Appendix G

Revised Surface Water Assessment – Mine Development

REGIS RESOURCES LTD

HYDRO ENGINEERING & CONSULTING PTY LTD

REPORT

McPhillamys Gold Project
Mine Development
Revised Surface Water Assessment

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1.0 INTRODUCTION

1.1 BACKGROUND

LFB Resources NL is seeking State significant development consent under Part 4 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) to develop and operate a greenfield open cut gold mine, associated mine infrastructure and a water supply pipeline in Central West NSW. The project application area is illustrated at a regional scale in Figure 1. LFB Resources NL is a 100% owned subsidiary of Regis Resources Limited (herein referred to as Regis).

As shown in Figure 1, the McPhillamys Gold Project (the project) is comprised of two key components; the mine site where the ore will be extracted, processed and gold produced for distribution to the market (the mine development), and an associated water pipeline which will enable the supply of water from approximately 90 km away near Lithgow to the mine site (the pipeline development). The mine development is around 8 km north-east of Blayney, within the Blayney and Cabonne local government areas (LGAs).

Up to 8.5 Million tonnes per annum (Mtpa) of ore will be extracted from the McPhillamys gold deposit over a total project life of 15 years. The mine development will include a conventional carbon-in-leach processing facility, waste rock emplacement, an engineered tailings storage facility (TSF) and associated mine infrastructure including workshops, administration buildings, roads, water management infrastructure, laydown and hardstand areas, and soil stockpiles.

In accordance with the requirements of the EP&A Act, the NSW Environmental Planning & Assessment Regulation 2000 (EP&A Regulation) and the Secretary's Environmental Assessment Requirements (SEARs) for the project, an Environmental Impact Statement (EIS) was prepared to assess the potential environmental, economic and social impacts of the project. The development application and accompanying EIS was submitted to the NSW Department of Planning, Industry and Environment (DPIE) and subsequently publicly exhibited for six weeks, from 12 September 2019 to 24 October 2019. During this exhibition period Regis received submissions from government agencies, the community, businesses and other organisations regarding varying aspects of the project.

In response to issues raised in submissions received, as well as a result of further detailed mine planning and design, Regis has made a number of refinements to the project. Accordingly, an Amendment Report has been prepared by EMM Consulting Pty Ltd (EMM 2020a) to outline the changes to the project that have been made since the public exhibition of the EIS and to assess the potential impacts of the amended project, compared to those that were presented in the EIS. This report forms part of the Amendment Report and presents an assessment of the surface water impacts of the amended project.

Further, this report assesses the potential surface water impacts associated with the mine development component of the McPhillamys Gold Project. References to 'the project' throughout this report are therefore referring to the mine development only. The potential surface water impacts associated with the pipeline development component are addressed in the Amendment Report (EMM 2020a).

1.2 PROJECT AMENDMENT OVERVIEW

A summary of the key amendments to the project since the exhibition of the EIS are summarised below and described in detail in Chapter 2 of the Amendment Report (EMM 2020a):

- **Site access** – a new location for the site access intersection off the Mid-Western Highway is proposed, approximately 1 km east of the original location assessed in the EIS, in response to feedback from Transport for NSW (TfNSW, former Roads and Maritime Services) and the community. A new alignment is subsequently proposed for the site access road to the mine administration and infrastructure area.

- **Mine and waste rock emplacement schedule** – revision of the mine schedule and the subsequent construction sequence of the waste rock emplacement has been undertaken, in particular consideration of predicted noise levels in Kings Plains. This achieved a reduction in predicted noise levels at nearby residences while extending the construction timeframe for the southern amenity bund.
- **Pit amenity bund** – the size of the pit amenity bund has been reduced as a result of optimisation of the open cut pit design and the changed location of exit ramps for haul trucks.
- **Tailings Storage Facility** – amendments to the design include changes to the embankment design and construction timing, the TSF footprint and the TSF post closure landform.
- **Water management system –** the secondary water management facility (WMF) has been removed from the water management system resulting in an avoidance of impacts to a potential item of historic heritage (MGP 23 - Hallwood Farm Complex [*Hallwood]*). The capacities of the WMFs have also been revised to achieve a reduced likelihood of discharge from the storages within the operational water management system as part of a revised nil discharge design.
- **Mine administration and infrastructure area –** the layout of this area has been revised and optimised.
- **Mine development project area –** a very small change has been made to the mine development project area along the eastern boundary (an additional 1 ha, or 0.04% change), to accommodate the required clean water management system. The change takes the project area from 2,513 hectares (ha) to 2,514 ha

Some amendments to the pipeline development have also been made – refer EMM (2020a). No amendments have been made to other key aspects of the project as presented in the EIS for which approval is sought, such as the proposed mining method, operating hours, annual ore extraction rate of up to 8.5 Mtpa, annual ore processing rate of up to 7 Mtpa, employee numbers, and rehabilitation methods and outcomes.

The amended mine development project layout, compared to that assessed in the EIS, is shown in Figure 2.

1.3 PURPOSE OF THIS REPORT

This report has been prepared to assess the potential surface water impacts associated with the amended project. The assessment considers and outlines the differences in impacts compared to the original project as presented in the EIS. In this way, it serves as an update to the McPhillamys Gold Project Surface Water Assessment (EMM, 2019) (Appendix J of the McPhillamys Gold Project EIS).

This SWA assesses likely impacts of the mine development on surface water resources both within and downstream of the mine development boundary. This includes potential impacts on streamflow and the local flood regime. The report also considers water management for the mine development, both in terms of upslope runoff diversions and management of water within disturbed portions of the mine development boundary. The assessment includes a water balance that forecasts the water supply and storage requirements for the mine operations and assesses the water and salt balance of the proposed final void. The 'take' of surface water from the Belubula River above Carcoar Dam water source has also been addressed.

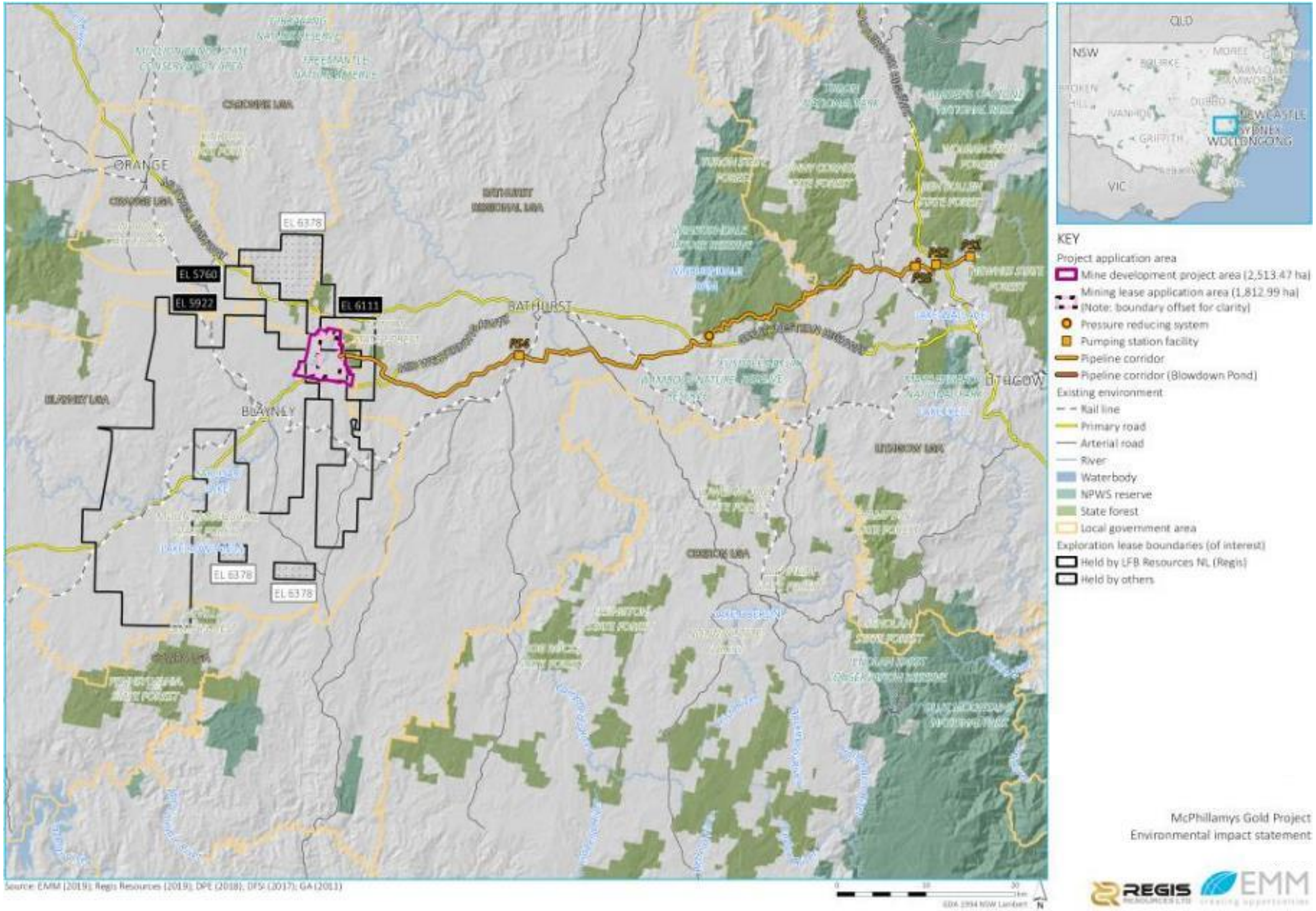


Figure 1 Site Locality and Regional Setting

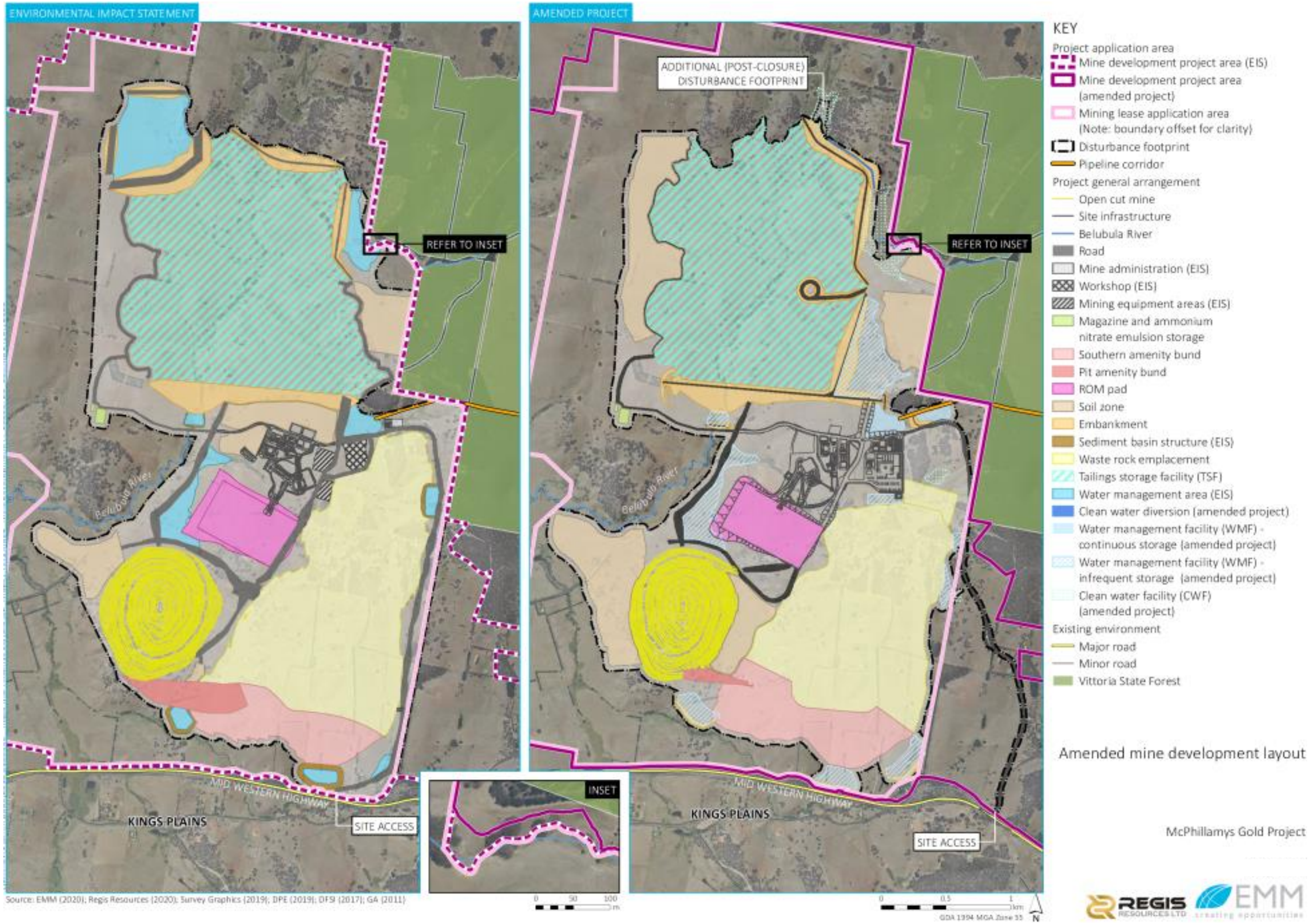


Figure 2 Amended Mine Development Layout

1.4 SUBMISSIONS ON THE EIS

A number of issues relevant to surface water were raised in submissions received on the EIS. These issues have also been considered in this revised assessment. Detailed responses to all the submissions received are provided in the Submissions Report prepared for the project (EMM 2020b), which has been prepared in conjunction with the Amendment Report (EMM 2020a). A summary of the key issues relevant to this assessment are provided in Table 1, together with where each matter has been addressed within this report.

Table 1 Key Submissions Issues Addressed – Surface Water

Organisation	Issue	Where Addressed
Department of Planning, Industry and Environment - Water	Further information regarding the Carcoar Dam surface water model.	Section 4.1.1
	Details as to timing, frequency, locations and justification for monitoring watercourse condition.	Section 5.2
NSW Environment Protection Authority (EPA)	Qualitative discharge assessment: potential impacts of construction phase discharges.	Sections 3.1.3 and 3.2.3.6
	Details regarding management of dewatering of 'clean water' dams to avoid and minimise downstream impacts.	Section 3.1.1.1
	Revision of assessment to use the relevant Australian and New Zealand Guidelines for Fresh and Marine Water Quality guideline values for slightly to moderately disturbed ecosystems.	Section 2.8.2.1
Community	Potential impacts on surface water quality (including contamination of the Belubula River as a result of surface water runoff, seepage and reduced flows). Potential impacts on surface water availability including flow reductions.	Sections 4.1.1, 4.1.4, 4.2.1 and 4.2.4

1.5 TERMINOLOGY

Throughout this report the term "mine project area" is used to refer to the mine development project area as illustrated in Figure 1.

2.0 BASELINE SURFACE WATER RESOURCES

2.1 RAINFALL AND EVAPORATION

Regis operates a weather station located near the southern end of the mine project area (refer Figure 3 and Figure 4). The Bureau of Meteorology (BoM) operates or has historically operated twelve rainfall recording stations nearby within 15 km of the mine project area which are shown on Figure 3 and summarised in Table 2. These stations have varying periods of record. The Millthorpe (Inala) station has the longest period of data (1899-2005) in the area and has a recorded average annual rainfall for this period of 798 millimetres (mm). The long term synthetic rainfall obtained from the SILO Data Drill[1] system (713,659mE; 6,290,913mN) for the mine project area gives an average annual rainfall of 702 mm.

Table 2 Summary of Bureau of Meteorology Rainfall Stations

Station Number	Station Name	Location (GDA94* Zone 55)		Approximate Distance from Mine Project Area (km)	Elevation (m AHD†)	Period of Record
		Easting (m)	Northing (m)			
063086	Blayney (Vittoria)	716,878	6,296,389	3.1	975	1902-1977
063258	Athol 1	713,659	6,290,913	3.4	unknown	1879-1930
063129	Vittoria (Taringa)	712,229	6,296,493	4.8	910	1962-1977
063279	Blayney (Athol)	710,485	6,287,321	8.2	870	1885-1901
063010	Blayney Post Office	709,857	6,287,113	8.8	863	1885-1992
063294	Blayney (Orange Rd)	708,517	6,287,874	9.3	880	1990-present
063306	Bathurst (The Rocks)	723,629	6,297,123	9.6	910	1996-present
063264	Newbridge (Stringybark Rd)	721,180	6,282,832	11.8	952	2011-present
063240	Newbridge Post Office	719,645	6,281,535	12.4	860	1968-1987
063299	Newbridge (Primary School)	719,411	6,281,441	12.4	880	2000-2011
063207	Newbridge Park	724,330	6,283,269	13.1	unknown	1897-1915
063053	Millthorpe (Inala)	703,073	6,297,189	13.3	960	1899-2005

* Geocentric Datum of Australia

† Australian Height Datum

Average monthly rainfall, calculated from long term data, recorded at Millthorpe (Inala) (station 063053) is shown in Table 3. Also shown in Table 3 are data for the McPhillamys weather station as well as long term synthetic rainfall obtained from the SILO Data Drill system for the mine project area.

[1] The SILO Data Drill is a system which provides synthetic data sets for a specified point by interpolation between surrounding point records held by the BoM. Refer https://www.longpaddock.qld.gov.au/silo/

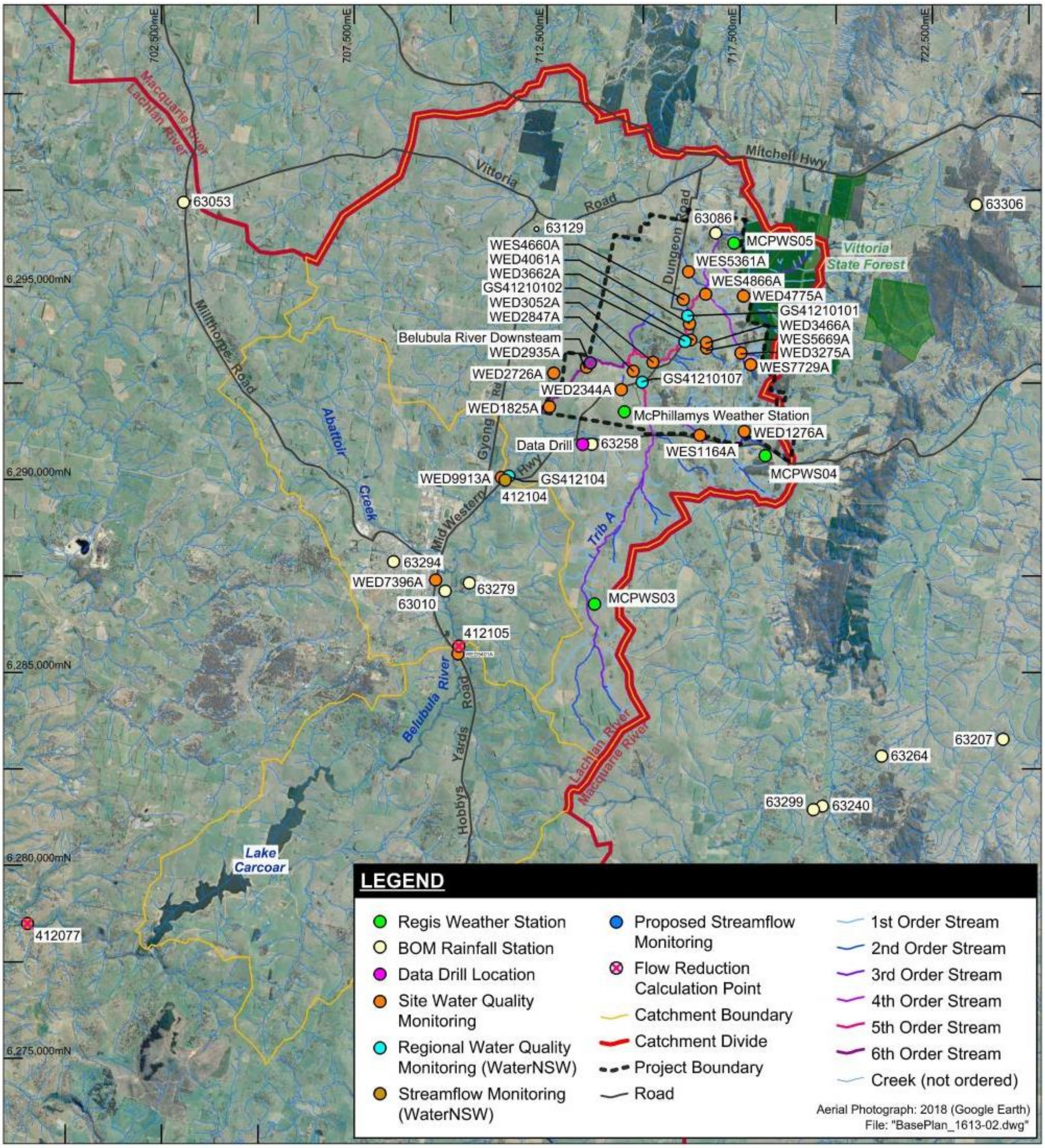


Figure 3 Regional Layout and Monitoring

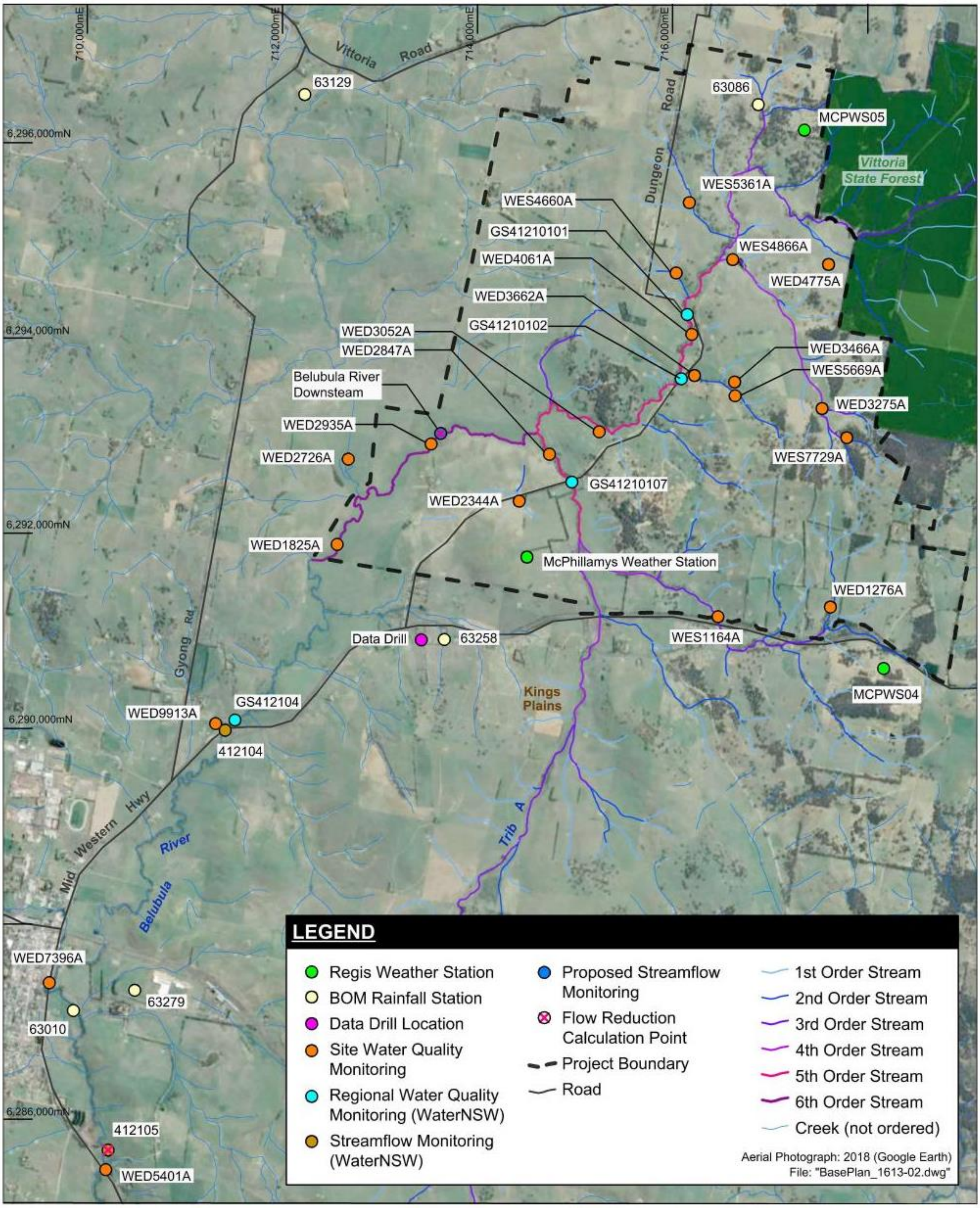


Figure 4 Local Monitoring Sites

Table 3 Average Monthly Rainfall

Data Source:	SILO Data Drill for Mine Project Area	Millthorpe (Inala) (063053)	McPhillamys Weather Station
Number of Years of Record:	131	106	6
	millimetres		
January	65.7	71.2	66.0
February	55.7	61.5	26.0
March	54.0	55.4	54.2
April	46.7	52.9	43.3
May	50.5	59.9	43.2
June	60.7	72.7	54.0
July	61.2	75.9	50.3
August	64.7	79.4	61.1
September	58.3	66.1	58.8
October	65.2	78	45.3
November	58.5	64.5	66.7
December	61.6	67.3	71.8
Annual Average	**701.8**	**783.1**	**640.5**

The data in Table 3 indicate a long term average annual rainfall for the mine project area of approximately 702 mm, with lower rainfall occurring in autumn months. The recorded 6 year McPhillamys weather station annual average of 640.5 mm is lower than the long term regional average but approximately equal to the corresponding period SILO Data Drill average (661.4 mm). The Millthorpe (Inala) station was closed in 2005 and hence calculated averages for this station do not consider dry weather in recent times. As the SILO data is generated from long term rainfall data it is considered to be the most appropriate data for use in this assessment. The 131 year daily SILO Data Drill rainfall has therefore been used for the water balance simulations (refer Section 3.2). Rainfall in the vicinity of the mine project area is generally associated with frontal systems in winter and depressions in summer months.

Average monthly pan evaporation, calculated from long term synthetic data obtained from the SILO Data Drill for the mine project area is provided in Table 4. This data is considered the most appropriate for the assessment because it is generated for the site location from long term regional data. The 131 year daily SILO Data Drill evaporation has therefore been used for the water balance simulations (refer Section 3.2).

Table 4 Average Monthly Evaporation – SILO Data for Mine Project Area

	Number of Years of Record:	130
millimetres	January	209.3
	February	163.7
	March	138.8
	April	83.7
	May	50.7
	June	30.8
	July	34.7
	August	54.4
	September	85.0
	October	126.0
	November	159.4
	December	202.6
	Annual Average	**1,339.1**

The data in Table 3 and Table 4 shows that average evaporation exceeds average rainfall in all but the three winter months.

2.2 REGIONAL AND LOCAL TOPOGRAPHY

The mine project area is located on the western slopes of the Great Dividing Range. The most significant regional topographic feature is Mt Canobolas with an elevation of 1,395 m AHD, located approximately 35 km to the west north-west of the mine project area. Other significant topographic features include:

- Mt Bulga (1,062 m AHD) – located approximately 29 km north-west.
- Crackerjack Rock (967 m AHD) – located approximately 14 km north-east.
- Mt Macquarie (1,204 m AHD) – located approximately 24 km south-west.

Topography immediately surrounding the mine project area tends to be undulating, with rolling hills with maximum elevations typically between 900 m AHD and 1,000 m AHD and open valleys. Slopes are typically moderate to gentle. To the east of the mine project area, a north-south orientated ridgeline forms the catchment divide between the Macquarie and Lachlan River catchments (refer Figure 3).

Topography within the mine project area is dominated by a series of rounded hills with maximum elevations ranging between 920 m AHD and 980 m AHD. Valleys between the hills are typically open, with slopes varying between 1:50 (V:H) and 1:10 (V:H), increasing to up to 1:4 (V:H) on sides of the more substantial hills. Areas with slopes of less than 1:50 (V:H) are typically associated with flood plains of the Belubula River and associated tributaries.

2.3 REGIONAL GEOLOGY AND SOILS

The McPhillamys deposit is located within the Silurian-aged Anson Formation of the eastern subprovince of the Lachlan Fold Belt B. The deposit occurs on the eastern side of the Sherlock Fault, part of the Godolphin-Copperhania thrust fault zone. The deposit lies along one of a series of north-south trending splays/horsetail structures that occur at the inflection of the Godolphin-Copperhania thrust fault zone where the orientation changes from north north-west/south south-east to south south-west/north north-east. The splays are defined by strong shearing and faulting and continue to the south for over 6 km.

The mine project area is underlain by metasediments and volcaniclastics of the Silurian and Anson Formation and Ordovician volcanics, with minor disconnected areas of shallow Quaternary alluvium associated with watercourses and drainage lines. Silurian volcaniclastics vary in composition from crystal tuffs to agglomeratic matrix supported accretions. Some ungrouped Devonian formations also exist within the eastern part of the site and consist of slate, laminated siltstone and lithic sandstone. Occurrences of the Byng Volcanics of the Ordovician Volcanics consisting of basalt and volcaniclastic sandstone are dominant west of the Godolphin Fault with minor occurrences within the headwaters of the Belubula River. Jointing/lineation associated with this geology is reported to be approximately parallel to the Godolphin Fault. There exists a shallow east-dipping domain boundary structure separating the Ordovician Macquarie Arc in the west from the Silurian Hill End Trough in the east, trending south-east to south-west and located less than 1 km west of the mine project area.

The bedrock in elevated portions of the mine project area is overlain by strongly acidic, brown, loamy topsoil over more clayey subsoil classified as a mix of Chromosols and Dermosols. The drainage lines are generally comprised of acidic, light clay topsoil over grey clayey subsoil (SSM, 2019, 2020).

2.4 REGIONAL AND LOCAL HYDROLOGY

The mine project area is located in the headwaters of the unregulated Belubula River which flows from north-east to south-west through the mine project area (refer Figure 3). The Belubula River is a tributary of the Lachlan River which terminates in the Great Cumbung Swamp near the banks of the Murrumbidgee River to the north-east of Balranald approximately 580 km west south-west of the mine project area – it flows into the Murrumbidgee River during flood events which in turn flows to the Murray River.

A substantial number of unnamed tributaries flow into the Belubula River. A stream assessment was carried out by EMM (2017) to target reclassification of stream orders and enhance overall knowledge and understanding of the local hydrology. For the purposes of this assessment, the unnamed tributaries are referred to as Trib A to Trib J (refer Section 2.8.4), with Trib A and Trib B combined being the most substantial of these with a catchment area of approximately 24.4 km^2. By comparison, the Belubula River just upstream of the confluence with Trib A has a catchment area of approximately 17.5 km^2.

Up until 1975, the upper reaches of the Belubula River were referred to as Dungeon Creek and Trib A was referred to as Kings Plains Creek however the more recently available topographical mapping refers to the Belubula River and leaves Trib A unnamed.

Carcoar Dam is located on the Belubula River approximately 26 km downstream or to the south-west of the mine project area (refer Figure 3). Carcoar Dam has a catchment area of approximately 230 km^2 and a storage capacity of approximately 35.8 gigalitres (GL). Carcoar Dam is managed by WaterNSW and is used primarily for regulated releases for licensed extraction, environmental, stock and domestic purposes. Only ten percent of total annual flow in the Belubula River comes from Carcoar Dam releases, with the remaining 90 percent derived from inflows from unregulated tributaries (Department of Primary Industries, 2013). Lake Rowlands is a 4.5 GL storage located approximately 6 km south of Carcoar Dam and is managed by Central Tablelands Water to supply town water to Blayney and other towns in the region.

Further descriptions of streamflow and geomorphology are provided in Sections 2.8.1 and 2.8.4 respectively.

2.5 FLOODING

The following features are noted in line with the NSW Floodplain Development Manual (NSW Government, 2005):

- Flood prone land;
- Flood planning area; and
- Floodway areas.

Flood prone land is defined as land susceptible to flooding during a Probable Maximum Flood (PMF) event (NSW Government, 2005). Flood planning areas are assumed to be approximately equivalent to the 1% Annual Exceedance Probability (AEP) flood extent. Floodway areas are defined as areas where significant discharge occurs during floods and are often aligned with naturally defined channels (NSW Government, 2005). This has been interpreted as being effective bankfull flow. For the purposes of this study and in the context of the project being located in the headwaters of the Belubula River, this has been assumed to be approximately the 10% AEP flood level.

Flow and flood height calculations for a range of design rainfall events (10%, 1%, 0.5%, 0.2%, 0.1% and PMF) adjacent to the proposed open cut are provided in Section 3.5.

2.6 SURFACE WATER LICENCES

The surface water related Water Sharing Plan (WSP) relevant to the project is the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012*, with the mine project area located in the 'Belubula River above Carcoar Dam Water Source'. Under the NSW *Water Management Act 2000*, the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* commenced on 14 September 2012. As stated in the WSP, it was estimated that the share components of unregulated river access licences authorised to take water from the Belubula River above Carcoar Dam Water Source totalled 0 unit shares. However, it is noted that there are three issued Water Access Licences (WALs) for this water source that confer a total unit share of 264 megalitres (ML)[2].

For State Significant Developments (SSDs) WALs are issued by the Natural Resources Access Regulator (NRAR) under the *Water Management Act 2000* for water intercepted and or used due to open cut mining activities within the fractured rock groundwater source and induced flow from adjacent water sources. WALs will also be required for surface water taken in excess of harvestable rights (refer Section 2.9) other than for excluded works as listed in the *Water Management (General) Regulation 2018*.

2.7 SURFACE WATER MONITORING NETWORK

The existing surface water monitoring network for the mine project area comprises a weather station (refer Figure 4) as well as rainfall, streamflow and water quality monitoring as summarised in the sub-sections to follow.

2.7.1 Streamflow

2.7.1.1 Mine Project Area Rainfall and Streamflow

Monitoring streamflow in the local creeks prior to and during operations and post-closure, especially low flows, is an important component for measuring potential impacts from the project. Flow monitoring stations (using constructed controls such as v-notch weirs or flumes) have been proposed for three locations within the mine project area at:

[2] Information accessed from the NSW Water Register, https://waterregister.waternsw.com.au, July 2019.

- Belubula River Downstream of the confluence with Trib A (currently installed and operational);
- Belubula River Upstream of the confluence with Trib A; and
- Trib A Upstream of the confluence with the Belubula River.

The locations of these sites are shown on Figure 5. Such weirs or flumes involve works within 40 m of the bank of a non-minor stream and hence a water supply works approval is required by DPIE - Water (prior to approval of the mine development). The first of these (Belubula River Downstream of the confluence with Trib A) has been approved by DPIE Water and was subsequently commissioned in March 2020 – refer Photo 1. Streamflow data for the first 4 months of record, together with rainfall recorded at the McPhillamys weather station, are plotted Figure 6.

The v-notch weir or flume design is based on providing accurate low flow measurements. V-notch weirs and flumes are self-rated (i.e. a theoretical relationship exists between upstream depth and flow rate) up to the capacity of the structure and hence there is no need for manual gauging to develop a rating which would rely on timing of flows and available resources. Flumes would require more intensive maintenance to ensure no blockage due to debris or transported sediment.

Photo 1 Belubula River Downstream Gauging Station

An application for the other two gauging stations will be made once design is complete with the aim to have all three gauging stations operational during 2020.

Three additional automatic rainfall stations (pluviometers) have been commissioned in the catchment areas of Trib A and the Belubula River upstream of the mine project area as indicated in Figure 4 (MCPWS03, MCPWS04 and MCPWS05). Recorded rainfall will allow improved interpretation of the streamflow response at the gauging stations.

