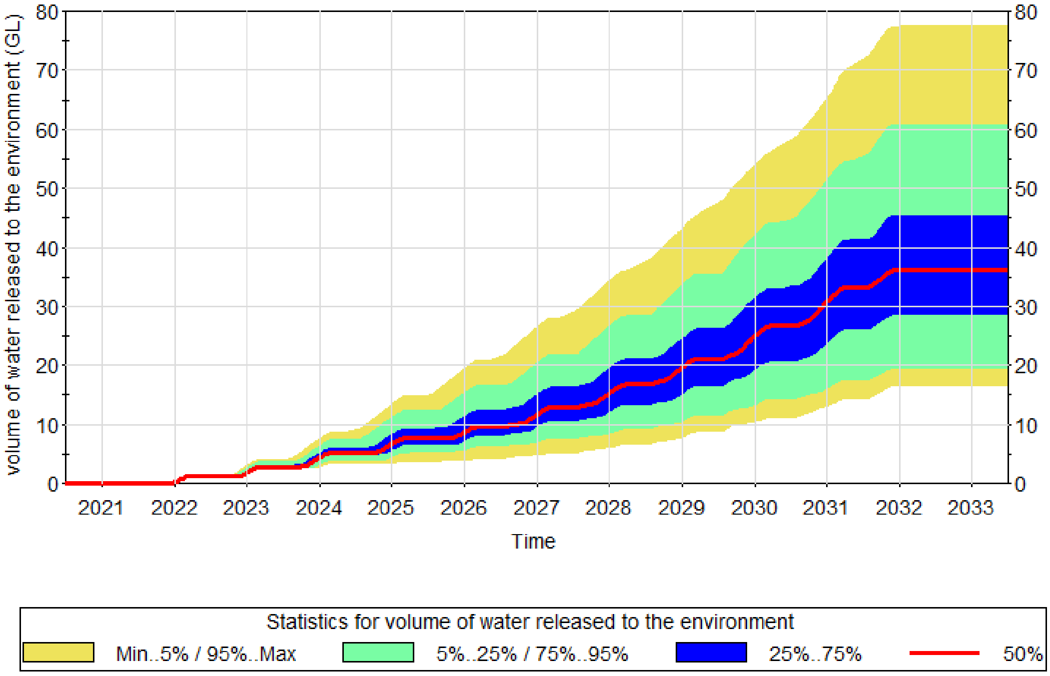

Figure 4-9 Cumulative volume of water released into the environment

4.2.3.5 Bore Field Production Requirements

Bore field production requirements are illustrated in Figure 4-10 and the cumulative bore field production is illustrated on Figure 4-11. Between 2022 and 2032, the water production is limited to the production of potable water (RO water) at a rate of 12.5L/s. For this purpose, additional groundwater bores may be constructed nearby the accommodation camp. No makeup water is required as the pit dewatering is predicted to generate more water than the ore processing demand. Only 5 % of models indicate a requirement for more than 12.5 L/sec in the second half of 2032 where 55L/sec is required for make-up water. The model assumes that the bore field is to supply the made-up water, but this water could alternatively be sourced from the Rustlers Roost pit lake which during that period would be recovering.

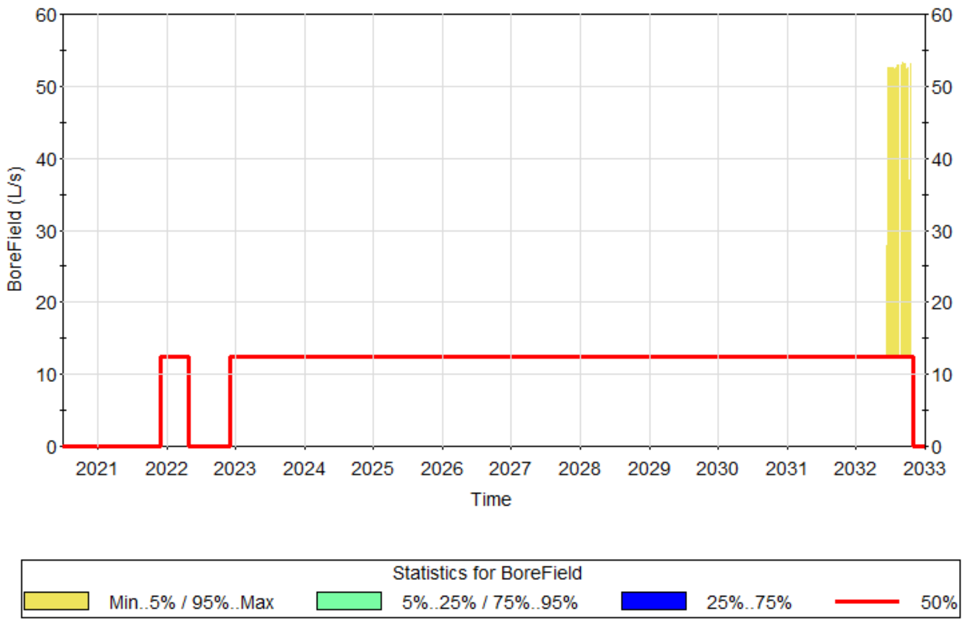

Figure 4-10 Bore Filed Production Rates Over Time

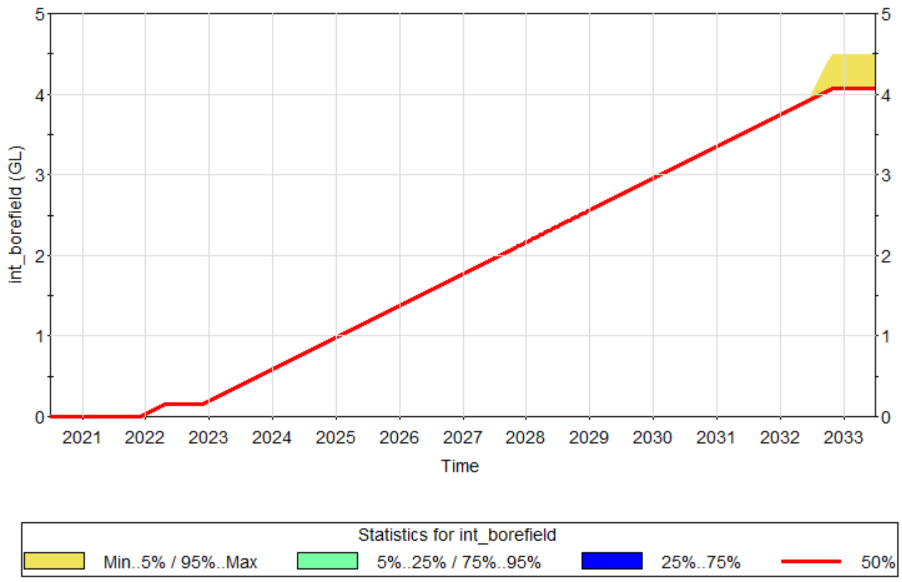

Figure 4-11 Cumulative Borefield Production over Time

4.2.3.6 Postmining Pit Lake Recovery and Pit Lake Overflow Likelihood

Pit lakes are forming under the balancing effect of inflows (groundwater seepage, direct rainfall into the lake and runoff on the pit catchment) and outflows (evaporation and potential water infiltration if the lake level rises above the water table elevation) post-mining. Table 4-6 shows the long-term pit lake stabilisation levels and the water table elevation that was estimated and adopted in the model.

Table 4-6 Pit lake stabilisation levels and water table elevation

Pit	Estimated representative water table elevation [mAHD]	Predicted pit lake stabilisation level (median case)	Comment
Rustlers Roost	57 to 61	59	The pit lake stabilises within the seasonal water table elevation range. Groundwater interaction with the pit lake is expected to be limited with potential seasonal variation (groundwater seepage during the dry season and pit lake infiltration during the wet season).
Taipan	35 to 39	37	The pit lake stabilises within the seasonal water table elevation range. Groundwater interaction with the pit lake is expected to be limited with potential seasonal variation (groundwater seepage during the dry season and pit lake infiltration during the wet season).
South Koolpin	38 to 48	41	The pit lake stabilises at the lower end of the water table elevation range. For some of the time the pit will act as a sink for groundwater with some potential for seasonal contribution from the pit to the groundwater during wet periods.

Pit	Estimated representative water table elevation [mAHD]	Predicted pit lake stabilisation level (median case)	Comment
North Koolpin	41 to 50	55	The pit lake stabilises significantly above the water table. No groundwater seepage is expected, and a net lake infiltration to the groundwater is to be expected.
BHS	67 to 72	70	The pit lake stabilises within the seasonal water table elevation range. Groundwater interaction with the pit lake is expected to be limited with potential seasonal variation (groundwater seepage during the dry season and pit lake infiltration during the wet season).
Zamu	35 to 39	NA	Zamu pit will be backfilled

The gradient between the water table and the pit lake level is determining the type of interaction between the lake and the groundwater. There are three possible cases:

- The lake water level stabilises above the water table. The net interaction between the lake and the groundwater aquifer is toward a net recharge of the aquifer. This is the case for the North Koolpin pit lake;
- The lake water level stabilises at or near the water table. Due to the seasonal variation of the lake water level (which is likely to respond to the seasonal variation faster than the groundwater levels), the interaction is likely to alternate between net seepage during the dry season (groundwater discharge to the pit) and net infiltration during the wet season (groundwater recharge from the pit). The Rustlers Roost pit lake, Taipan pit lake and BHS pits are predicted to be in this situation; and
- The lake water level stabilises beneath the water table. In this case, the pit lake acts as a sink to the regional groundwater and a net groundwater infiltration (recharge to groundwater) dominates. South Koolpin pit is in this category; however, due to the small hydraulic gradient, the interaction between the open pit and the groundwater is limited.

Details of potential post-mining water levels of every pit are provided below.

Rustlers Roost Pit Lake

Figure 4-12 shows Rustlers Roost pit lake water level during and post-mining operations. The red line shows the median case, while the various colour bands show the confidence intervals. It is anticipated that by 2060 (about 30 years post mining) the pit lake level would have returned near the currently observed level at 58 mAHD (with a seasonal variability of 1 m). The uncertainty band is relatively narrow, and for most cases, the stabilised level is at 58 mAHD +/-1 m. Uncertainty in our current conceptual understanding suggests that the recovery process to equilibrium could take somewhere between 10 years and 50 years to complete. The pit is not predicted to overflow and instead to act in the same way as current pit lake.

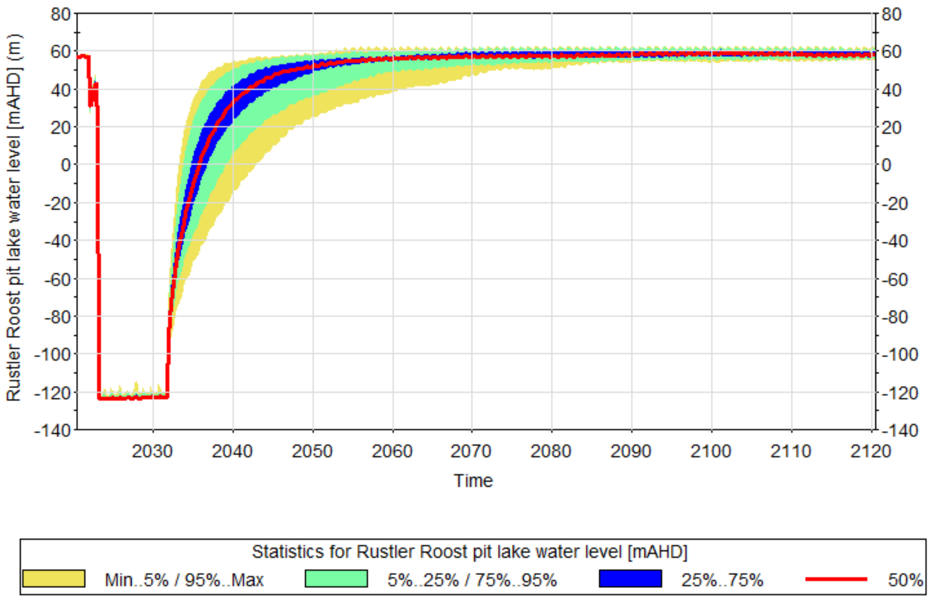

Figure 4-12 Modelled Rustlers Roost pit lake water levels

Zamu Pit

Figure 4-13 shows Zamu pit lake water level during and post-mining operations. The Zamu pit will be fully backfilled after mining of the other Quest 29 pits. The model shows a variable recovery due to the plan of using Zamu pit as the discharge point for the dewatering of the Taipan, South Koolpin and North Koolpin pits. The proposed pit is also expected to have a lower spill level than the historical pit and the model predicts that, with the disposal of dewatering water from the Taipan, South Koolpin and North Koolpin pit, there is a small risk (<25%) of the pit overflowing in 2031 (with a <5% chance of overspill in 2029 and 2030), as illustrated in Figure 4-14.

