Appendix J

Mine development surface water assessment

HYDRO ENGINEERING & CONSULTING PTY LTD

REPORT

McPhillamys Gold Project
Mine Development
Surface Water Assessment

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i	Final Revision	DNB	Client	TSM	27/8/2019

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1.0 INTRODUCTION

1.1 BACKGROUND

Hydro Engineering & Consulting Pty Ltd (HEC) has been engaged by EMM Consulting (EMM) on behalf of LFB Resources NL, a 100% owned subsidiary of Regis Resources Limited (herein referred to as Regis) to complete a Surface Water Assessment (SWA) for the McPhillamys Gold Project mine development.

Regis is seeking development consent for the construction and operation of the McPhillamys Gold Project (the proposal), a greenfield open cut gold mine and water supply pipeline in the Central West of New South Wales (NSW). The proposal application area is illustrated at a regional scale in Figure 1. The mine development component of the Proposal is located approximately 8 kilometres (km) north-east of Blayney within the Blayney and Cabonne local government areas (LGAs). This locality has a long history of alluvial and hard rock mining, with exploration for gold and base metals occurring since the mid to late 19th century. The mine development boundary (herein referred to as the project area) is illustrated in Figure 1 and covers the Mining Lease application area for the mine development as well as the parts of the mine development that do not require a Mining Lease.

The mine development is in the upper reaches of the Belubula River catchment, within the greater Lachlan River catchment. The Lachlan River is one of the major tributaries within the Murray-Darling Basin, with a catchment area of approximately 85,000 square kilometres (km^2). Water will be supplied to the mine via a pipeline approximately 90 km long, transferring surplus water from the Centennial Coal Company Limited managed Angus Place Colliery (Angus Place), Springvale Coal Services Operations (SCSO) and Energy Australia's (EA) Mt Piper Power Station (MPPS) near Lithgow. The supply of water from Angus Place, SCSO and MPPS will enable a beneficial use of otherwise surplus water and provide a reliable water source for the mine development.

1.2 OVERVIEW OF THE MINE DEVELOPMENT

The key components of the Proposal are as follows:

- A project life of 15 years comprising:
  - Construction: around one to two years, including pre-construction activities;
  - Mine operating life: around 10 years of ore extraction and processing;
  - Rehabilitation: will progress during operations and will extend around three to four years after the end of mining and processing, after which environmental monitoring will continue until lease relinquishment in accordance with the relevant approval conditions.

  There will be some overlap of these phases.
- A single, approximately circular open cut with a diameter of approximately 1,050 metres and a final depth of approximately 460 metres will be developed by conventional open cut mining encompassing drill, blast, load and haul operations. Up to 8.5 million tonnes per annum (Mtpa) of ore will be extracted during the project life.
- Construction and use of a conventional carbon-in-leach processing facility with an approximate processing rate of 7 Mtpa to produce approximately 200,000 ounces, and up to 250,000 ounces, per annum of product gold. The processing facility will comprise a run-of-mine (ROM) pad and crushing, grinding, gravity, leaching, gold recovery, tailings thickening and cyanide destruction. Product gold will be taken off-site to customers via road transport.
- A waste rock emplacement will be developed in the south-eastern portion of the mine project area up to an approximate height of 1,060 m AHD to accommodate overburden material from

the open cut mine. The emplacement has also been designed to encapsulate potentially acid forming material (PAF) from the open cut.

- The southern portion of the waste rock emplacement (southern amenity bund) and the pit amenity bund will be constructed and rehabilitated in the early years of the mine development to provide noise and visual bunds for the remainder of operations.
- An engineered Tailings Storage Facility (TSF) will be progressively developed in the north-eastern portion of the project area.
- Construction and operation of ancillary infrastructure including:
  - administration buildings;
  - workshops and stores facilities; including associated plant parking, laydown and hardstand areas;
  - internal road network;
  - explosives magazine; and
  - on-site laboratory.
- The project area will be accessed via a new intersection off the Mid-Western Highway, which will be constructed during the initial construction phase of the project. Existing property access from Dungeon Road will also be used until construction of the new access.
- Regarding water management, the mine development is proposed to be a nil discharge site. The water management system will divert clean water around the mine site and control the volume of water from disturbed areas by maximising its reuse on site. The water management system will comprise clean water management facilities including piped diversions, water management facilities for operational water (including the raw water storage) and development and construction water management facilities.
- Regarding water supply, a pipeline approximately 90 km in length will transfer water from Centennial's Angus Place, SCSO and EA's MPPS operations near Lithgow to the project. The pipeline will deliver approximately 13 ML per day (up to a maximum of 15.6 ML per day) to the project.
- Environmental management and monitoring equipment.
- Rehabilitation will occur progressively throughout the project life. At the end of mining and processing, all infrastructure will be removed from the project area and all disturbed areas will be rehabilitated to integrate with natural landforms as far as practicable.

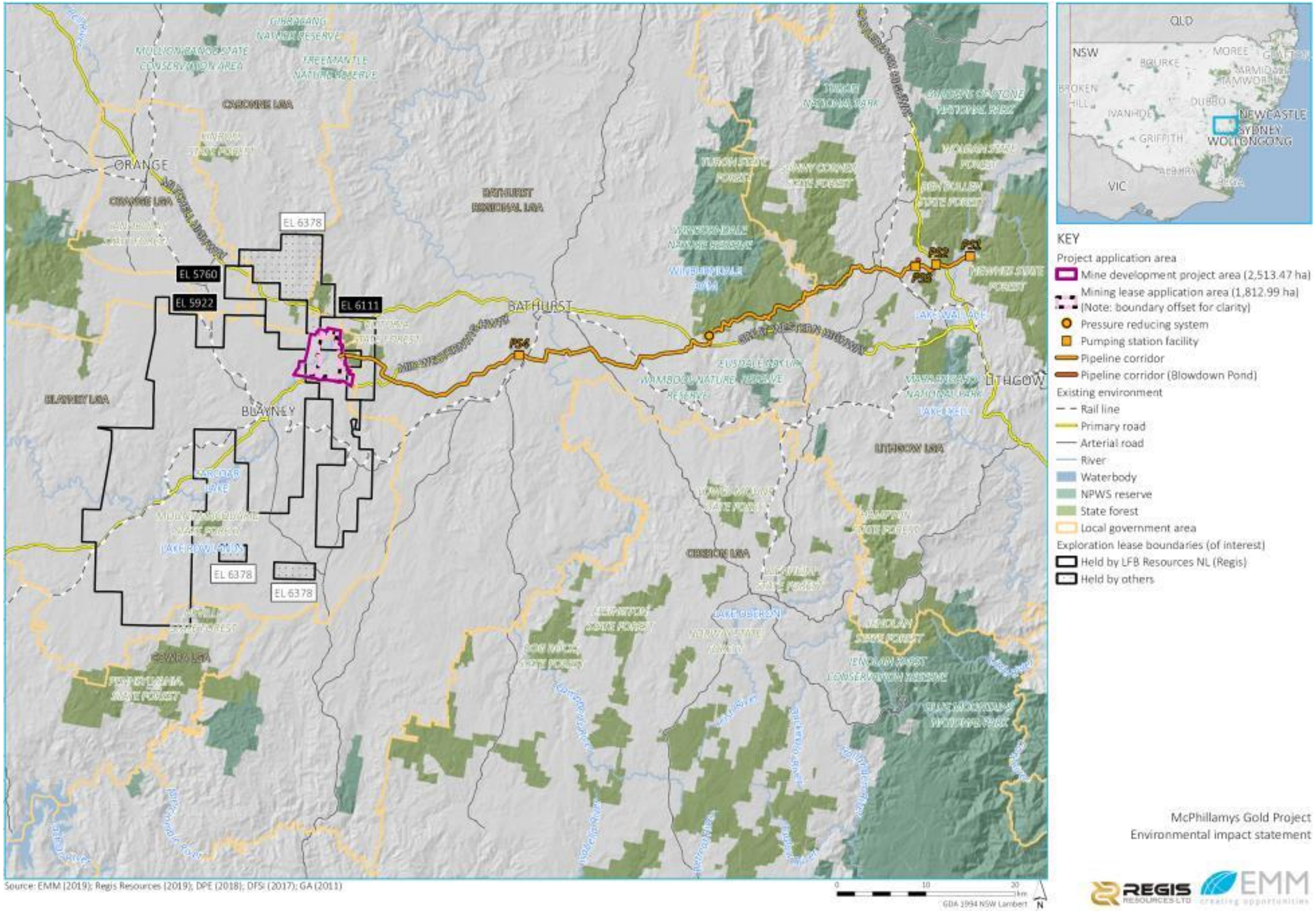

Figure 1 Site Locality

1.3 PURPOSE OF REPORT

This SWA assesses likely impacts of the mine development on surface water resources both within and downstream of the project 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 project 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 required surface water licencing with respect to the 'take' of surface water from the Belubula River above Carcoar Dam water source has also been addressed.

1.4 STUDY REQUIREMENTS

1.4.1 Environmental Assessment Requirements

The SWA is guided by the Environmental Assessment Requirements (EARs) issued by the Department of Planning and Environment on 24 July 2018 and revised on 19 December 2018 for SSD 18_9505 (the project). The requirements relating to water are outlined in Table 1, including where they have been addressed for surface water – for groundwater refer to the Groundwater Assessment also prepared as part of the Environmental Impact Statement (EMM, 2019c). Detailed agency requests/comments have also been addressed in this and other specialists' reports including those from the Department of Industry Crown Lands and Water Division (DoI Water), Cabonne Council, NSW Environment Protection Authority (EPA), NSW Office of Environment & Heritage (OEH) and NSW transport - Roads and Maritime Services.

Table 1 Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
Planning and Environment (General Requirements)	In particular, the EIS must include: … • a full description of the development, including:	 Section 1.2
	… • a water management strategy	Section 3.0
	… • the likely interactions between the development and any other existing approved or proposed mining related development in the vicinity of the sites.	Section 4.1.5 & Section 4.2.5
	• an assessment of the likely impacts of the development on the environment, focusing on the specific issues identified below, including:	
	• a description of the existing environment likely to be affected by the development, using sufficient baseline data;	Section 2.0
	• an assessment of the potential impacts of all stages of the development, including any cumulative impacts, taking into consideration relevant laws, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Section 4.0

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
Planning and Environment (General Requirements)	• a description of the measures that would be implemented to avoid, mitigate and/or offset the impacts of the development, and an assessment of:	Section 4.0
	• whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented;	Section 4.0
	• the likely effectiveness of these measures;	Section 4.0
	• whether contingency plans would be necessary to manage any residual risks;	Section 4.0
	• a description of the measures that would be implemented to monitor and report on the environmental performance of the development; and	Section 5.0
	• a consolidated summary of all the proposed environmental management and monitoring measures, identifying all the commitments in the EIS;	Section 5.0
Planning and Environment (Key Issues - Water)	The EIS must address the following specific issues: … • Water – including:	
	• an assessment of the likely impacts of the development on the quantity and quality of surface, and groundwater, having regard to the NSW Aquifer Interference Policy;	Section 4.0 Refer Groundwater Assessment (EMM, 2019c)
	• an assessment of the hydrological characteristics of the site and downstream;	Section 2.0
	• an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and systems and other water users including impacts to water supply from Carcoar Dam, riparian and licensed water users, use and discharge of water during construction, commissioning and maintenance of the pipeline infrastructure;	Refer Groundwater Assessment (EMM, 2019c), Biodiversity Assessment (EMM, 2019b) and Pipeline Development Water Assessment (EMM, 2019f)
	• a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures, and measures to minimise water use;	Section 3.2
	• demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	Section 3.2

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
Planning and Environment (Key Issues - Water)	• a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Refer Chapter 9 of the EIS (EMM, 2019g)
	• a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;	Section 3.1, Section 4.0 & Section 5.0
	• a description of construction erosion and sediment controls, how the impacts of the development on areas of erosion, salinity or acid-sulphate risk, steep gradient land or erodible soils types would be managed and any contingency requirements to address residual impacts; and	Section 3.1.3
	• an assessment of the potential flooding impacts of the project.	Section 4.1.3 & Section 4.2.3
Cabonne Council	Requirements for the State Significant development for the proposed gold mine are as follows: … 2. Natural and Cultural Environment	
	• Environmental characteristics of the site (land ownership, meteorology, topography, drainage, geology, water resources…)	Section 2.0
	• Environmental impact of the proposed development upon the natural environment, in particular the existing hydrology of the landscape and any impact posed by the development proceeding.	Section 4.0
	3. Water Management	
	• Impact assessment (surface water run-off)	Section 4.1.1 & Section 4.2.1
	• Impact assessment (groundwater system)	Refer Groundwater Assessment (EMM, 2019c)
	• Water demand and supply (existing and proposed) …	Section 3.0
	10. Environmental monitoring	Section 5.0
Department of Industry (Crown Lands and Water Division)	Water: • Annual volumes of surface water and groundwater proposed to be taken by the activity (including through pit inflows and direct capture from storages) from each surface and groundwater source as defined by the relevant water sharing plan (WSP). This is recognised as a key issue for this project as the Department is aware of limitations in available surface water entitlement within the relevant water source.	Section 3.2.3, Section 4.1.1 & Section 4.2.1

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
Department of Industry (Crown Lands and Water Division)	• The identification of an adequate and secure water supply for the life of the project. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased.	Section 3.2.3, Section 4.1.1 & Section 4.2.1
	• A detailed and consolidated site water balance and proposed water management infrastructure.	Section 3.2
	• Assessment of impacts on surface and groundwater sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 4.0 Refer Groundwater Assessment (EMM, 2019c)
	• Assessment of the hydrological characteristics of the site and downstream, and an impact assessment of the project on downstream water users and the environment. An assessment over wet, dry and average periods will be required. Impacts to water supply from Carcoar Dam and riparian and licensed water users will need to be addressed.	Section 2.0, Section 4.1.1 & Section 4.2.1
	• An assessment of risk and potential impacts to downstream surface and ground water users and the environment due to the proposed location of a TSF on the headwaters of the Belubula River. The ability to effectively monitor and apply mitigation measures to potential impacts is of critical concern due to no buffer between the TSF and the watercourse and the potential for interaction with the fractured groundwater system which increases the uncertainty of flow paths. The risk assessment should clearly identify the users and the water source as risk and consider the ability to rehabilitate if seepage/TSF failure occurs and the associated time period.	Refer Chapter 9 of the EIS (EMM, 2019g) Refer Groundwater Assessment (EMM, 2019c) Section 3.1, Section 3.2, Section 4.0 & Section 5.0 Tailings Storage Facility Risk Assessment (Risk Mentor 2019)
	• Key policies for the project to be assessed against including; the *NSW Aquifer Interference Policy* (2012) using DoI Water's assessment framework, the "Guidelines for Controlled Activities on Waterfront Land" (NRAR 2018) and the Harvestable Right provisions of the Water Management Act 2000.	Refer Groundwater Assessment (EMM, 2019c) Section 2.6 & Section 2.9
	• An assessment against the rules of the groundwater and surface water sharing plans relevant to the site.	Refer Chapter 9 of the EIS (EMM, 2019g)
	• Full technical details and data of all surface and groundwater modelling, and an independent peer review.	Section 3.2 Peer review conducted by WRM – Attachment D
	• Proposed management and disposal of produced or incidental water.	Section 3.1 & Section 3.2

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
Department of Industry (Crown Lands and Water Division)	• Proposed surface and groundwater monitoring activities and methodologies.	Section 5.0 & refer Groundwater Assessment (EMM, 2019c)
	• Consideration of relevant policies and guidelines.	Section 1.4.2
	• A statement of where each element of the SEARs is addressed in the EIS in the form of a table.	This table
NSW Environment Protection Authority	Attachment A: Water	
	1. Describe the project including position of any intakes and discharges, volumes, water quality and frequency of all water discharges.	Section 3.1 & Section 3.2 (water quantity only)
	2. Demonstrate that all practical options to avoid discharge have been implemented and environmental impact minimised where discharge is necessary.	Section 3.1 & Section 3.2
	3. Include a water balance for the including *(sic)* water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.	Section 3.2 (quantity balance only)
	4. Describe existing surface and groundwater quality. An assessment needs to be undertaken for any resources likely to be affected by the proposal.	Section 2.0 & Section 4.0 Refer Groundwater Assessment (EMM, 2019c)
	5. Describe any drainage lines, creeks *(sic)* lines etc that will be impacted by the project.	Section 2.8.4
	6. State the Water Quality Objectives for the receiving waters relevant to the proposal. These refer to the community's agreed environmental values and human uses endorsed by the NSW Government as goals for ambient waters). Where groundwater may be impacted, the assessment should identify appropriate groundwater environmental values.	Section 2.8.2 Refer Groundwater Assessment (EMM, 2019c)
	7. State the indicators and associated trigger values or criteria for the identified environmental values. This information should be sourced from the ANZECC (2000) Guidelines for Fresh and Marine Water Quality.	Section 2.8.2
	8. State any locally specific objectives, criteria or targets which have been endorsed by the NSW Government.	Section 2.8.2
	9. Describe the nature and degree of impact that any proposed discharges will have on the receiving environment.	Section 4.0
	10. Whether the project will significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Section 4.0

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
NSW Environment Protection Authority	11. Identify potential impacts on watercourses and the management/mitigation measures that will be implemented where mining activities occur in proximity to or within a watercourse.	Section 4.0
	12. Assess impacts against the relevant ambient water quality outcomes. Demonstrate how the proposal will be designed and operated to: - protect the Water Quality Objectives for receiving waters where they are currently being achieved;	Section 4.0
	13. contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved.	
	14. Assess the impacts on groundwater and groundwater dependent ecosystems.	Refer Groundwater Assessment (EMM, 2019c)
	15. Describe in detail how stormwater will be managed both during and after construction.	Section 3.1
	16. Provide detailed water management strategies for all disturbance areas, paying particular attention to the waste rock emplacement areas and potential impacts on groundwater and offsite surface water resources including particular reference to the management of channel and overland flows into and within the disturbance area.	Section 3.1 & Section 4.0
	17. Provide plans for any proposed relocation/realignment of all creeks and/or drainage lines including design, timelines and completion criteria and sufficient evidence to demonstrate that the proposed plans are achievable, reasonable and feasible in the short and the long term.	Section 3.1.1 Refer ATCW (2019)
	18. Describe how predicted impacts will be monitored and assessed over time.	Section 5.0
	19. The proponent should develop a water quality and aquatic ecosystem monitoring program to monitor the responses for each component or process that affects the Water Quality Objectives that includes, for example: - adequate data for evaluating compliance with water quality standards and/or Water Quality Objectives - measurement of pollutants identified or expected to be present in any discharge	Section 5.0
	20. Water quality monitoring should be undertaken in accordance with the *Approved Methods for the Sampling and Analysis of Water Pollutant in NSW* (2004).	Section 5.0

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
NSW Office of Environment and Heritage	**Water and soils**	
	8. The EIS must map the following features relevant to water and soils including:	
	a. …	
	b. Rivers, streams, wetlands, estuaries (as described in s4.1 of the Biodiversity Assessment Method (Pipeline) and s4.1 of the Biodiversity Assessment Method (Mine Site)).	Section 2.8.4
	c. Wetlands as described in s4.1 of the Biodiversity Assessment Method (Pipeline) and s4.1 of the Framework for Biodiversity Assessment (Mine Site).	Refer Mine Development Biodiversity Assessment Report (EMM, 2019b) & Pipeline Development Biodiversity Development Assessment Report (OzArk, 2019)
	d. Groundwater.	Refer Groundwater Assessment (EMM, 2019c)
	e. Groundwater dependent ecosystems.	Refer Groundwater Assessment (EMM, 2019c) & Mine Development Biodiversity Assessment Report (EMM, 2019b)
	f. Proposed intake and discharge locations.	Section 3.0
	9. The EIS must describe background conditions for any water resource likely to be affected by the McPhillamys Gold Project, including:	
	a. Existing surface and groundwater.	Section 3.0
	b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations.	Section 2.0
	c. Water Quality Objectives (as endorsed by the NSW Government) including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Section 4.0 & Section 3.2
	d. Indicators and trigger values/criteria for the environmental values identified at c. in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 2.8.2

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
NSW Office of Environment and Heritage	10. The EIS must assess the impacts of the project on water quality including:	
	a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the project protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Section 2.8.2
	b. Identification of proposed monitoring of water quality.	Section 4.1.4
	11. The EIS must assess the impact of the project on hydrology, including:	
	c. Water balance including quantity, quality and source.	Section 4.0
	d. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas.	Section 4.0
	e. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	Refer Mine Development Aquatic Ecology Assessment (EMM, 2019a)
	f. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (eg river benches).	Section 4.0
	g. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Refer Mine Development Aquatic Ecology Assessment (EMM, 2019a)
	h. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	Section 4.1.1 & Section 4.2.1
	a. Identification of proposed monitoring of hydrological attributes.	Section 4.0
	Flooding	
	12. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including:	
	a. Flood prone land	Section 2.5
	b. Flood planning area, the area below the flood planning level.	Section 2.5

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
NSW Office of Environment and Heritage	c. Hydraulic categorisation (floodways and flood storage areas).	Section 2.5
	13. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood, or an equivalent extreme event.	Section 3.5
	14. The EIS must model the effect of the proposed project (including fill) on the flood behaviour under the following scenarios:	
	a. Current flood behaviour for a range of design events as identified in 11 above. This includes the 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Not considered relevant to this assessment due to the location of the project in the headwaters of the Belubula River catchment.
	15. Modelling in the EIS must consider and document:	
	a. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood.	Section 3.5
	b. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection *(sic)* of other development or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories.	Section 4.1.3 & Section 4.2.3
	c. Relevant provisions of the NSW Floodplain Development Manual 2005.	Section 2.5
	16. The EIS must assess the impacts on (sic) the proposed project on flood behaviour, including:	
	a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure.	Section 4.1.3 & Section 4.2.3
	b. Consistency with Council floodplain risk management plans. c. Compatibility with the flood hazard of the land. d. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. e. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. f. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	Flooding impacts will be confined to within the project boundary hence these impacts are not relevant.

Table 1 (Continued) Environmental Assessment Requirements – Surface Water

Source	Requirement	SWA Section / Comment or Why Not Addressed
NSW Office of Environment and Heritage	g. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. h. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. j. Any impacts the development may have on the social and economic costs to the community as a consequence of flooding.	Flooding impacts will be confined to within the project boundary hence these impacts are not relevant.
NSW Roads and Maritime	Roads and Maritime requests the following issues be addressed in the Environmental Assessment: … • Identification and assessment of potential impacts of mining operations, such as blasting, lighting, visual and drainage, including the pipeline development on the function and integrity of all affected roads.	Relevant surface water items, Section 4.0

1.4.2 Guidelines for Assessing Impacts

The guidelines used as a basis for assessing impacts in this report are shown in Table 2.

Table 2 Summary of Guidelines for Assessing Impacts

Document	Description
National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a)	The surface water quality monitoring results collected to date have been compared to these guidelines where appropriate (Section 2.8.2).
National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b)	Surface water quality monitoring would continue to be conducted in accordance with these guidelines (Section 2.7.2).
Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC, 2006)	The Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000a) has been applied in accordance with this guideline, including consideration of the NSW Government Water Quality and River Flow Objectives (NSW Government, 2016).

Table 2 (Continued) Summary of Guidelines for Assessing Impacts

Document	Description
State Water Management Outcomes Plan (NSW Office of Water, 2013)	The assessment includes consideration of the policy developed under the State Water Management Outcomes Plan and the *Water Management Act 2000*, including the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* and *Water Sharing Plan for the Lachlan Regulated River Water Source 2016*.
Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC, 2004b)	Surface water quality monitoring would continue to be conducted in accordance with these guidelines (Section 2.7.2).
Managing Urban Stormwater: Soils & Construction (Landcom, 2004) and associated Volume 2E: Mines and Quarries (DECCW, 2008)	Existing and planned erosion and sediment controls would be designed in accordance with Landcom (2004) and NSW Department of Environment, Climate Change and Water [DECCW] (2008) to control suspended solids in runoff (refer Section 3.1.3).
Managing Urban Stormwater: Treatment Techniques (EPA, 1997)	Would be considered and applied as relevant to drainage design/management around mine infrastructure area.
Managing Urban Stormwater: Source Control (EPA, 1998)	Would be considered and applied as relevant to drainage design/management in mine infrastructure areas.
Floodplain Development Manual (NSW Department of Infrastructure, Planning and Natural Resources, 2005)	Not considered relevant to this assessment due to the location of the project in the headwaters of the Belubula River catchment.
Floodplain Risk Management Guide (DECCW, 2010)	Not considered relevant to this assessment as the Modification is outside areas which could be affected by current sea level rise predictions and the location of the project in the headwaters of the Belubula River catchment.
A Rehabilitation Manual for Australian Streams (Cooperative Research Centre for Catchment Hydrology and Land and Water Resources Research and Development Corporation, 2000)	This guideline would be considered upon approval of the project.
Technical Guidelines: Bunding & Spill Management (now Storing and Handling Liquids: Environmental Protection - Participants Manual [NSW Department of Environment and Climate Change (DECC), 2009]; Environmental Compliance Report: Liquid Chemical Storage, Handling and Spill Management - Part B Review of Best Practice and Regulation [DEC, 2005])	Would be used in design of containment systems for hazardous chemicals and would be incorporated into standard operating procedures for spill response.

2.0 BASELINE SURFACE WATER RESOURCES

2.1 RAINFALL AND EVAPORATION

Regis operates a weather station located near the southern end of the project boundary on Sturgeon Hill (refer Figure 2) and an additional temperature gauge nearby adjacent to Trib A (refer Figure 2). The Bureau of Meteorology (BoM) operates or has historically operated twelve rainfall recording stations nearby within 15 km of the project boundary which are shown on Figure 2 and summarised in Table 3. 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 project gives an average annual rainfall of 705 mm.

Table 3 Summary of Bureau of Meteorology Rainfall Stations

Station Number	Station Name	Location (GDA94* Zone 55)		Approximate Distance from Project (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 4 Also shown in Table 4 are data for the Sturgeon Hill weather station as well as long term synthetic rainfall obtained from the SILO Data Drill system for the 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://legacy.longpaddock.qld.gov.au/silo/.

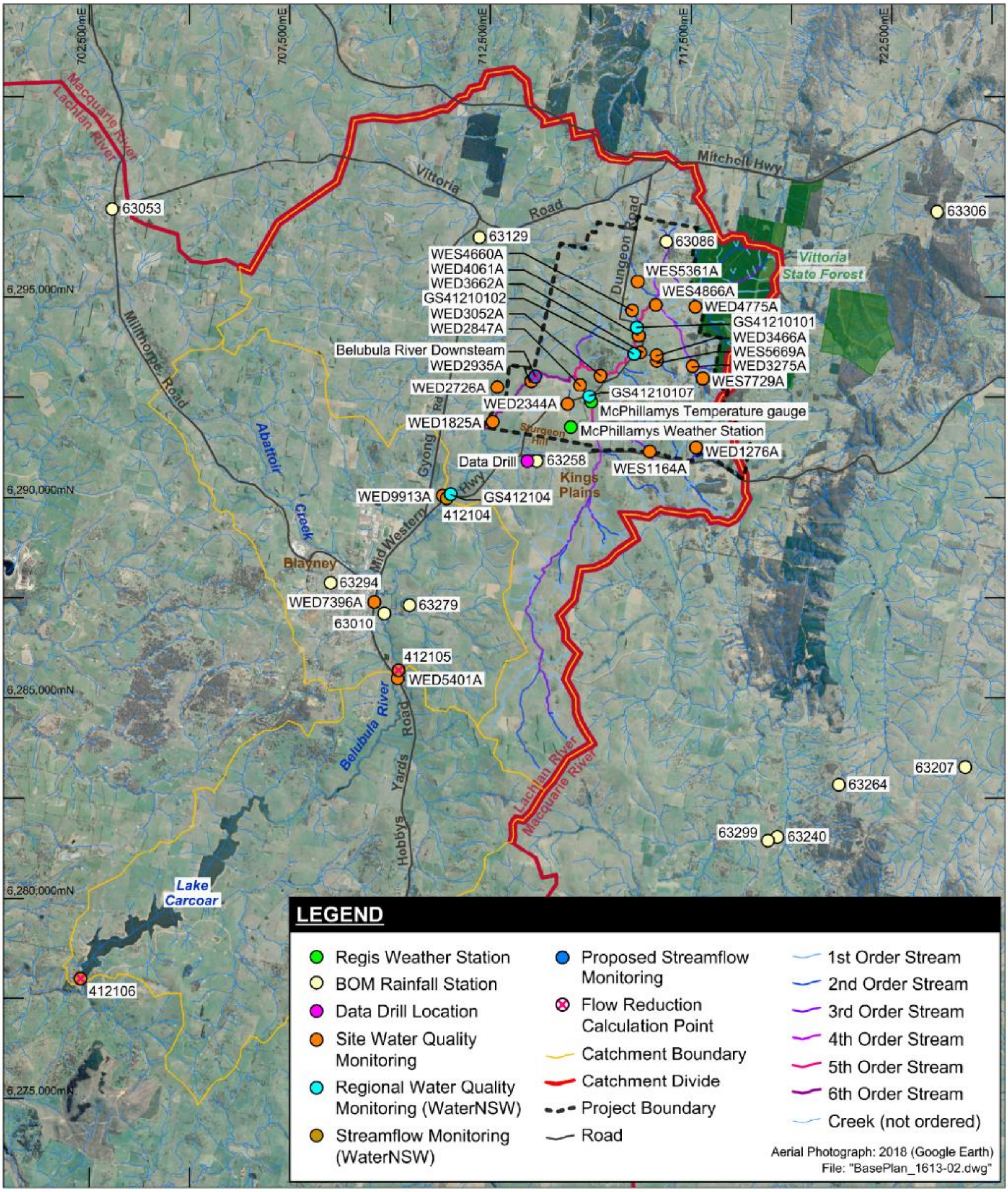

Figure 2 Regional Layout and Monitoring

Table 4 Average Monthly Rainfall

Data Source:	SILO Data Drill for Project Area	Millthorpe (Inala) (063053)	Sturgeon Hill Weather Station
	millimetres		
Number of Years of Record	130	106	6
January	65.5	71.2	66.0
February	55.6	61.5	23.1
March	53.6	55.4	52.0
April	46.7	52.9	51.7
May	50.4	59.9	40.1
June	60.9	72.7	54.0
July	61.4	75.9	50.3
August	64.9	79.4	61.1
September	58.4	66.1	58.6
October	65.6	78	45.3
November	58.7	64.5	66.7
December	62.0	67.3	71.8
Annual Average	**703.6**	**783.1**	**682.1**

The data in Table 4 indicate a long term average annual rainfall for the area of approximately 703.6 mm, with lower rainfall occurring in autumn months. The recorded 6 year Sturgeon Hill weather station annual average of 682.1 mm is lower than the long term regional average and approximately equal to the corresponding period SILO Data Drill average (681.6 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 SILO Data Drill has therefore been used for the water balance simulations (refer Section 3.2). Rainfall in the vicinity of the 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 project area is provided in Table 5. This data is considered the most appropriate for the assessment because it is generated for the site location from long term regional data.

Table 5 Average Monthly Evaporation

Data Source:	SILO Data Drill for Project Area
	millimetres
Number of Years of Record	130
January	209.0
February	163.8
March	139.0
April	83.6
May	50.8
June	30.8
July	34.6
August	54.3
September	84.8
October	125.7
November	158.9
December	202.0
Annual Average	**1,336.9**

The data in Table 4 and Table 5 shows that average evaporation exceeds average rainfall in all but the three winter months.

2.2 REGIONAL AND LOCAL TOPOGRAPHY

The project 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 project. 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 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 project area, a north-south orientated ridgeline forms the catchment divide between the Macquarie and Lachlan River catchments (refer Figure 2).

Topography within the 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 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 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 development 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 project.

The bedrock in elevated portions of the 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 (EMM, 2019d).

2.4 REGIONAL AND LOCAL HYDROLOGY

The project area is located in the headwaters of the unregulated Belubula River which flows from north-east to south-west through the project area (refer Figure 2). 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 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 (2019e) to target reclassification of stream orders. Although reclassification was unsuccessful, the overall knowledge and understanding of the local hydrology was enhanced. For the purposes of this assessment, the unnamed tributaries are referred to as Trib A to Trib K (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 project area (refer Figure 2). 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.

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 project located in the 'Belubula River above Carcoar Dam Water Source'. Under the *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].

WALs are issued by DoI Water 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).

2.7 SURFACE WATER MONITORING NETWORK

The existing surface water monitoring network for the project comprises a weather station and nearby lower elevation temperature gauge (refer Figure 2) as well as streamflow and water quality monitoring as summarised in the sub-sections to follow.

2.7.1 Streamflow

2.7.1.1 Project Area Streamflow

Regis has installed surface water level sensors in Trib A and the Belubula River within the vicinity of the project area. However, no natural, robust controls were identified at these locations to enable streamflow gauging and the subsequent development of a rating curve relationship. Therefore, streamflow data is not available for the project area at present.

Monitoring flow in the local creeks prior to mining, 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) are proposed for three locations within the project area at:

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

- Belubula River Downstream of the confluence with Trib A;
- 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 3. V-notch weirs and flumes are self-rated (i.e. a theoretical relationship between upstream depth and flow rate exists) 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. The v-notch weir or flume design is based on providing accurate low flow measurements. Given the nature of a v-notch weir, a relatively small volume of water would pond behind the weir and hence a water supply works approval is required by DoI Water (prior to approval of the mine development). Flumes would require more intensive maintenance to ensure no blockage due to debris or transported sediment. Approval is being sought for the Belubula Downstream flow monitoring station and an application for the other two sites will be made once design is complete with the aim to have all three gauging stations in place during 2019.

2.7.1.2 Regional Streamflow

There are six existing or former stream gauging stations (WaterNSW, 2018a) on the Belubula River downstream of the project area, three of which are at or upstream of Carcoar Dam (refer Figure 2) with a summary for each provided in Table 6.

Table 6 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 412106	Belubula River at Carcoar Dam	702,284	6,277,985	216.7	2012-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

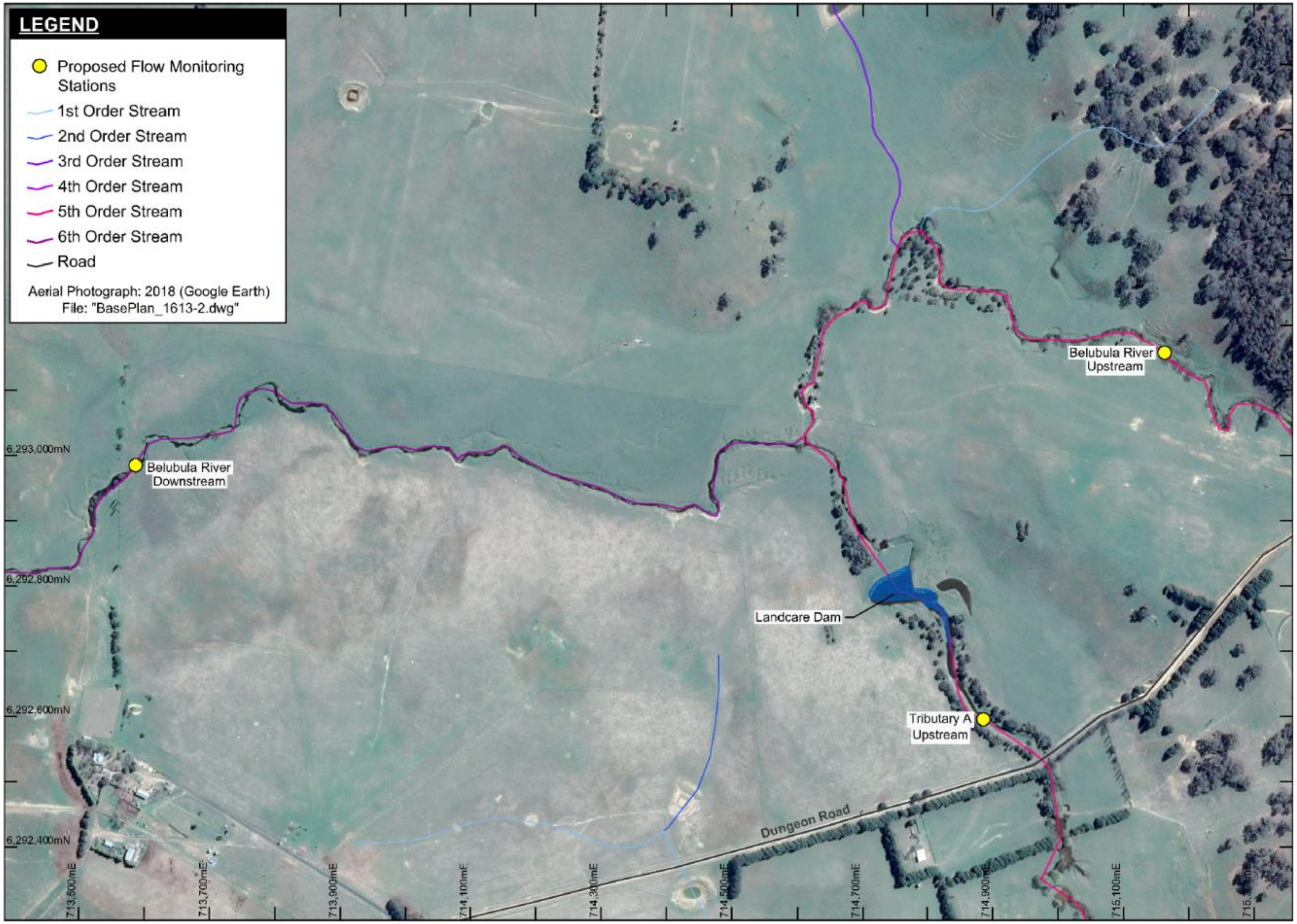

Figure 3 Proposed Streamflow Monitoring Sites

2.7.2 Water Quality

Water quality within the project area has been monitored by Regis since May 2014 at twenty-one locations as shown in Figure 2 and summarised in Table 7. 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 7, 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 7 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 proposed flow monitoring locations within the 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 2 and listed in Table 8.

Table 8 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 three regional streamflow stations at or upstream of Carcoar Dam (locations shown on Figure 2) is shown in Figure 4.

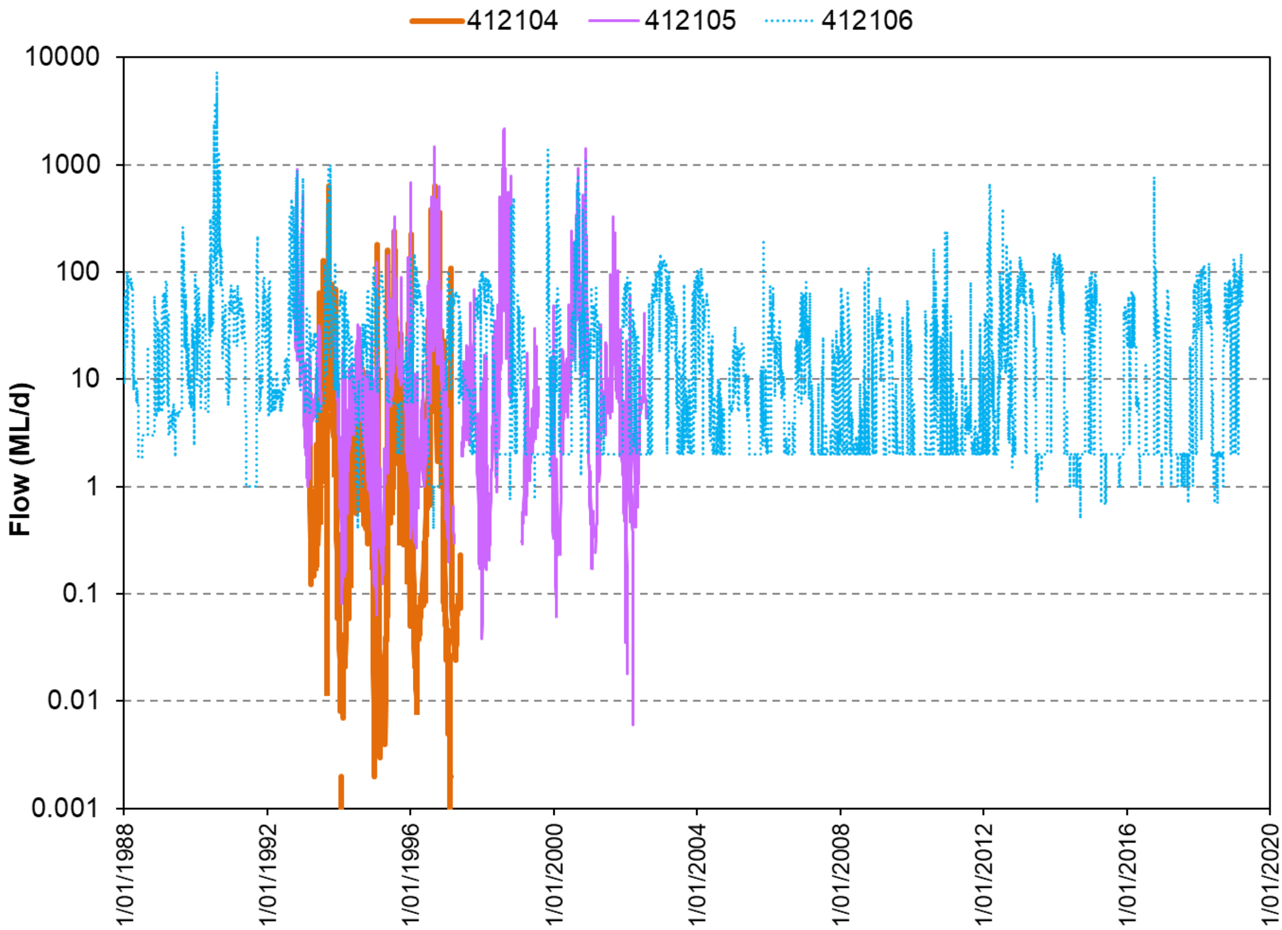

Figure 4 Regional Streamflow Data

Figure 5 shows a flow duration plot for each streamflow gauging station 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 flow at this gauge. The Belubula River at Carcoar Dam (GS 412106) location is not a natural system and shows releases from Carcoar Dam have occurred 97.6% of the time.

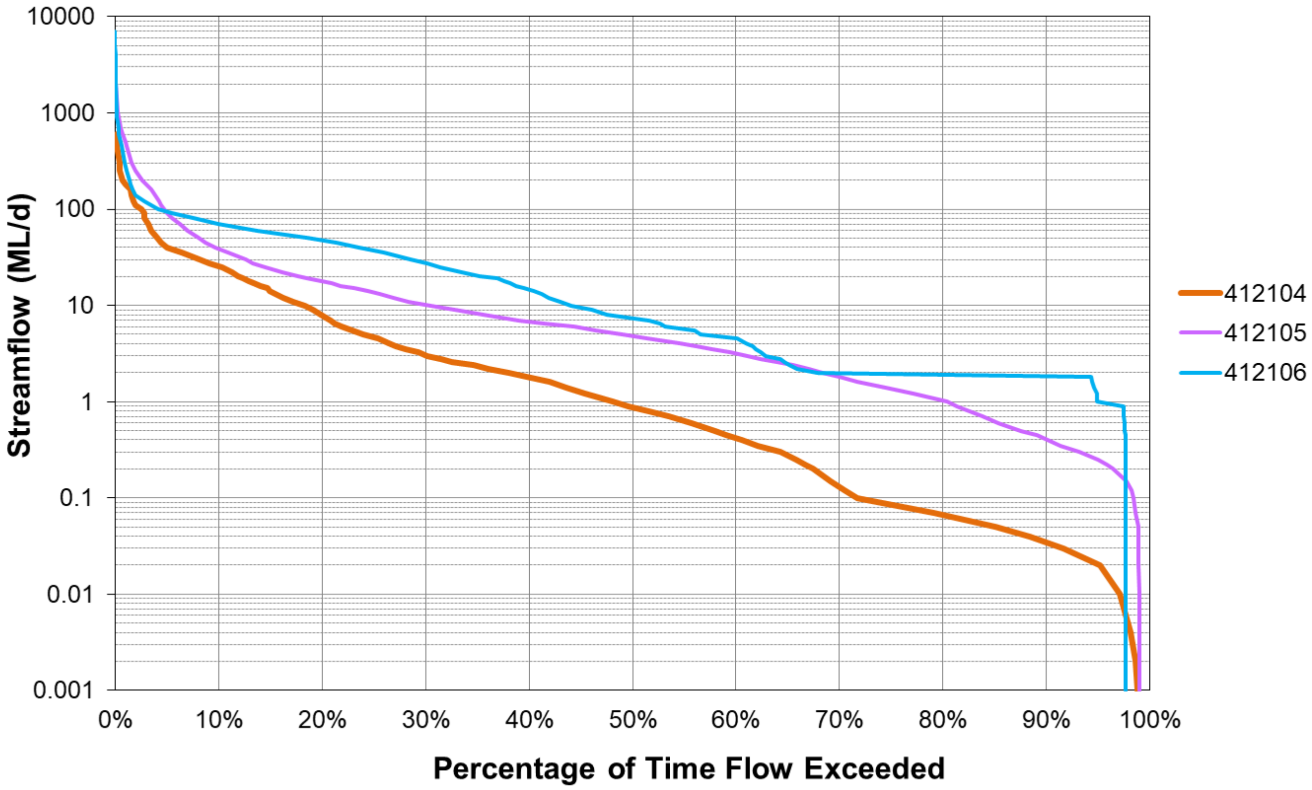

Figure 5 Flow Duration Plot for Gauging Stations on the Belubula River

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 the project area 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.

Data has been compared in Table 9 with default guideline trigger values (ANZECC, 2000) for protection of aquatic ecosystems (at 80% level of species protection) in south-eastern Australian upland rivers and guideline values for Primary Industries water supplies (livestock drinking water quality). The 80% level of species protection was selected due to the disturbed nature of the surface water systems within and downstream of the project area. 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. Site specific WQOs would be derived from the monitored data 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.

The number of samples at each site that have exceeded the WQOs are given in Table 9. 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 14 of 21 sites recording exceedances. Recorded EC exceeded the WQO at all sites excepting WED1276A and WED5401A, although the water salinity may be characterised as fresh at all sites based on the recorded EC values (less than approximately 2,300 micro Siemens/centimetre [µS/cm]). There were no exceedances of the WQO for sulphate, arsenic, cadmium or cyanide recorded at any location. The WQO for zinc was exceeded in some samples collected at WED2344A, WED3466A, WED4775A and WES7729A. The total nitrogen and total phosphorus WQOs were exceeded in the majority of samples from all sites in which total nitrogen and total phosphorus were recorded. These baseline results suggest that the ANZECC (2000) guidelines are not representative of the background conditions in the project area and site specific WQOs should be developed prior to project commencement using all available baseline data (as part of the Water Management Plan for the project, if approved).