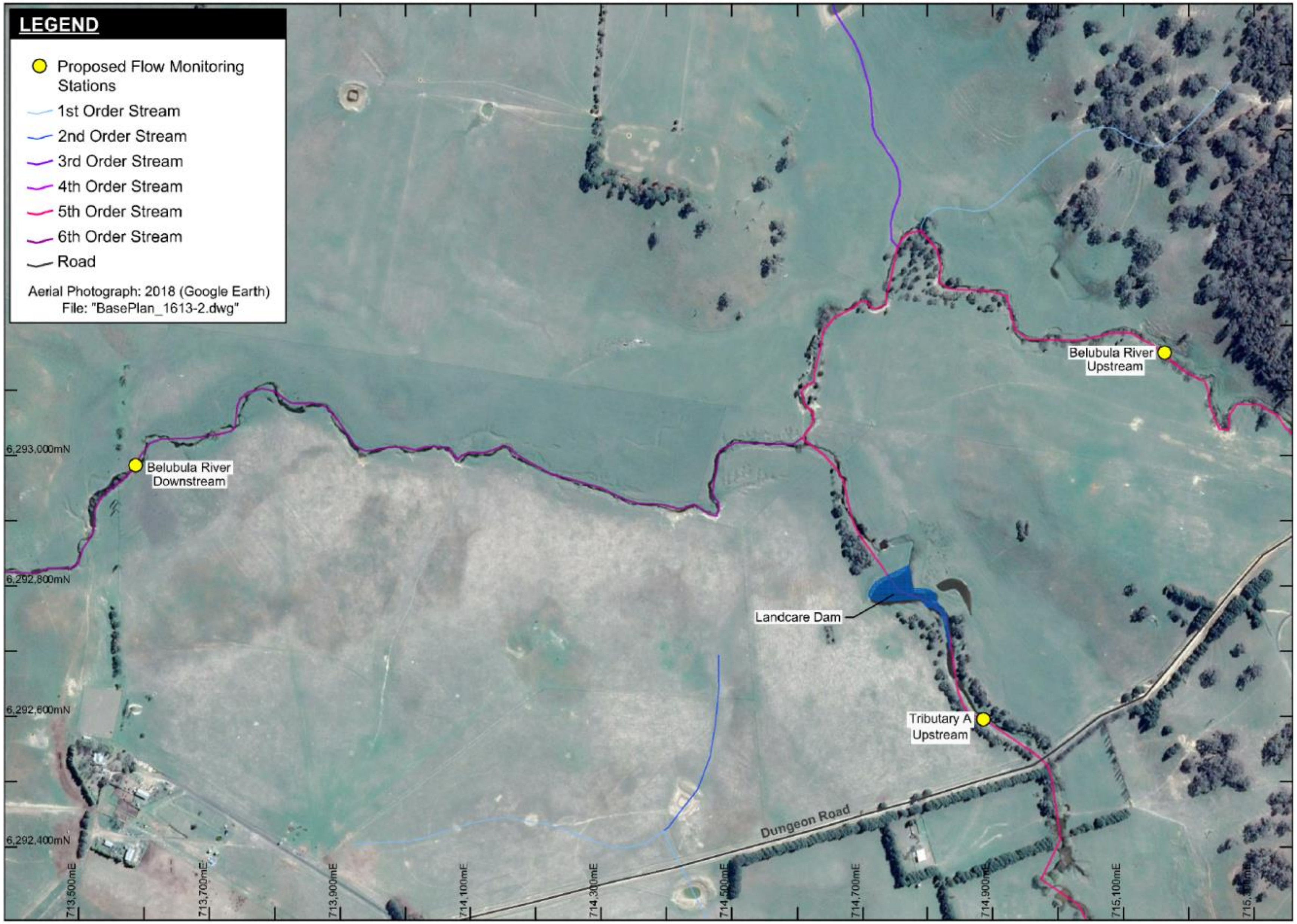


Figure 5 Streamflow Monitoring Sites

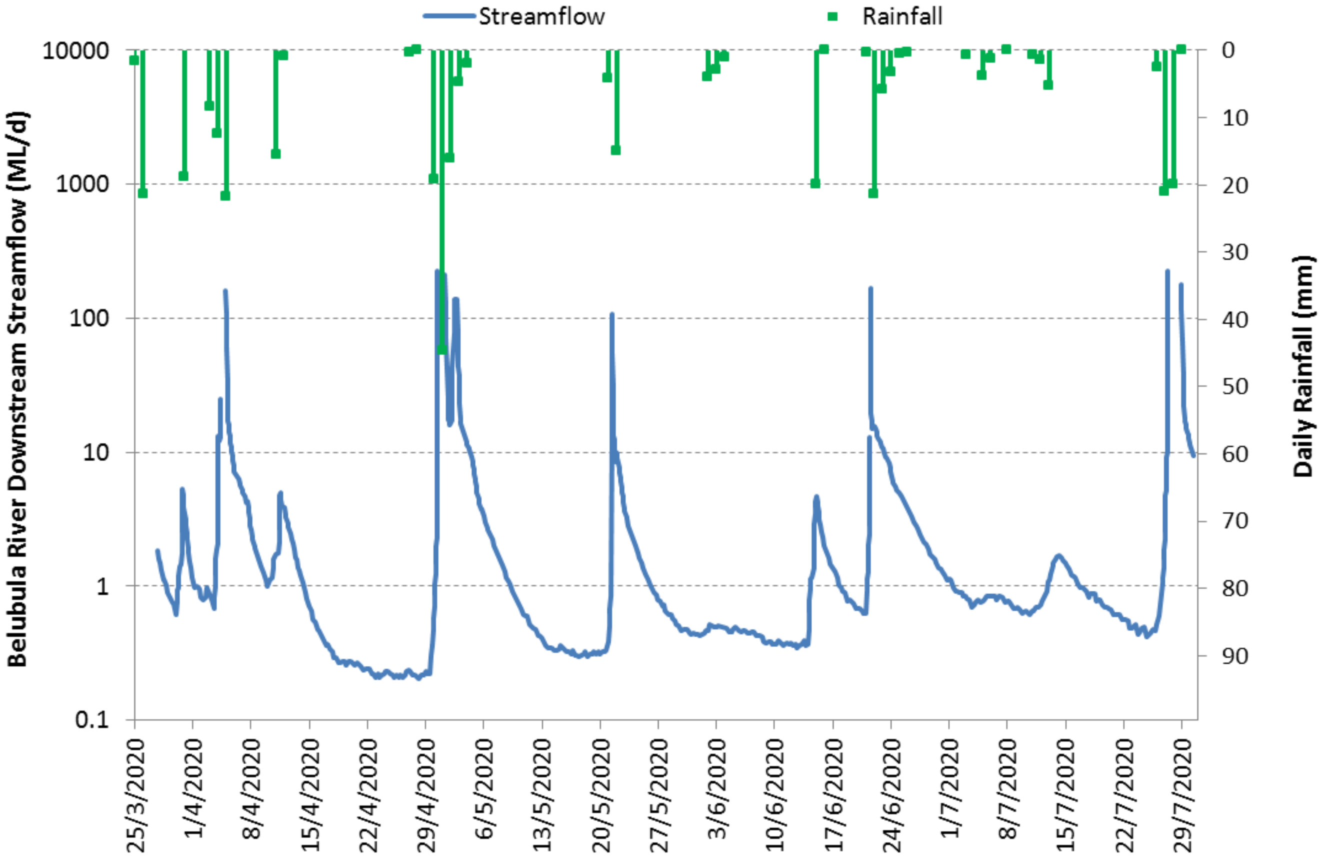


Figure 6 McPhillamys Recorded Streamflow and Rainfall Data

2.7.1.2 Regional Streamflow

There are six existing or former stream gauging stations (WaterNSW, 2018a) on the Belubula River downstream of the mine project area, three of which are at or upstream of Carcoar Dam (refer Figure 3) with a summary for each provided in Table 5.

Table 5 Summary of Regional Streamflow Monitoring Locations

Station Number	Station Name	Location (GDA94 Zone 55)		Catchment Area (km^2)	Period of Record
		Easting (m)	Northing (m)		
GS 412104	Belubula River at Upstream Blayney	711,413	6,289,984	111.0	1993-1997
GS 412105	Belubula River at Downstream Blayney	710,213	6,285,684	158.5	1992-2002
GS 412077	Belubula River at Carcoar	698,987	6,278,516	233	1966-current
GS 412056	Belubula River at The Needles	671,515	6,282,881	1,610	1957-current
GS 412195	Belubula River at Lyndon	655,479	6,283,501	2,131	2008-current
GS 412033	Belubula River at Helensholme	637,541	6,282,983	2,560	1938-current

2.7.2 Water Quality

Water quality within or near the mine project area has been monitored by Regis since May 2014 at twenty-one locations as shown in Figure 3 and summarised in Table 6. Samples were originally collected on a monthly basis for the first 10 months then quarterly until February 2017 at which time monthly sampling recommenced.

As noted in Table 6, some monitoring sites comprise springs and therefore the water quality characteristics of these sites may be more representative of groundwater rather than surface water.

Table 6 Summary of Existing Surface Water Quality Monitoring Sites in the Project Area

ID	Name	Location (GDA94 Zone 55)	
		Easting (m)	Northing (m)
WES1164A	Mid-Western Highway Spring	716,465	6,291,146
WED1276A	Bishenden	717,617	6,291,245
WED1825A	Gordon Stream Crossing 2	712,561	6,291,885
WED2344A	Gordon Paddock Dam	714,427	6,292,328
WED2847A	Gordon Landcare Dam	714,737	6,292,809
WED2935A	Gordon Stream Crossing 1	713,524	6,292,914
WED3052A	Skovgaard Bushrangers South	715,247	6,293,039
WED3275A	Stonestreet East	717,532	6,293,277
WED3466A	Stonestreet West Spring Confluence	716,618	6,293,458
WED3662A	Stonestreet West	716,224	6,293,616
WED4061A	Skovgaard Bushrangers NE	716,196	6,294,038
WED4775A	Wills East	717,598	6,294,754
WES5669A	Wills Spring NE	716,618	6,293,458
WES7729A	Stonestreet Spring SE	717,785	6,292,978
WES4660A	Wills Spring West	716,036	6,294,666
WED5401A	Brewery Bridge	710,189	6,285,482
WED7396A	Goose Park	709,611	6,287,398
WED9913A	Hildenbeutel Property	711,386	6,289,999
WED2726A	Hoadley Property (MCP Control Site)	712,675	6,292,759
WES4866A	Wills Spring Stockyard (B)	716,616	6,294,803
WES5361A	Chapman Spring	716,171	6,295,385

The existing and proposed flow monitoring locations within the mine project area (refer Section 2.7.1) will also include continuous water quality monitoring sensors for pH, Electrical Conductivity (EC), temperature and turbidity.

Limited regional water quality data is available for Lake Carcoar (WaterNSW, 2018b) and four decommissioned stations (NSW DPI Office of Water, n.d.) shown on Figure 3, Figure 4 and listed in Table 7.

Table 7 Summary of Regional Surface Water Quality Monitoring Sites

ID	Name	Parameter	Date Range	No. Points
GS 412104	Belubula River at Upstream Blayney	pH	January 1989 to May 1997	221
		EC		220
GS 41210101	Belubula River at Dungeon Road Crossing	pH	June 1989 to March 1997	82
		EC		90
GS 41210102	Side Creek S Plains	pH	June 1989 to September 1990	9
		EC		9
GS 41210107	Kings Plain Creek at Dungeon Road Crossing	pH	July 1991 to February 1997	25
		EC		25
Lake Carcoar	Lake Carcoar	pH	June 2015 to September 2018	23
		TDS*	June 2015 to May 2018	12

* Total Dissolved Solids

2.8 SURFACE WATER CHARACTERISTICS

2.8.1 Streamflow

All available data for the two Belubula River streamflow gauging stations upstream of Carcoar Dam (locations shown on Figure 3), as well as releases from Carcoar Dam, are shown in Figure 7.

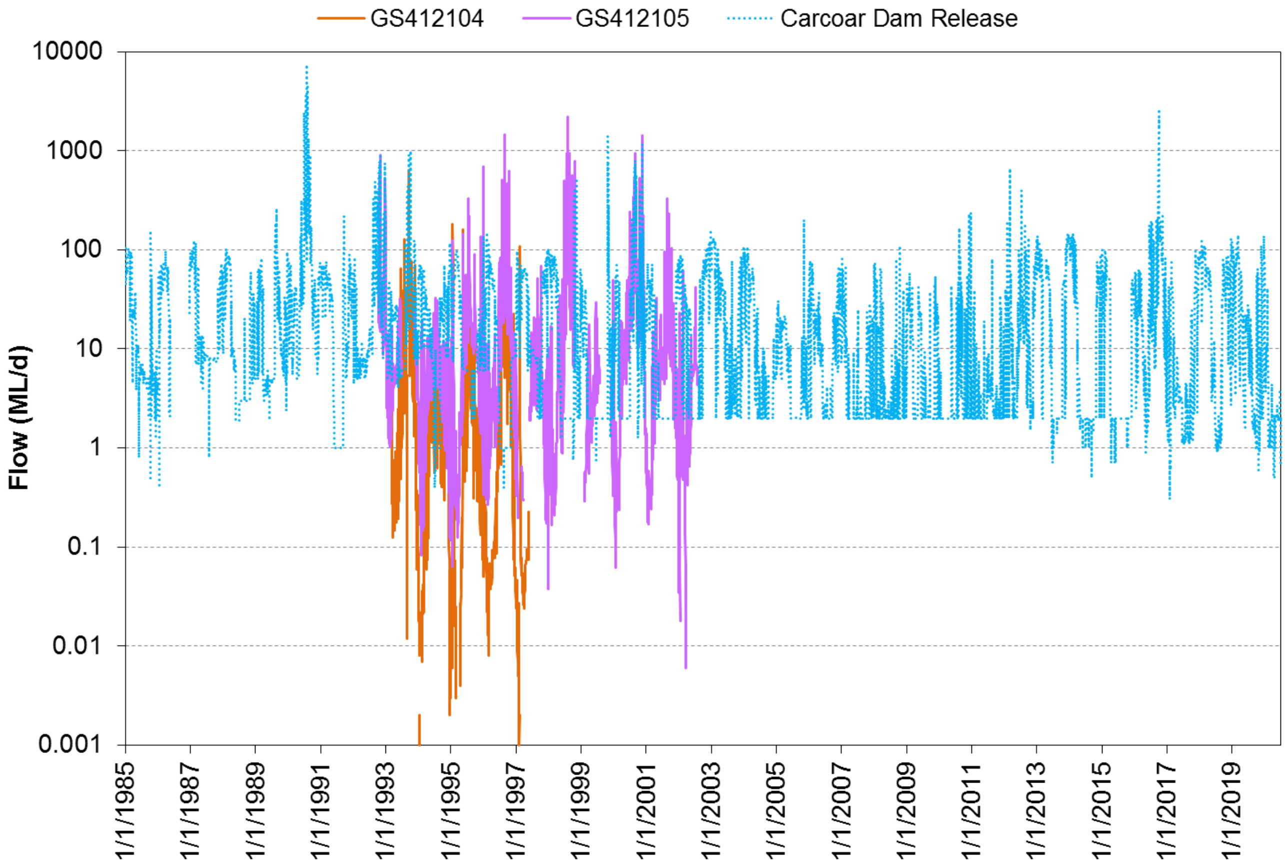


Figure 7 Regional Streamflow Data

Figure 8 comprises flow duration plots for each of the recorded flows for the period of record. The record indicates that the Belubula River at Upstream Blayney (GS 412104) was effectively perennial for the 4 years of recorded data with no flow only recorded on approximately 1.2% of days in the record. The Belubula River at Downstream Blayney (GS 412105) record was also effectively perennial for the 10 years of recorded data with no flow only recorded on approximately 1.0% of days in the record. The Blayney Sewage Treatment Plant (STP) releases upstream of GS 412105, which potentially affects flows recorded at this station. The Carcoar Dam release is not a natural system and shows that releases from Carcoar Dam have occurred on 97.7% of days.

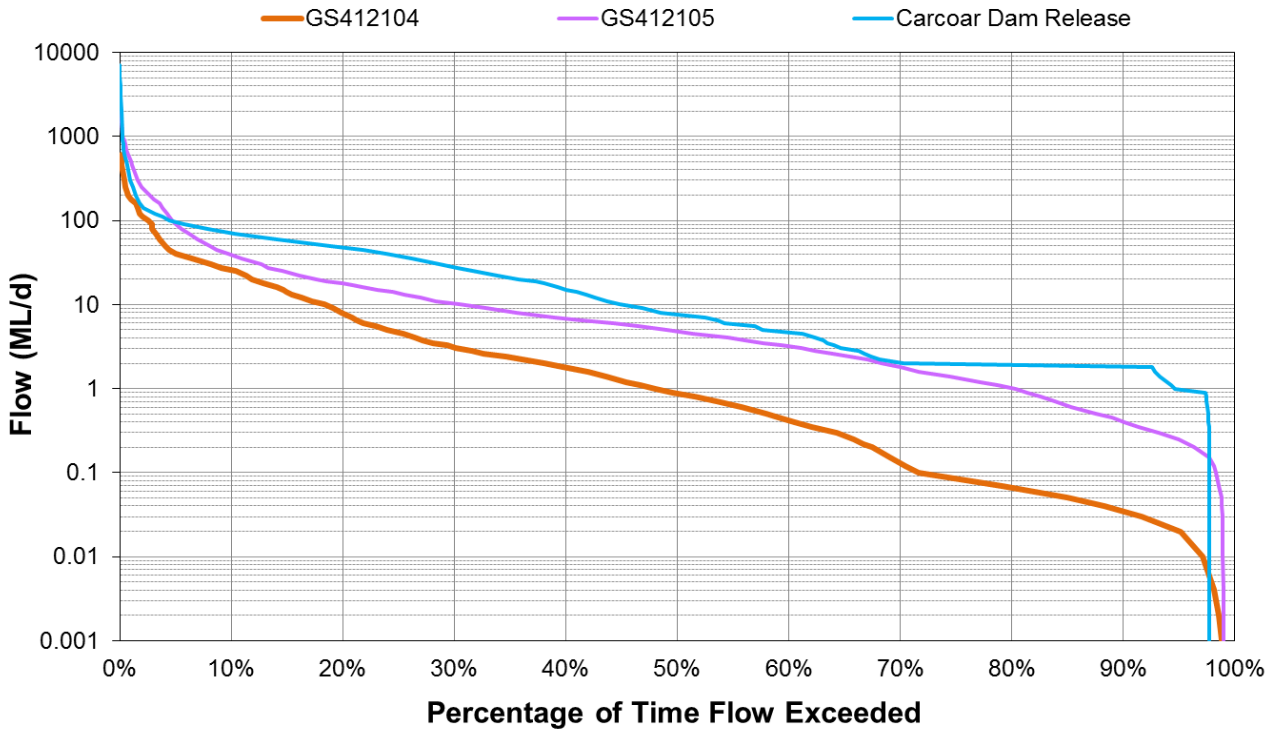


Figure 8 Flow Duration Plots - Belubula River

2.8.2 Water Quality

2.8.2.1 Project Area Water Quality

Summary statistics for recorded pH, EC and other parameters for monitoring locations within or near the mine project area are provided in Table 8[3]. Note that in calculating statistics, where the sample was recorded at less than the laboratory limit of detection, the concentration was assumed to be conservatively equal to the laboratory limit of detection. Plots of each water quality parameter showing data for each monitoring location are provided in Attachment A.

Data has been compared in Table 8 with default guideline trigger values (ANZECC, 2000) for protection of aquatic ecosystems (with toxicants at 95% level of species protection – for slightly to moderately disturbed ecosystems) in south-eastern Australian upland rivers and guideline values for Primary Industries water supplies (livestock drinking water quality). Note that NSW Water Quality Objectives (WQOs) are the same as ANZECC (2000) default guideline trigger values for these parameters. Where more than one trigger value was published for an individual parameter, the lower value (narrower range for pH) has been assumed as the WQO. Results for metals analyses in Table 8 are total metals concentrations. Site specific WQOs (trigger values) would be derived from the monitored data ahead of project commencement and in accordance with ANZG (2018) guidelines as part of the Water Management Plan for the project if approved and endorsement for use of these site specific WQOs would be sought from the NSW Government.

[3] Provided by EMM via email 30 July 2020.

Table 8 Summary of Surface Water Quality Data in the Mine Project Area Vicinity

ID	Statistic	pH	EC (µS/cm)	Sulphate (mg/L*)	Arsenic (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Zinc (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Cyanide (mg/L)	
											Total	Free
	Water Quality Objective	6.5-8	30-350	1,000	0.024	0.0002	0.3†	0.008	0.25	0.02	-	0.007‡
WES1164A	Minimum	7.18	383.9	<1	<0.001	<0.0001	0.16	<0.005	<0.1	<0.01	<0.004	<0.004
	Median	7.93	956	30	<0.001	<0.0001	0.62	0.007	0.35	0.05ˣ	<0.004	<0.004
	Maximum	8.37	1,438	385	0.007	<0.0001	0.91	0.023	1	0.13	<0.004	<0.004
	No. Samples	15	15	14	14	14	6	14	14	14	8	8
	No. Samples Exceeding WQO	7	15	0	0	0	4	5	10	10	-	0
WED1276A	Minimum	5.73	78.9	<1	0.002	<0.0001	0.98	<0.005	1.9	0.09	<0.004	<0.004
	Median	7.32	170.4	<1	0.004	<0.0001	3.7	0.008	4.4	0.2	<0.004	<0.004
	Maximum	8.37	246.8	8	0.013	<0.0001	7.2	0.015	9.7	0.53	<0.004	<0.004
	No. Samples	32	32	30	31	31	27	31	30	30	21	11
	No. Samples Exceeding WQO	6	0	0	0	0	27	13	30	30	-	0
WED1825A	Minimum	6.87	503.3	5	0.001	<0.0001	0.05	0.004	0.5	<0.01	<0.004	<0.004
	Median	8.23	951	70	0.004	<0.0001	0.89	0.007	1.7	0.1	<0.004	<0.004
	Maximum	9.07	1,650	176	0.026	<0.0001	15	0.025	28	2.34	<0.004	<0.004
	No. Samples	28	28	27	27	27	31	27	27	27	21	9
	No. Samples Exceeding WQO	20	28	0	1	0	21	6	27	26	-	0
WED2344A	Minimum	7.34	122.9	<1	<0.001	<0.0001	0.05	0.004	1.6	0.16	<0.004	<0.004
	Median	7.87	378.1	13	0.003	<0.0001	2.235	0.012	7.4	0.4	<0.004	<0.004
	Maximum	9.11	839	38	0.009	<0.0001	22.3	0.068	16.7	1.55	0.006	<0.004
	No. Samples	37	36	33	34	34	36	34	33	33	26	12
	No. Samples Exceeding WQO	13	20	0	0	0	31	23	33	33	-	0
WED2847A	Minimum	7.49	300.8	8	0.002	<0.0001	0.05	0.002	0.8	0.02	<0.004	<0.004
	Median	8.53	896	38	0.005	<0.0001	0.28	0.006	1.9	0.1	<0.004	<0.004
	Maximum	9.48	1,262	120	0.015	<0.0001	2.94	0.014	7.3	0.52	<0.004	<0.004
	No. Samples	36	36	33	34	34	36	34	33	33	26	12
	No. Samples Exceeding WQO	34	35	0	0	0	17	8	33	32	-	0

ID = insufficient data; * milligrams/litre; † Interim indicative working level; ˣ This data has multiple limits of detection some of which are above the water quality objective

‡ Cyanide WQO relates to un-ionised cyanide. Un-ionised cyanide is typically a high percentage of free cyanide – refer Table 8.3.8 in ANZG (2018).

Table 8 (Continued) Summary of Surface Water Quality Data in the Mine Project Area Vicinity

ID	Statistic	pH	EC (µS/cm)	Sulphate (mg/L*)	Arsenic (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Zinc (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Cyanide (mg/L)	
											Total	Free
	Water Quality Objective	6.5-8	30-350	1,000	0.024	0.0002	0.3†	0.008	0.25	0.02	-	0.007‡
WED2935A	Minimum	7.08	498.4	<1	0.002	<0.0001	0.05	0.002	0.5	<0.01	<0.004	<0.004
	Median	8.14	963	51.5	0.004	<0.0001	0.36	0.005	1.3	0.07	<0.004	<0.004
	Maximum	8.64	1,557	251	0.027	<0.0001	2.8	0.014	6	0.75	<0.004	<0.004
	No. Samples	34	34	31	32	32	34	32	31	31	25	12
	No. Samples Exceeding WQO	23	34	0	1	0	20	7	31	26	0	0
WED3052A	Minimum	7	474.4	13	0.001	<0.0001	0.05	0.004	0.2	<0.01	<0.004	<0.004
	Median	7.76	1,067	73	0.003	<0.0001	1.29	0.005	0.8	0.09	<0.004	<0.004
	Maximum	8.48	1,550	239	0.019	<0.0001	5.5	0.015	4	1.04	<0.004	<0.004
	No. Samples	31	31	29	30	30	32	30	29	29	23	11
	No. Samples Exceeding WQO	4	31	0	0	0	22	10	28	24	0	0
WED3275A	Minimum	6.39	42.6	<1	0.001	<0.0001	0.12	0.004	0.8	0.1	<0.004	<0.004
	Median	6.98	62.7	1	0.004	<0.0001	2.49	0.011	3.1	0.23	<0.004	<0.004
	Maximum	9.31	126.6	11	0.028	<0.0001	20	0.044	15.1	2.52	<0.004	<0.004
	No. Samples	33	33	33	34	34	34	34	33	33	23	10
	No. Samples Exceeding WQO	11	0	0	1	0	32	22	33	33	0	0
WED3466A	Minimum	7.04	858	19	<0.001	<0.0001	0.12	0.003	0.3	<0.01	<0.004	<0.004
	Median	7.37	907.5	27	0.001	<0.0001	0.41	0.007	1.1	0.06	<0.004	<0.004
	Maximum	7.89	1,048	39	0.008	<0.0001	13	0.048	2.2	0.78	<0.004	<0.004
	No. Samples	20	20	20	20	20	8	20	20	20	10	10
	No. Samples Exceeding WQO	0	20	0	0	0	4	7	20	17	0	0
WED3662A	Minimum	7.72	713	<10	0.001	<0.0001	0.05	<0.005	0.5	0.02	<0.004	<0.004
	Median	8.04	1,021	40.5	0.004	<0.0001	0.16	0.005	1.35	0.1	<0.004	ID
	Maximum	8.29	1,180	100	0.007	<0.0001	2.09	0.014	2.7	0.27	<0.004	<0.004
	No. Samples	14	14	14	15	15	26	15	14	14	14	1
	No. Samples Exceeding WQO	9	14	0	0	0	9	3	14	11	0	0

ID = insufficient data; * milligrams/litre; † Interim indicative working level
‡ Cyanide WQO relates to un-ionised cyanide. Un-ionised cyanide is typically a high percentage of free cyanide – refer Table 8.3.8 in ANZG (2018).

Table 8 (Continued) Summary of Surface Water Quality Data in the Mine Project Area Vicinity

ID	Statistic	pH	EC (µS/cm)	Sulphate (mg/L*)	Arsenic (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Zinc (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Cyanide (mg/L)	
											Total	Free
	Water Quality Objective	6.5-8	30-350	1,000	0.024	0.0002	0.3†	0.008	0.25	0.02	-	0.007‡
WED4061A	Minimum	6.56	377.3	<1	0.001	<0.0001	0.21	0.003	0.3	0.01	<0.004	<0.004
	Median	7.60	844	58	0.003	<0.0001	2.18	0.005	1	0.13	<0.004	<0.004
	Maximum	7.93	1,040	190	0.015	<0.0001	12.9	0.017	2.4	0.5	<0.004	<0.004
	No. Samples	26	26	24	24	24	26	24	24	24	19	9
	No. Samples Exceeding WQO	0	26	0	0	0	25	6	24	22	0	0
WED4775A	Minimum	6.53	68.7	<1	0.001	<0.0001	0.15	0.004	2	0.1	<0.004	<0.004
	Median	7.44	324	2	0.005	<0.0001	5.4	0.02	12	0.72	<0.004	<0.004
	Maximum	8.88	1,194	200	0.018	0.0003	48	0.5	84	3.4	0.006	<0.004
	No. Samples	29	29	30	30	30	35	30	30	30	25	11
	No. Samples Exceeding WQO	4	14	0	0	1	33	22	30	30	0	0
WES5669A	Minimum	6.62	719	8	<0.001	<0.0001	0.56	0.001	<0.1	<0.01	<0.004	<0.004
	Median	7.23	903	22	0.002	<0.0001	2.1	0.005	0.5	0.05	<0.004	<0.004
	Maximum	8.52	1,058	48	0.007	<0.0001	16	0.019	5.2	0.22	<0.004	<0.004
	No. Samples	21	21	19	19	19	7	19	19	19	10	10
	No. Samples Exceeding WQO	2	21	0	0	0	7	6	15	19	0	0
WES7729A	Minimum	5.43	58.4	<1	0.002	<0.0001	1.1	0.002	0.7	0.06	<0.004	<0.004
	Median	6.88	148.9	6	0.015	<0.0001	4	0.045	6	0.68	<0.004	<0.004
	Maximum	7.61	553.4	28	0.04	0.0006	84	0.693	28.4	4.83	<0.004	<0.004
	No. Samples	19	19	19	19	19	8	19	19	19	9	9
	No. Samples Exceeding WQO	5	1	0	6	2	8	16	19	19	0	0
WED5401A	Minimum	6.28	179.6	<1	0.001	<0.0001	0.72	0.004	0.4	0.08	<0.004	<0.004
	Median	7.08	504.2	15	0.002	<0.0001	1.5	0.006	1.1	0.2	ID	ID
	Maximum	7.68	688	46	0.01	<0.0001	3.8	0.031	2.8	1	<0.004	<0.004
	No. Samples	15	15	19	19	19	19	19	19	19	4	4
	No. Samples Exceeding WQO	1	12	0	0	0	19	6	19	19	0	0

ID = insufficient data; * milligrams/litre; † Interim indicative working level

‡ Cyanide WQO relates to un-ionised cyanide. Un-ionised cyanide is typically a high percentage of free cyanide – refer Table 8.3.8 in ANZG (2018).

Table 8 (Continued) Summary of Surface Water Quality Data in the Mine Project Area Vicinity

ID	Statistic	pH	EC (µS/cm)	Sulphate (mg/L*)	Arsenic (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Zinc (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Cyanide (mg/L)	
											Total	Free
	Water Quality Objective	6.5-8	30-350	1,000	0.024	0.0002	0.3†	0.008	0.25	0.02	-	0.007‡
WED7396A	Minimum	6.78	154.9	5	0.001	<0.0001	0.07	0.006	0.5	<0.05	<0.004	<0.004
	Median	7.33	406.4	14	0.002	<0.0001	1.2	0.013	1.2	0.2	ID	ID
	Maximum	9.22	754.5	38	0.012	<0.0001	6.2	0.043	5.5	1.4	<0.004	<0.004
	No. Samples	15	15	20	20	20	20	20	20	20	4	4
	No. Samples Exceeding WQO	2	12	0	0	0	19	17	20	20	0	0
WED9913A	Minimum	6.88	396.6	4	0.002	<0.0001	0.68	0.003	0.6	0.06	<0.004	<0.004
	Median	7.41	576.5	23	0.004	<0.0001	2.3	0.007	1.5	0.3	ID	ID
	Maximum	8.12	1124	52	0.011	<0.0001	6	0.016	3.1	0.7	<0.004	<0.004
	No. Samples	15	15	19	19	19	19	19	19	19	4	4
	No. Samples Exceeding WQO	1	15	0	0	0	19	6	19	19	0	0
WED2726A	Minimum	7.34	361.2	23	<0.001	<0.0001	0.088	0.002	0.4	<0.05	<0.004	<0.004
	Median	7.82	441.7	59	0.002	<0.0001	0.42	0.004	1.4	0.09	ID	ID
	Maximum	9.5	720	120	0.01	<0.0001	1.3	0.018	3.8	0.2	<0.004	<0.004
	No. Samples	11	11	15	15	15	15	15	15	15	3	3
	No. Samples Exceeding WQO	3	11	0	0	0	10	2	15	15	0	0
WES4660A	Minimum	6.6	233.3	50	<0.001	<0.0001	0.018	0.002	1	<0.05	<0.004	<0.004
	Median	7.71	1,446	390	<0.001	<0.0001	0.092	0.005	1.9	0.05	ID	ID
	Maximum	7.92	1,514	450	0.002	<0.0001	2.1	0.016	2.8	0.2	<0.004	<0.004
	No. Samples	7	7	9	9	9	9	9	9	9	2	2
	No. Samples Exceeding WQO	0	6	0	2	0	2	3	9	9	0	0
WES4866A	Minimum	6.77	156.1	<1	0.001	<0.0001	0.32	0.002	0.4	<0.05	<0.004	<0.004
	Median	7.39	930.5	7	0.002	<0.0001	0.76	0.008	1.1	0.08	ID	ID
	Maximum	8.04	1,275	47	0.008	<0.0001	3.1	0.032	3.4	0.3	<0.004	<0.004
	No. Samples	10	10	13	13	13	13	13	13	13	3	3
	No. Samples Exceeding WQO	1	9	0	0	0	13	5	13	13	0	0

ID = insufficient data; * milligrams/litre; † Interim indicative working level

‡ Cyanide WQO relates to un-ionised cyanide. Un-ionised cyanide is typically a high percentage of free cyanide – refer Table 8.3.8 in ANZG (2018).

Table 8 (Continued) Summary of Surface Water Quality Data in the Mine Project Area Vicinity

ID	Statistic	pH	EC (µS/cm)	Sulphate (mg/L*)	Arsenic (mg/L)	Cadmium (mg/L)	Iron (mg/L)	Zinc (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	Cyanide (mg/L)	
											Total	Free
	Water Quality Objective	6.5-8	30-350	1,000	0.024	0.0002	0.3†	0.008	0.25	0.02	-	0.007‡
WES5361A	Minimum	6.98	205.4	460	0.001	<0.0001	0.067	0.001	0.7	<0.05	<0.004	<0.004
	Median	7.3	1,801	600	0.001	<0.0001	0.495	0.0045	2.1	0.08	ID	ID
	Maximum	7.57	1,918	1,100	0.009	0.002	11	0.023	9.7	0.7	<0.004	<0.004
	No. Samples	11	11	14	14	14	14	14	14	14	3	3
	No. Samples Exceeding WQO	0	10	1	0	0	11	5	14	14	0	0

ID = insufficient data; * milligrams/litre; † Interim indicative working level

‡ Cyanide WQO relates to un-ionised cyanide. Un-ionised cyanide is typically a high percentage of free cyanide – refer Table 8.3.8 in ANZG (2018).

The number of samples at each site that have exceeded the WQOs are given in Table 8. Exceedances of the WQOs can be as a result of natural catchment conditions and/or land use modification.

The data in Table 8 indicate that the surface water quality within the vicinity of the mine project area ranges from slightly acidic to alkaline. The pH values are on occasions both above and below the WQO range with 17 of 21 sites recording exceedances. Recorded EC exceeded the WQO at all sites excepting WED1276A and WED3275A, although the water salinity may be characterised as fresh at all sites based on the recorded EC values (less than approximately 1,920 micro Siemens/centimetre [µS/cm]). There were no exceedances of the WQO for total or free cyanide recorded at any location. There was only one exceedance of sulphate at any location – at WES5361A. The WQO for zinc was exceeded in some samples from all sites. The WQO for arsenic was exceeded in a total of 11 samples collected at WED1825A, WED2935A, WED3275A, WES7729A and WES4660A out of 121 samples from those sites, while the WQO for cadmium was exceeded in a total of three samples collected at WED4775A and WES7729A out of the 49 samples from those sites. The total nitrogen and total phosphorus WQOs were exceeded in the majority of samples from all sites. These baseline results suggest that the ANZECC (2000) default guideline trigger values are not representative of the background conditions in the mine project area and site specific trigger values should be developed prior to project commencement using all available baseline data in accordance with ANZG (2018) guidelines (as part of the Water Management Plan for the project, if approved).

2.8.2.2 Imported Water Quality

Water sourced from Centennial's Angus Place, SCSO and MPPS near Lithgow will be transferred to the mine project area via a purpose-built pipeline and is expected to have an average TDS of approximately 3,500 mg/L (EMM, 2019d). The imported water will be contained within the proposed operational water management system as detailed in Section 3.1.2 with the mine project area designed to be a no discharge site. The site is also to be equipped with a Reverse Osmosis plant for the production of potable water.

2.8.2.3 Regional Water Quality

Summary statistics for recorded pH and EC for monitoring locations within the Lake Carcoar catchment are provided in Table 9. Note that in calculating statistics, where the sample was recorded at less than the laboratory limit of detection, the concentration was assumed to be conservatively equal to the laboratory limit of detection. Plots of each water quality parameter showing data for each monitoring location are provided in Attachment A.

Table 9 provides a comparison of the data to the WQOs (refer Section 2.8.2.1) and the number of samples at each site that have exceeded the WQOs are provided. Exceedances of the WQOs can be as a result of natural catchment conditions and/or land use modification.

Data in Table 9 indicate that the surface water quality within the vicinity of the project area ranges from slightly acidic to alkaline. The pH values are on occasions both above and below the WQO range with all five sites recording exceedances. EC data (either recorded directly or converted from TDS) also exceeded the WQO in a high proportion of samples at all sites, although the water salinity may be characterised as fresh at all sites based on the recorded EC values (less than approximately 2,300 µS/cm). These baseline results suggest that the ANZECC (2000) default guideline trigger values are not representative of the background conditions in the Lake Carcoar catchment.

Table 9 Summary of Regional Surface Water Quality Data

ID	Statistic	pH	EC (µS/cm)
	Water Quality Objective	6.5-8	30-350
GS412104	Minimum	5.90	10
	Median	7.56	768
	Maximum	8.40	1,758
	No. Samples	221	220
	No. Samples Exceeding WQO	26	206
GS412101010	Minimum	6.26	98
	Median	7.30	702
	Maximum	8.01	1,322
	No. Samples	82	82
	No. Samples Exceeding WQO	5	67
GS412101020	Minimum	6.85	107
	Median	7.58	430
	Maximum	8.06	745
	No. Samples	9	9
	No. Samples Exceeding WQO	1	5
GS412101070	Minimum	6.89	6
	Median	7.62	708
	Maximum	8.48	922
	No. Samples	25	25
	No. Samples Exceeding WQO	4	22
Lake Carcoar	Minimum	7.80	234
	Median	8.10	336
	Maximum	8.70	484
	No. Samples	23	12
	No. Samples Exceeding WQO	18	6

2.8.3 Surface Water-Groundwater Interactions

Baseflow is the portion of streamflow that persists and sustains flow in between rainfall events. Following a flow event, it is initially derived from water recharged from stream-bank storage, but in longer dry weather periods it is derived from groundwater discharging to the stream.

Groundwater discharge to surface watercourses occurs in isolated areas associated with alluvium, geological structures or in the lower reaches of the Belubula River downstream of the mine development area (EMM, 2019c). Field observations suggest that the upper reaches of the Belubula River are losing streams while groundwater is understood to discharge to the river in the lower reaches, below the confluence with Trib E (refer Figure 9) (EMM, 2020c).

In the mine development area, groundwater discharges as springs and seeps are evident on the sides of hills and are typically dammed for agricultural use. Some of the seeps (and dams) are ephemeral and some have been observed to run dry over the baseline monitoring period (EMM, 2020c). Most springs in the mine development area are associated with areas where the topographic gradient changes abruptly and intercepts shallow groundwater flow. Whilst some springs do contribute flow to the Belubula River, a large amount of the discharging groundwater will be lost via evapotranspiration or used for stock and domestic purposes. Groundwater is currently predicted to contribute approximately 5% of overall surface flows in the Belubula River upstream of the confluence with Trib A (EMM, 2020c). Downstream of the Mid-Western Highway, the contribution from groundwater is inferred to increase to around 20% and will vary with climatic conditions. During drought periods, flow of local groundwater to the Belubula River will sustain flows in the watercourse along the length of the river from the Mid-Western Highway to Carcoar Dam (EMM, 2020c).