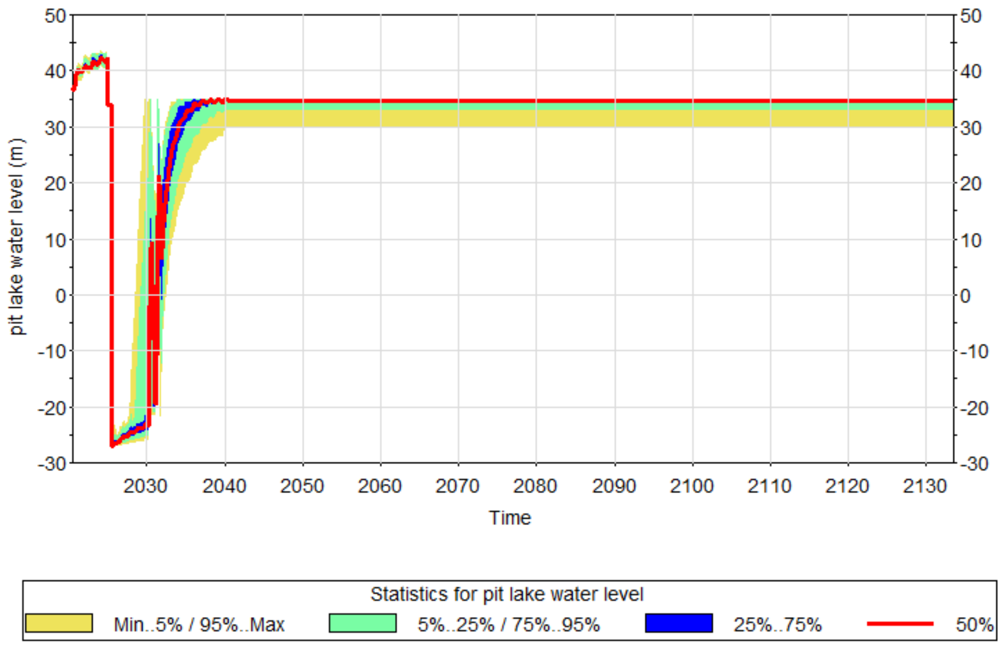

Figure 4-13 Predicted Zamu Pit Lake Water Level over Time

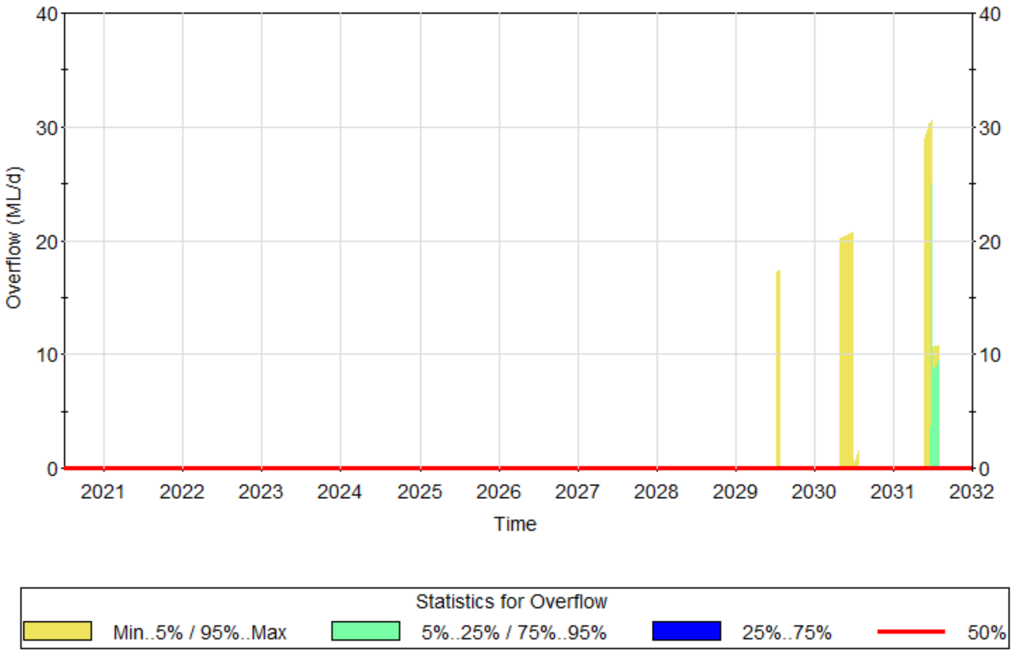

Figure 4-14 Predicted Zamu Pit Overflow over Time

Taipan Pit

Figure 4-15 illustrates the Taipan pit lake water level during and post-mining operations. Taipan pit water levels are predicted to increase from 2025 to 2028 during the dry season as this pit is to be used as a dry season storage for dewatering of the Zamu pit, before the dewatering of the historical Taipan pit starts in 2029. The pit lake recovery is expected to occur over a brief period of up to a couple of years. According to current uncertainty analysis, there is <5% of chance for the pit to overflow during the Zamu pit dewatering period as illustrated in Figure 4-16.

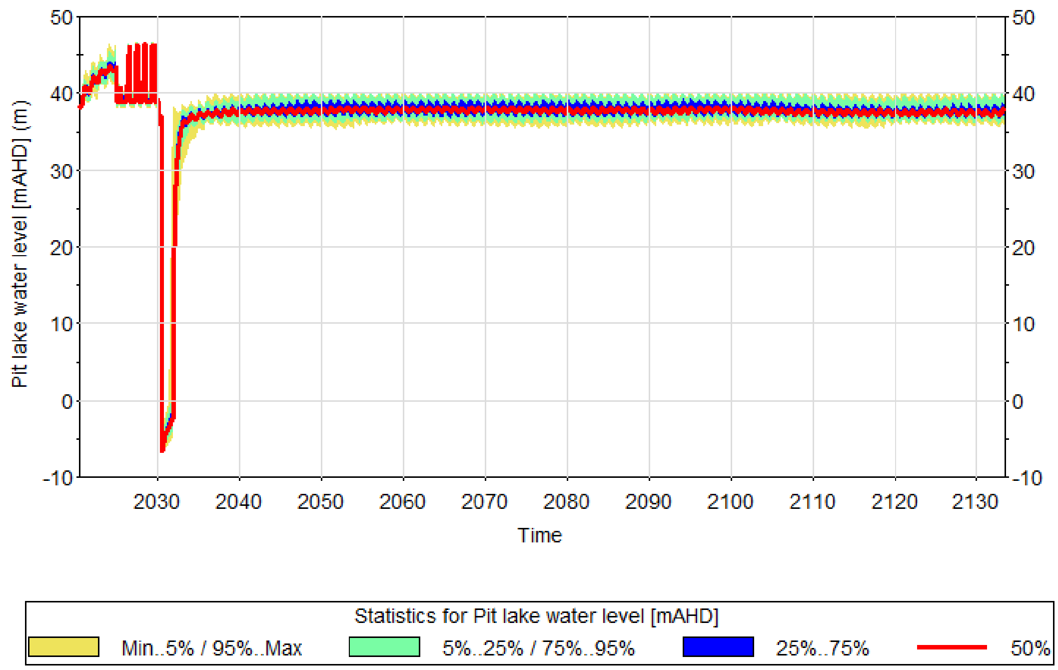

Figure 4-15 Predicted Taipan Pit Lake Levels over Time

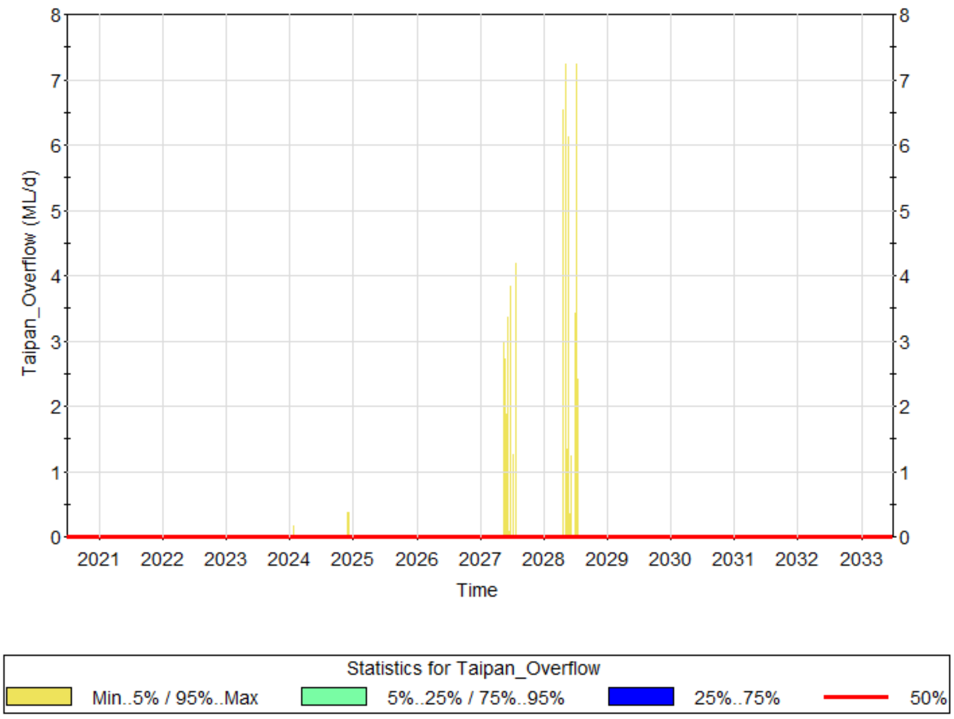

Figure 4-16 Predicted Taipan pit lake overflow rates over time

South Koolpin pit

For the Taipan pit lake, the South Koolpin pit lake may experience increase water levels due to the Zamu pit dewatering between 2025 and 2029 into South Koolpin (Figure 4-17). According to current uncertainty analysis, there is <5% probability of the pit overflowing during its time as a dry season storage for the Zamu pit dewatering (Figure 4-18).

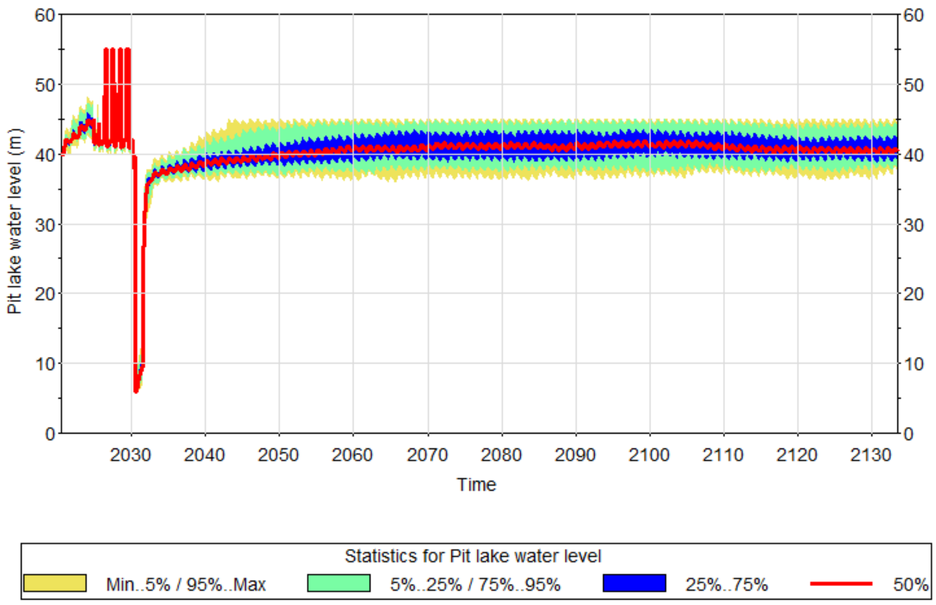

Figure 4-17 Predicted South Koolpin pit lake level over time

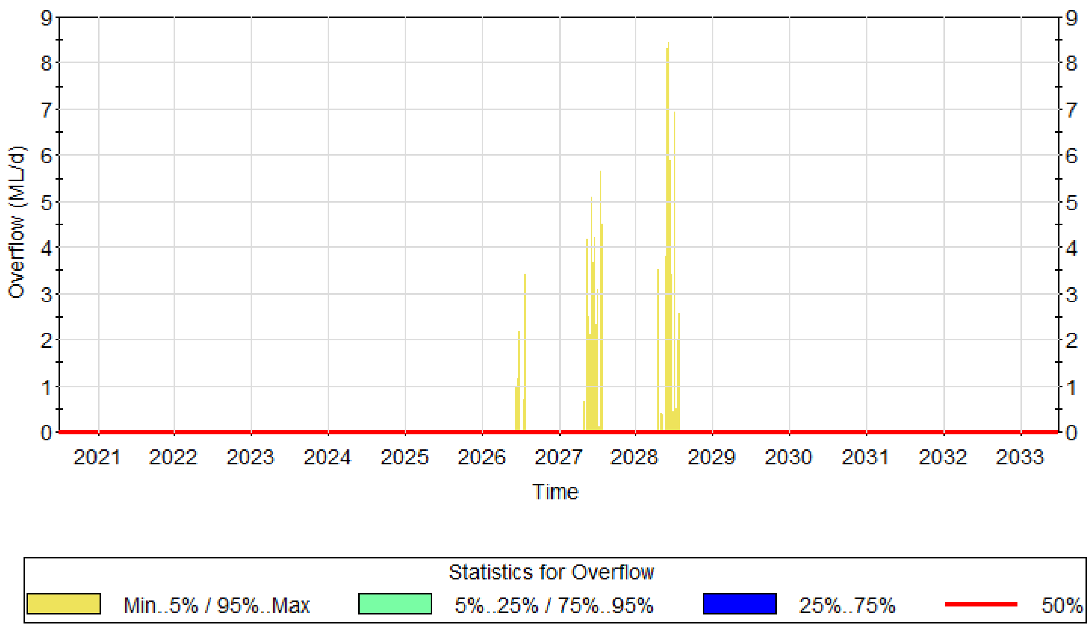

Figure 4-18 Predicted South Koolpin pit overflow rates over time

North Koolpin pit

As for the Taipan and South Koolpin pit lakes, the North Koolpin pit lake levels increase due to the Zamu pit dewatering between 2025 and 2029 (Figure 4-19). According to current uncertainty analysis, the pit has <5% probability of overflowing during this period (Figure 4-20).