Table 9 Summary of Surface Water Quality Data in the Project Area

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)	Total Cyanide (mg/L)
	Water Quality Objective	6.5-8	30-350	1,000	0.36	0.0008	-	0.031	0.25	0.02	0.018
WES1164A	Minimum	7.31	384	1	0.001	0.0001	0.16	0.005	0.1	0.01	0.004
	Median	8.04	961	30	0.001	0.0001	0.16	0.007	0.3	0.05	0.004
	Maximum	8.37	1,438	385	0.007	0.0001	0.16	0.023	1.0	0.13	0.004
	No. Samples	13	13	8	8	8	1	8	8	8	5
	No. Samples Exceeding WQO	7	13	0	0	0	-	0	5	7	0
WED1276A	Minimum	5.73	101	1	0.002	0.0001	2.74	0.005	2.1	0.09	0.004
	Median	7.35	173	2	0.004	0.0001	3.98	0.006	4.1	0.17	0.004
	Maximum	8.37	238	10	0.013	0.0001	6.32	0.015	9.7	0.53	0.004
	No. Samples	27	27	20	19	19	9	19	20	20	14
	No. Samples Exceeding WQO	5	0	0	0	0	-	0	20	20	0
WED1825A	Minimum	6.87	504	5	0.001	0.0001	0.11	0.005	0.8	0.01	0.004
	Median	8.24	961	70	0.004	0.0001	1.99	0.007	1.7	0.10	0.004
	Maximum	8.76	1,650	176	0.026	0.0001	8.84	0.025	28.0	2.34	0.004
	No. Samples	25	25	21	20	20	13	20	21	21	17
	No. Samples Exceeding WQO	19	25	0	0	0	-	0	21	20	0
WED2344A	Minimum	7.34	134	1	0.002	0.0001	0.33	0.005	2.6	0.16	0.004
	Median	7.87	381	16	0.004	0.0001	4.52	0.019	8.7	0.52	0.004
	Maximum	9.11	839	38	0.009	0.0001	22.30	0.068	16.7	1.55	0.006
	No. Samples	31	31	26	25	25	15	25	26	26	20
	No. Samples Exceeding WQO	11	19	0	0	0	-	6	26	26	0
WED2847A	Minimum	8.01	412	10	0.002	0.0001	0.08	0.005	0.8	0.02	0.004
	Median	8.53	955	38	0.008	0.0001	0.56	0.006	1.9	0.16	0.004
	Maximum	9.48	1,262	85	0.015	0.0001	2.94	0.014	6.5	0.47	0.004
	No. Samples	31	31	25	24	24	14	24	25	25	18
	No. Samples Exceeding WQO	31	31	0	0	0	-	0	25	25	0

ND = no data, * milligrams/litre

Table 9 (Continued) Summary of Surface Water Quality Data in the Project Area

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)	Total Cyanide (mg/L)
	Water Quality Objective	6.5-8	30-350	1,000	0.36	0.0008	-	0.031	0.25	0.02	0.018
WED2935A	Minimum	7.08	498	1	0.002	0.0001	0.15	0.002	0.6	0.01	0.004
	Median	8.15	971	51	0.004	0.0001	0.76	0.006	1.1	0.07	0.004
	Maximum	8.64	1,557	127	0.027	0.0001	2.80	0.014	6.0	0.75	0.004
	No. Samples	30	30	24	23	23	14	23	24	24	19
	No. Samples Exceeding WQO	22	30	0	0	0	-	0	24	21	0
WED3052A	Minimum	7.36	474	14	0.001	0.0001	0.05	0.005	0.2	0.01	0.004
	Median	7.79	1,073	73	0.003	0.0001	1.41	0.006	0.8	0.07	0.004
	Maximum	8.48	1,550	188	0.019	0.0001	5.50	0.015	4.0	1.04	0.004
	No. Samples	27	27	21	20	20	13	20	21	21	17
	No. Samples Exceeding WQO	4	27	0	0	0	-	0	20	18	0
WED3275A	Minimum	8.01	412	10	0.002	0.0001	0.08	0.005	0.8	0.02	0.004
	Median	8.53	955	38	0.008	0.0001	0.56	0.006	1.9	0.16	0.004
	Maximum	9.48	1,262	85	0.015	0.0001	2.94	0.014	6.5	0.47	0.004
	No. Samples	31	31	25	24	24	14	24	25	25	19
	No. Samples Exceeding WQO	31	31	0	0	0	-	0	25	25	0
WED3466A	Minimum	7.07	885	24	0.001	0.0001	0.12	0.005	0.4	0.01	0.004
	Median	7.42	908	27	0.001	0.0001	0.12	0.007	1.4	0.05	0.004
	Maximum	7.89	1,048	39	0.004	0.0001	0.12	0.048	2.2	0.78	0.004
	No. Samples	16	16	10	10	10	1	10	10	10	4
	No. Samples Exceeding WQO	0	16	0	0	0	0	1	10	8	0
WED3662A	Minimum	7.72	713	10	0.001	0.0001	0.15	0.005	0.5	0.02	0.004
	Median	8.05	1,020	41	0.004	0.0001	0.38	0.006	1.3	0.09	0.004
	Maximum	8.29	1,120	100	0.007	0.0001	2.09	0.014	2.1	0.27	0.004
	No. Samples	13	13	13	12	12	12	12	13	13	13
	No. Samples Exceeding WQO	8	13	0	0	0	-	0	13	13	0

ND = no data

Table 9 (Continued) Summary of Surface Water Quality Data in the Project Area

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)	Total Cyanide (mg/L)
	Water Quality Objective	6.5-8	30-350	1,000	0.36	0.0008	-	0.031	0.25	0.02	0.018
WED4061A	Minimum	6.96	377	10	0.001	0.0001	0.78	0.005	0.3	0.01	0.004
	Median	7.61	865	61	0.003	0.0001	2.68	0.005	1.1	0.13	0.004
	Maximum	7.93	1,040	190	0.015	0.0001	12.90	0.017	2.4	0.32	0.004
	No. Samples	24	24	18	17	17	11	17	18	18	15
	No. Samples Exceeding WQO	0	24	0	0	0	-	0	18	17	0
WED4775A	Minimum	6.53	69	1	0.002	0.0001	5.40	0.006	6.0	0.11	0.004
	Median	7.43	426	10	0.006	0.0001	12.15	0.022	15.0	0.77	0.004
	Maximum	8.88	1,194	191	0.017	0.0002	27.50	0.061	44.0	2.90	0.006
	No. Samples	24	24	23	22	22	14	22	23	23	19
	No. Samples Exceeding WQO	2	13	0	0	0	-	7	23	23	0
WES5669A	Minimum	6.90	719	8	0.001	0.0001	ND	0.005	0.1	0.01	0.004
	Median	7.21	936	18	0.002	0.0001	ND	0.005	0.5	0.05	0.004
	Maximum	8.52	1,058	48	0.003	0.0001	ND	0.012	0.8	0.22	0.004
	No. Samples	17	17	10	10	10	ND	10	10	10	4
	No. Samples Exceeding WQO	1	17	0	0	0	-	0	8	9	0
WES7729A	Minimum	5.43	81	1	0.005	0.0001	ND	0.027	2.6	0.12	0.004
	Median	6.87	165	8	0.022	0.0001	ND	0.091	8.8	0.78	0.004
	Maximum	7.61	553	20	0.040	0.0006	ND	0.362	25.5	3.16	0.004
	No. Samples	15	15	8	8	8	ND	8	8	8	2
	No. Samples Exceeding WQO	4	2	0	0	0	-	7	8	8	0
WED5401A	Minimum	6.28	232	6	-	-	-	-	-	-	-
	Median	-	-	-	0.002	0.0001	1.40	0.004	0.4	0.10	0.004
	Maximum	6.42	262	6	-	-	-	-	-	-	-
	No. Samples	2	2	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	2	0	0	0	0	-	0	1	1	0

ND = no data

Table 9 (Continued) Summary of Surface Water Quality Data in the Project Area

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)	Total Cyanide (mg/L)
	Water Quality Objective	6.5-8	30-350	1,000	0.36	0.0008	-	0.031	0.25	0.02	0.018
WED7396A	Minimum	7.07	319	-	-	-	-	-	-	-	-
	Median	-	-	10	0.002	0.0001	0.89	0.012	0.6	0.10	0.004
	Maximum	7.58	360	-	-	-	-	-	-	-	-
	No. Samples	2	2	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	0	1	0	0	0	-	0	1	1	0
WED9913A	Minimum	7.38	452	-	-	-	-	-	-	-	-
	Median	-	-	23	0.003	0.0001	1.50	0.007	1.5	0.10	0.004
	Maximum	7.39	921	-	-	-	-	-	-	-	-
	No. Samples	2	2	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	0	2	0	0	0	-	0	1	1	0
WED2726A	Minimum	8.45	501	-	-	-	-	-	-	-	-
	Median	-	-	73	0.002	0.0001	0.42	0.003	1.4	0.05	0.004
	Maximum	9.14	598	-	-	-	-	-	-	-	-
	No. Samples	2	2	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	2	2	0	0	0	-	0	1	1	0
WES4660A	Minimum	-	-	410	0.001	0.0001	0.04	0.002	1.9	0.05	0.004
	Median	6.63	1,430	-	-	-	-	-	-	-	-
	Maximum	-	-	420	0.001	0.0001	97	4	2.4	0.08	0.004
	No. Samples	1	1	2	2	2	2	2	2	2	1
	No. Samples Exceeding WQO	0	1	0	0	0	-	1	2	2	0
WES4866A	Minimum	-	-	-	-	-	-	-	-	-	-
	Median	7.28	1,136	19	0.001	0.0001	0.36	0.004	1.5	0.06	0.004
	Maximum	-	-	-	-	-	-	-	-	-	-
	No. Samples	1	1	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	0	1	0	0	0	-	0	1	1	0

ND = no data

Table 9 (Continued) Summary of Surface Water Quality Data in the Project Area

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)	Total Cyanide (mg/L)
	Water Quality Objective	6.5-8	30-350	1,000	0.36	0.0008	-	0.031	0.25	0.02	0.018
WES5361A	Minimum	-	-	-	-	-	-	-	-	-	-
	Median	7.83	1,621	580	0.001	0.0001	0.37	0.001	9.7	0.07	0.004
	Maximum	-	-	-	-	-	-	-	-	-	-
	No. Samples	1	1	1	1	1	1	1	1	1	1
	No. Samples Exceeding WQO	0	1	0	0	0	-	0	1	1	0

ND = no data

2.8.2.2 *Imported Water Quality*

Water sourced from Centennial's Angus Place and SCSO and MPPS near Lithgow, will be transferred to the project via a purpose-built pipeline and is expected to have an average TDS of approximately 3,500 mg/L (EMM, 2019f). The imported water will be contained within the proposed operational water management system as detailed in Section 3.1.2 with the project 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 10. 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 10 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 10 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. Recorded EC (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) guidelines are not representative of the background conditions in the Lake Carcoar catchment and site specific WQOs should be developed prior to project commencement using all available baseline data (as part of the Water Management Plan for the project, if approved).

Table 10 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
GS41210101	Minimum	6.26	98
	Median	7.30	702
	Maximum	8.01	1,322
	No. Samples	82	82
	No. Samples Exceeding WQO	5	67
GS41210102	Minimum	6.85	107
	Median	7.58	430
	Maximum	8.06	745
	No. Samples	9	9
	No. Samples Exceeding WQO	1	5

Table 10 (Continued) Summary of Regional Surface Water Quality Data

ID	Statistic	pH	EC (µS/cm)
	Water Quality Objective	6.5-8	30-350
GS41210107	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 thought to discharge to the river in the lower reaches, below the confluence with Trib A (EMM, 2019c).

In the mine development area, groundwater discharges as springs and seeps are observed on the sides of hills and are typically dammed for agricultural use. The seeps (and dams) are ephemeral and some have been observed to run dry over the baseline monitoring period (EMM, 2019c). Groundwater is currently predicted to contribute approximately 5% of overall surface flows in the Belubula River upstream of the confluence with Trib A (EMM, 2019c).

2.8.4 Geomorphology

2.8.4.1 Objective and Methodology

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

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

2.8.4.2 Topographical Information

Topographical mapping of the 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[3]. At the downstream end of the project area the Belubula River is a 6th order stream with ten main mapped tributaries: Trib A through to Trib J (refer Figure 6).

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 11 for the Belubula River and each of the ten tributaries.

Table 11 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.

The Belubula River to the downstream boundary of the project includes the catchment areas of all ten tributaries provided in Table 11 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 11, Trib A is notably flatter than the other tributaries and the Belubula River.

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

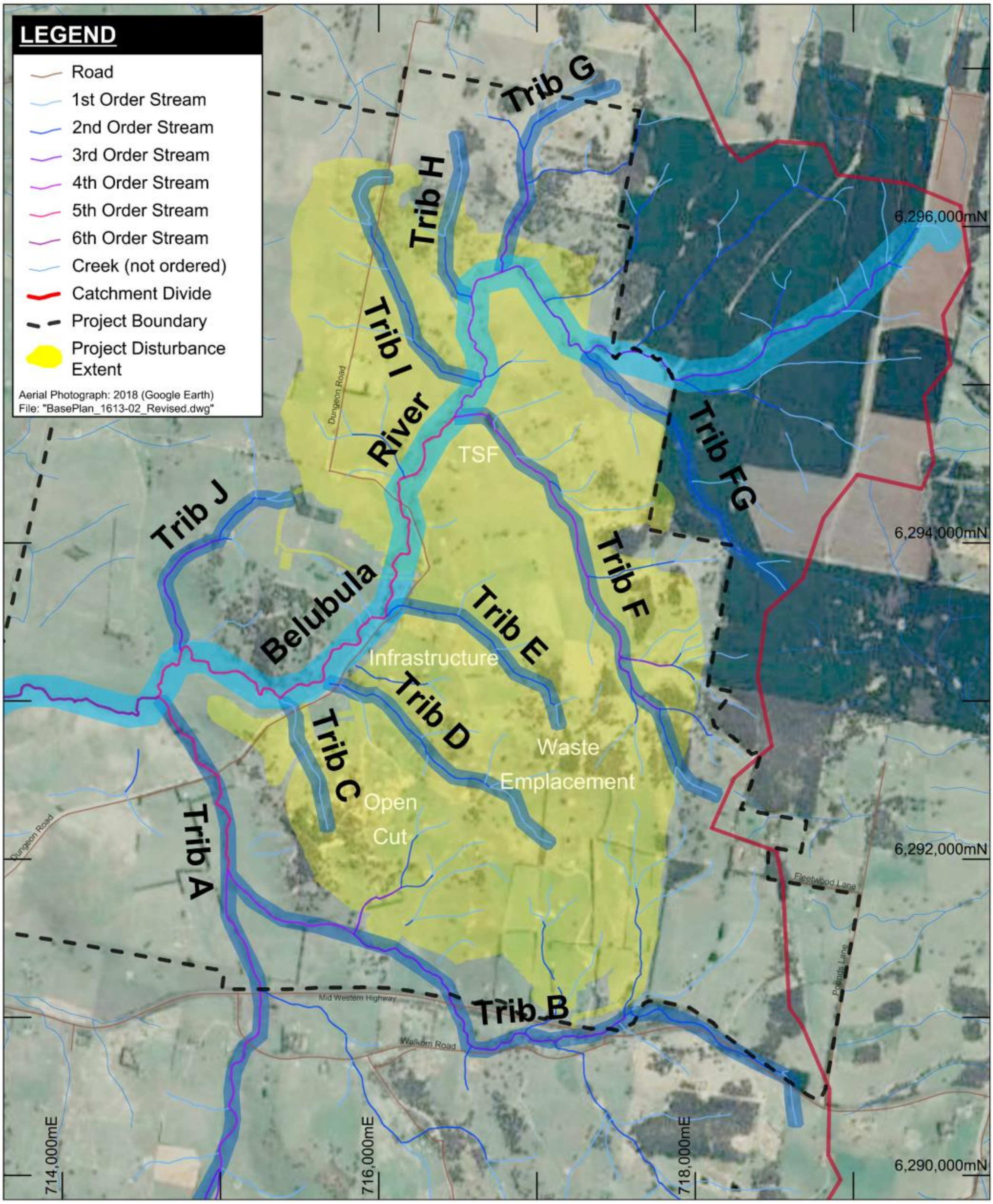

Figure 6 Tributary Naming

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 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 project area (EMM, 2019d). 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). For further information on geology and soils in the project area, refer to the Groundwater Assessment (EMM, 2019c) and Soil Assessment (EMM, 2019d).

2.8.4.4 Vegetation and Land Use

The 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 Vittoria State Forest is present in the upper headwaters of the Belubula River (refer Figure 2 and Figure 7). For further information on vegetation in the area, refer to the Biodiversity Assessment (EMM, 2019b).

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 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 footprint of 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 footprint of the proposed open cut. Trib J was also excluded given the proposed project extent would not impact this stream.

Daily rainfall totals of 0.2 mm were recorded on each day of the reconnaissance at the site weather station. No rainfall was observed by HEC personnel during the reconnaissance hence this rainfall must have occurred out of daylight hours. 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 sections 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 7 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 1 and Photo 2. 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.

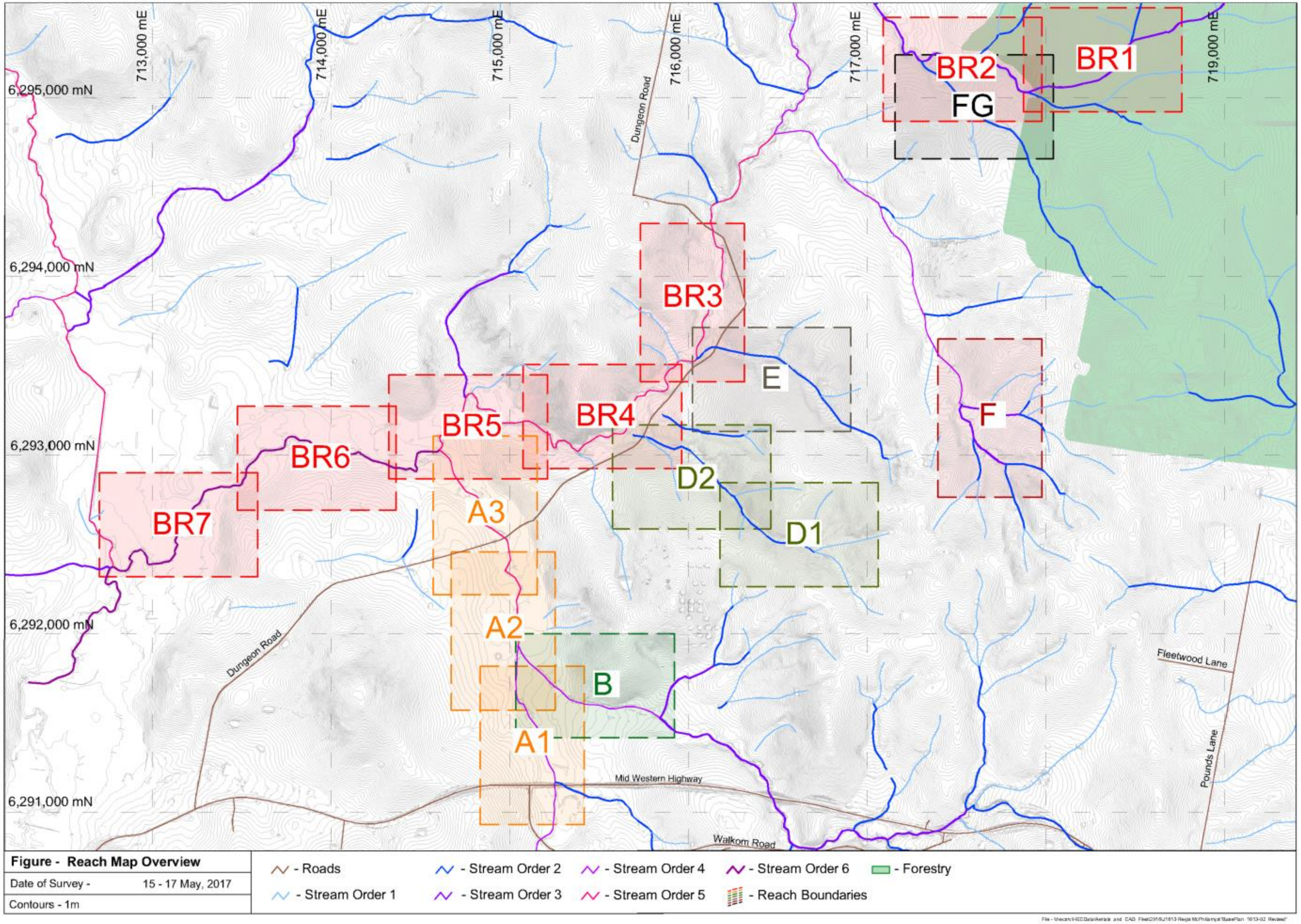

Figure 7 **Belubula River and Tributaries: Overview Reach Map**

Photo 1 Typical Section: Belubula Headwaters Forest (212-Upstream)

Photo 2 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 4. 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 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 3 Typical Section: Belubula Headwaters Grazing (238-Downstream)

Photo 4 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 5). 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 6. 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 shown in Photo 6 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 5 Typical Section: Belubula Upstream of Trib A Straight (346-Downstream)

Photo 6 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 project 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 7). 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 7 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 7 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 8). 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 9). 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 8 Typical Section: Trib FG Downstream of the Forest (253-Upstream)

Photo 9 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 will be covered by project infrastructure including the waste rock emplacement, Raw Water Management Facility (RWMF) 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 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 10). 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 11). 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 10 Typical Section: Trib F Partly Cleared (263-Downstream)

Photo 11 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 12). 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 12 Typical Section: Trib E Upstream (171-Upstream)

Photo 13 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 14). 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 14 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 15). 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 16). 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 15 Typical Section: Trib B Valley Confined (283-Downstream)

Photo 16 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 17).

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 18). 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 18). 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 was predominantly 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 17 Typical Section: Trib A Swampy Meadow (294-Downstream)

Photo 18 Typical Section: Trib A Channel Between Dams (298-Downstream)

Photo 19 Typical Section: Trib A Downstream of Trib B (309-Downstream)

Photo 20 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 12.

Table 12 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 13. 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 14.

Table 13 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 14 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 McPhillamys Gold Project is 2,907 hectares (ha). A small proportion of the property 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 15.

Table 15 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	2	9
Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources	2,760	207	71	136
Total	**2,907**	**218**	**73**	**145**

Table 15 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 2,907 ha). The estimated total capacity of existing farm dams eligible under harvestable rights on Regis landholdings totals 73 ML. Therefore, the remaining harvestable right equates to 145 ML.

The project area itself is located within the *Water Sharing Plan for Lachlan Unregulated and Alluvial Water Sources* zone. Table 15 illustrates that the remaining harvestable right within this zone equates to 136 ML. This equates to capture of all runoff (at a rate of 0.75 ML/ha per year) from an area of 181 ha.

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 86 ha. This is within the harvestable right area by 95 ha or a yield (at 0.75 ML/ha per year) of 7.1 ML/year.

3.0 PROPOSED SURFACE WATER MANAGEMENT

3.1 WATER MANAGEMENT SYSTEM

The mine development 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 site 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 source and expected water 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 pipeline supply water); or
- development/construction water (i.e. runoff from disturbed areas and unestablished rehabilitation which is potentially sediment-laden).

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 services plans (refer Figure 8 to Figure 12). 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 8 to Figure 12). 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 channels, dams, pumps and pipelines shown in Figure 13. Clean water would be directed to six diversion dams sized to contain total runoff from a 1:100 (1%) AEP, 72 hour duration rainfall event with dewatering within 10 days of such an event. The TSF Clean Water Facility (CWF) would be in place prior to the commencement of construction of the TSF main embankment (i.e. in Month 9) to capture and divert (via pumping) upslope clean water runoff. The TSF CWF would be dewatered and decommissioned at the end of Month 13 to allow for commissioning of the TSF. The Clean Water Collection and Diversion Facility (CWCDF) and CWF1 would both be commissioned at the same time as the TSF CWF and would remain in place for the duration of the mine development. CWF2 would be commissioned in Month 8 when the RWMF embankment construction is due to commence. CWF2 would remain in place for the duration of the mine development. CWF3 and CWF4 would both be commissioned at the end of Month 8 when the construction of the site access road is due to take place. CWF3 and CWF4 would both remain in place for the duration of the mine development. A pump and associated pipeline would be installed for each diversion dam, capable of dewatering the design runoff volume of each in 10 days, with the pipeline outlet located downstream of the proposed TSF and associated TSF Runoff WMF (refer Figure 13).

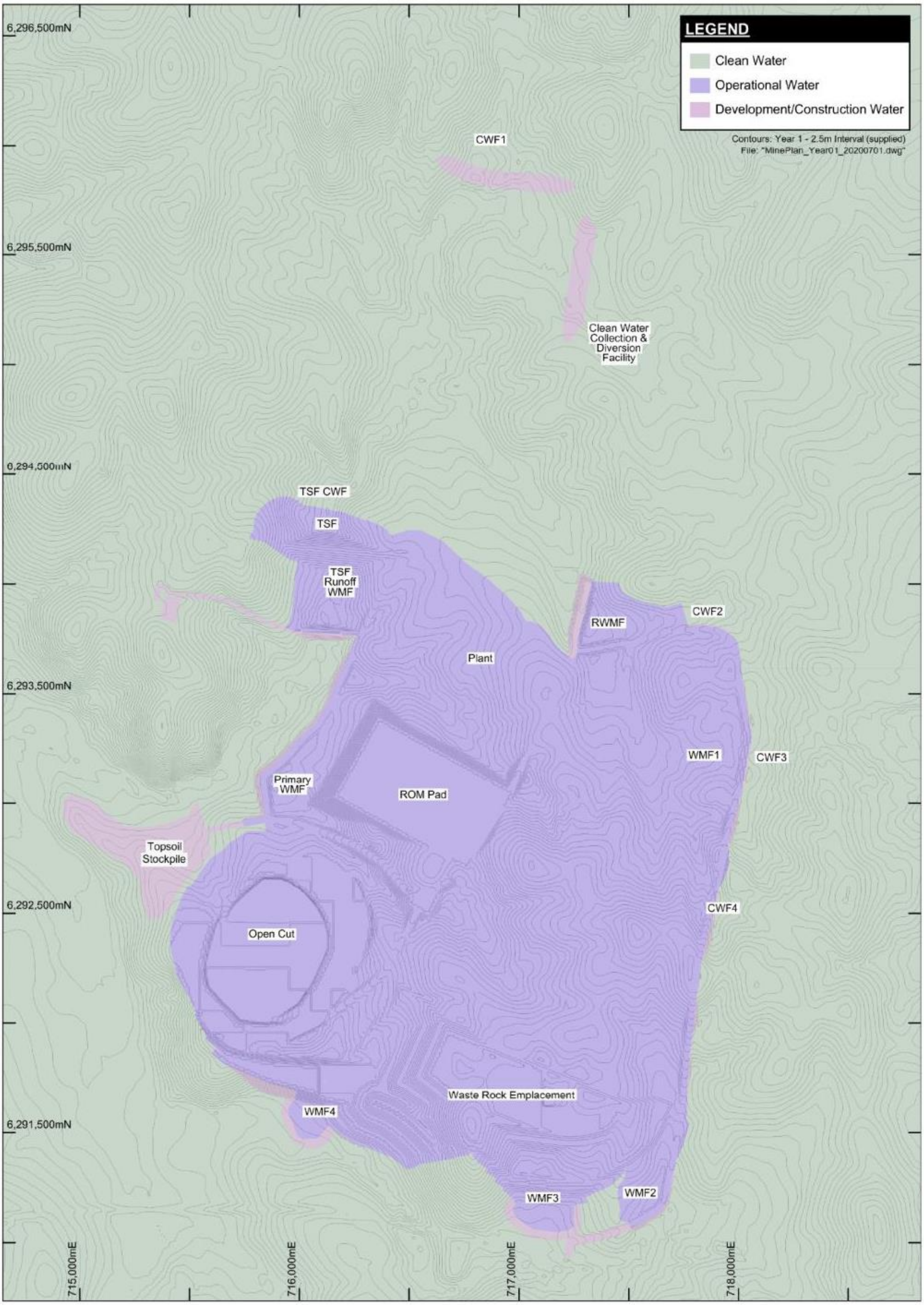

Figure 8 Proposed Catchment Classifications – Year 1

Figure 9 Proposed Catchment Classifications – Year 2

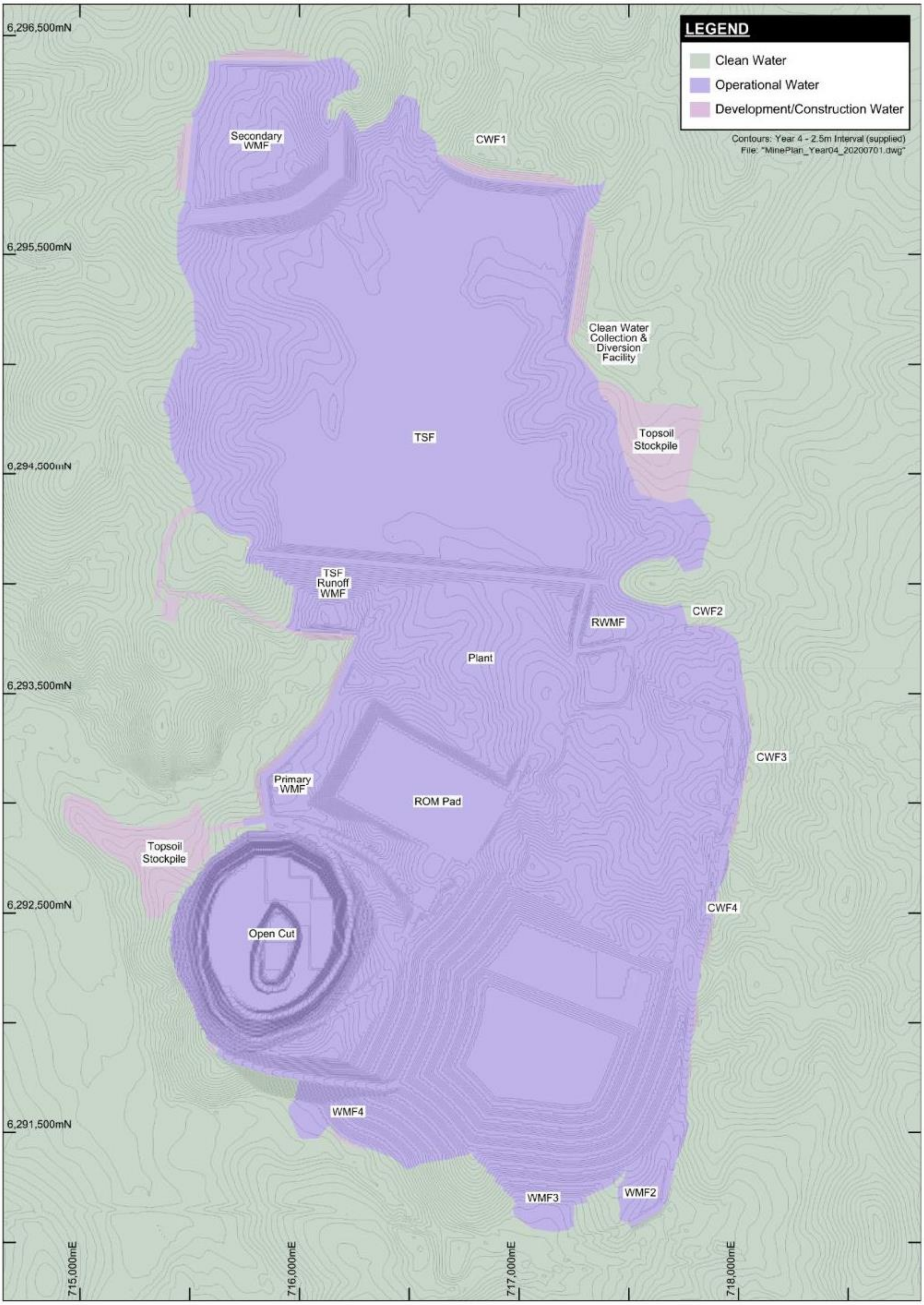

Figure 10 Proposed Catchment Classifications – Year 4

Figure 11 Proposed Catchment Classifications – Year 8

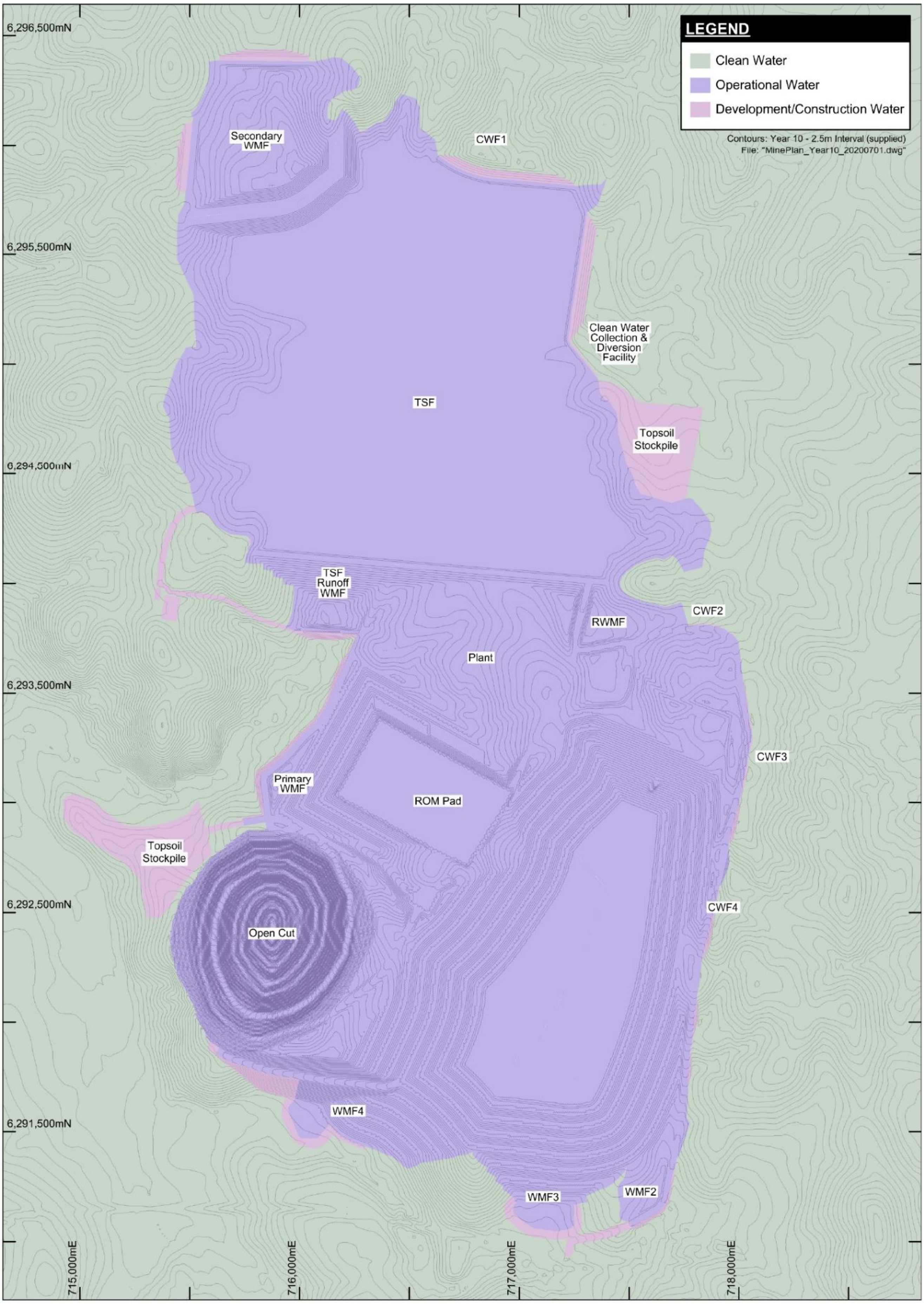

Figure 12 Proposed Catchment Classifications – Year 10

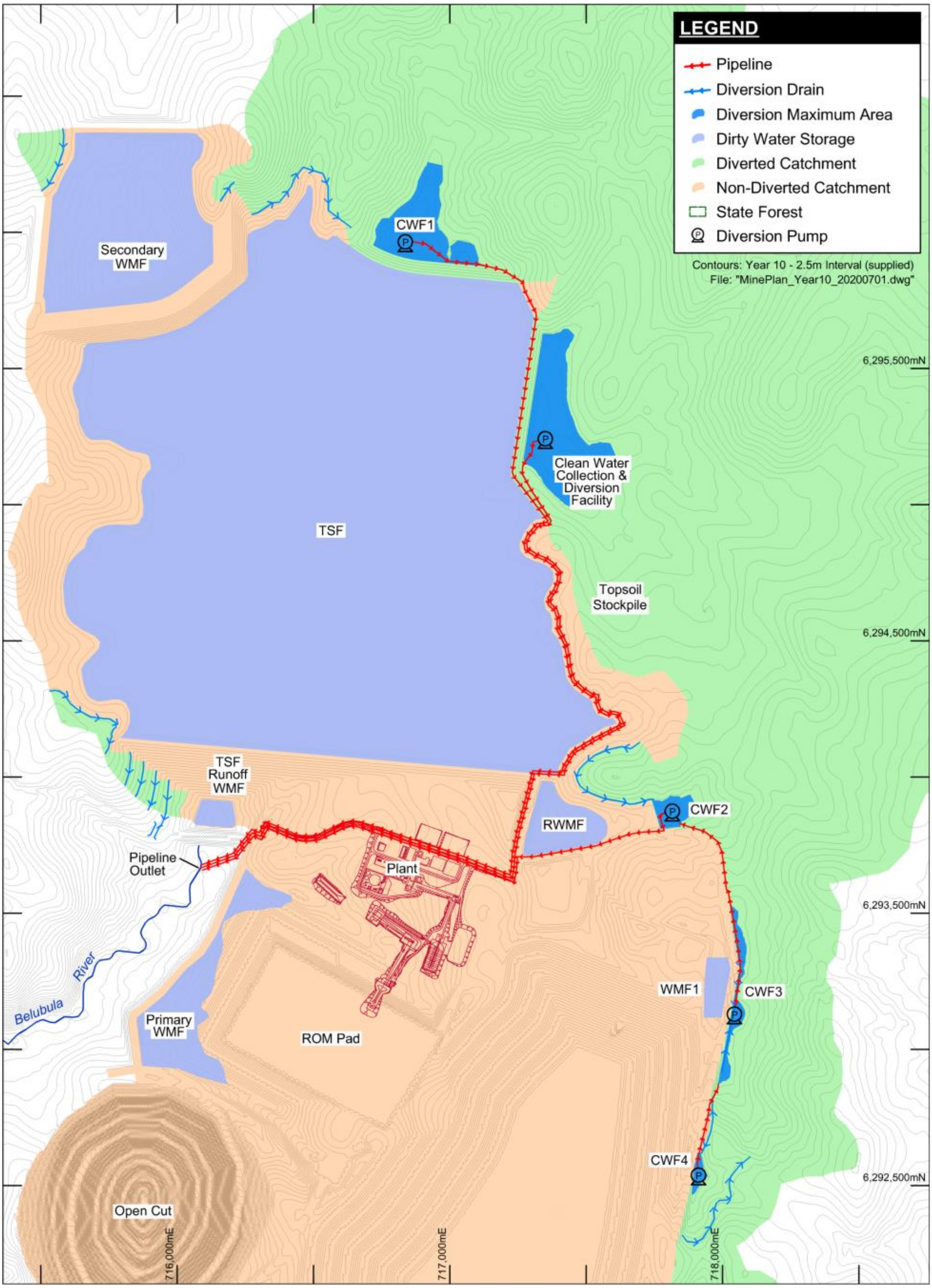

Figure 13 Clean Water Diversion System – During Mining

Table 16 summarises the 1% AEP, 72 hour design runoff volume for each of the clean water diversion dams and provides the design pump rate and associated length.

Table 16 Clean Water System Design Criteria and Proposed Capacity

Diversion Dam	1% AEP Design Runoff Volume (ML)	Estimated Pump Rate for 10 Day Dewatering of 1% AEP Design Capacity (L/s)	Estimated Pipeline Length (m)	Proposed Capacity for No Spill in Water Balance Simulation (ML)
TSF CWF	174.2	202	958	275
CWCDF	196.5	227	3,423	313
CWF1	76.3	88	4,230	124
CWF2	9.7	11	2,006	18
CWF3	21.1	24	560	36
CWF4	2.1	2	309	7

A GoldSim water balance model of the six 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 end of mining (i.e. 10 years). The model simulates 129 "realizations" derived using historical daily climatic data from 1889 to 2017. The first realization uses climatic data from 1889 to 1898, the second uses data from 1890 to 1899 and the third from 1891 to 1900 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.

Rainfall runoff modelling was carried out in line with assumptions provided 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 the pump rates given in Table 16. The 1% AEP design runoff volumes given in Table 16 were used as an initial basis for checking if spill was simulated and the capacity of each dam increased until spill was not simulated. The resulting proposed capacity is provided in Table 16. Graphs of simulated water inventory for each of the six dams are provided in Attachment C 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 green line representing the 95th percentile volumes and the broken green lines representing the 99^{h} percentile volumes. It is important to note that none of these plots represents a single climatic realization – these probability plots are compiled from all 129 realizations – e.g. the median volume plot does not represent model forecast volume for median climatic conditions. The plots in Attachment C show that the 99th percentile volumes do not exceed the proposed capacities.

An engineered stilling basin would be located at the pipeline outlet given the high total design flow rates in Table 16. The stilling basin 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.

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 defined as part of the operational water system for the mine development (refer Figure 8 to Figure 12). The operational water system also includes external water supply imported to site via the supply pipeline 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 14, Figure 15, Figure 16 and Figure 18 show the planned surface water management features, catchment and sub-catchment areas for the Year 1, Year 2, Year 4, Year 8 and Year 10 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 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. Figure 19 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 Secondary WMF will be the main water storage on site with a capacity of approximately 4,370 ML – completed by the end of Year 2. Note that prior to this date, the Secondary WMF will be under construction however by mid-way through Year 2, its water storage capacity would be approximately 1,000 ML. Operational water captured in other storages will be pumped to the Secondary WMF which then supplies water to the Process Plant (via the Process Water Tank) as a second priority and truckfill (for haul road dust suppression) as a first priority. Prior to capacity being available in the Secondary WMF (i.e. prior to mid-way through Year 2) operational water will be pumped to the Primary WMF which will be the first priority for supply to the Process Plant (prior to commissioning of the TSF) and truckfill.

Processing will commence in Year 2 and from this time tailings will be pumped to the TSF with tailings decant water[4] recovered via pumping direct to the Process Plant (first priority) or to the Secondary WMF. A seepage management system will be implemented for the TSF in accordance with leading best practice (ATCW, 2019). 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. Any seepage from the TSF will be captured in a subsurface seepage collection system located at the toe of the TSF main embankment and will be pumped back to the TSF[5]. Seepage interception bores will be

[4] 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.

[5] Information provided by ATCW.

constructed downstream of the TSF seepage collection system to intercept any potential seepage before it progresses further downstream.

The Primary WMF, WMF1, WMF2, WMF3 and WMF4 will capture runoff from the waste rock emplacement and other infrastructure areas with accumulated water pumped to the Secondary WMF. These dams will spill externally hence have been sized to have a spill risk of less than 1% (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.

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

The RWMF will be the receiving storage for external water imported to site and will supply both the Process Plant (third priority to the TSF and the Secondary WMF) and truckfill (second priority to the Secondary WMF). External water will start to be imported once the RWMF is commissioned in Month 8. The RWMF will also top up the Secondary WMF (once commissioned) to increase supply reliability during extended dry periods.

The site will be equipped with a Reverse Osmosis plant for the production of potable water.