2.8.4 Geomorphology

2.8.4.1 Objective and Methodology

In order to assess the geomorphology of streamlines within the mine project area, a stream geomorphological assessment was carried out to document the existing geomorphological characteristics and condition of the streams in the mine project area.

The stream geomorphological assessment comprised a desktop assessment of aerial photography, available topographical and geological mapping of the study area as well as ground reconnaissance of the main streams in the mine project area.

2.8.4.2 Topographical Information

Topographical mapping of the mine project area shows that the catchment boundary in the headwaters of the Belubula River comprises steep hills. The Belubula River flows across the foothill slopes and out onto a wide gently sloping valley with constrictions via natural hills in places. The Belubula River stream network has been classified according to the Strahler classification scheme (Strahler, 1952) using 1:25,000 scale topographical mapping[4]. At the downstream end of the mine project area, the Belubula River is a 6th order stream with ten main mapped tributaries: Trib A through to Trib J (refer Figure 9).

A summary of attributes calculated from a combination of the local 1:25,000 scale topographic map and other topographic data (including aerial/LIDAR survey) is provided in Table 10 for the Belubula River and each of the ten tributaries.

Table 10 Summary of Stream Attributes

Stream	Catchment area (km^2)	Stream length (km)	Average bed gradient (%)	Sinuosity**
Belubula River*	43.5	10.0	1.2	1.5
Trib A	24.4	10.8	0.7	1.2
Trib B	6.6	4.7	2.3	1.2
Trib C	0.4	0.9	5.9	1.1
Trib D	1.2	1.9	4.0	1.1
Trib E	0.9	1.5	5.0	1.2
Trib F	3.2	3.2	2.6	1.1
Trib FG	1.0	2.1	2.5	1.1
Trib G	1.5	1.6	3.5	1.1
Trib H	0.4	1.1	4.3	1.1
Trib I	1.0	1.8	3.3	1.3
Trib J	0.9	1.9	4.6	1.2

* All attributes calculated to the proposed downstream gauging station (refer Section 2.7.1).

** Sinuosity is defined as the stream length divided by the straight-line stream length.

[4] http://spatialservices.finance.nsw.gov.au/mapping_and_imagery/maps

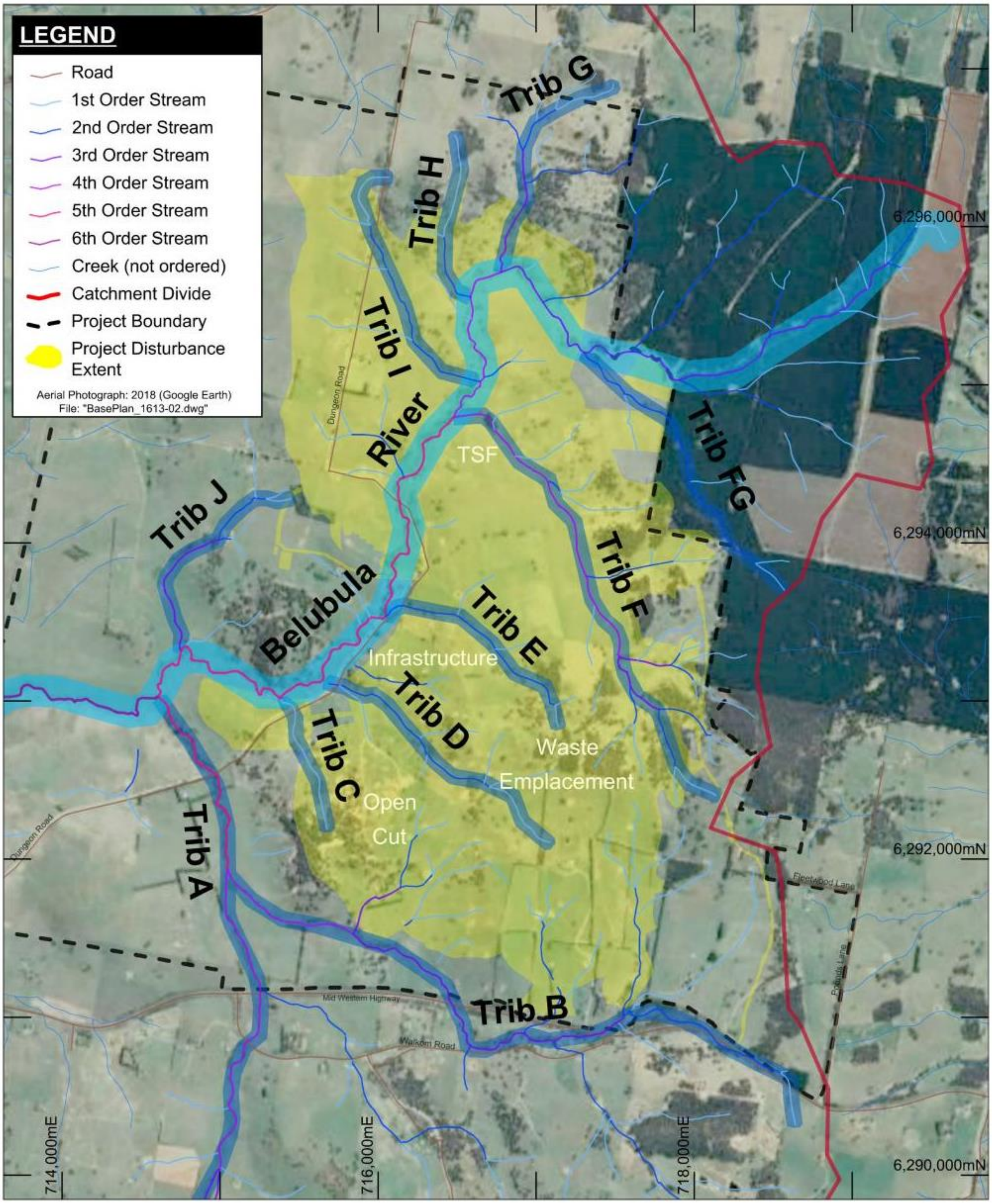


Figure 9 Tributary Naming

The Belubula River to the downstream boundary of the mine project area includes the catchment areas of all ten tributaries provided in Table 10 and therefore has the largest catchment area. It should be noted that at the confluence of Trib A with the Belubula River, the catchment area of Trib A is 24.4 km^2 while the catchment area of the Belubula River is 17.5 km^2. The Belubula River and Trib A also have a similar stream length: both greater than 10 km. Based on the average bed gradient given in Table 10, Trib A is notably flatter than the other tributaries and the Belubula River.

2.8.4.3 Geology and Soils in Floodplain and Riparian Areas

The Belubula River floodplain is mapped as Quaternary Alluvium with the watercourses and drainage lines within the mine project area comprising minor disconnected areas of shallow alluvium. The alluvial deposits are less than 5 m thick, disconnected and confined to incised channels (EMM, 2019c). The soil mapped in the depositional parts of the landscape (Alluvium Soil Association) was mapped in valley floors that extend upstream from the southwestern corner of the mine project area (SSM, 2019, 2020). The Alluvium Soil Association was dominated by Grey Dermosols and Chromosols, though included a range of soil types from Kandosols (structureless soils) to Vertosols (cracking clays). Further information on geology and soils in the mine project area is provided in the Groundwater Assessment (EMM, 2019c) and Soil Assessment (SSM, 2019) prepared for the EIS.

2.8.4.4 Vegetation and Land Use

The local catchment has been substantially cleared for grazing with vegetation over the majority of the catchment comprising grassland derived from clearing of woodland vegetation. Some remnant woodland areas are evident in the elevated parts of the catchment and some stands of trees were observed along the banks and overbank areas. The upper headwaters of the Belubula River comprise the Vittoria State Forest (refer Figure 3, Figure 4 and Figure 10). Further information on vegetation in the area is provided in the Biodiversity Assessments carried out for the EIS (EMM, 2019b) and Amended Project (EMM 2020e)..

2.8.4.5 Ground Reconnaissance

The ground reconnaissance was conducted on 15th, 16th and 17th of May 2017. A series of Global Positioning System (GPS) referenced photographs were taken along each stream detailing features and geomorphic characteristics. The features and geomorphic characteristics of the stream reaches were noted on a series of reach maps (refer Attachment B) which form a baseline record of the stream characteristics in the mine project area. Given the location of the proposed TSF, the ground reconnaissance did not include sections of the Belubula River which would be overlain by the TSF nor did it include Trib G, Trib H and Trib I. Trib C was not included in the ground reconnaissance due to it being a small drainage that would be wholly within the proposed open cut area. Trib J was also excluded given the proposed mine project area would not impact this stream.

Daily precipitation totals of 0.2 mm were recorded on each day of the reconnaissance at the McPhillamys weather station. No rainfall was observed by HEC personnel during the reconnaissance hence this precipitation must have occurred out of daylight hours or been due to dew/frost. Prior to the reconnaissance there was 0.2 mm and 0.8 mm recorded on the 5th and 6th of May respectively. The Belubula River had minor flow in some reaches, as did Trib A and Trib B, however there was no visible flow in most other tributaries. The ground was moist in the morning due to overnight minor rainfall and morning mist and frost.

The following sub-sections provide a generalised description of the Belubula River and its tributaries.

2.8.4.5.1 Belubula River Headwaters

The Belubula River headwaters upstream of the proposed TSF (Reaches BR-1 and BR-2 – refer Figure 10 and Attachment B) comprised a third order stream which originates in the Vittoria State Forest before flowing through grazing paddocks.

The most upstream surveyed reach (refer Reach BR-1 in Attachment B) is within the forestry area and the creek generally comprised a discontinuous channel 1-2 m wide and up to 1 m deep – refer Photo 2 and Photo 3. Instream vegetation was predominately grasses, saplings and mature eucalypt trees while riparian vegetation comprised dense pine forest. The bed material comprised silty clay with scour holes and ponding as a result of fallen trees.

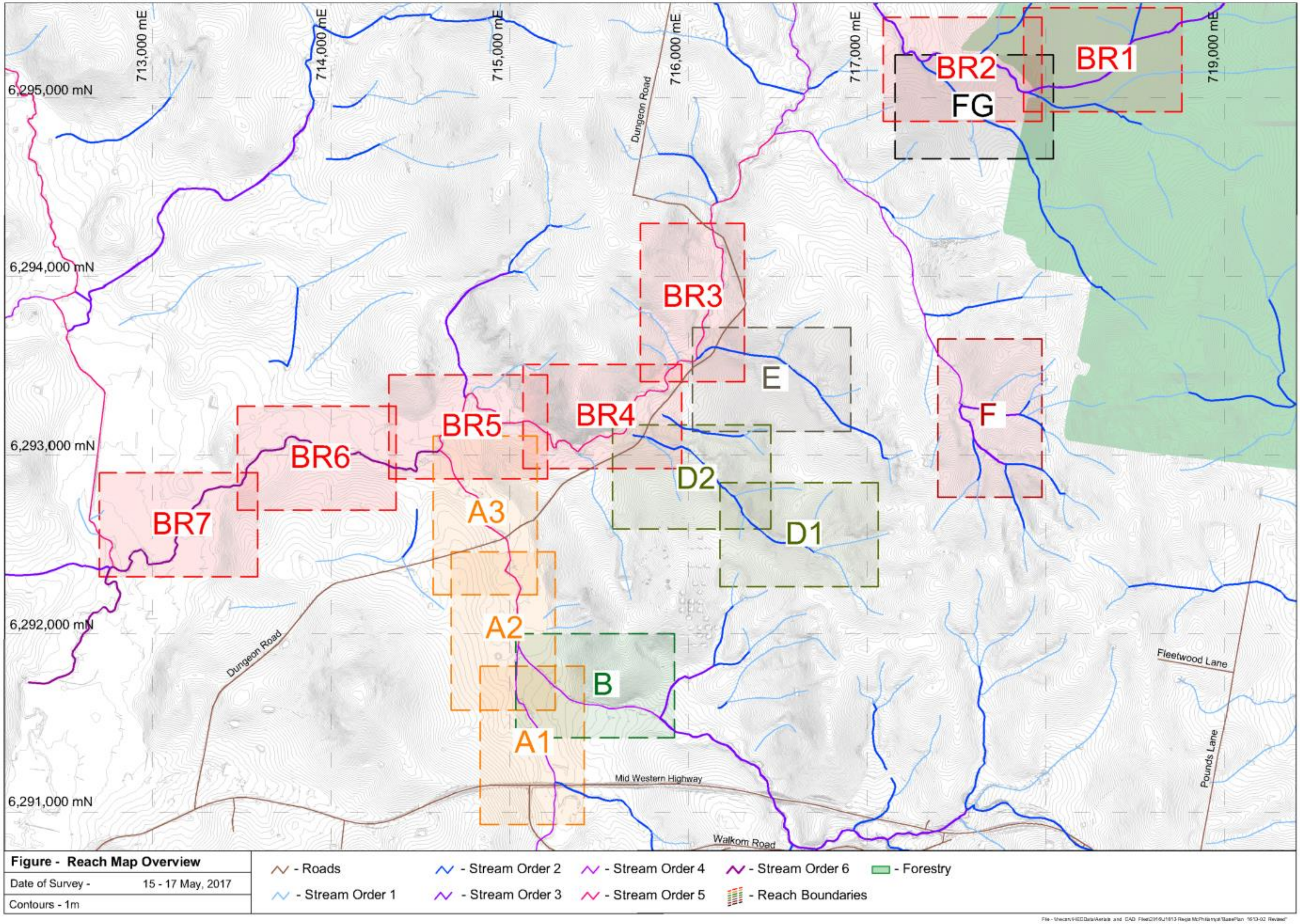


Figure 10 Belubula River and Tributaries: Overview Reach Map

Photo 2 **Typical Section: Belubula Headwaters Forest (212-Upstream)**

Photo 3 **Typical Section: Belubula Headwaters Forest (214-Downstream)**

Immediately downstream of the forestry area (refer Reach BR-2 in Attachment B), the Belubula River passed under a dirt track via a circular concrete culvert before forming a more defined channel with less vegetation both instream and in the riparian zone (refer Photo 3). This part of the Belubula flowed into a relatively large farm dam with an approximate capacity of 10 megalitres (ML) (estimated from contours) as shown in Photo 5. The meandering channel was approximately 2 m wide and 1-2 m deep with a silty clay material and localised rock outcrops. Instream vegetation comprised grasses with isolated tree groves. The presence of cattle was noted with only minor impacts apparent on erosion of the bed and banks. Large scour holes were observed due to fallen trees and the associated woody debris was prevalent in the tree grove sections.

Photo 4 Typical Section: Belubula Headwaters Grazing (238-Downstream)

Photo 5 Typical Section: Belubula Headwaters Large Farm Dam (244-Downstream)

From this farm dam downstream to Dungeon Road, the TSF footprint will encompass the Belubula River hence this section was not included in the ground reconnaissance.

2.8.4.5.2 Belubula River Upstream of Trib A

Downstream of Dungeon Road to upstream of the confluence with Trib A (refer Reach BR-3, BR-4 and BR-5 of Attachment B), the Belubula River is a fifth-order stream with a well-defined channel and both straight and meandering sections. Typical straight sections comprised a channel approximately 2 m wide and 1 m deep with overbank terraces approximately 4 m wide and 1 m deep (refer Photo 6). Meandering sections were typically a narrower (approximately 1 m wide) and deeper (approximately 1.5 m deep) primary channel typically constricted on the right bank (looking downstream) by a steep hillside and a wider left overbank (up to 6 m) – refer Photo 7. Willows dominated the instream vegetation of both the straight and meandering sections creating a number of small pools within the stream. The overbanks were generally grassed (occasional eucalypts/casuarinas) with moderate cattle degradation of the bed and banks apparent in sections of the creek. A short section of the creek immediately downstream of Dungeon Road had been fenced off from cattle with a dense stand of casuarina saplings in the overbank areas. A number of at grade road crossings were present where vegetation had been removed as evident in Photo 7 however it appeared these crossings were not maintained. The channel bed generally comprised silts with cobbles in places. Bank slumping of the primary banks were the main erosional feature (aside from cattle degradation).

Photo 6 Typical Section: Belubula Upstream of Trib A Straight (346-Downstream)

Photo 7 Typical Section: Belubula Upstream of Trib A Meandering (393-Upstream)

2.8.4.5.3 Belubula River Downstream of Trib A

Downstream of Trib A to the mine project area boundary (refer Reach BR-5, BR-6 and BR-7 of Attachment B), the Belubula River is a sixth order stream with a well-defined channel with very little vegetation and significant stock impacts. Typical sections comprised a channel between 2 m and 6 m wide and between 1 m and 3 m deep (refer Photo 8). Vegetation clearing and unrestricted stock access had resulted in an actively eroding bed and banks with bed down-cutting and bank undercutting observed along most sections of the creek. The overbanks were generally grassed while the channel was grassed in sections but comprised bed materials such as isolated rock, cobbles and silt. A number of at grade road crossings were present which appeared to be in use.

Photo 8 Typical Section: Belubula Downstream of Trib A (453-Upstream)

2.8.4.5.4 Trib FG

Trib FG is a second order stream which originates in the Vittoria State Forest and joins the Belubula River just upstream of the large farm dam (refer Section 2.8.4.5.1, Figure 10 and Reach FG of Attachment B).

The section of Trib FG immediately downstream of the forest was significantly eroded with the bed down-cutting resulting in a channel depth of up to 3 m and bank retreat resulting in a channel width of approximately 35 m (refer Photo 9). The overbanks were generally grassed while the channel was grassed in sections but was predominantly silt.

The section of Trib FG just upstream of the confluence with the Belubula River was grassed with occasional trees (refer Photo 10). The grassed large swale had a small low-flow channel less than 0.5 m deep and 0.5 wide with no actively eroding sections.

Photo 9 **Typical Section: Trib FG Downstream of the Forest (253-Upstream)**

Photo 10 **Typical Section: Trib FG Upstream of the Belubula River (246-Downstream)**

2.8.4.5.5 Trib F

Almost the entire length of Trib F is planned to be disturbed by project infrastructure including the waste rock emplacement, Mine Water Management Facility (MWMF) and TSF. A network of small streams means Trib F is a fourth order stream in this upstream reach. The surveyed section of Trib F is in the upper reaches (refer Figure 10 and Reach F in Attachment B) and will be covered by the waste rock emplacement but was included to provide an indication of the pre-project stream characteristics in this area. There were two distinct typical sections observed in Trib F: partly cleared and cleared.

The partly cleared section generally comprised a discontinuous swale 1 m wide and less than 0.5 m deep (refer Photo 11). Instream vegetation was predominately grass while riparian vegetation comprised stands of mature trees and grass.

The cleared section generally comprised a meandering swale approximately 2 m wide and 0.5 m to 1 m deep (refer Photo 12). Four farm dams were present in this reach (the most upstream was approximately 3 ML in capacity and the remaining three were less than 0.5 ML) as well as extensive contour banks. Instream vegetation was sparse as was grass on the overbanks and there were reeds present in some of the farm dams. Vegetation clearing and unrestricted stock access had resulted in some actively eroding areas particularly between the farm dams.

Photo 11 Typical Section: Trib F Partly Cleared (263-Downstream)

Photo 12 Typical Section: Trib F Cleared (270-Downstream)

2.8.4.5.6 Trib E

Trib E is a second order stream (refer Reach E of Attachment B) that will pass through the infrastructure area and plant area so will be modified as part of the project. There were two distinct typical sections in Trib E: upstream swale and downstream channel.

The upstream section of Trib E comprised a swale between 1 m and 2 wide and approximately 0.5 m deep (refer Photo 13). Instream vegetation was predominately grass while riparian vegetation comprised stands of mature trees and grass.

The downstream section generally comprised a well-defined channel approximately 2 m wide and 0.5 m to 1 m deep (refer Photo 13). Overbank areas were approximately 10 m wide and between 1 m and 1.5 m deep. Three small farm dams were present in this reach (each less than 0.5 ML approximate capacity) and grazing from cattle and sheep had caused some minor degradation of the stream bed and banks. Instream vegetation was predominantly grass with reeds in the farm dams while overbank vegetation comprised grass and occasional mature trees. Alluvial fans were observed upstream of two of the farm dams in the upstream incised valley section of the creek. Further downstream, the creek widened out prior to the confluence with the Belubula River.

Photo 13 Typical Section: Trib E Upstream (171-Upstream)

Photo 14 Typical Section: Trib E Downstream (194-Downstream)

2.8.4.5.7 Trib D

Trib D is a second order stream (refer Reach D-1 and D-2 of Attachment B) that passes through the proposed infrastructure area and adjacent to the open cut so will be modified as part of the project. Trib D generally comprised a grassed channel between 2 m and 4 m wide and approximately 0.5 m deep (refer Photo 15). Four farm dams were present in this reach (two with an approximate capacity of 1 ML and two with a capacity less than 0.5 ML) and grazing from cattle and sheep had caused some minor degradation of the stream bed and banks (knick points and minor bed down-cutting). Instream vegetation was predominantly grass with reeds in the farm dams while riparian vegetation comprised grass and occasional mature trees. Alluvial fans were observed upstream of the farm dams, similar to Trib E. The bed material comprised sandy silt with occasional rock outcrops and sections of gravel. Trib D crosses Dungeon Road upstream of the confluence with the Belubula River via culverts with fence flood gates on the downstream side. Downstream of the fence flood gates, Trib D had no channel form as it flows toward the Belubula River.

Photo 15 Typical Section: Trib D (158-Downstream)

2.8.4.5.8 Trib B

Trib B is a fourth order stream in the surveyed reach just upstream of the confluence with Trib A (refer Reach B in Attachment B). There were two distinct typical sections in Trib B: valley confined channel and grassed meander.

The valley confined sections were characterised by a down-cut channel, a steep right bank and an open left overbank modified by a manmade bund approximately 0.5 m wide and 0.5 m high. The silty channel was between 1 m and 2 m deep and 0.5 m to 1 m wide with willows dominating the instream vegetation (refer Photo 16). Cattle trampling had caused bed and bank degradation.

The grassed meander sections were downstream of the valley confined sections once the valley had opened up and the manmade bund was no longer present. The grassed meander sections generally comprised a flooded, rocky channel approximately 1.5 m wide and approximately 0.3 m deep (refer Photo 17). A small farm dam was present in this reach (estimated capacity less than 0.5 ML) and cattle grazing had caused some minor degradation of the stream bed and banks. Instream vegetation was predominantly grass with occasional willows while riparian vegetation comprised grass. The bed material comprised silt with scattered boulders.

Photo 16 Typical Section: Trib B Valley Confined (283-Downstream)

Photo 17 Typical Section: Trib B Grassed Meander (279-Downstream)

2.8.4.5.9 Trib A

Trib A is a fourth order stream upstream of the confluence with Trib B and a fifth order stream downstream of the confluence with Trib B (refer Reach A-1 to A-3 in Attachment B). There were four distinct typical sections in Trib A: swampy meadow, channel between dams, downstream of Trib B and downstream of Dungeon Road.

The swampy meadow sections were characterised by a series of minor shallow depressions joined by short, intermittent and often braided shallow swales. It was difficult to discern the flow path with no formal bed and banks and no defined secondary drainage features. Riparian vegetation comprised tall grasses which had colonised the area with elevated soil moisture provided by ephemeral ponding (refer Photo 18).

Downstream of the swampy meadow but upstream of the confluence with Trib B, three farm dams (all less than 0.5 ML in estimated capacity) were linked by a small flooded channel. This channel was part way between the swampy meadow upstream and the defined channel downstream of Trib B. The small channel was less than 0.3 m deep and less than 0.3 m wide and was flowing through moderate length grass (refer Photo 19). The riparian vegetation comprised tall grasses and occasional willows with reeds in two of the farm dams. Cattle grazing had caused some minor degradation of the channel which was apparent in the immediate vicinity of the farm dams.

The sections downstream of Trib B but upstream of Dungeon Road were grassed meander sections which generally comprised a flooded, rocky channel approximately 2 m wide and approximately 0.5 m deep (refer Photo 20). Five small farm dams were present in this reach (each with an estimated capacity less than 0.5 ML) and grazing from cattle had caused some moderate degradation of the stream bed and banks. Instream vegetation predominantly comprised grass with willows forming small ponded areas while riparian vegetation comprised grass. The bed material comprised silt with scattered boulders. Trib A flowed under Dungeon Road via three concrete culverts followed by fence flood gates.

The section of Trib A downstream of Dungeon Road comprised a uniform channel which flowed into a large farm dam known as the Landcare Dam (approximately 10 ML estimated capacity). The uniform channel comprised a low flow channel approximately 2 m wide and approximately 1 m deep with a secondary channel 2 m to 3 m wide on each side and 1 m to 1.5 m deep on each side. The silty organic bed material was grassed in places and the secondary channel was also grassed. The overbank areas comprised a stand of regularly planted mature trees immediately above the secondary channel with the remainder of the overbank areas covered with short grass. A fence around the mature trees meant cattle were not able to access the channel itself however the overbank areas were intensely grazed.

Photo 18 Typical Section: Trib A Swampy Meadow (294-Downstream)

Photo 19 **Typical Section: Trib A Channel Between Dams (298-Downstream)**

Photo 20 **Typical Section: Trib A Downstream of Trib B (309-Downstream)**

Photo 21 Typical Section: Trib A Downstream of Dungeon Road (320-Downstream)

2.8.4.5.10 Summary

The Belubula River and its tributaries have been impacted by past land clearing, forestry activity, grazing, construction of on-stream farm storage dams and road crossings. The condition of the streams found during the ground reconnaissance was highly variable over relatively short reaches ranging from ill-defined shallow swales and drainage depressions to well-defined deeply incised channels with overbank areas. The channel form appears to reflect the stream characteristics such as:

- the size of the upstream catchment;
- the local stream gradient;
- the density of riparian and instream vegetation;
- local surface geology; and
- associated anthropogenic land use disturbance.

The streams are noticeably degraded in some sections and are of higher quality in other less disturbed areas. The primary determinant of stream condition appears to be riparian vegetation. In many surveyed reaches, there is little tree cover in the riparian zone due to clearing of the land for grazing which has likely led to the existing degraded state of many of the surveyed reaches. Drainage of the highly modified agricultural land is characterised by topographical depressions providing drainage pathways comprising overland flows and ephemeral streams with only the downstream sections of the Belubula River as well as Trib A and Trib B exhibiting flow, pools or standing water between rainfall events.

2.8.4.6 *River Styles® Classifications*

Watercourses and other waterbodies were classified into groups of similar geomorphic characters consistent with the River Styles® framework (Brierley & Fryirs, 2005). Watercourse classifications found within the project area are summarised in Table 11.

Table 11 Summary Watercourse Geomorphic Classification in the Project Area

Valley Setting	Classification Description	Classification Identified in Reaches
Confined	No floodplain pockets, silt bed material	D-1, D-2, E
Partly-Confined	Meandering, incised channel, silt and clay bed material	BR-2, BR-3, BR-4, BR-5
	Straight, incised channel, silt bed material	B, F, FG
Laterally-Unconfined	Discontinuous channel, occasional pools, silt and clay bed material	BR-1
	Meandering, incised channel, silt bed material	BR-6, BR-7, A-1, A-2, A-3

The valley setting of the most upstream surveyed reach of the Belubula River (i.e. BR-1) was classed as laterally-unconfined with downstream reaches upstream of the Trib A confluence deemed partly-confined before the valley becomes laterally-unconfined again downstream of the Trib A confluence. Trib D and E were identified as having a confined valley setting compared with partly-confined Trib B, F and FG while all surveyed Trib A reaches were deemed laterally-unconfined.

2.8.4.7 *Stream Condition Analysis*

Stream condition indices have been assigned to each of the surveyed reaches of the Belubula River and tributaries. Stream condition indices were analysed based on a semi-quantitative index method of assessing the condition of constructed mine creek diversions in the Bowen Basin which was developed by ID&A under an ACARP industry research program (2001). The original index has been revised by HEC to provide a site-specific attribute and ranking system tailored to the watercourses in the project area which can be used to calculate an index of stream condition (ISC). The ISC considers the five major attributes affecting stream condition with each attribute assigned a ranking between 1 and 5 in order to identify subtle changes in the creeks over time as summarised in Table 12. As there are five attributes each ranked from 1 to 5, the ISC is calculated by summing the rankings from each attribute and dividing by 25 to give an overall index expressed as a percentage. By observing and ranking specific attributes in the reaches prior to the project, the change in the ISC can be related to project impacts if applicable and a qualitative assessment made of the magnitude of and changes to stream attributes over time. The calculated ISC for each surveyed reach is summarised in Table 13.

Table 12 Index of Stream Condition Attributes and Scoring

Attribute	Ranking and Score	
Anthropogenic Impacts (not project related)	5	Pristine – no cattle access, no road crossings or easement clearing.
	4	Minor disruption – isolated cattle access, at grade crossing, fence crossings or farm dams with minor interruption of flow distribution.
	3	Moderate disruption – frequent cattle access points/locations, major crossing or farm dam with moderate interruption of flow distribution.
	2	Major disruption – extensive cattle access locations, major crossing or farm dam with extensive interruption of flow distribution.
	1	Complete disruption – major crossing or farm dam causing complete interruption of flow distribution.
Condition of bed	5	No significant actively eroding or accreting areas. No evidence of bed aggrading or down-cutting.
	4	Minor erosion and/or deposition affecting less than 10% of stream bed length. No evidence of bed aggradation or down-cutting.
	3	Moderate erosion and/or deposition affecting less than 30% of stream bed length. Bed is either (slowly) aggrading or down cutting.
	2	Large, deep erosion scours and/or deposition affecting more than 50% of stream bed length. Bed is either rapidly aggrading or down-cutting.
	1	Major erosion and deposition creating major change to flow patterns. Bed has rapidly down-cut (has reached bed-rock or has been substantially choked by sediment deposition) which is significantly reducing flow capacity.
Condition of banks	5	No significant slumping or under-cutting. No root exposure.
	4	Minor bank scour or slumping affecting less than 10% of stream length. No fresh slumping. Minor root exposure.
	3	Moderate bank scours and/or slumps affecting up to 30% of stream length. Recent bank slumps are small. Moderate root exposure.
	2	Large scale erosion, extensive slumping or under-cutting affecting over 50% of stream length. Widespread root exposure.
	1	Major bank erosion causing rapid bank retreat and over-widening of bed. Extensive root exposure.
Geomorphic Development	5	Defined overbank area in 80-100% of the stream length. Channel profile integrated into a wide, stable overbank flow area.
	4	Defined overbank area in 60-80% of stream length.
	3	Defined overbank area in 40-60% of stream length.
	2	Defined overbank area in 20-40% of stream length.
	1	Defined overbank area in less than 20% of stream length. Poor connection between channel and overbank flow area.
	0	No geomorphic development.
Condition of vegetation in riparian zone	5	Vegetation with dense (80-100%) cover of mixed tree, shrubs and grasses.
	4	Vegetation with moderate (60-80%) cover.
	3	Vegetation with minor (40-60%) cover.
	2	Vegetation with low (20-40%) cover.
	1	Vegetation with extremely low cover (<20%).
	0	No vegetation

Table 13 Summary of Index of Stream Condition for Surveyed Reaches

Reach	Anthropogenic Impacts	Condition of Bed	Condition of Banks	Geomorphic Development	Condition of Vegetation in Riparian Zone	ISC
BR-1	5	4	4	1	5	76%
BR-2	3	3	4	2	2	56%
BR-3	3	3	3	3	2	56%
BR-4	3	3	2	3	2	52%
BR-5	3	3	2	3	2	52%
BR-6	2	3	1	1	1	32%
BR-7	2	3	1	1	1	32%
FG	4	2	2	1	1	40%
F	3	4	4	1	2	56%
E	3	4	4	2	2	60%
D-1	4	5	5	2	2	72%
D-2	3	3	3	2	2	52%
B	3	3	3	3	2	56%
A-1	3	4	5	2	1	60%
A-2	3	4	4	3	1	60%
A-3	2	3	4	4	2	60%

Anthropogenic impacts are most obvious in downstream reaches or reaches with cattle access and a number of farm dams. Livestock trampling was observed to have the highest impact on the downstream reaches of the Belubula (BR-6 and BR-7). For a third of the surveyed streams, bed erosion was deemed non-existent or minor but bed erosion in most streams (9 out of 16) was classified as moderate. Condition of banks was poorest in the downstream Belubula River reaches (BR-6 and BR-7) where major bank erosion had caused significant bank retreat. All but one reach (BR-1) have low scores for condition of vegetation in the riparian zone due to extensive clearing for grazing in most of the reach catchment areas.

2.9 HARVESTABLE RIGHT

The total current and proposed landholding area of Regis property associated with the mine project area is 2,907 hectares (ha). A small proportion of the landholding area lies within the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* zone while the majority of the property area lies within the *Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources 2012* zone. Using the online maximum harvestable right calculator (WaterNSW, 2019) for each landholding area, the maximum harvestable right dam capacity was assessed as shown in Table 14.

Table 14 Summary of Harvestable Rights Calculations

Water Sharing Plan	Total Landholding Area – current and proposed (ha)	Harvestable Right (ML)	Volume of Dams Eligible under Harvestable Rights (ML)	Remaining Volume of Harvestable Right (ML)
Water Sharing Plan for Macquarie Unregulated and Alluvial Water Sources	148	11	1.5	9.5
Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources	2,760	207	77.2	129.8
Total	**2,908**	**218**	**78.7**	**139.3**

Table 14 illustrates that the total harvestable right based on the Regis landholding area (current and proposed) is 218 ML. This equates to a harvestable right rate (from the maximum harvestable right calculator) of 0.075 ML/ha per year (i.e. 218 ML = 10% x 0.75 ML/ha x 2,908 ha). The estimated total capacity of existing farm dams eligible under harvestable rights on Regis landholdings totals 78.7 ML. Therefore, the remaining harvestable right equates to 139.3 ML.

The proposed water management system includes a number of upslope clean water diversions (refer Section 3.1.1). These include two embankment dams: Clean Water Facility (CWF) 2 and CWF3 which are to be located on existing minor streams (i.e. first and second order), upslope (east) of the waste rock emplacement and process plant area. These are planned to have a combined total capacity of 24.6 ML. Subtracting the combined capacity of CWF2 and CWF3 from the above harvestable right capacity leaves a capacity of 114.7 ML.

The mine project area itself is located within the *Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources* zone. Table 14 indicates that the volume of harvestable right located within the *Water Sharing Plan for the Macquarie Bogan Unregulated and Alluvial Water Sources 2012* zone is 9.5 ML. Subtracting this volume from the above harvestable right capacity leaves a capacity of 105.2 ML. This equates to capture of all runoff (at a rate of 0.75 ML/ha per year) from an area of 140.3 ha.

The maximum undisturbed area from minor streams (i.e. first and second order) captured within the mine project area (based on the ultimate staged development of the operational water management system – refer Section 3.1.2) is estimated to be 134.5 ha. This is within the harvestable right area by 5.8 ha or a yield (at 0.75 ML/ha per year) of 4.3 ML/year.

3.0 PROPOSED SURFACE WATER MANAGEMENT

3.1 WATER MANAGEMENT SYSTEM

The project area water management system comprises the structures and associated operational procedures that would be used to manage water and its movement and use on-site. The accepted principles of mine water management involve attaining efficiency in operations, in this case through limiting generation of waste water and the segregation of mine site water according to water quality and associated use constraints. The practical application of these principles involves controlling the volume of poor quality water by maximising its re-use and by limiting the contamination of clean water. Water is assigned one of the following classifications based on its source/expected quality:

- clean water (i.e. runoff from undisturbed or established rehabilitation areas);
- operational water (i.e. runoff from mining areas such as haul roads, the waste rock emplacement, hardstand areas and the open cut as well as imported pipeline supply water); or
- development/construction water (i.e. runoff from disturbed areas and unestablished rehabilitation which potentially contains elevated levels of sediment).

The extent and location of clean, operational and development/construction runoff areas for the operational duration of the mine development are depicted on the catchment classification plans (refer Figure 11 to Figure 14). During the course of the mine development, some areas would change (i.e. disturbed areas would be returned to undisturbed runoff area status through rehabilitation/revegetation activities). The following sections describe the water management systems that manage individual water classifications.

3.1.1 Clean Water System

Runoff from undisturbed or rehabilitated areas is defined as part of the clean water system for the mine development (refer Figure 11 to Figure 14). The clean water system is managed differently during mining and post mining as follows.

3.1.1.1 During Mining

During mining, the majority of clean water will be diverted around the mine development via a series of diversion drains, dams, pumps and pipelines shown in Figure 15. Runoff from undisturbed areas would be captured in a system of upslope runoff diversion drains and either directed to existing gully lines or to one of three Clean Water Facilities (CWFs) which would be dewatered by pumping to the Belubula River during and following rainfall events. Clean water would not be retained within CWFs for any extended period of time. Runoff diversion drains would be constructed 'on contour' with low longitudinal gradients and designed as grassed channels or with rockfill rip-rap to control the risk of erosion. Engineered drop structures would be used where runoff is directed 'down slope' between diversion drains or at diversion drain outfalls (to existing gully lines).