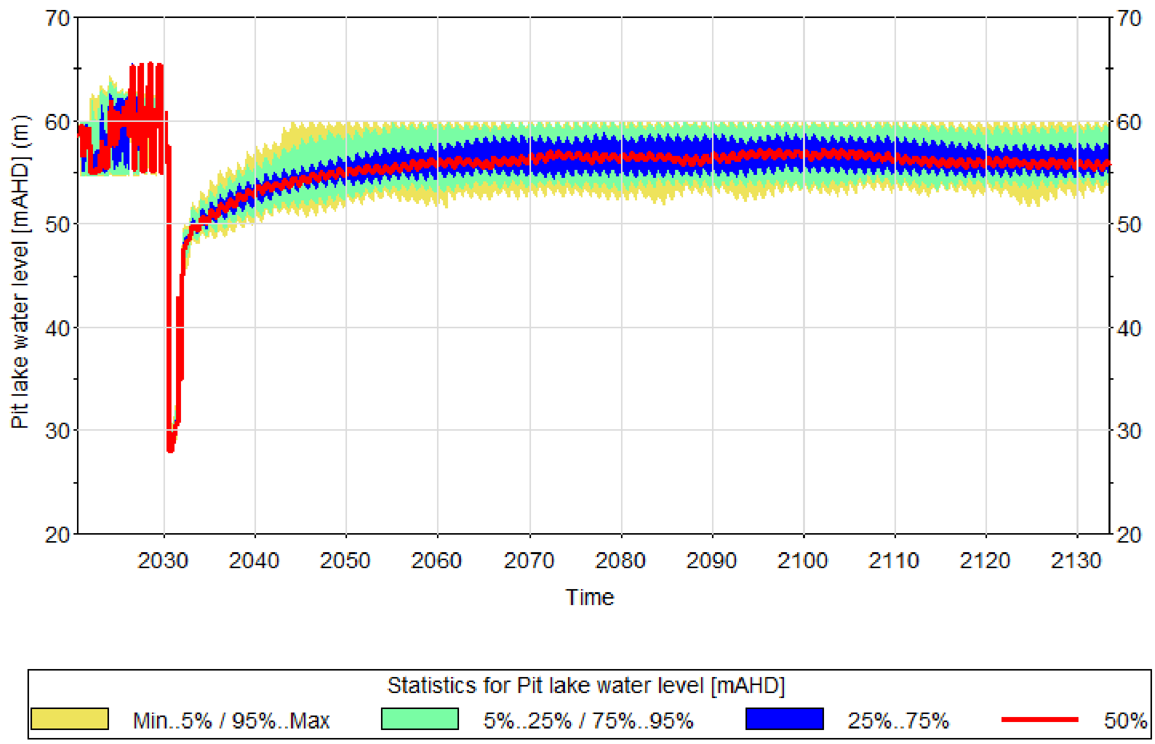

Figure 4-19 North Koolpin pit lake water level

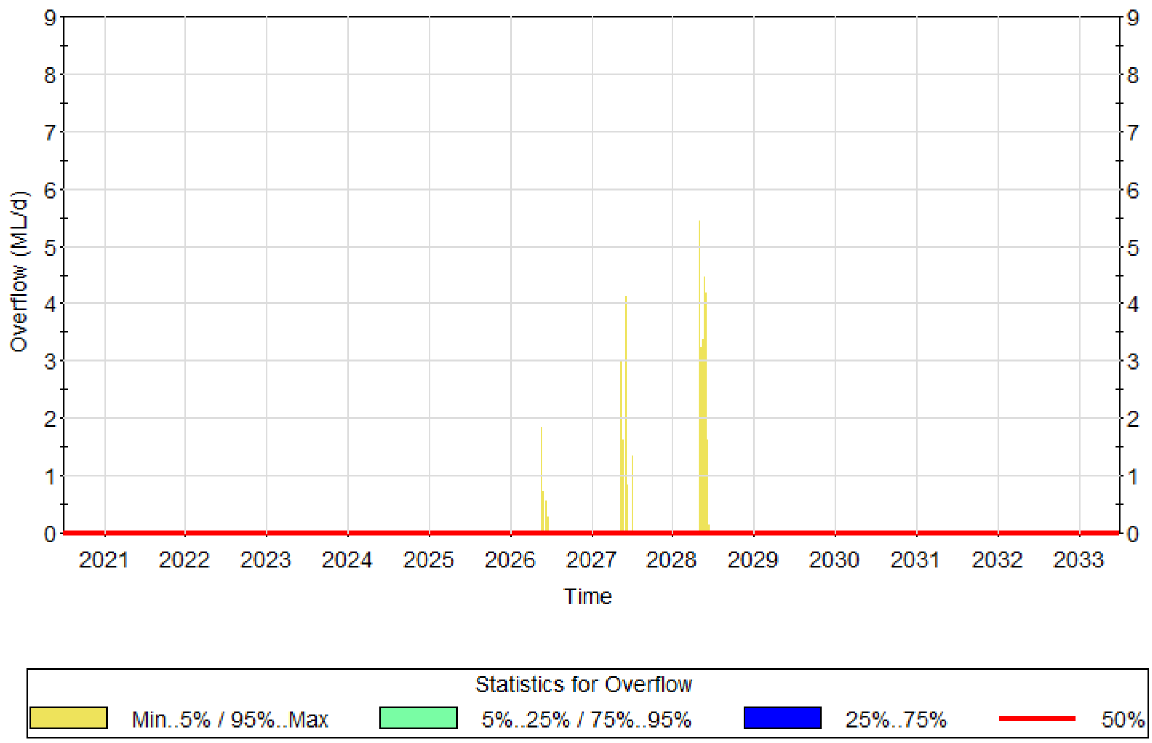

Figure 4-20 North Koolpin pit overflow

BHS pit

As for the other Quest 29 pit lakes, the BHS pit lake levels increase due to the Zamu pit dewatering between 2025 and 2029 (Figure 4-21). According to current uncertainty analysis, the pit has <5% probability of overflowing during this period (Figure 4-22).

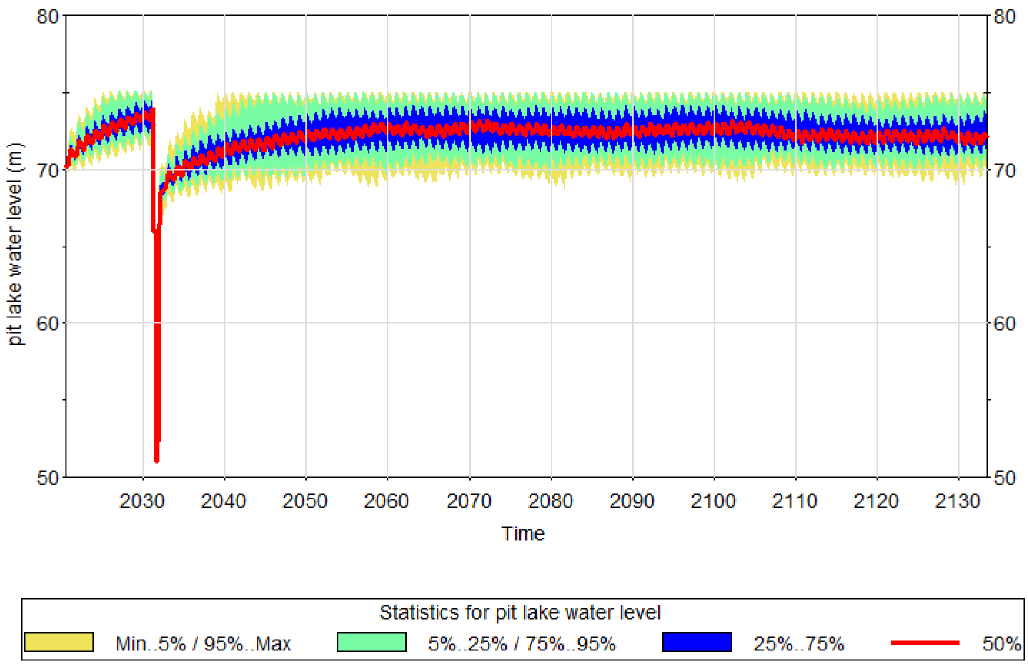

Figure 4-21 BHS pit lake level

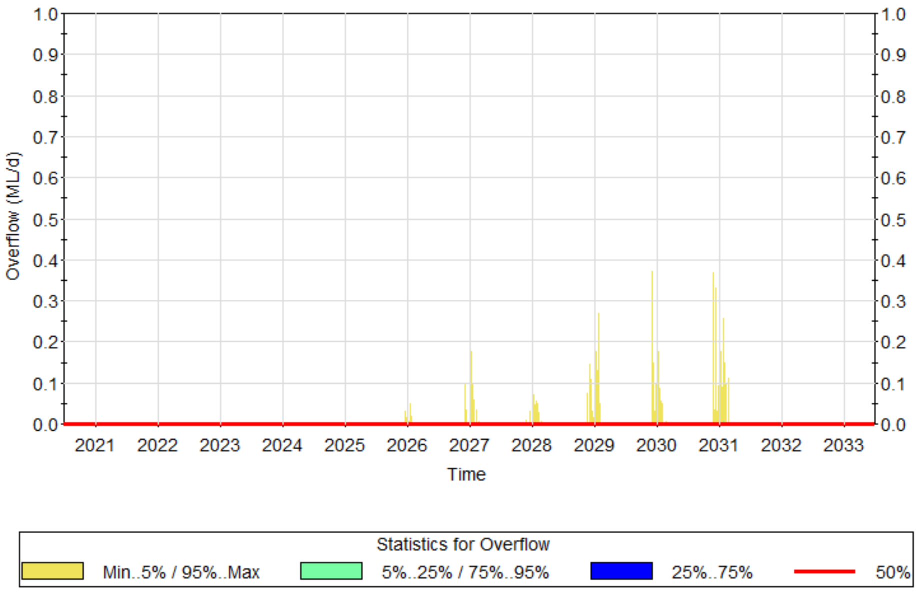

Figure 4-22 BHS pit overflow

4.2.3.7 Key Findings of the Water Balance Modelling

The site water balance was modelled with Goldsim software to estimate the water production and management related to the mining activities on site (pit dewatering, ore processing and other water consumption on site). The model was run in a stochastic mode to account for the parameter uncertainties that are controlling the water production. The model shows that:

- The groundwater seepage into the pits is the main inflow into the water management system as it constitutes an average of 77% of all inflows to the system with an average of 4,000 ML/yr for the life of mining operations. It is also the most uncertain contributor due to the lack of data to constrain the representative value of hydraulic conductivity of the regional aquifer (and implicit heterogeneity of fractured rock aquifers). Pit dewatering volume should be monitored during operations to provide constraints on the hydraulic conductivity and refine the predictions, especially Rustlers Roost pit and any variation with depth. The uncertainty in the hydraulic conductivity results in uncertainty for the volume of water to manage and for the period for complete recovery of pit water levels. It has however, little influence on the final pit lake stabilisation levels which approximate the groundwater table level;

- During mining operations excess water will be discharged to the creeks during the wet season and stored on the site during the dry season. An estimated amount of 36 GL of water will need to be released to the local creeks during mining operation during the wet season. According to current uncertainty analysis, this amount could comprise between 17 GL and 78 GL. The water management system on the site can accommodate the dry season storage in almost all model runs, with only the very highest hydraulic conductivity scenarios resulting in temporary dry season discharge (i.e. 5% of modelled scenarios);

- Post-mining, the pit lakes are unlikely to overflow. The water level for all pit lakes stabilised around the groundwater table levels, suggesting that the pit lakes interaction with groundwater will vary seasonally, sometimes acting as a sink and sometimes as a source;

- As excess water is produced during mining operations, the bore field is only required to supply the demand of drinkable water (reverse osmosis water). Only 5 % of models indicate a requirements for more than 12.5 L/sec in the second half of 2032 where 55L/sec is required for make up water. The model has assumed this water is to be supplied by the bore field, but it could also be sourced from an extension of the Rustlers Roost pit dewatering; and

- Post-mining, the Rustlers Roost pit lake is predicted to stabilise within 30 years post-mining (median estimate) to a level similar to the current one. The likelihood of overflow is very small (regardless of the uncertainty on model parameters including aquifer hydraulic conductivity).

4.3 Surface Water Management

This section provides an overview of potential contaminants associated with mining activities and site infrastructure, the potential impacts on surface water quality and relevant contingency planning and mitigation measures to minimise and control potential impacts.

4.3.1 Potential Contaminants

A large portion of the Project site has been previously subjected to intense open cut mining and mineral processing, leaving the site with significant sources that have the potential to contribute to reduced water quality, particularly in the generation of acid and metalliferous drainage (AMD). The term ‘metalliferous drainage’ is used in this document to encompass both acid rock drainage and neutral mine drainage.

The available geological, geochemical and water quality data, suggests however that for the waste materials currently stored on the sites surface, the potential to leach a significant dissolved chemical load to surface or groundwater is low

(CDM Smith 2019). Historical water sampling results have shown limited exposure of surface and groundwater and interaction with existing mine infrastructure (TSF, WRD and leach ponds) with only occasional increase concentrations of dissolved metals and slight decreased pH (refer to section 3.2).

With mining to progress and materials from deeper within the geological profile to be disturbed either by being raised to the surface or dewatered, the quality of groundwater and surface water may decrease. Any occurrence of AMD materials during the life of mine will be managed within the relevant Acid and Metalliferous Drainage Management Plan (AMDMP) (refer to Appendix T in the Draft EIS).

4.3.2 Potential Impacts

The key potential impact is the reduction in water quality of local surface water and groundwater resources and the subsequent decline in ecosystem health due to the sources identified in Section 4.3.1. Specific potential impacts include:

- Adverse effects on downstream ecosystems due to the passive release of poor quality water;
- Adverse effects on downstream ecosystems due to the release of fugitive sediments;
- Adverse effects on fauna and riparian vegetation and groundwater users due to reduced surface water quality; and
- Adverse impacts on the receiving waters that may negatively impact the aquatic ecology of and or affect the beneficial values of the water resource.

The main source of impact would be the potential overflow from storage facilities listed in Section 4.2.1 and 4.2.2. However, all surface water management infrastructure will be designed in accordance with industry best practice to retain a surge capacity that prevents overtopping during high rainfall events and the subsequent release of contaminants into the environment.

4.3.3 Environmental Discharge

Apart from the scenario described in section 4.1, PGO will not be actively discharging to surface water during the life of mining. There is, however, likely to be passive discharge during high flow periods from the following:

- Surface runoff from the existing and proposed WRD at Rustlers Roost and Quest 29;
- Surface runoff from exiting heap leach pads at Rustlers Roost and Quest 29;
- Overflow from existing leach ponds at Rustlers Roost and Quest 29; and
- Overflow from existing pit lakes (Taipan and Zamu pit) at Quest 29.

PGO will establish a comprehensive monitoring program and contact the relevant regulatory bodies in the event that discharges exceed the accepted criteria.

4.3.4 Contingency Planning and Mitigation Measures

General water management practices will continue to be employed, including:

- Monitoring all dam levels and pumping contained water when and where appropriate. Daily checks of all water holding facilities during the wet season will be conducted. When significant rainfall events are forecast, pumps are to be utilised to increase water storage capacity and reduce the risk of overflow;
- Use of bunding to redirect drainage of excess water and prevent sedimentation from WRDs, haul road and other site infrastructure; and
- Continued monitoring of surface water quality as outlined in Section 5.