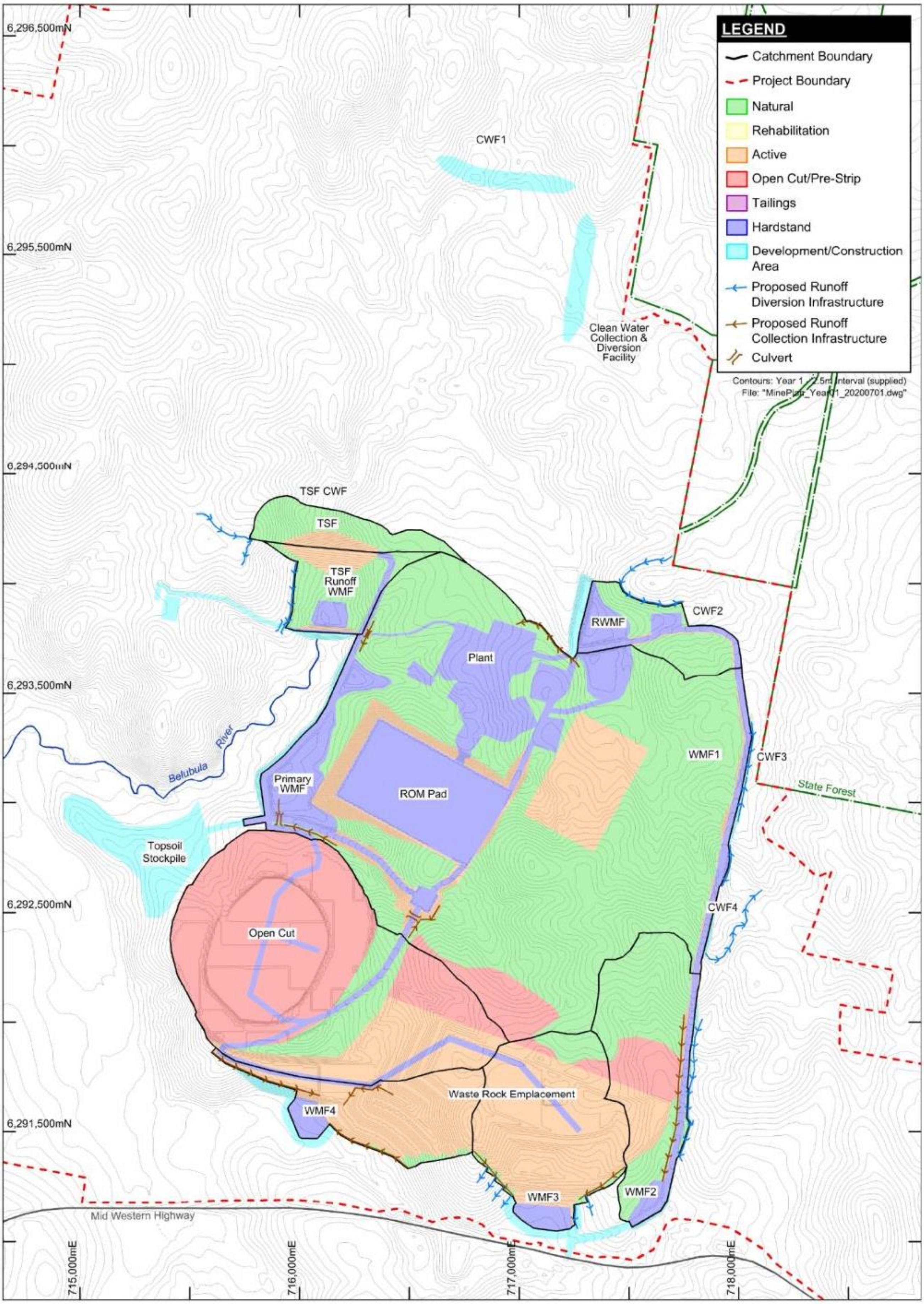

Figure 14 Operational Water System – Year 1

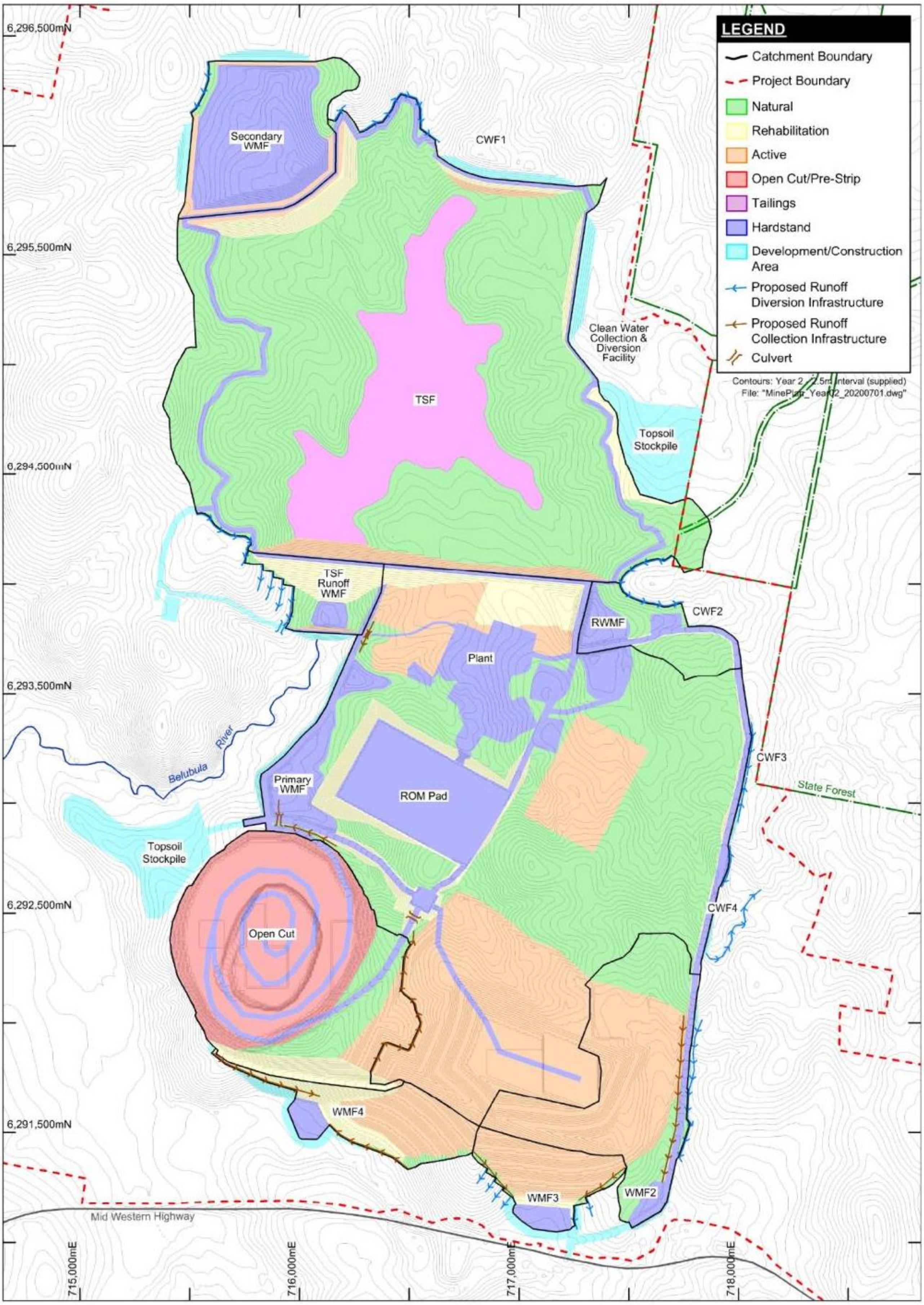

Figure 15 Operational Water System – Year 2

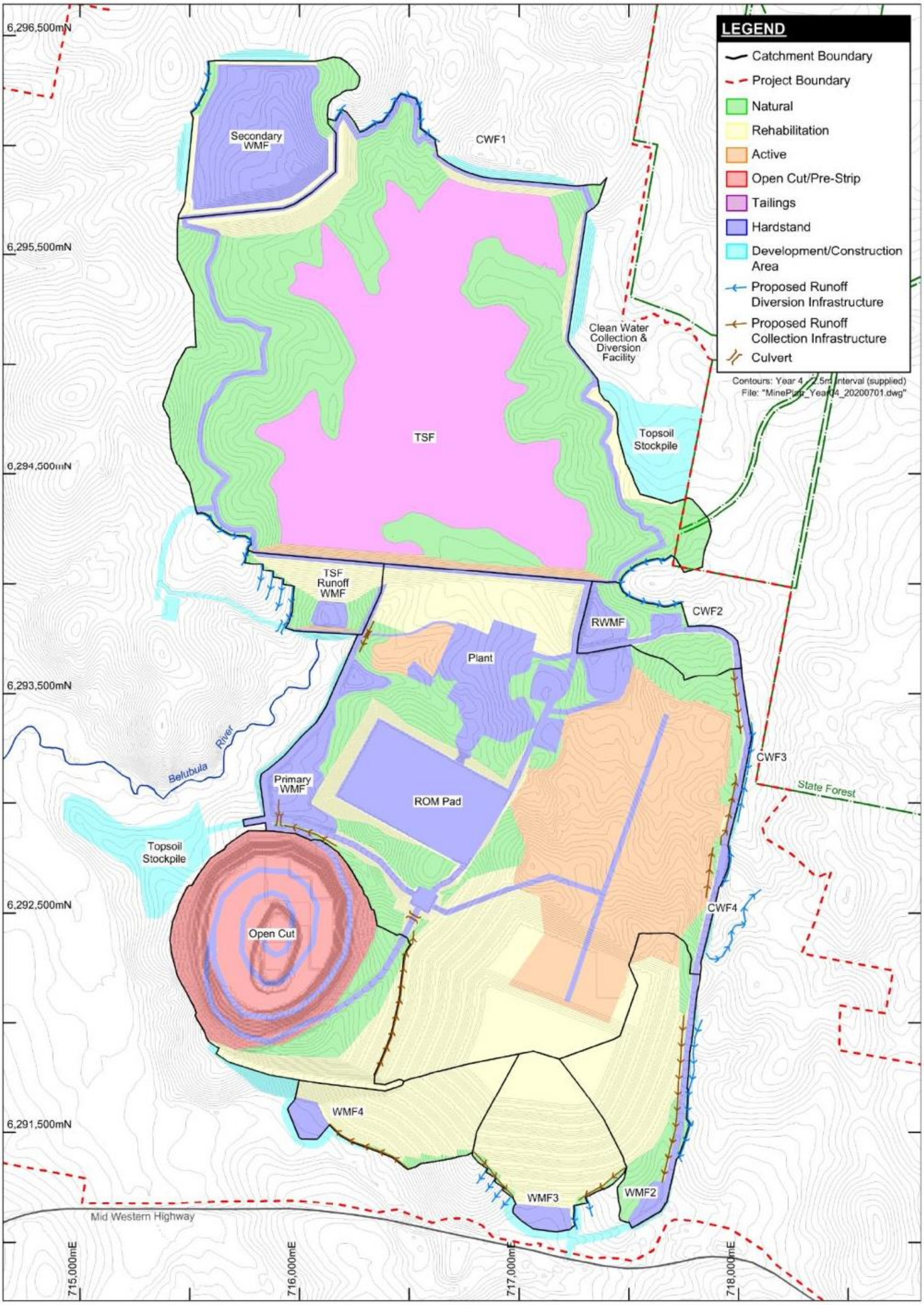

Figure 16 Operational Water System – Year 4

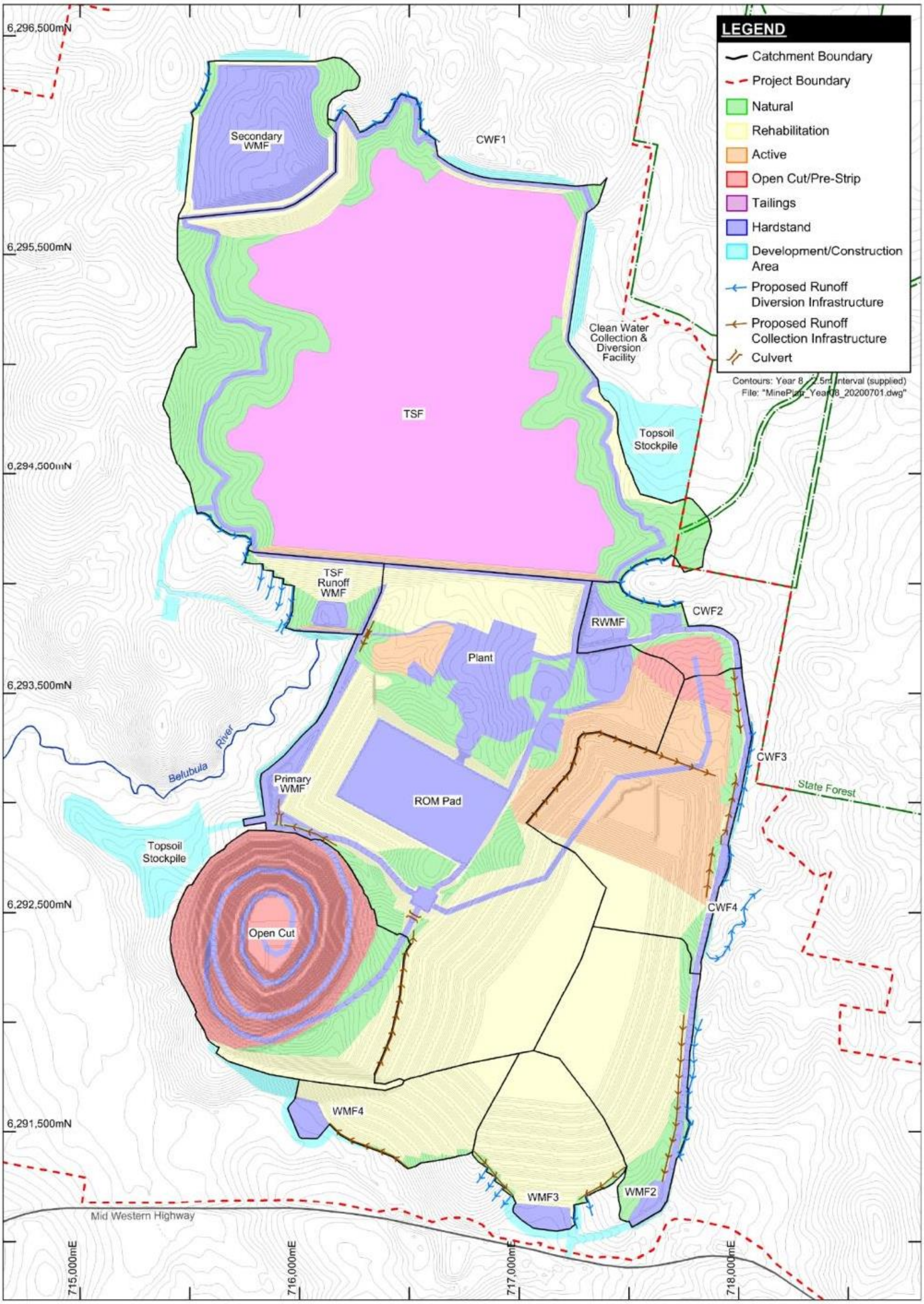

Figure 17 Operational Water System – Year 8

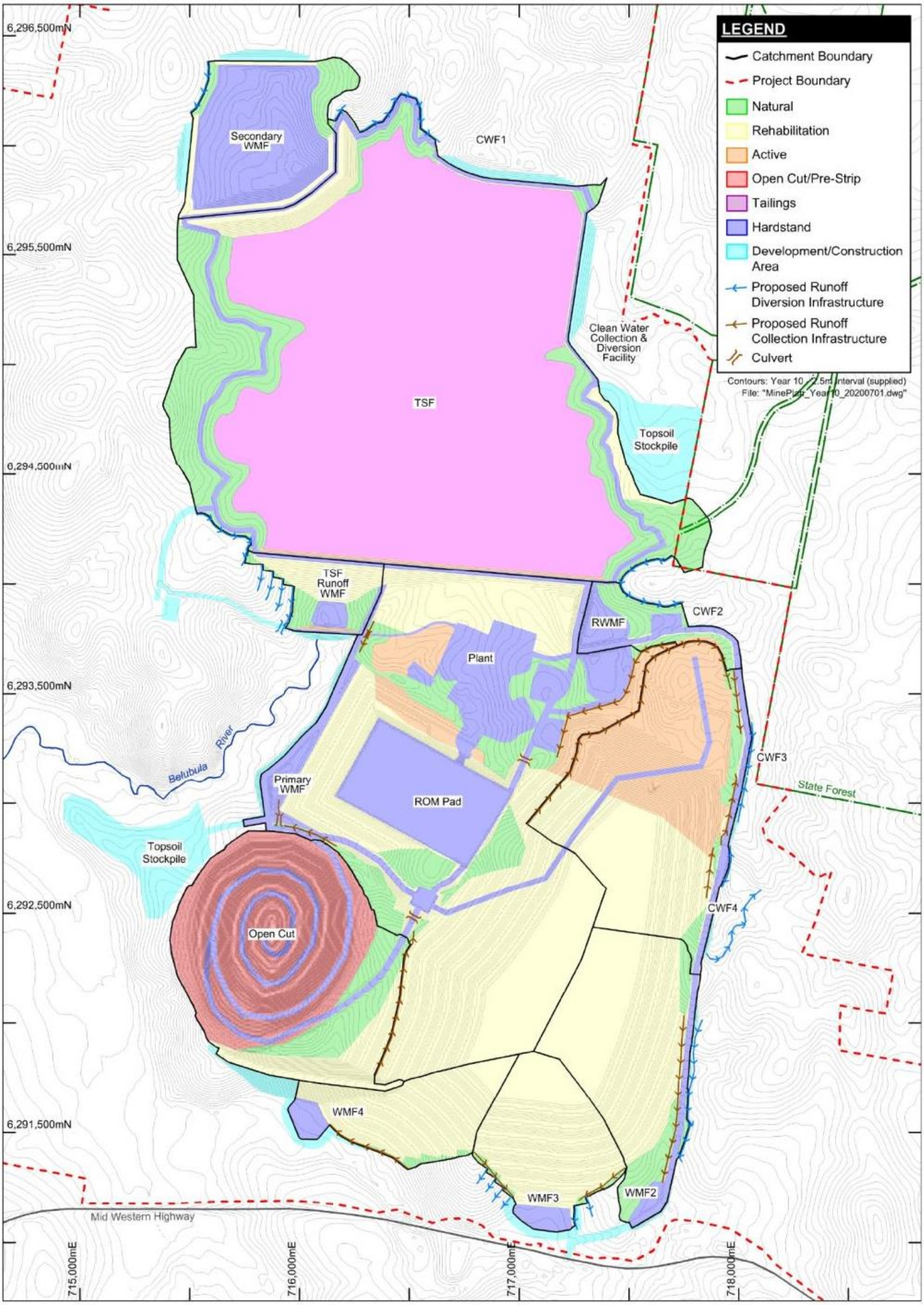

Figure 18 Operational Water System – Year 10

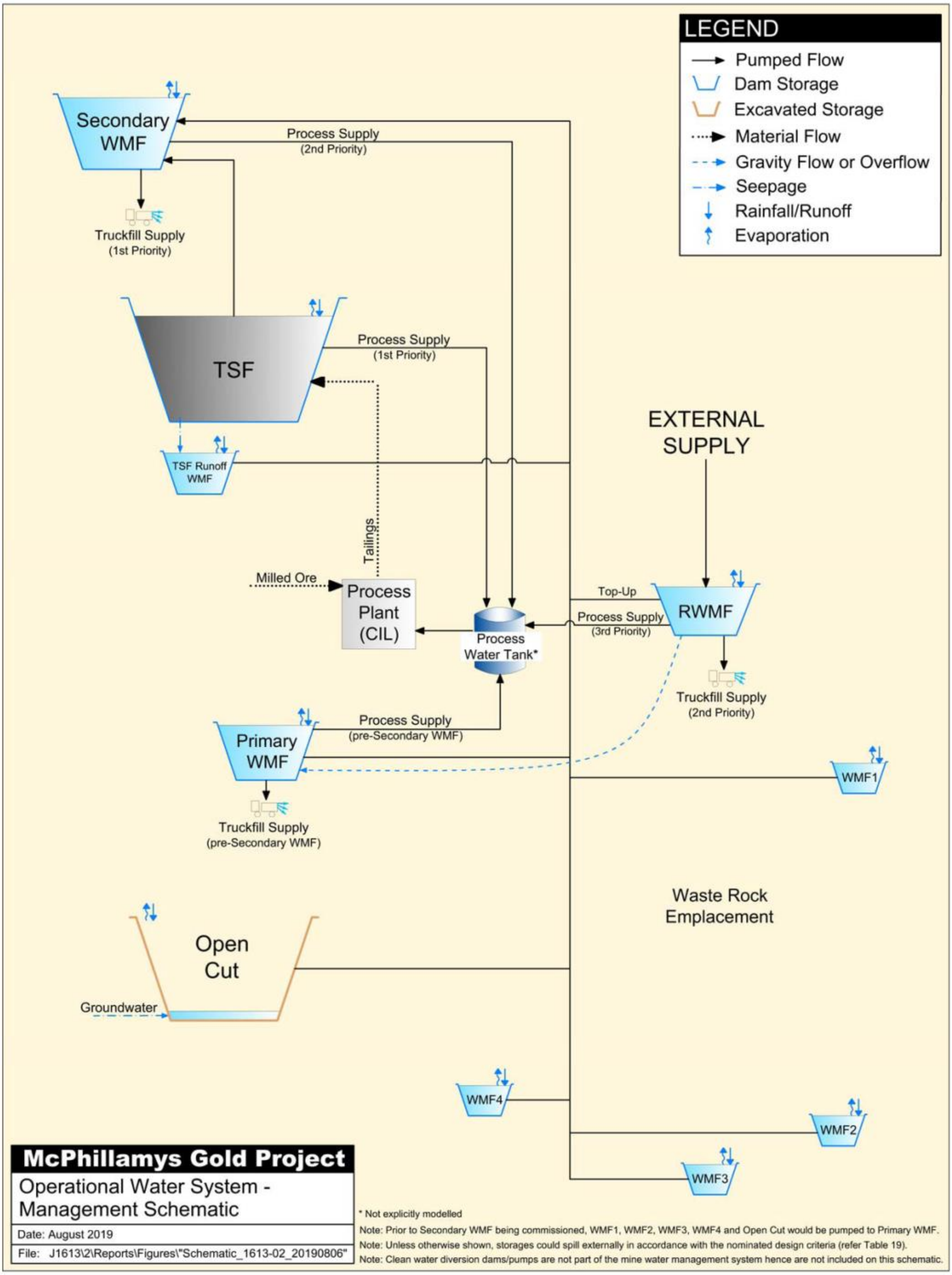

Figure 19 Operational Water System – Management Schematic

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 development (refer Figure 8 to Figure 12). 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 DECCW (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.

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. straw bale sediment filters, 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.

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. 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.

An Erosion and Sediment Control Plan would be developed to detail the erosion and sediment control measures to be implemented during construction and operation of 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 assessing:

- 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 dams; 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 19. The model has been developed using the GoldSim® simulation package. The model 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 external 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 end of mining (i.e. 10 years). The model simulates 129 "realizations" derived using historical daily climatic data[6] from 1889 to 2017. The first realization uses climatic data from 1889 to 1898, the second uses data from 1890 to 1899 and the third from 1891 to 1900 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 and Assumptions

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 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 14 through to Figure

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

18. Figure 20 summarises the total catchment area reporting to the operational water management system over time.

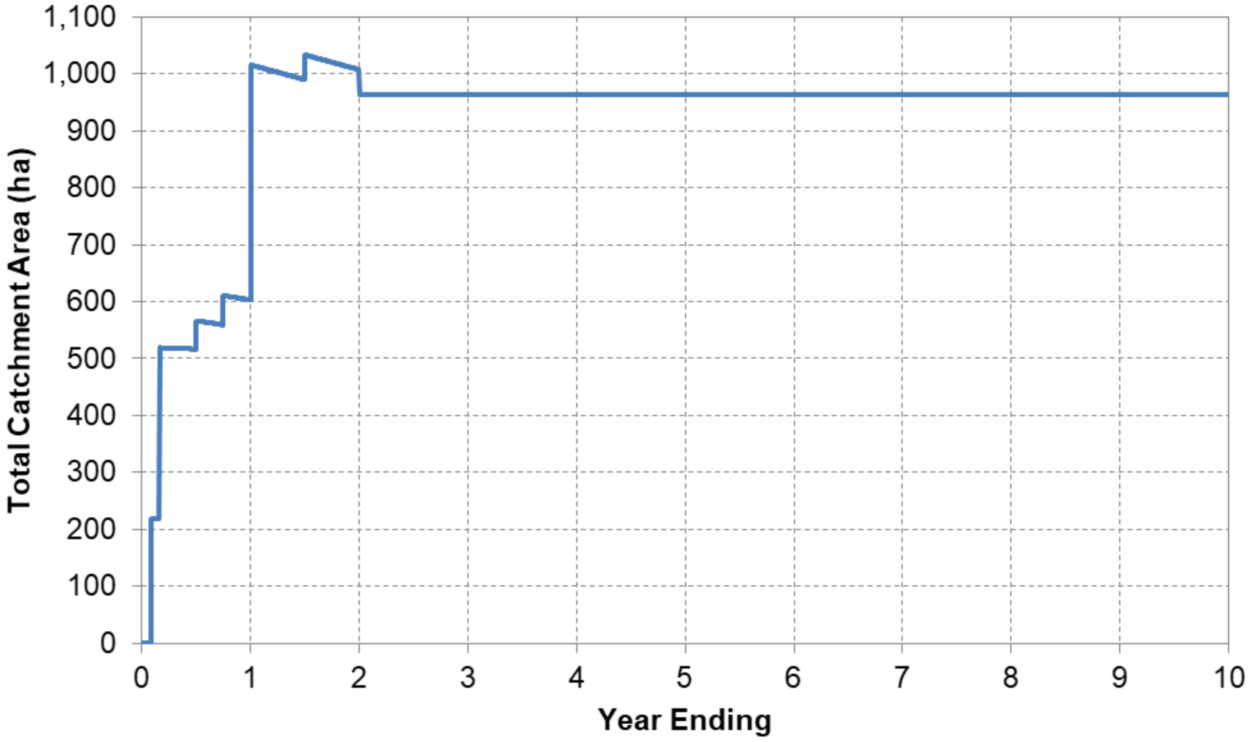


Figure 20 Operational Water System – Catchment Area Over Time

Figure 20 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 2 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 stage.

Daily pan evaporation was multiplied by a pan factor in the calculation of storage evaporation losses for 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 17.

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 17 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

The Process Plant make-up water demand is required to replace water pumped to the TSF with tailings. Annual Process Plant demand is summarised in Table 18 and was based on:

- indicative future processing tonnages (refer Table 18);
- ore moisture of 3% (w/w); and
- tailings solids concentration of 62%.

Table 18 Indicative Ore Processing Rates and Process Plant Demand

Year	Dry Ore Milled (Million tonnes)	Process Plant Demand (ML/d*)
1	0	0
2	4.7	7.54
3	7.0	11.15
4	7.0	11.15
5	7.0	11.18
6	7.0	11.15
7	7.0	11.15
8	7.0	11.15
9	7.0	11.18
10	5.9	9.41

* megalitres/day

The model calculates water liberated as tailings settle ('decant' water – refer Section 3.1.2) which is available for reclaim as a proportion of water pumped with the tailings. 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.

Seepage has not been simulated as it is assumed that any seepage from the TSF would be predominantly captured by the seepage management system before being returned to the water management system (ATCW, 2019).

3.2.2.5 Haul Road Dust Suppression Demand

Truckfill demand (i.e. for haul road dust suppresion) was calculated based on active haul road lengths calculated from the mine stage plans provided (refer Figure 14 to Figure 18) multiplied by an assumed 30 m watering width. Note that haul road lengths are lineraly 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 set to 4.8 ML/d based on two 50 tonne trucks running twice an hour, 24 hours a day (advice from Regis). Calculated haul road dust suppression demand is summarised in Figure 21. Early in the simulation period the median demand varies from approximately 0.3 ML/d in winter months to the maximum of 4.8 ML/d in the summer months. From Year 3, the median demand ranges from approximately 0.3 ML/d in winter months to the 3.0 ML/d in the summer months. The average annual haul road dust suppression demand over the operational period was predicted as 503 ML/year. For modelling purposes demand was assumed drawn from the Secondary WMF as a first priority (or Primary WMF prior to the Secondary WMF being commissioned) and RWMF as a second priority.

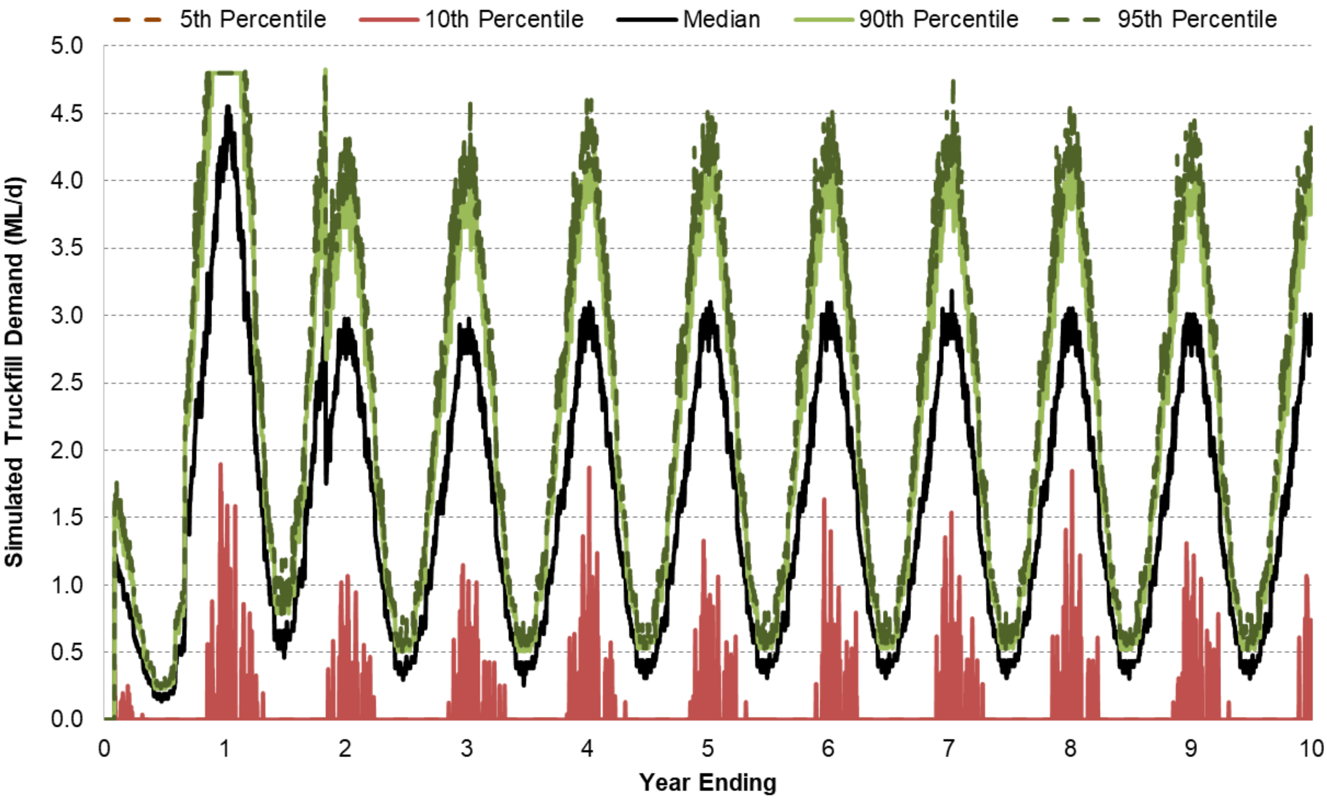


Figure 21 Simulated Haul Road Dust Suppression Demand

3.2.2.6 Groundwater Inflow

Groundwater inflow to the open cut was set to a time-varying rate as predicted by groundwater modelling (EMM, 2019c). 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 22.

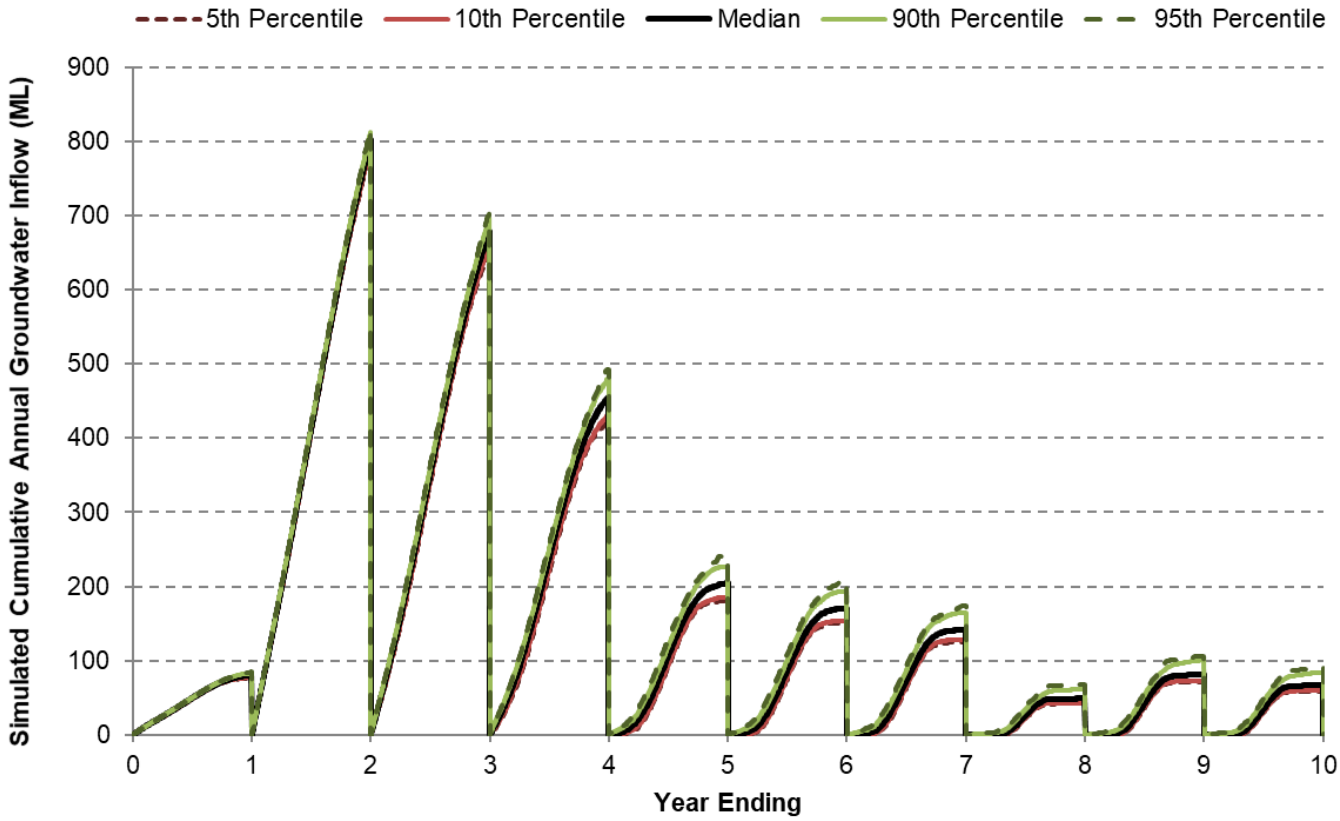


Figure 22 Simulated Groundwater Inflow Net of Evaporation

3.2.2.7 External Supply

Supply of water from Angus Place, SCSO and MPPS via the external supply pipeline has been included in the model at a maximum rate of 15.6 ML/d available from the start of Month 8 when the RWMF is commissioned. Operating "trigger" volumes have been assumed in the model (refer Section 3.2.2.8) to define when water would be sourced from the external pipeline. External supply water would be pumped to the RWMF to either directly supply demands or top-up the Secondary WMF.

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 specific design criteria as summarised in Table 19. For WMF1, WMF2, WMF3, WMF4 and the Primary WMF which spill externally, a spill risk assessment identified an acceptable spill risk for each dam and iterative simulations were carried out to identify the required capacity. All storages were assumed empty at the start of the simulation.

Table 19 Modelled Storage Capacities and Design Criteria

Storage	Capacity (ML)	Design Criterion
WMF1	109.9	<1% annual spill risk
WMF2	143.8	<1% annual spill risk
WMF3	105.5	<1% annual spill risk
WMF4	141.3	<1% annual spill risk
Primary WMF	442.0 or 133.6*	<1% annual spill risk
Secondary WMF	4,370.7	No spill simulated
RWMF	309.1	<1% annual spill risk
TSF	Varies	No spill simulated
TSF Runoff WMF	272.0	<1% annual spill risk

* Capacity of Primary WMF decreases in Year 6 as a result of ROM Pad rehabilitation activities.

As noted in Table 19, the capacity of the TSF varies depending on embankment construction stage and tailings deposition level (refer Figure 23). 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 and reclaim pumping do not commence until the start of Year 2. The TSF reclaim pumping rate and Secondary WMF trigger level were set so that no spills were simulated from either the TSF or the Secondary WMF.

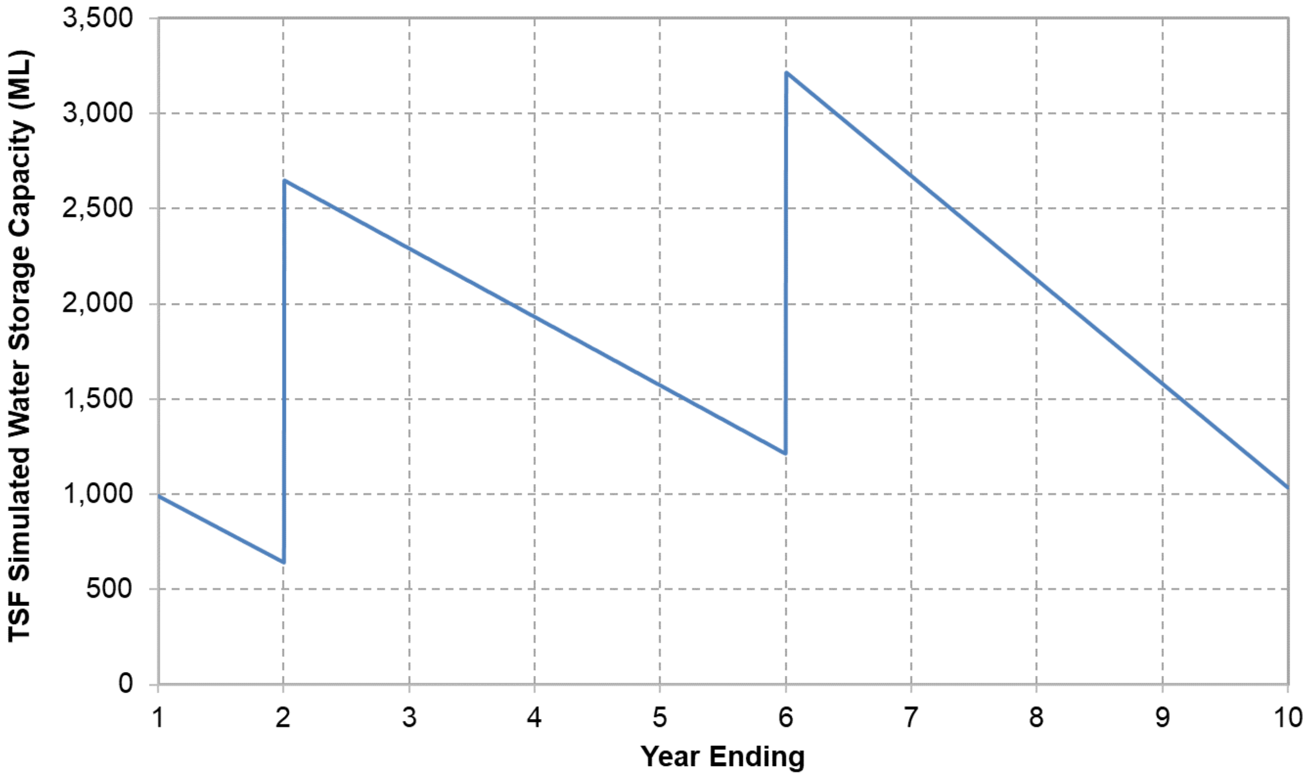


Figure 23 Assumed Time-Varying Capacity of TSF

Modelled transfer rates between storages are summarised in Table 20. Operating volumes and transfer rates were set based on optimisation of the water balance model to achieve the design criteria in Table 19.

Table 20 Modelled Operating Volumes and Transfer Rates

From	To	Pumping Conditions	Transfer Rate (L/s)
WMF1	Primary WMF	If Secondary WMF not commissioned; AND WMF1 stores greater than 90% of capacity (i.e. 99 ML); AND Primary WMF stores less than its NOV† (i.e. 398 ML or 120.2ML$^{\Delta}$)	40
	Secondary WMF	If Secondary WMF commissioned; AND WMF1 stores greater than dead storage (i.e. 3 ML); AND Secondary WMF stores less than its NOV (i.e. 3,846 ML)	
WMF2	Primary WMF	If Secondary WMF not commissioned; AND WMF2 stores greater than 10% of capacity (i.e. 14 ML); AND Primary WMF stores less than its NOV (i.e. 398 ML or 120.2ML$^{\Delta}$)	40
	Secondary WMF	If Secondary WMF commissioned; AND WMF2 stores greater than dead storage (i.e. 3 ML); AND Secondary WMF stores less than its NOV (i.e. 3,846 ML)	
WMF3	Primary WMF	If Secondary WMF not commissioned; AND WMF3 stores greater than 80% of capacity (i.e. 84 ML); AND Primary WMF stores less than its NOV (i.e. 398 ML or 120.2ML$^{\Delta}$)	20
	Secondary WMF	If Secondary WMF commissioned; AND WMF3 stores greater than dead storage (i.e. 7 ML); AND Secondary WMF stores less than its NOV (i.e. 3,846 ML)	
WMF4	Primary WMF	If Secondary WMF not commissioned; AND WMF4 stores greater than 90% of capacity (i.e. 127 ML); AND Primary WMF stores less than its NOV (i.e. 398 ML or 120.2ML$^{\Delta}$)	20
	Secondary WMF	If Secondary WMF commissioned; AND WMF4 stores greater than dead storage (i.e. 8 ML); AND Secondary WMF stores less than its NOV (i.e. 3,846 ML)	
Primary WMF	Open Cut	If Secondary WMF not commissioned; AND Primary WMF stores greater than 70% of capacity (i.e. 309 ML or 93.5 ML$^{\Delta}$)	400
	Secondary WMF	If Secondary WMF commissioned; AND Primary WMF stores greater than dead storage (i.e. 20 ML); AND Secondary WMF stores less than its NOV (i.e. 3,846 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.

† Normal Operating Volume.

$^{\Delta}$ Note that the volumes stated for the Primary WMF will change depending on the extent of the ROM Pad.

** Maximum Operating Volume.

‡ High Operating Volume.

Table 20 (Continued) Modelled Operating Volumes and Transfer Rates

From	To	Pumping Conditions	Transfer Rate (L/s)
Open Cut	Primary WMF	If Secondary WMF not commissioned; AND open cut stores greater than dead storage (i.e. 1 ML); AND Primary WMF stores less than its NOV (i.e. 398 ML or 120.2ML[Δ])	100/300*
	Secondary WMF	If Secondary WMF commissioned; AND open cut stores greater than dead storage (i.e. 1 ML); AND Secondary WMF stores less than its HOV[‡] (i.e. 4,152 ML)	100/300*
RWMF	Water Demand	If RWMF stores greater than dead storage (i.e. 1 ML); AND there is shortfall from Secondary WMF	200
	Secondary WMF	If RWMF stores greater than dead storage (i.e. 1 ML); AND Secondary WMF stores less than its MOV** (i.e. 2,185 ML)	
Secondary WMF	Water Demand	If Secondary WMF stores greater than dead storage (i.e. 10 ML); AND there is shortfall from TSF	200
TSF	Process Demand	If TSF stores greater than dead storage (i.e. 100 ML)	Not pump limited
	Primary WMF	If Secondary WMF not commissioned; AND TSF stores greater than dead storage (i.e. 100 ML); AND Primary WMF stores less than its NOV (i.e. 398 ML or 120.2ML[Δ])	150
	Secondary WMF	If Secondary WMF commissioned; AND TSF stores greater than dead storage (i.e. 100 ML); AND Secondary WMF stores less than its HOV (i.e. 4,152 ML)	

* 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.

Δ Note that the volumes stated for the Primary WMF will change depending on the extent of the ROM Pad.

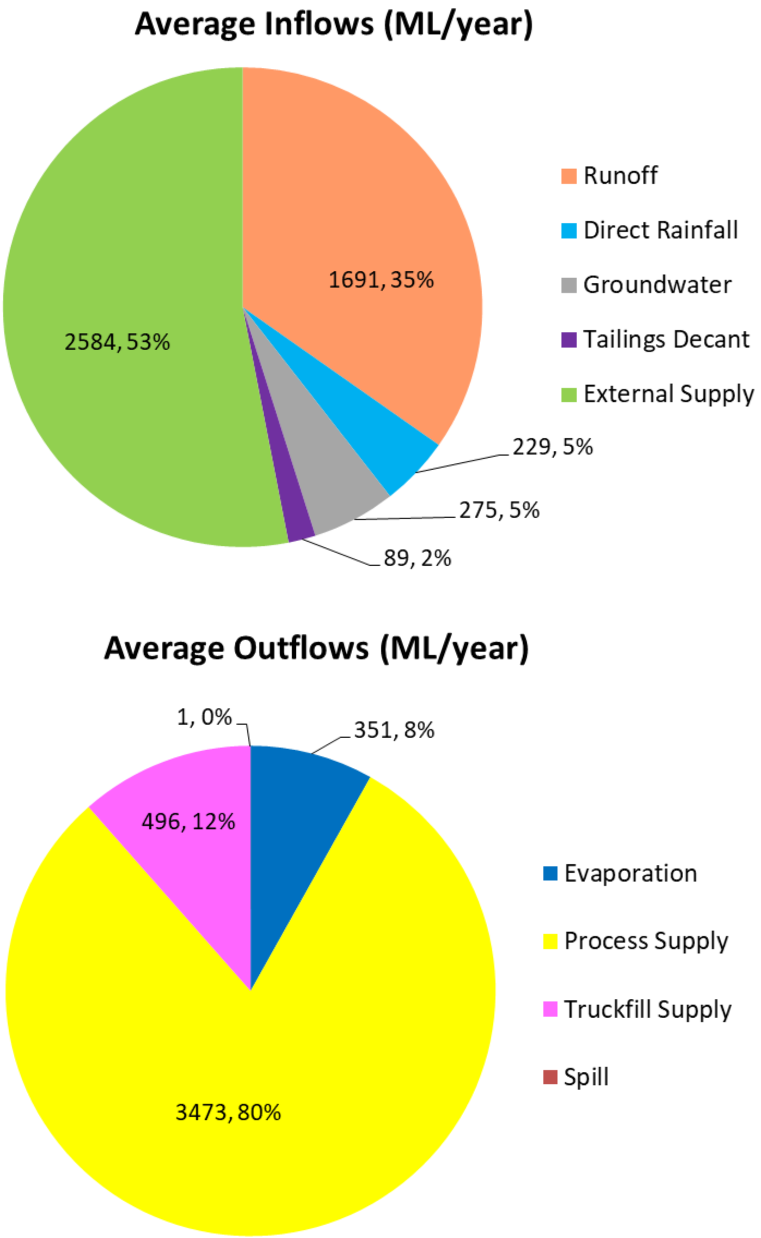
** Maximum Operating Volume.

‡ 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 24. Model results indicate that, on average, external supply provides the highest system inflow (53%) of the total inflow followed by runoff from the operational water management system. The majority of outflows (80%) comprise Process Plant supply followed by supply to truckfill (i.e. haul road dust suppression). There is a low risk of spill – refer Section 3.2.3.6.



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

Figure 24 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 25 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 realization – these probability plots are compiled from all 129 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 Secondary WMF – the forecast 95th percentile inventory only nears the capacity while the Secondary WMF is being built (i.e. between mid-way through Year 1 and the start of Year 2).

The forecast median stored water inventory is just under 2,500 ML once the Secondary WMF is commissioned. However, in the short-term prior to the Secondary WMF 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 dry times.

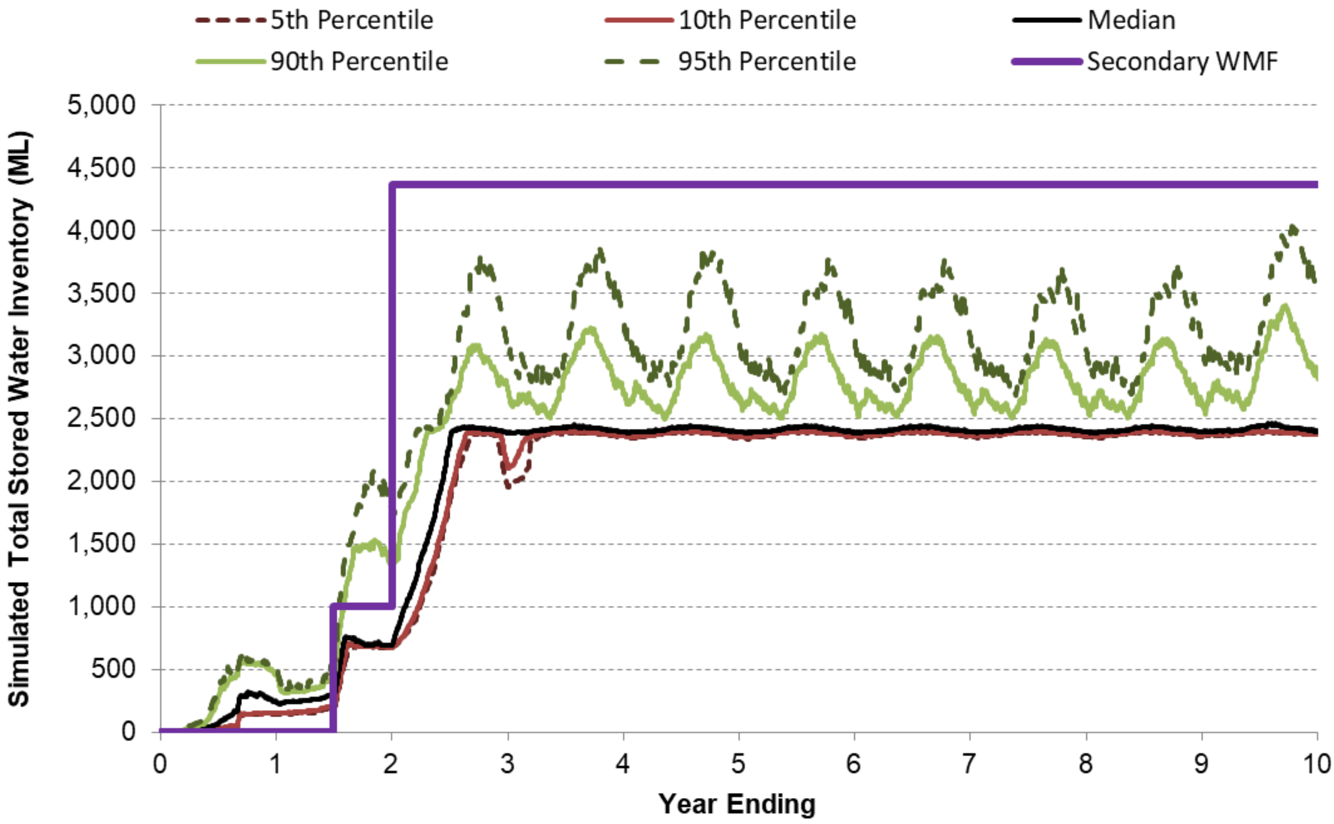


Figure 25 Simulated Total Water Inventory

3.2.3.3 Water Supply Reliability

Predicted average supply reliability is expressed as total water supplied divided by total demand (i.e. a volumetric reliability) over the simulation period. Average supply reliability over all climatic realizations, as well as the lowest single realization reliability (representing a simulated 'worst case' 10 year period), for Process Plant supply and haul road dust suppression are summarised in Table 21.

Table 21 Summary of Modelled 10 Year Water Supply Reliability

	Process Plant	Haul Road Dust Suppression
Average	99.9%	98.7%
Lowest	99.9%	98.0%

The results in Table 21 indicate a predicted high level of average supply reliability. Model simulations indicate that there is a risk of haul road dust suppression shortfall in the near term prior to the RWMF being commissioned (i.e. prior to external water being brought to site). Figure 26 shows plots of forecast annual shortfall volumes for haul road dust suppression.