The largest of the CWFs is CWF1, located upslope of the TSF, with an estimated catchment area of 6.8 km^2. CWF1 would be in place prior to the commencement of basin construction works within the TSF storage area (i.e. approximately in Month 10) to capture and divert (via pumping) upslope clean water runoff. The embankment which forms CWF1 is also the northern TSF embankment. This embankment is planned to be built progressively in stages, with a smaller embankment initially resulting in a smaller capacity diversion storage. The capacity of the pumping system which dewaters CWF1 has been sized accordingly, with a larger capacity pump initially and a lower pump rate when the ultimate embankment is constructed. The pump capacities have been sized such that the CWF1 storage capacity is not exceeded in any simulated climatic scenario (based on the full historical climate record - i.e. CWF1 is not simulated to spill to the TSF). The pump capacities have also been sized such that the ponded CWF1 water level is not simulated to exceed 954 m AHD, substantially avoiding inundation of the Vittoria State Forest.

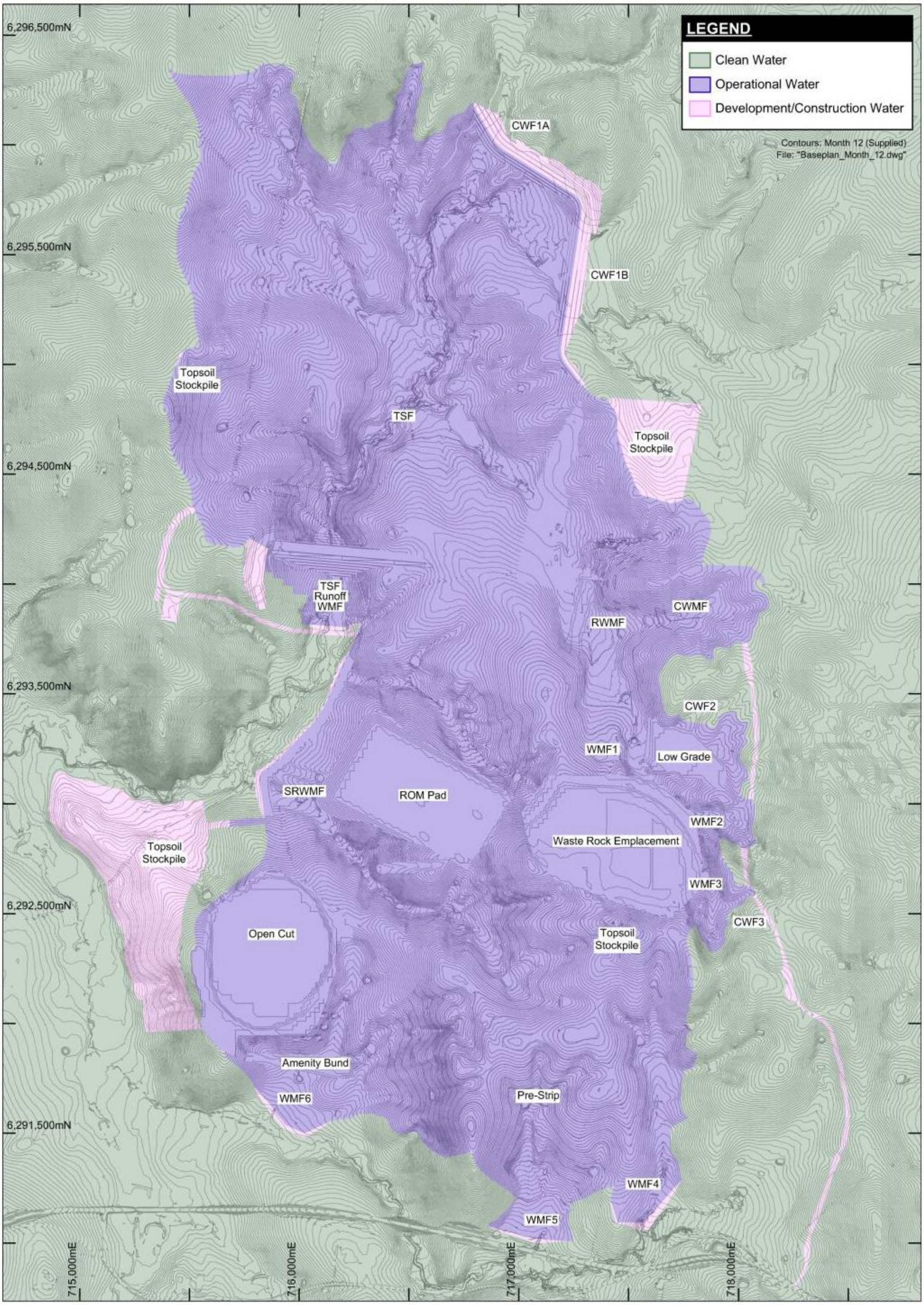


Figure 11 Proposed Catchment Classifications – Year 1

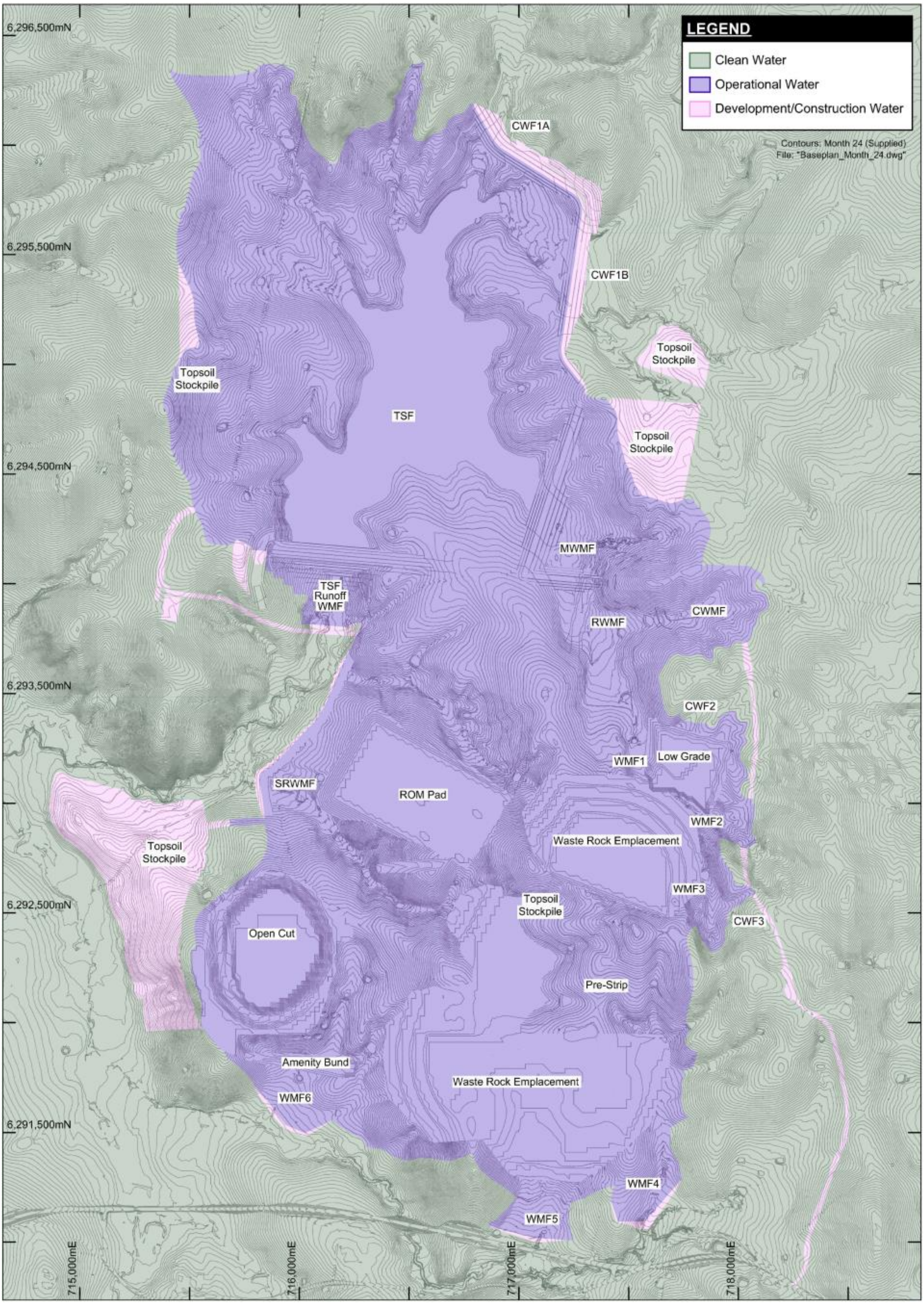


Figure 12 Proposed Catchment Classifications – Year 2

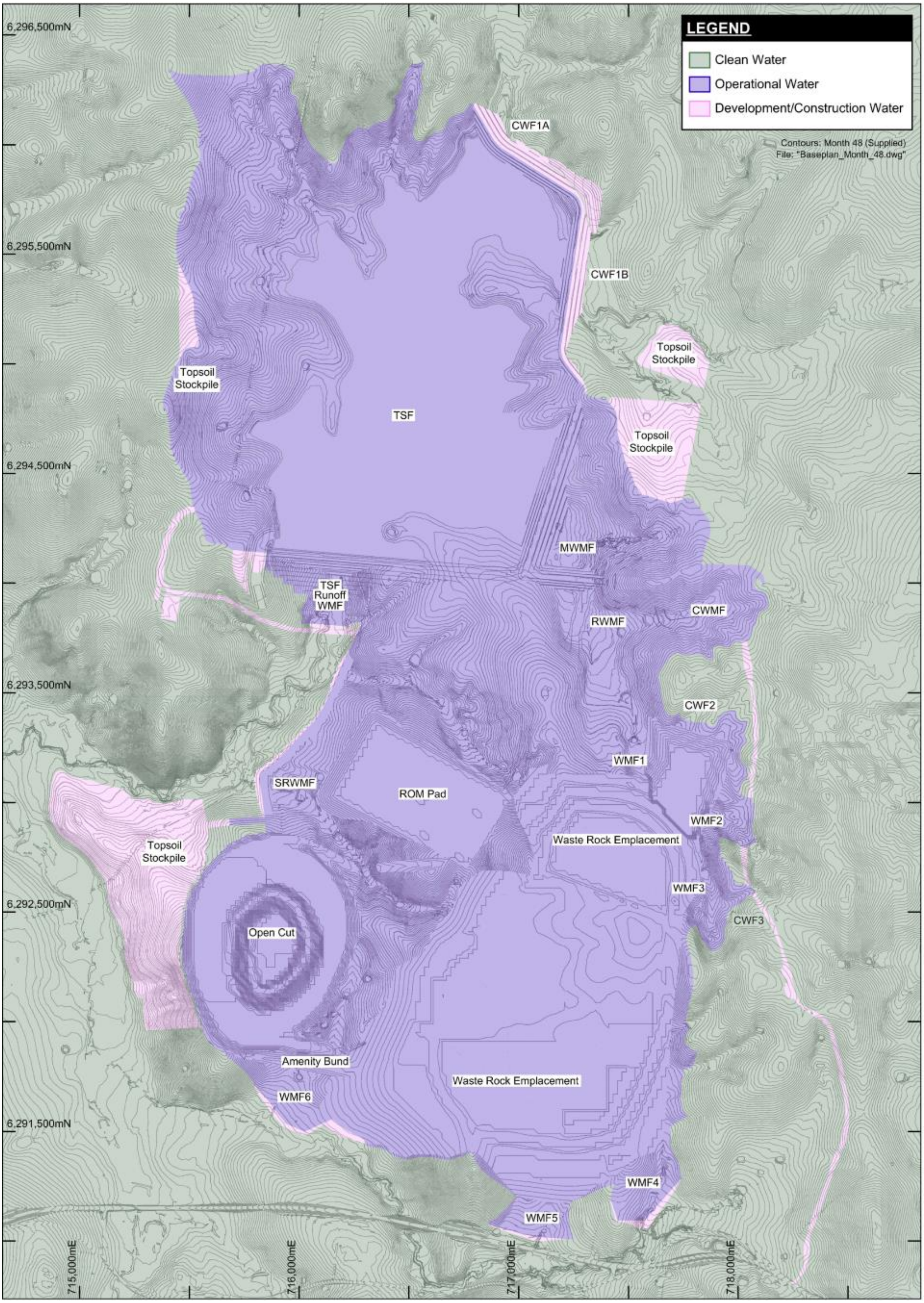


Figure 13 Proposed Catchment Classifications – Year 4

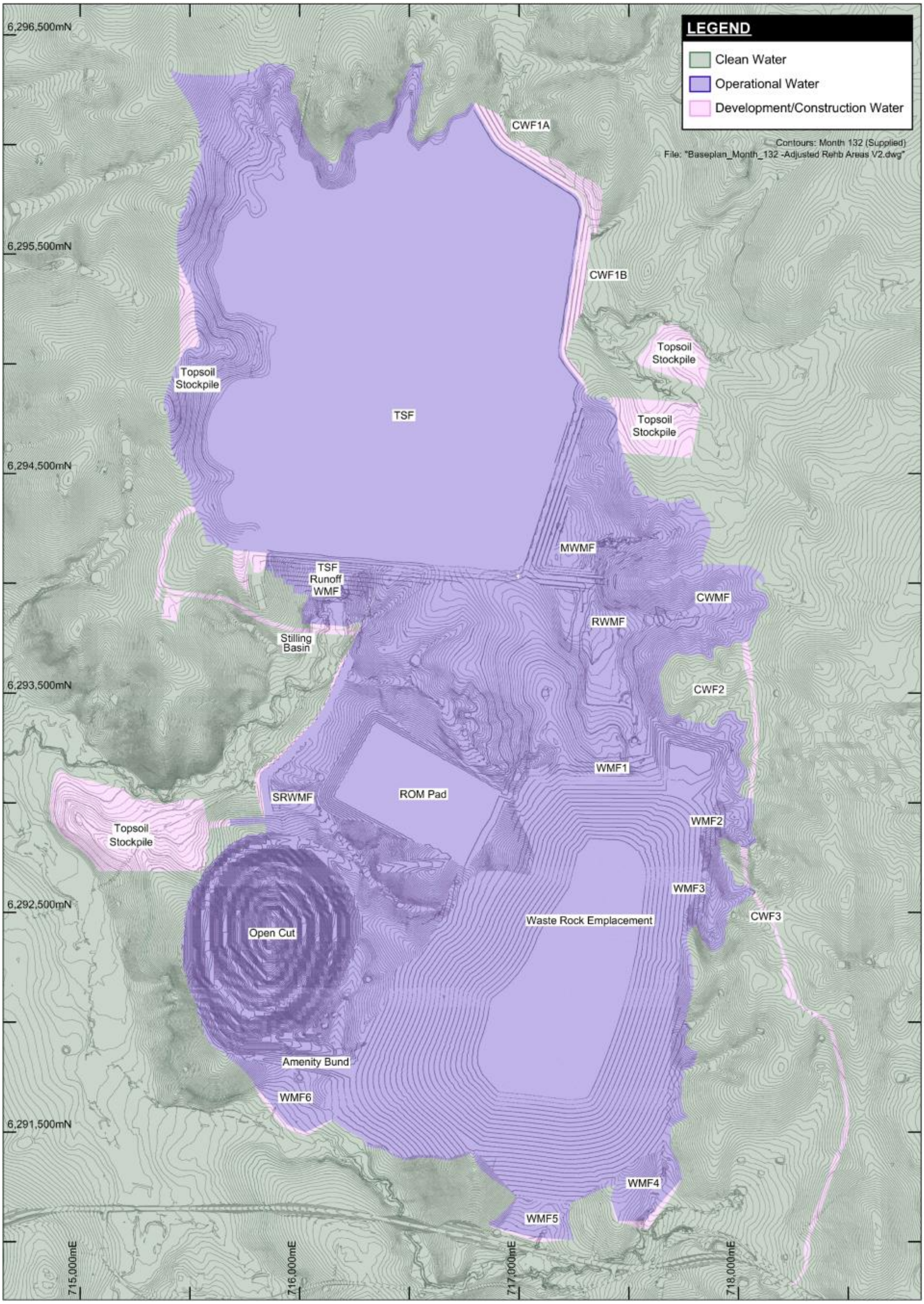


Figure 14 Proposed Catchment Classifications – Year 11

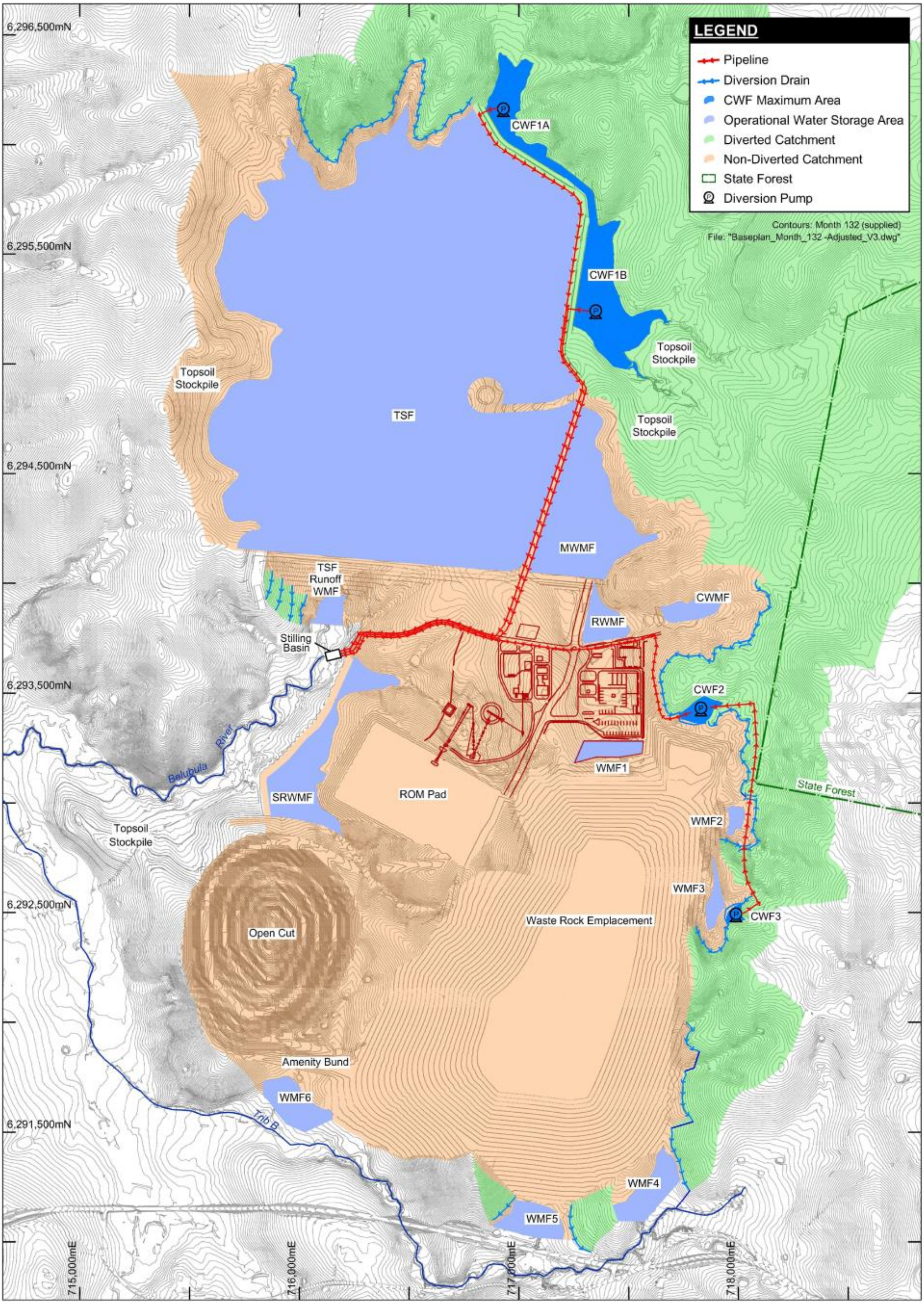


Figure 15 Clean Water Diversion System – During Mining

The CWF1 dewatering system (pump and pipeline) would discharge downstream of the proposed TSF and associated TSF Runoff WMF (refer Figure 15).

CWF2 and CWF3 are located upslope (east) of the waste rock emplacement and process plant area. CWF2 and CWF3 would be commissioned prior to commencement of mining and waste rock emplacement and would remain in place for the duration of the mine development. A pump and associated pipeline would be installed for each diversion dam. Water contained in CWF3 would be pumped to CWF2, while the CWF2 pipeline outlet would be located downstream of the proposed TSF and TSF Runoff WMF (refer Figure 15). Operational water balance modelling has been used to size the dewatering pump capacities for CWF1, CWF2 and CWF3 such that no spills are predicted to occur to the operational water management system.

A GoldSim water balance model of the three clean water diversion dams was developed to simulate the volume of water held in and pumped from the storages. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes direct rainfall and catchment runoff.

Outflow includes evaporation and pumped outflows to the Belubula River.

The model operates on a less than daily time step. Model simulations begin at the start of Year 1 and continue to the planned end of mining (i.e. 10¾ years). The model simulates 131 "realizations" derived using historical daily climatic data from 1889 to 2019 inclusive. The first realization uses climatic data from 1889 to 1899, the second uses data from 1890 to 1900 and the third from 1891 to 1901 and so on. The results from all realizations are used to generate water storage volume estimates. This method effectively includes all recorded historical climatic events in the water balance model, including the highest recorded, the lowest recorded and median rainfall periods.

Rainfall runoff modelling was carried out in line with assumptions (for the operational water balance model) described in Section 3.2.2.1 while evaporation was modelled as outlined in Section 3.2.2.3. Pumped outflows to the Belubula were allowed above an assumed dead storage at design pump rates and proposed storage capacities – these are listed in Table 15. Graphs of simulated water levels for each of the three CWFs are provided in Attachment C as frequency plots generated for the simulation period. Plots are given for the realizations with 10^{th} percentile (dry), median, 90^{th} percentile (wet) and highest total runoff for the 10¾ year simulation period. The plots indicate that the maximum design water levels given in Table 15 are not exceeded.

Table 15 Clean Water System Design Criteria and Proposed Capacity

Diversion Dam	Design Maximum Water Level (m AHD)	Approximate Proposed Capacity to Design Water Level (ML)	Design Pump Rate (L/s)*	Estimated Pipeline Length (km)
CWF1 (Stage 1)	952	221	670	3.6
CWF1 (Stage 2)	954	506	400	
CWF2	973.5	21.6	115	2.1
CWF3	998.5	3.0	35	1.1

* Litres/second

The CWF1 and CWF2 pipeline outfalls would be carefully designed to dissipate flow energy before allowing the flow to re-enter the Belubula River – this would involve the use of an engineered stilling basin. Erosion protection (e.g. rockfill rip-rap) would be integrated into the design to further control the risk of erosion. The stilling basin and erosion protection would be designed to ensure the flow velocity and associated flow energy is dissipated and flow returned to the Belubula River at a suitable velocity to control erosion. An example of such an operating system (in use at another mine in NSW) is shown in Photo 22.

Photo 22 Typical Engineered Pipeline Outfall Stilling Basin

The upstream face of the CWF confining embankments would be stabilised with hydromulch (or suitable equivalent) immediately upon construction, with subsequent development of a grassed cover. Such a grassed cover is evident in the embankment above the pipeline outfall shown in Photo 22. This would mitigate the risk of increased suspended solids in the diverted water.

3.1.1.2 Post Mining

Post mining, all catchment areas (with the exception of the final void) would be either undisturbed or would have been rehabilitated and hence would be part of the clean water system. Permanent clean water diversion channels would be constructed to allow a free-draining landform. The alignment and design of the diversion channels will be confirmed during the detailed design stage. Further discussion on the final landform surface water management is provided in Section 3.3.

3.1.2 Operational Water System

Runoff from mining areas such as haul roads, the waste rock emplacement, hardstand areas and the open cut is part of the operational water system for the mine development (refer Figure 11 to Figure 14). The operational water system also includes external water supply imported to site via the imported pipeline supply however runoff from the mine development would be used as a priority over imported water to reduce the likelihood of spill from the storages within the operational water system. The risk of spill and other key results are simulated using the operational water balance model (refer Section 3.2).

Figure 16, Figure 17, Figure 18 and Figure 19 show the planned surface water management features, operational water system catchment and sub-catchment areas for the Year 1, Year 2, Year 4 and Year 11 stage plans respectively. These figures are based on mine stage contour plans (showing progression of the open cut, waste rock emplacement and dam embankments) provided by

Regis. The key changes compared with the water management system given in Appendix J of the McPhillamys Gold Project EIS are as follows:

- relocation of the north-eastern perimeter embankments of the TSF to the south-west, reducing the footprint of the TSF;
- removal of the Secondary MWF from the north-western margin of the mine project area (its function to be replaced by the MWMF – refer below);
- a slight reduction in the eastern extent of the waste rock emplacement, resulting in alterations to the clean and operational water systems around its eastern perimeter; and
- revision of the operational water management facilities that results in no predicted spills in the operational water balance model (refer Section 3.2).

It is noted that, for conservativism within the operational water balance model, larger areas of soil pre-strip within the waste rock emplacement area and TSF have been assumed (and accordingly presented in the stage plans included in this assessment) compared to those presented in the Amended Project report (EMM, 2020a). This conservatism, in assuming greater than predicted levels of disturbance in the early mine life, has been adopted to ensure operational water management facilities (WMFs) were sized conservatively.

The operational water system will be comprised of a number of WMFs, the open cut and the TSF, together with a system of pumped transfers and drains. Figure 20 shows a schematic representation of these storages and their inter-linkages for the duration of the mine development. The operational water balance model is based on this management schematic (refer Section 3.2).

The construction water management facility (CWMF) will be the initial site water supply storage, providing water for construction activities and dust suppression. This storage would have an estimated capacity of 75 ML. Prior to commissioning of the imported pipeline supply, water would be sourced from an on-site bore or bores, with an assumed capacity of up to 20 L/s. The imported pipeline supply (providing up to 15.6 megalitres/day [ML/d]) would be commissioned prior to the end of Year 1. Once commissioned, the imported pipeline supply would be used to supply the CWMF, obviating the need for the site bore(s). The CWMF would also provide supply to a site water treatment plant, used to produce site potable water.

The raw water management facility (RWMF) will be the long term site water supply storage, for storing water provided from the imported pipeline supply, with an ultimate capacity of approximately 220 ML. This would be commissioned during Year 2, shortly after the start of ore processing at an initially lower capacity, reaching its full capacity by Year 2. The only water supplied to this storage would be from the imported pipeline supply (other than catchment rainfall runoff). Following commissioning of the RWMF, the CWMF would be preserved as an additional raw water storage, to provide increased system flexibility.

The MWMF will be the main water storage on site with an ultimate capacity of approximately 2,009 ML – completed to this capacity by Year 4 The MWMF will initially have a lower capacity and will first come into service in Year 2 (i.e. just after the end of Year 1) coincident with the start of ore processing. Note that prior to this date, the Site Runoff Water Management Facility (SRWMF) will be the operational main water storage on site, with a storage capacity of approximately 530 ML. Operational water captured in other storages will be pumped to the MWMF (or, prior to its commissioning, the SRWMF) which then supplies water to the Process Plant (via the Process Water Tank) and truckfill (for haul road dust suppression). The MWMF will be maintained with a minimum storage 'reserve' of 200 ML by supply from the RWMF (and prior to its commissioning the CWMF) in order to maintain supply reliability during extended low rainfall periods.