In the event of a localised spill or release of contaminants, the following emergency response procedures will be enacted to avoid affecting the quality of adjacent surface waters:

- Take all possible safe action to contain the spill and prevent further release;
- Report the incident in accordance the relevant emergency and spill response procedures;
- Assess the environmental impact;
- Notify appropriate authorities, in accordance with regulatory requirements; and PGO management if significant environmental harm is likely; and
- Undertake remedial action.

4.4 Groundwater Management

This section provides an overview of potential contaminants associated with mining activities and site infrastructure, the potential impacts on groundwater quality and relevant contingency planning and mitigation measures to minimise and control potential impacts.

4.4.1 Potential Contaminants

Previous groundwater monitoring has identified areas with an increased potential to adversely affect groundwater including the WRD, TSF, and the pits, through seepage.

Seepage of water through the waste rock and tailings piles can result in the development of acidic conditions from the dissolution of pyritic sulphide minerals such as pyrite. This acidic drainage may liberate metals from the waste rock and tailings which can then enter the groundwater including metals and metalloids such as aluminium, arsenic, cadmium, copper, cobalt, chromium, iron, lead, manganese, nickel, selenium and zinc.

4.4.2 Potential Impacts

Metalliferous seepage from the sources identified in Section 4.3 have the potential for adverse effects on the quality of local groundwater resources that may impact on the beneficial uses including stock watering and health of groundwater dependent ecosystems.

Monitoring results for the groundwater observation bores indicates that groundwater quality in the vicinity of the Rustlers Roost and Quest 29 heap leach pads may have been affected as some elevated sulfate and dissolved metal levels were recorded (Section 3.2.5).

4.4.3 Abstraction for Groundwater Use

Production bores will be established to supply the Project's processing plant at Rustlers Roost with relatively clean raw water in case of the dewatering of the pit is not able to meet the demand. Furthermore, production bores will be required at the accommodation camp site location to provide for potable water supply. Projected volumes of required groundwater are uncertain at this stage of the project and will depend on when the Rustlers Roost pit dewatering volume, the final processing plant water, and the accommodation camp water requirements.

4.4.4 Contingency Planning and Mitigation Measures

Continued monitoring will identify and determine the movement of affected groundwater on site. PGO recognises that mitigation of the potential impacts on groundwater quality in this area is complex and requires the commissioning of hydrogeological studies including input from AMD specialists augmented by the ongoing monitoring and interpretation of water quality.

The contingency and mitigation measures outlined in Section 4.3.4 for surface water will also apply to for groundwater. However, in addition to these mitigation measures, PGO will:

- Rehabilitate of WRD and TSF during mine closure with suitable inert cover material, to prevent potential AMD leaching into groundwater with the WRD to be rehabilitated as a priority. PGO will commission investigations to determine the availability of suitable material on site;
- Commission a hydrogeological study whether new monitoring bores are needed and if so, where they should be located;
- Commissioning of new production bores to spread out the groundwater abstraction, in case of identified impacts on water levels;
- If groundwater quality trigger values are exceeded during monitoring, PGO will increase the frequency of monitoring, notify the regulator and assess and undertake groundwater investigation and remediation works if required appropriate to the type of impact (in conjunction with hydrogeological and geochemical advice); and
- Report any incidents in accordance with appropriate procedures (see Section 10.5 of the Draft EIS).

4.5 Post-Mining Pit Lake Water Quality Analysis

4.5.1 Summary of Analysis

Analysis of the existing pit lake water quality determined that as an aquatic ecosystem habitat for the Rustlers Roost pit lake was moderately poor, with high nutrient concentrations and low oxygen concentrations. However, pit lake water quality for contaminant of potential concern concentrations was good, with only slight exceedances of ecosystem values for total iron and ammonium and drinking water for ammonium.

A predictive analysis of post-mining pit lake water quality was completed for the Rustlers Roost main pit and the Quest 29 satellite pits (Land & Water Consulting 2022). Full report is provided in Appendix N od the Supplement to the Draft EIS document. The objective was to provide potential water quality composition of key elements in pit lake water during and following recovery of the water table.

For the Rustlers Roost pit the analysis predicts the following:

- Lake water in the Rustlers Roost pit is predicted to have high concentrations of contaminants of potential environmental concern (CPEC, relative to screening criteria) for Years 1 – 5 after mining has ceased. This is largely driven by the surface water run-off contacting the PAF rock in pit walls;
- In year 10 copper is predicted to be elevated above the ANZECC & ARMCANZ 2000 Long-Term Irrigation Water and also the Mount Bundy Creek Site-Specific Trigger Value (SSTV), ANZG default guideline value (DGV) and ambient groundwater;
- At this point the calculations assume pit wall run-off is contributing to <20% inflow. This decreases further at year 20 and copper continues to exceed ANZECC & ARMCANZ 2000 Long-Term Irrigation Water due to the strong pit wall run-off signature; and
- By Year 30, most CPEC are at ambient groundwater concentrations except cobalt and copper which exceed the average ambient ground water concentration (and Mount Bundy Creek SSTV).

The predictions are conservative and likely over-predict lake water concentrations. The predictions also do not cater for limnological, hydrological and hydrogeological development of the pit.

For the Quest 29 the analysis predicts the following:

- When adopting the CSF and mean groundwater concentrations, lake water in the Quest 29 pits is predicted to have high concentrations of CPEC (relative to screening criteria) for Years 1 – 5 after mining has ceased. This is largely driven by the surface water run-off contacting the PAF rock in pit walls; and

- In year 10, cobalt, copper, nickel, and zinc are predicted to be elevated above the ANZECC & ARMCANZ 2000 Long-Term Irrigation Water and also the Mount Bundy Creek SSTV, ANZG DGV and ambient groundwater. At this point the calculations assume pit wall run-off is contributing to 20% inflow. This decreases at year 20 and only copper continues to exceed ANZECC & ARMCANZ 2000 Long-Term Irrigation Water due to the strong pit wall run-off signature. By Year 30, most CPEC are at ambient groundwater concentrations except cobalt, copper, and nickel, which exceed the average ambient ground water concentration (and maximum concentration, nickel excepted).

Eight linkages were identified in the conceptual site model completed for the water quality analysis, concerning potential impacts to migratory avian species (and bats), human receptors (abstraction for drinking water external to the site), stock watering and supply of water for groundwater dependant ecosystems.

Given the presumed nature of lakes recovery, the elevated concentrations are predicted to occur in the early recovery period where net flow outwards is minimal during recovery. Thus, this period is considered low risk to receptors.

When the lakes recover the flow may become through flow and at this point the predicted concentrations are either below groundwater concentrations, laboratory limits of reporting (LOR) or in the case of cobalt, copper and nickel are still elevated above ecological criteria (i.e. ANZG DGV). The risk then may be mitigated by reactive retardation as the groundwater flows outwards from the pits, with respect to down hydraulic gradient receptors (groundwater dependant ecosystems).

Note that concentrations are not predicted to exceed stock watering criteria by year 10 post mining i.e. during the net inflow period. Tier 2 review of avian toxicity data does not indicate an unacceptable risk profile to migratory birds using the lakes during the recovery period or post steady state.

The results and recommendations from the post-mining pit lake water quality analysis have informed contingency measures included in Section 4.5.2. The analysis also provided several recommendations for to undertake additional sampling to improve the predictions. Proposed actions and the timeframe for completed the actions are presented in Table 4-7.

Table 4-7 Pit Lake Water Quality Actions

Analysis Recommendations	Actions	Timeframe
Consider oxygen consumption tests on PAF and PAF-LC rock to assess: a. Annual rate of acidity generation (per kg, per m^2 and wt% FeS_2 – depending on material); b. The reactive lifetime of the material c. Timing and magnitude of peak acidity d. Rate of ANC consumption e. 'Lag time' or onset to acid conditions	Primary Gold to commission oxygen consumption tests on PAF and PAF-LC and input into an update of the predictive post-mining pit lake water quality analysis.	Rustlers Roost – between 2024 and 2026 when excavation of the Rustlers Roost main pit provides accessibility to additional samples. Quest 29 – between 2030 and 2031 when excavation of the Koolpin and Taipan pits provides accessibility to additional samples.
Consider OxCon Rapid Oxygen Consumption Cell Tests:	Primary Gold to commission oxygen consumption cell tests and input into an update of the predictive	Rustlers Roost – between 2024 and 2026 when excavation of the Rustlers Roost main pit provides

Analysis Recommendations	Actions	Timeframe
a. Determination of intrinsic sulfide oxidation rate, reactive lifetime of materials and the rate of ANC consumption under simulated site conditions. Consider OxCon Wallrock Oxygen Consumption: b. Determination of intrinsic sulfide oxidation rate, reactive lifetime of materials and the rate of ANC consumption. c. Sulfide oxidation rate as a function of surface area (m^2) under simulated site conditions.	post-mining pit lake water quality analysis.	accessibility to additional samples. Quest 29 – between 2030 and 2031 when excavation of the Koolpin and Taipan pits provides accessibility to additional samples.
Create a block model of the geology/ lithology to better understand the distribution of PAF rock and magnitude of release rates per area of pit wall – this should then allow refinement of the pit wall source and possibly an adjustment to the in pit release rate profile too.	A sulfur blook model based on the geotechnical model has been developed. As per commitments in the SEIS, during operations waste rock geochemistry testing and acid base accounting must continue and include sulphide sulfur, NAG and metals content in waste. As mining progresses the existing Sulfur block model will be continuously updated.	Rustlers Roost – ongoing during operation. Reviewed yearly. Quest 29 – ongoing during operation. Reviewed yearly.
Consider reactive transport modelling for cobalt, copper and nickel at year 30 post closure to provide additional level of redundancy in terms of understanding fate and transport of these CPEC to down hydraulic gradient receptors assuming predications are not as conservative as believed to be.	Should the additional geochemical analysis and refinement of the block model indicate post-closure guideline exceedances of cobalt, copper and nickel at 30 years post mining, Primary Gold will complete reactive transport modelling	Following completing of the oxygen consumption tests
Review the predictions and discussions made within this report against the current acid mine/ rock drainage management plan to ensure consistency in proposed management measures with respect to the linkages identified and requirements for drainage management.	Predictions and discussions reviewed and addressed in AMDMP.	Complete

4.5.2 Contingency Planning and Mitigation Measures

A predictive analysis of post-mining pit lake water quality was completed for the Rustlers Roost main pit and the Quest 29 satellite pits (Koolpin and Taipan pits) (Land & Water Consulting 2022). The modelling predicted potential exceedances of guideline values for contaminants, being cobalt and copper at Rustlers Roost by year 30 and cobalt, copper and nickel at Quest 29 by year 30. When the lakes recover the flow may become through flow and at this point the predicted concentrations are either below groundwater concentrations, laboratory limits of reporting or in the case of cobalt, copper and nickel are still elevated above ecological criteria (i.e. ANZG 2018 DGV). The risk then may be mitigated by reactive retardation as the groundwater flows outwards from the pits, with respect to down hydraulic gradient receptors (groundwater dependant ecosystems).

The analysis is conservative and additional geochemical testing is to be completed during the operational phase to refine the predictions, and thus inform the most appropriate contingencies (refer to Section 4.5.1). In reality, if the PAF rock is stored / managed appropriately to mitigate oxidation of sulfidic material, then release rates could be much lower, and subsequent leach concentrations would be lower. Nevertheless, there are a range of contingency measures that could be employed to firstly prevent elevated concentrations of contaminants in the post-mining pit lake water or reduce these concentrations to below guideline levels, including:

- Insitu Pit Lake Treatment – this technique involves the control of oxidation conditions by introducing substances, including alkaline material and organic carbon substrate, with nutrients directly into the mine pit to make the water more reducing. This technique can create conditions that allow for the precipitation of dissolved of dissolved metals. While this process is typically undertaken for significantly contaminated mining pits, if completed in the early stage of the pit recharge it could styme the generation of contaminants and retain these at appropriate levels;

- Addition of Neutralising Material – With the addition of neutralising agents the pH in the pit can be controlled during refill. There is calculated to be a significant volume of excess NAF material from the mining. Should additional modelling indicate a necessity to ameliorate the pH during the post-mining refill process Primary Gold can consider in-pit disposal of NAF material excavated from the oxide layer or introduce a specific neutralising agent such as limestone rock; and

- Mechanical Water Treatment – this approach would involve mechanical filtration to remove suspended particulates and certain types of organic matter and would typically be utilised as a last resort once other water quality optimisation techniques have been employed. With the proactive management of PAF material and mining pit refill conditions, this is not considered a necessary contingency measure.

The necessity for employing any of the above contingency measures will be determined based on the results of the additional geochemical analysis referenced in Section 4.5.1. It is possible that with additional analysis, the predictive post-mining water quality model will indicate concentrations of cobalt, copper and nickel are likely to be lower than ecological criteria.

Section 5 Monitoring

5.1 Monitoring Program

The monitoring program has been designed to provide sufficient data to assess impacts from the proposed operation. The data will be supplemented with additional works as required and detailed in Section 4.2.

The monitoring program detailed below will apply for the term of the WMP. Table 5-1 outlines the monitoring frequency adopted for the current monitoring program. The sampling program has been developed based on analysis of historical data, focusing on parameters of concern likely to be encountered at the site. With the expansion of the TSF and WRD at Rustlers Roost and some of the pits at Quest 29, a number of surface and groundwater sampling sites will be consumed by the new mining infrastructure. With the progress of the Project, PGO commits to maintaining a comprehensive network of suitable surface and groundwater monitoring sites. The potential new surface water sites have been outlined in Figure 3-10.

Table 5-1 Summary of the existing water monitoring program

Monitoring – locations	Current Numbers	Frequency
Rustlers Roost		
Surface Water	9	Monthly
Groundwater	7	Quarterly
Sediment	5	Annual
Macroinvertebrate	4	Annual
Fish	0	Annual
Quest29		
Surface Water	10	Monthly
Groundwater	7	Quarterly
Sediment	0	Annual
Macroinvertebrate	0	Annual
Fish	0	Annual
Accommodation Camp		
Surface Water	2	Monthly
Groundwater	0	Quarterly
Sediment	2	Annual
Macroinvertebrate	2	Annual
Fish	2	Annual
Tom's Gully		
Surface Water	3	Monthly
Groundwater	n/a	Quarterly
Sediment	3	Annual
Macroinvertebrate	3	Annual
Fish	3	Annual

5.1.1 Quality Control

A comprehensive Quality Assurance/Quality Control (QA/QC) program for the WMP will be implemented. Details of the QA/QC program are presented in Section 6.