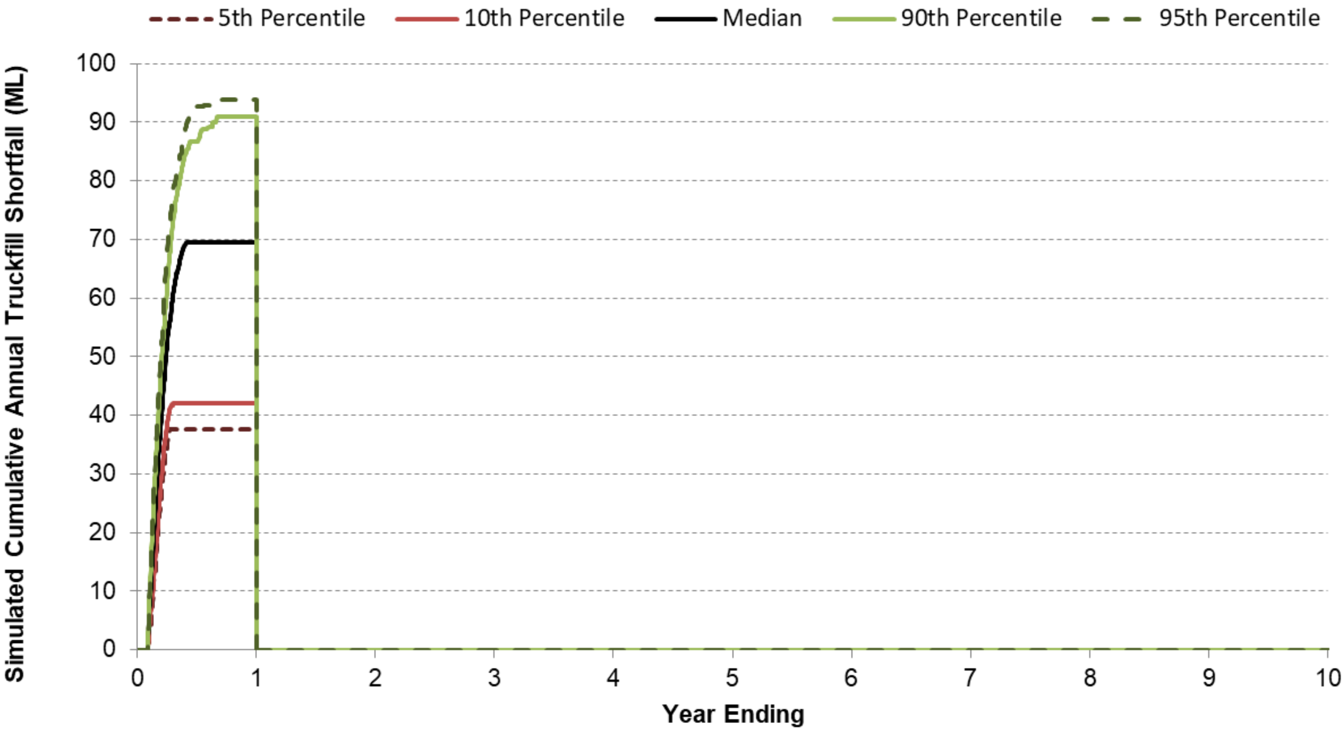


Figure 26 Simulated Annual Haul Road Dust Suppression Shortfall Volumes

Figure 26 shows a peak haul road dust suppression shortfall volume of 94 ML in Year 1 at the 95th percentile risk level. No shortfalls are predicted once the external supply pipeline is simulated to come online after Month 8.

In the period prior to external supply, haul road dust suppression water will be sourced from groundwater bores using a portion of the 400 ML/year of groundwater licences currently owned by Regis. If further water shortage occurs, Regis would investigate one or more of the following actions:

- reduce haul road dust suppression demand by the use of dust suppression agents;
- reduce site water demand by scaling back construction/production; and/or
- investigate alternative water supplies.

Annual forecast water balance modelling will inform near term water supply reliability for the mine development as it progresses. Such forecasts will allow Regis to plan for contingency measures such as those listed above.

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 fifteen days over the simulation period (or 0.4% of days) where stored water volume in the open cut exceeds 200 ML. Figure 27 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 risk occurring in the second year.

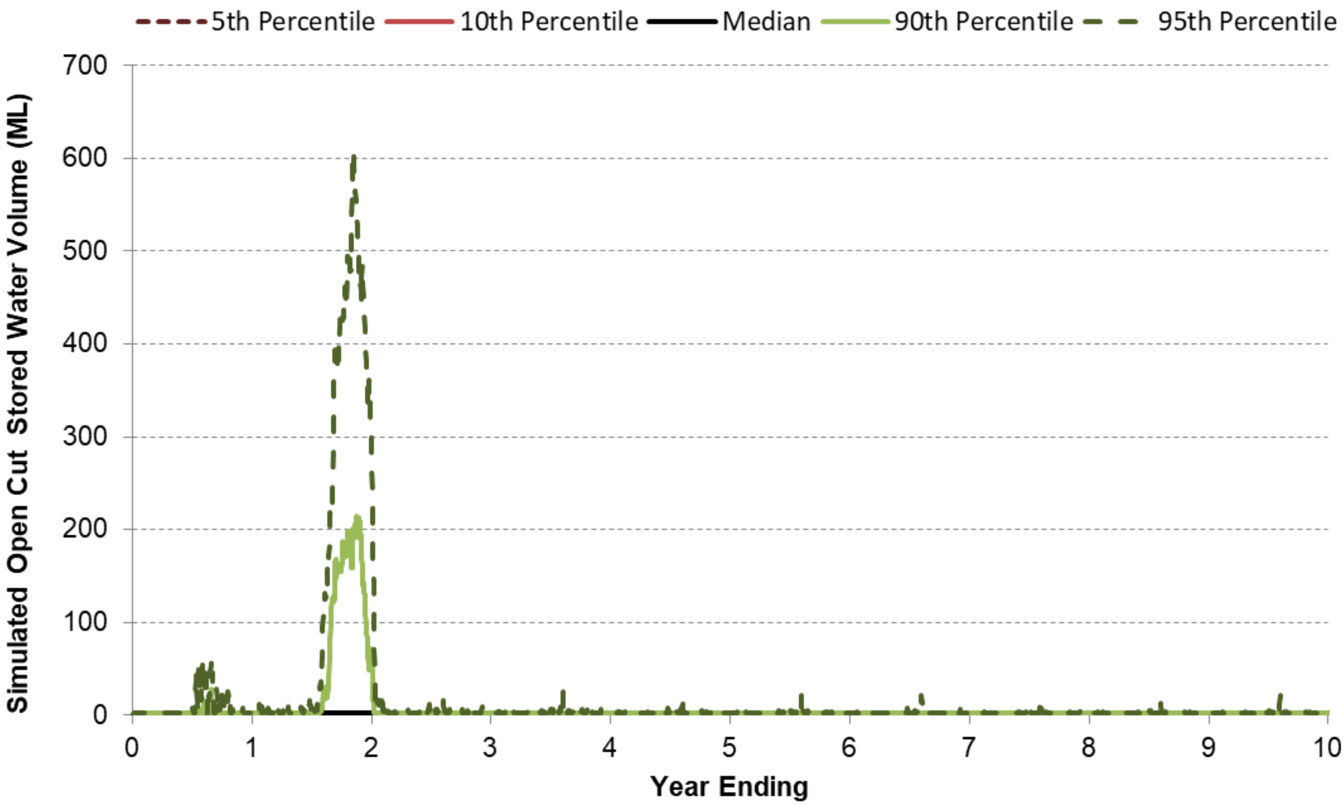


Figure 27 Simulated Open Cut Water Volumes

3.2.3.5 External Supply

External water drawn from the supply pipeline would vary through the project life. Figure 28 shows predicted annual total volume brought to site via the supply pipeline 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 3 (when the Secondary WMF is still filling up). Model results indicate that, during periods of lower rainfall (indicated by the 90th/95th percentile results) and while the Secondary WMF was filling up in Year 3, the project would make full use of its external supply (i.e. 13 ML/day for 365 days/year is 4,745 ML). However, under most circumstances, the external supply pipeline would not need to be utilised to its full capacity.

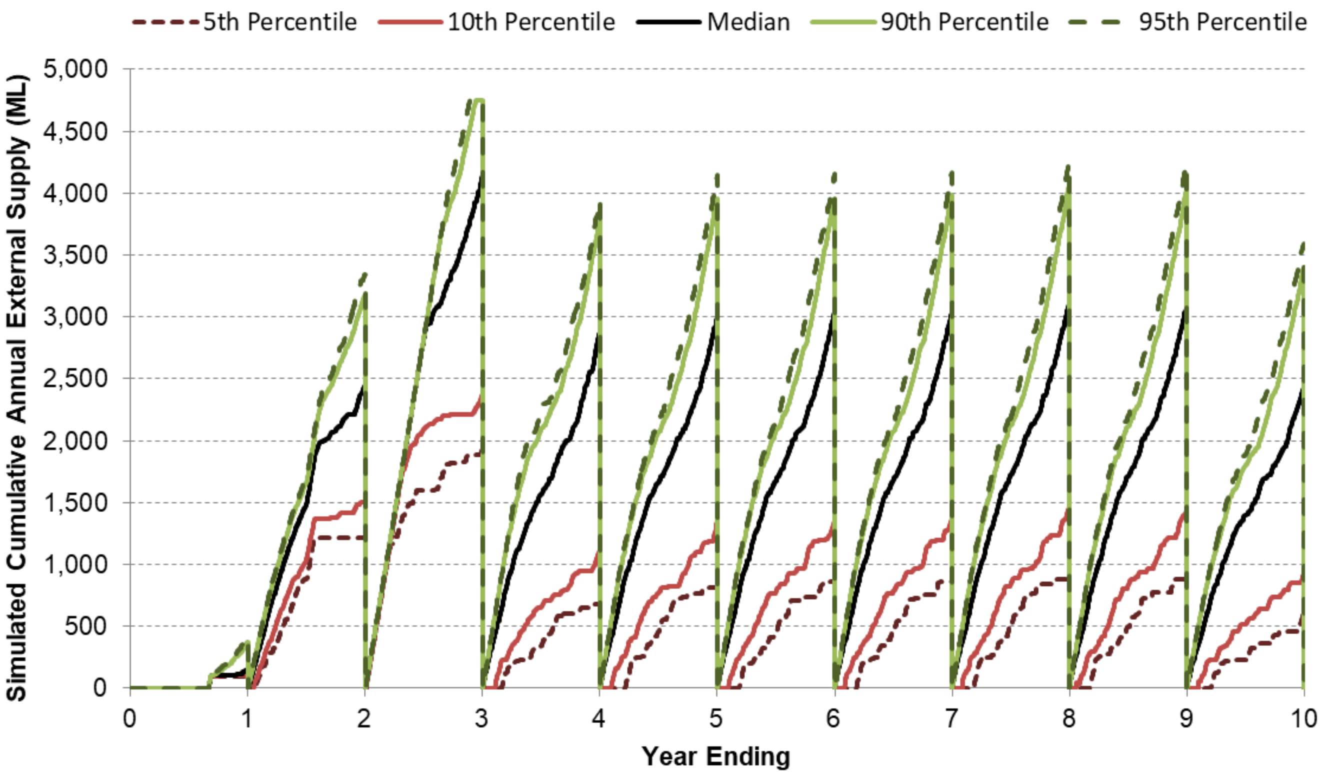


Figure 28 Simulated Annual External Supply

3.2.3.6 Spill Risk

Predicted external spill from dams are shown in Figure 29 at different probabilities. These are expressed in total megalitres over the 10 year simulation period. The simulated spill occurrences can be converted to an annual spill risk which, for all dams, is in line with the design criteria specified in Table 19 (i.e. less than 1% spill risk for WMF1, WMF2, WMF3, WMF4 and the TSF Runoff WMF and no simulated spills from the Primary WMF, Secondary WMF or the TSF).

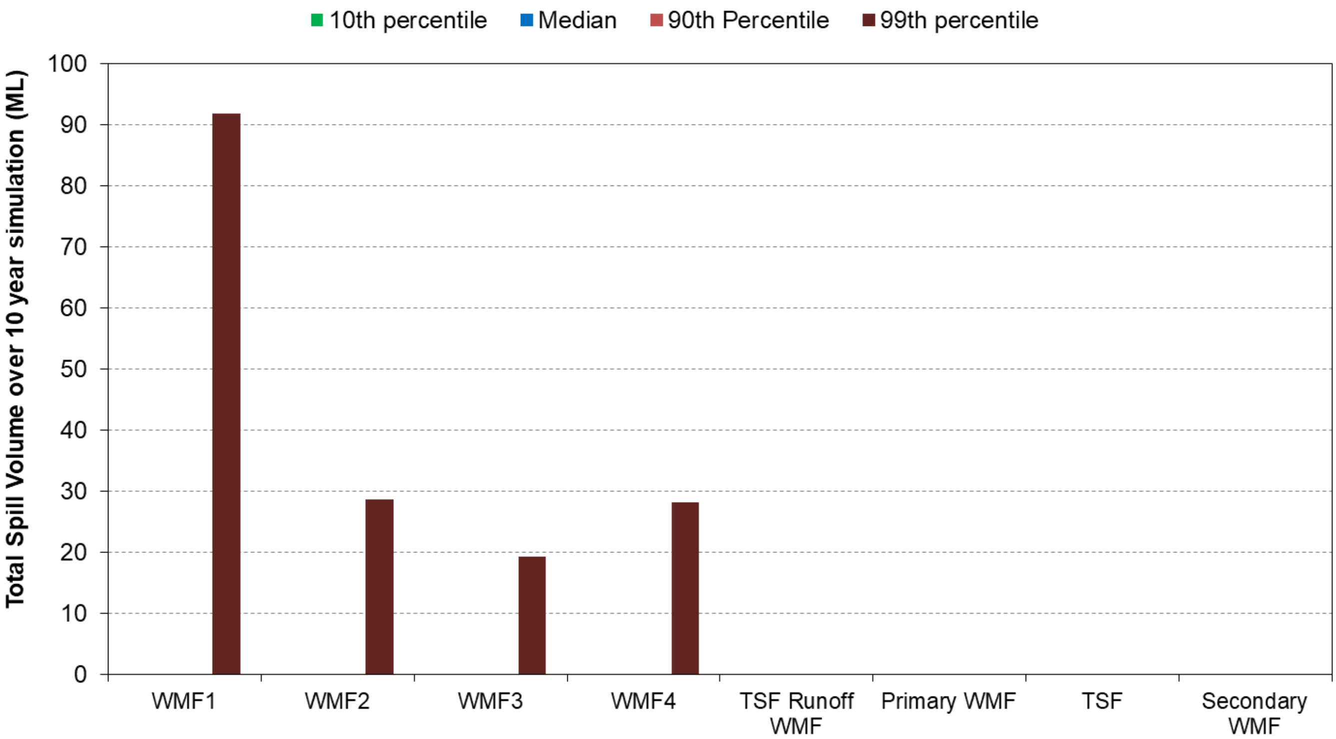


Figure 29 Predicted Spill Volumes

3.2.3.7 Summary Outcomes

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

1. Water supply via the external pipeline 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 just under 2,500 ML once the Secondary WMF is commissioned. However, in the short-term prior to the Secondary WMF 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 dry times.
3. Model simulations indicate that there is a risk of haul road dust suppression shortfall in the near term prior to the RWMF being commissioned (i.e. prior to external water being brought to site). Overall predicted average supply reliability is high for both the Process Plant and haul road dust suppression, with greater than 99.9% and 98.7% of demand able to be supplied respectively. No shortfalls are simulated once the external supply pipeline has been completed.
4. Model predictions suggest that on average, there would be less than a total of fifteen 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, 2,584 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) and while the Secondary WMF was being filled in Year 3, the project would make full use of its external supply (i.e. 13 ML/day for 365 days/year is 4,745 ML). However, under most circumstances, the external supply pipeline capacity would not need to be utilised to its full capacity.
6. Predicted annual spill risk for each dam is in line with the design criterion (i.e. less than 1% spill risk for WMF1, WMF2, WMF3, WMF4 and the TSF Runoff WMF and no simulated spills from the Primary WMF, Secondary WMF or the TSF).

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-20^{th} 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 22 presents mean annual changes for these two climate variables.

Table 22 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"[7] 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 development 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 life of the mine development 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.

[7] 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%.

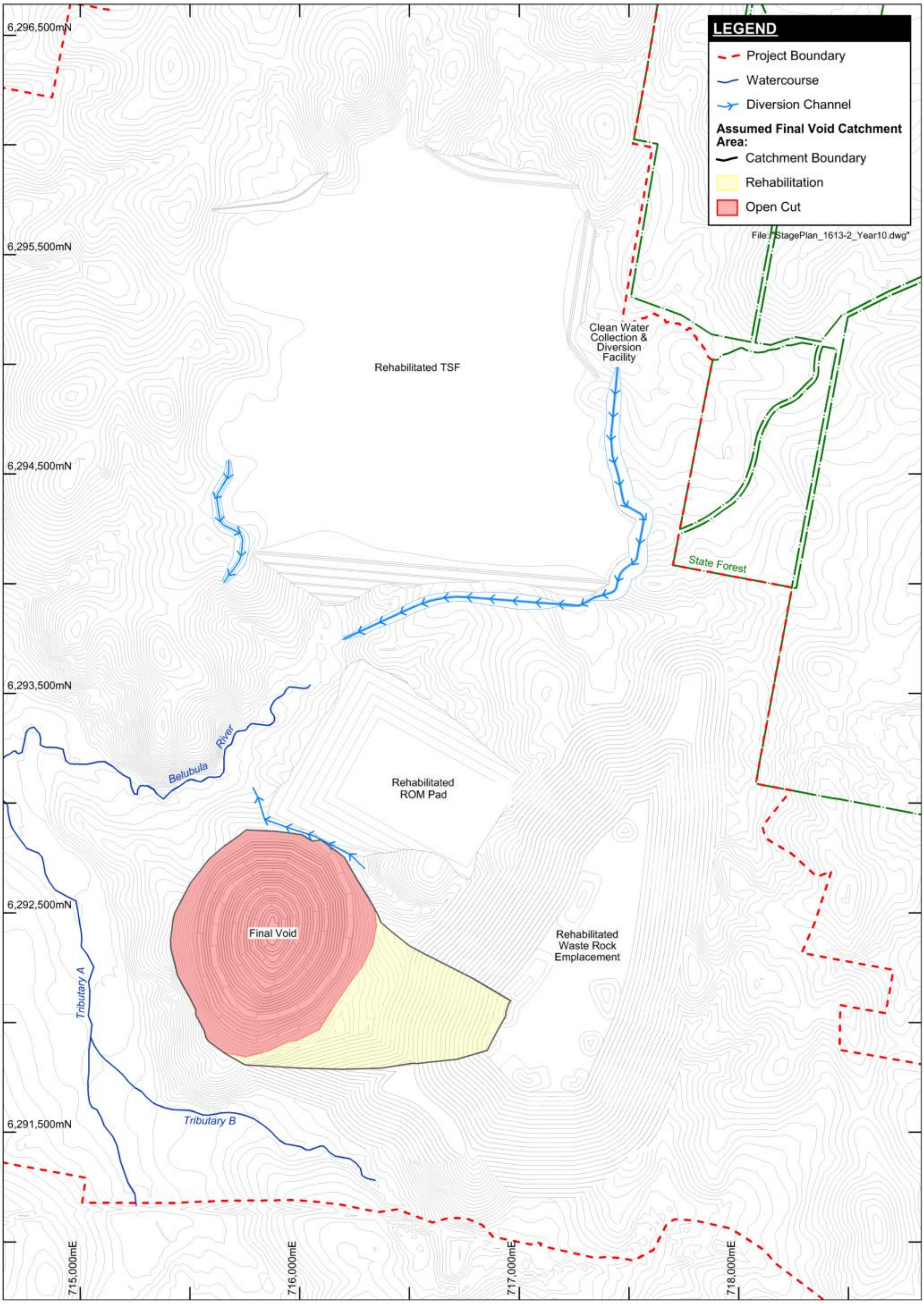


Figure 30 Final Landform Surface Water Management Layout

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. The alignment and design of the diversion channels will be confirmed during the detailed design stage.

3.4 FINAL VOID WATER 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 110.1 ha comprising 39.3 ha of rehabilitated sub-catchment and 70.8 ha of remnant open cut pit sub-catchment.
- A 129 year climatic data set (1889 to 2017 inclusive) obtained from the SILO Data Drill for the mine development 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 spillway at which point the monthly pan factors were taken from McMahon et al. (2013) as listed in Table 17. 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 (2019c).
- 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.

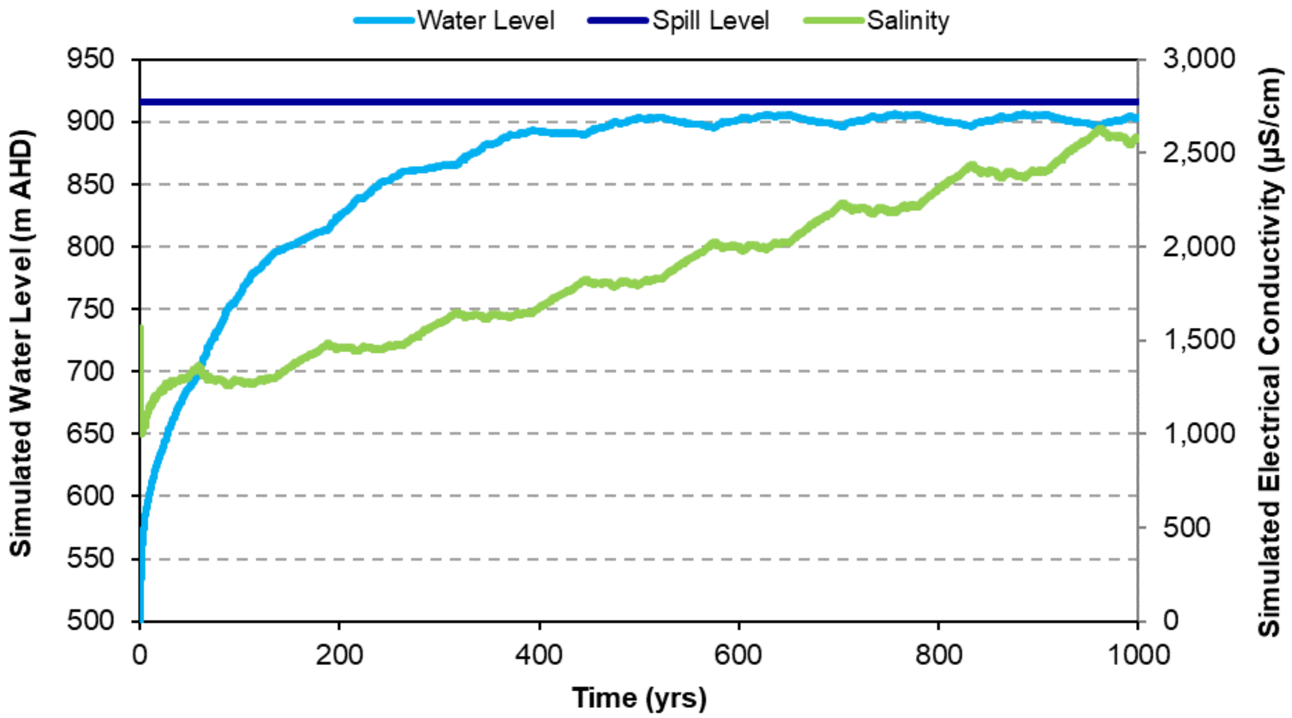


Figure 31 Predicted Final Void Water Levels and EC: Base Case

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 400 years. Final void salinity levels would increase slowly as a result of evapo-concentration.

Groundwater modelling suggests the final void is predicted to be a sink for at least 500 years (EMM, 2019c). 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 EARs 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).

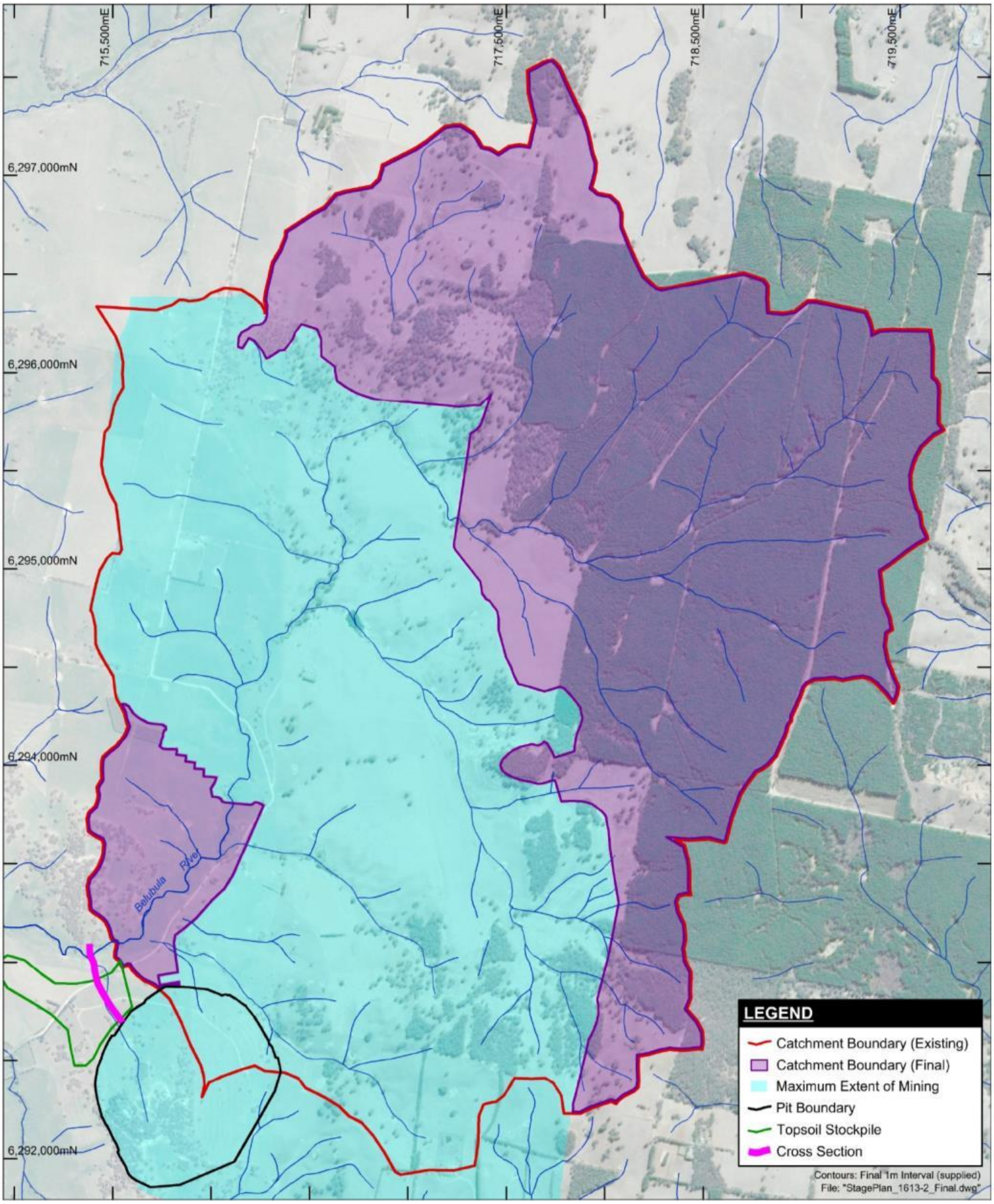


Figure 32 Simplified Flooding Assessment Layout

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[8] 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).

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 23.

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

Table 23 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 24 and shown on the cross-section in Figure 33. The estimated peak flood levels in Table 24 compare with a ground level of 916 m AHD for the edge of the proposed open cut.

Table 24 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

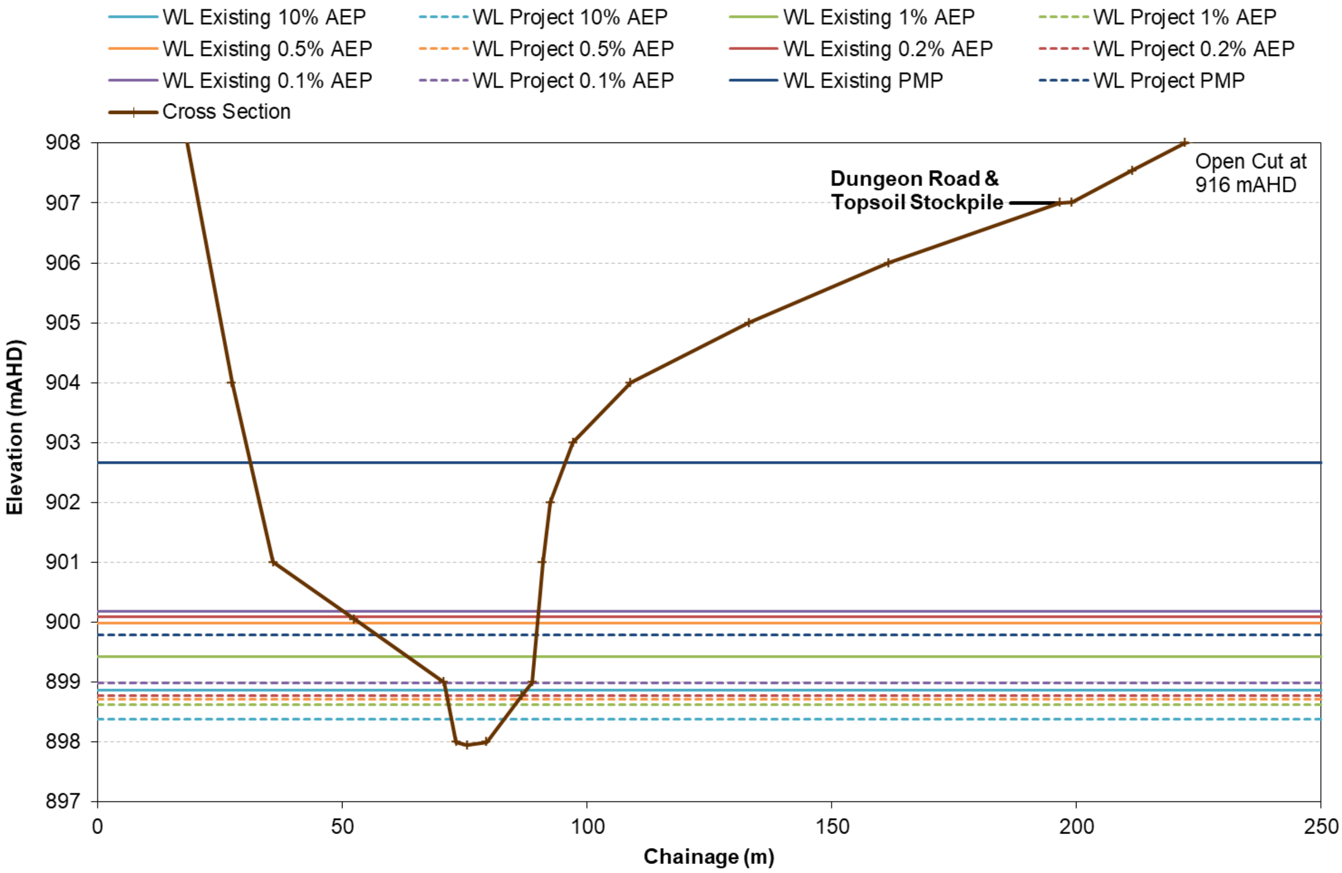


Figure 33 Simplified Flooding Assessment: Cross-Section With Estimated Peak Flood Levels

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

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 baseflow reduction and catchment excision associated with the operational water management system (refer Figure 14 to Figure 18).

The groundwater model predicts baseflow 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 15% and up to 14% in Trib A (EMM, 2019c). There is no predicted impact to baseflow downstream of the confluence with Trib A (EMM, 2019c).

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. The rainfall-runoff component of the water balance model was 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.

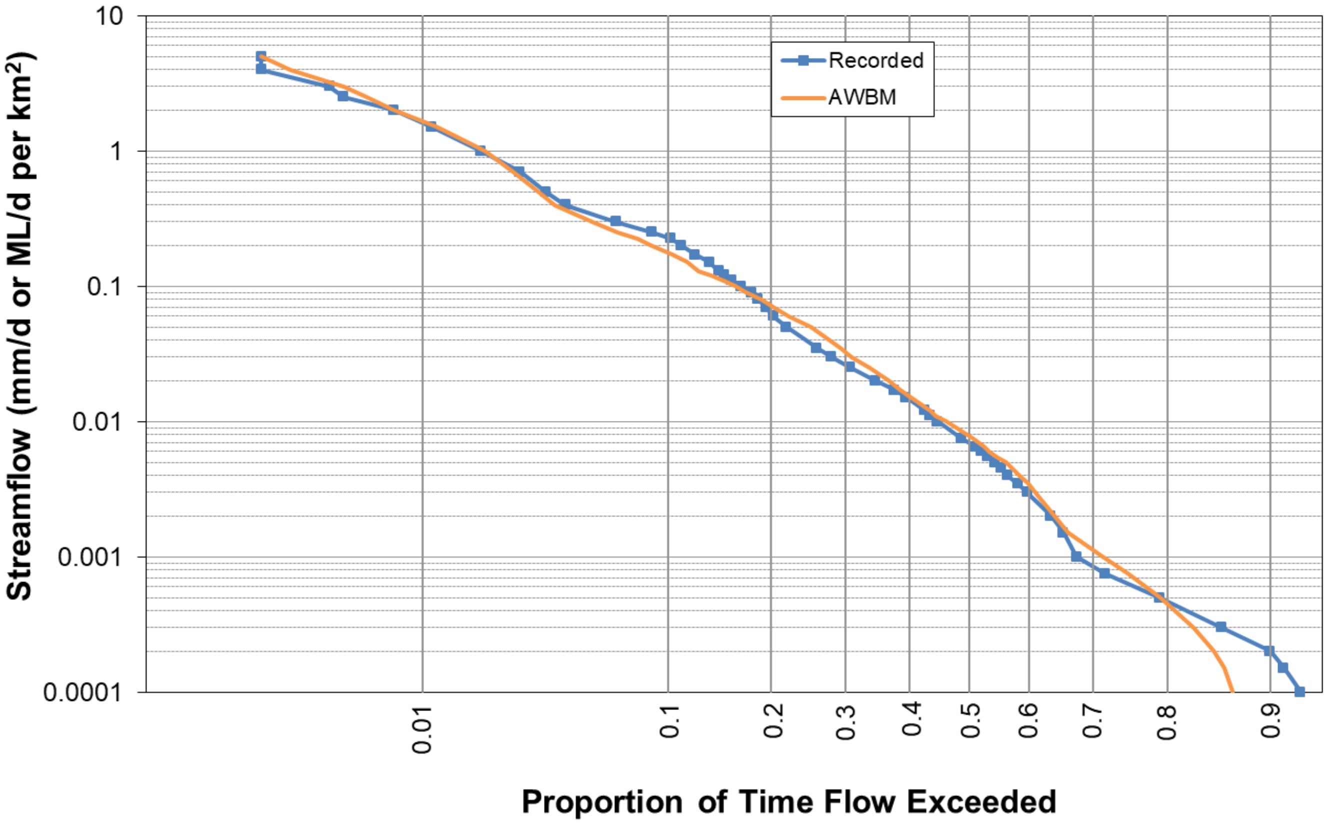


Figure 34 Flow Duration Curve Comparison at GS 412104: Recorded vs. AWBM

The calibrated AWBM runoff parameters were 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. The simulation period for this stored water volume calibration was limited by the extent of available dam release data which spanned 1985 to 2018. Results showing the comparison between the recorded and modelled stored water volumes in Lake Carcoar during this period are shown in Figure 35. The linear correlation coefficient for the recorded to modelled stored water volume is 0.90 and hence is considered a fair fit.

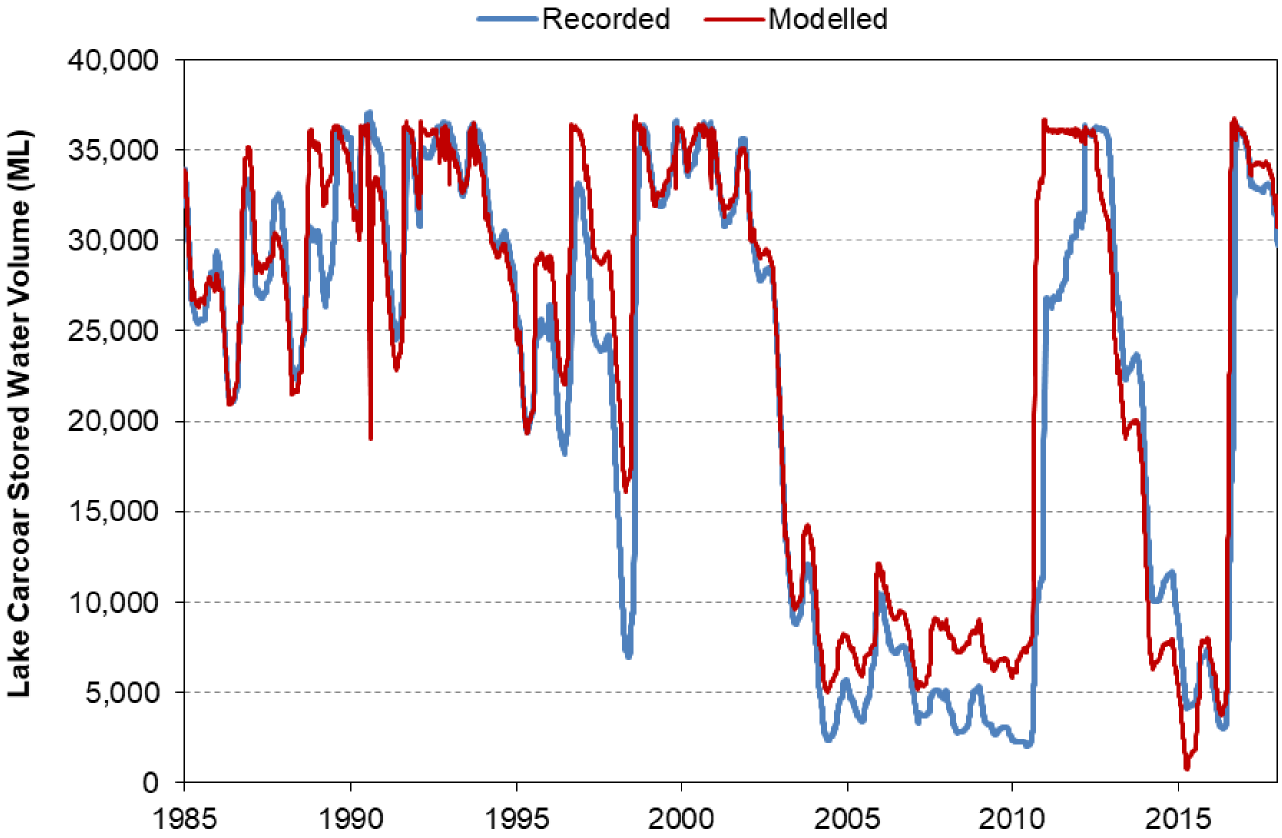


Figure 35 Comparison of Recorded and Modelled Stored Water Volume in Lake Carcoar

The fair calibration between recorded and modelled stored water volumes in Lake Carcoar confirmed that the runoff calibration (refer Figure 34) over the available streamflow data set (for GS 412104) provided 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 Lake Carcoar GoldSim water balance model was then run using the full period of available historical daily climatic data from 1889-2017 (refer Section 3.2.1) to obtain a series of annual total inflows to Lake Carcoar. The total annual flow for each of the 128 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 results generated. A comparison of the modelled “existing” and “with project” total annual inflows to Lake Carcoar are summarised in Table 25.

Table 25 Modelled Inflow to Lake Carcoar for Streamflow Impact

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)
95%	1,463	1,402	61
90%	1,941	1,861	80
80%	2,408	2,308	100
70%	3,056	2,929	127
60%	3,645	3,494	151
50%	5,836	5,594	242
40%	7,917	7,590	327
30%	13,975	13,397	578
20%	24,995	23,961	1,034
10%	42,296	40,546	1,750
5%	57,984	55,585	2,399

Table 25 shows that the existing modelled inflow to Lake Carcoar is 5,836 ML/year or higher 50% of the time. 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 242 ML/year to 5,594 ML/year or higher. This is a 4.1% reduction in median annual inflow to Lake Carcoar. A 4.1% reduction applies across the entire flow regime given in Table 25 and therefore this represents the predicted reduction in total inflow to Lake Carcoar at the maximum mine development extent. 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 2) is 8.7% and at the proposed Belubula Downstream gauging station (refer Figure 2) it is 22.2%.

Table 26 provides a summary of modelled streamflow impacts to the Belubula River at three different locations: Lake Carcoar, Mid Western Highway and the proposed downstream Belubula River gauging station. Table 26 focusses on the lower modelled flows and shows that regardless of the locations, decreased modelled flow due to the maximum project extent remains consistent for various statistical percentages of time. Currently, annual inflows to Lake Carcoar are estimated to be at least 1,463 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 climatic conditions. At maximum disturbance, the project is predicted to reduce streamflow during these low rainfall climatic conditions to Lake Carcoar by 61 ML/year to 1,402 ML/year (compared to existing conditions).

Table 26 Modelled Streamflow Impact 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)
At Lake Carcoar	95%	1,463	1,402	61
	90%	1,941	1,861	80
	50%	5,836	5,594	242
At Mid Western Highway	95%	697	636	61
	90%	924	844	80
	50%	2,792	2,550	242
At Proposed Downstream Belubula River Gauging Station	95%	273	212	61
	90%	362	282	80
	50%	1,093	851	242

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.

The Belubula River downstream of Carcoar Dam is managed under the conditions set out in the *Water Sharing Plan for the Belubula Regulated River Water Source 2012*. The total issued share component of general security, high security and domestic and stock water access licences from the Belubula River regulated water source was 23,771 unit shares in the 2017 to 2018 period (Burrell et al., 2019). In the 2013 to 2018 period, the average annual water usage from the Belubula River regulated water source was 3,853 ML/year (Burrell et al., 2013 – 2019). A predicted reduction of 61 ML/year inflow to Lake Carcoar due to the project surface water 'take' equates to 0.3% of the total issued share component of the Belubula River downstream of Carcoar Dam or 1.6% of the average annual water usage.

4.1.2 Catchment Types

The modelled median annual inflow to Lake Carcoar from all existing catchments is approximately 5,840 ML. Of the inflow of 5,840 ML/year to Lake Carcoar, 5,400 ML/year originates from the catchments downstream of the Project site. Only an estimated 440 ML/year of the 5,840 ML/year total existing inflow to Lake Carcoar originates from the catchments within, or upstream of, the Project site.

Table 27 presents the calculated catchment type areas and the modelled median annual flow reduction attributable to each catchment type associated with the Project. In the first column of Table 27 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), or not disturbed by mining operations (i.e. undisturbed).

Table 27 Catchment Calculations

Catchment Type	Catchment Area (ha)	Predicted Annual Reduction in Median Flow (ML/year)
Undisturbed	793	198
Disturbed	964	242

Note that while Table 27 records a modelled median annual flow reduction of 198 ML/year attributable to "undisturbed" catchment, the Project's proposed clean water system is estimated to divert 198 ML/year of water from undisturbed catchments around the Project site and into the Belubula River, which reports to Lake Carcoar. As such, the estimated net reduction in median annual flow at the southern boundary of the Project site would be 242 ML/year, which equates to an approximate 9% reduction in flow at this point.

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 total and peak flow downstream of the mine development area.

As the 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 increase during the operational phase of the mine development, although only for short durations due to the adopted requirement to dewater the 1% AEP, 72 hour duration rainfall event in 10 days.

4.1.4 Water Quality

Potential impacts on surface water quality downstream of the mine development along with proposed mitigation methods are summarised in Table 28. These measures would be included in a project water management plan ahead of construction.

Table 28 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 2019) 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 either not spill under all historical climate scenarios at all or have a less than 1% spill risk (refer Section 3.2.3.6).
Un-intercepted runoff from areas requiring erosion and sediment control treatment prior to flowing off site (i.e. topsoil stockpiles).	Erosion and sediment controls would be designed in accordance with Landcom (2004) and DECCW (2008) guidelines (refer Section 3.1.3).
Un-intercepted seepage from the TSF	A seepage management system has been designed for the TSF in accordance with leading best practice (refer ATCW 2019). 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 further into the catchment (i.e. downstream towards the Belubula River). Seepage management measures will be documented in the waste management plan and water management plans for the project.
Un-intercepted seepage from the waste rock emplacement	The waste rock emplacement will be stripped and conditioned prior to beginning waste 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 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 be engineered to capture any seepage reporting to the toe of the emplacement for recirculation in the operational water management system. Seepage management measures will be documented in the waste management plan and water management plans for the project.

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.

4.2 POST CLOSURE PHASE

4.2.1 Streamflow and Inflows to Lake Carcoar

The groundwater model predicts baseflow 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 15% and up to 14% in Trib A (EMM, 2019c). There is no predicted impact to baseflow downstream of the confluence with Trib A (EMM, 2019c).

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 project post closure and rehabilitation (i.e. reporting to the final void) is 110 ha. The model was run with the maximum catchment area captured by the project post closure (110 ha, i.e. 0.47% 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 29.

Table 29 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 Mine Modelled Inflow (ML/year)	Decreased Modelled Inflow Post Mine (ML/year)
95%	1,463	1,456	7
90%	1,941	1,932	9
80%	2,408	2,397	11
70%	3,056	3,042	14
60%	3,645	3,628	17
50%	5,836	5,808	28
40%	7,917	7,880	37
30%	12,709	12,649	60
20%	13,975	13,909	66
10%	24,995	24,877	118
5%	42,296	42,096	200

Table 29 shows that, with the excision of the 110 ha of catchment captured by the final void, the existing modelled inflow to Lake Carcoar that occurs 50% of the time reduces by 28 ML/year to

5,809 ML/year or higher. This is a 0.47% reduction in median annual inflow to Lake Carcoar. A 0.47% reduction applies across the entire flow regime given in Table 29 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 2) is 1.0% and at the proposed Belubula Downstream gauging station (refer Figure 2) it is 2.5%.

As discussed in Section 4.1.1, the Belubula River downstream of Carcoar Dam is managed under the conditions set out in the *Water Sharing Plan for the Belubula Regulated River Water Source 2012*. The total issued share component of general security, high security and domestic and stock water access licences from the Belubula River regulated water source was 23,771 unit shares in the 2017 to 2018 period (Burrell et al., 2019). In the 2013 to 2018 period, the average annual water usage from the Belubula River regulated water source was 3,853 ML/year (Burrell et al., 2013 – 2019). A predicted reduction of 28 ML/year inflow to Lake Carcoar due to the project surface water 'take' post closure equates to 0.1% of the total issued share component or 0.7% of the average annual water usage.

4.2.2 Final Void Catchment Area

The catchment area reporting to the final void post closure has been calculated as 110 ha. When this area is excised from the catchment reporting to Lake Carcoar, the existing modelled median inflow to Lake Carcoar reduces by 28 ML/year to 5,809 ML/year.

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 915.5 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.

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. 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 as.

4.2.5 Cumulative Impacts

As per 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 a rainfall station is proposed for installation within the catchment of Trib A. The three proposed streamflow monitoring stations (refer Section 2.7.1) should be installed to collect baseline monitoring data ahead of mine development.

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 is recommended to be undertaken during the operational phase:

- Streamflow: all three proposed streamflow monitoring stations (refer Section 2.7.1);
- Channel Stability: annual monitoring via established photo and assessment points on the Belubula River downstream of the proposed TSF (to be established immediately prior to construction) at approximately 50 m intervals;
- Water Quality: all three proposed 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 included;
- 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.
- Water Use, Sourcing and Pumping: Monitoring of monthly volumes of water pumped between storages in the water management system, in particular water volumes pumped:
    - From the TSF to the Secondary WMF;
    - From the open cut to the Secondary WMF;
    - From the Primary WMF, WMF1, WMF2, WMF3 and WMF4 to the Secondary WMF;
    - To RWMF from the external supply pipeline;
    - To Secondary WMF from RWMF;
    - To the Process Plant (from the TSF, Secondary WMF, Primary WMF and RWMF); and
    - To haul road dust suppression (from the Secondary WMF, Primary WMF and RWMF).

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. 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

Regis is seeking 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.

Water will be supplied to the project 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) guidelines are not representative of the background conditions in the project area. As such, site specific WQOs should be developed prior to project commencement using all available baseline data.

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 145 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 86 ha which is within the harvestable right area by 95 ha or a yield (at 0.75 ML/ha per year) of 71 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 is potentially sediment-laden); 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 pipeline supply water).

During mining, the majority of clean water will be diverted around the mine development via a series of diversion channels, 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 DECCW (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 results of a water balance model for the operational phase of the project indicate that, on average, external supply provides the highest system inflow (53%) of the total inflow followed by runoff from the operational water management system. The majority of outflows (80%) comprise Process Plant supply followed by supply for haul road dust suppression. The model predictions suggest that site storages will provide sufficient storage capacity during the operational phase of the project. The predicted spill occurrences for all dams are in line with the design criteria for the project.