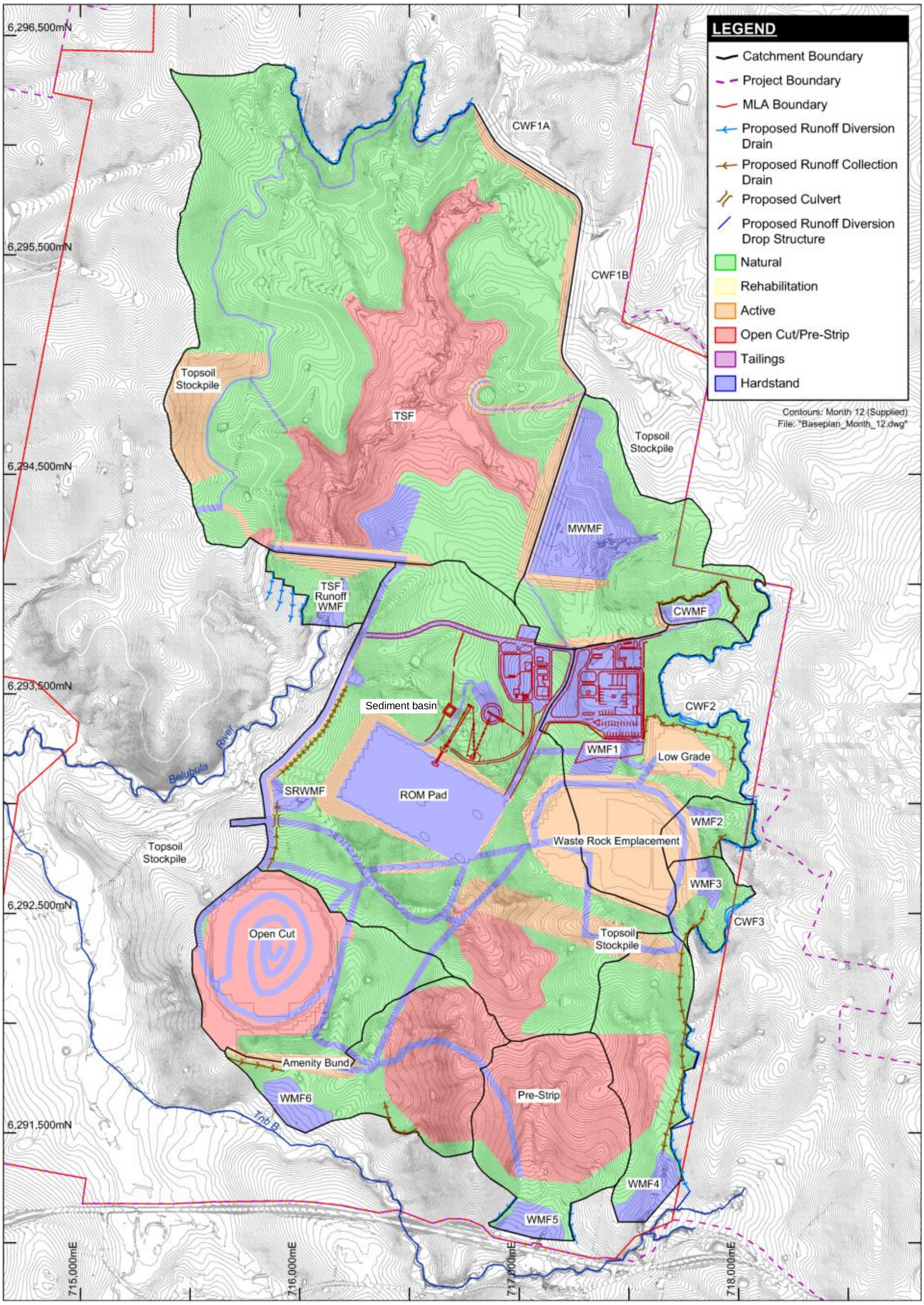


Figure 16 Operational Water System – Year 1

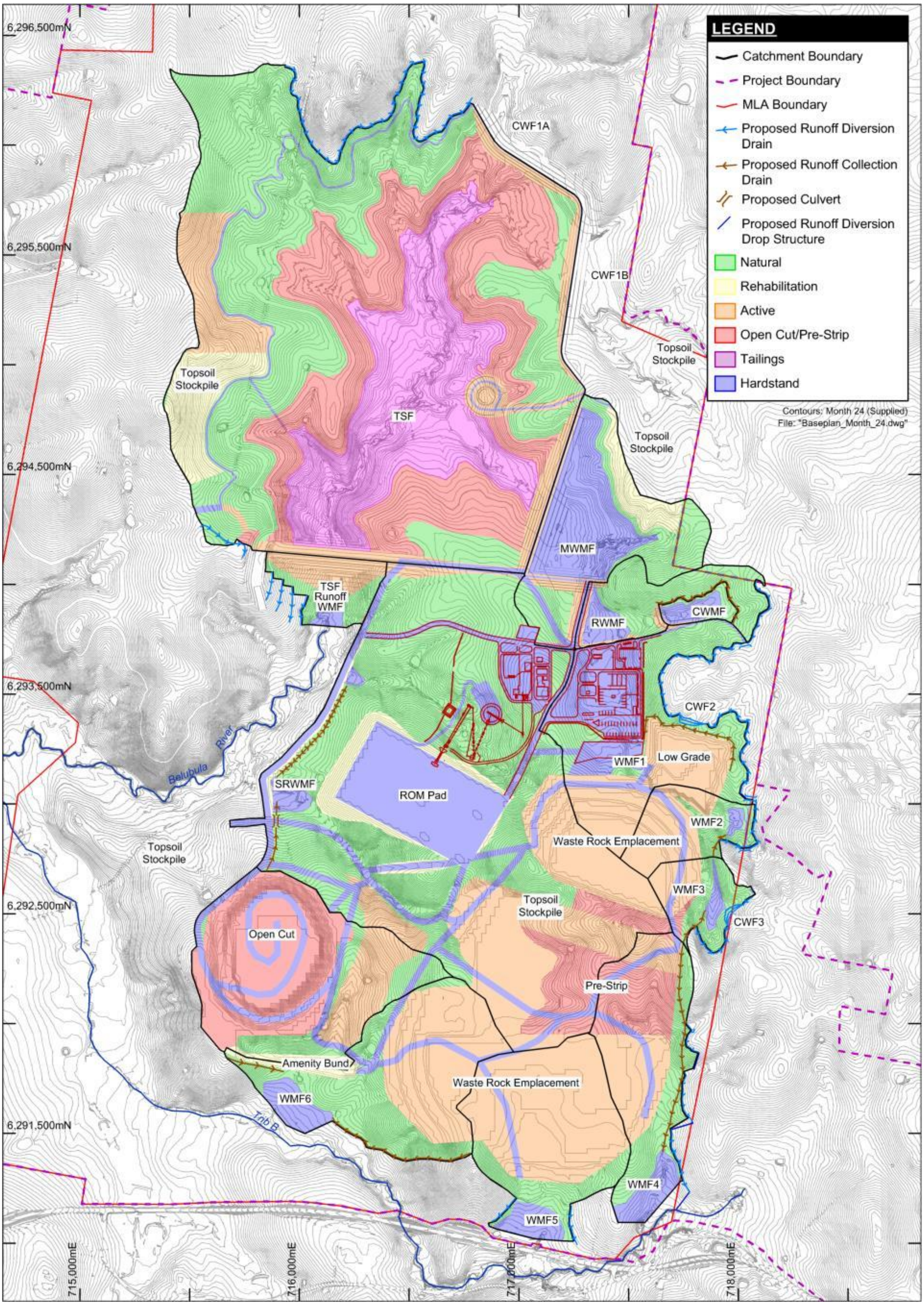


Figure 17 Operational Water System – Year 2

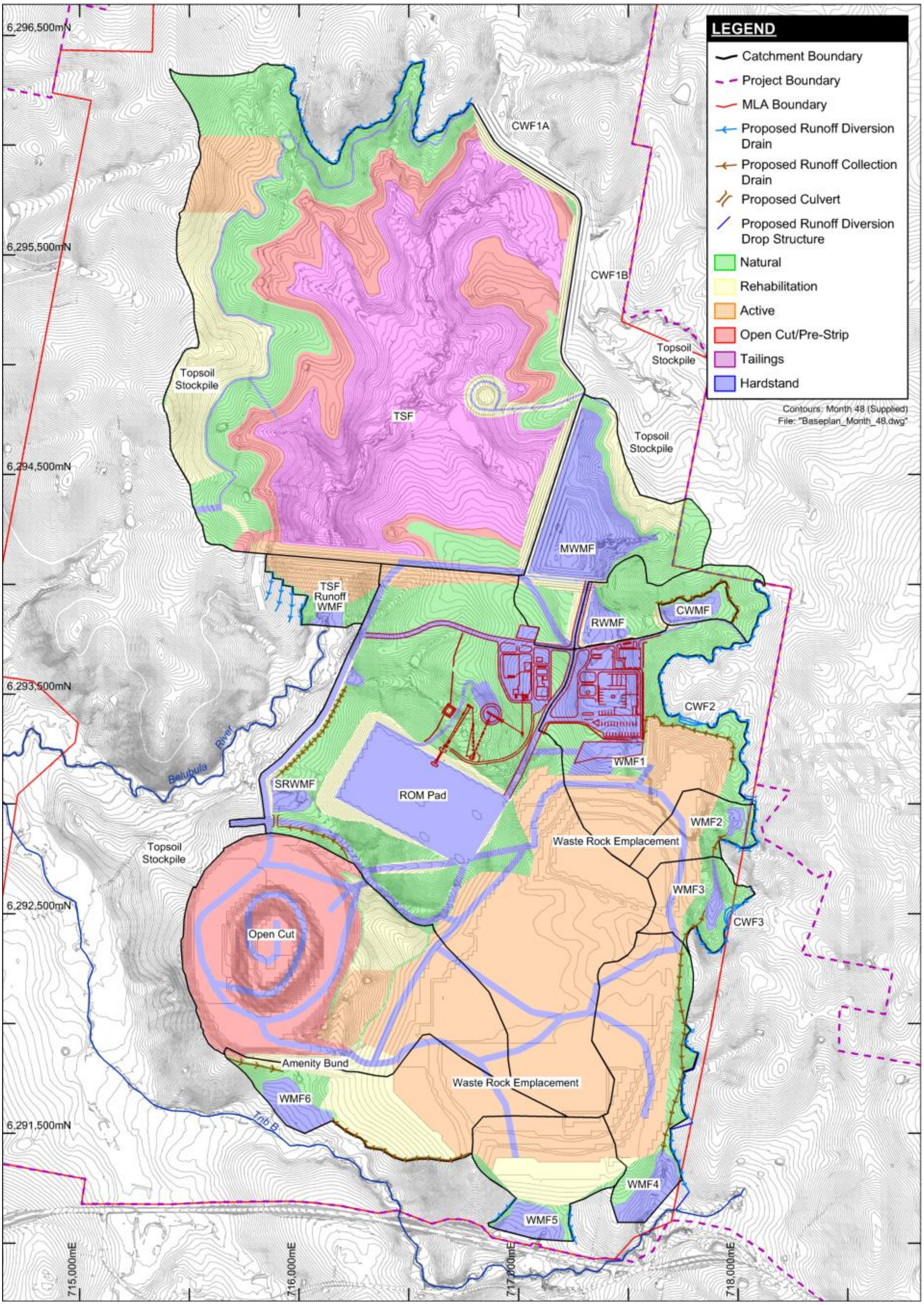


Figure 18 Operational Water System – Year 4

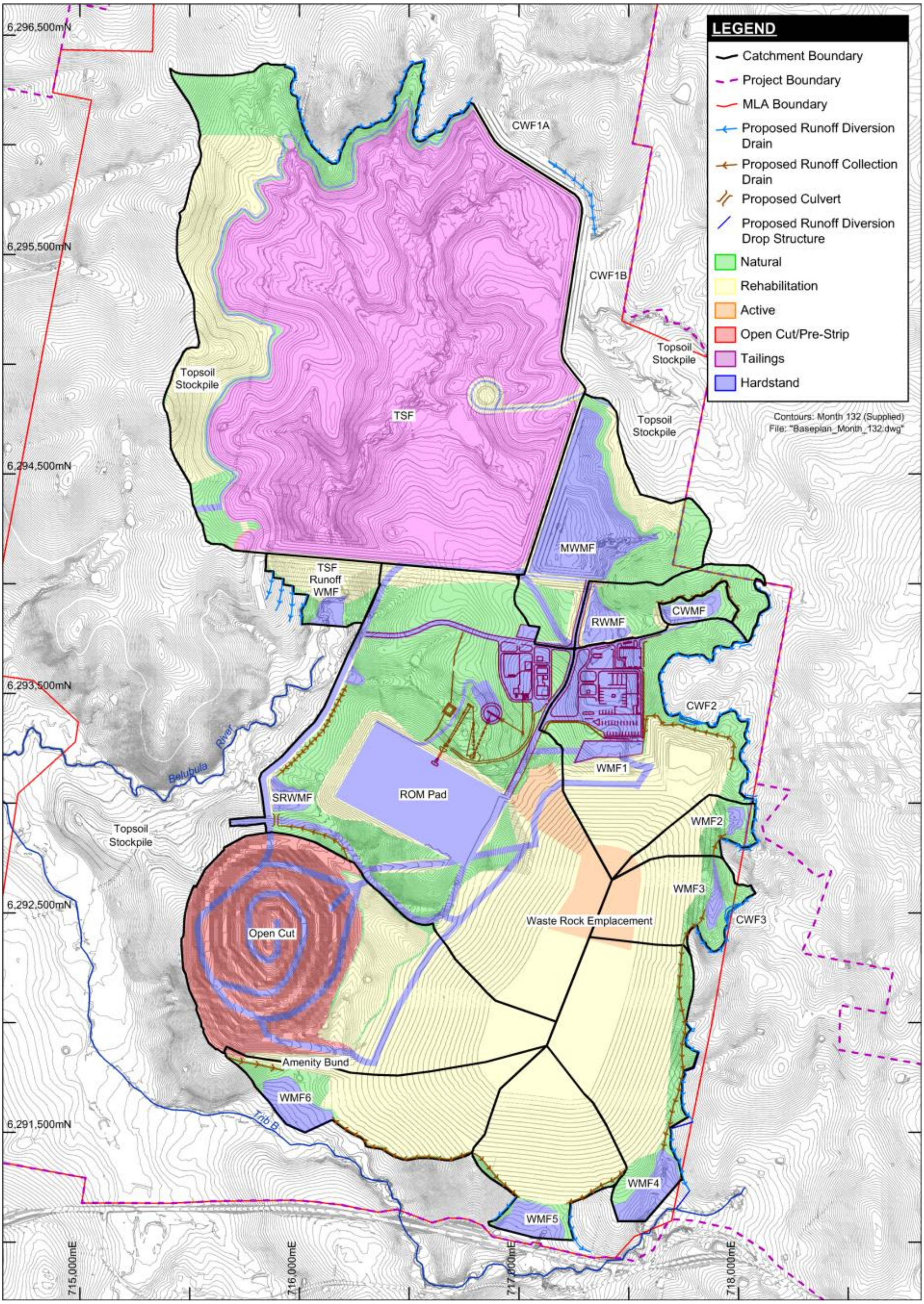


Figure 19 Operational Water System – Year 11

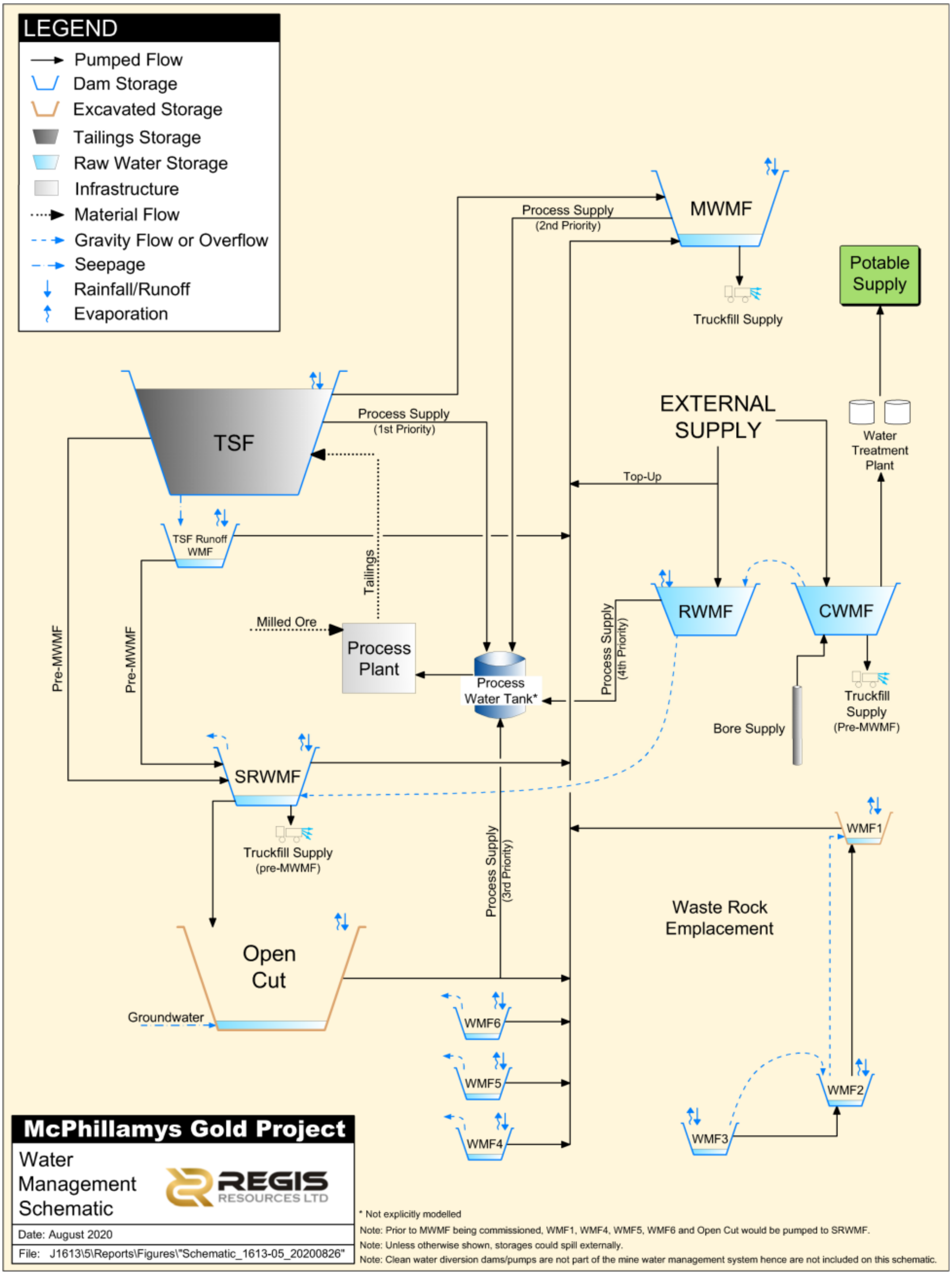


Figure 20 Operational Water System – Management Schematic

Processing will commence early in Year 2 with tailings discharged to the TSF and tailings decant water[5] recovered via pumping direct to the Process Plant (first priority) or to the MWMF. A seepage management system will be implemented for the TSF in accordance with leading practice (ATCW, 2020). The TSF Runoff WMF will be located downstream of the TSF and will serve as a sediment dam for construction of the TSF main embankment and to capture runoff from the crest and outer main embankment during its operational life. Once the TSF is commissioned, any runoff accumulating in the TSF Runoff WMF will be pumped to the TSF and reclaimed together with tailings decant water. Prior to TSF commissioning, any runoff accumulating in the TSF Runoff WMF will be pumped to the SRWMF. The TSF Runoff WMF has the potential to spill off site, hence its storage and pumping system capacity have been sized such that no spills are predicted during the operational life of the project – i.e. post construction (refer Section 3.2.3). Any seepage from the TSF during its operational life will be captured in a subsurface seepage collection system located at the toe of the TSF main embankment, upstream of the TSF Runoff WMF, and will be pumped back to the MWMF. Seepage interception bores will be constructed downstream of the TSF seepage collection system to monitor for and, if required, intercept any seepage before it progresses further downstream It is evident from the above that multiple measures will be implemented to manage TSF water and seepage in order to protect against downstream contamination.

The SRWMF, WMF1, WMF2, WMF3, WMF4, WMF5 and WMF6 will capture runoff from the waste rock emplacement and other infrastructure areas with accumulated water pumped to the MWMF. Other than WMF1, WMF2 and WMF3, these dams could spill off site, hence their storage and pumping system capacities have been sized such that no spills are predicted during the operational life of the project (refer Section 3.2.3). The waste rock emplacement area will be stripped and conditioned prior to the commencement of waste emplacement, thereby reducing the potential for seepage through the underlying lithology. It is noted, as per the EIS design, the amended project includes a conservative design of the waste rock emplacement area and run of mine (ROM) pad with inbuilt contingencies to ensure the balance of non-acid forming (NAF) waste rock is adequate to encapsulate all potentially acid forming (PAF) material encountered during the mine life (EMM 2020a).

The open cut will receive groundwater inflow and rainfall runoff with accumulated water to be pumped to the MWMF (or the SRWMF prior to commissioning of the MWMF).

3.1.3 Development/Construction Water System

Runoff from disturbed areas and establishing rehabilitation is defined as part of the development/construction water system for the mine project area. The development/construction water system would be in place during construction only and would be managed using erosion and sediment control measures designed in accordance with Landcom (2004) and DECC (2008). The following principles, which have been taken from the Landcom (2004) guidelines, underpin the approach to erosion and sediment control for the mine development:

- Minimising surface disturbance and restricting access to undisturbed areas.
- Progressive rehabilitation/stabilisation of mine infrastructure areas.
- Separation of runoff from disturbed and undisturbed areas where practicable.
- Construction of surface drains to control and manage surface runoff.
- Construction of sediment dams to contain runoff up to a specified design criterion.

[5] Tailings decant water is water liberated from tailings slurry as it settles within a tailings storage. This water reports to the tailings surface, ponds and is available for reclaim pumping.

Activities that have the potential to cause or increase erosion, and subsequently increase the generation of sediment, involve exposure of soils during construction of infrastructure (i.e. during vegetation clearance, soil stripping and earthworks activities) and ongoing mining activities involving clearing and stripping and stockpiling mine materials.

Temporary sediment traps and sediment filters (e.g. sediment fences) would be installed where necessary downslope of disturbance areas in accordance with Section 6.3.7 of Landcom (2004). The temporary erosion and sediment control systems would remain in place until all earthwork activities are completed and the disturbed area is rehabilitated.

One of the key construction activities would be the construction of the main embankment of the TSF. Management of runoff in this area has been planned and is described as follows. Prior to the commencement of construction activities for the main embankment of the TSF, a coffer dam would be established in the main Belubula River channel approximately 500 m upstream of the main embankment. Runoff collecting from upstream areas, undisturbed by construction activities, would be pumped from the coffer dam around the TSF construction works to the Belubula River downstream. Also prior to commencement of construction of the main embankment of the TSF, the TSF Runoff WMF would be constructed – this would then become the sediment dam for the construction of the main embankment of the TSF. During the construction phase of the main embankment of the TSF, with the coffer dam in place, the estimated catchment of the TSF Runoff WMF would be 99.2 ha. Based on methods and guidelines given in Landcom (2004) and DECC (2008) and adopting conservative assumptions[6], the estimated required minimum capacity of the TSF Runoff WMF is 21.2 ML. This compares with an estimated design capacity of 25.8 ML. Once the main embankment of the TSF is above ground, the catchment area reporting to the TSF Runoff WMF will reduce to an estimated 54.5 ha. During construction of the main embankment of the TSF, water accumulating in the TSF Runoff WMF and behind the main embankment of the TSF once it is above ground, will be used in construction works (e.g. for moisture conditioning of earthfill, dust suppression) or will be pumped to the SRWMF. Operational water balance modelling (Section 3.2) indicates that there is a risk of spill from the TSF Runoff WMF during construction of the main embankment of the TSF; however it should be emphasised that the TSF Runoff WMF will be functioning as a sediment dam at this stage and designed to spill occasionally in accordance with Landcom (2004).

A similar construction sequence would be adopted for the remainder of the mine project area, with downstream WMFs constructed ahead of any development activity in the WMF catchment. For example, the SRWMF would be commissioned prior to construction occurring in the process plant area and WMF4, WMF5 and WMF6 would be constructed ahead of topsoil stripping activities in the upslope waste rock emplacement area. In addition upslope clean water diversion drains (refer Section 3.1.1.1) would be constructed in advance of any development activity downslope to reduce the catchment reporting to the WMFs. Given the likely high sediment generation potential of the ROM and ore crushing area upslope of the SRWMF, a sediment basin is proposed immediately downslope of this area (upslope of the SRWMF – refer Figure 16), with a design capacity (based on Landcom [2004]) of 11.7 ML. This will control the volume of sediment accumulating in the SRWMF.

Routine (i.e. monthly) inspections of sediment control structures and diversion drains as well as inspections following rainfall events of 20 mm or more in a 24 hour period will be conducted during operations by site personnel. During these inspections, sediment control structures will be checked for capacity, structural integrity and effectiveness. Inspections will be documented using a check sheet as recommended in Landcom (2004) (refer Volume 1, Table 8.1). Maintenance work would be carried out as required.

[6] Type F Basin; 85th percentile 5-day rainfall; high runoff potential soil.

Inspection and management procedures will be documented in an Erosion and Sediment Control Plan (part of the Water Management Plan for the project). This would be developed to detail the erosion and sediment control measures to be implemented prior to the mine development.

3.2 OPERATIONAL WATER BALANCE MODELLING

A water balance model of the mine development has been developed to simulate the management of the operational water system over the project life. The overall aim of the model is to enable assessment of mine development water supply/demand, inform infrastructure sizing and assess risks. Key outcomes include estimates of:

- the overall water balance showing proportions of inflows and outflows;
- water supply reliability for future demands (Process Plant and truckfill);
- the risk of disruption to mining as a result of excess water in the open cut;
- the risk of spill from externally spilling WMFs; and
- the external supply requirement.

3.2.1 Model Description

The water balance model has been developed to simulate the majority of the storages and linkages shown in schematic form in Figure 20. The model has been developed using the GoldSim® simulation package and simulates the volume of water held in and pumped between all simulated water storages. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes direct rainfall, runoff, groundwater inflow to the open cut, water liberated from settling tailings, water sourced from the imported pipeline supply and all pumped inflows from other storages.

Outflow includes evaporation, spill, pumped outflows to other storages and pumped outflows to a demand sink (i.e. the Process Plant and truckfill).

The model operates on a less than daily time step. Model simulations begin at the start of Year 1 and continue to the planned end of mining (i.e. 10¾ years). The model simulates 131 "realizations" derived using historical daily climatic data[7] from 1889 to 2019. The first realization uses climatic data from 1889 to 1899, the second uses data from 1890 to 1900 and the third from 1891 to 1901 and so on. The results from all realizations are used to generate water storage volume estimates, supply reliability and other relevant water balance statistics. This method effectively includes all recorded historical climatic events in the water balance model, including high, low and median rainfall periods.

3.2.2 Key Model Data

A summary of key model assumptions and supplied data are provided in the sub-sections that follow.

3.2.2.1 Rainfall Runoff Modelling

Rainfall runoff in the model is simulated using the AWBM (Boughton, 2004). The AWBM is a nationally-recognised catchment-scale water balance model that estimates catchment yield (flow) from rainfall and evaporation. AWBM simulation of flow from six different sub-catchment types was undertaken, namely: hardstand (for example, roads and infrastructure areas), natural (undisturbed) areas, open cut and pre-strip areas, waste rock emplacement, rehabilitation and tailings. For the natural sub-catchment type, model parameters were derived from regionally calibrated values. For

[7] Data sourced from the SILO Data Drill for the mine project area location (refer Section 2.1).

other sub-catchment types, model parameters were initially taken from literature-based guideline values or experience with similar projects. The different AWBM parameters are used to represent different runoff characteristics from each sub-catchment type. For example, the surface store capacity is a parameter describing the capacity of the store that, when full, will 'overflow' and contribute to runoff and baseflow. For the hardstand sub-catchment type, the surface store capacities are generally smaller than the natural sub-catchment type meaning the hardstand sub-catchment stores require less rainfall to fill and contribute to runoff. This is representative of the higher volume of runoff expected from hardstand areas when compared to natural areas.

3.2.2.2 Catchment Areas

The catchment area for each storage was divided into the sub-catchment areas noted in Section 3.2.2.1 which were estimated from mine stage contour plans (showing progression of the open cut, waste rock emplacement and dam embankments) provided by Regis (refer Section 3.1.2). The calculated catchment areas for the mine development are shown in Figure 16 through to Figure 19. Figure 21 summarises the total catchment area reporting to the operational water management system over time.

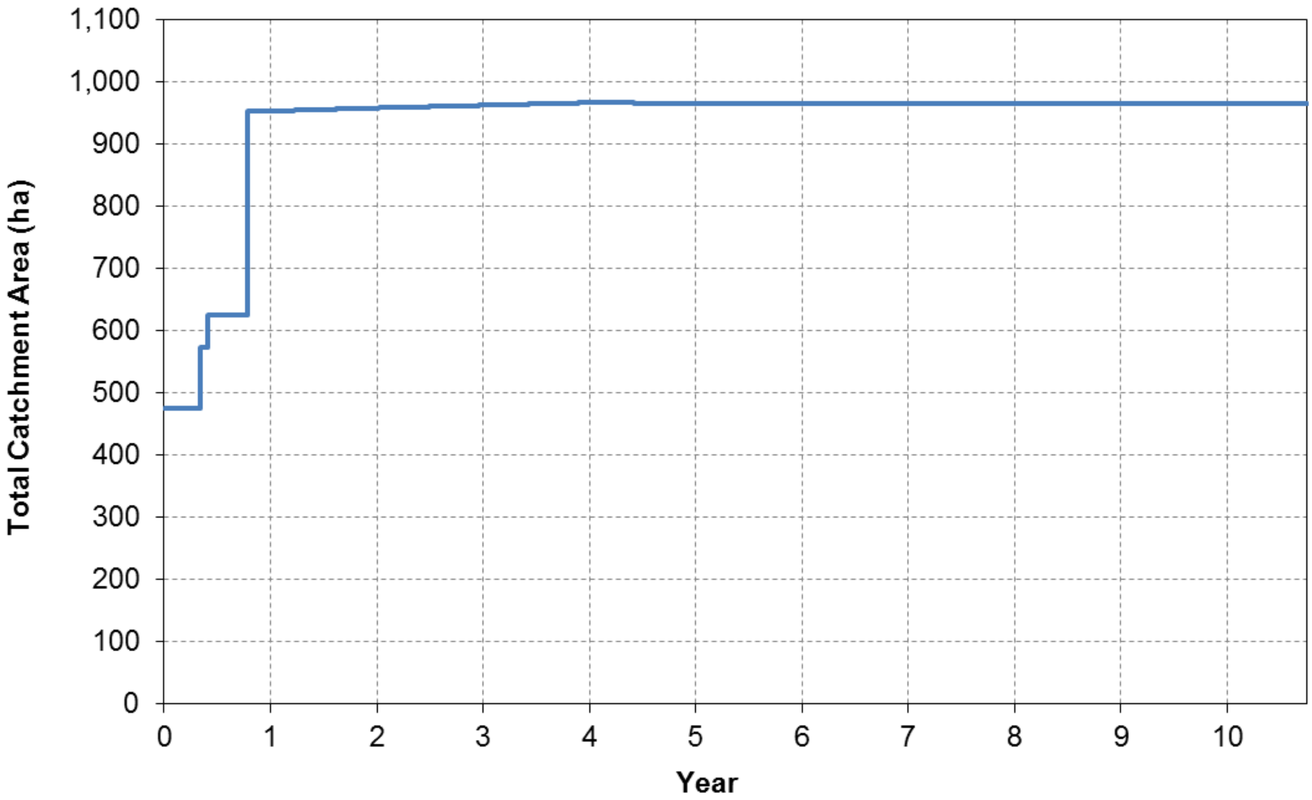


Figure 21 Operational Water System – Catchment Area Over Time

Figure 21 indicates that the catchment area reporting to the operational water system generally increases as each storage is commissioned before reaching a maximum of 964 ha after 4 years and staying constant for the remainder of the simulation period.

3.2.2.3 Evaporation from Storage Surfaces

Storage volumes simulated by the water balance model are used to calculate a storage surface area (i.e. water area) based on storage level-volume-area relationships for each water storage provided by either Regis or ATCW or developed using mine stage plans. For the staged construction of the TSF, level-volume-area relationships and corresponding dates were provided by ATCW for the start and end of each TSF stage.

Daily pan evaporation was multiplied by a pan factor in the calculation of storage evaporation losses from water storage areas. Monthly pan factors were taken from McMahon et al. (2013) data for Canberra Airport (located 200 km south of the mine development) and are listed in Table 16.

A pan factor of 1.2 was used in the estimation of evaporation from wet tailings surfaces (due to the darker tailings surface). A pan factor of 0.7 was used for calculation of evaporation from water stored in-pit (due to shading effects and lower wind speed at depth).

Table 16 Adopted Monthly Pan Evaporation Factors

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pan Factor:	0.785	0.791	0.770	0.801	0.820	0.849	0.881	0.879	0.873	0.883	0.852	0.811

3.2.2.4 Process Plant Demand and Tailings Disposal

Process Plant make-up water is required to replace water pumped to the TSF with tailings. Annual Process Plant demand is summarised in Table 17 and was based on:

- indicative future processing tonnages (refer Table 17);
- ore moisture of 3% (w/w); and
- tailings solids concentration of 62%.

Table 17 Indicative Ore Processing Rates and Process Plant Demand

Year	Dry Ore Milled (Million tonnes)	Process Plant Demand (ML/d)
1	0	0
2	4.8	10.37
3	7.0	11.20
4	7.0	11.16
5	7.0	11.16
6	7.0	11.16
7	4.9	7.05
8	6.4	10.98
9	7.0	11.16
10	7.0	11.16
11	6.4	7.50

The model calculates water liberated as tailings settle ('decant' water – refer Section 3.1.2) as a proportion of water pumped with the tailings, which is then available for reclaim. Tailings decant water has been assumed to be time-varying to allow for the lower reclaim volumes expected in the first year of tailings deposition into the TSF (on the basis of advice from ATCW). For the first 3 months of deposition, zero decant has been assumed. Between 3 and 6 months of deposition, 5% decant has been assumed and then from 6 months onwards 10% decant has been assumed.

In the TSF, decant water is subject to evaporation from the 'active' tailings beach area. Water which ponds within the storage (including rainfall runoff) is also subject to evaporation.

TSF seepage has not been simulated because the TSF seepage management system is designed to capture such seepage before returning it to the operational water management system (ATCW, 2020).

3.2.2.5 Dust Suppression and Construction Demand

Truckfill demand (i.e. for haul road and access road dust suppresion) was calculated based on estimated active road lengths calculated from the mine stage plans provided (refer Figure 16 to Figure 19) multiplied by an assumed 30 m watering width for haul roads and 10 m for unsealed portions of the site access road. Note that haul road lengths are linearly interpolated between calculated values at the discrete points in time represented by the mine stage plans. Truckfill demand was calculated from these areas by multiplying by the daily pan evaporation excess over rainfall (on days where rainfall exceeded evaporation, zero demand was assumed). Maximum haul road demand was based on two 50 tonne water trucks emptying twice an hour, operating 24 hours a day from Month 7 (equating to 4.8 ML/d) and, prior to this, 11 hours per day weekdays and half day Saturdays (per advice from Regis).

In addition, water will be required for moisture conditioning of earthfill during TSF construction. Based on advice from ATCW, this is estimated to amount to 100 ML, with a seven month construction period assumed. This demand was applied regardless of rainfall.

Calculated truckfill demand is summarised in Figure 22. Early in the simulation period (prior to Month 7) the demand varies up to 2.2 ML/d. From Year 3, the median demand ranges from approximately 0.5 ML/d in winter months to the maximum of 4.8 ML/d in the summer months. The average annual haul road dust suppression demand over the operational period was predicted as 801 ML/year. For modelling purposes demand was assumed drawn from the MWMF (or SRWMF and CWMF prior to the MWMF being commissioned).

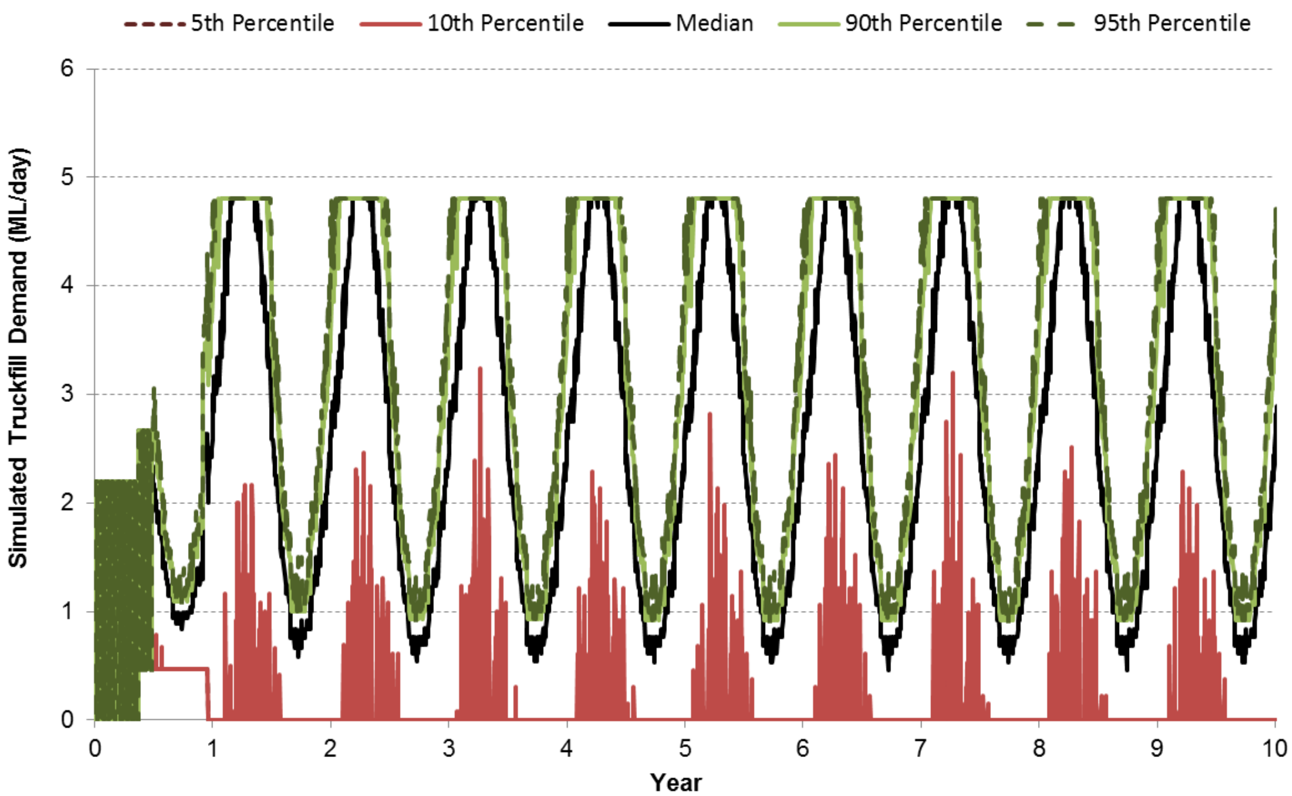


Figure 22 Simulated Haul Road Dust Suppression Demand

3.2.2.6 Groundwater Inflow

Groundwater inflow to the open cut was set to a time-varying rate as predicted revised groundwater modelling carried out for the amended project design (EMM, 2020d). Inflows were originally provided as net of entrained water but did not include evaporation from the pit wall. The water balance model was used to calculate the predicted groundwater inflows to the open cut, net of evaporation from the pit wall. Calculations allowed for a time-varying pit area versus time (as advised by EMM) multiplied by a pan factor of 0.7. The calculated groundwater inflow rate net of evaporation is summarised in Figure 23.

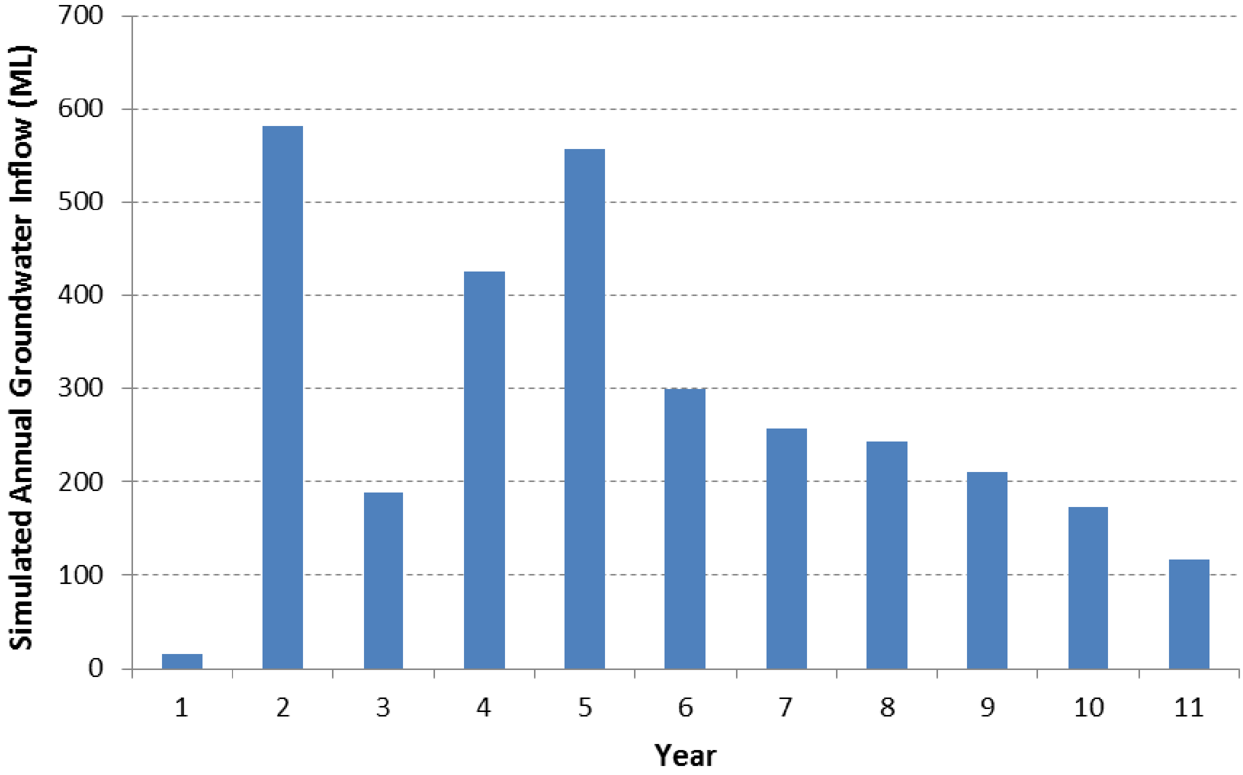


Figure 23 Simulated Average Groundwater Inflow Net of Evaporation

3.2.2.7 External Supply

Supply of water from Angus Place, SCSO and MPPS via the imported pipeline supply has been included in the model at a maximum rate of 15.6 ML/d available from the start of Month 9, initially supplying the CWMF and then the RWMF when that is commissioned at the start of Month 13. Operating "trigger" volumes have been assumed in the model (refer Section 3.2.2.8) to define when water would be sourced from the imported pipeline supply. Water would be transferred from the RWMF to maintain a storage reserve in the MWMF.

3.2.2.8 Storage Capacities, Operating Volumes and Transfer Rates

Storage capacities were initially sized by preliminary runs of the water balance model to inform civil design. Civil design then considered earthworks, waste rock availability and available land area to size the storages. The resulting design storage capacities were entered in the model and operating volumes and transfer rates were set in order to achieve a criterion of no simulated spills in any of 131 modelled realizations (climate scenarios). Storage capacities are summarised in Table 18. All storages were assumed empty at the start of the simulation except the CWMF which was assumed two-thirds full.

Table 18 Modelled Storage Capacities

Storage	Capacity (ML)	Established By
WMF1	70	Project start
WMF2	60 15.6	Project start Month 12
WMF3	19.5 21.3	Project start Month 12
WMF4	123	Project start
WMF5	136	Month 6
WMF6	158	Project start
SRWMF	528	Project start
MWMF	860 1,290 2,009	Month 13 Month 24 (end Year 2) Month 48 (end Year 4)
RWMF	108 217	Month 15 Month 24 (end Year 2)
CWMF	75	Project start
TSF	Varies	Month 13
TSF Runoff WMF	25.8	Project start

WMF1 is an excavated storage located just south of the process plant and infrastructure area (workshops, offices, etc.). Its capacity has been based on available area for this storage and an excavation depth of 4 m. Should its capacity be exceeded, ponded water would spread over the surrounding area located upslope of the infrastructure area. Spill off site would be prevented by the presence of the infrastructure area, the RWMF, MWMF and TSF further downslope (refer Figure 16).

WMF2 and WMF3 are small storages located to the east of the initial waste rock emplacement. These would be pumped out to WMF1. Any spills from these two storages would also report to WMF1.

As noted in Table 18, the capacity of the TSF varies depending on embankment construction stage and tailings deposition level (refer Figure 24). Water storage level-volume-area relationships were provided by ATCW and estimated from existing topographic contours for the initial storage (at commissioning). Note that tailings deposition does not commence until Month 13. Reclaim pumping is simulated from the commencement of storage construction, assumed to be in Month 5.

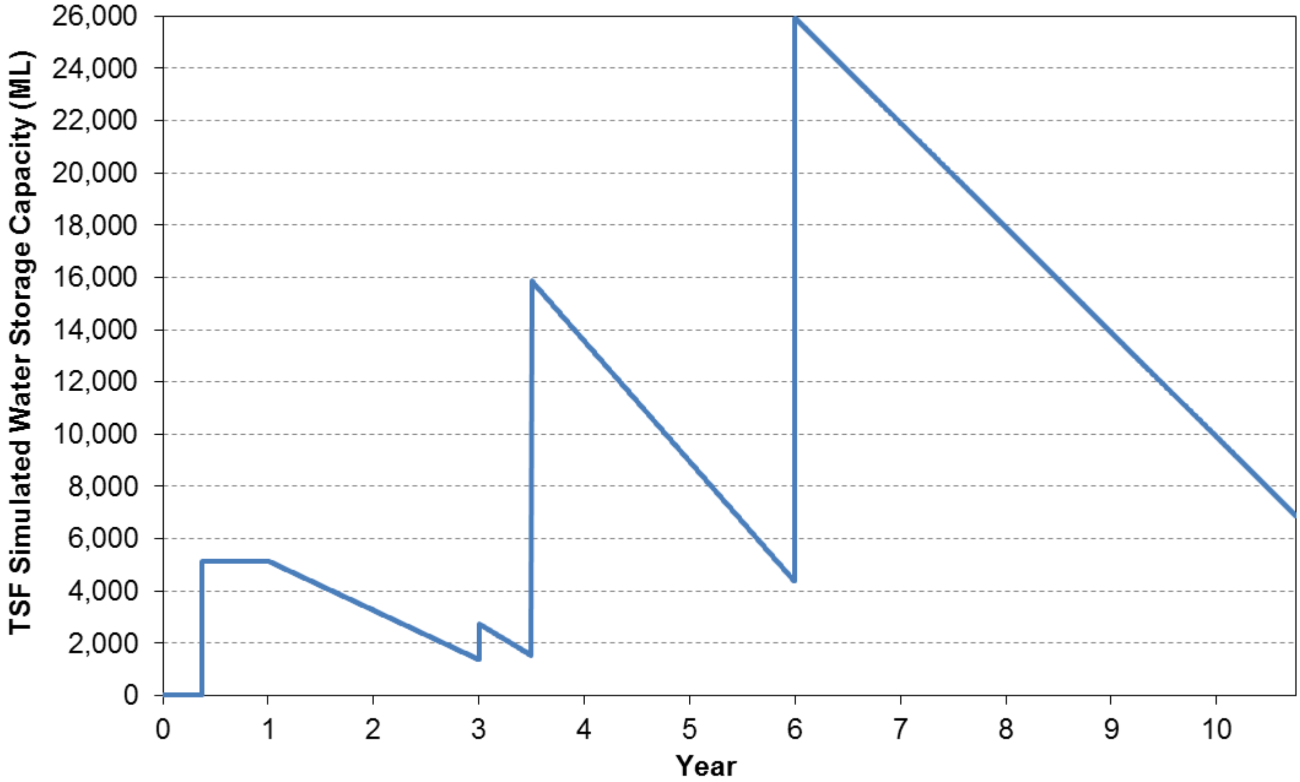


Figure 24 Assumed Time-Varying Capacity of TSF

Modelled transfer rates between storages are summarised in Table . Operating volumes and transfer rates were set based on optimisation of the water balance model to achieve a criterion of no simulated spills.