Laboratory Quality Control

Samples will be analysed at a NATA accredited laboratory. The laboratory quality assurance processes include reagent blanks, matrix spikes, internal standards and surrogate spikes. A full description of Laboratory Quality Control is presented in Section 6.

Field Quality Control

The QC program is to be undertaken in accordance with the general relevant requirements set out in the Australian Standard AS4482.1. QC samples provide information that discounts or potentially identifies any errors due to possible sources of cross contamination, inconsistencies in sampling and analytical techniques used. The QC program to be completed includes a split duplicate. Descriptions of quality assurance sampling and their collection frequency is provided in Section 6.

5.2 Surface Water

Surface water and mine affected water will be monitored monthly. The monitoring program is based on assessing the baseline (SWTG1A), onsite locations and downstream impact site (SWTG2) across the WMP period. The monitoring program is detailed in Table 5-1 and locations provided in Figure 3-8 and Figure 3-9. In addition, Figure 3-10 shows the potential updated surface water monitoring sites.

Mine affected waters and the receiving environment (i.e. Mount Bundey Creek, Marrakai Creek and McKinlay River tributary) will be sampled on a daily basis if basins overflow and/or during a pumped discharge.

5.2.1 Assessment Guideline Values

Site specific trigger values for surface water in the Project area have been based on a CSIRO review of SSTV for Tom's Gully mine for Mount Bundey Creek (Stauber and Batley 2018). The SSTVs have been designed to facilitate assessment of water quality at the surface water monitoring locations.

In addition, the SSTVs reference ANZG (2018) trigger values for 90% aquatic ecosystem protection in tropical lowland river systems and local background conditions. A summary of the SSTVs is provided in Table 5-2.

Table 5-2 Surface Water Quality Guidelines Values

Analytes	Units	SSTV
pH	pH	5.8-8.0
Electrical Conductivity	µS/cm	41
Turbidity	NTU	87
Total Suspended Solids	mg/L	54
Total Cyanide	mg/L	0.018
Sulphate	mg/L	210
Ammonia (pH 8)	mg/L	1.4
Aluminium	µg/L	295
Arsenic (total)	µg/L	42
Cadmium	µg/L	0.4

Analytes	Units	SSTV
Chromium	µg/L	6
Copper	µg/L	1.8
Iron	µg/L	2,700
Lead	µg/L	5.6
Manganese	µg/L	2,500
Molybdenum	µg/L	34**
Nickel	µg/L	13
Zinc	µg/L	15

5.2.2 Surface Water Sampling Locations

A summary of surface water and mine affected water locations to be sampled is provided in Table 5-3 and displayed on Figure 3-8 and Figure 3-9.

5.2.3 Water Sampling Procedure

All samples will be analysed using a National Association of Testing Authorities (NATA) accredited laboratory. Surface water samples will be collected in accordance with the Australian Standard Surface Water Sampling Guidelines by trained environmental personnel. The Australian Standards used include:

- Australian/New Zealand Standard, Water Quality – Sampling Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples. AS/NZS 5667.1, 1998;
- Australian/New Zealand Standard, Water Quality – Sampling Part 4: Guidance on sampling from lakes, natural and man-made. AS/NZS 5667.4, 1998; and
- Australian/New Zealand Standard, Water Quality – Sampling Part 6: Guidance on sampling from rivers and streams. AS/NZS 5667.6, 1998.

Table 5-3 Surface Water Sampling Locations

Site Code	Sampling location / Description	Position		Analysis Type* Frequency				
		Latitude	Longitude	0	1	2	3	4
Rustlers Roost								
SW6	Spill way proximal to Annie's Dam	-12.923545	131.489554	M	M	M	M	M
SW7	Downstream from Annie's Dam nearby lower pond in an unnamed tributary of the Marrakai Creek	-12.922619	131.487260	M	M	M	M	M
SW2	Creek line to the east of southern heap leach pond	-12.928670	131.501560	M	M	M	M	M
SW5	Southern heap leach pond	-12.928539	131.501017	M	M	M	M	M
SW10	ROM drainage before influence from heap leach	-12.922680	131.496812	M	M	M	M	M
SW11	Downstream from SW10 in drainage line at base of heap leach pad	-12.924117	131.496836	M	M	M	M	M
SW12	Northern drainage of WRD	-12.911724	131.493673	M	M	M	M	M
SW22	Pit lake western side	-12.915881	131.497434	M	M	M	M	M

Site Code	Sampling location /	Position		Analysis Type* Frequency				
SWQ2	Mount Bundey Creek culvert crossing, approximately 500m downstream of confluence with Quest29 drainage line	-12.913087	131.526381	M	M	M	M	M
Quest29								
SWQ1	Charlies Creek, north of BHS pit at culvert crossing	-12.936324	131.574809	M	M	M	M	M
SWQ2	Mount Bundey Creek culvert crossing, approximately 500m downstream of confluence with Rustlers Roost creek line	-12.913087	131.526381	M	M	M	M	M
SWQ4	Mount Bundey Creek, approximately 6 km downstream from Quest 29 lease, upstream from Rustlers Roost creek line confluence	-12.914471	131.536777	M	M	M	M	M
SWQ Leach	Quest 29 lower leach pond	-12.938021	131.577894	M	M	M	M	M
SWQ BHS Pit	BHS pit lake	-12.938386	131.576396	M	M	M	M	M
SWQ3	Zamu pit	-12.958068	131.586851	M	M	M	M	M
SWQ5	Northern Taipan pit bund	-12.958234	131.583856	M	M	M	M	M
SWQ6	Small drain downstream of Zamu pit after confluence from SWQ3 and SWQ5	-12.958795	131.586416	M	M	M	M	M
SWQ7	Small drainage line upstream of Zamu pit	-12.954703	131.586032	M	M	M	M	M
SWQ8	Further downstream from SWQ6, approx. 200 m outside of Quest 29 lease boundary	-12.965656	131.594375	M	M	M	M	M
Accommodation Camp								
CC02	Coulter Creek approximately 500 m downstream from accommodation camp boundary	-12.847370	131.563955	M	M	M	M	M
CC01	Coulter Creek approximately 1.5 km downstream form CC02 outside of mining lease	-12.843499	131.573087	M	M	M	M	M
Tom's Gully								
SWTG1A	Mount Bundey Creek upstream of mine at lease boundary	-12.828336	131.545764	M	M	M	M	M
SWTG2	Mount Bundey Creek at Arnhem Highway Crossing	-12.828622	131.574529	M	M	M	M	M
SWTG3	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	-12.837374	131.599889	M	M	M	M	M

**M= Monthly*

Type	*Analytes*
Type 0	*Water Height Level Reading (Particularly for wet season and during wet season discharge, also to gauge evaporation levels in dry season).*
Type 1	*Field parameters (pH, EC, Temp, Flow)*
Type 2	*Total and Filtered Metals (Al, As, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, U & Zn)*
Type 3	*Major Cations (Ca, K, Na & Mg) Anions (Cl, SO4)– Filtered)*
Type 4	*Titratable Acidity, Alkalinity, Hardness (CaCO3) & Total Suspended Solids (TSS) & Turbidity*

5.3 Groundwater

Groundwater levels and quality will be monitored at quarterly intervals at several production and monitoring bores located upstream, within and downstream of the site. This will also include any newly commissioned production and monitoring bores in the future. The data and information gathered during these monitoring programs will be used to assess potential impacts of mining operations on local groundwater resources (level and quality).

The monitoring program is provided in Table 5-1. Groundwater monitoring locations are shown in Figure 3-8. Nine groundwater bores will be monitored for the term of this WMP.

5.3.1 Assessment Guideline Values

The majority of surrounding land use comprises pastoral leases used for cattle farming with the likely future land use the continuation of pastoral activities. PGO acknowledges good water quality is essential for successful livestock production with poor water quality likely to reduce animal production and impair fertility. High contaminant loads may produce residues within animal products and adversely affect saleability and/or create human health risks (ANZG 2018). Therefore, as a minimum the ANZG Stock water trigger values have been adopted to assess groundwater quality.

A summary of groundwater assessment guideline values are provided in Table 5-4.

Table 5-4 Groundwater Assessment Guideline Values

Analytes	Units	ANZG Livestock Trigger Values
pH	pH	6.0-8.0
Electrical Conductivity	µS/cm	3,000
Total Suspended Solids	mg/L	5,000
Sulphate	mg/L	1,000
Calcium	mg/L	1,000
Aluminium	µg/L	5,000
Arsenic (total)	µg/L	500
Cadmium	µg/L	10
Chromium	µg/L	1,000
Cobalt	µg/L	1,000*
Copper	µg/L	1,000
Iron	µg/L	NA
Lead	µg/	100
Manganese	µg/L	NA
Molybdenum	µg/L	150
Nickel	µg/L	1,000
Uranium	µg/L	200
Zinc	µg/L	20,000

5.3.2 Sampling Locations

A summary of groundwater locations to be sampled is provided in Table 5-5 and displayed on Figure 3-8.

Table 5-5 Groundwater Sampling Locations

Site Code	Position		Analysis Type* Frequency				
	Latitude	Longitude	0	1	2	3	4
Rustlers Roost							
RR MB02	-12.928138	131.501481	Q	Q	Q	Q	Q
RR MB03	-12.931479	131.492211	Q	Q	Q	Q	Q
RR MB04	-12.923166	131.487615	Q	Q	Q	Q	Q
RR MB05	-12.918846	131.49531	Q	Q	Q	Q	Q
RR MB06	-12.915522	131.502737	Q	Q	Q	Q	Q
RR MB07	-12.908878	131.498342	Q	Q	Q	Q	Q
RR MB08	-12.903331	131.492669	Q	Q	Q	Q	Q
Quest29							
Q29 MB03	-12.962217	131.587492	Q	Q	Q	Q	Q
Q29 MB04	-12.957727	131.584775	Q	Q	Q	Q	Q
Q29 MB05	-12.954557	131.585617	Q	Q	Q	Q	Q
Q29 MB06	-12.952175	131.579835	Q	Q	Q	Q	Q
Q29 MB07	-12.949718	131.58156	Q	Q	Q	Q	Q
Q29 MB08	-12.940141	131.581646	Q	Q	Q	Q	Q
Q29 MB09	-12.936416	131.574607	Q	Q	Q	Q	Q

**Q= Quarterly*

Type	*Analytes*
Type 0	*Water Height Level Reading (Particularly for wet season and during wet season discharge, also to gauge evaporation levels in dry season).*
Type 1	*Field parameters (pH, EC, Temp, Flow)*
Type 2	*Total and Filtered Metals (Al, As, Cd, Co, Cr, Cu, Fe, Pb, Mn, Ni, U & Zn)*
Type 3	*Major Cations (Ca, K, Na & Mg) Anions (Cl, SO_4)– Filtered)*
Type 4	*Titratable Acidity, Alkalinity, Hardness ($CaCO_3$) & Total Suspended Solids (TSS) & Turbidity*

5.3.3 Groundwater Sampling Procedure

Groundwater sampling will be conducted in accordance with DME Advisory Note on the Methodology for the Sampling of Ground Waters (AA7-024) and in accordance with the site Sampling Procedure. In general sampling will comprise:

- Gauging water levels relative to Top of Casing (TOC) using an electronic interface meter to determine the relative elevation of the water table;
- Groundwater to be developed using low flow methodology prior to sampling. During development, field parameters including Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), redox potential (Eh) and temperature will be monitored. Bores will be developed until these parameters have stabilised for three consecutive readings, indicating that groundwater representative of the target aquifer has been obtained. The parameters will be considered stable when three consecutive readings are within:
  - 0.05 for pH
  - 3 % for EC
  - 10 % for DO

  - 0.2 °C for temperature
  - 10 mV for Eh.

- Samples to be collected in pre-prepared laboratory supplied bottles containing appropriate preservatives for each proposed analyte. The integrity of groundwater samples to be analysed for heavy metals will be maintained through field filtration using a 0.45-micron filter followed by acidification. Unfiltered samples will also be monitored for assessment of metals against stock water quality guidelines; and
- All relevant sampling equipment will be decontaminated between samples and sample locations using a phosphate free detergent and final rinse with deionised water.

5.4 Groundwater Dependent Ecosystems

The objective of the monitoring program is to protect the ecological condition of the Type 3 GDEs in the Project area:

- Data collected will be used to monitor the degree of hydro(geo)logical change and influencing factors (informing the likelihood component of the risk assessment);
- Data collected will be used to monitor the condition of the GDEs and their sensitivity to changes and influencing factors (informing the consequence component of the risk assessment); and
- A key component of this summary is the acknowledgment there remains uncertainty within the current system – and with this consideration a future works program has been developed.

The proposed monitoring program is driven by the GDEMP objective that aims to protect the ecological condition of the Type 3 GDEs in the Project area. The monitoring data provides the backbone of the GDEMP and will occur as an array of monitoring components that will track the conditions during the construction, operational and post-operational phases of the Project. The GDE monitoring program will be undertaken concurrently with the surface and groundwater monitoring programs.

The data collected will be used to address a series of monitoring objectives which are aligned with the risk assessment methodology, as detailed below.

1. Monitor the degree of hydrogeological change and influencing factors, including background influences (which informs the likelihood element of the risk assessment), by:
   a. Monitoring groundwater levels in the alluvial aquifer in areas of probable drawdown and in areas outside of the predicted zone of influence;
   b. Monitoring groundwater levels in regional aquifers to monitor the predicted drawdown at depth, its propagation towards the surface and the relationship / hydraulic gradient to groundwater levels within the alluvial aquifer supporting the GDEs;
   c. Monitoring streamflow;
   d. Monitoring soil moisture levels using leaf water potentials as a surrogate; and
   e. Monitoring climatic conditions (rainfall, temperature).
2. Monitoring the condition of GDEs, their sensitivity to hydro(geo)logical change, and other influencing factors including background influences (which informs the consequence element of the risk assessment), by:
   a. Monitoring the condition of GDEs by:
      i. Leaf water potential monitoring; to identify likely depth of water use by the vegetation, this can be related to the existing depth of the water table at each site.
      ii. Remote sensing; Using high resolution temporal data develop a time series of NDVI response to climate to observe any trends that may be related to changes in groundwater levels.

iii. Vegetation surveys; to assess the condition of the vegetation and assess any trends against changes in groundwater levels.

b. Monitoring other threats to GDEs (e.g. weeds and pests, grazing pressure, soil erosion, storms, fire) by vegetation surveys.