The model predictions indicate a haul road dust suppression shortfall in Year 1 prior to the provision of pipeline supply water. In the period prior to external supply, haul road dust suppression water will be sourced from groundwater bores using a portion of the 400 ML/year of groundwater licences currently owned by Regis. No supply shortfalls are simulated once the external supply pipeline is simulated to come online in Month 8. Model results indicate that, during periods of lower rainfall and while the Secondary WMF was filling up in Year 3, the project would make full use of its external supply. However, under most circumstances, the external supply pipeline would not need to be utilised to its full capacity.

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 400 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 development 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 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.

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

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 development 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.

7.0 REFERENCES

ATCW (2019). *McPhillamys Gold Project Blayney, NSW Tailings Storage Facility Definitive Feasibility Study*. Report Number: 113272-02R002 prepared for Regis Resources Limited, June.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000a). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy, Paper No. 4. Volume 1. The Guidelines, Chapter 1-7.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) (2000b). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy, Paper No. 4. Volume 2. Aquatic Ecosystems – Rationale and Background Information, Chapter 8.

Boughton, W.C. (2004). "The Australian Water Balance Model", *Environmental Modelling and Software*, vol.19, pp. 943-956.

Burrell M., Moss P., Ali, A. and Petrovic, J. (2015). *General Purpose Water Accounting Report 2013-2014: Lachlan and Belubula Catchments*, NSW Department of Industry, Sydney.

Burrell M., Moss P., Ali, A. and Petrovic, J. (2016). *General Purpose Water Accounting Report 2014-2015: Lachlan and Belubula Catchments*, NSW Department of Industry, Sydney.

Burrell M., Moss P., Ali, A. and Petrovic, J. (2017). *General Purpose Water Accounting Report 2015-2016: Lachlan and Belubula Catchments*, NSW Department of Industry, Sydney.

Burrell M., Moss P., Petrovic, J., Ali, A., Nicholls, D. and Ching,M. (2018). *General Purpose Water Accounting Report 2016-17: Lachlan and Belubula Catchments*, NSW Department of Industry, Sydney.

Burrell M., Moss P., Petrovic, J., Ali, A., Nicholls, D. and Ching,M. (2019). *General Purpose Water Accounting Report 2017-18: Lachlan and Belubula Catchments*, NSW Department of Industry, Sydney.

Brierley, G. J., & Fryirs, K. A. (2005). *Geomorphology and River Management: Applications of the River Styles Framework*, Malden, MA, Blackwell Publishing.

Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology (2015a). *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*. Commonwealth Scientific and Industrial Research Organisation and the Australian Bureau of Meteorology, Australia.

Commonwealth Scientific and Industrial Research Organisation and Bureau of Meteorology (2015b). *Climate Change in Australia.* Accessed 30 June 2015, http://www.climatechangeinaustralia.gov.au/en/. Commonwealth Scientific and Industrial Research Organisation and the Australian Bureau of Meteorology, Australia.

Cooperative Research Centre for Catchment Hydrology and Land and Water Resources Research and Development Corporation (2000). *A Rehabilitation Manual for Australian Streams*, Volume 2.

Chow, V.T. (1986). *Open Channel Hydraulics*, McGraw-Hill International Editions, Singapore.

Department of Environment and Climate Change (2007). "Guidelines for Practical Consideration of Climate Change", *Floodplain Risk Management Guideline*. The Department of Environment and Climate Change NSW, October.

Department of Environment and Climate Change (2007). *Storing and Handling Liquids: Environmental Protection - Participants Manual*. The Department of Environment and Climate Change NSW, May.

Department of Environment and Conservation (2005). *Environmental Compliance Report: Liquid Chemical Storage, Handling and Spill Management - Part B Review of Best Practice and Regulation.* NSW Department of Environment and Conservation, November.

Department of Environment and Conservation (2004b). *Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales,* Department of Environment and Conservation NSW, March.

Department of Environment and Conservation (2006). *Using the ANZECC Guidelines and Water Quality Objectives in New South Wales.* Department of Environment and Conservation NSW, June.

Department of Environment and Climate Change NSW (2008). *Managing Urban Stormwater Soils and Construction – Volume 2E – Mines and Quarries*. Department of Environment and Climate Change NSW, June.

Department of Environment, Climate Change and Water (2010). *Draft flood risk management guide: incorporating sea level rise benchmarks in flood risk assessments.* Department of Environment, Climate Change and Water, January.

Department of Infrastructure, Planning and Natural Resources (2005). *Floodplain Development Manual – the management of flood liable land.* Department of Infrastructure, Planning and Natural Resources, April.

Department of Primary Industries Water (2017) *New South Wales Water Register*. Accessed 16 November 2018, http://www.water.nsw.gov.au/water-licensing/registers.

EMM (2019a). *McPhillamys Gold Project Mine Development Aquatic Ecology Assessment*. Prepared for Regis Resources Ltd, May.

EMM (2019b). *McPhillamys Gold Project Mine Development Biodiversity Assessment Report*, Prepared for Regis Resources Ltd, May.

EMM (2019c). *McPhillamys Gold Project Groundwater Assessment.* Prepared for Regis Resources Ltd, May.

EMM (2019d). *McPhillamys Gold Project Land Capability and Soil Assessment.* Prepared for Regis Resources Ltd, May.

EMM (2019e). *McPhillamys Gold Project Stream Order Assessment*, Prepared for Regis Resources Ltd, May.

EMM (2019f). *McPhillamys Gold Mine Project - Pipeline development Water Assessment*, Prepared for Regis Resources Ltd, August.

EMM (2019g). *McPhillamys Project Environmental Impact Statement: Water Resources*, Chapter 9, Prepared for Regis Resources Ltd, July.

Environment Protection Authority (1997). *Managing Urban Stormwater: Treatment Techniques.* NSW Environment Protection Authority, November.

Environment Protection Authority (1998). *Managing Urban Stormwater: Source Control,* NSW Environment Protection Authority, December.

Franks, DM, Brereton, D, Moran, CJ, Sarker, T and T, Cohen (2010). *Cumulative Impacts – A Good Practice Guide for The Australian Coal Mining Industry*, Centre for Social Responsibility in Mining & Centre for Water in the Minerals Industry, Sustainable Minerals Institute, The University of Queensland. Australian Coal Association Research Program, Brisbane

Institution of Engineers Australia (1998). *Australian Rainfall and Runoff – Volume 1 A Guide to Flood Estimation.*

IPCC (2015). *Climate Change 2014: Synthesis Report.* Contribution of Working Groups I, II and III to the "Fifth Assessment Report of the Intergovernmental Panel on Climate Change". Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.), Intergovernmental Panel on Climate Change, Geneva, Switzerland, 151 pp.

Landcom (2004). *Managing Urban Stormwater: Soils & Construction.* 4th Edition, March.

McMahon, T.A., Peel, M.C., Lowe, L., Srikanthan, R. & McVicar, T.R., (2013). "Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis", *Hydrology and Earth System Sciences*, vol. 17, pp. 1331-1363.

Natural Resources Access Regulator (2018). *Guidelines for Controlled Activities on Waterfront Land*, NSW Department of Industry, May.

New South Wales Department of Primary Industry Office of Water (n.d.). *PINNEENA: WQ Version 11.1*, CD-ROM. New South Wales Department of Primary Industry Office of Water (2012). *NSW Aquifer Interference Policy.* State of New South Wales, September.

New South Wales Government (2005). *Floodplain Development Manual*. Department of Infrastructure, Planning and Natural Resources, April.

New South Wales Government (2016). *NSW Water Quality and River Flow Objectives – Manning River Water Quality and River Flow Objectives*. Accessed 29 September 2016, http://www.environment.nsw.gov.au/ieo/Manning/report-02.htm.

New South Wales Office of Water (2013). *State Water Management Outcomes Plan* (Accessed 29 September 2016) http://www.lwater.nsw.gov.au/-data/assets/pdf-file/0011/547445/swmop-part1.pdf.

Ozark (2019). *Pipeline Development Biodiversity Assessment*, Prepared for Regis Resources Ltd, May.

Risk Mentor (2019). *McPhillamys Tailings Storage Facility (TSF) Risk Assessment*, Prepared for Regis Resources Ltd.

SILO Data Drill (2017). https://www.longpaddock.qld.gov.au/silo/datadrill. Accessed 13 November 2017.

SRK Consulting (2019). *McPhillamys Gold Project: Geochemical Characterisation*. Report prepared for Regis Resources Limited, June.

Strahler, AN (1952). "Dynamic basis of geomorphology", *Bulletin of the Geological Society of America*, no. 63, pp. 923–938.

WaterNSW (2018a). http://www.realtimedata.water.nsw.gov.au/water.stm. Accessed 17 February 2018.

WaterNSW (2018b), *Water Data Services*, Request for water quality data at Carcoar Dam, received 31 October.

WaterNSW (2019), *Maximum Harvestable Right Calculator*, State of New South Wales, Accessed 12 March 2019, https://www.waternsw.com.au/customer-service/water-licensing/basic-water-rights/harvestable-rights-dams/maximum-harvestable-right-calculator.