Table 19 Modelled Operating Volumes and Transfer Rates

From	To	Pumping Conditions	Transfer Rate (L/s)
WMF1	SRWMF	If MWMF not commissioned; AND WMF1 storage is greater than 90% of capacity (i.e. 63 ML); AND SRWMF storage is less than its NOV† (i.e. 476 ML)	150
		If MWMF not commissioned; AND WMF1 storage is greater than dead storage (i.e. 4 ML); AND SRWMF storage is less than its LOV∆ (i.e. 159 ML)	
	MWMF	If MWMF commissioned; AND WMF1 storage is greater than dead storage (i.e. 4 ML); AND MWMF storage is less than its HOV‡ (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
WMF2	WMF1	WMF2 storage is greater than 'dead' storage (i.e. 4 ML); AND WMF1 storage is less than half capacity (i.e. 35 ML)	40
WMF3	WMF2	WMF3 storage is greater 'dead' storage (i.e. 8 ML); AND WMF1 storage is less than half capacity (i.e. 35 ML)	20

* If there is more than 40 ML stored in the open cut, the normal 100 L/s pump rate would be increased to 300 L/s.

† Normal Operating Volume. ∆ Low Operating Volume. ‡ High Operating Volume.

Table 19 (Continued) Modelled Operating Volumes and Transfer Rates

From	To	Pumping Conditions	Transfer Rate (L/s)
WMF4	SRWMF	If MWMF not commissioned; AND WMF4 storage is greater than dead storage (i.e. 3 ML);AND SRWMF storage is less than its NOV[†] (i.e. 476 ML)	150
	MWMF	If MWMF commissioned; AND WMF4 storage is greater than dead storage (i.e. 3 ML); AND MWMF storage is less than its HOV[‡] (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
WMF5	SRWMF	If MWMF not commissioned; AND WMF5 storage is greater than dead storage (i.e. 27 ML);AND SRWMF storage is less than its NOV (i.e. 476 ML)	150
	MWMF	If MWMF commissioned; AND WMF5 storage is greater than dead storage (i.e. 27 ML); AND MWMF storage is less than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
WMF6	SRWMF	If MWMF not commissioned; AND WMF6 storage is greater than dead storage (i.e. 30 ML);AND SRWMF storage is less than its NOV (i.e. 476 ML)	150
	MWMF	If MWMF commissioned; AND WMF6 storage is greater than dead storage (i.e. 30 ML); AND MWMF storage is less than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
SRWMF	Open Cut	If MWMF not commissioned; AND SRWMF storage is greater than 70% of capacity (i.e. 370 ML)	400
		If MWMF commissioned; AND MWMF storage is greater than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
	MWMF	If MWMF commissioned; AND SRWMF storage is greater than dead storage (i.e. 12 ML); AND MWMF storage is less than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	400
Open Cut	SRWMF	If MWMF not commissioned; AND open cut storage is greater than dead storage (i.e. 4 ML); AND SRWMF storage is less than its NOV (i.e. 476 ML)	100/300*

* If there is more than 40 ML stored in the open cut, the normal 100 L/s pump rate would be increased to 300 L/s.

[†] Normal Operating Volume. [‡] High Operating Volume

Table 19 (Continued) Modelled Operating Volumes and Transfer Rates

From	To	Pumping Conditions	Transfer Rate (L/s)
Open Cut	MWMF	If MWMF commissioned; AND open cut storage is greater than dead storage (i.e. 4 ML); AND MWMF storage is less than its HOV[‡] (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	100/300*
Site Bore(s)	CWMF	If imported pipeline supply not commissioned; AND CWMF storage is less than 75% capacity (56 ML)	30
Imported pipeline supply	CWMF	If imported pipeline supply commissioned; AND RWMF not commissioned; AND CWMF storage is less than 50% capacity (37.5 ML)	181 (15.6 ML/d)
CWMF	MWMF	If RWMF not commissioned; AND CWMF storage is greater than dead storage (i.e. 2 ML); AND MWMF storage is less than 206 ML	200
Imported pipeline supply	RWMF	If imported pipeline supply commissioned; AND RWMF commissioned; AND RWMF storage is less than MOV** (65% of capacity – prior to Month 24 = 70 ML; thereafter = 141 ML)	181 (15.6 ML/d)
RWMF	MWMF	If RWMF commissioned; AND RWMF storage is greater than dead storage (i.e. 2 ML); AND MWMF storage is less than 206 ML	200
MWMF	Water Demand	If MWMF storage is greater than dead storage (i.e. 8.5 ML); AND there is shortfall from TSF	Not pump limited
TSF	Process Demand	If TSF storage is greater than dead storage (i.e. 100 ML)	Not pump limited
	SRWMF	If MWMF not commissioned; AND TSF storage is greater than dead storage (i.e. 100 ML); AND SRWMF storage is less than its LOV[∆] (i.e. 159 ML)	150
	MWMF	If MWMF commissioned; AND TSF storage is greater than dead storage (i.e. 100 ML); AND MWMF storage is less than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	
		If MWMF commissioned; AND TSF freeboard is less than 750 ML; AND MWMF storage is less than its HOV (Prior to Month 24: 85% of capacity = 731 ML; thereafter: 90% of capacity = 1,161 ML or 1,808 ML)	300

* If there is more than 40 ML stored in the open cut, the normal 100 L/s pump rate would be increased to 300 L/s.

** Maximum Operating Volume. ‡ High Operating Volume. ∆ Low Operating Volume.

Table 19 (Continued) Modelled Operating Volumes and Transfer Rates

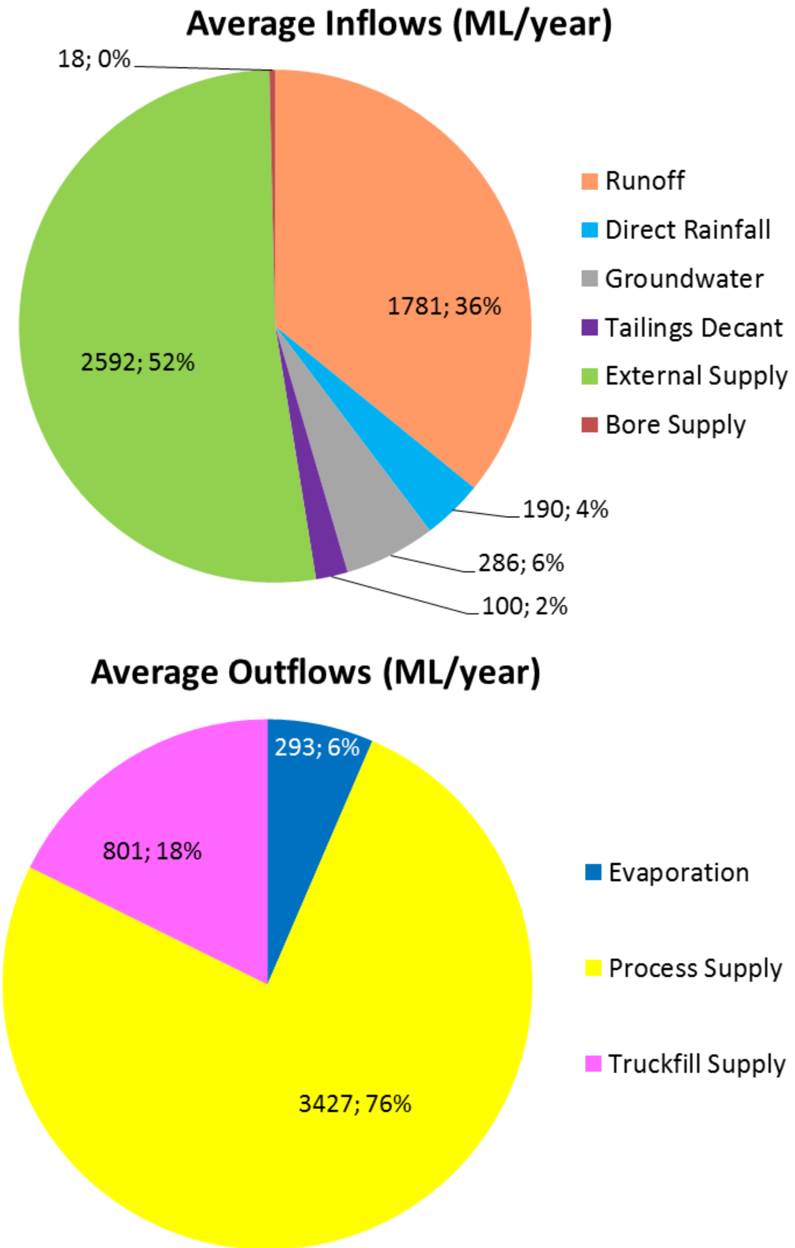
From	To	Pumping Conditions	Transfer Rate (L/s)
TSF Runoff WMF	SRWMF	If MWMF not commissioned; AND TSF Runoff WMF storage is greater than 18.1 ML; AND SRWMF storage is less than its LOV[Δ] (i.e. 159 ML)	40
	MWMF	If MWMF commissioned; AND TSF Runoff WMF storage is greater than dead storage (i.e. 6 ML); AND MWMF storage is less than its VHOV[X] (95% of capacity: prior to Month 13 817 ML; then prior to Month 24 1,096 ML; thereafter 1,708 ML)	

[Δ] Low Operating Volume. [X] Very High Operating Volume.

3.2.3 Simulated Future Performance

3.2.3.1 Overall Site Water Balance

Model predicted average inflows and outflows (averaged over the 10 year simulation period and all realizations) are shown in Figure 25. Model results indicate that, on average, imported pipeline supply provides the highest system inflow (52%) of the total inflow followed by runoff from the operational water management system. The majority of outflows (76%) comprise process plant supply followed by supply to truckfill.



Note: total average inflows will not equal average outflows due to statistical variation and the change in water stored on site.

Figure 25 Average Predicted System Water Balance

3.2.3.2 Stored Water Volumes

Predicted total stored water volume in all storages (including the open cut and TSF) is shown in Figure 26 as probability plots over the simulation period. These probability plots show the range of likely total stored water volumes, with the solid black line representing the median or 50th percentile volumes, the solid red and green lines representing the 10th and 90th percentile volumes and the broken red and green lines representing the 5th/95th percentile volumes. There is a 90% chance that the total water volume will fall in between the 5th/95th percentile volume plots. It is important to note that none of these plots represents a single climatic scenario (realization) – these probability plots are compiled from all 131 realizations (refer Section 3.2.1) – e.g. the median volume plot does not represent model forecast volume for median climatic conditions. Also shown is the capacity of the MWMF – the forecast 90th percentile inventory only exceeds this capacity in the first two years – i.e. prior to full development of the MWMF.

The forecast median stored water inventory will be approximately 500 ML once the MWMF is commissioned. However, in the short-term prior to the MWMF being commissioned, the operational water management system does not have the capacity to store a large volume of water on site to buffer supply during low rainfall periods.

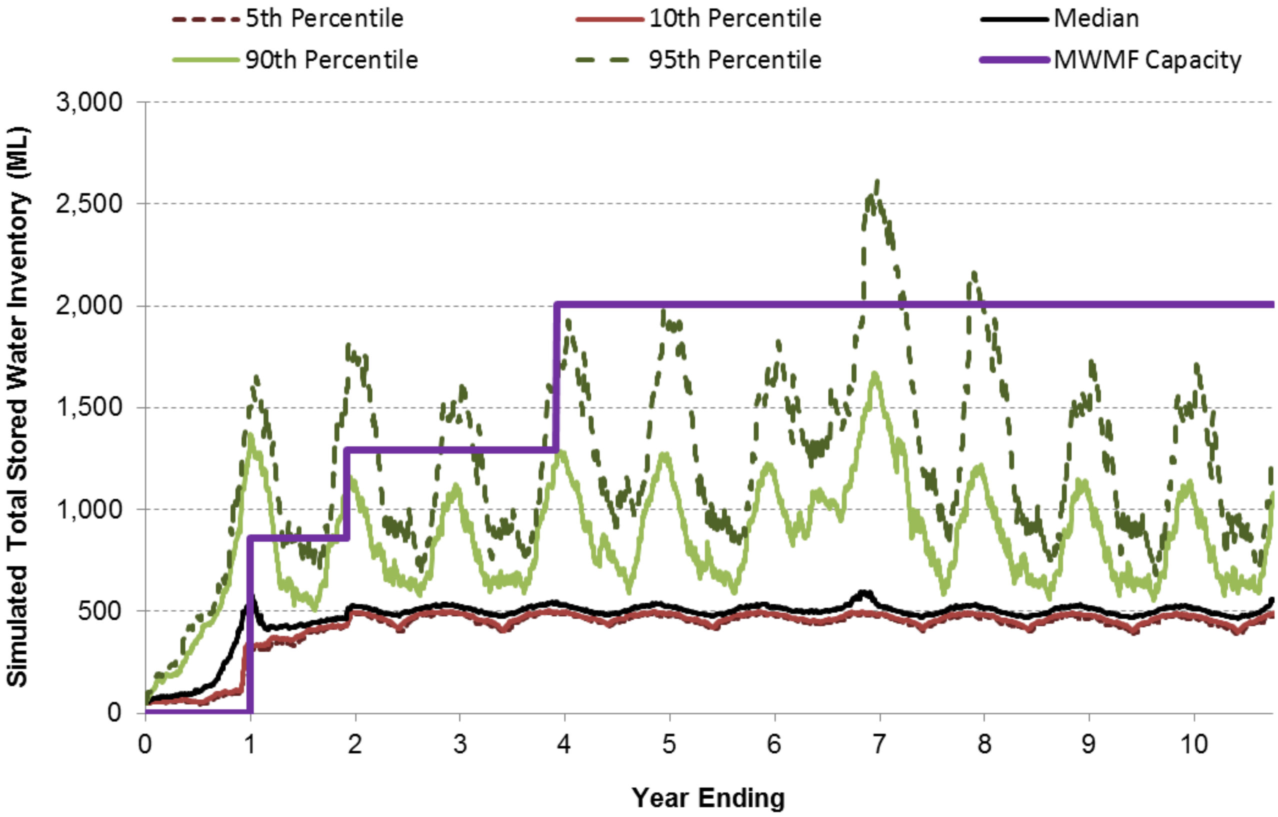


Figure 26 Simulated Total Water Inventory

The predicted stored water volume in the MWMF is given in Figure 27 also as probability plots over the simulation period. Figure 27 shows that the capacity of the MWMF is not exceeded.

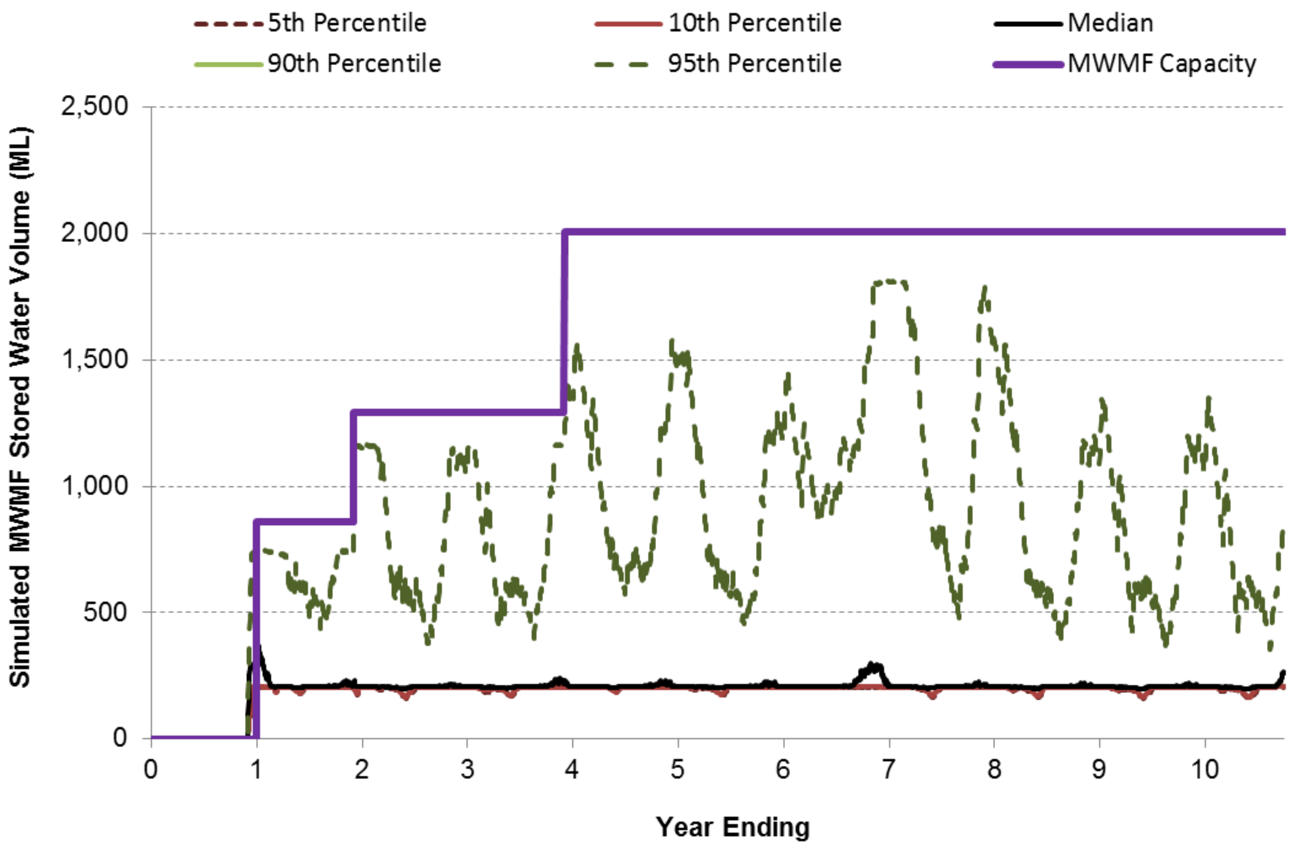


Figure 27 Simulated MWMF Volume

3.2.3.3 Water Supply Reliability

Supply shortfalls for process plant supply and truckfill are tracked within the model. Model forecasts indicate no supply shortfalls for all 131 climatic simulations. This is mainly as a result of the imported pipeline supply with up to 15.6 ML/d available from the start of Month 9.

In the period prior to the imported pipeline supply, truckfill water will be sourced from groundwater bores using a portion of the 400 ML/year of groundwater licences currently owned by Regis. Modelling indicates that a bore supply rate of 15 L/s should be adequate to meet dust suppression demands prior to commissioning of the imported pipeline supply.

3.2.3.4 Potential Mining Disruption

The risk of mining disruption has been assessed by comparing the number of days per year that more than 200 ML is held in the open cut (an arbitrary volume chosen to represent conditions which *could* lead to mining disruption). Model predictions suggest that on average, there would be less than 50 days over the simulation period (or 1.3% of days) where stored water volume in the open cut exceeds 200 ML. Figure 28 shows a plot of predicted stored water volume in the open cut as probability plots over the simulation period. These results indicate that there is a low risk that mining operations would be significantly impacted by rainfall, with the greatest risks occurring in the second and seventh years.

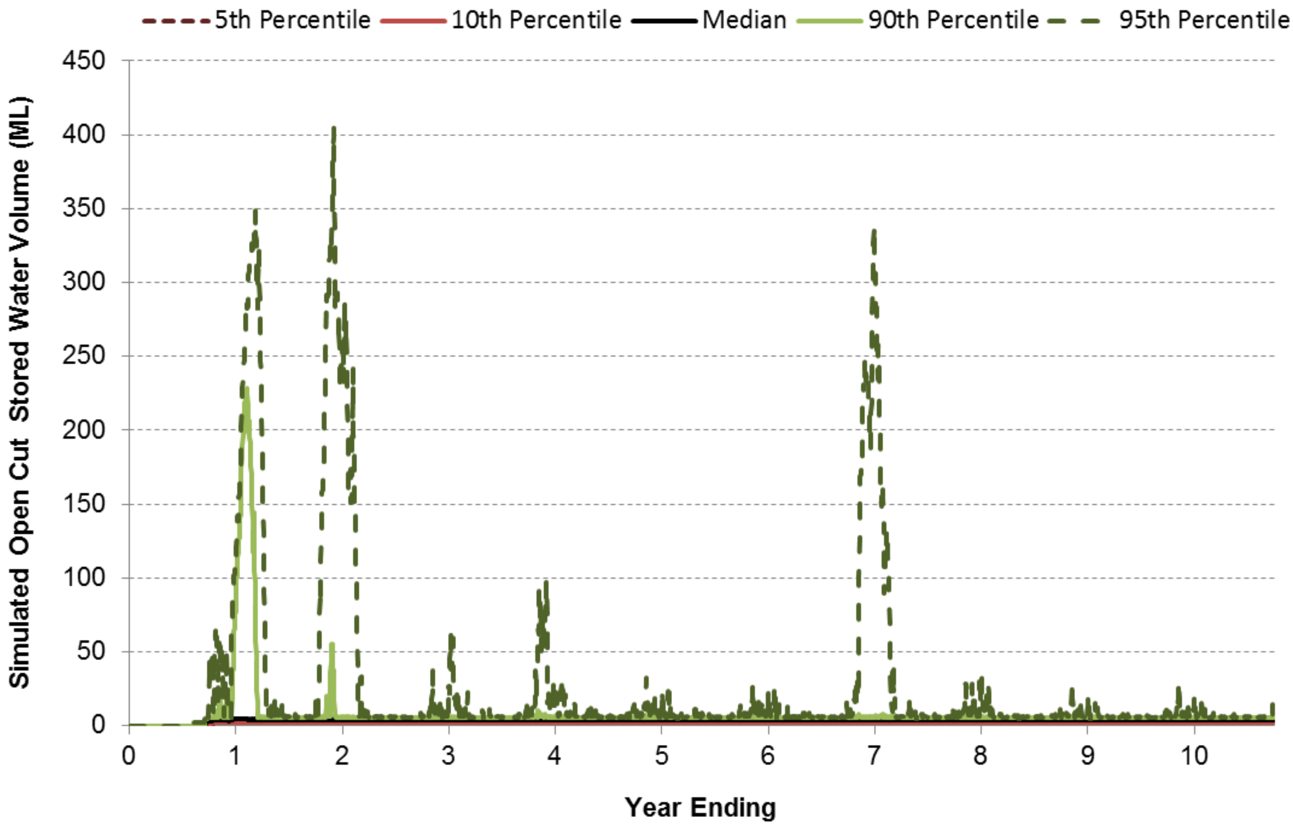


Figure 28 Simulated Open Cut Water Volumes

3.2.3.5 Imported Pipeline Supply

External water drawn from the imported pipeline supply would vary through the project life. Figure 29 shows predicted annual total volume brought to site via the imported pipeline supply at different probabilities. The 95th percentile values are those that would be expected to have a 5% chance of being exceeded. Median annual external supply is predicted to peak in Year 6. Model results indicate that, during periods of lower rainfall (indicated by the 90th/95th percentile results), the project would use up to approximately 4,000 ML of imported pipeline supply. This amounts to approximately 70% of the imported pipeline supply capacity. Modelling indicates that under most circumstances, the external supply pipeline would not need to be utilised to its full capacity on an annual basis.

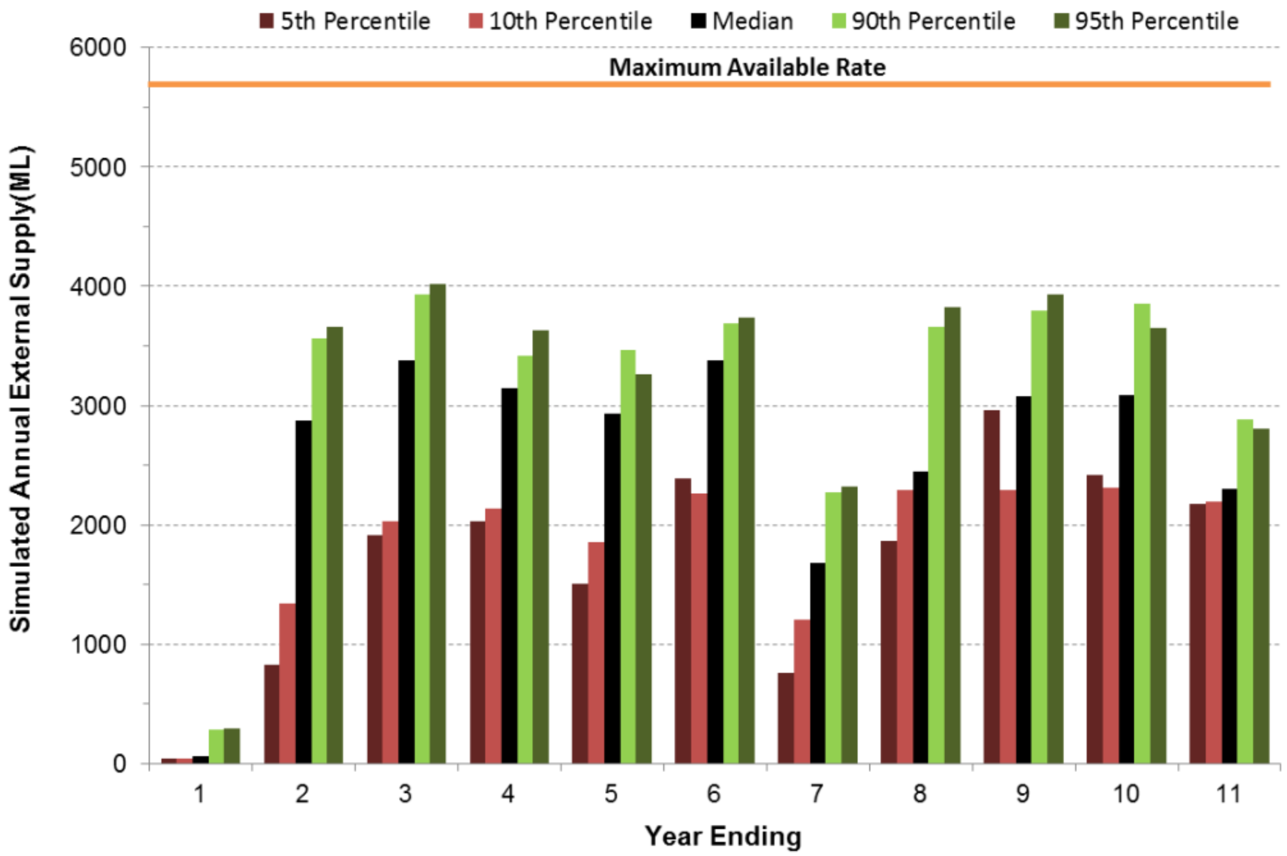


Figure 29 Simulated Annual External Supply

3.2.3.6 Spill Risk

There are no simulated external (off-site) spills from the modelled storages during the operational life of the project. As indicated in Section 3.1.3, spills are simulated from the TSF Runoff WMF during construction of the TSF but before commissioning of the TSF – i.e. when the TSF Runoff WMF is functioning as a sediment dam. Sediment dams are designed to spill occasionally in accordance with Landcom (2004).

3.2.3.7 Summary Outcomes

Operational water balance forecasts for the project may be summarised as follows:

1. Water supply via the imported pipeline supply provides the greatest average modelled system inflow, while the largest average outflow comprises supply to the process plant.
2. The forecast median stored water inventory is approximately 500 ML once the MWMF is commissioned. However, in the short-term prior to the MWMF being commissioned, the operational water management system does not have the capacity to store a large volume of water on site to buffer supply during low rainfall periods.
3. Model simulations indicate that there is a predicted high level of supply reliability with no significant shortfalls simulated. This is due to the the imported pipeline supply and, in the period prior to the imported pipeline supply, supply from site groundwater bores.
4. Model predictions suggest that on average, there would be less than a total of 50 days where stored water volume in the open cut exceeds 200 ML. These results indicate that there is a low risk that mining operations would be significantly impacted by rainfall.
5. On average, 2,590 ML/year would be sourced from the external pipeline. Model results indicate that, during periods of lower rainfall (indicated by the $90^{th}/95^{th}$ percentile results), the project

would use up to approximately 4,000 ML of imported pipeline supply, which amounts to approximately 70% of the imported pipeline supply capacity. Modelling indicates that under most circumstances, the external supply pipeline would not need to be utilised to this capacity on an annual basis.

6. There are no simulated external (off-site) spills from the modelled storages during the operational life of the project.

3.2.4 Climate Change Effects

Recent (post 1950) changes to temperature are evident in many parts of the world including Australia. The Intergovernmental Panel on Climate Change (IPCC) has, in its 2015 assessment (IPCC, 2015), concluded that:

> *Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, and in global mean sea level rise; and it is extremely likely to have been the dominant cause of the observed warming since the mid-20th century.*

Predicting future climate using global climate models is now undertaken by a large number of research organizations around the world. In Australia much of this effort has been conducted and co-ordinated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). CSIRO and BoM have published a comprehensive assessment of future climate change effects on Australia and future projections (CSIRO and BoM, 2015a). This is based on an understanding of the climate system, historical trends and model simulations of climate response to future global scenarios. Simulations have been drawn from an archive of more than 40 global climate models (GCMs) developed by groups around the world. Modelling has been undertaken for four Representative Concentration Pathways (RCPs) used by the latest IPCC assessment, which represent different future scenarios of greenhouse gas and aerosol emission changes and land-use change.

Predictions of future climate from these various models and RCPs have been used to formulate probability distributions for a range of climate variables including temperature, mean and extreme rainfall and potential evapotranspiration. Predictions are made relative to the IPCC reference period 1986 to 2005 for up to 13 future time periods between 2030 and 2090. Predictions for 2030 are relatively insensitive to future emission scenarios because they largely reflect greenhouse gases that have already been emitted. Longer term predictions become increasingly more sensitive to future emission scenarios.

Assessments of likely future concurrent rainfall and evapotranspiration changes have been undertaken using the online Climate Futures Tool (CSIRO and BoM, 2015b). Projected changes from all available climate models are classified into broad categories of future change defined by these two variables, which are the most relevant available parameters affecting rainfall runoff. The Climate Futures Tool excludes GCMs which were not found to perform satisfactorily over the Australian region. The assessments assumed a conservatively high emissions scenario – RCP 8.5 (representing a future with little curbing of emissions, with a carbon dioxide level continuing to rapidly rise to the end of the century). Assessments were performed for 2030 (i.e. at the end of the mine development life) and 2090 (latest projected year available – which is of relevance for the post-mine period) for the Central Slopes region of the continent. Table 20 presents mean annual changes for these two climate variables.

Table 20 Predicted Mean Change in Annual Rainfall and Evapotranspiration using Climate Futures Tool

Climate Variable	Mean Change From Reference Period by	
	2030	2090
Annual Rainfall	-0.7%	-3.3%
Annual Evapotranspiration	3.6%	13.7%

The most likely climate future in 2030 is predicted to involve "little change"[8] in annual rainfall with a "small increase" in annual evapotranspiration, while the most likely climate future in 2090 is for a "large increase" in annual evapotranspiration combined with a "drier" rainfall scenario. These effects are likely to, in the longer term, lead to reductions in rainfall runoff in the mine project area and the Central Slopes region generally.

An assessment was also carried out of the change in extreme (1:20 AEP) annual rainfall. The predicted most likely scenario by 2030 is for "little change" or a "small increase", while by 2090 the prediction is for a "small increase".

The implications of climate change predictions on water management are unlikely to be significant over the project life because they are fairly small compared to natural climatic variability and the relatively short duration of the mine development.

Longer term climate change predictions do however have potential implications for post mine water management (refer Section 3.4.4).

3.3 FINAL LANDFORM SURFACE WATER MANAGEMENT

The surface water management system proposed for the final landform is illustrated in Figure 30.

Post mining, all mining areas, except for the final void, will be regraded to a stable landform and revegetated. All disturbed areas, except for the final void catchment, will be rehabilitated. A number of permanent clean water diversion channels will be constructed to allow a free-draining landform. A clean water diversion channel will be constructed adjacent to the northern boundary of the open cut area to divert upslope runoff to the Belubula River. A conceptual alignment of diversion channels is shown in Figure 30. The alignment and design of the diversion channels will be confirmed during the detailed design stage. Final drainage of the rehabilitated TSF is described in ATCW (2020).

[8] The Climate Futures Tool uses standard terms to describe future magnitudes of change – these have been shown in quotation marks. "Little change" in annual rainfall is for a change between -5% to 5%, "small increase" in evapotranspiration is an increase of between 1% to 4.59%, "large increase" in evapotranspiration is an increase of more than 4.59% and a "drier" annual rainfall scenario is a change of between -5% to -15%. In the context of extreme (1:20 AEP) annual rainfall, "little change" is for a change between -10% to 10%, while "small increase" is a change between 10% to 30%.

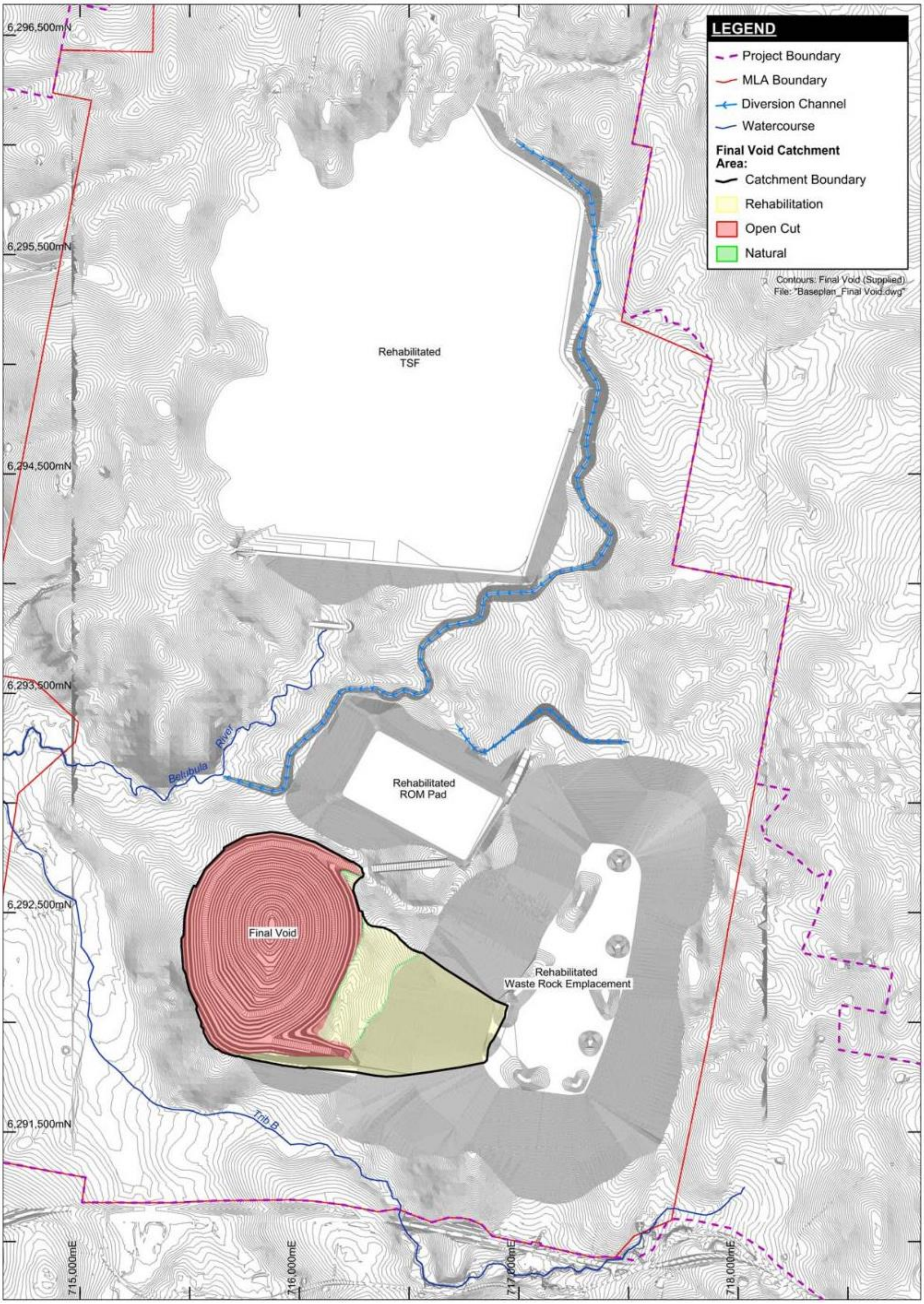


Figure 30 Final Landform Surface Water Management Layout

3.4 FINAL VOID WATER AND SALT BALANCE MODELLING

3.4.1 Model Description

The planned final landform is described in Section 3.3 and shown in Figure 30. A daily timestep, final void water and salt balance model has been set up using the GoldSim® simulation package. The model simulates the volume and salinity of the final void water body by simulating the inflows, outflows and resultant volume of water and salt mass:

Change in Storage = Inflow – Outflow

Where:

Inflow includes direct rainfall, runoff and groundwater inflow.

Outflow includes evaporation.