5.5 Sediment

Sediment sampling will be undertaken to augment the water quality sampling on an annual basis. The purpose of sediment sampling will be to characterise the quality of sediments within the flow channels.

Sediment sampling will be undertaken along upper and lower Mount Bundey Creek, Marrakai Creek and Coulter Creek. Sediment sampling locations are proposed to coincide with the above-mentioned surface water monitoring locations in the vicinity of the Project site. The monitoring program is detailed in Table 5-6 and Table 5-7 and locations provided on Figure 3-8 and Figure 3-9.

5.5.1 Assessment Guideline Value

The environmental systems adjacent to the Project are considered to be highly disturbed systems and a precautionary approach to applying Interim Sediment Quality Values (ISQG) has been adopted (i.e. utilising the upper and lower guideline values). The assessment includes sediment quality in the receiving environment but also physical habitat changes from the operation (i.e. deposition of fine sediment). A summary of adopted sediment assessment guideline values are provided in Table 5-6. Along with metals data, sediments will be assessed for total organic carbon, particle size distribution, redox and pH.

Table 5-6 Sediment Assessment Values

Analytes – Metals / Metalloids	Units	ISQG-Low*	ISQG-High*
Antimony	mg/kg	2	25
Arsenic	mg/kg	20	70
Cadmium	mg/kg	1.5	10
Chromium	mg/kg	80	370
Copper	mg/kg	65	270
Lead	mg/kg	50	220
Mercury	mg/kg	0.15	1
Nickel	mg/kg	21	52
Silver	mg/kg	1	3.7
Zinc	mg/kg	200	410

5.5.2 Sampling Locations

A summary of surface water and mine affected water locations to be sampled for sediment is provided in Table 5-7 and displayed on Figure 3-8 and Figure 3-9.

Table 5-7 Sediment Sampling Locations

Site Code	Sampling location / Description	Latitude	Longitude	Frequency
Rustlers Roost				
RRMCUS	Marrakai creek upstream site – control site	- 12.919623	131.480976	Annual
RRMCDS	Marrakai creek downstream Site	- 12.904950	131.469576	Annual
RRSW2	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad	- 12.928670	131.501560	Annual
RRSW23	Upper Mount Bunt Creek tributary downstream from RRSW2	- 12.930765	131.50637	Annual
Accommodation Camp				
CC02	Coulter Creek approximately 500 m downstream from accommodation camp boundary	-12.847370	131.563955	Annual
CC01	Coulter Creek approximately 1.5 km downstream form CC02 outside of mining lease	-12.843499	131.573087	Annual
Tom's Gully				
SWTG1A	Mount Bundey Creek upstream of mine at lease boundary.	-12.828336	131.545764	Annual
SWTG2	Mount Bundey Creek at Arnhem Highway Crossing	-12.828622	131.574529	Annual
SWTG3	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	-12.837374	131.599889	Annual

Analytes:
Electrical Conductivity and pH.
Metals (Al, As, Ag, Cd, Co, Cr, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Sb, Zn and U)
Major Cations and Anions (Na, K, Ca, Mg, Cl, SO4, CO3, HCO3, NH3, NO3)
Particle Size
Distribution (sieve and hydrometer)
Total Organic Carbon

5.5.3 Sediment Sampling Procedure

Sampling of creek bed sediments will be based on the Australian Standard - Guide to the investigation and sampling of sites with potentially contaminated soil (AS 4482.1-2005). The general procedure is:

- Sediment samples taken from reasonably straight stream reaches;
- Where the waterway features multiple channels, sampling should be undertaken from the primary or low flow channel;
- Nitrile gloves worn while sampling and disposal of gloves at the completion of each sampling event to avoid cross contamination;
- Collection of 5 sub-samples of approximately 1 kg each from within the cross-section of the bed profile between the surface and a depth of 200 mm;
- Sub-samples evenly spaced across the primary channel at the sampling location;
- Combine and mix the sub-samples thoroughly in a clean decontaminated bucket; 1 kg sample placed into a polyethylene zip lock bag or sample container as provided by the laboratory, two 250 mL glass jar for the particle size distribution analysis and two 250 mL glass jars for the remaining general analytical suites; and
- Label the laboratory sample bag and jars clearly indicating the site code.

5.6 Biota

Biological monitoring comprises annual macroinvertebrate, fish, habitat assessment and in-situ water quality testing. The monitoring will be undertaken during receding wet season flows and includes:

- Macroinvertebrate Survey (Northern Territory AUSRIVAS methodology);
- Fish Survey – Fish sampling primarily using a mixture of backpack electrofishing and bait trapping;
- Habitat Assessment – Habitat assessments include the whole reach (100 m section of the river), the habitats sampled, and the surrounding terrestrial environment. This included information on:
  - Site description
  - Water Quality
  - Characteristics of macroinvertebrate habitat
  - Instream physical characteristics (flow velocity and depth, instream habitat characteristics, bank height, riparian width)
  - Riparian vegetation characteristics (types, %cover, exotic species, erosion, land use),
  - Water quality observations (clarity, odour, oils, foam/scum, plume, sediment oils, sediment odours) and
  - Sketch of the site and cross section.
- In-situ water quality – water quality measured using a multi-parameter water quality meter and laboratory analysis of water samples at each site covering physico-chemical parameters, major anions, major cations, metals (dissolved and total) and cyanide.

5.6.1 Sampling Locations

A summary of biological sampling locations to be sampled are provided in Table 5-8 and displayed on Figure 3-8 and Figure 3-9.

Table 5-8 Biological Sampling Locations

Site Code	Sampling location / Description	Latitude	Longitude	Frequency	Biota Category*
Rustlers Roost					
RRMCUS	Marrakai creek upstream site – control site	- 12.919623	131.480976	Annual	M, H
RRMCDS	Marrakai creek downstream Site	- 12.904950	131.469576	Annual	M, H
RRSW2	Upper Mount Bundey Creek tributary upstream, adjacent to leach heap pad	- 12.928670	131.501560	Annual	M, H
RRSW23	Upper Mount Bunt Creek tributary downstream from RRSW2	- 12.930765	131.50637	Annual	M, H
Accommodation Camp					
CC02	Coulter Creek approximately 500 m downstream from accommodation camp boundary	-12.847370	131.563955	Annual	M, F, H
CC01	Coulter Creek approximately 1.5 km downstream form CC02 outside of mining lease	-12.843499	131.573087	Annual	M, F, H
Tom's Gully					

SWTG1A	Mount Bundey Creek upstream of mine at lease boundary- control site	-12.828336	131.545764	Annual	M, F, H
SWTG2	Mount Bundey Creek at Arnhem Highway Crossing	-12.828622	131.574529	Annual	M, F, H
SWTG3	300 m upstream of confluence between Mount Bundey Creek and Coulter Creek	-12.837374	131.599889	Annual	M, F, H

**Biota Sampling Categories*
M – Macroinvertebrates
F – Fish
H – Habitat Assessment

Section 6 Monitoring Program – Quality Assurance and Control

Quality Assurance (QA) involves all of the actions, procedures, checks and decisions, undertaken to ensure the representativeness and integrity of samples and accuracy and reliability of analytical results (National Environmental Protection Council 1999). Quality Control (QC) involves protocols to monitor and measure the effectiveness of QA procedures.

The QA/QC procedures outlined in the following Sections have been based on AS 5567.1 – 1998.

6.1 Data Quality Indicators

To minimise the potential for unrepresentative data, the following Data Quality Indicators (DQIs) will be used to evaluate sampling techniques and laboratory analysis of collected samples:

- Data representativeness - expresses the degree which sample data accurately and precisely represents a characteristic of a population or an environmental condition. Representativeness is achieved by collecting samples in an appropriate pattern across the Site, and by using an adequate number of sample locations to characterise the site. Consistent and repeatable sampling techniques and methods are utilised throughout the sampling;
- Completeness - defined as the percentage of measurements made which are judged to be valid measurements. The completeness goal is set at there being sufficient valid data generated during the study. If there is insufficient valid data, then additional data are required to be collected;
- Comparability - is a qualitative parameter expressing the confidence with which one data set can be compared with another. This is achieved through maintaining a level of consistency in techniques used to collect samples and ensuring analysing laboratories use consistent analysis techniques and reporting methods;
- Precision - measures the reproducibility of measurements under a given set of conditions. The precision of the data is assessed by calculating the Relative Percent Difference (RPD) between duplicate sample pairs.

$$RPD(\%) = \frac{|C_o - C_d|}{C_o + C_d} \times 200$$

Where C_o = Analyte concentration of the original sample

C_d = Analyte concentration of the duplicate sample

Primary has adopted nominal acceptance criteria of 30 % RPD for field duplicates and splits for inorganics, however it is noted that this will not always be achieved, particularly in heterogeneous soil or fill materials, or at low analyte concentrations;

- Accuracy - measures the bias in a measurement system. Accuracy can be undermined by such factors as field contamination of samples, poor preservation of samples, poor sample preparation techniques and poor selection of analysis techniques by the analysing laboratory. Accuracy is assessed by reference to the analytical results of laboratory control samples, laboratory spikes, laboratory blanks and analyses against reference standards. The nominal “acceptance limits” on laboratory control samples are defined as follows:
  - Laboratory spikes – 70-130% for metals/inorganics 60-140% for organics.
  - Laboratory duplicates – <30% for metals/inorganics, <50% for organics.

- Laboratory blanks – <practical quantitation limit.

Accuracy of field works is assessed by examining the level of contamination detected in field and equipment blanks. Blanks should return concentrations of all organic analytes as being less than the practical quantitation limit of the testing laboratory.

The individual testing laboratories will conduct an internal assessment of the laboratory QC program; however, the results will also be independently reviewed and assessed.

6.2 Summary of Data Quality Acceptance Criteria

Data quality acceptance criteria adopted for this Project are set out in Table 6-1 These are generally based on the minimum requirements detailed in the Australian Standard AS4482.1- 2005.

Table 6-1 Data Quality Acceptance Criteria

Measurement	Sediment	Water	Frequency	Acceptance Criteria	
				RPD (%)	Recovery (%)
Quality control samples to be prepared or taken on site (field)					
Blind field duplicate (BFD) samples (primary laboratory)	Yes	Yes	1 in 20 samples collected or 1 per batch	30 or 50	
Quality control samples to be prepared by laboratory					
Laboratory blanks	Yes	Yes	1 per batch		
Laboratory duplicates	Yes		1 in 10 samples collected or 1 per batch (whichever is smaller)	30	
Matrix spike recoveries	Yes		1 per batch		70 to 130
Laboratory control sample spike recoveries	Yes		1 per batch		70 to 130
Surrogate spikes	Yes	Yes	Each analysis done by GC- MS (all organics except TPH C >10		

6.3 Field Program

All field work will be conducted with reference to the advisory note of the DITT for the sampling of surface waters and groundwaters. Key requirements of these procedures are as follows:

- Decontamination procedures - including the use of new disposable gloves for the collection of each sample, decontamination of all multiple use sampling equipment between each sampling location (using a phosphate free detergent and potable water rinse for augers, de-ionised water for the IP) and the use of dedicated sampling containers provided by the laboratory;
- Sample identification procedures - collected samples will be immediately transferred to sample containers of appropriate composition and preservation for the required laboratory analysis. All sample containers to be clearly

labelled with a sample number, sample location, sample depth and sample date. The sample containers are then transferred to an ice filled cooler for sample preservation prior to and during shipment to the testing laboratory;

- Chain of custody protocols - a chain-of-custody form is to be completed and forwarded to the testing laboratory with each discrete batch of samples; and
- Sample duplicate frequency - field duplicates (blind) to be collected and analysed at a rate not less than ten per cent (i.e. not less than one duplicate per ten primary samples).

6.3.1 Field Quality Control

Field quality control procedures will include the collection and analysis of the following:

- Blind field duplicates or BFDs: Comprise a single sample that is divided into two separate sampling containers. Both samples are sent anonymously to the primary Project laboratory. Blind duplicates provide an indication of the analytical precision of the laboratory, but are inherently influenced by other factors such as sampling techniques and sample media heterogeneity.

Section 7 Proposed Actions and Commitments

7.1 Commitment Summary

In addition to the surface and mine affected water, groundwater, sediment and biological monitoring the following commitments relevant to this Water Management Plan are made.

Commitment 1.

PGO will complete the detailed design for the relevant Water Storage Infrastructure and provide it to DITT for review and approval prior to construction.

Commitment 2

The tailings management strategy (including TSF expansion) will be completed and provided to DITT for review and approval prior to modification and use.

Commitment 3 Review of the groundwater monitoring network will be undertaken to inform locations of additional monitoring bores to provide effective coverage throughout the life of mine and beyond closure.

Commitment 4

Installation of flow meters and water storage gauges to validate the water balance model. Weekly readings will be collected on all transfers across site and storage levels.

Commitment 6

A water treatment plan will be established and provided for review as part of the Waste Discharge Licence Application and Mining Management Plan.

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Appendix A Site-Specific Trigger Values for Toms Gully Mine

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Review of Site-Specific Trigger Values for Toms Gully Mine, NT

Jenny L. Stauber and Graeme. E. Batley

January, 2018

Report prepared for Primary Gold Limited

Commercial-in-confidence

Citation

Stauber, J.L. and Batley, G.E. (2018). Review of site-specific trigger values for Toms Gully Mine, NT. CSIRO Land and Water, Australia.

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Executive Summary

Primary Gold Limited is planning to reopen the Toms Gully mine which has been in care and maintenance since November 2010. The site is characterised by acid mine drainage produced through pyrite and chalcopyrite in the pit walls, waste rock and tailings. In addition, there are a number of water storages from previous operations that contain poor quality water, including two evaporation ponds and the larger water storage in the open pit. It is proposed to discharge treated water into Mount Bundey Creek during either the wet season (when there is sufficient dilution capacity) or the dry season and/or provide water to a third party for potential agricultural and horticultural uses, both of which will require water treatment prior to discharge to meet agreed beneficial uses and water quality guidelines.