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.*

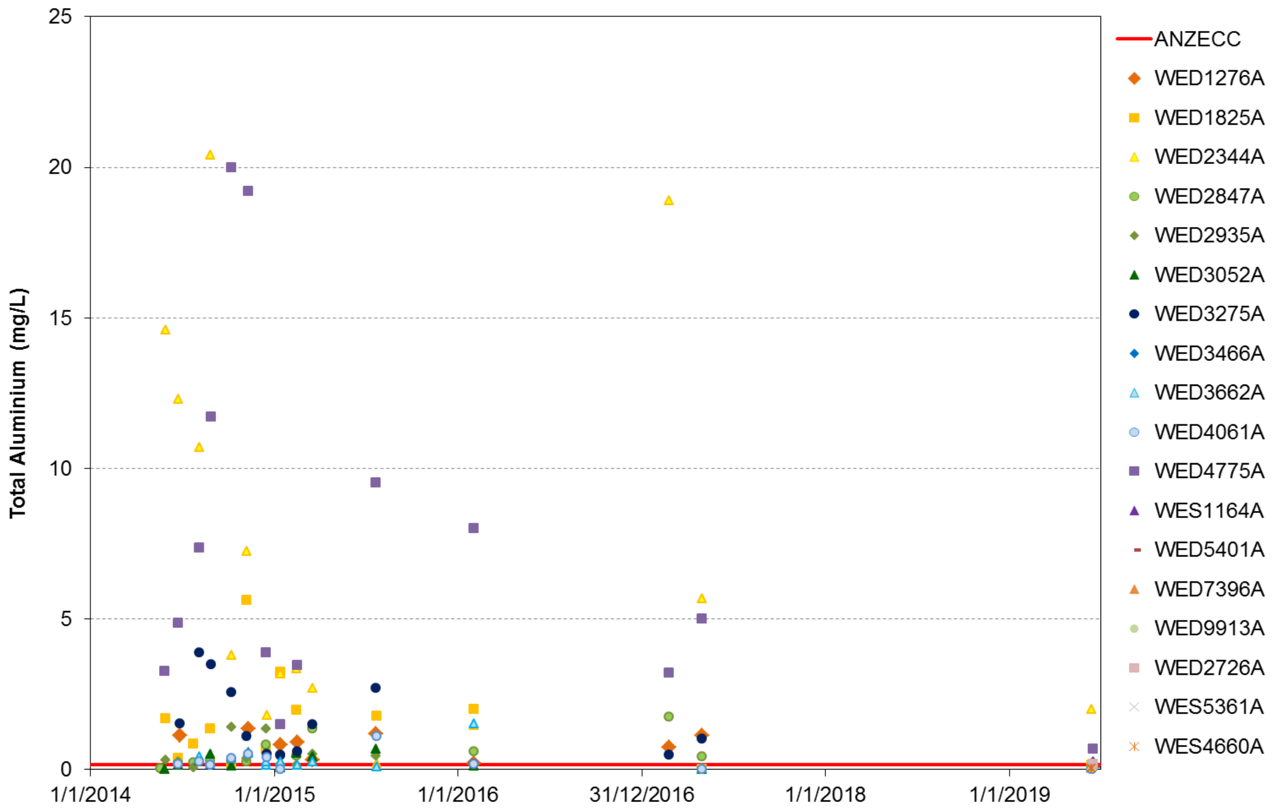


Figure A1 Total Aluminium

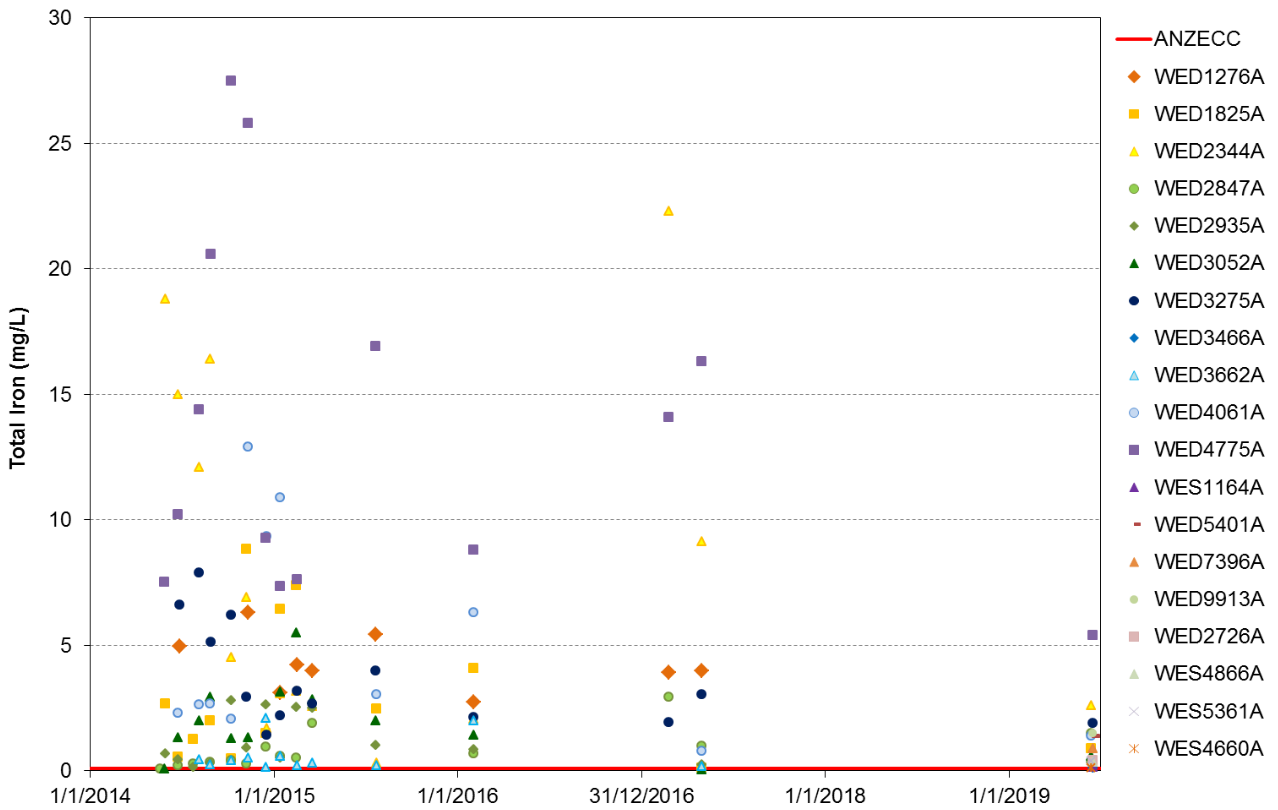


Figure A2 Total Iron

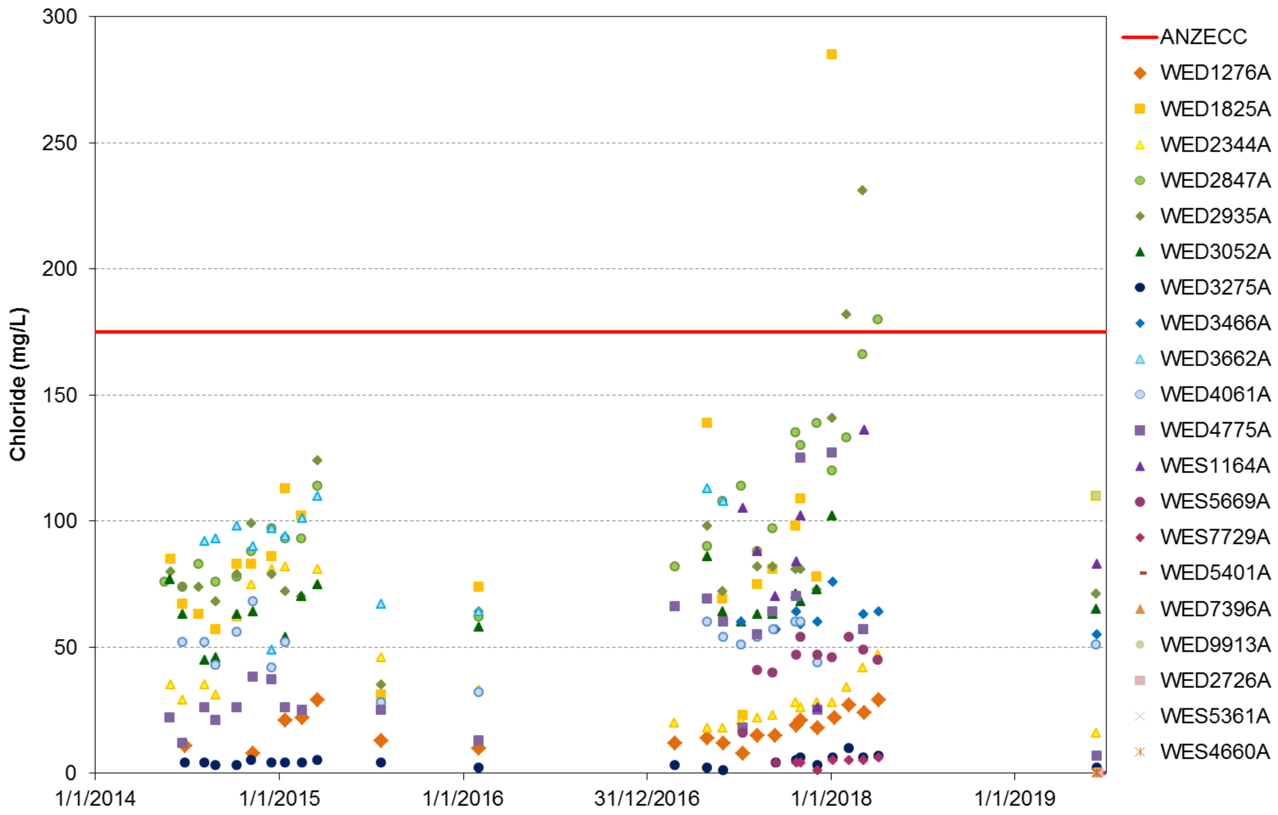


Figure A3 Chloride

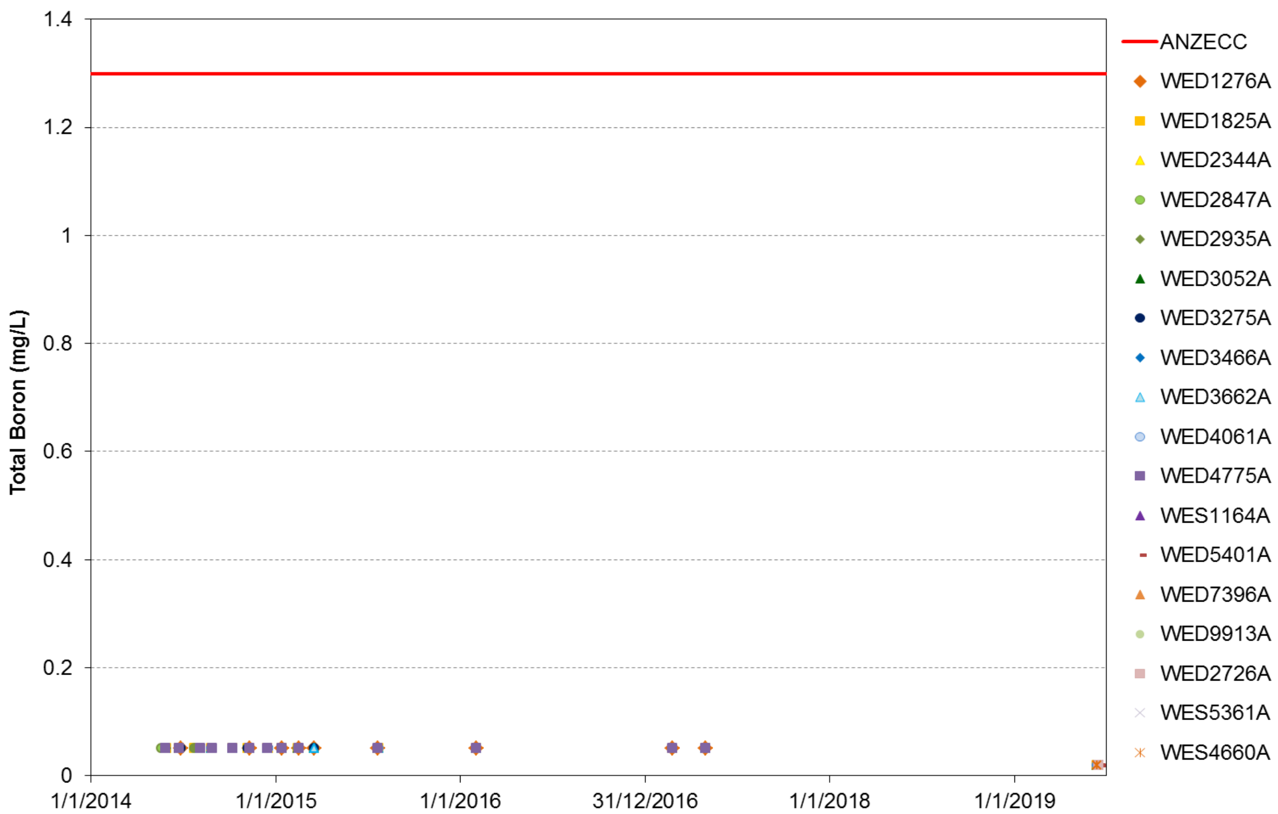


Figure A4 Total Boron

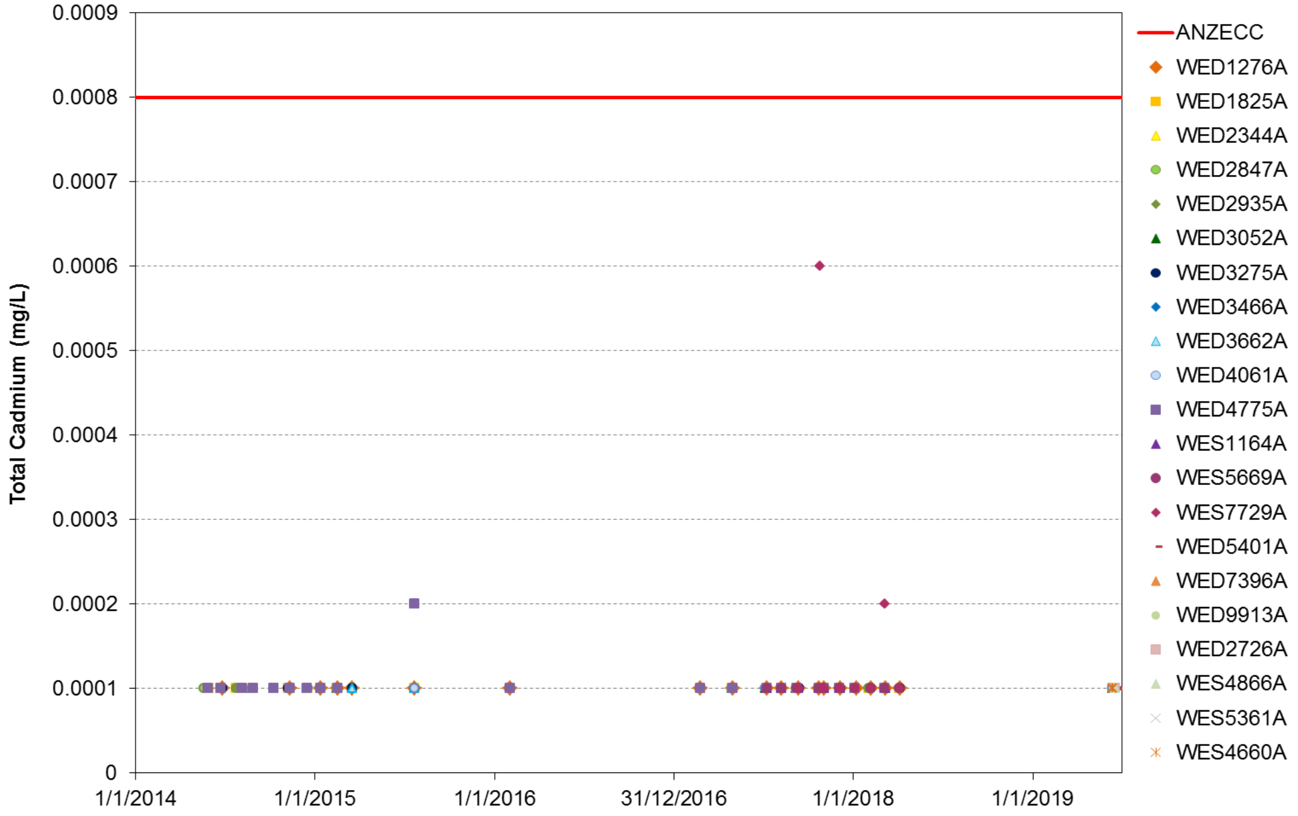


Figure A5 Total Cadmium

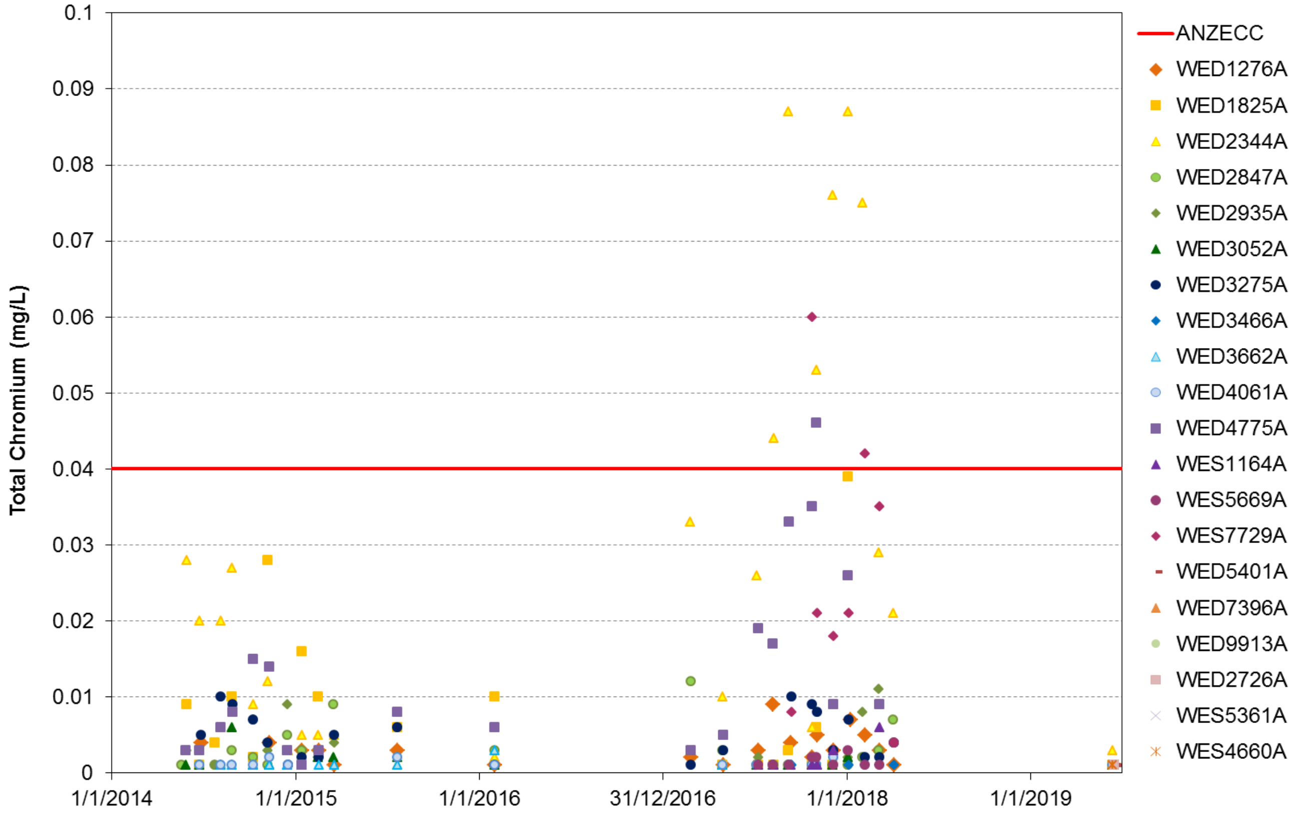


Figure A6 Total Chromium

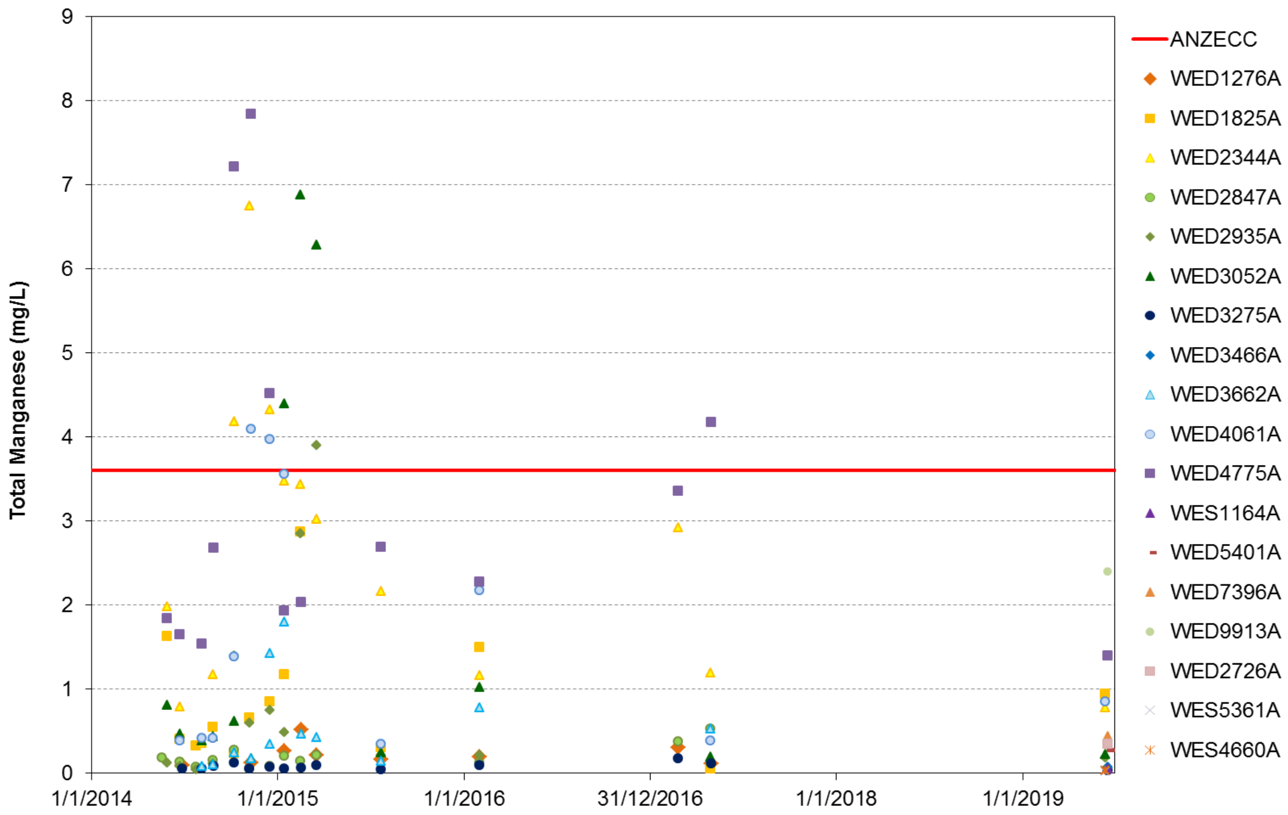


Figure A7 Total Manganese

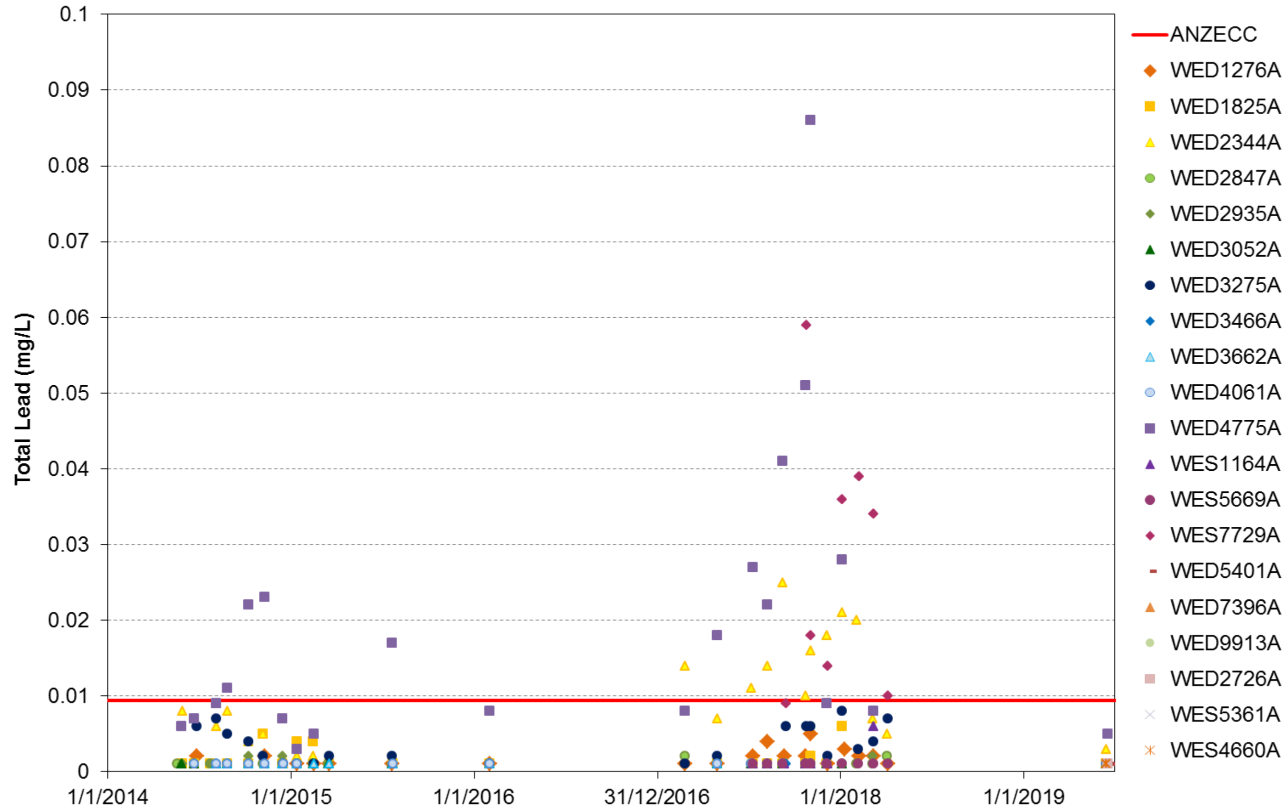


Figure A8 Total Lead

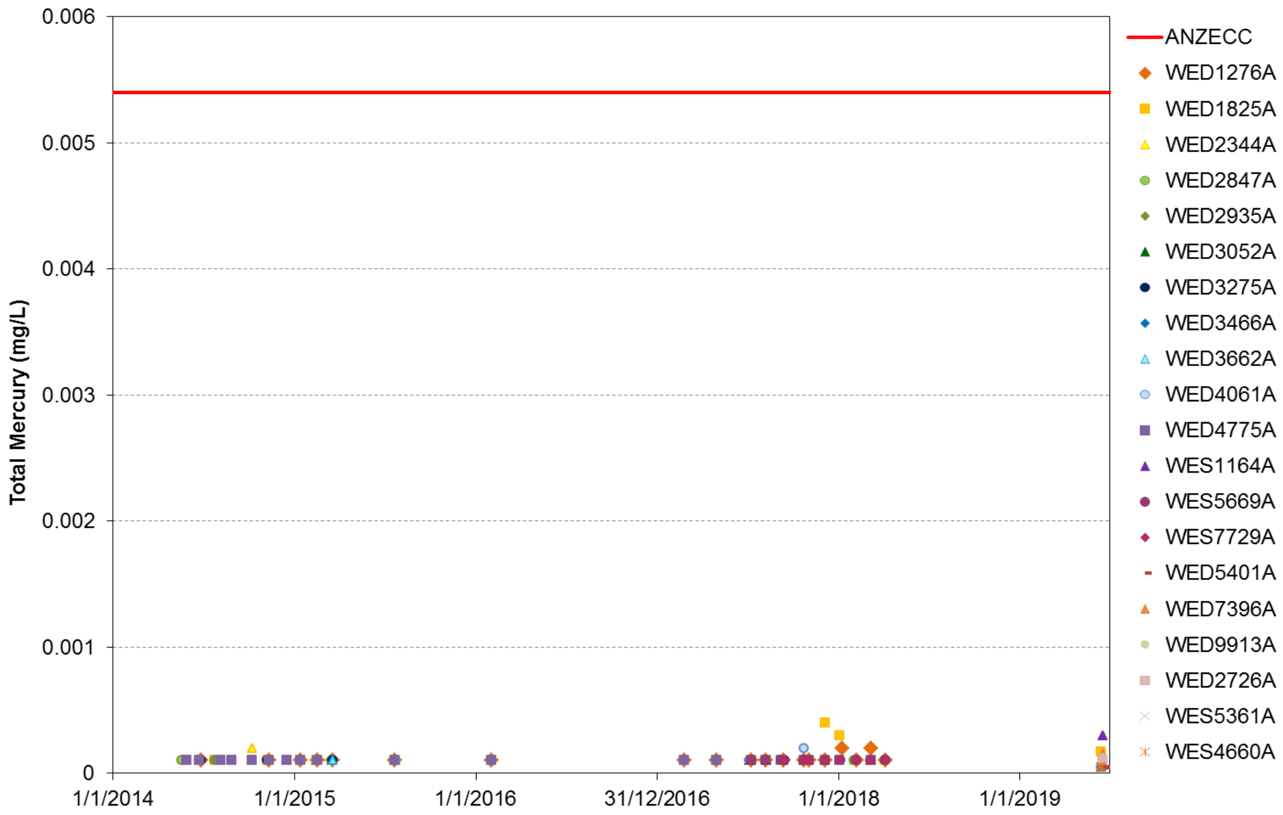


Figure A9 Total Mercury

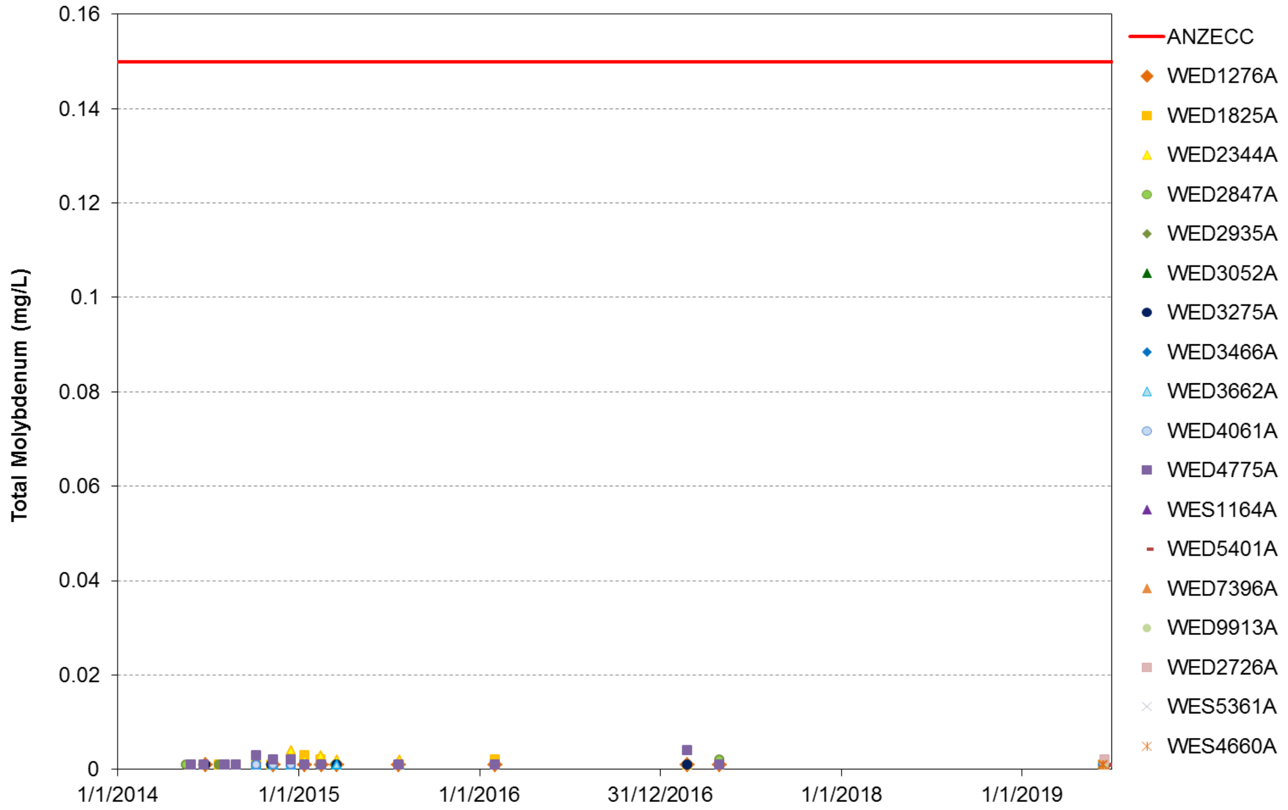


Figure A10 Total Molybdenum

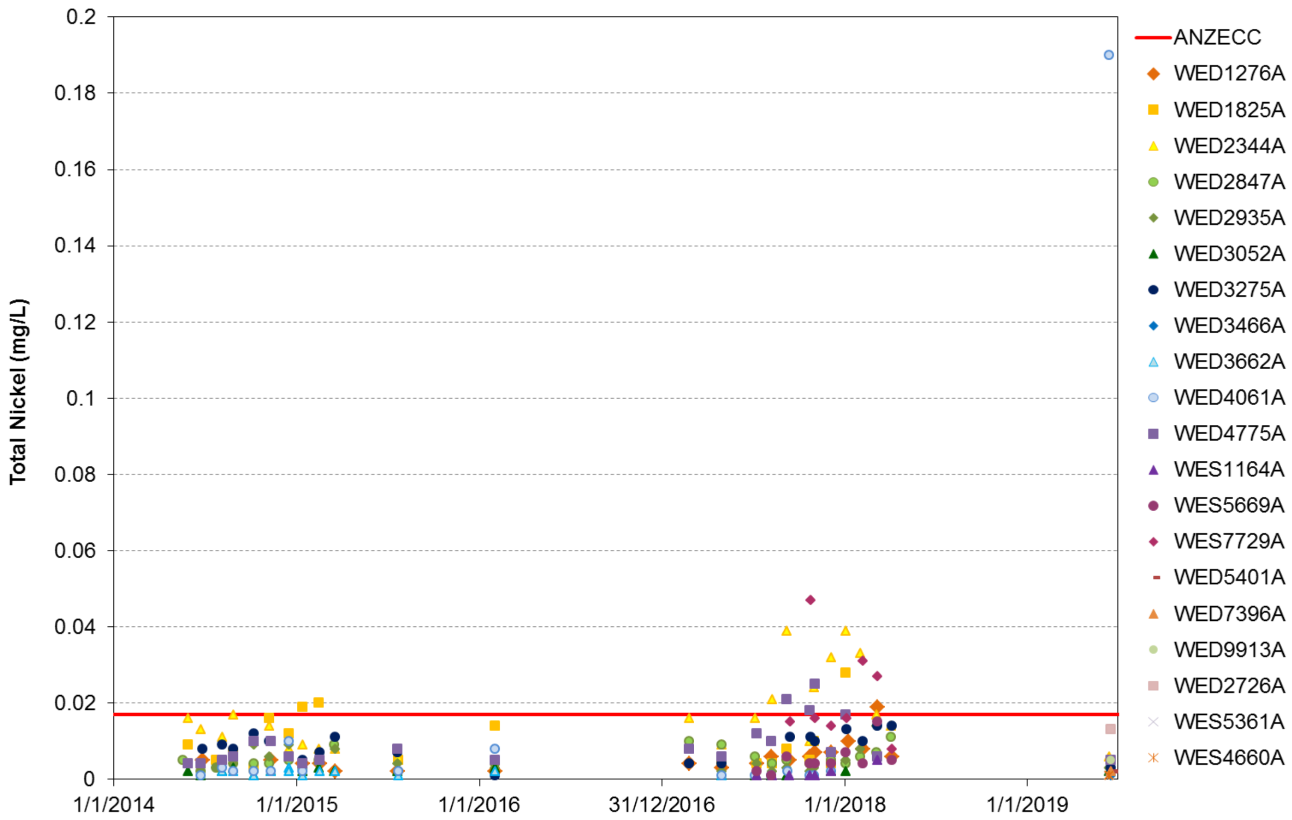


Figure A11 Total Nickel

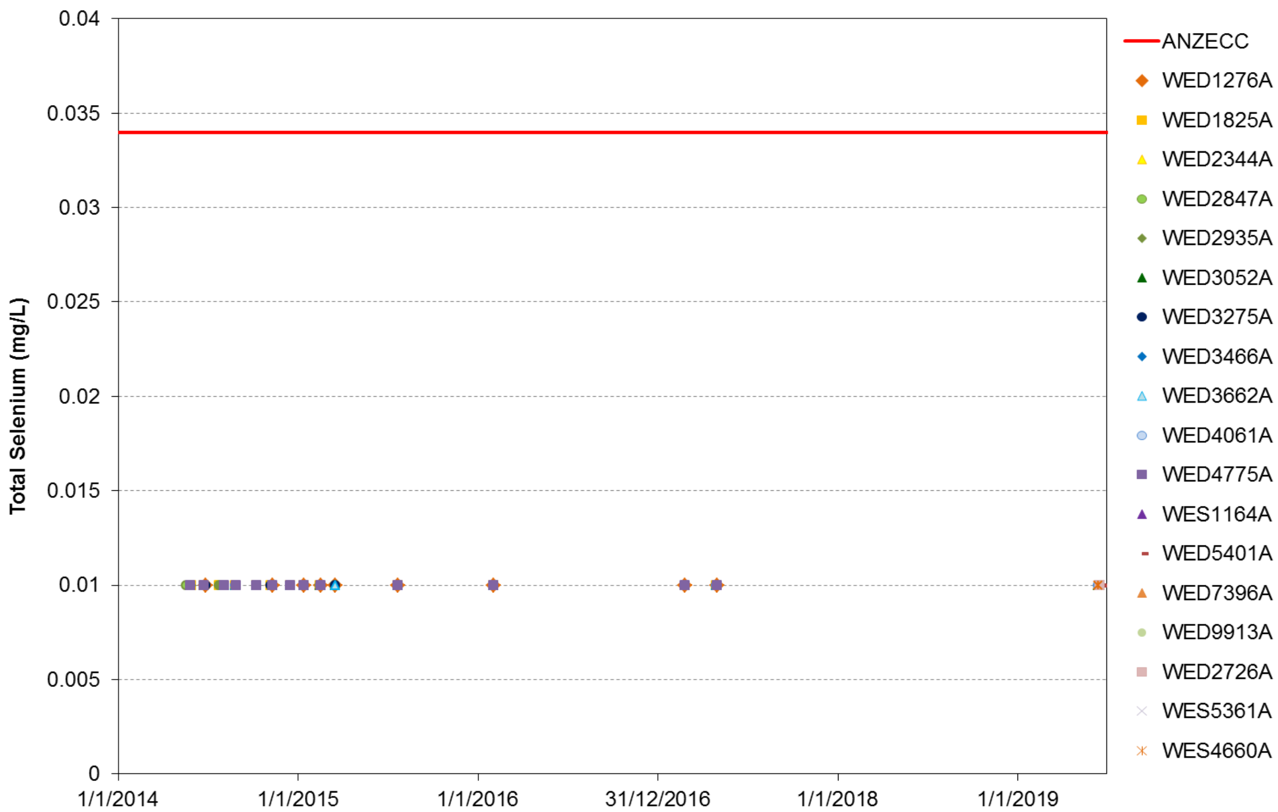


Figure A12 Total Selenium

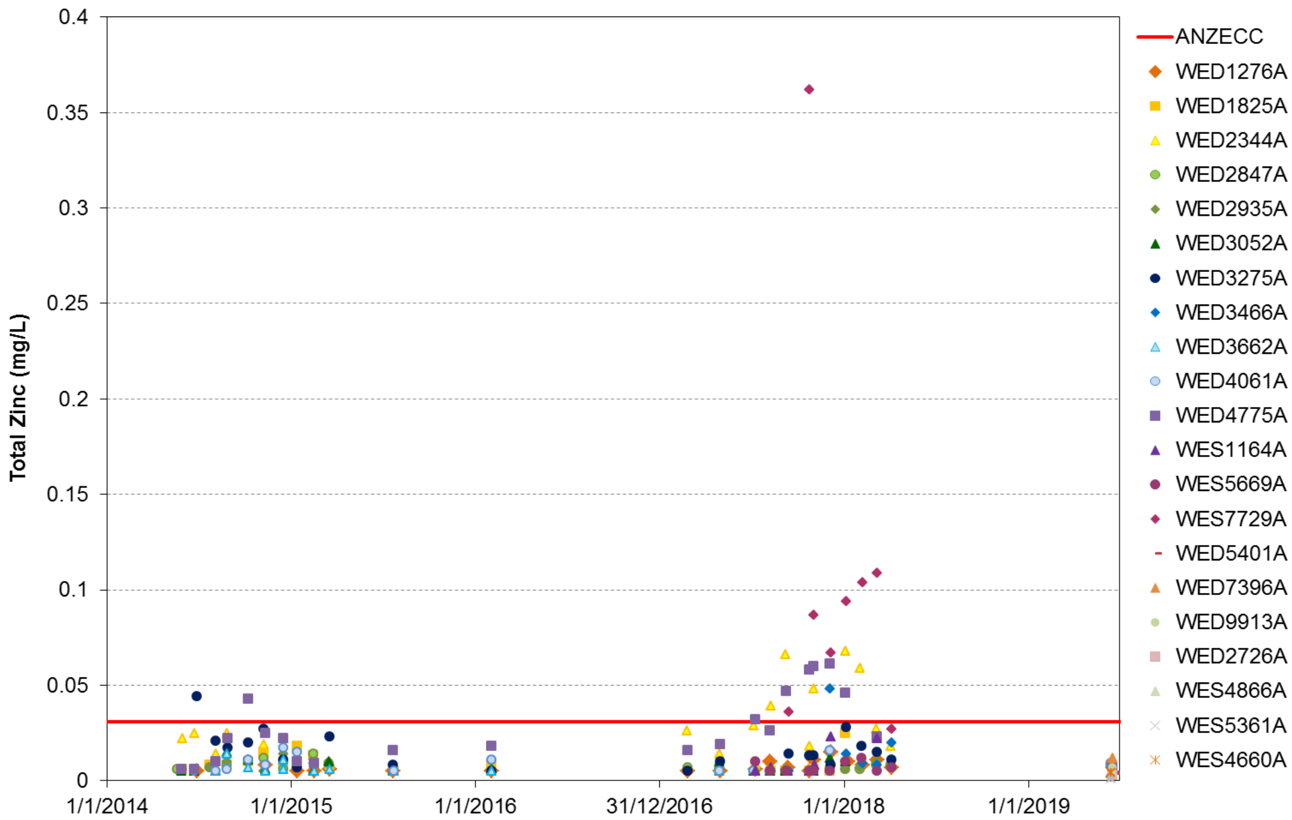


Figure A13 Total Zinc

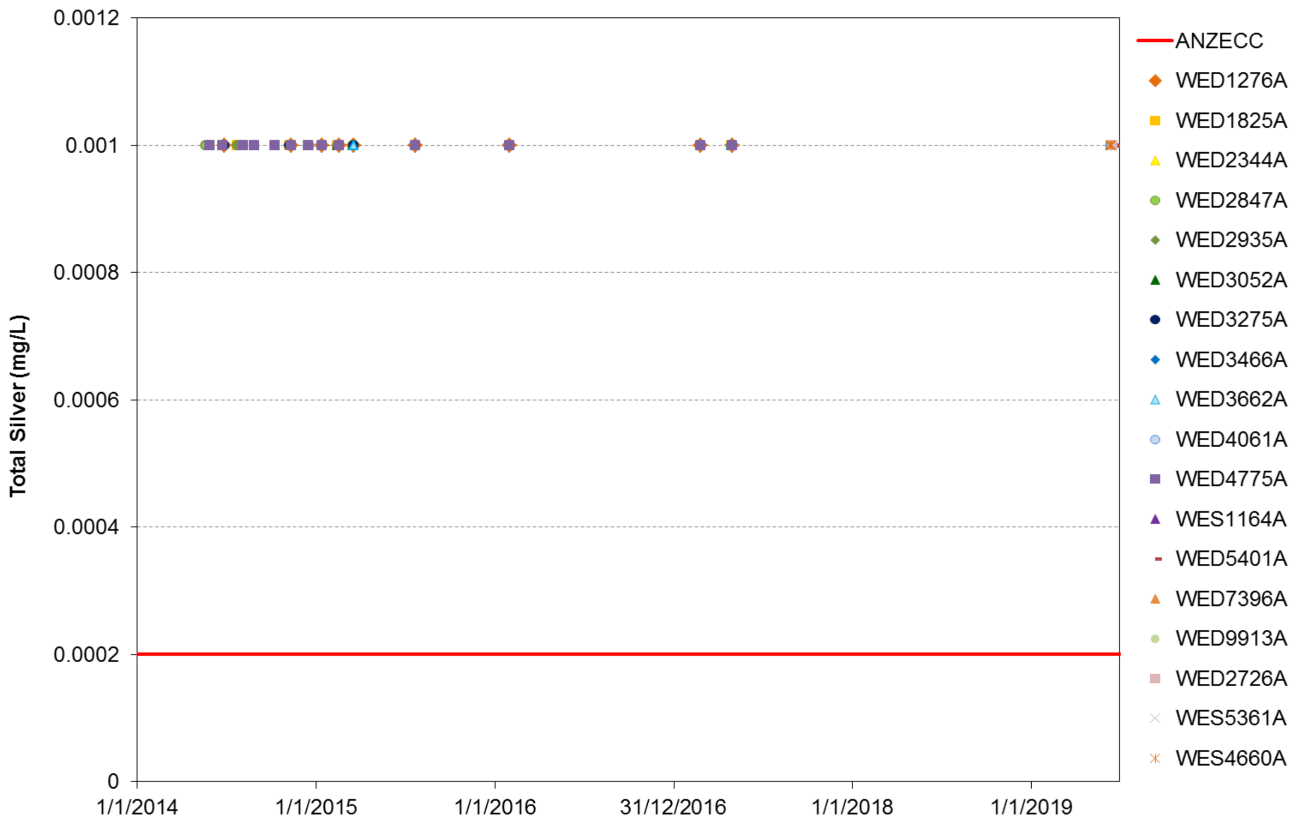


Figure A14 Total Silver

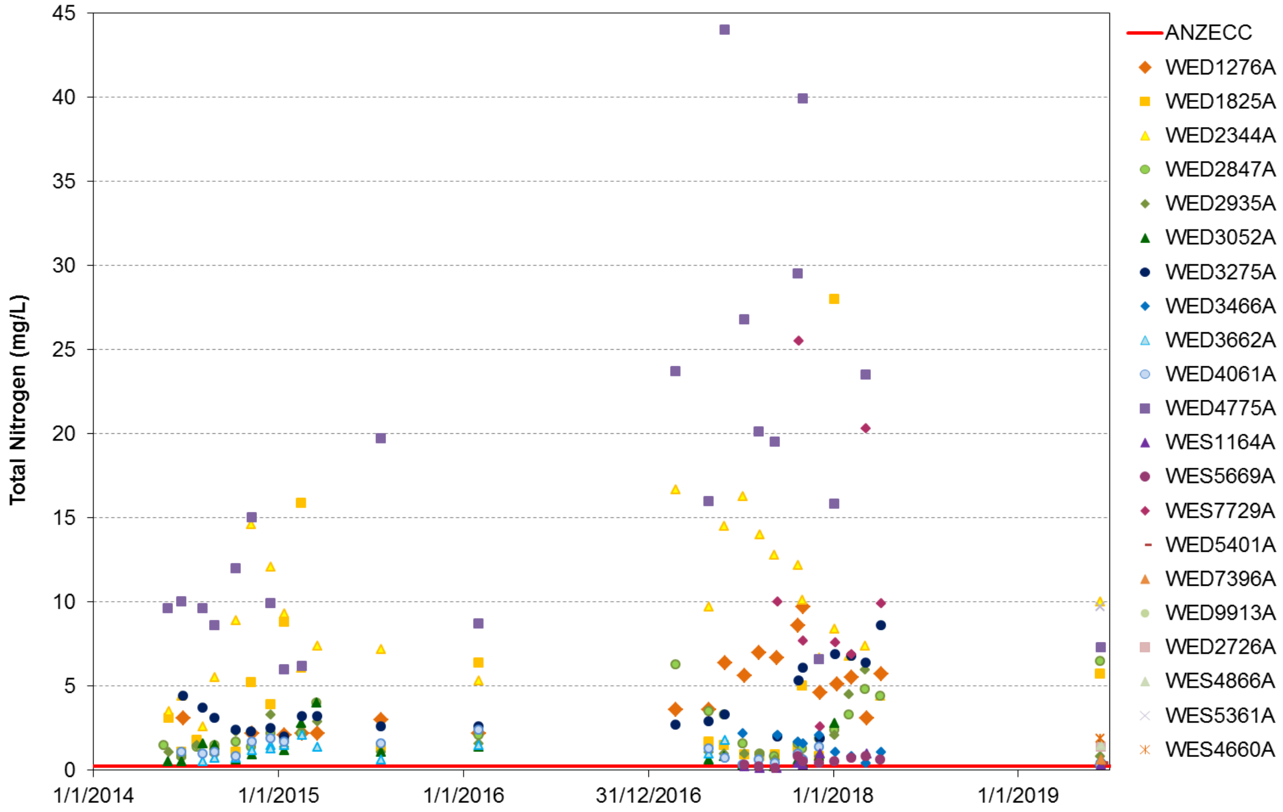


Figure A15 Total Nitrogen

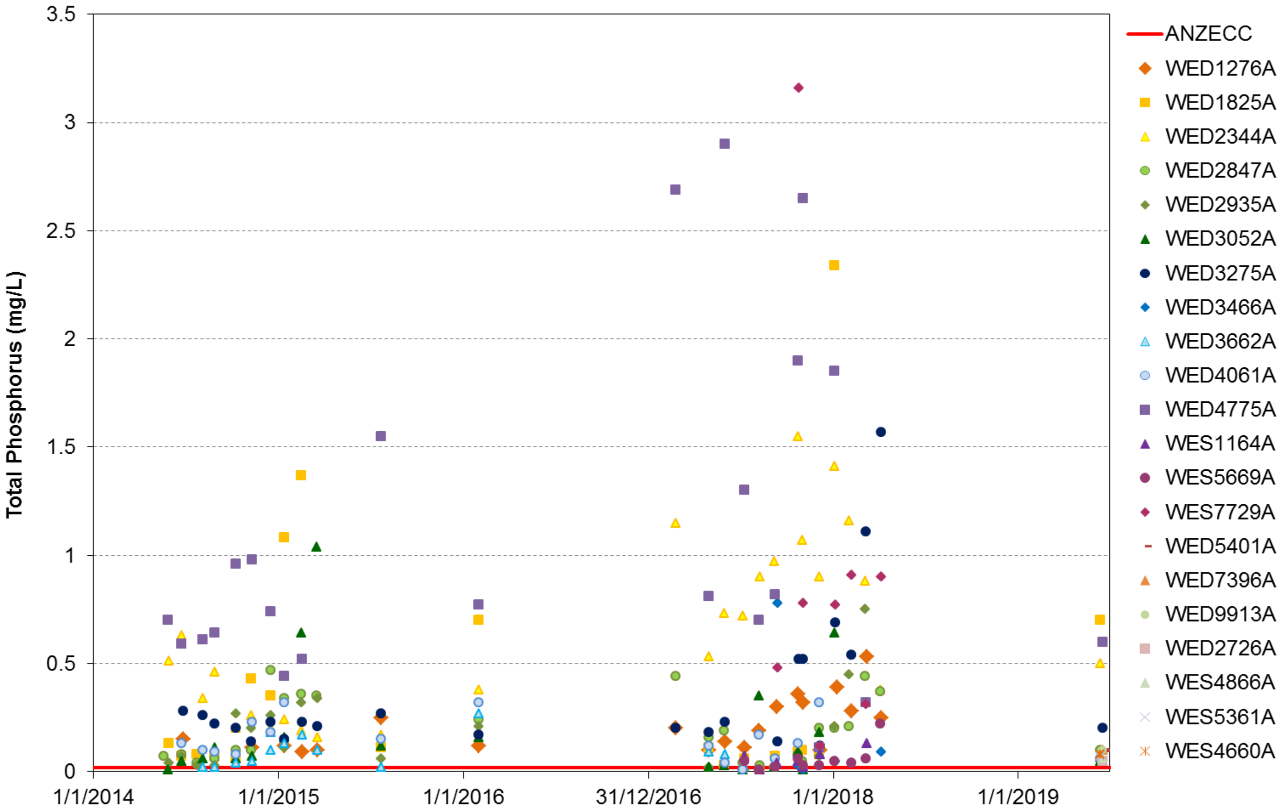


Figure A16 Total Phosphorus

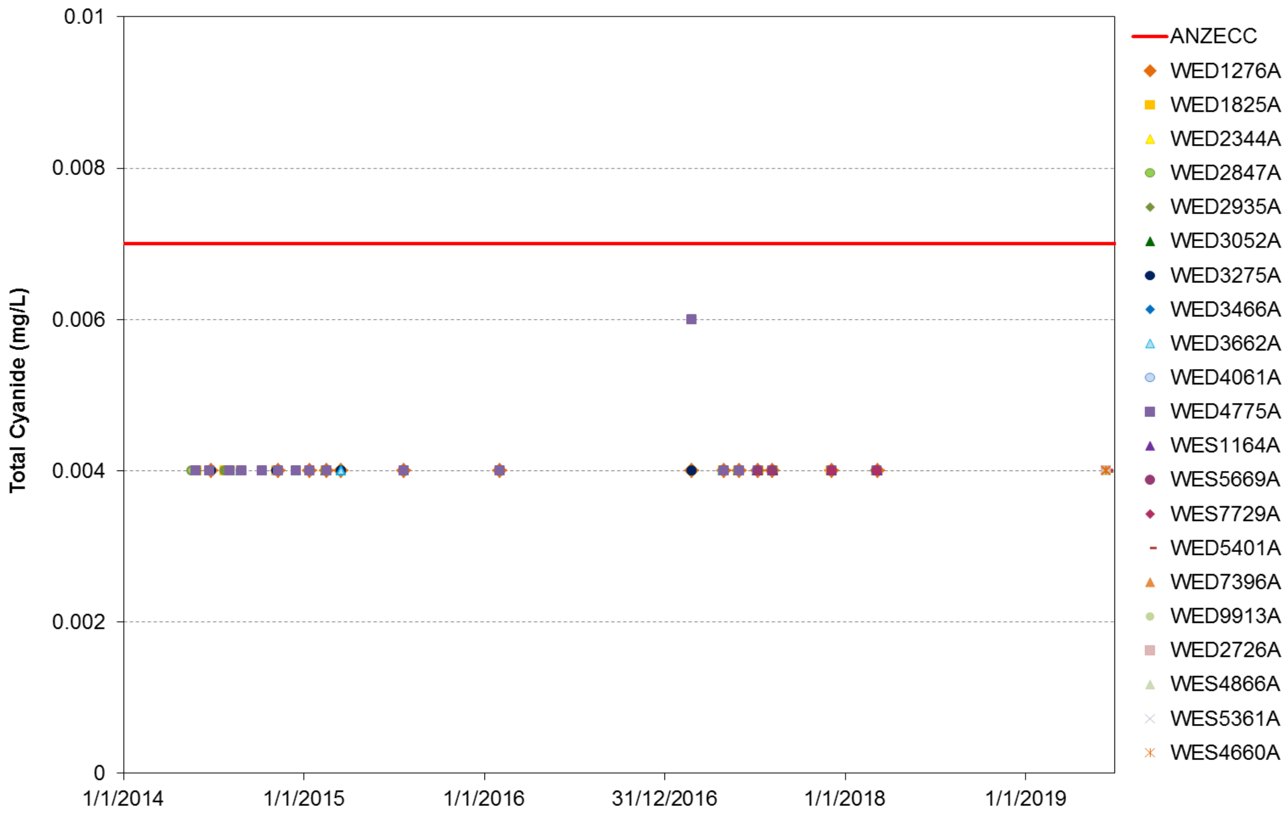


Figure A17 Total Cyanide

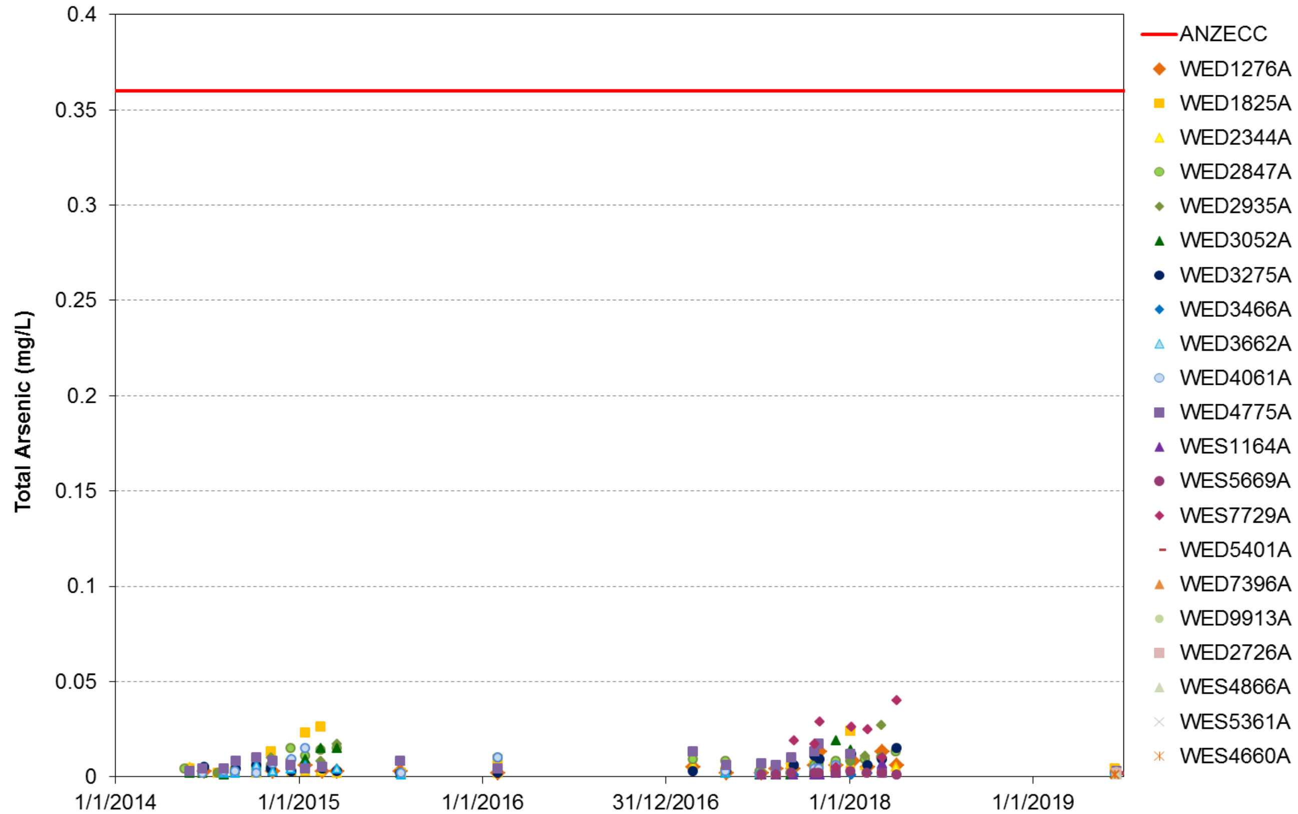


Figure A18 Total Arsenic

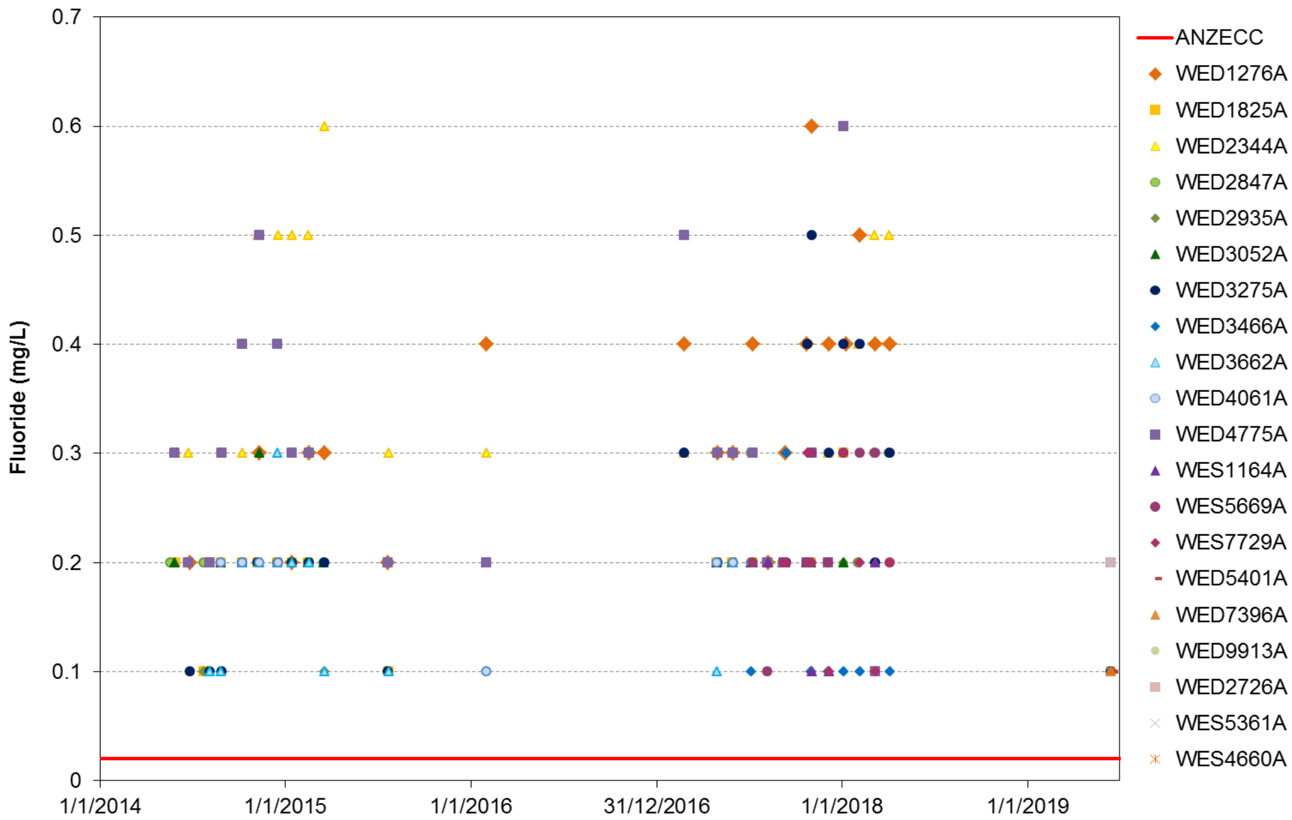


Figure A19 Fluoride

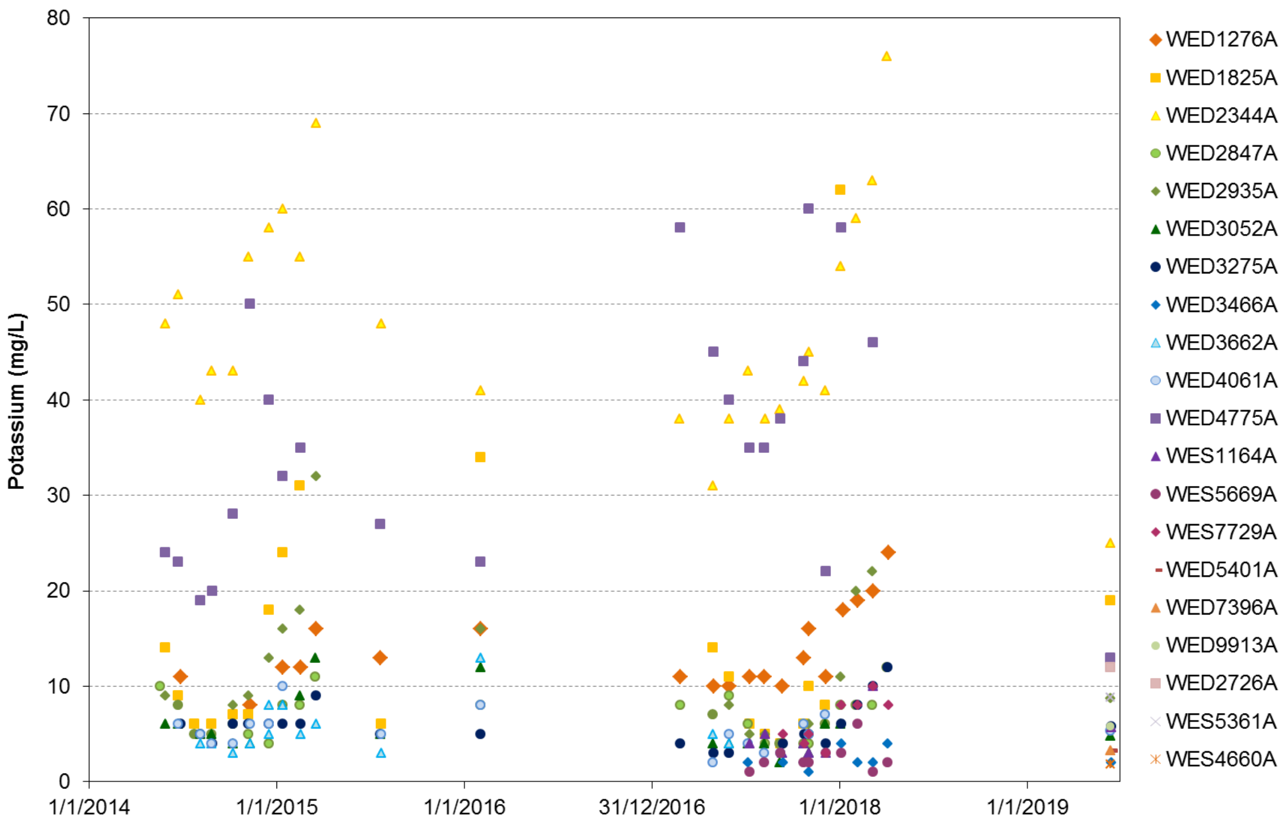


Figure A20 Potassium

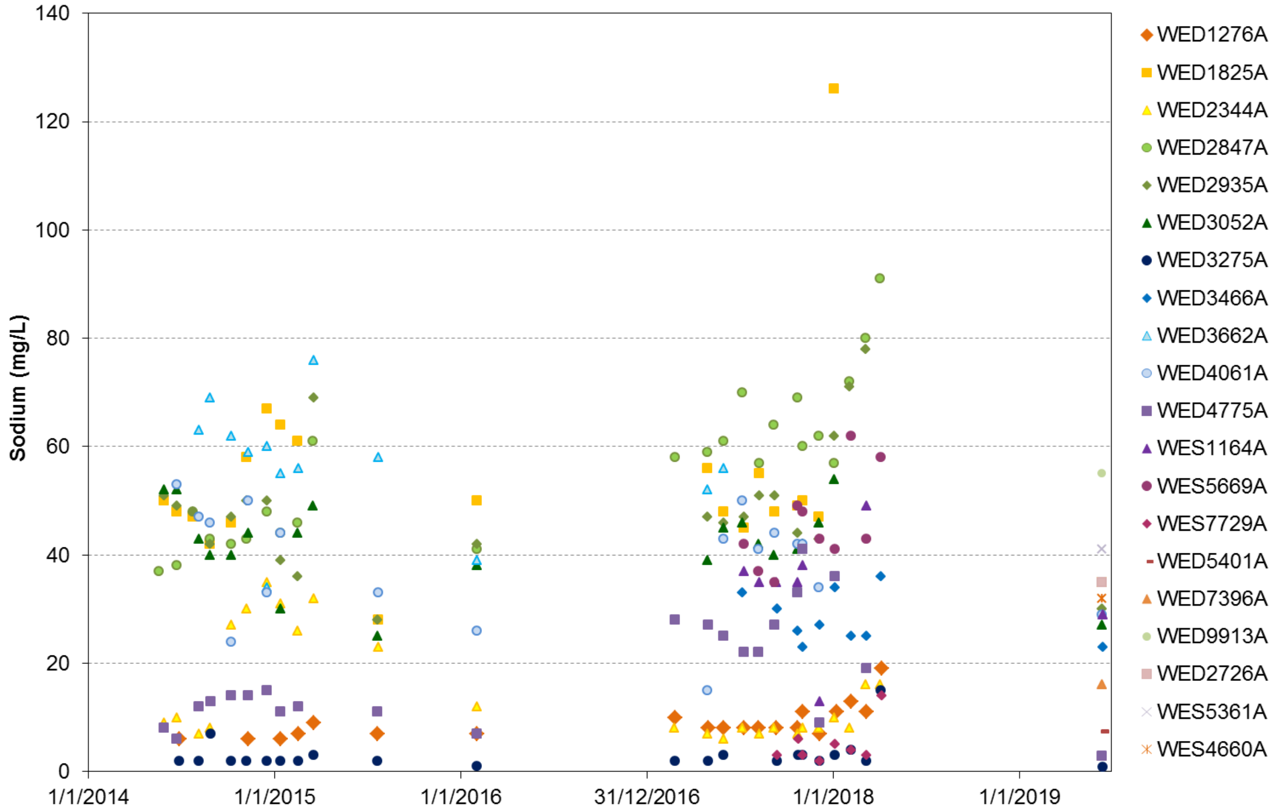


Figure A21 Sodium

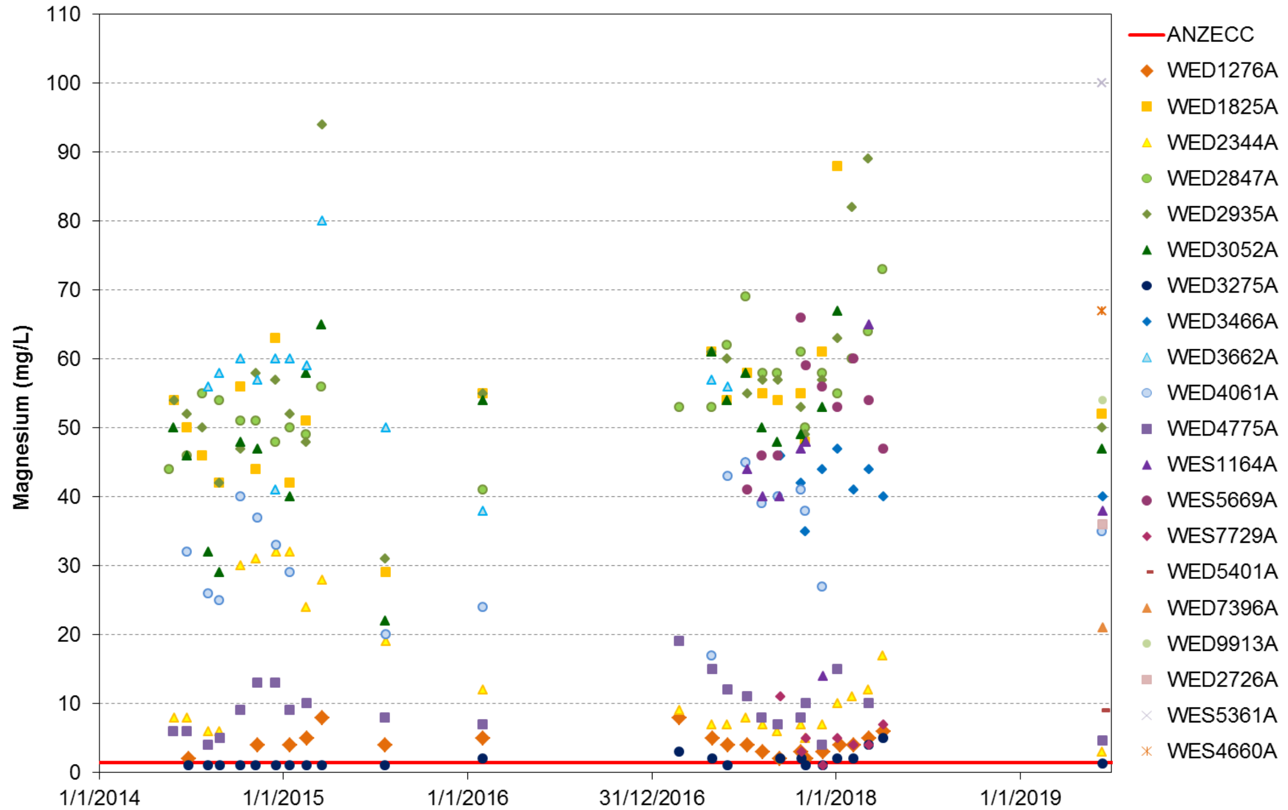


Figure A22 Magnesium

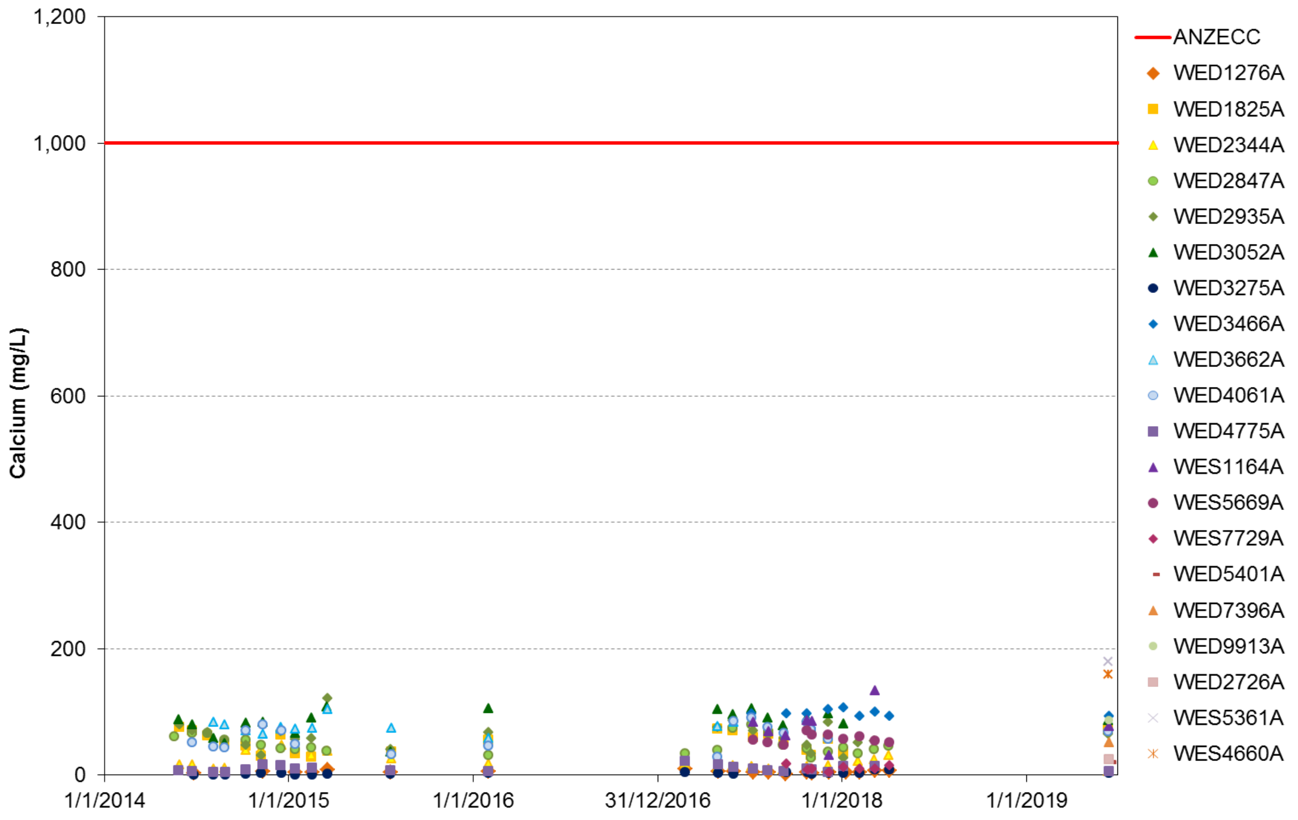


Figure A23 Calcium

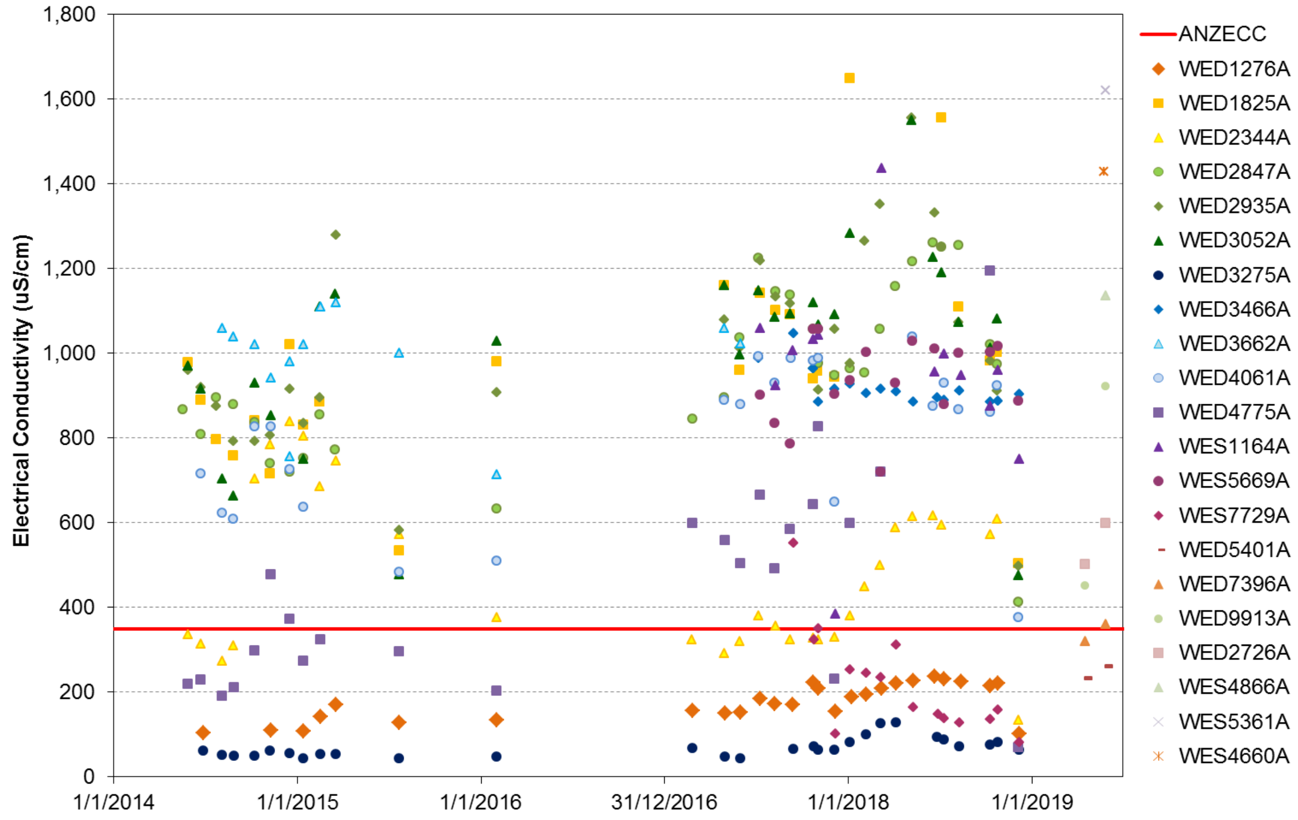


Figure A24 Electrical Conductivity

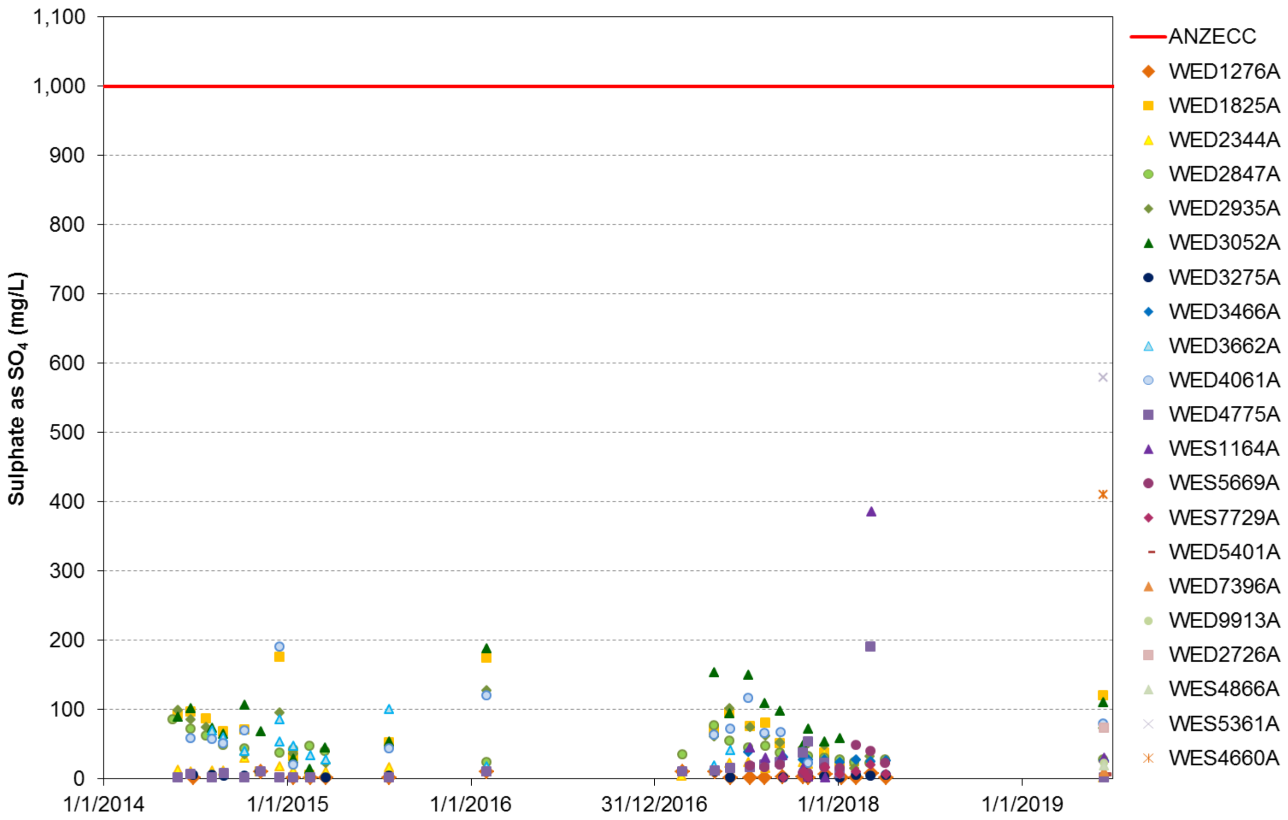


Figure A25 Sulphate as SO_4

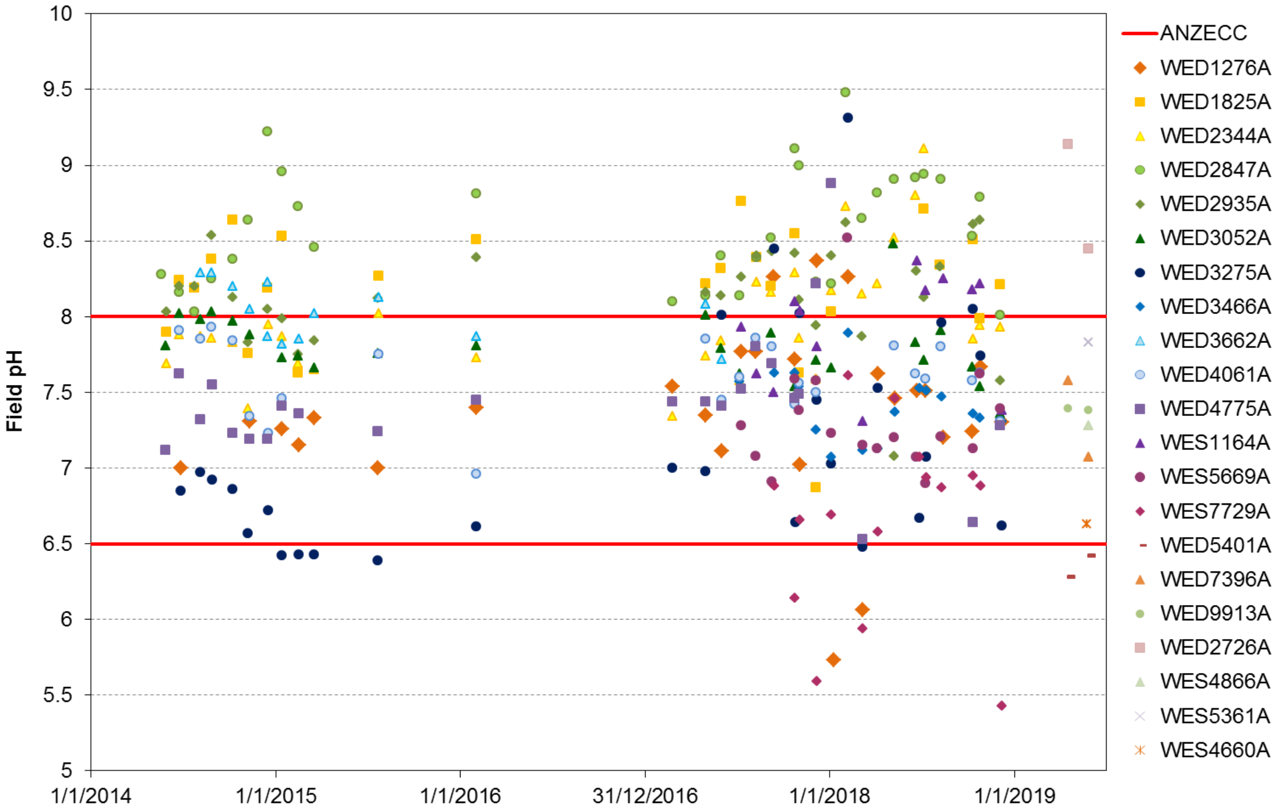


Figure A26 Field pH

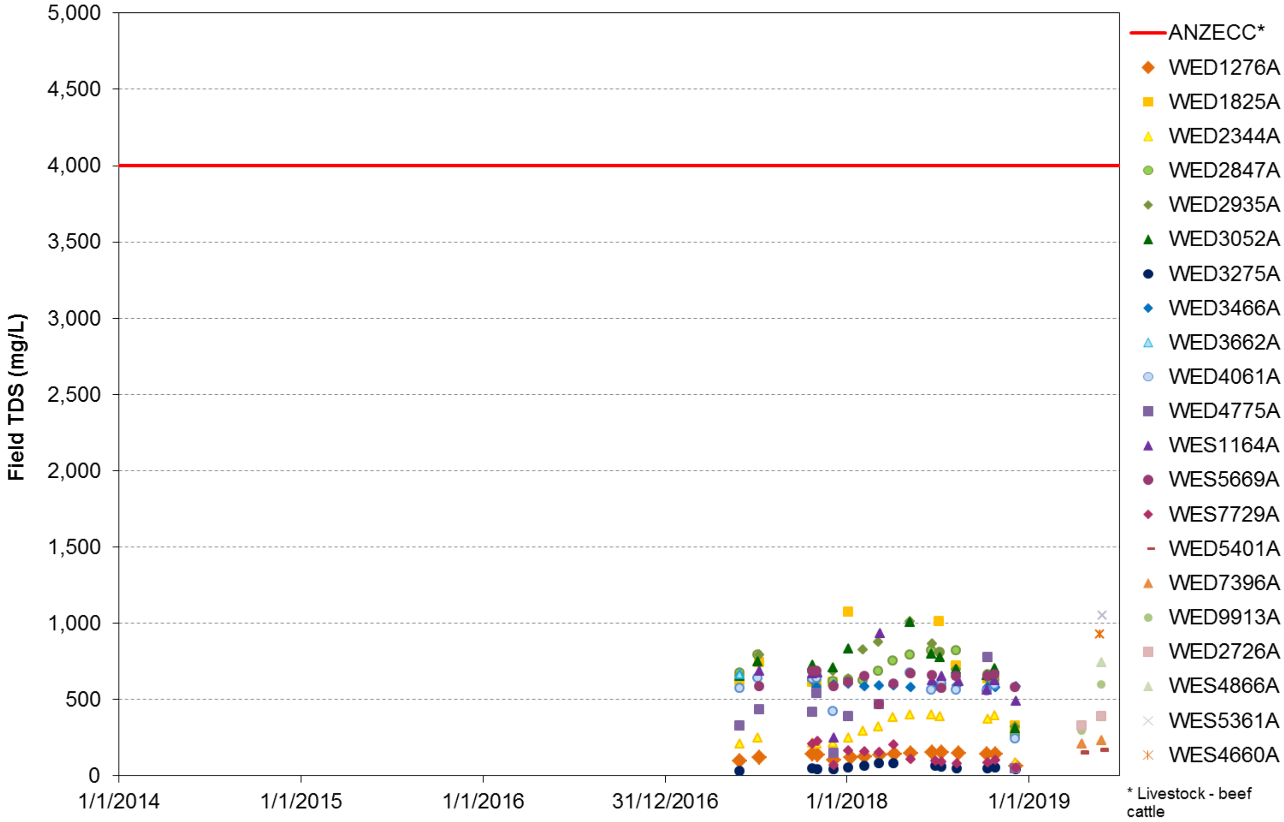


Figure A27 Field TDS

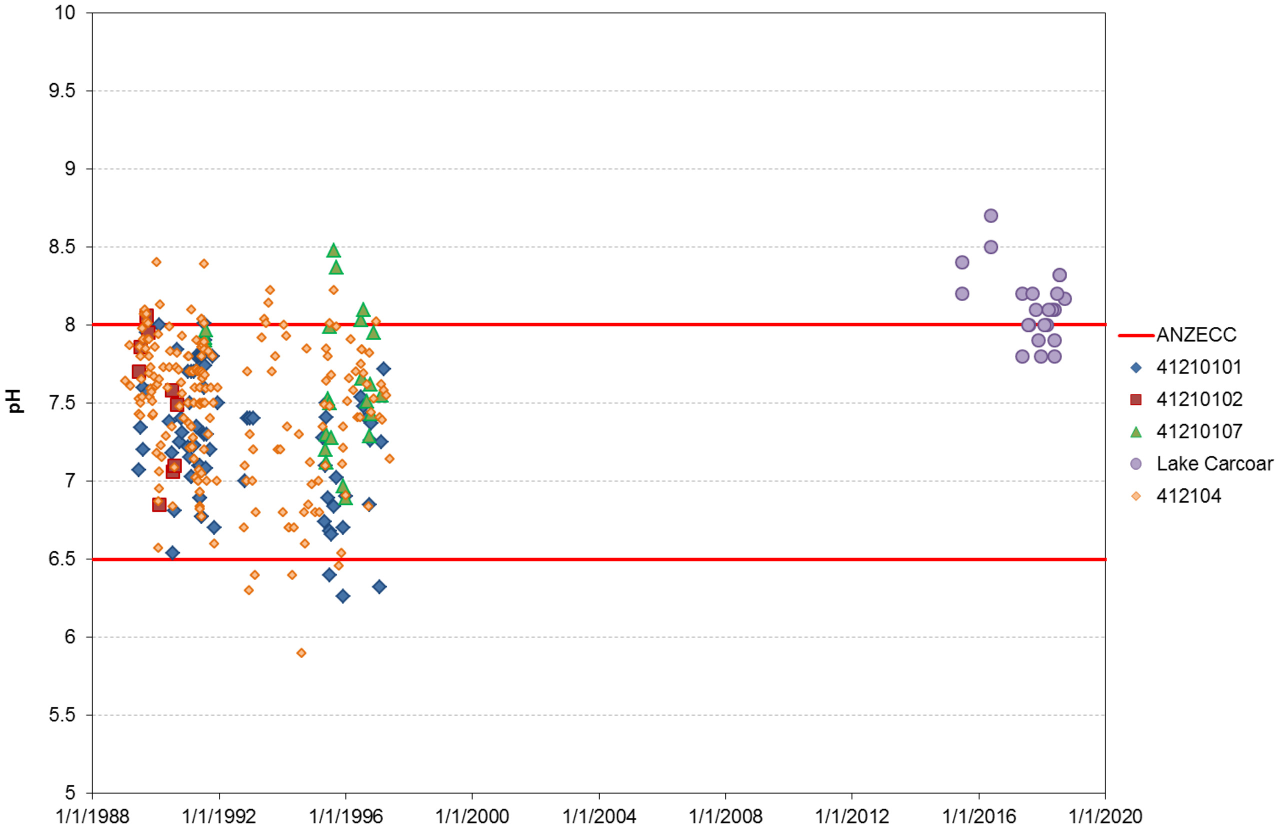


Figure A28 Regional pH

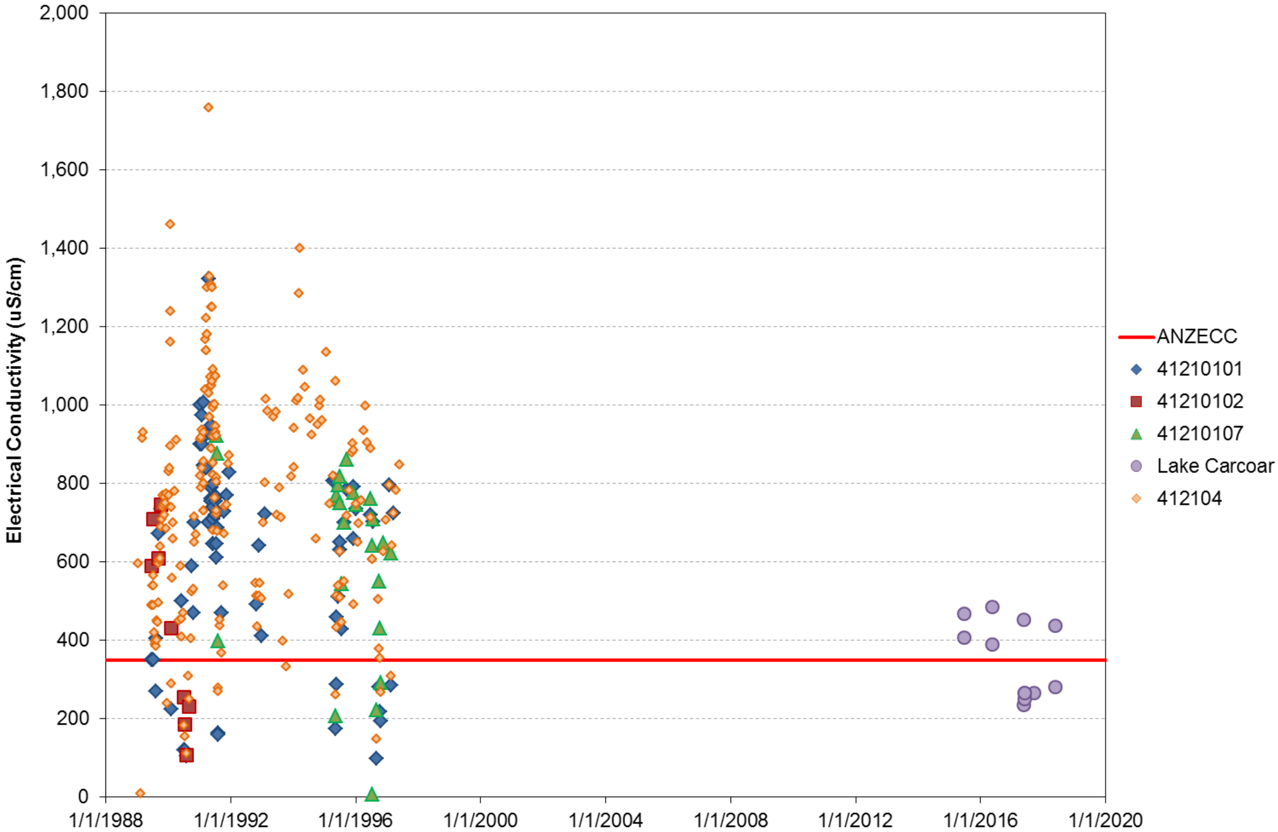


Figure A29 Regional Electrical Conductivity

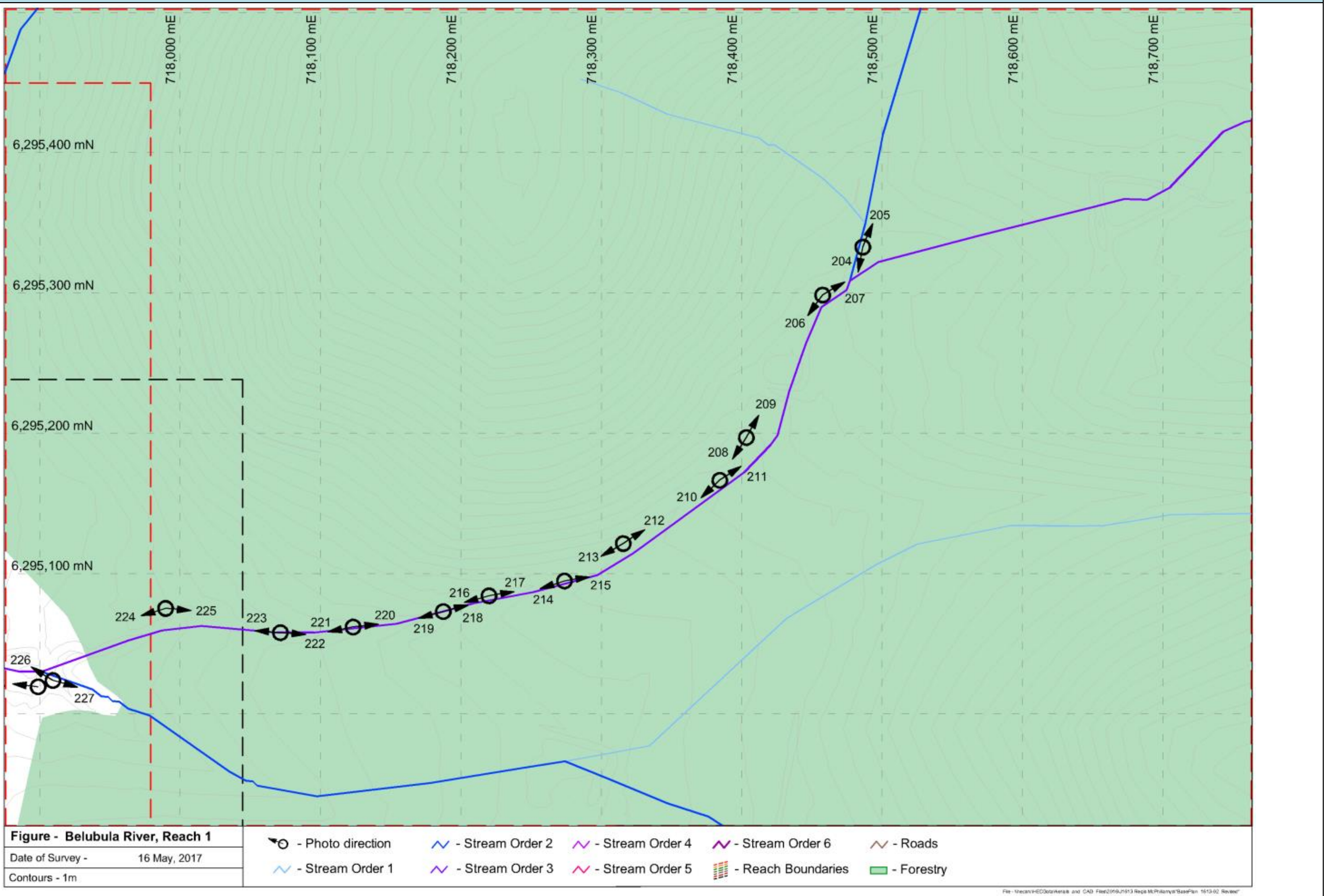
ATTACHMENT B Geomorphology Ground Reconnaissance

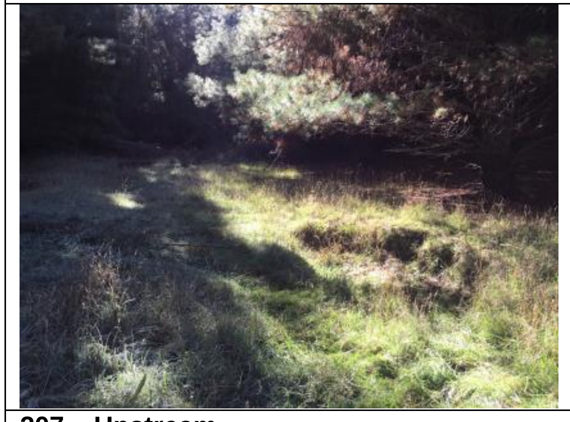
This attachment provides the results of the geomorphology ground reconnaissance including individual stream maps (refer Figure 6 of the main report for the reach map overview) and associated GPS referenced photographs. The reconnaissance was split into sixteen reach maps as summarised in the table below.

Reach Map	Stream	Description	Maximum Stream Order	Typical Sections	Typical Section Photographs
BR-1 BR-2	Belubula River	Headwaters upstream of TSF	Third	Forest Grazing Large Farm Dam	212, 214 238 244
BR-3 BR-4 BR-5		Downstream of TSF, upstream of Trib A confluence	Fifth	Straight Meandering	346 393
BR-5 BR-6 BR-7		Downstream of Trib A confluence	Sixth	-	453
FG	Trib FG		Second	Downstream of forestry Upstream of the Belubula	253 246
F	Trib F		Fourth	Partly cleared Cleared	263 270
E	Trib E		Second	Upstream Downstream	171 194
D-1 D-2	Trib D		Second	-	158
B	Trib B		Fourth	Confined Grassed Meander	283 279
A-1 A-2 A-3	Trib A		Fifth	Swampy Meadow Channel Between Dams Downstream of Trib B Downstream of Dungeon Road	294 298 309 320

The figures and tables to follow present each reach map and all the associated photographs taken during the site reconnaissance.

Belubula River Reach 1



		
204 – Downstream	**205 – Upstream**	**206 – Downstream**
		
207 – Upstream	**208 – Downstream**	**209 – Upstream**
		
210 – Downstream	**211 – Upstream**	**212 – Upstream**

213 – Downstream

214 – Downstream

215 – Upstream

216 – Downstream

217 – Upstream

218 – Upstream

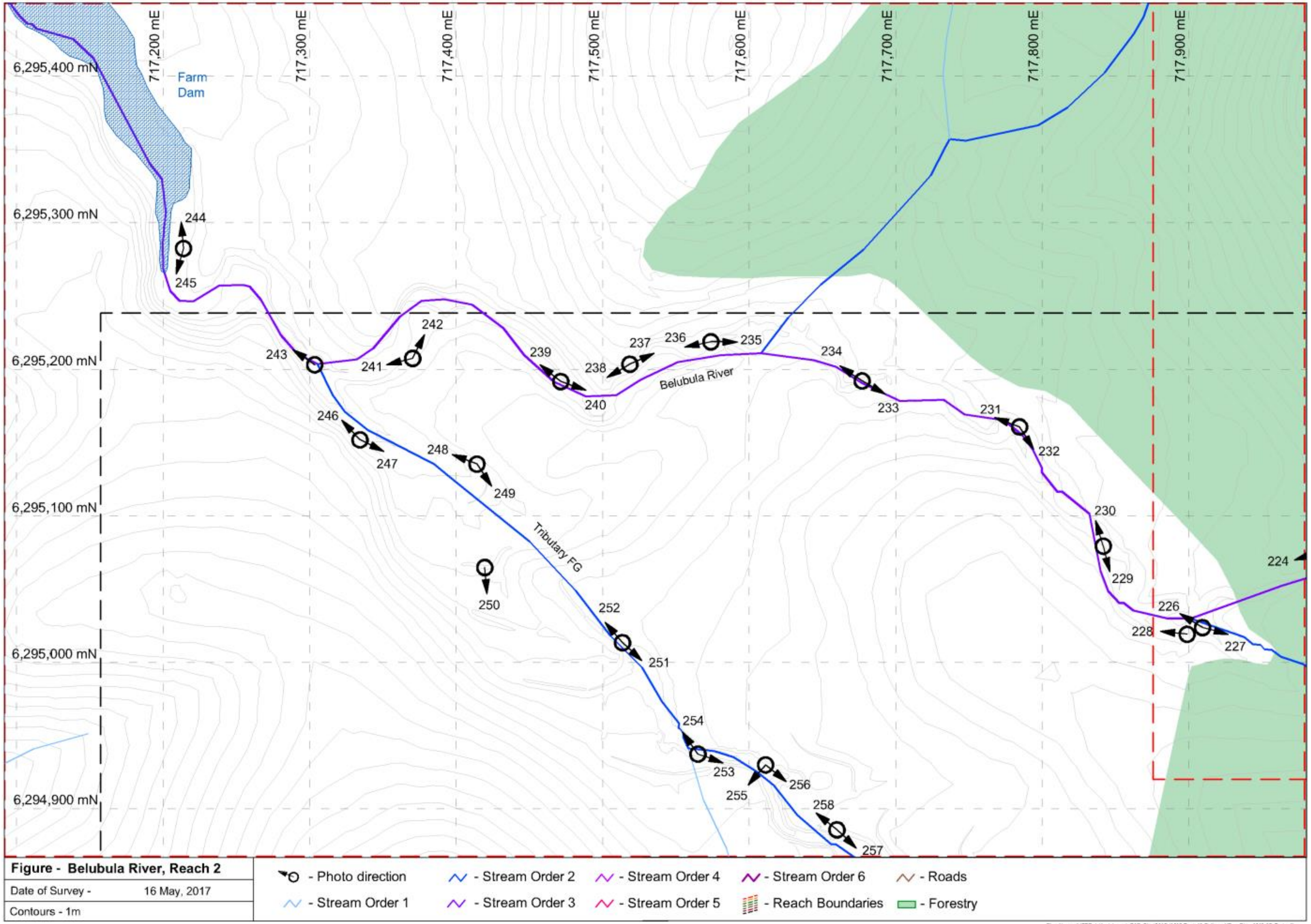
219 – Downstream

220 – Upstream

221 – Downstream

		
222 – Upstream	**223 – Downstream**	**224 – Downstream**
		
225 – Upstream		

Belubula River Reach 2



		
226 – Downstream	**227 – Upstream**	**228 – Downstream**
		
229 – Upstream	**230 – Downstream**	**231 – Downstream**
		
232 – Upstream	**233 – Upstream**	**234 – Downstream**


235 – Upstream


236 – Downstream