3.4.2 Key Data and Assumptions

The model simulates inflow from remnant final void catchment rainfall runoff (including direct rainfall), groundwater inflow from bedrock as well as outflow due to evaporation on a daily basis. Key model input data include the following:

- A catchment area of 107.1 ha comprising 40.0 ha of rehabilitated sub-catchment and 67.1 ha of remnant open cut pit sub-catchment.
- A 131 year climatic data set (1889 to 2019 inclusive) obtained from the SILO Data Drill for the mine project area location (refer Section 2.1). The data set was repeated several times over to generate an extended period of data for final void simulation – to ensure equilibrium water levels were reached during the simulation period.
- A constant pan factor of 0.7 was assumed for calculation of evaporation from the final void until the water level reached 10 m below spill level at which point the monthly pan factors were taken from McMahon et al. (2013) as listed in Table 16. The lower pan factor used for lower final void levels reflects lower evaporation likely at depth as a result of shading effects.
- Rainfall runoff from the remnant open cut pit and rehabilitated waste rock sub-catchments was estimated using the AWBM applied to the final void sub-catchments, in a manner similar to the operational water balance model (refer Section 3.2.2.1).
- Predicted rates of groundwater flux versus water level in the open cut were provided by EMM (2020d).
- Catchment runoff salinity (EC) values for final void remnant open cut pit and rehabilitated waste rock sub-catchment areas were based on the results of standard geochemical tests on waste rock samples. An EC value of 439 µS/cm was adopted for the catchment runoff salinity based on the median water leach extraction test results on volcaniclastic waste rock samples (SRK, 2019).
- Seepage salinity (EC) values through the rehabilitated waste rock were varied with time, with an initial adopted EC value of 4,260 µS/cm (single highest value from all mild acid leachate test results on volcaniclastic waste rock), reducing to 439 µS/cm (median value from water leach extraction tests) over a period of 1,000 years.
- Adopted groundwater inflow EC was based on estimates of groundwater inflow proportions from different lithological units and the median EC values recorded in groundwater samples from each unit. An average groundwater inflow EC of 1,537 µS/cm was adopted based on a median EC of 1,932 µS/cm and 67% proportion of inflow from metasedimentary units, a median EC of 741 µS/cm and 30% proportion of inflow from volcaniclastic units and a median EC of 670 µS/cm and 3% proportion of inflow from limestone units (SRK, 2019).

In simulating pit lake salinity, the model assumes conservation of mass and fully mixed conditions.

3.4.3 Simulated Future Performance

Model predicted final void water levels and EC values are shown in Figure 31.

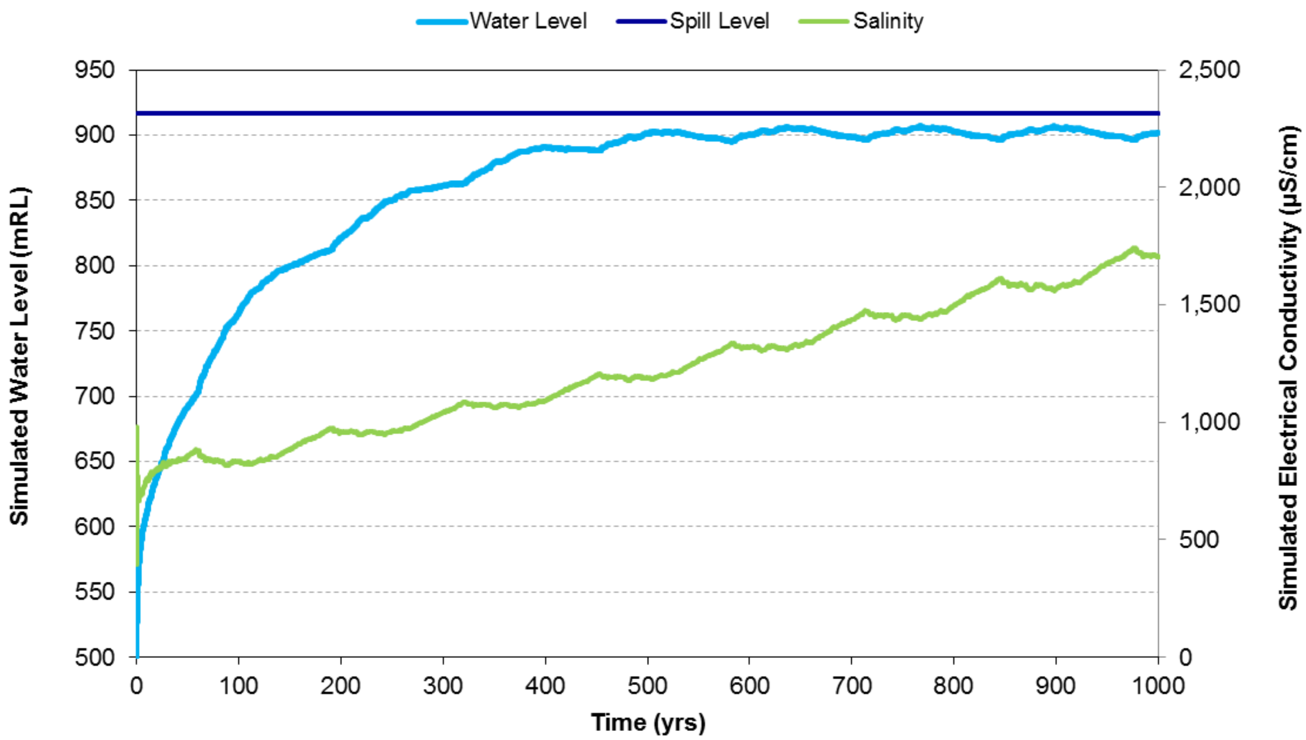


Figure 31 Predicted Final Void Water Levels and EC

Results indicate that the final void would reach an equilibrium level more than 9 m below the spill level, with an average equilibrium level approximately 14 m below the spill level (i.e. the final void is contained). Equilibrium levels would be reached very slowly over a period of more than 500 years. Final void salinity levels would increase slowly as a result of evapo-concentration.

The final void water balance, geochemical assessment and groundwater modelling will continue to be refined and verified as additional data becomes available and closure planning for the project will be reviewed as required.

3.4.4 Climate Change Effects

The longest term climate change prediction only extends to 2090 (refer Section 3.2.4) hence applying climate change factors to the final pit lake simulation would not be relevant for the long simulation period of the final void model. However, based on the 2090 estimates for changes in rainfall and evaporation, the most likely longer term climate change prediction would result in lower equilibrium water levels, these being reached sooner and with an increased rate of salinity rise.

3.5 FLOODING

3.5.1 Background

The SEARs for the EIS specify detailed flood modelling (OEH agency requests) however HEC contacted OEH directly to confirm that a simplified flooding assessment would be satisfactory given the following key points:

1. The mine development is located in the headwaters of the Belubula River hence the flooding risk resulting from upstream floodwaters would be minor.

2. The open cut is located no closer than 250 m from the Belubula River.
3. The mine development will capture runoff from disturbed areas (most notably the tailings dam, waste rock emplacement area and open cut) which will result in a reduction in catchment area reporting downstream hence the impact on flooding to downstream floodwaters would be a reduction in total flow downstream of the project area.

HEC received confirmation from OEH via email on the 27th of February 2019 that the proposed simplified flooding assessment "would be appropriate to meet the flooding assessment" (I. Rivas 2019, pers. comm. 27 February).

The simplified flooding assessment is summarised in the sections to follow and includes flood modelling using simple analytical calculation of peak flow rate for a range of AEP flood events (10%, 1%, 0.5%, 0.2%, 0.1% and PMF) for a point adjacent to the proposed open cut of the mine development (refer Figure 32) for both the existing case and at maximum mine development disturbance. A cross-section of the Belubula River at this point has been used to estimate peak flood levels for these events, by calculating 'normal' depth of flow for this cross-section (ultimately to assess the potential requirement for a flood levee).

3.5.2 Peak Flow Rates

The first step in the analysis involved obtaining design rainfall intensity data for the site location. This was sourced from the BoM website[9] for the location defined as: Zone 55, 717,321 mE, 6,294,807 mN. The relevant design rainfall duration is the catchment time of concentration – that is the shortest duration when the entire catchment is contributing runoff. This was calculated using the Bransby-Williams equation (IEAust , 1998):

$$t_c = \frac{58L}{A^{0.1}\ S_e^{0.2}}$$

Where:

t_c is the time of concentration (minutes);

S_e is the equal area slope of the main stream projected to the catchment divide (m/km);

L is the main stream length measured to the catchment divide (km); and

A is the area of the catchment (km^2).

Peak flow rate was estimated using the rational method (IEAust , 1998), viz:

$$Q = CIA/3.6$$

Where:

Q is the design peak flow rate (cubic metres/second [m^3/s]);

C is the catchment runoff coefficient varying from 0 to 1 (dimensionless);

I is the design rainfall intensity (mm/hour); and

A is the catchment area (km^2).

[9] http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016

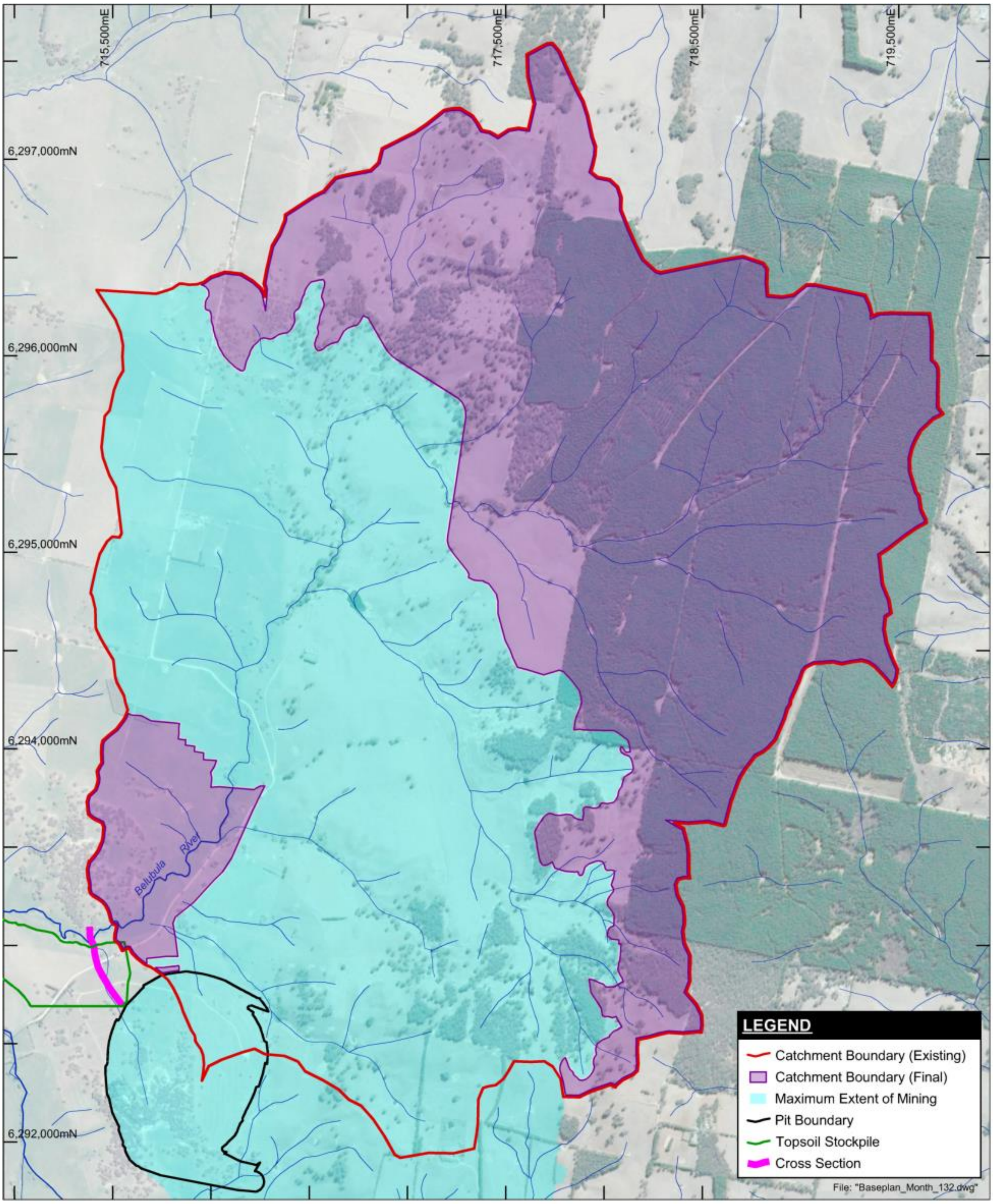


Figure 32 Simplified Flooding Assessment Layout

For the maximum mining extent scenario, the upper catchment of the Belubula River is separated from the lower section by the mine (refer Figure 32) and runoff is captured in clean water dams and pumped downstream. To estimate the effect this would have on peak flows during mining, only the lower catchment was considered for the rational method. The maximum pump rate expected for the diversion system was added to the rational method flow to calculate the peak flow during mining.

Runoff coefficients for the 10% and 1% AEP events were taken from Section 1.4.1 of Book 4 of Australian Rainfall and Runoff (IEAust , 1998). For the remaining four events, the runoff coefficient was chosen to provide a conservative estimate of peak flow.

A summary of the calculations that were to to obtain peak flows adjacent to the proposed open cut are provided in Table 21.

Table 21 Summary of Peak Flow Estimation Adjacent to Proposed Open Cut

Scenario	AEP	A (km^2)	t_c (min)	I (mm/h)	C	Diverted Pump Rate (m^3/s)	Peak Flow Rate (m^3/s)
Existing	10%	15.698	206	13.1	0.26	n/a	15.1
	1%			19.7	0.47		40.4
	0.5%			22.2	0.9		86.9
	0.2%			25.2	0.9		99.0
	0.1%			27.7	0.9		108.6
	PMP			177.6	1		774.5
Maximum Mining Extent	10%	0.678	51	34.5	0.42	0.52	3.3
	1%			53.0	0.75		8.0
	0.5%			59.5	0.9		10.6
	0.2%			67.5	0.9		12.0
	0.1%			112.6	0.9		19.6
	PMP			355.7	1		67.5

3.5.3 Peak Flood Level Estimates

Flood levels were estimated using the Mannings equation (assumes uniform steady flow) at the cross-section shown on Figure 32 where the vertical distance between the edge of the proposed open cut and the Belubula River is at a minimum. A Mannings *n* (roughness) value of 0.05 was used for high grass flood plains (Chow, 1986) and the bed slope was measured from 1 m topographic contours. Estimated peak flood levels are summarised in Table 22 and shown on the cross-section in Figure 33. The estimated peak flood levels in Table 22 compare with an estimated ground level of 916 m AHD for the edge of the proposed open cut.

Table 22 Summary of Peak Flood Level Estimation Adjacent to Proposed Open Cut

AEP	Existing		During Mining	
	Flood Level (m AHD)	Maximum Flow Depth (m)	Flood Level (m AHD)	Maximum Flow Depth (m)
10%	898.9	0.92	898.4	0.43
1%	899.4	1.47	898.6	0.67
0.5%	900.0	2.04	898.7	0.77
0.2%	900.1	2.15	898.8	0.82
0.1%	900.2	2.23	899.0	1.04
PMP	902.7	4.71	899.8	1.84

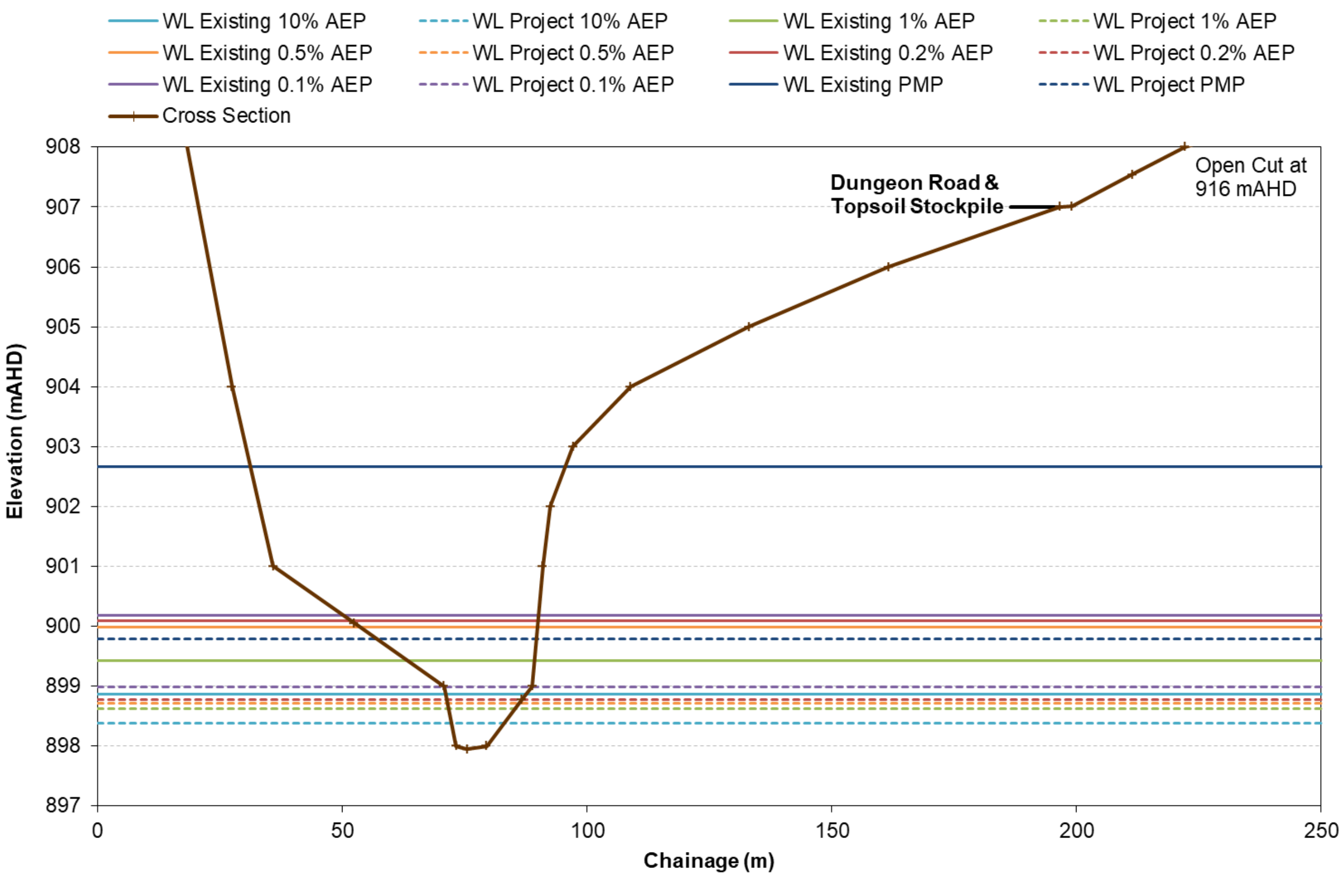


Figure 33 Simplified Flooding Assessment: Cross-Section With Estimated Peak Flood Levels

Figure 33 shows that the highest estimated peak flood level of 902.7 m AHD is for the existing catchment scenario for a PMP rainfall event. This peak level is 4.3 m below the existing Dungeon Road and a proposed topsoil stockpile at 907 m AHD. The proposed open cut is another 9 m above this infrastructure at 916 m AHD hence a flood levee is not considered warranted. All other estimated peak flood levels are approximately 900 m AHD or below.

4.0 POTENTIAL SURFACE WATER IMPACTS AND MITIGATION MEASURES

4.1 OPERATIONAL PHASE

4.1.1 Streamflow and Inflows to Lake Carcoar

4.1.1.1 Background

The main potential surface water impact during the operational phase of the project is reduced streamflow in the Belubula River and hence inflows to Lake Carcoar due to flow reduction and catchment excision associated with the operational water management system (refer Figure 16 to Figure 19).

The groundwater model (EMM, 2020d) predicts some loss of flow to the Belubula River upstream of Trib A (currently predicted to contribute approximately 5% of overall surface flows) with a reduction of up to 0.059 ML/d and up to 0.046 ML/d in Trib A (during the project life – peaking in Years 10 and 11). There is no modelled flow impact downstream of the confluence with Trib A (EMM, 2020d). The predicted peak total flow reduction during the project life therefore totals 38 ML/year.

4.1.1.2 Belubula River Flow Modelling

The potential impact on inflows to Lake Carcoar due to catchment excision has been assessed using a GoldSim® water balance model of Lake Carcoar including a rainfall-runoff model (AWBM, refer Section 3.2.2.1) for simulation of inflows[10].

As part of submissions received regarding the EIS, DPIE – Water requested additional information and modelling to improve the understanding of the likely reductions in storage volumes and reliability of supply from Carcoar Dam. Output from the EIS AWBM was provided to DPIE for review and consultation undertaken[11]. DPIE in turn provided additional guidance on modelling as well as data records of historical storage levels and release volumes. These were incorporated in updated modelling described below. DPIE – Water also requested the conduct of model sensitivity analyses which are described below.

The rainfall-runoff component of the Lake Carcoar water balance model was initially calibrated by reviewing the available surface water flow data (refer Section 2.3), taking the longest continuous data set for the Belubula River at Upstream Blayney station (GS 412104) and adjusting model parameters until a good fit was obtained. The resulting flow duration curve from the AWBM compared to the recorded flow duration curve for GS 412104 is provided in Figure 34. The linear correlation coefficient for the AWBM to recorded flow duration curve is 0.99 and hence is considered a good fit. This component of the modelling was unchanged from the EIS (no additional river flow data were available).

[10] Inflows were simulated using a single set of daily rainfall data for the catchment centroid – obtained from the SILO Data Drill (2020). Pan evaporation data for Lake Carcoar were also obtained from this source.

[11] Via video conference 14 April 2020.

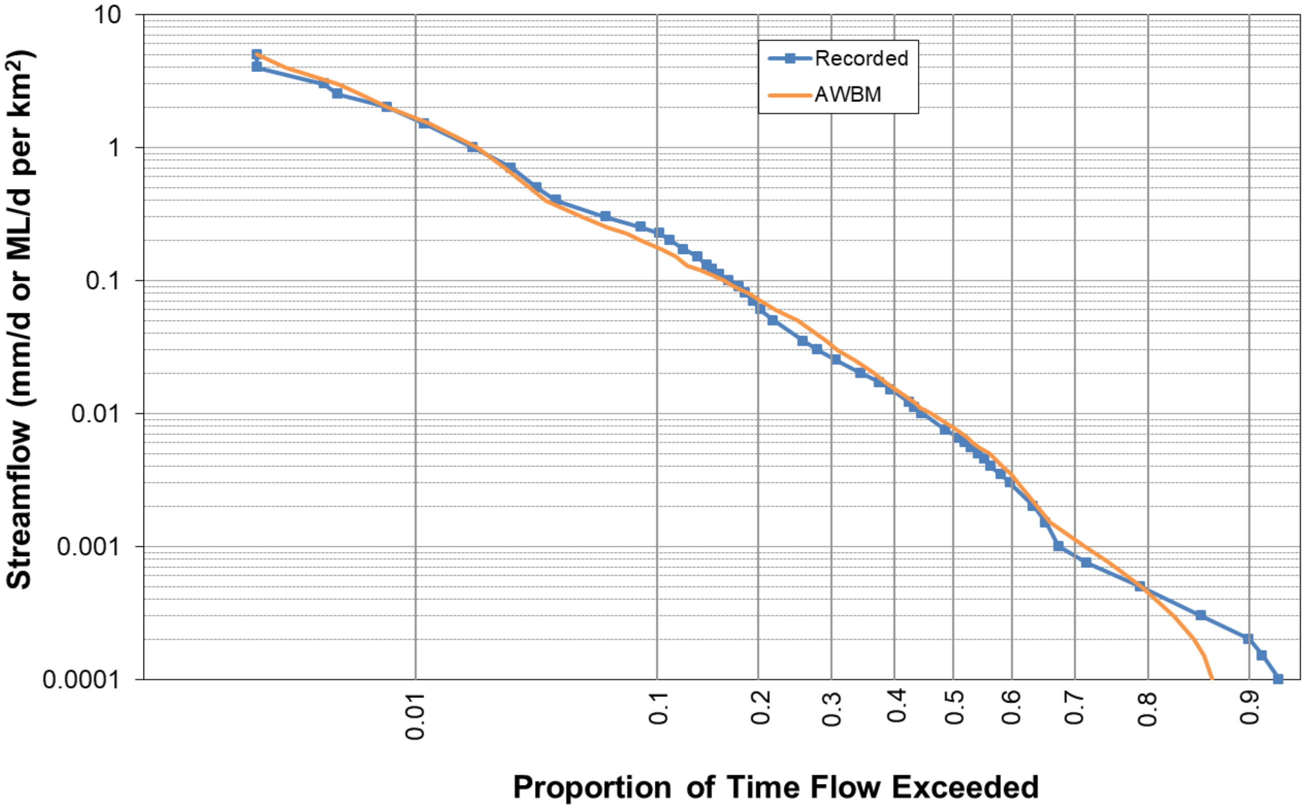


Figure 34 Flow Duration Curve Comparison at GS 412104: Recorded vs. AWBM

The calibrated AWBM runoff parameters for GS 412104 were then entered into the GoldSim water balance model and the simulation run to compare the modelled stored water volume in Lake Carcoar to the recorded stored water volume in Lake Carcoar. Model parameters were then adjusted to improve the match between modelled and recorded stored water volume. As requested by DPIE – Water, there was an emphasis on improving the modelled match during periods of low reservoir volume and recession. The period for this stored water volume calibration was limited by the extent of available dam release data[12] which spanned 1985 to 2020. Key model refinements included:

- implementation of flow 'routing' or attenuation of peak flow produced by the AWBM;
- increasing the surface storage capacity of the AWBM which reduces the volume of flow in response to rainfall.

Results showing the comparison between the recorded and modelled stored water volumes in Lake Carcoar during this period are shown in Figure 35 – this also shows modelled stored water volumes using the model parameters used for the EIS surface water assessment (unadjusted from the GS 412104 model parameters). The linear correlation coefficient for the recorded to revised modelled stored water volume is 0.94 and hence is considered a good fit. This is particularly evident in the model fit for the period of low volumes from 2003 to 2010 and in the recession which occurred in 2018 to 2020.

[12] Data provided by DPIE and included the use of recorded daily flow at GS 412077 (Belubula River at Carcoar) for periods when release data was missing.

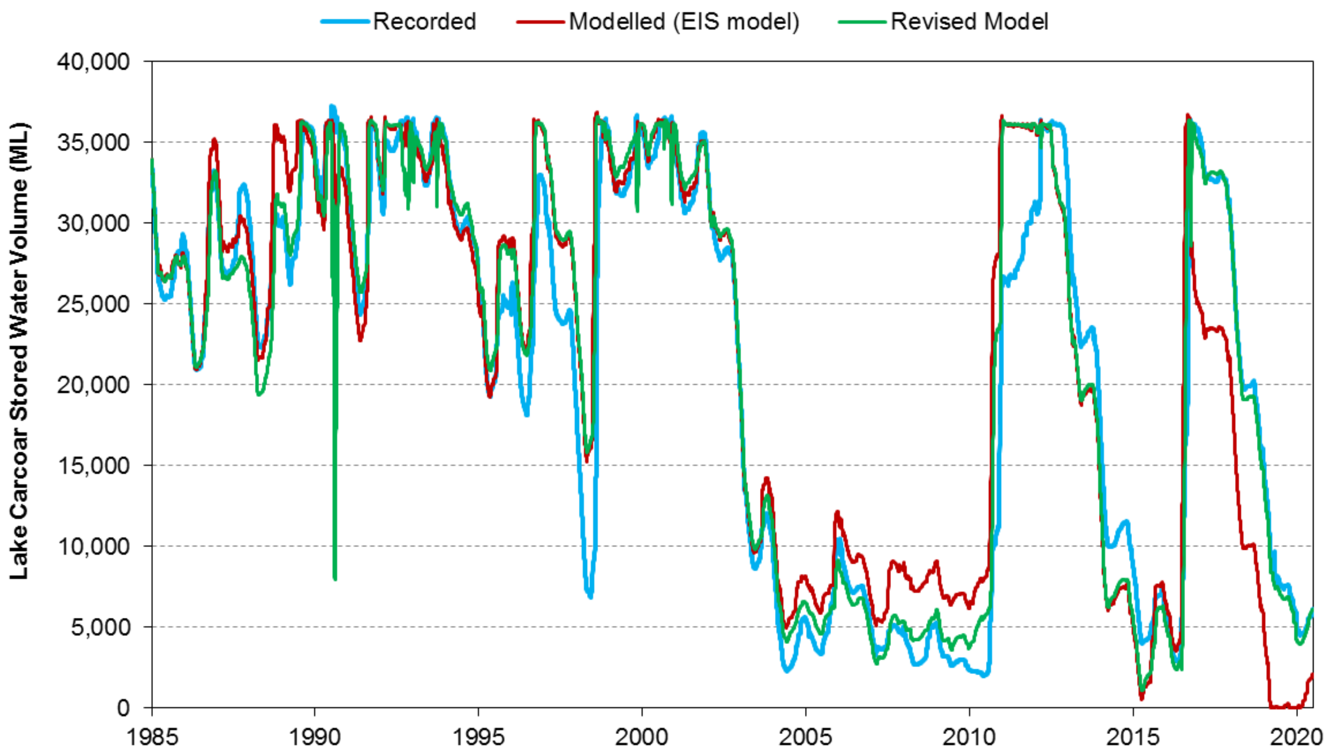


Figure 35 Comparison of Recorded and Modelled Stored Water Volume in Lake Carcoar

The good calibration between recorded and modelled stored water volumes in Lake Carcoar confirms that the model provides a reasonable fit for longer term simulation. The model is considered fit for purpose for assessing the potential effects of the project on inflows to Lake Carcoar.

The revised Lake Carcoar GoldSim water balance model was then run using the full period of available historical daily climatic data from 1889-2020 (refer Section 3.2.1) to obtain a series of annual total inflows to Lake Carcoar. The total annual flow for each of the 131 complete years of data was ranked and, using methods in IEAust (1998), assigned annual exceedance probability values. The same model was then run with the maximum catchment area captured by the project (964 ha, i.e. 4.1% of the total Lake Carcoar catchment) excised with the same probability total annual flows generated. A comparison of the modelled “existing” and “with project” total annual inflows to Lake Carcoar are summarised in Table 23. For comparison, results from the modelling reported in Appendix J of the McPhillamys Gold Project EIS are also tabulated.

Table 23 Modelled Inflow to Lake Carcoar for Streamflow Impact from Catchment Excision

Percentage of Time Flow is Greater Than the Modelled Inflow	Existing Modelled Inflow (ML/year)		With Project Modelled Inflow (ML/year)		Decreased Modelled Inflow Due to Maximum Project Extent (ML/year)	
	Revised Model	EIS Model	Revised Model	EIS Model	Revised Model	EIS Model
95%	1,574	1,463	1,509	1,402	65	61
90%	2,014	1,941	1,930	1,861	83	80
80%	2,554	2,408	2,448	2,308	106	100
70%	3,058	3,056	2,932	2,929	127	127
60%	3,628	3,645	3,478	3,494	150	151
50%	4,485	5,836	4,299	5,594	186	242
40%	6,236	7,917	5,978	7,590	258	327
30%	12,317	13,975	11,807	13,397	510	578
20%	22,646	24,995	21,709	23,961	937	1,034
10%	36,156	42,296	34,660	40,546	1,496	1,750
5%	56,104	57,984	53,782	55,585	2,322	2,399

Table 23 shows that the existing modelled inflow to Lake Carcoar is 4,485 ML/year or higher 50% of the time (compared with 5,836 ML/year in the EIS model). With the excision of the 964 ha of catchment captured by the operational water management system, the existing modelled inflow to Lake Carcoar that occurs 50% of the time reduces by 186 ML/year to 4,299 ML/year or higher (compared with 5,594 ML/year in the EIS model with a reduction of 242 ML/year). This is a 4.1% reduction in median annual inflow to Lake Carcoar. This level of change is expected to be imperceptible in comparison with the natural variability in catchment conditions.

The percentage reduction in flow increases if the streamflow assessment location is moved upstream from the total Lake Carcoar inflow point. For example, the percentage reduction in median annual flow at the Belubula River at the Upstream Blayney gauging station (GS 412104, refer Figure 3) is 8.7% and at the Regis Belubula Downstream gauging station (refer Figure 3) it is 22.2%. At upstream locations, the degree of flow routing was reduced from that modelled at Lake Carcoar, consistent with hydrologic principles.

Table 25 provides a summary of modelled streamflow impacts to the Belubula River at three different locations: Lake Carcoar, Mid-Western Highway and the downstream Belubula River gauging station. For comparison, results from the modelling reported in Appendix J of the McPhillamys Gold Project EIS are also tabulated. The results shown in Table 25 are focussed on the lower, median and higher modelled flows. EIS modelling indicated that, regardless of the locations, decreased modelled flow due to the maximum project extent remained consistent for various statistical percentages of time. This has now changed due to the implementation of varying degrees of flow routing along the river – for example the median annual flow reduction increases slightly from 186 ML at the inflow to Lake Carcoar, to 190 ML at the Mid-Western Highway and 193 ML at the downstream Belubula River gauging station. Nevertheless, revised model results predict lower flow reductions than the EIS model.

Table 24 Modelled Streamflow Impact from Catchment Excision at Various Locations

Location	Percentage of Time Flow is Greater Than the Modelled Flow	Existing Modelled Flow (ML/year)		With Project Modelled Flow (ML/year)		Decreased Modelled Flow Due to Maximum Project Extent (ML/year)	
		Revised Model	EIS Model	Revised Model	EIS Model	Revised Model	EIS Model
Inflow to Lake Carcoar	95%	1,574	1,463	1,509	1,402	65	61
	90%	2,014	1,941	1,930	1,861	83	80
	50%	4,485	5,836	4,299	5,594	186	242
	10%	36,156	42,296	34,660	40,546	1,496	1,750
	5%	56,104	57,984	53,782	55,585	2,322	2,399
At Mid-Western Highway	95%	764	697	697	636	66	61
	90%	1,001	924	914	844	87	80
	50%	2,193	2,792	2,003	2,550	190	242
	10%	17,289	20,153	15,788	18,403	1,501	1,750
	5%	26,714	27,635	24,394	25,236	2,320	2,399
At Downstream Belubula River Gauging Station	95%	300	273	233	212	66	61
	90%	388	362	302	282	86	80
	50%	869	1,093	676	851	193	242
	10%	7,047	7,893	5,485	6,143	1,562	1,750
	5%	10,467	10,824	8,146	8,425	2,321	2,399

Currently, annual inflows to Lake Carcoar are estimated to be at least 1,574 ML/year 95% of the time. This percentage value (95% of the time, flows are predicted to be greater than the modelled flow) can be used to represent streamflow during low rainfall years. At maximum disturbance, the project is predicted to reduce streamflow during these low rainfall years to Lake Carcoar by 65 ML/year, with modelled inflows reducing to 1,509 ML/year (compared to existing conditions). The 65 ML/year reduction does not differ substantially from the EIS model prediction of 61 ML/year.

Currently, annual inflows to Lake Carcoar are estimated to be at least 56,104 ML/year 5% of the time. This percentage value (5% of the time, flows are predicted to be greater than the modelled flow) can be used to represent streamflow during high rainfall years. At maximum disturbance, the project is predicted to reduce streamflow during these high rainfall years to Lake Carcoar by 2,322 ML/year, with modelled inflows reducing to 53,782 ML/year (compared to existing conditions). The 2,322 ML/year reduction is slightly less that the EIS model prediction of 2,399 ML/year.

It should be noted that the results presented above, only apply in the short term at the maximum disturbance of the project and in the long term, following rehabilitation, the area excised from the Lake Carcoar catchment would reduce – refer Section 4.2.1. It should also be noted that the above tabulated reductions due to catchment excision would be in addition to groundwater-induced losses which are predicted by groundwater modelling (EMM, 2020d) to peak at 38 ML/year. The median predicted Lake Carcoar inflow reduction therefore totals 224 ML/year.

4.1.1.3 Sensitivity Analysis

As requested by DPIE – Water, a sensitivity analysis has been undertaken to assess the effect that changes to the rainfall runoff model (AWBM) parameters would have on predicted inflows to Lake Carcoar. As agreed with DPIE – Water, AWBM surface store capacities were varied by +/- 20% to simulate lower and higher runoff rates. Sensitivity modelling results are summarised in Table 23.

Table 25 Modelled Inflow to Lake Carcoar for Streamflow Impact from Catchment Excision – Sensitivity Analyses

Percentage of Time Flow is Greater Than the Modelled Inflow	Existing Modelled Inflow (ML/year)			With Project Modelled Inflow (ML/year)			Decreased Modelled Inflow Due to Maximum Project Extent (ML/year)		
	Higher Runoff	Base Case	Lower Runoff	Higher Runoff	Base Case	Lower Runoff	Higher Runoff	Base Case	Lower Runoff
95%	1,775	1,574	1,394	1,702	1,509	1,336	73	65	58
90%	2,242	2,014	1,832	2,149	1,930	1,756	93	83	76
80%	2,765	2,554	2,366	2,651	2,448	2,268	114	106	98
70%	3,515	3,058	2,835	3,370	2,932	2,718	145	127	117
60%	4,971	3,628	3,215	4,765	3,478	3,082	206	150	133
50%	7,412	4,485	3,544	7,106	4,299	3,398	307	186	147
40%	12,412	6,236	4,286	11,899	5,978	4,109	514	258	177
30%	18,030	10,436	6,151	17,284	10,004	5,896	746	432	255
20%	19,895	12,317	7,031	19,072	11,807	6,740	823	510	291
10%	30,269	22,646	16,027	29,016	21,709	15,364	1,253	937	663
5%	43,768	36,156	28,579	41,957	34,660	27,396	1,811	1,496	1,183

Significant changes in modelled inflows are apparent from Table 23 when the modelled AWBM surface store capacities are varied by +/- 20%. The effect of such changes in surface store capacities on the modelled versus recorded Lake Carcoar volumes is illustrated in Figure 36. It may be seen from Figure 36 that adjusting AWBM surface store capacities by +/- 20% significantly reduces model ability to accurately simulate the recorded volumes in Lake Carcoar.