Primary Gold requested that CSIRO assess the suitability of the site-specific trigger values (SSTVs) derived by GHD in 2015 and, if required, re-derive trigger values for physical and chemical indicators appropriate to the proposed range of beneficial uses of on-site water. The aim was to assist Primary Gold with their water management strategy, particularly to help maintain a neutral water balance and appropriately dispose of any legacy wastewaters.

For physico-chemical parameters, SSTVs for wet season use only were recalculated using the most recent wet season water quality monitoring data from 2015-2017. The revised SSTVs were similar to previous values, with marginally lower 50th and 80th percentile values for conductivity, and higher values (less conservative) for TSS, turbidity, dissolved iron and dissolved aluminium. No SSTVs could be derived for the dry season due to lack of flow, and hence a lack of monitoring data. If discharges are likely to occur in the dry season, then currently only wet season or default ANZECC/ARMCANZ (2000) Guideline Values (GVs) for physico-chemical parameters can be used.

For sulfate, for which no GV exists, chronic ecotoxicity data from the study by Elphick et al. (2011) in soft waters was used to re-derive an 80% species protection value for sulfate of 316 mg/L. This value was higher than the more conservative 95% species protection value of 129 mg/L from Elphick et al. (2011) that was used by GHD (2015).

For toxicants such as metals, default ANZECC/ARMCANZ (2000) GVs should be used. If an 80% species protection level is chosen at the discharge point, then there should be commitment for continuous improvement such that 90 or 95% species protection is achieved at the end of the 1-2 km mixing zone.

If an appropriate treatment before discharge will likely mean that 90 or 95% species protection values could be achieved in Mount Bundey Creek then discharges in both the wet and dry seasons can occur, without the need for a mixing zone, and assuming no additional contamination from seepage or groundwater infiltration. Minimal impacts could be confirmed using direct toxicity assessment with relevant tropical species and this would help to ensure that there is no chronic toxicity of the discharge beyond the compliance point.

For other beneficial uses, such as stock watering or irrigation, lower levels of treatment may be satisfactory, as defined in ANZECC/ARMCANZ (2000) as these GVs are less stringent than for aquatic ecosystem protection. Monitoring of sulfate and other ions in soils, as proposed by Primary Gold, will be required to ensure that there is no build-up of these ions in soils over the longer term.

Table of Contents

1 Introduction

Primary Gold Limited is planning to reopen the Toms Gully mine which has been in care and maintenance since November 2010. The Toms Gully Underground project will utilise the existing Toms Gully mine footprint, dewatering the existing pit to gain access to historic underground workings. The site is characterised by acid mine drainage produced through pyrite and chalcopyrite in the pit walls, waste rock and tailings. In addition, there are a number of water storages from previous operations that contain poor quality water, including two evaporation ponds and the larger water storage in the open pit. Release of untreated water would require dilutions of up to 250:1 to meet aquatic ecosystem water quality objectives for cobalt and zinc, based on the pit water quality in 2012 (EIS, 2015). Therefore, it was proposed to discharge **treated** water into Mount Bundey Creek during either the wet season (when there is sufficient dilution capacity) or the dry season, both of which will require water treatment prior to discharge to meet agreed beneficial uses and water quality guidelines.

The only discharges into Mount Bundey Creek since November 2010 have been:

1. passive discharges via surface water runoff in the wet season, and groundwater
2. licenced discharges from SWTG12 (concrete weir at wetland oxbow overflow point) from 1/2/13 to 31/8/14.

Primary Gold lodged a draft Environmental Impact Statement document (EIS) as required by the Northern Territory Environmental Protection Authority (NT EPA). Since the EIS, Primary Gold has been investigating a number of water treatment options including liming and Virtual Curtain technology to improve water quality prior to discharge. Rather than storing poor quality water in an evaporation dam on site, it was hoped to discharge the water offsite either by a stream discharge (into the ephemeral Mount Bundey Creek) or by supplying the water to local pastoralists to either flood irrigate pastures or to water a mango plantation. The purpose of disposing of water is to maintain a neutral water balance and reduce water management resourcing and the requirement for engineered water-holding structures.

The current compliance site is SWTG2, slightly upstream of the Arnhem Highway Crossing, although this may move slightly further upstream in future, to be further away from road runoff. For a short section downstream from the Arnhem Highway Crossing (approximately 3 km), the beneficial use of the water is for stock drinking. However, for all other parts of Mount Bundey Creek, upstream and downstream, including at the SWTG2 compliance point, the beneficial uses of Mount Bundey Creek are environmental, riparian and cultural, and this applies to all tributaries of the Mary River. Given that water quality guideline values (GVs) for aquatic ecosystem protection are more stringent than for other beneficial uses, these are the values that should apply to Toms Gully.

In previous waste discharge licences for Toms Gully, there had been agreement that the 80% species protection GV be applied as Mount Bundey Creek is considered to be a highly disturbed environment. For future discharges, this level of species protection has not yet been agreed to by the NT EPA, as the regulator is now requesting comparison of these GVs with those for higher levels of protection, i.e. 90% and 95% (See Table 1). As a general rule, continual improvement from such a highly disturbed state is recommended in the existing water quality management framework (ANZECC/ARMCANZ, 2000).

Table 1. ANZECC/ARMCANZ (2000) default guideline values for aquatic ecosystem protection

Toxicant	Guideline value for different % species protection, µg/L		
	95%	90%	80%
Al (pH>6.5)	55	80	150
As	13	42	140
Cd[a]	0.2	0.4	0.8
Cr	1	6	40
Cu	1.4	1.8	2.5
Fe (total)[b]	700	950	1400
Pb[a]	3.4	5.6	9.4
Mn	1900	2500	3600
Ni[a]	11	13	17
Zn	8	15	31
Total ammonia (pH 8)	900	1430	2300

[a]Low hardness value
[b] New guideline under review

Primary Gold requested that CSIRO assess the suitability of the site-specific trigger values derived by GHD in 2015 and, if required, re-derive trigger values for physical and chemical indicators appropriate to the proposed range of beneficial uses of on-site water. The aim was to assist Primary Gold with their water management strategy, particularly to help maintain a neutral water balance and appropriately dispose of any legacy wastewaters.

2 Review of Site-Specific Guideline Values (Trigger Values) Derived by GHD

The assessment of the acceptability of discharges associated with the Toms Gully project area has relied primarily on the development of site-specific trigger values (SSTVs) (now referred to as GVs (Warne et al., 2015)). The ANZECC/ARMCANZ (2000) water quality guidelines discusses the use of site-specific trigger values noting: *'If background concentrations cannot be measured at a site, measurement at an equivalent high-quality reference site that is deemed to closely match the geology, natural water quality etc., of the site(s) of interest is suggested. If the background concentration has been clearly established and it exceeds the trigger value, the 80th percentile of the background concentration can be accepted as the site-specific trigger value for ensuing steps." Noting also that: 'Users may apply direct toxicity assessment to background or reference waters using locally adapted species, to confirm that there is no toxicity.'*

Another relevant statement from ANZECC/ARMCANZ (2000) is that: *'Toxicant concentrations may vary seasonally. Because of this and the need to be confident about the best estimate of background concentrations, it is recommended that background data be gathered on a monthly basis for at least two years. This applies to both physical-chemical stressors as well as toxicants. Until this minimum data requirement has been established, comparison of the test site median should be made with reference to the default ANZECC/ARMCANZ (2000) guidelines. For those months, seasons or flow periods that constitute logical time intervals or events to consider and derive background data, the 80th percentile of background data (from a minimum of 10 observations) should be compared with the default guideline value.'*

The derivation of SSTVs undertaken by GHD did not specifically follow all the above recommendations in ANZECC/ARMCANZ (2000) (see below). In selecting a relevant GV, a choice was made between the SSTV values and the 80% species protection default GVs from ANZECC/ARMCANZ (2000). The choice of 80% species protection (usually for highly disturbed systems) is yet to be agreed by the regulator, as at the edge of a mixing zone normally the 95% protection or at worst the 90% protection value would be expected to be used. However, there are precedents for selection of the 80% species protection level. We are aware that there is at least one other mine in the NT where the regulator has agreed to 80% species protection, with the aim to gradually improve towards higher levels of species protection.

2.1 Physico-chemical stressors

Toms Gully site is situated at approximately 40 m AHD so would be classed as a tropical lowland river ecosystem for determining default GVs for physico-chemical stressors. The climate is highly seasonal with a distinct wet season from December to April each year. Mount Bundey Creek is an ephemeral creek with limited flow and isolated pools during the dry season.

Site-specific trigger values for physico-chemical parameters (pH, DO, EC, turbidity, and TSS) were derived by GHD (April 2015). They obtained monitoring data (93 samples) for one upstream reference site (SWTG1A) collected between April, 2003 and February, 2015. It is more usual to derive SSTVs from a number of reference sites (not just one). However, Primary Gold has confirmed that no other reference sites were accessible or appropriate.

Background concentrations were derived by GHD for the Mount Bundey Creek reference site, SWTG1A, *'based on samples collected annually from 2003 to 2008 followed by intermittent sampling from 2010 to*

2015'. More frequent wet season data were collected from the 2010/11 wet season and onwards over 4 wet seasons. In the GHD report, plots are shown of sampling frequency for SWTG1A and the compliance point SWTG2, but different axis labels were used so the actual dates of sampling were not easily estimated. The actual raw data were not provided in the GHD report, with only a summary table of the minimum, median, maximum, 20th and 80th percentiles, together with plots of some data in Section 6. From these plots, it appears that both wet and dry season data were used to derive the SSTVs. Because the site is subject to wet and dry season flows, it is not appropriate to use data from both seasons in deriving SSTVs. It would be more relevant to derive separate SSTVs for each season, assuming sufficient dry season data are available.

Ideally SSTVs should be derived from the most recent data. Including data from 2003 to 2008 is not advisable unless trends in the data can be observed using control charting to show that values were not significantly changing. Ideally, a minimum requirement of 10 wet season data points should be used from the most recent monitoring data over several years.

GHD compared the 80th percentile of the monitoring data from the reference site to the ANZECC/ARMCANZ GVs for tropical lowland systems, and then usually took the least conservative of the two values as the SSTV.

- pH: The GV for pH was appropriate, with a SSTV of 5.8-8.0.
- Electrical conductivity: ANZECC/ARMCANZ recommends the lower values from the range 20-250 µS/cm for ephemeral rivers in NT, but recognises that values can be higher during the wet season first flush. GHD quoted this range as the SSTV, but we are unsure of whether the upper or lower limit will be used for compliance and whether this differs between seasons. The 80th percentile of the monitoring data was much lower, 57 µS/cm, and hence would be a more conservative value.
- Total suspended solids (TSS): There is no ANZECC/ARMCANZ GV for TSS (only a value for turbidity), so the 80th percentile of the combined monitoring data from both the wet and dry seasons was used (32 mg/L).
- Turbidity: GHD selected the upper ANZECC/ARMCANZ value of 15 NTU as the GV because there were too few data from the monitoring program to derive a SSTV. It is unclear if this would be applied to the wet season only.

2.2 Nutrients

No SSTVs were derived due to limited historical monitoring data, so default ANZECC/ARMCANZ GVs for tropical lowlands would apply. It is not known how agricultural land use in the area may contribute to nutrient levels in Mount Bundey Creek.

2.3 Toxicants

For toxicants, including metals, it is usual to apply the ANZECC/ARMCANZ (2000) GVs as these are based on a toxicological response of freshwater biota, rather than a statistical distribution of the background chemical monitoring data from a reference site. In this way, ecosystem protection is related to the chemical concentrations that would have no chronic toxicity to freshwater biota. Note that GVs for some toxicants are currently being revised and these new guidelines should be released in 2018. However, for the purposes of this report, we have used the current 2000 toxicant GVs (Table 1), except for iron, for which a new GV based on total iron, is under peer review.

For most toxicants, GHD have used the ANZECC/ARMCANZ (2000) GVs appropriately, where values exist. Exceptions include:

- Sulfate (for which no ANZECC/ARMCANZ GV exists): GHD used a GV of 129 mg/L based on a chronic ecotoxicity study with temperate organisms in soft water (temperatures ranged from 11 to 25°C) by Elphick et al. (2011). This value is for 95% species protection and is a reasonable conservative approach.
- Ammonia: GHD used a GV of 2.3 mg/L ammonia at pH 8.0 and 20°C for 80% species protection. The median pH of the monitoring data at the reference site was 6.5 (so ammonia toxicity is potentially less) but the 80th percentile of temperature is 31°C (so ammonia is potentially more toxic). Overall, GHD has taken a conservative value (at 31°C and pH 6.5, the GV could be up to 34.5 mg/L), but given that pH changes over a wide range, their approach is conservative and appropriate.
- Aluminium: GHD used the 80th percentile of the monitoring data (260 µg/L) rather than the more conservative and ecotoxicologically-based ANZECC/ARMCANZ (2000) value of 150 µg/L. They justified this by suggesting that there were catchment-specific characteristics that increased aluminium background concentrations, including the impacts of rainfall runoff. This approach is consistent with ANZECC/ARMCANZ (2000) which allows the use of background concentrations as GVs.
- Iron: There was no ANZECC/ARMCANZ GV for iron in freshwaters at the time, so the 80th percentile of reference site monitoring data (430 µg/L) was used. A new guideline for iron of 1400 µg/L for 80% species protection is now available (undergoing peer review) and this is based on toxicity of dissolved and particulate iron to freshwater biota, rather than a statistical distribution of iron monitoring data. However, if iron background concentrations are naturally higher, the 80th percentile of reference site monitoring data is acceptable as a GV.
- Mo, Co and U GVs were classified as low reliability by ANZECC/ARMCANZ (2000).

2.4 Historical water quality at the compliance point

2.4.1 Physico-chemical stressors

For physico-chemical stressors, the median of the monitoring data is compared to the GV (usually derived from the 80th percentile of the reference site monitoring data). A total of 215 samples were collected from the downstream compliance site SWTG2 (approximately 800 m downstream from the project area) from July, 2002 to February, 2015, with the majority collected in the wet season. Table 6-2 in the GHD report compares the median SWTG2 site data over this entire period, with their SSTVs. It is more usual to compare the annual site median with the SSTV, not a site median over 13 years, and in the case of a seasonal difference, to separate data for each season, to be consistent with the ANZECC/ARMCANZ (2000) approach. In addition, only the most recent data should have been used, as operations and discharges have changed since the site went into care and maintenance, and previous data may bear little resemblance to the proposed discharges of treated water outlined in the current EIS.