237 – Upstream


238 – Downstream


239 – Downstream


240 – Upstream

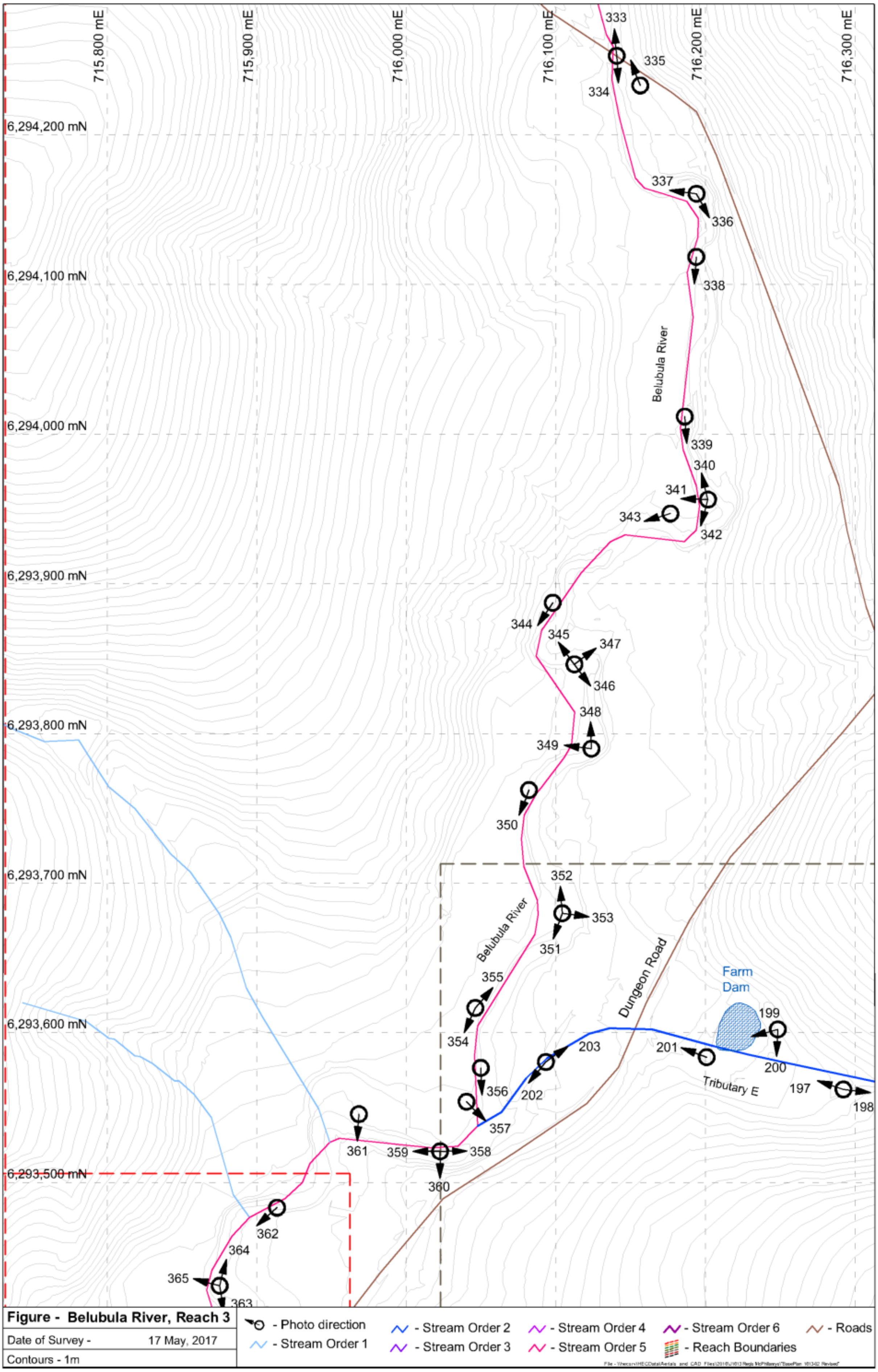

241 – Downstream


242 – Upstream


243 – Downstream

	
244 – Downstream	**245 – Upstream**

Belubula River Reach 3



	
333 – Upstream	**334 – Downstream**
	
335 – Upstream	**336 – Downstream**
1 	
337 – Upstream	**338 – Downstream**
	
339 – Downstream	**340 – Upstream**

	
341 – Right Bank	**342 – Downstream**
	
343 – Downstream	**344 – Downstream**
	
345 – Upstream	**346 – Downstream**
	
347 – Left Bank	**348 – Upstream**

	
349 – Right Bank	**350 – Downstream**
	
351 – Downstream	**352 – Upstream**
	
353 – Left Bank	**354 – Downstream**
	
355 – Upstream	**356 – Downstream**

	
357 – Downstream	**358 – Upstream**
	
359 – Downstream	**360 – Left Bank**
	
361 – Left Bank	**362 – Downstream**

Belubula River Reach 4

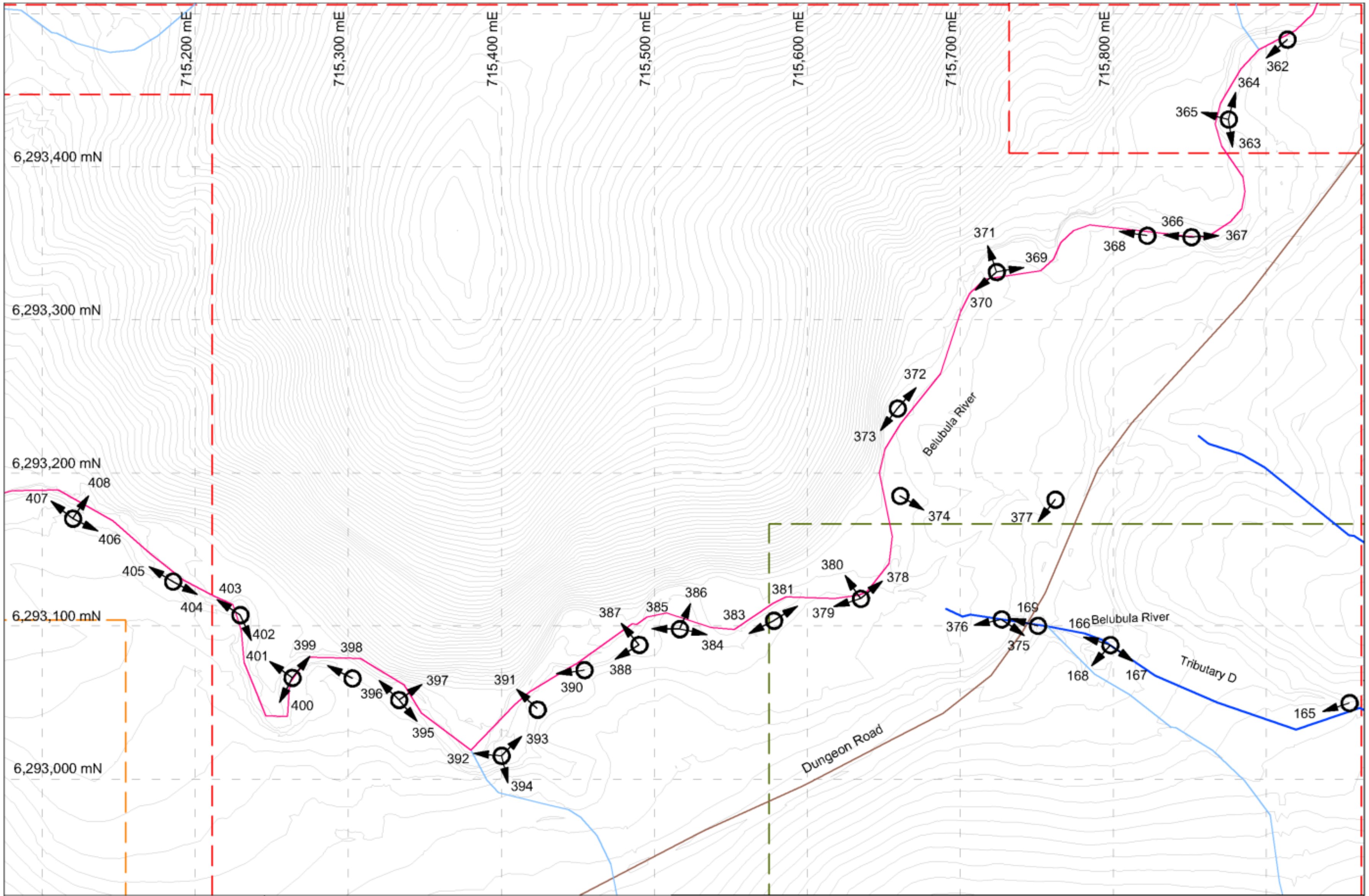


Figure - Belubula River, Reach 4	
Date of Survey -	17 May, 2017
Contours - 1m	

- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

		
363 – Downstream	**364 – Upstream**	**365 – Right Bank**
		
366 – Downstream	**367 – Upstream**	**368 – Downstream**
		
369 – Upstream	**370 – Downstream**	**371 – Right Bank**

372 – Upstream

373 – Downstream

374 – Left Bank Downstream

378 – Upstream

379 – Downstream

380 – Right Bank

381 – Upstream

383 – Downstream

384 – Upstream

385 – Downstream

386 – Right Bank

387 – Right Bank

388 – Downstream

390 – Downstream

391 – Right Bank

392 – Downstream

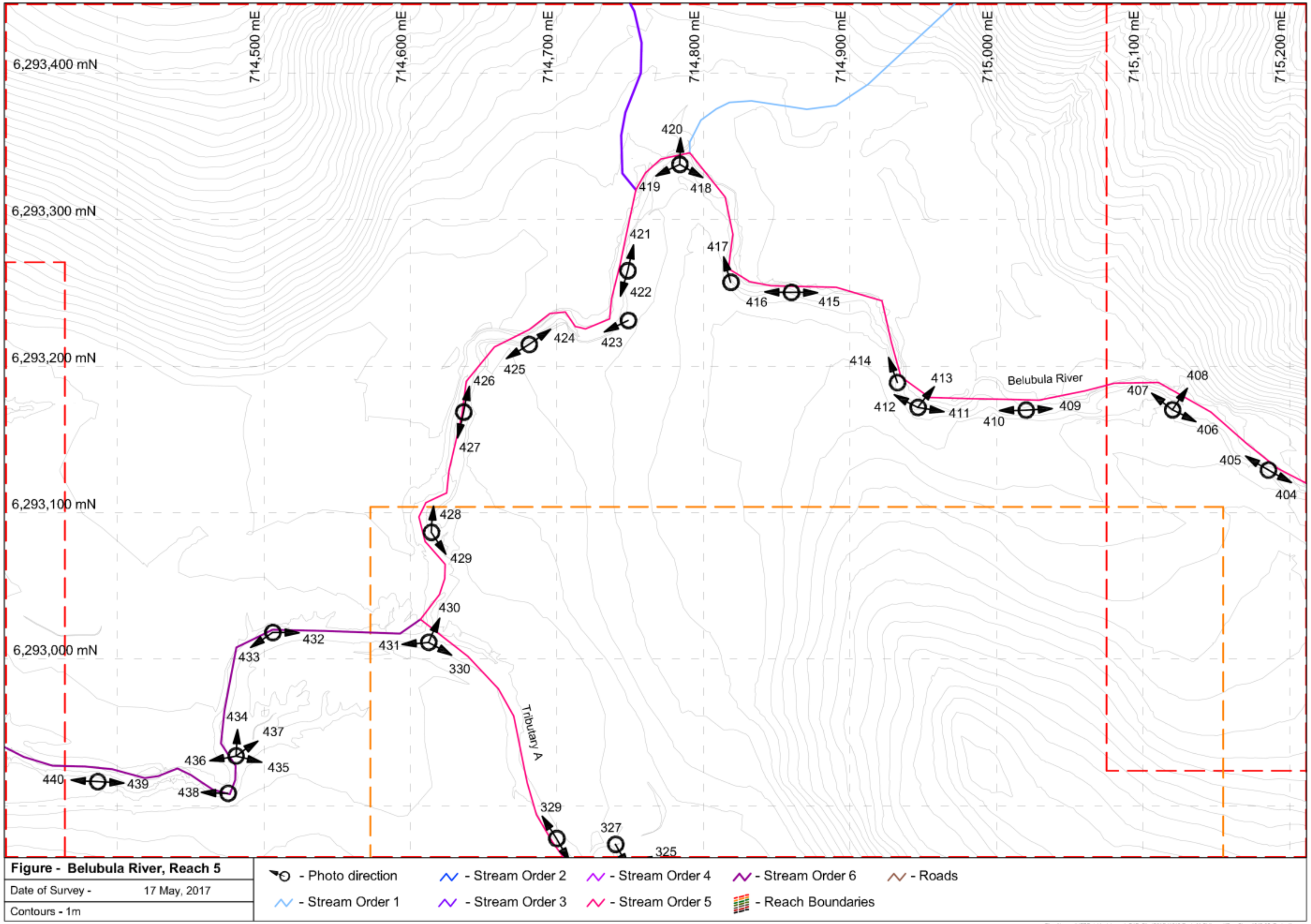
393 – Upstream

394 – Left Bank

		
395 – Upstream	**396 – Downstream**	**397 – Right Bank**
		
398 – Downstream	**399 – Upstream**	**400 – Downstream**
		
401 – Right Bank	**402 – Upstream**	**403 – Downstream**

	
404 – Upstream	**405 – Downstream**

Belubula River Reach 5



406 – Upstream

407 – Downstream

408 – Right Bank

409 – Upstream

410 – Downstream

411 – Upstream

412 – Downstream

413 – Right Bank

414 – Downstream

		
415 – Upstream	**416 – Downstream**	**417 – Downstream**
		
418 – Upstream	**419 – Downstream**	**420 – Right Bank**
		
421 – Upstream	**422 – Downstream**	**423 – Downstream**

424 – Upstream

425 – Downstream

426 – Upstream

427 – Downstream

428 – Upstream

429 – Downstream

430 – Upstream

431 – Downstream

330 – Left Bank

		
432 – Upstream	**433 – Downstream**	**434 – Upstream**
		
435 – Right Bank	**436 – Left Bank**	**437 – Upstream Left Bank**
		
438 – Downstream	**439 – Upstream**	**440 – Downstream**

Belubula River Reach 6

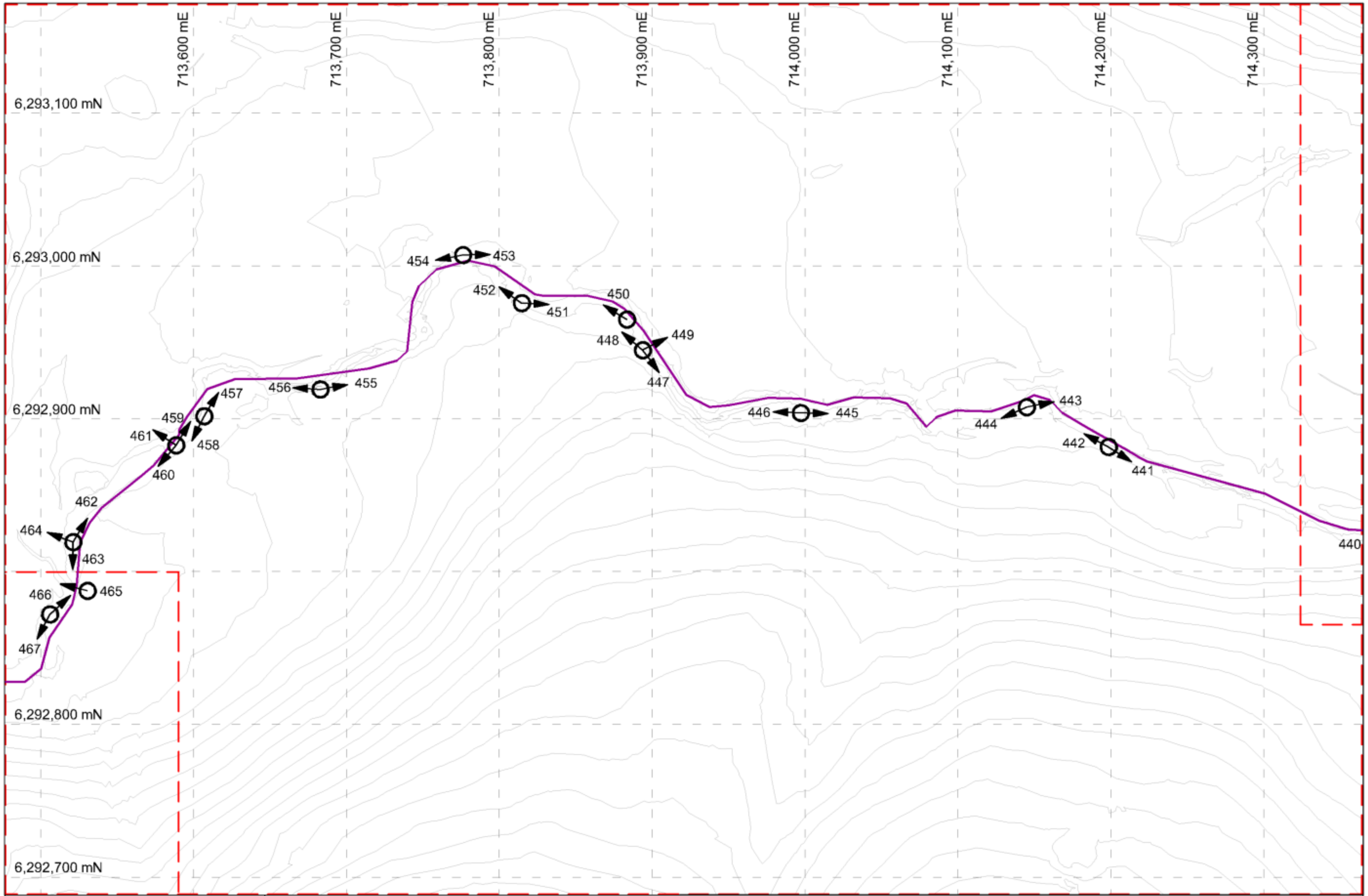


Figure - Belubula River, Reach 6	
Date of Survey -	17 May, 2017
Contours - 1m	

- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

441 – Upstream

442 – Downstream

443 – Upstream

444 – Downstream

445 –Upstream

446 – Downstream

447 –Upstream

448 – Downstream

449 – Right Bank

		
450 – Downstream	**451 – Upstream**	**452 – Downstream**
		
453 – Upstream	**454 – Downstream**	**455 – Upstream**
		
456 – Downstream	**457 – Upstream**	**458 – Downstream**

459 – Upstream

460 – Downstream

461 – Right Bank

462 – Upstream

463 – Downstream

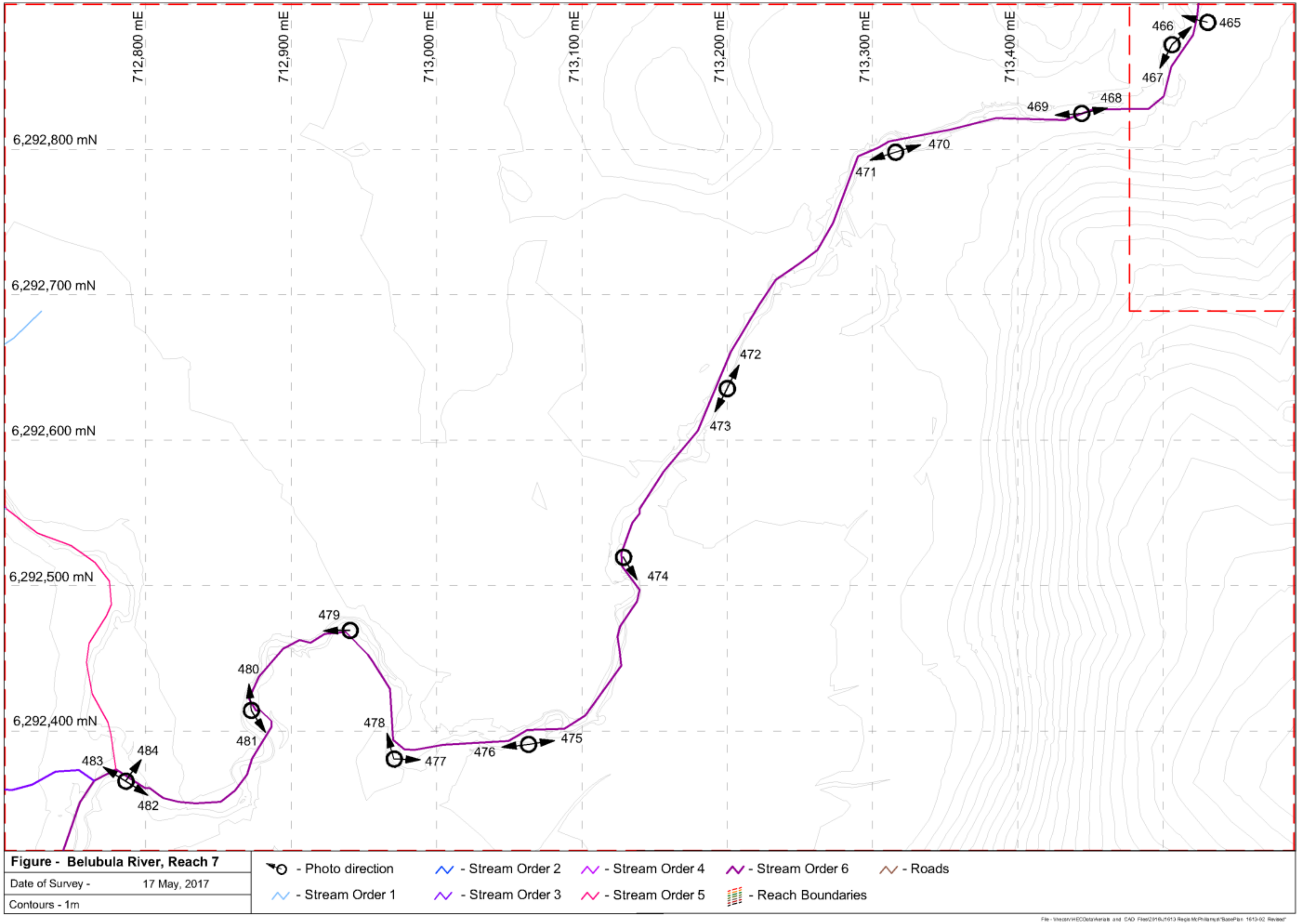
464 – Right Bank

465 – Right Bank

466 – Upstream

467 – Downstream

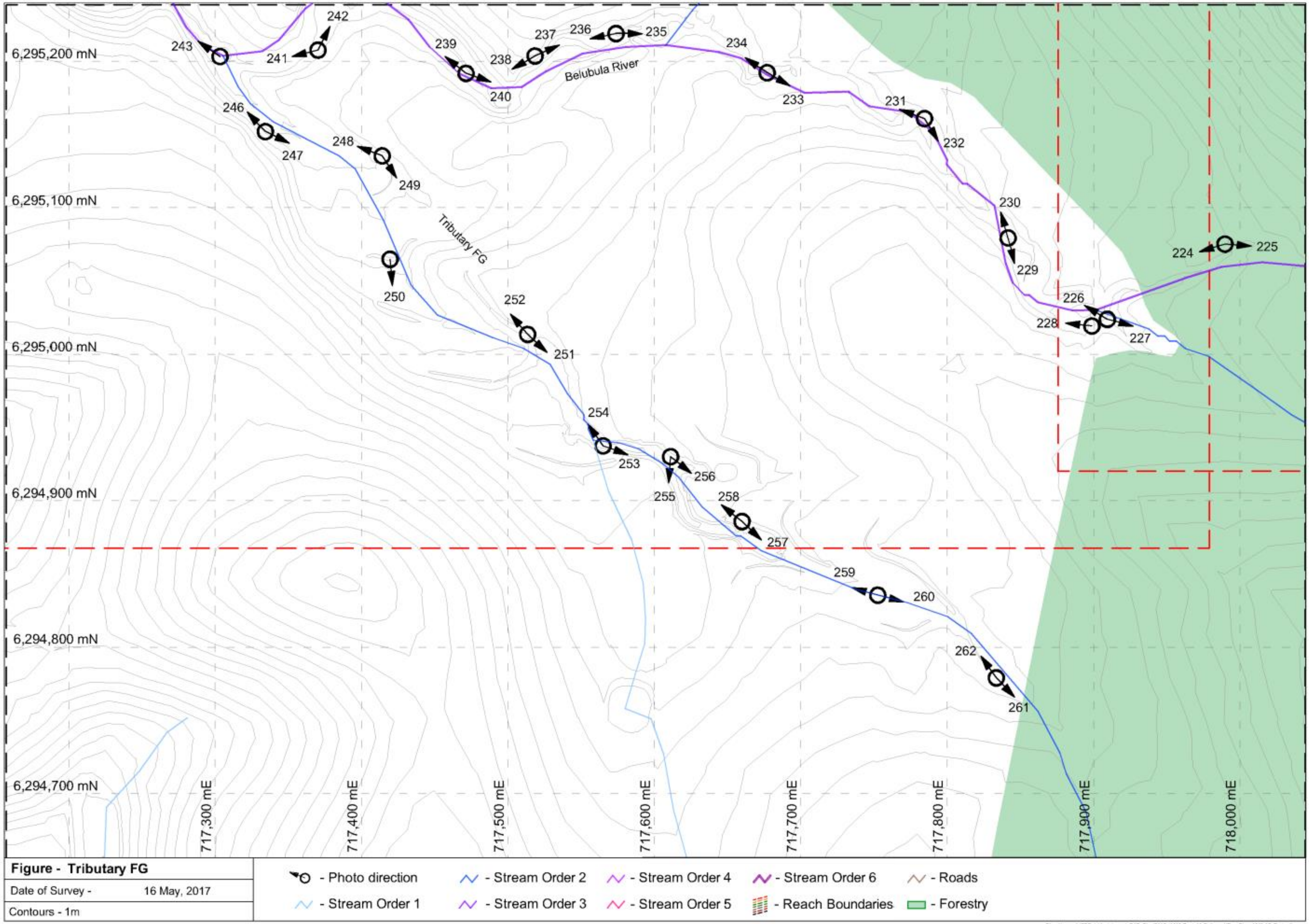
Belubula River Reach 7



		
468 – Upstream	**469 – Downstream**	**470 – Upstream**
		
471 – Downstream	**472 – Upstream**	**473 – Downstream**
		
474 – Downstream	**475 – Upstream**	**476 – Downstream**

		
477 – Upstream	**478 – Downstream**	**479 – Downstream**
		
480 – Upstream	**481 – Downstream**	**482 – Upstream**
		
483 – Downstream	**484 – Right Bank**	

Trib FG

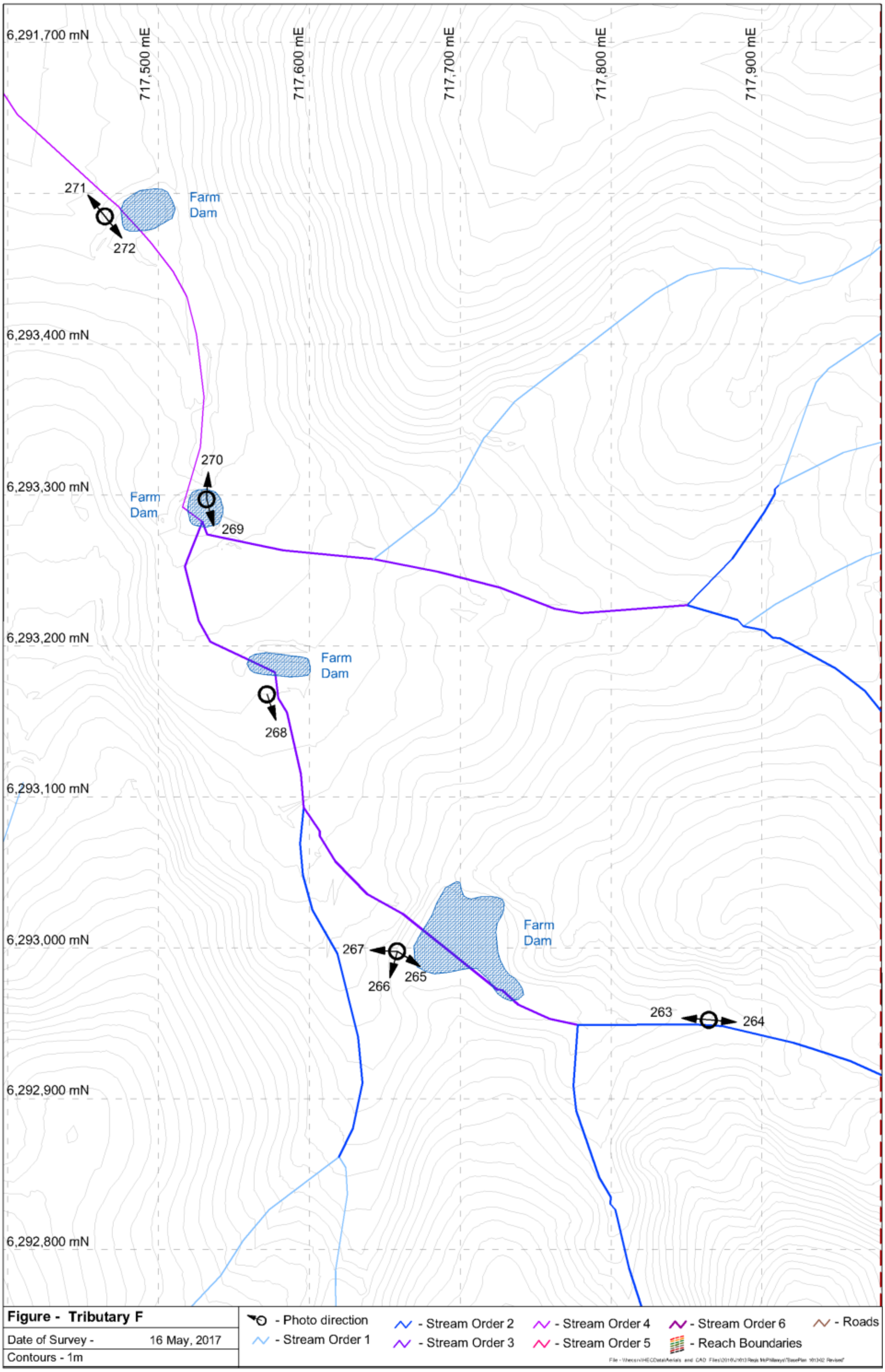


6,295,200 mN
6,295,100 mN
6,295,000 mN
6,294,900 mN
6,294,800 mN
6,294,700 mN
717,300 mE
717,400 mE
717,500 mE
717,600 mE
717,700 mE
717,800 mE
717,900 mE
718,000 mE
Belubula River
Tributary FG
224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262
Figure - Tributary FG
Date of Survey - 16 May, 2017
Contours - 1m
- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads
- Forestry