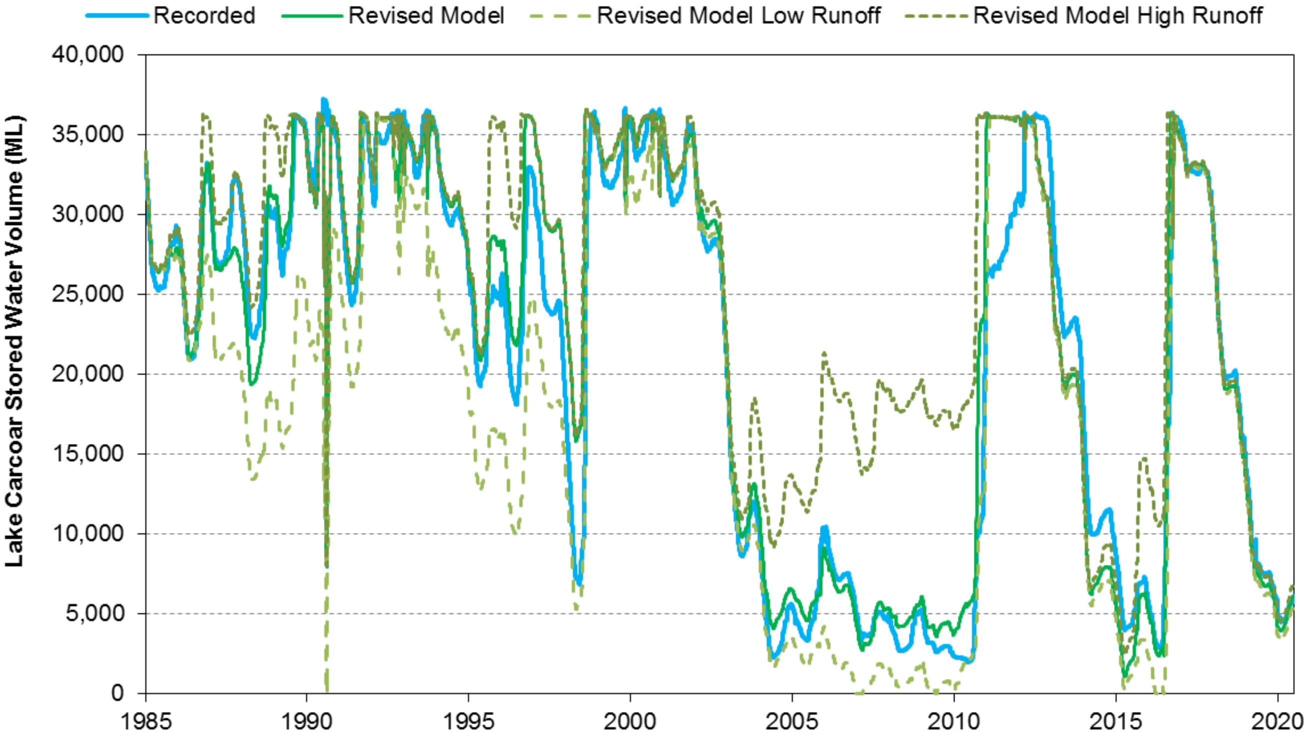


Figure 36 Comparison of Recorded and Modelled Stored Water Volume in Lake Carcoar – Sensitivity Analyses

4.1.2 Catchment Types

The modelled median annual inflow to Lake Carcoar from all existing catchments is approximately 4,480 ML. Of the inflow of 4,480 ML/year to Lake Carcoar, 4,150 ML/year originates from the catchments downstream of the mine project area. Only an estimated 330 ML/year of the 4,480 ML/year total existing inflow to Lake Carcoar originates from the catchments within, or upstream of, the mine project area. This compares with an estimated 440 ML/year reported in the Appendix J of the McPhillamys Gold Project EIS. The lower estimated yield from the revised model is predominantly due to model recalibration as described in Section 4.1.1.2.

Table 26 presents the calculated catchment type areas and the modelled median annual flow to Lake Carcoar reduction attributable to each catchment type associated with the project. In the first column of Table 26 the catchment type is described as either "undisturbed" or "disturbed". This description denotes whether the catchment area will be the subject of mining operations (i.e. disturbed and captured within the operational system), or not disturbed by mining operations (i.e. undisturbed and diverted around the mine project area). . For comparison, results from the modelling reported in the EIS are also tabulated.

Table 26 Catchment Calculations

Catchment Type	Catchment Area (ha)		Predicted Annual Reduction in Median Flow (ML/year)	
	Amended Project	EIS	Amended Project & Revised Model	EIS Model
Undisturbed	751	793	144	198
Disturbed	964	964	186	242

Note that while Table 26 shows a modelled median annual flow reduction of 144 ML/year attributable to "undisturbed" catchment, the Project's proposed clean water system is estimated to divert this water from undisturbed catchments around the mine project area and into the Belubula River, which reports to Lake Carcoar. As such, the estimated net reduction in median annual flow would be 186 ML/year. This compares with 242 ML/year reported in the EIS. This number has reduced predominantly as a result of model recalibration as described in Section 4.1.1.2.

4.1.3 Flooding

As noted in Section 3.5.1, the mine development will capture runoff from disturbed areas which will result in a reduction in catchment area reporting downstream hence the impact on flooding to downstream floodwaters would be a reduction in peak flow downstream of the mine project area.

As the mine project area is located in the headwaters of the catchment, localised flooding impacts would be confined to land owned by Regis. The proposed clean water diversion dams are the most notable area where inundation of land will temporarily occur during the operational phase of the mine development, although only for short durations due to the adopted high pumped dewatering rates (refer Table 15 and Attachment C). There is no significant change as a result of the amended project in this regard.

4.1.4 Water Quality

Potential impacts on surface water quality downstream of the mine project area along with proposed mitigation methods are summarised in Table 27. These measures would be included in a project water management plan ahead of construction. The risk of spill from the operational water management system has been reduced compared with the EIS. Release of water from the operational water system is not planned. Otherwise there is no significant change as a result of the amended project in this regard.

4.1.5 Cumulative Impacts

Cumulative impacts have been described in a mining context by Franks, et al. (2010) as:

> *"…arise from compounding activities of a single operation or multiple mining and processing operations, as well as the aggregation and interaction of mining impacts with other past, current and future activities that may not be related to mining."*

In the context of surface water resources potentially impacted by the mining development there has been significant past development in the upstream, immediate and downstream catchment areas since European settlement, including widespread agricultural development, historical mining operations and urbanisation. There has also been significant development of the surface water resources themselves including regulation and extraction of water from local and regional surface water resources (i.e. Carcoar Dam).

There are no other mining developments located in the Carcoar Dam catchment hence there are no cumulative mining impacts expected during operations.

The effects of past development are inevitably incorporated into the baseline descriptions of surface water resources developed for the mining development which are based on contemporary monitoring. There is no significant change as a result of the amended project in this regard.

Table 27 Summary of Potential Risks to Surface Water Quality During Operations and Proposed Mitigation Methods

Risk	Proposed Mitigation Method
Accidental spill of hazardous materials contained on site (i.e. fuel, reagent, ore stockpiles, tailings).	Dedicated storage areas for fuel and reagent and runoff containment systems for ore stockpiles would be developed during the construction phase and maintained over the operational period while potential pollutants remain on site. The tailings pipeline would remain wholly within the operational water management system (refer ATCW, 2020) with localised bunds proposed to confine risk areas.
Spill from the operational water management system containing environmentally significant contaminants.	Water management facilities within the operational water management system have been designed to not spill under all historical climate scenarios (refer Section 3.2.3.6).
Un-intercepted runoff from areas requiring erosion and sediment control treatment prior to flowing off site (i.e. soil stockpiles).	Erosion and sediment controls would be designed in accordance with Landcom (2004) and DECC (2008) guidelines (refer Section 3.1.3).
Erosion/sediment migration associated with pumped diversions.	Engineered stilling basin and erosion protection would be constructed at diversion outfall. Upstream face of the CWF confining embankments would be stabilised upon construction.
Un-intercepted seepage from the TSF	A seepage management system has been designed for the TSF in accordance with leading practice (refer ATCW. 2020). Groundwater monitoring bores will be installed around the TSF to monitor for early warning of potential seepage from the TSF. Seepage interception bores will be located downstream of the groundwater monitoring bores to intercept any potential seepage before it progresses into the catchment (i.e. downstream towards the Belubula River). Further details are contained in EMM (2020b) and EMM (2020d). Seepage monitoring and management measures will be documented in the water management plans for the project.
Un-intercepted seepage from the waste rock emplacement	The waste rock emplacement foundation will be stripped and conditioned prior to beginning waste rock placement, thereby reducing the potential for seepage through the underlying lithology. The waste rock emplacement has been designed to ensure potentially acid forming materials are only exposed for short periods of time before being capped with non-acid forming materials. Water management facilities capturing surface runoff from the waste rock emplacement are positioned downslope and would feature excavated basins engineered to capture any seepage reporting to the toe of the emplacement for recirculation in the operational water management system. Seepage monitoring and management measures will be documented in the waste management plan and water management plans for the project.

4.2 POST CLOSURE PHASE

4.2.1 Streamflow and Inflows to Lake Carcoar

Groundwater modelling (EMM, 2020d) predicts flow to the Belubula River upstream of Trib A (which is currently predicted to contribute approximately 5% of overall surface flows) to reduce by up to 0.058 ML/d and up to 0.055 ML/d in Trib A. There is no predicted impact to baseflow downstream of the confluence with Trib A (EMM, 2020d). The predicted peak groundwater-induced total flow reduction post closure therefore totals 41 ML/year.

The potential impact on inflows to Lake Carcoar due to catchment excision following mine closure has been assessed using the water balance model detailed in Section 4.1.1. As specified in Section 3.4, the catchment area captured by the mine project area post closure and rehabilitation (i.e. reporting to the final void) is 107 ha. The model was run with the catchment area captured by the mine project area post closure (107 ha, i.e. 0.46% of the total Lake Carcoar catchment) excised. A comparison of the modelled "existing" and "post closure" total annual inflows to Lake Carcoar are summarised in Table 28. For comparison, results from the EIS modelling are also tabulated.

Table 28 Modelled Inflow to Lake Carcoar for Streamflow Impact Post Closure

Percentage of Time Flow is Greater Than the Modelled Inflow	Existing Modelled Inflow (ML/year)		Post Closure Modelled Inflow (ML/year)		Decreased Modelled Inflow Post Closure (ML/year)	
	Revised Model	EIS Model	Revised Model	EIS Model	Revised Model	EIS Model
95%	1,574	1,463	1,566	1,456	7	7
90%	2,014	1,941	2,005	1,932	9	9
80%	2,554	2,408	2,542	2,397	12	11
70%	3,058	3,056	3,044	3,042	14	14
60%	3,628	3,645	3,612	3,628	17	17
50%	4,485	5,836	4,464	5,809	21	28
40%	6,236	7,917	6,208	7,879	29	37
30%	12,317	13,975	12,260	13,909	57	66
20%	22,646	24,995	22,542	24,877	104	118
10%	36,156	42,296	35,990	42,096	166	200
5%	56,104	57,984	55,846	57,710	258	274

Table 28 shows that, with the excision of the 107 ha of catchment captured by the final void, the existing modelled inflow to Lake Carcoar that occurs 50% of the time reduces by 21 ML/year to 4,464 ML/year or higher (this compares with a predicted 28 ML/year reduction for the EIS model). This is a 0.46% reduction in median annual inflow to Lake Carcoar. A 0.46% reduction applies across the entire flow regime given in Table 28 and therefore this represents the predicted reduction in total inflow to Lake Carcoar post closure. This level of change is expected to be imperceptible in comparison with the natural variability in catchment conditions.

The percentage reduction in flow increases if the streamflow assessment location is moved upstream from the total Lake Carcoar inflow point. For example, the percentage reduction in median annual flow at the Belubula River at the Upstream Blayney gauging station (GS 412104, refer Figure 4) is 1.0% and at the Regis Belubula Downstream gauging station (refer Figure 3) it is 2.5%.

It should be noted that the above tabulated reductions due to catchment excision would be in addition to groundwater-induced losses which are predicted by groundwater modelling (EMM, 2020d) to peak at 41 ML/year. The median peak predicted Lake Carcoar inflow reduction therefore totals 62 ML/year.

4.2.2 Final Void Catchment Area

The catchment area reporting to the final void post closure has been calculated as 107 ha. This is 3 ha less than the final void catchment area reported in Appendix J of the McPhillamys Gold Project EIS. When this area is excised from the catchment reporting to Lake Carcoar, the existing modelled median inflow to Lake Carcoar reduces by 21 ML/year to 4,464 ML/year. This compares with a 28 ML/year reduction to 5,809 ML/year reported in the EIS. The lower reduction is due to the lower void catchment area and the lower modelled catchment yield as a result of model recalibration as described in Section 4.1.1.2.

4.2.3 Flooding

With reference to Section 3.5, the peak flood level for the existing catchment of the Belubula River downstream of the project area during a PMP rainfall event is estimated at 902.7 m AHD. The edge of final void nearest to the Belubula River is at 916 m AHD and hence there is negligible potential for flooding of the final void during a PMP rainfall event from the Belubula River downstream of the project area post closure. There is no significant change as a result of the amended project in this regard.

4.2.4 Water Quality

As described in Section 3.3, all mining areas, excepting the final void catchment, will be regraded to a stable landform and revegetated post closure. All disturbed areas, excepting the final void catchment, will be rehabilitated and a number of permanent clean water diversion channels will be constructed to allow a free-draining landform.

The results of the final void water balance modelling (Section 3.4) indicate that the final void would be contained, with no spills predicted. Final void salinity levels would increase slowly as a result of evapo-concentration. There is no significant change as a result of the amended project in this regard. The final void water balance, geochemical assessment and groundwater modelling will continue to be reviewed and verified as additional data becomes available and closure planning for the project will continue to be refined throughout the project life.

4.2.5 Cumulative Impacts

As indicated in Section 4.1.5, there are no other mining developments located in the Carcoar Dam catchment hence there are no cumulative mining impacts expected post closure.

5.0 RECOMMENDED ON-GOING MONITORING

5.1 BASELINE MONITORING

The current water quality monitoring program for the mine development (refer Section 2.7) will continue in order to further add to the baseline data collected and allow development of site specific trigger values. Monitoring of rainfall at the site weather station will continue and additional rainfall automatic stations have been installed within the catchments of Trib A and the upstream Belubula River. The two remaining proposed streamflow monitoring stations (refer Section 2.7.1) should be installed to collect baseline monitoring data ahead of mine development in order to be able to assess impacts during the project.

5.2 OPERATIONAL PHASE

A water management plan will be developed following approval of the project. The water management plan will document the monitoring, mitigation and management measures to be adopted during the operational phase of the project.

In addition to the baseline monitoring, the following monitoring is recommended during the operational phase:

- Streamflow: operation of the existing plus two proposed streamflow monitoring stations (refer Section 2.7.1).
- Channel Stability: bi-annual monitoring (spring and autumn) via established photo and assessment points on the Belubula River downstream of the proposed TSF Runoff WMF (to be established immediately prior to construction) at approximately 50 m intervals downstream to the confluence with Trib A. The bi-annual timing is designed to assess the potential effects of high intensity summer storms and prolonged winter rainfall periods.
- Water Quality: all streamflow monitoring stations will include continuous water quality monitoring sensors for pH, EC, temperature and turbidity (refer Section 2.7.1). Monthly monitoring of water quality for all site water storages should also be undertaken.
- Erosion and Sediment Control Structures: as noted in Section 3.1.3, routine (i.e. monthly) inspections of sediment control structures as well as inspections following rainfall events of 20 mm or more in a 24 hour period will be conducted during operations by site personnel.
- Water Inventory: monthly monitoring of the stored water volume in each storage on site including the open cut and TSF.
- Water Use, Sourcing and Pumping: Monitoring of monthly volumes of water pumped between storages in the water management system by flow meter, in particular water volumes pumped:
  - From the TSF and TSF Runoff WMF to the MWMF;
  - From the open cut to the NWMF;
  - From the SRWMF, WMF1, WMF4, WMF5 and WMF6 to the MWMF;
  - To the RWMF and CWMF from the external supply pipeline;
  - To MWMF from the RWMF;
  - To the Process Plant (from the TSF and MWMF);
  - To truckfill (from the MWMF and CWMF); and
  - To Water Treatment Plant from CWMF
- Diverted Volumes: monthly volumes of water pumped from CWF1, CWF2 and CWF3 to the Belubula River by flow meter.

5.3 POST CLOSURE PHASE

It is recommended that monitoring of streamflow, channel stability and water quality continue for two years following cessation of operations and completion of construction final clean water diversions. Monitoring data should be reviewed at annual intervals (as part of the annual review process) over this period. Reviews should involve assessment against long term performance objectives that are based on baseline conditions or a justifiable departure from these, with due allowance for climatic variations. If objectives are not substantially met within the two year period, management measures should be revised and the monitoring period extended.

5.4 POTENTIAL CONTINGENCY MEASURES

Potential contingency measures in the event of unforeseen impacts or impacts in excess of those predicted would include:

- conducting additional monitoring (e.g. increase in monitoring frequency or additional sampling locations) to inform the proposed contingency measures;
- refinements to the water management system design such as additional sedimentation dams, increases to pumping capacity, installation of new structures as required to address the identified issue;
- the implementation of stream remediation measures and possible additional controls (e.g. rock armouring) to reduce the extent and effect of erosion; and/or
- the implementation of revegetation measures in conjunction with other stabilisation techniques (as required) to remediate impacts of vegetation loss due to erosion.

6.0 SUMMARY AND CONCLUSIONS

LFB Resources NL (a 100% owned subsidiary of Regis Resources Limited) is seeking State significant development consent for the construction and operation of the McPhillamys Gold project, an open cut gold mine and water supply pipeline in the Central West of NSW. The mine development is in the upper reaches of the Belubula River catchment, within the greater Lachlan River catchment. Carcoar Dam, located on the Belubula River approximately 26 km downstream or to the south-west of the project area, is managed by WaterNSW and is used primarily for regulated releases for licensed extraction, environmental, stock and domestic purposes.

An EIS was prepared for the project and, during public exhibition, Regis received submissions from government agencies, the community, businesses and other organisations regarding varying aspects of the project. In response to issues raised in submissions received, as well as a result of further detailed mine planning and design, Regis has made a number of refinements to the project, resulting in an amended project. Refinements have included revision of the mine schedule and the subsequent construction sequence of the waste rock emplacement, changes to the TSF embankment design and construction timing, the TSF footprint and the TSF post closure landform. The key changes of the amended project water management system compared with that given in Appendix J of the McPhillamys Gold Project EIS are as follows:

- relocation of the north-eastern perimeter embankments of the TSF to the south-west, reducing the footprint of the TSF;
- removal of the Secondary MWF from the north-western margin of the mine project area (its function to be replaced by the MWMF);
- a slight reduction in the eastern extent of the waste rock emplacement, resulting in alterations to the clean and operational water systems around its eastern perimeter; and
- revision of the operational water management facilities that results in no predicted spills for the mine life.

Water will be supplied to the mine project area via a pipeline approximately 90 km long, transferring surplus water from coal mines and a power station near Lithgow. The supply of this water will enable a beneficial use of otherwise surplus water and provide a reliable water source for the mine development.

Baseline water quality data suggests that contemporary (ANZECC, 2000) default guideline trigger values are not representative of the background conditions in the mine project area. As such, site specific trigger values should be developed prior to project commencement using all available baseline data in accordance with ANZG (2018) guidelines.

The mine site is located within the *Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources* zone. The total harvestable right based on the Regis landholding area (current and proposed) is 218 ML with the remaining harvestable right, after accounting for the volume of existing farm dams, equating to 148.3 ML. The maximum undisturbed area from minor streams (i.e. first and second order) captured within the project area (based on staged development of the operational water management system) is estimated to be 135.9 ha which is within the harvestable right area by 49.2 ha or a yield (at 0.75 ML/ha per year) of 36.9 ML/year.

A water management system has been developed for the project comprising structures and associated operational procedures to manage:

- clean water (i.e. runoff from undisturbed or established rehabilitation areas);
- development/construction water (i.e. runoff from disturbed areas and unestablished rehabilitation which potentially contains elevated levels of sediment); and

- operational water (i.e. runoff from mining areas such as haul roads, the waste rock emplacement, hardstand areas and the open cut as well as imported pipeline supply water).

During mining, the majority of clean water will be diverted around the mine development via a series of diversion drains, dams, pumps and pipelines. Post mining, all catchment areas (with the exception of the final void) would be either undisturbed or would have been rehabilitated and hence would be part of the clean water system. Permanent clean water diversion channels would be constructed to allow a free-draining landform.

The development/construction water system would be in place during construction only and would be managed using erosion and sediment control measures designed in accordance with Landcom (2004) and DECC (2008). The operational water system will be comprised of a number of Water Management Facilities (WMFs), the open cut and the TSF, together with a system of pumped transfers and drains. The operational water system also includes external water supply imported to site via the imported pipeline supply.

The results of a water balance model for the operational phase of the project indicate that, on average, external supply provides the highest system inflow (52%) of the total inflow followed by runoff from the operational water management system. The majority of outflows (76%) comprise process plant supply followed by supply for truckfill (dust suppression and construction requirements). The model predictions suggest that site storages will provide sufficient storage capacity during the operational phase of the project. There are no simulated external (off-site) spills from the modelled operational water system storages during the operational life of the project.

The model predictions indicate no predicted supply shortfall due to the provision of imported pipeline supply and, in the period prior to the imported pipeline supply, supply from site groundwater bores using a portion of the 400 ML/year of groundwater licences currently owned by Regis. Model results indicate that, during periods of lower rainfall, the project would use up to approximately 4,000 ML of imported pipeline supply, which amounts to approximately 70% of the imported pipeline supply capacity, however under most circumstances, the external supply pipeline would not need to be utilised to this capacity on an annual basis. Modelling indicates that there is a low risk that mining operations would be significantly impacted by rainfall.

The implications of climate change predictions on water management are unlikely to be significant over the life of the mine development as they are fairly small compared to natural climatic variability and the relatively short duration of the mine development.

Model predictions indicate that the final void would reach an equilibrium water level more than 9 m below the spill level, with an average equilibrium level approximately 14 m below the spill level (i.e. the final void is contained). Equilibrium levels would be reached very slowly over a period of more than 500 years with final void salinity levels increasing slowly as a result of evapo-concentration.

An assessment of the flooding potential of the mine and downstream as a result of the mine development identified that:

- the mine project area is located in the headwaters of the Belubula River hence the flooding risk resulting from upstream floodwaters would be minor;
- the open cut is located no closer than 250 m from the Belubula River; and
- the mine project area will capture runoff from disturbed areas (most notably the tailings dam, waste rock emplacement area and open cut) which will result in a reduction in catchment area reporting downstream hence the impact on flooding to downstream floodwaters would be a reduction in total flow downstream of the mine project area.

There are no other mining developments located in the upstream Carcoar Dam catchment hence there are no cumulative mining impacts expected during operations or post closure.

The potential surface water impacts associated with the amended project and how these have changed from those reported in Appendix J of the McPhillamys Gold Project EIS are summarised in Table 29 below.

Table 29 Summary of Potential Surface Water Impacts of Amended Project

Potential Impact	Description (Amended Project)	Difference from EIS
Reduced streamflow in the Belubula River and hence inflows to Lake Carcoar due to flow reduction and catchment excision during project.	4.1% decreased inflows to Lake Carcoar at maximum project development: • median: 186 ML/year; • high flows (exceeded 5% of the time): 2,322 ML/year; • low flows (exceeded 95% of the time): 65 ML/year. Slight increase in median flow reduction further upstream (e.g. 193 ML/year at Belubula River gauging station).	4.1% decreased inflows to Lake Carcoar at maximum project development: • median: 242 ML/year; • high flows (exceeded 5% of the time): 2,399 ML/year; • low flows (exceeded 95% of the time): 61 ML/year. No change in flow reduction (ML/year) with distance upstream from Lake Carcoar. Change from EIS due to improved calibration of catchment model as requested and using data supplied by DPIE – Water.
Reduced streamflow in the Belubula River and hence inflows to Lake Carcoar due to flow reduction and catchment excision post closure	0.46% decreased inflows to Lake Carcoar post closure: • median: 21 ML/year; • high flows (exceeded 5% of the time): 258 ML/year; • low flows (exceeded 95% of the time): 7 ML/year.	0.46% decreased inflows to Lake Carcoar post closure: • median: 28 ML/year; • high flows (exceeded 5% of the time): 274 ML/year; • low flows (exceeded 95% of the time): 7 ML/year. Change from EIS due to improved calibration of catchment model as requested and using data supplied by DPIE – Water.
Downstream flooding.	Reduction in catchment area reporting downstream, hence reduction in peak flow downstream of the mine project area.	No significant change compared to EIS. Amended project diverted catchment totals 751 ha, while EIS diverted catchment totalled 793 ha.
Clean water diversions – upstream ponding/inundation.	Localised impacts confined to land owned by Regis. Pumping systems sized to maintain ponding below 954 m AHD in CWF1, substantially avoiding inundation of the Vittoria State Forest.	Reduced inundation compared with EIS due to slight reduction in project diverted catchment total and revised clean water system.
Downstream water quality during project.	Operational system designed to not spill under all historical climate scenarios. Clean water diversions include outfall stilling basin and stabilisation of diversion embankments.	Risk of spill from the operational water management system has been reduced compared with the EIS. Otherwise no significant change compared with EIS.

Table 29 Summary of Potential Surface Water Impacts of Amended Project (Continued)

Potential Impact	Description (Amended Project)	Difference from EIS
Downstream water quality post closure.	Final void contained with no spills predicted. Remnant final landform rehabilitated, with permanent clean water diversion channels to allow a free-draining landform.	No significant change compared with EIS.
Cumulative impacts.	No other mining developments located in the Carcoar Dam catchment hence no cumulative mining impacts expected.	No change compared with EIS.

Mitigation measures have been proposed to manage potential impacts on surface water quality downstream of the mine during construction and operations. A detailed monitoring program has been developed for the project comprising baseline monitoring, operational monitoring and post closure monitoring. The water quality monitoring program for the mine project area will be continued through the operational phase with additional streamflow, channel stability, water quality, erosion and sediment control and water inventory and water use, sourcing and pumping monitoring proposed. Monitoring of streamflow, channel stability and water quality is recommended to continue for two years following cessation of operations.

The performance of the water management system should be reviewed at least annually using the monitored data in combination with the site water balance model to identify changes in the system and compare against predictions. In the event of unforeseen impacts or impacts in excess of those predicted, contingency measures have been proposed.

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ATTACHMENT A Surface Water Quality Plots

Notes regarding the following plots:

- *Where the values recorded were less than the laboratory limit of detection, the value has been plotted at the limit of detection.*
- *"ANZECC" = ANZECC (2000a) default guideline trigger value.*

ATTACHMENT B Geomorphology Ground Reconnaissance

ATTACHMENT C Simulated Water Levels for Clean Water Diversion Dams

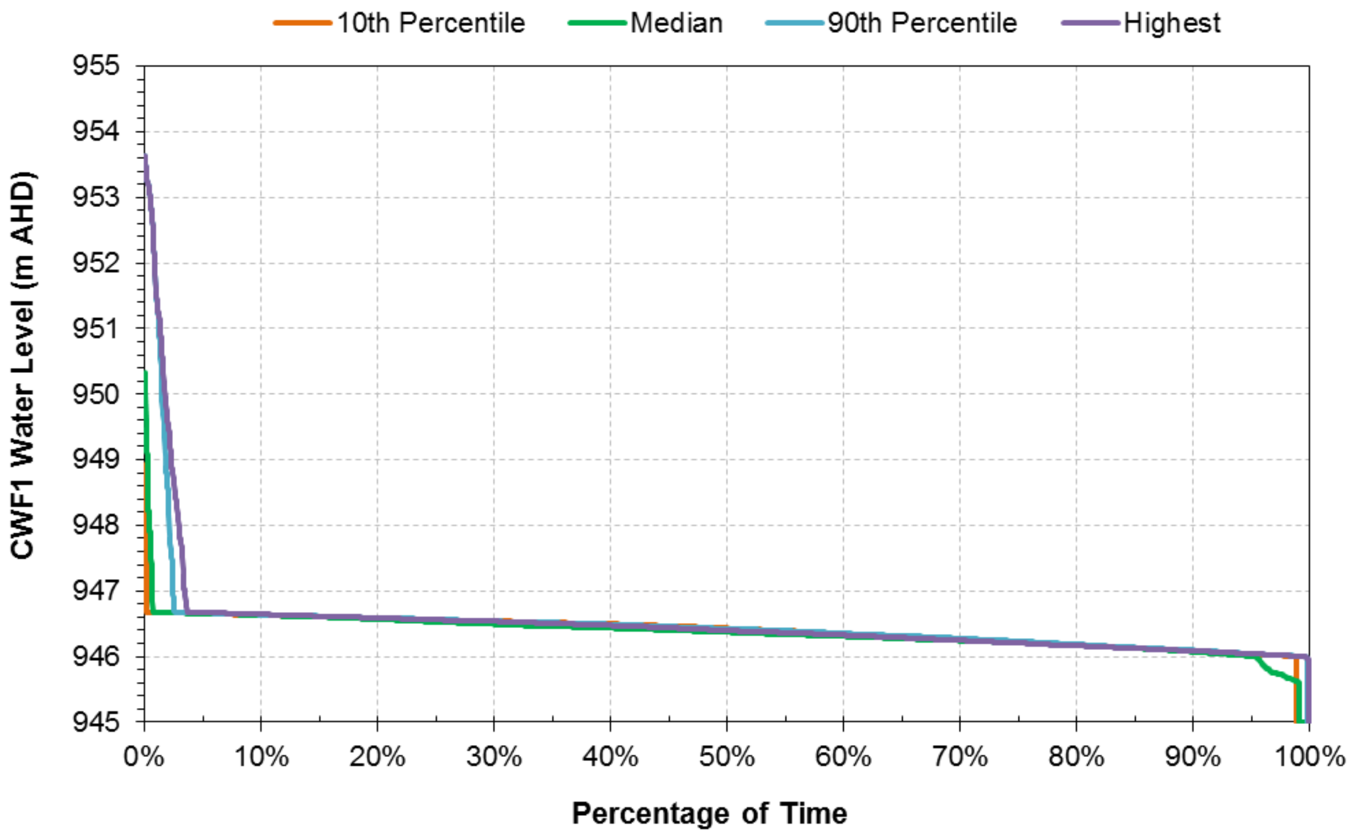

Figure C1 Frequency of Simulated Stored Water Levels in CWF1

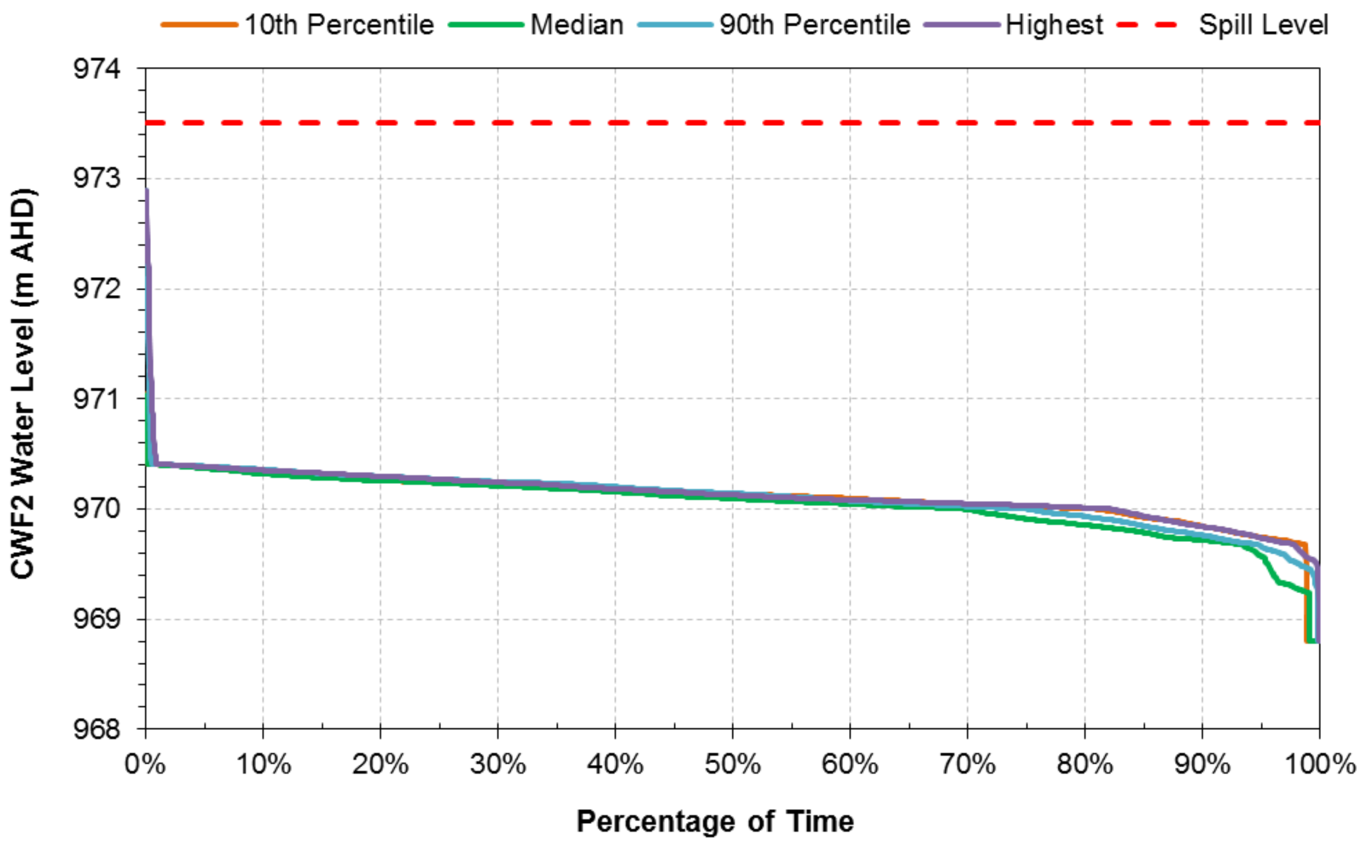

Figure C2 Frequency of Simulated Stored Water Levels in CWF2

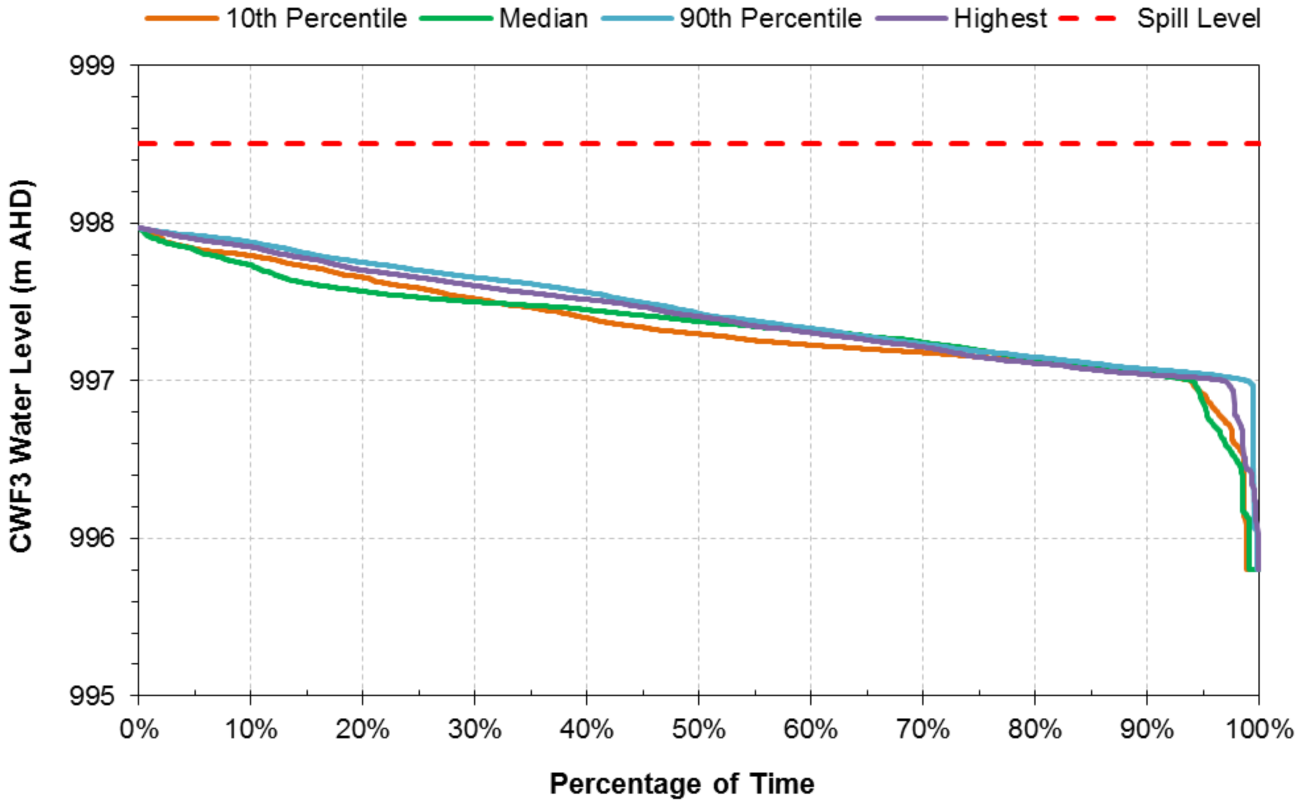

Figure C3 Frequency of Simulated Stored Water Levels in CWF3