There were very wide ranges in concentrations of many parameters at SWTG1A, notably pH, hardness and alkalinity, with turbidity, and occasionally EC, elevated above SSTVs. This may have potential impacts on aquatic biota downstream. An aquatic macroinvertebrate, fish and habitat survey in April 2015 (during a lower than usual wet season) showed that the downstream site near SWTG2 had the lowest abundance of macroinvertebrates (Primary Gold, 2015). Water quality monitored at the time showed elevated EC and low pH downstream at the site on the edge of the lease boundary. A more recent survey in May, 2017, at the end of a more typical wet season, showed similar results, with the macroinvertebrate community characterised by pollution-tolerant families. Limited fish data suggested poor fish condition, and low abundance and diversity immediately downstream of the new tailings dam discharge (Primary Gold Ltd, 2017).

2.4.2 Toxicants

For toxicants, action is triggered if the 95th percentile of the monitoring data exceeds the SSTV or default GV. The Guidelines note that this is equivalent to: *'no action is triggered if 95% of the values fall below the guideline value. The more stringent approach is recommended here because, unlike physical and chemical stressors, toxicant default values are based upon actual biological effects data and so by implication, exceedance of the value indicates the potential for ecological harm. Note that because the proportion of values required to be less than the default trigger value is very high (95%), a single observation greater than the trigger value would be legitimate grounds for action in most cases, even early in a sampling program.'*

In the GHD report, median values of the downstream monitoring site SWTG2, were compared to the SSTVs, rather than the 95th percentile. Their summary does include maximum values (from July, 2002 to February, 2015), and, if these were used, exceedances of SSTVs would occur for cyanide, sulfate, and most dissolved metals, including Al, Cd, Co, Cu, Fe, Mn, Mo, Ni, U and Zn. However, it should be noted that since August, 2014, there have been no direct discharges into Mount Bundey Creek and concentrations of metals have substantially decreased. For this reason, drawing conclusions from historical monitoring data is of limited use.

3 Derivation of Revised SSTVs for SWTG1A

3.1 Wet-season SSTVs

The SSTVs derived by GHD used combined wet and dry season historical monitoring data over 2003-2015, far longer than the two years of monitoring data recommended by ANZECC/ARMCANZ (2000). SSTVs for wet and dry seasons should be derived separately. From the more recent dataset provided by Primary Gold, SSTVs for pH, electrical conductivity (EC), total suspended solids (TSS), turbidity, sulfate, aluminium and iron were derived for reference site SWTG1a, for the wet season only and only for the period 2015 to 2017.

The revised SSTVs are shown in Table 2. The revised SSTVs were similar to previous values, with marginally lower 50th and 80th percentile values for conductivity, and higher values for TSS, turbidity, dissolved iron and dissolved aluminium. The revised SSTV for sulfate was 1.5 mg/L, similar to the previous value of 2 mg/L. In keeping with ANZECC/ARMCANZ (2000), the revised 80th percentile values should be used as SSTVs for the wet season only.

Table 2. Recalculated 50th and 80th percentile values using only wet season data for 2015-2017

	Revised 50th percentile	Revised 80th percentile	Old 50th percentile[a]	Old 80th percentile[a]
pH	6.7	6.9	6.5	7.0
EC, µS/cm	28	41	42	57
TSS, mg/L	40	54	17	32
Turbidity, NTU	51	87	22	60
Sulfate, mg/L	1.0	1.5	1	2
Al (total), µg/L	520	1680	-	-
Al (dissolved), µg/L	174	295	-	260
Fe (total), µg/L	1200	2700	-	-
Fe (dissolved), µg/L	256	492	-	430

[a] Old values derived by GHD based on combined wet and dry season data for 2003-2015

Recommended revised SSTVs for Toms Gully Mine are shown in Table 3. SSTVs for all physico-chemical parameters, as well as total iron and dissolved aluminium, were based on the 80th percentile of wet season monitoring data from the reference site SWTG1A, to take into account natural backgrounds. For all other toxicants, the default guidelines from ANZECC/ARMCANZ (2000) were used as these are based on actual ecotoxicological effects.

Sulfate: The exception was sulfate, for which no ANZECC/ARMCANZ guideline exists. Sulfate toxicity is known to decrease with increasing hardness and Dunlop et al. (2016) derived a site-specific GV of 936 mg SO_4/L for 80% species protection for hard waters (550 mg/L as $CaCO_3$). However, as Bundey Creek at site SWTG1A has a median hardness of 9 mg $CaCO_3$/L (i.e. very soft), this GV is not applicable. Instead, the 95% species protection GV for soft waters from Elphick et al. (2011) of 129 mg/L was recommended in the GHD report. A more recent study by Maeys and Nordin (2013) used the data from Elphick together with data from additional species, and derived a similar value for 95% species protection for soft waters (0-30 mg

$CaCO_3$/L) of 128 mg SO_4/L. Neither study derived a sulfate GV for lower levels of species protection. Using the 8 chronic data points (EC10s) from Elphick et al. (2011) at their lowest hardness values (15-40 mg $CaCO_3$/L), we re-derived a sulfate GV for 80% species protection of 316 mg/L, and 210 mg/L for 90% species protection. Although Bundey Creek has a lower hardness, these values are recommended, if 95% species protection is not required.

Table 3. Final recommended trigger values for discharges into Bundey Creek

Parameter	Trigger Value[a]	Trigger Value (90% species protection)	Final Proposed Trigger Values for the Discharge Point or Compliance Site SWTG2 after dilution
pH	6.9	-	5.8-8.0
EC, µS/cm	41	-	41
TSS, mg/L	54	-	54
Turbidity, NTU	87	-	87
Sulfate, mg/L	316[b]	210[b]	210
Al (pH>6.5), µg/L	295[c]	-	295[c]
As, µg/L	140	42	42
Cd, µg/L	0.8	0.4	0.4
Cr, µg/L	40	6	6
Cu, µg/L	2.5	1.8	1.8
Fe, µg/L	2700[d]	950[e]	2700[d]
Pb, µg/L	9.4	5.6	5.6
Mn, µg/L	3600	2500	2500
Ni, µg/L	17	13	13
Zn, µg/L	31	15	15
Total ammonia (pH 8), mg/L	2.3	1.4	1.4

[a] based on 80th percentile of reference site monitoring data for pH, EC, TSS and turbidity; based on 80% species protection for toxicants
[b] data for soft waters re-derived from Elphick et al. (2011) chronic toxicity study
[c] based on dissolved Al from background data
[d] based on total Fe from background data
[e] new ANZECC/ARMCANZ GV for total Fe (under review)

3.2 Dry season SSTVs

Given that Mount Bundey Creek only flows strongly for 3-4 weeks/year, Primary Gold proposes to also discharge treated water to Mount Bundey Creek in the dry season. Examination of the dry season data for SWTG1A showed that there were data for only 3 samples from 2015 to 2017, which did not meet the minimum sample requirements for derivation of SSTVs. Therefore no SSTVs could be calculated for physicochemical parameters specifically for the dry season. If discharges are to occur in the dry season, then wet season SSTVs, together with toxicant TVs (ANZECC/ARMCANZ, 2000), could be used.

4 Future Compliance with Guideline Values for Stock Drinking Water and Irrigation

Previous monitoring at SWTG12 (wetland oxbow onsite near Mount Bundey Creek – the onsite discharge point) showed that discharge water had low pH, elevated EC, and elevated Co, Cu and Zn concentrations. Therefore, fortnightly monitoring at 13 surface water sites, including Coulter Creek upstream and downstream, for a large range of parameters, is proposed in the Water Management Plan.

The EIS proposed that pit water be treated to meet stock water GVs, to ensure that discharges to Mount Bundey Creek meet the aquatic ecosystem 80% species protection GVs at the compliance site downstream. This means that the section of Mount Bundey Creek that flows through the mining lease would be used as a mixing zone. In this mixing zone for several km (NT EPA says 7 km), the GV for 80% of species aquatic ecosystem protection would not be met. Our understanding is that previous water discharges (2005-2007) had required dilutions of 100:1 for untreated water discharge (from the evaporation pond) into the creek during high flow, but there were no agreed GVs for aquatic ecosystem protection at the time.

Although the EIS states that the compliance point for surface water discharge for the proposed project will be DP1 on Mount Bundey Creek **at the lease boundary**, Primary Gold has suggested that the compliance point will now be a few hundred metres further upstream than SWTG2 to avoid the influence of the road on water quality. A mixing zone of 1-2 km from the point of discharge was proposed.

Table 4 summarises the ANZECC/ARMCANZ (2000) guidelines for stock drinking water. Site water currently stored in pit and evaporation ponds would require treatment before discharge at DP1 to meet stock water GVs for sulfate and a range of metals including Al, Cd, Co, Cu, Ni and Zn. With appropriate treatment technologies, discharge from these storages could meet SSTVs for 80% protection (or better). Meeting sulfate SSTVs would be the biggest challenge, but should be possible using a combination of treatments. If only treated water was discharged, then there would be no need for a mixing zone in Mount Bundey Creek, assuming no seepage or groundwater infiltration of contaminated water. The treated discharge should comply with SSTVs (Table 3) and no dilution would be required. This would mean that discharges could occur in the dry season if necessary.

Lake Bazzamundi is an artificial wetland that was previously used to store mine water and bore water that was compliant with ANZECC/ARMCANZ stock water GVs. No water has been actively pumped into the lake since cessation of underground dewatering in 2010. The lake passively overflows from the south into Coulter Creek. The second proposed compliance site will be DP2 on Coulter Creek at the lease boundary, but there will be no surface water release at this location.

Groundwater, which is assumed to flow from Lake Bazzamundi to the northwest, is fresh and slightly acidic. Water from bores near the underground workings is expected to be of suitable quality for direct release into Lake Bazzamundi, providing the pastoralist with additional water in the dry season. Most bores have groundwater is bicarbonate dominated, but several bores along the edge of the sulfide and oxide waste dumps that is sulfate-dominated, probably due to acid leachate contamination. The Water Management Plan outlines the proposed groundwater concentrations with water quality monitoring upstream, within the site, and downstream on a quarterly basis. Water quality will be assessed against ANZECC/ARMCANZ (2000) stock water GVs and if met, should enable stock watering as a beneficial use.

Table 4. ANZECC/ARMCANZ (2000) guideline values for stock drinking water and irrigation

Analyte	Stock Drinking Water GV (ANZECC/ARMCANZ, 2000)	Irrigation GV (Short-term ANZECC/ARMCANZ 2000)
Sulfate, mg/L	1000	-
EC, µS/cm	~ 3000	-
Al, µg/L	5000	20000
As, µg/L	500	2000
Cd, µg/L	10	50
Co, µg/L	1000	100
Cr, µg/L	1000	1000
Cu, µg/L	1000	5000
Fe, µg/L	-	-
Pb, µg/L	100	5000
Mn, µg/L	-	10000
Ni, µg/L	1000	2000
U, µg/L	200	100
Zn, µg/L	20000	5000

Another possible beneficial water use is for irrigation of mango crops. The ANZECC/ARMCANZ (2000) GVs for short-term irrigation (up to 20 years) are shown in Table 4. There are no GVs for sulfate, chloride or sodium specifically for mango cultivation. Generally the irrigation GVs are less stringent than the stock watering GVs for metals, except for Co, Cr and U. There were very few monitoring data for water quality in Lake Bazzamundi. Site CCO2 (a reference site on Coulter Creek below Lake Bazzamundi) had elevated EC in the April, 2015 and May, 2017 aquatic biota surveys, but all downstream sites had no GV exceedances. There were no exceedances of dissolved metals compared to stock GVs at this site or downstream.

Given the lack of GVs, Primary Gold proposed to regularly survey soils to ensure that there is no long-term build-up of sulfate or other ions in soils over time.

5 Recommendations

For physico-chemical parameters, SSTVs for wet season use only were recalculated using the most recent wet season water quality monitoring data from 2015-2017 (Table 3). No SSTVs could be derived for the dry season due to lack of flow, and hence a lack of monitoring data. If discharges are likely to occur in the dry season, then wet season SSTVs for physico-chemical parameters would have to be used.

For sulfate, for which no GV exists, chronic ecotoxicity data from the study by Elphick et al. (2011) in soft waters was used to re-derive an 80% species protection value for sulfate of 316 mg/L. This value was higher than the more conservative 95% species protection value of 129 mg/L from Elphick et al. (2011) used by GHD (2015).

For toxicants such as metals, default ANZECC/ARMCANZ (2000) GVs should be used. If an 80% species protection level is chosen, then there should be commitment for continual improvement such that 90 or 95% species protection is achieved at the end of the 1-2 km mixing zone.

Liming, Virtual Curtain technology or some equivalent water treatment before discharge, will be required before discharges will meet the SSTVs for physico-chemical parameters and toxicants. Sulfate, aluminium and EC remain elevated after Virtual Curtain treatment (G. Douglas, pers. comm), but could be removed with additional post-treatment, e.g. reverse osmosis. Appropriate treatment before discharge will likely mean that 90 or 95% species protection GVs could be achieved in Mount Bundey Creek with discharges in both the wet and dry seasons, without the need for a mixing zone, and assuming no additional contamination from seepage or groundwater infiltration.

While Primary Gold proposed to undertake water and sediment quality monitoring, as well as biological monitoring downstream, direct toxicity assessment (DTA) of discharges using tropical freshwater species relevant to these soft waters should also be undertaken. This will ensure that there is no chronic toxicity of the discharge beyond the compliance point and will provide a further line of evidence in the weight of evidence approach now recommended in the revised guidelines. This knowledge gap has been identified in the Water Management Plan. DTA of the treated water discharge (with upstream water as the diluent) would provide a “safe” dilution and would be undertaken prior to each wet season, with results used by NT EPA for discharge approval. However, the WMP does not currently include DTA in its monitoring plan.

For other beneficial uses such as stock watering or irrigation, lower levels of treatment may be satisfactory, as GVs are less stringent than for aquatic ecosystem protection. Monitoring of sulfate and other ions in soils as proposed by Primary Gold, will be required to ensure that there is no build-up of these ions in soils over the longer term.

6 References

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CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

FOR FURTHER INFORMATION

Dr Jenny Stauber
t +61 2 9710 6808
e jenny.stauber@csiro.au
w www.csiro.au