		
262 – Downstream	**261 – Upstream**	**260 – Upstream**
		
259 – Downstream	**258 – Downstream**	**257 – Upstream**
		
256 – Upstream Right Bank	**255 – Upstream Left Bank**	**254 – Downstream**

		
253 – Upstream	**252 – Downstream**	**251 – Upstream**
		
250 – Upstream	**249 – Upstream**	**248 – Downstream**
		
247 – Upstream	**246 – Downstream**	

Trib F


6,291,700 mN
6,293,400 mN
6,293,300 mN
6,293,200 mN
6,293,100 mN
6,293,000 mN
6,292,900 mN
6,292,800 mN
717,500 mE
717,600 mE
717,700 mE
717,800 mE
717,900 mE
Farm Dam
Farm Dam
Farm Dam
Farm Dam
271
272
270
269
268
267
266
265
263
264
Figure - Tributary F
Date of Survey - 16 May, 2017
Contours - 1m
- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

263 – Downstream

264 – Upstream

265 – Upstream

266 – Left Bank

267 – Downstream

268 – Upstream

269 – Upstream

270 – Downstream

	
271 – Downstream	**272 – Upstream**

Trib E

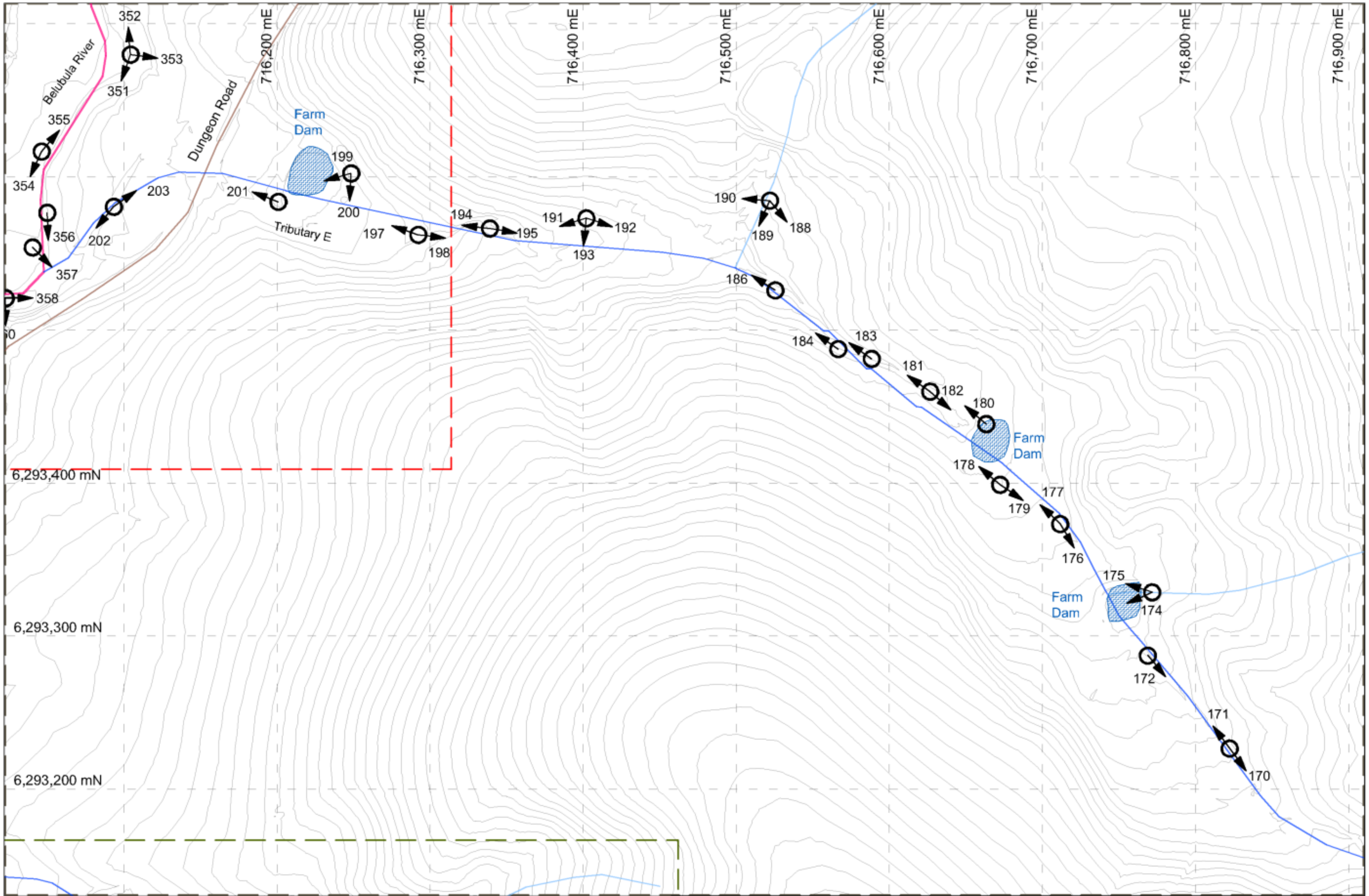


Figure - Tributary E	
Date of Survey -	16 May, 2017
Contours - 1m	

- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

		
170 – Upstream	**171 – Downstream**	**172 – Upstream**
		
174 – South-West to Dam	**175 – North-West to Dam**	**176 – Upstream**
		
177 – Downstream	**178 – Downstream**	**179 – Upstream**

		
180 – Downstream	**181 –Downstream**	**182 – Upstream**
		
183 – Downstream	**184 – Downstream**	**186 – Downstream**
		
188 – Trib Left Bank	**189 – Trib Downstream**	**190 – Trib Right Bank**


191 – Downstream


192 – Upstream


193 – Left Bank


194 – Downstream


195 – Upstream


197 – Downstream

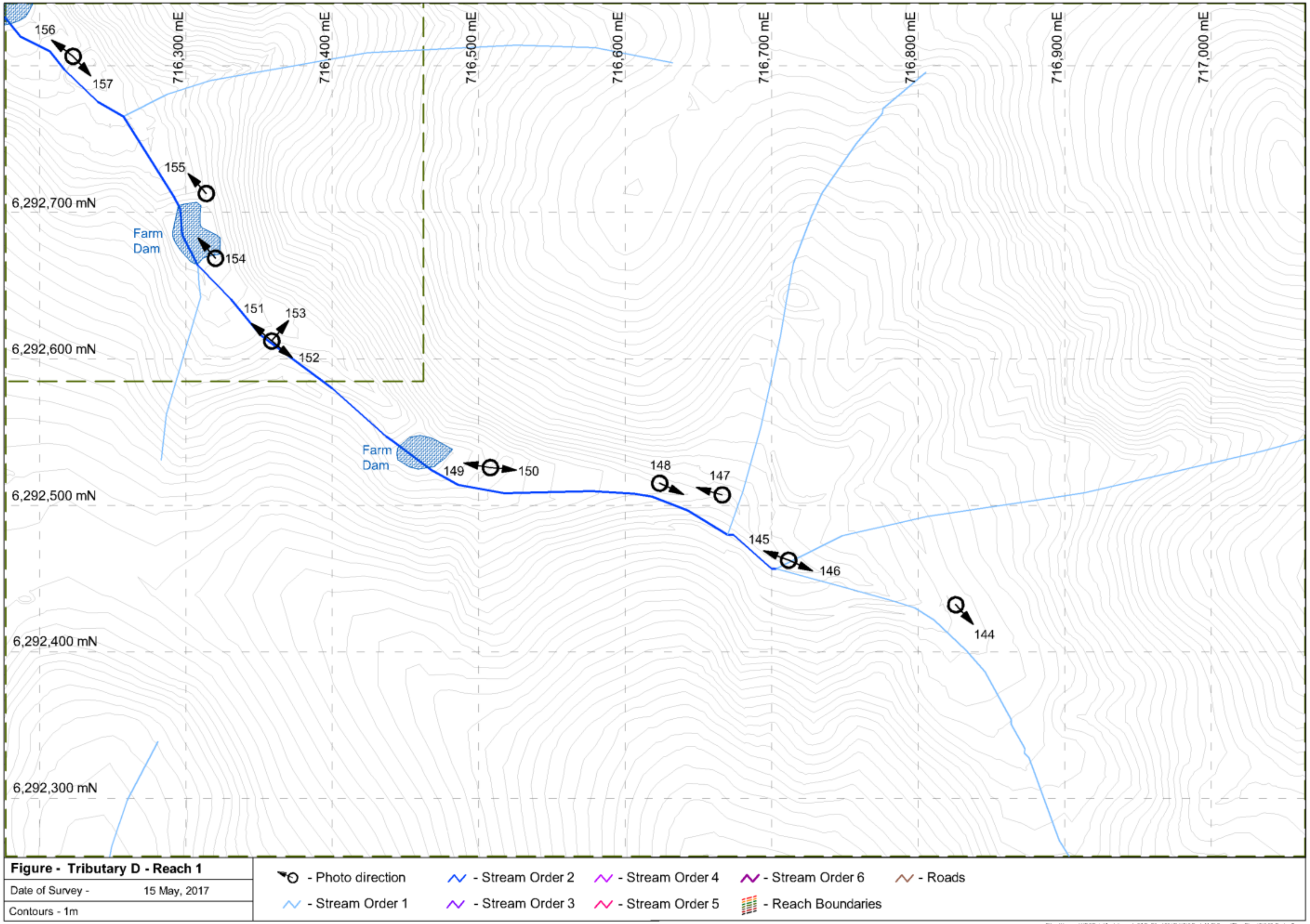

198 – Upstream


199 – Downstream to Dam


200 – Left Bank

		
201 – Downstream	**202 – Downstream**	**203 - Upstream**

Trib D Reach 1



144 – Upstream

145 – Downstream

146 – Upstream

147 – Downstream

148 – Upstream

149 – Downstream

150 – Upstream

151 – Downstream

152 - Upstream

		
153 – Right Bank	**154 – Downstream**	**155 - Downstream**

Trib D Reach 2

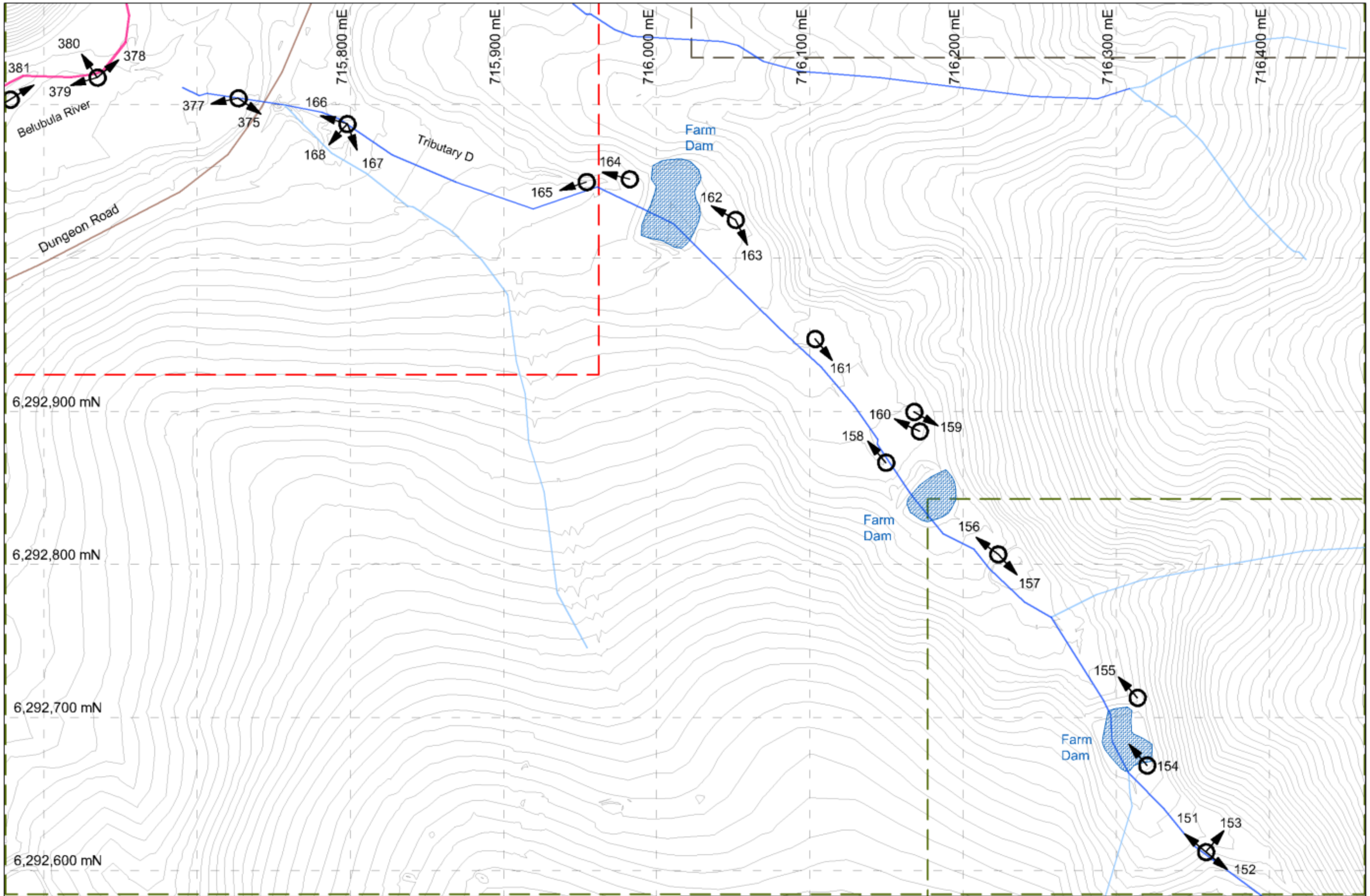


Figure - Tributary D - Reach 2

Date of Survey - 15 May, 2017

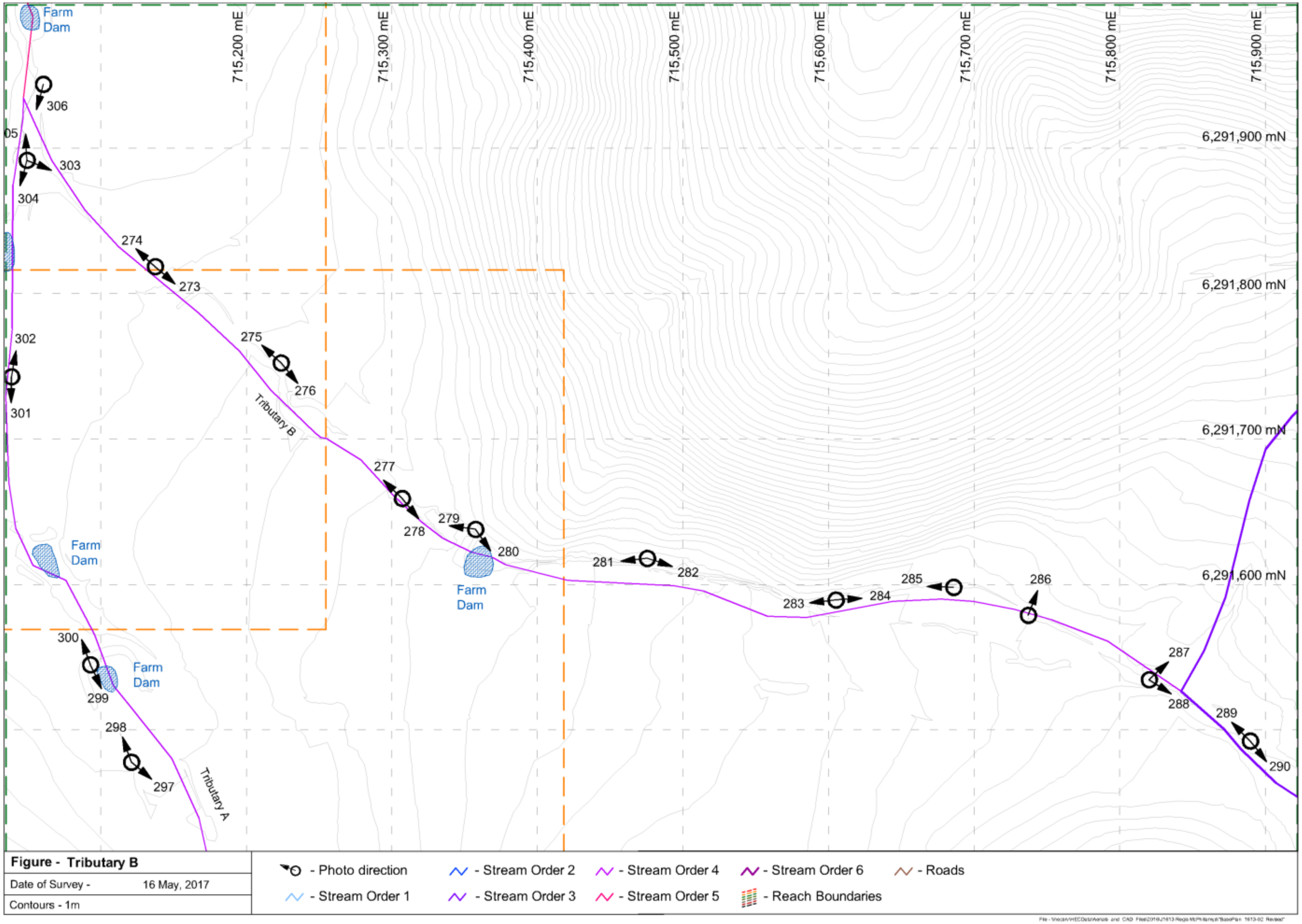
Contours - 1m

- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

		
156 – Downstream	**157 – Upstream**	**158 – Downstream**
		
159 – Upstream	**160 – Downstream**	**161 – Upstream**
		
162 – Downstream	**163 – Upstream**	**164 – Downstream**

		
165 – Downstream	**166 – Downstream**	**167 – Upstream**
		
168 – Left Bank	**375 – Upstream**	**377 – Downstream**

Trib B



Farm Dam
715,200 mE
715,300 mE
715,400 mE
715,500 mE
715,600 mE
715,700 mE
715,800 mE
715,900 mE
6,291,900 mN
6,291,800 mN
6,291,700 mN
6,291,600 mN
306
05
303
304
274
273
302
275
276
301
Tributary B
277
278
279
280
Farm Dam
Farm Dam
281
282
283
284
285
286
287
288
289
290
300
299
Farm Dam
298
297
Tributary A
Figure - Tributary B
Date of Survey - 16 May, 2017
Contours - 1m
- Photo direction
- Stream Order 1
- Stream Order 2
- Stream Order 3
- Stream Order 4
- Stream Order 5
- Stream Order 6
- Reach Boundaries
- Roads

		
290 – Upstream	**289 – Downstream**	**288 – Upstream**
		
287 – Right Bank	**286 – Right Bank**	**285 – Downstream**
		
284 – Upstream	**283 – Downstream**	**282 – Upstream**


281 – Downstream


280 – Upstream


279 – Downstream


278 – Upstream


277 – Downstream

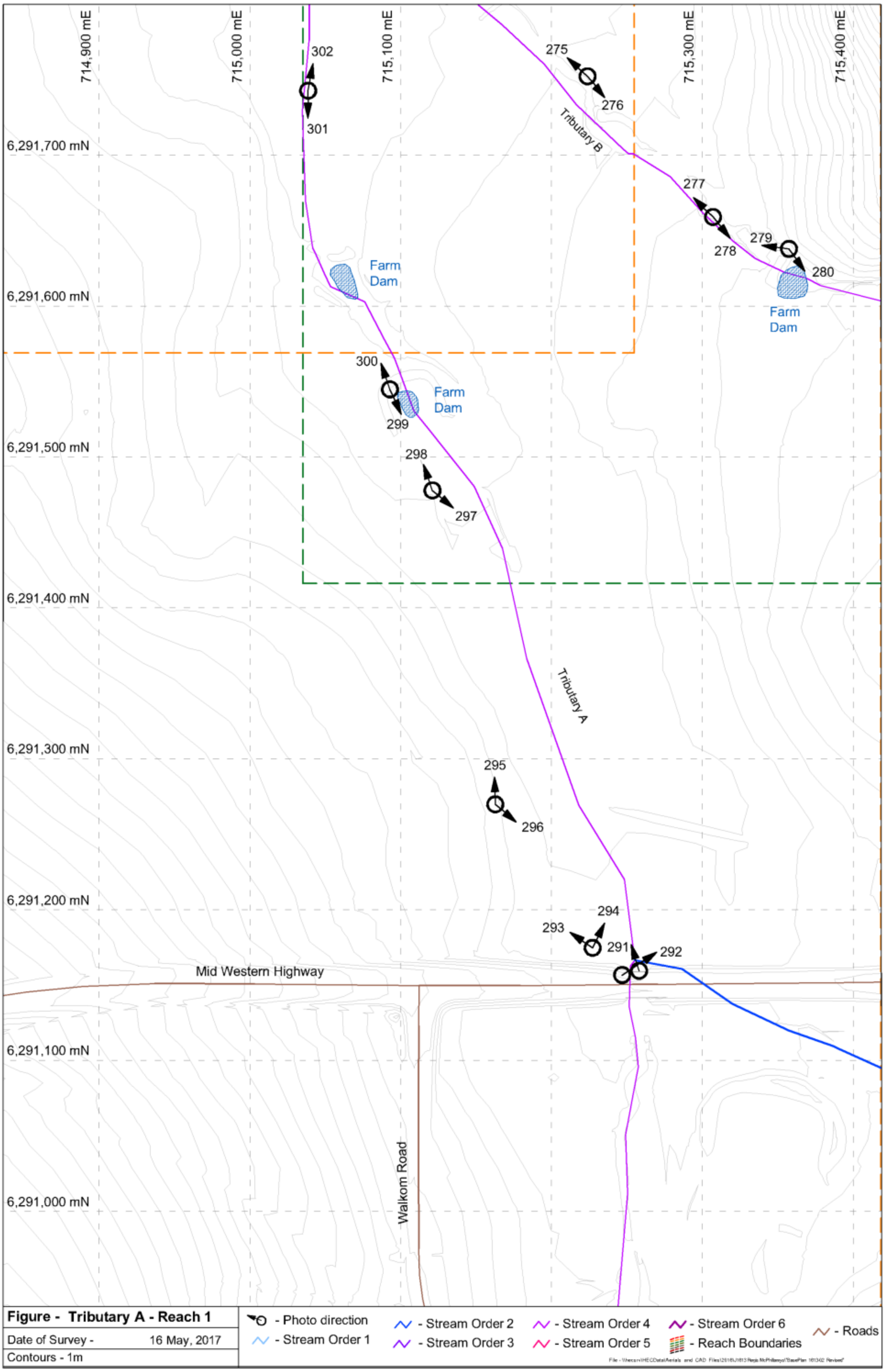

276 – Upstream


275 – Downstream


274 – Downstream


273 – Upstream

Trib A Reach 1




291 – Downstream


292 – Right Bank


293 – Downstream Left Bank


294 – Downstream Right Bank


295 – Downstream

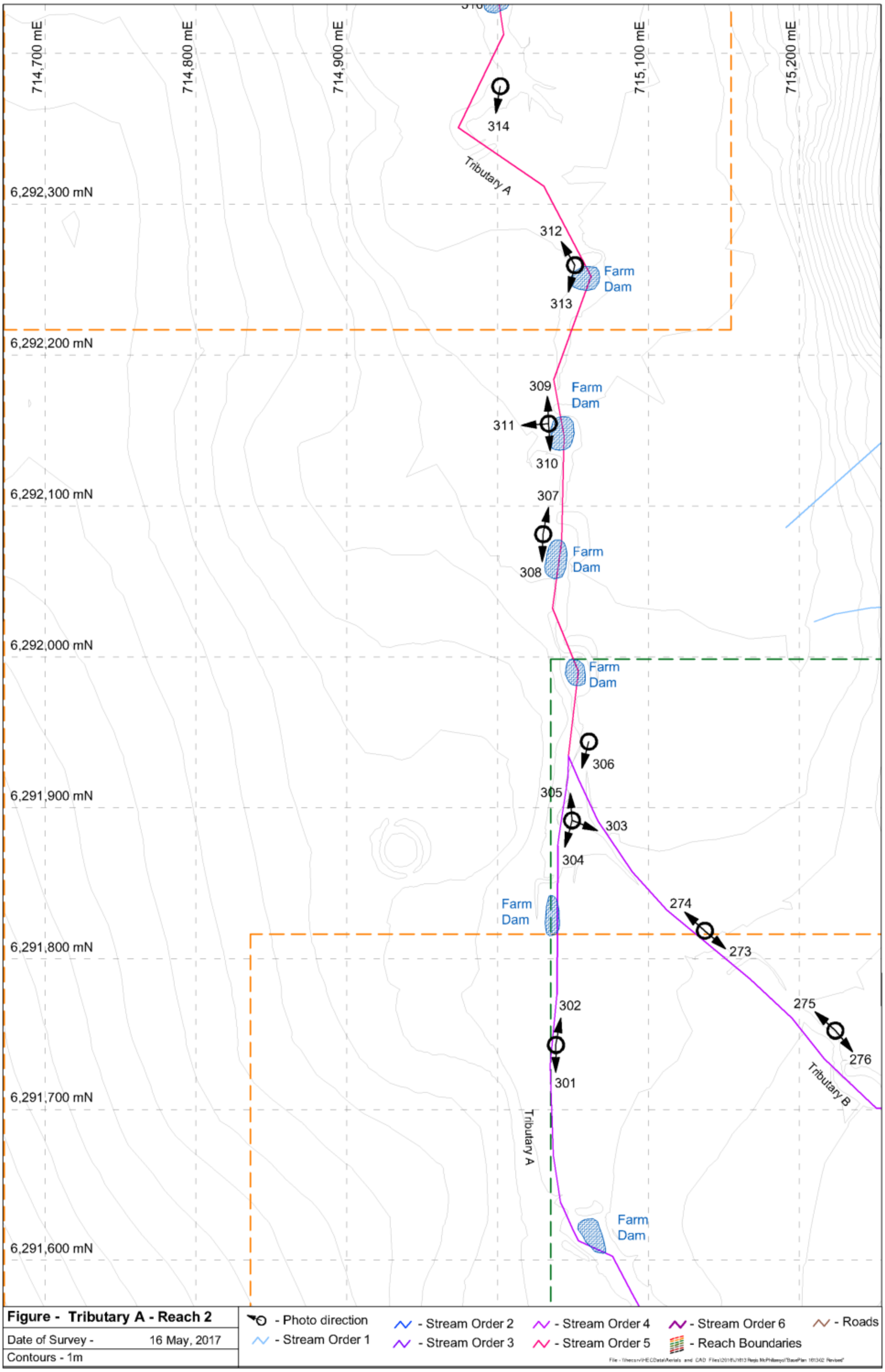

296 – Upstream


297 – Upstream


298 – Downstream

	
299 – Upstream	**300 – Downstream**

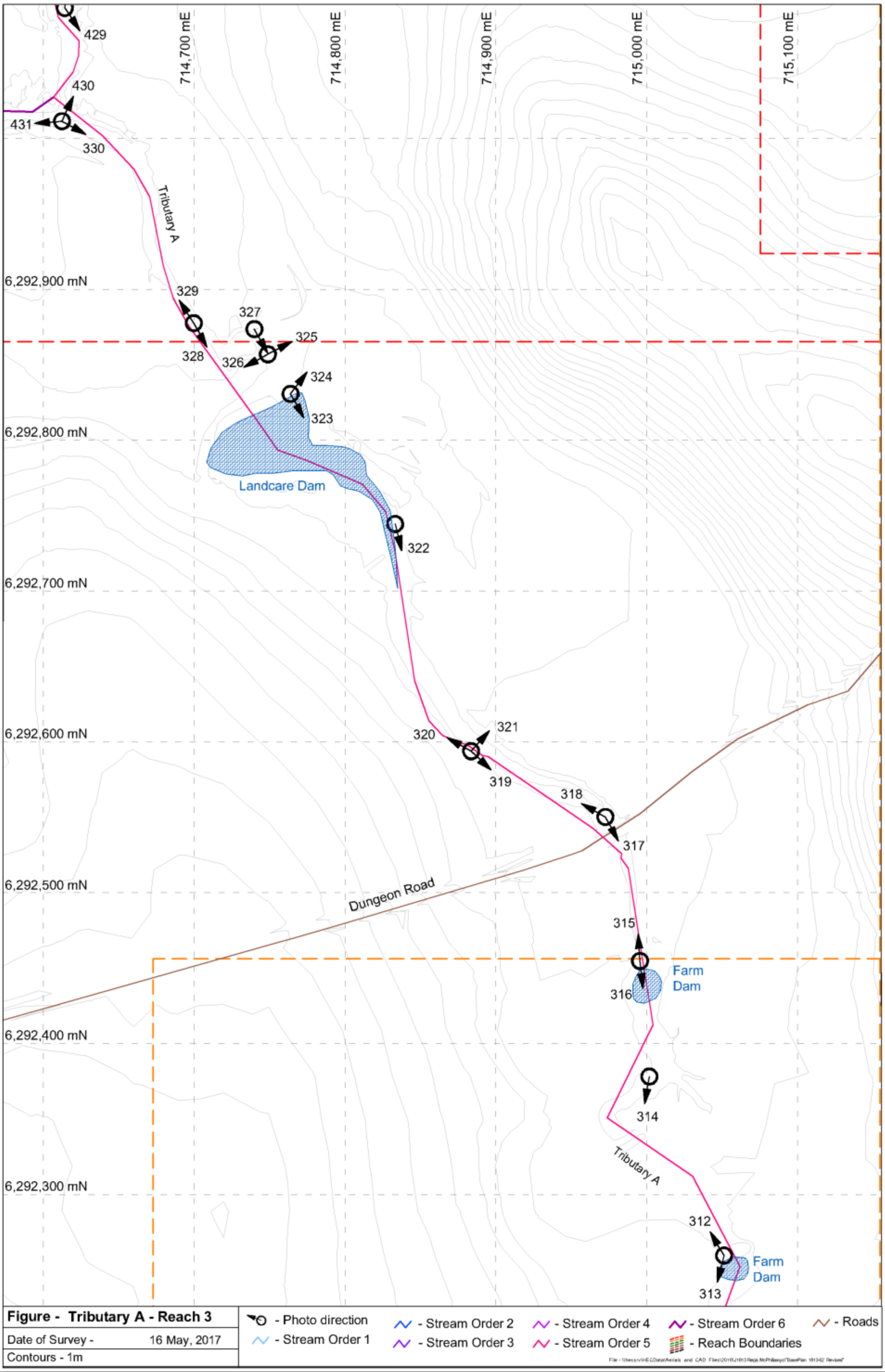
Trib A Reach 2



	
301 – Upstream	**302 – Downstream**
	
303 – Upstream to Trib B	**304 – Upstream**
	
305 – Downstream	**306 – Upstream**
	
307 – Downstream	**308 – Upstream**

	
309 – Downstream	**310 – Upstream**
	
311 – Left Bank	**312 – Downstream**
	
313 – Upstream	**314 – Upstream**

Trib A Reach 3



	
315 – Downstream	**316 – Upstream**
	
317 – Upstream	**318 – Downstream**
	
319 – Upstream	**320 – Downstream**
	
321 – Right Bank	**322 – Upstream**

	
323 – Upstream	**324 – Farm Dam Spillway**
	
325 – Right Bank	**326 – Left Bank**
	
327 – Downstream	**328 – Upstream**
	
329 – Downstream	**330 – Upstream**

ATTACHMENT C Simulated Water Inventory for Clean Water Diversion Dams

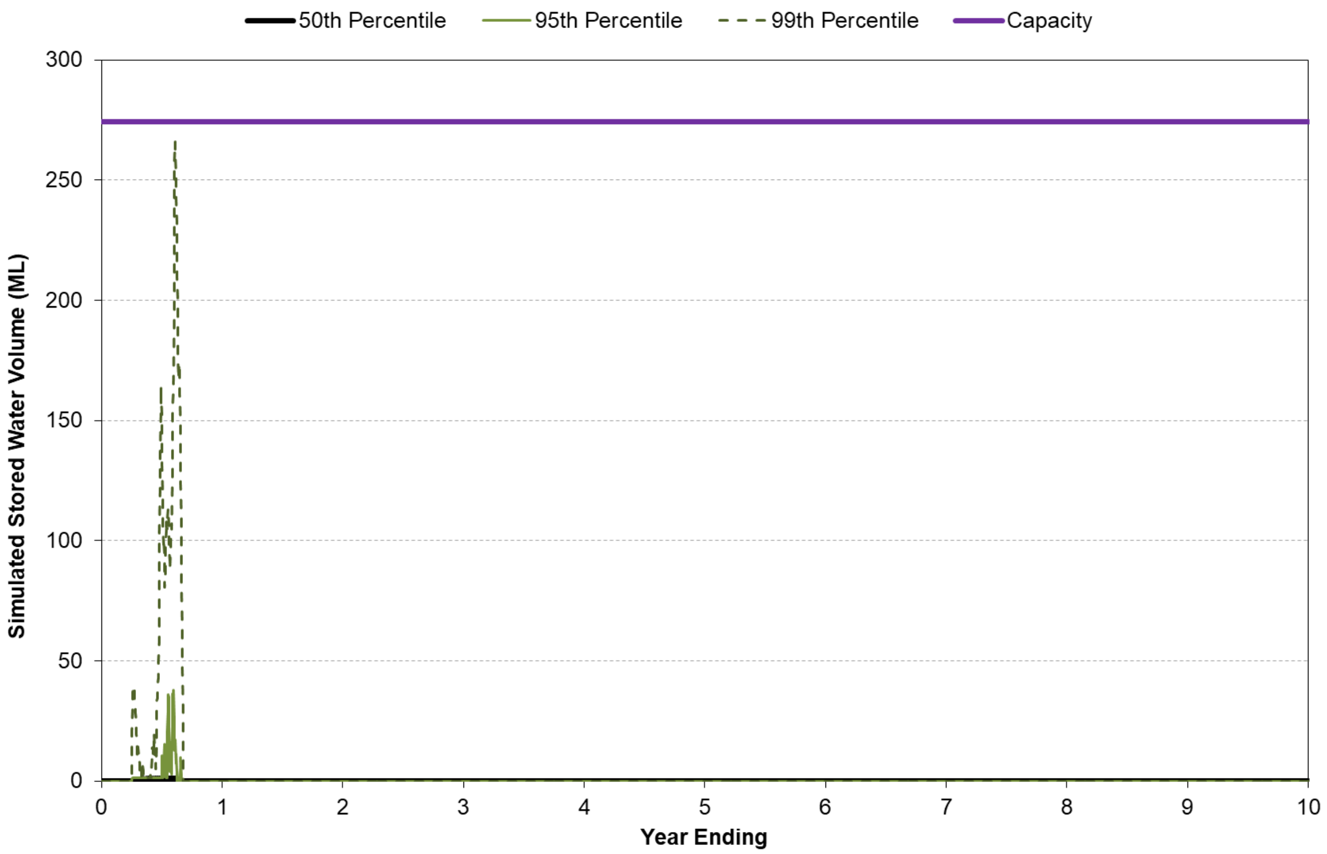


Figure C1 Simulated Stored Water Volume in TSF CWF

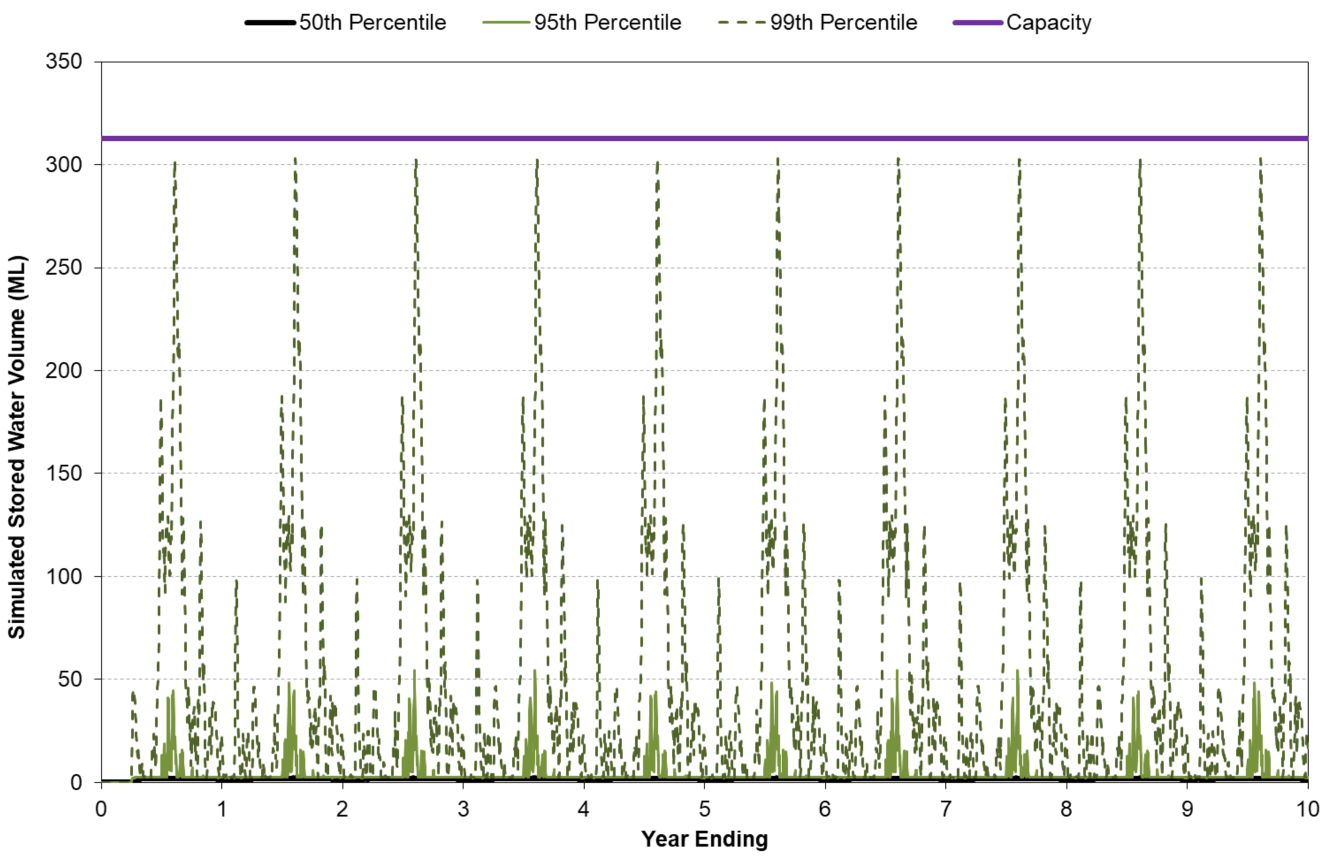


Figure C2 Simulated Stored Water Volume in CWCDF

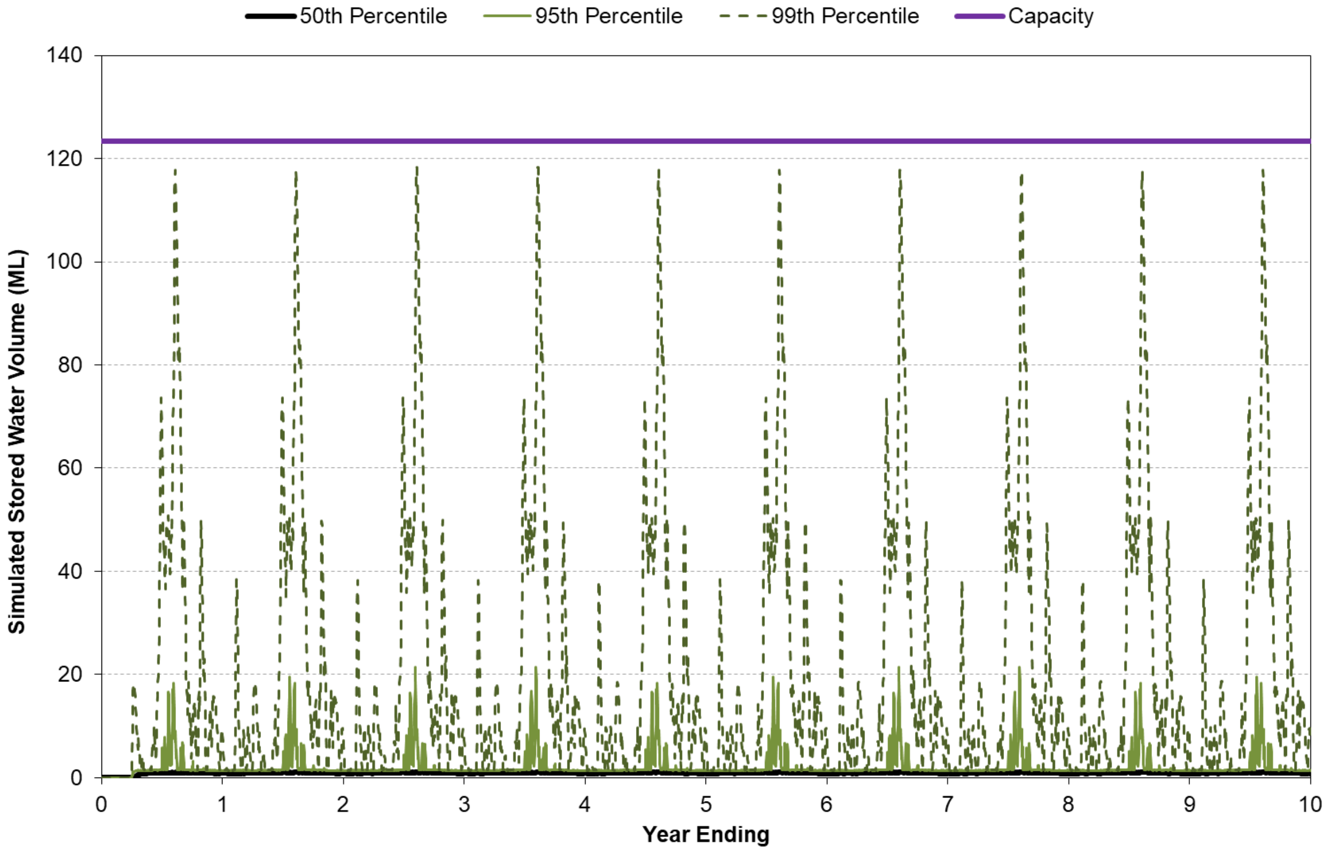


Figure C3 Simulated Stored Water Volume in CWF1

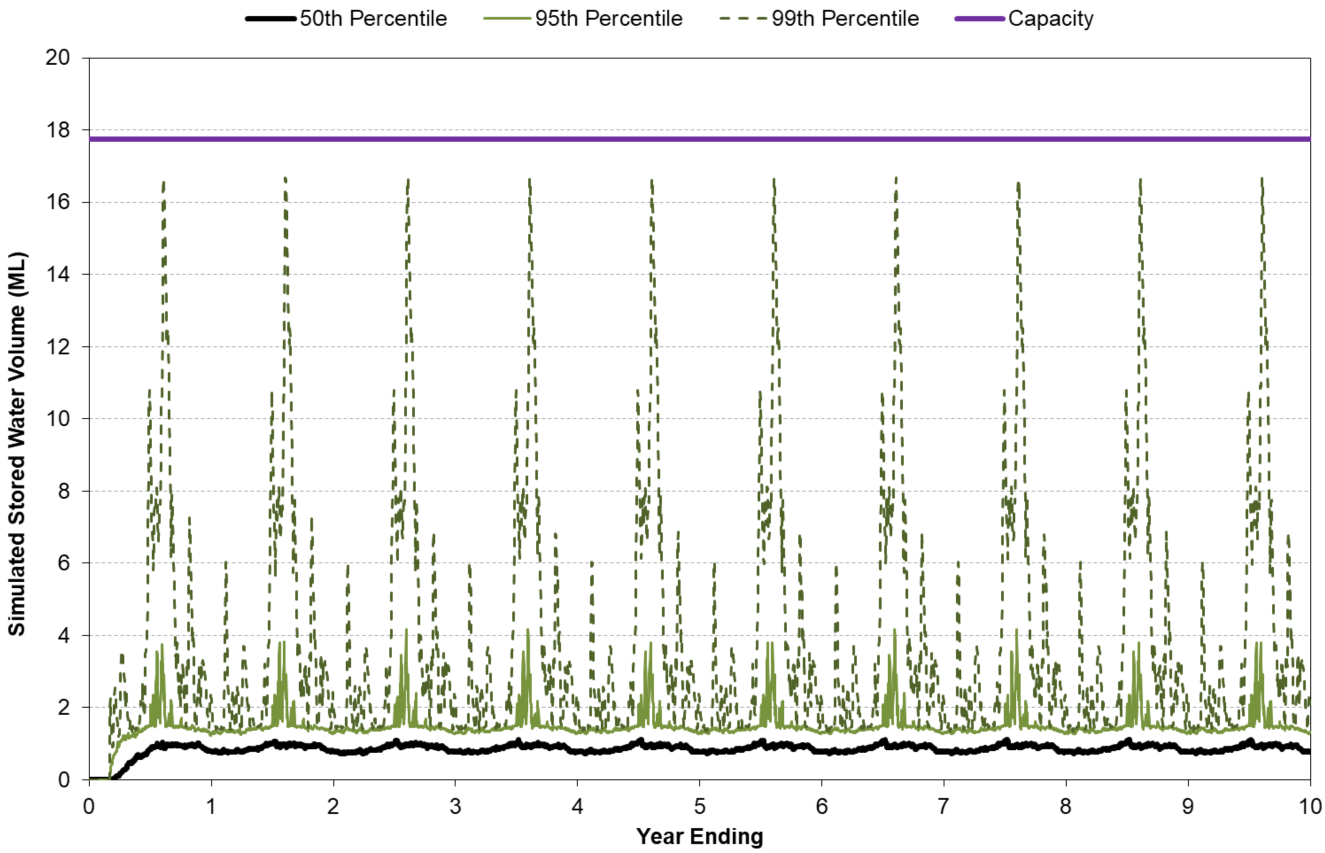


Figure C4 Simulated Stored Water Volume in CWF2

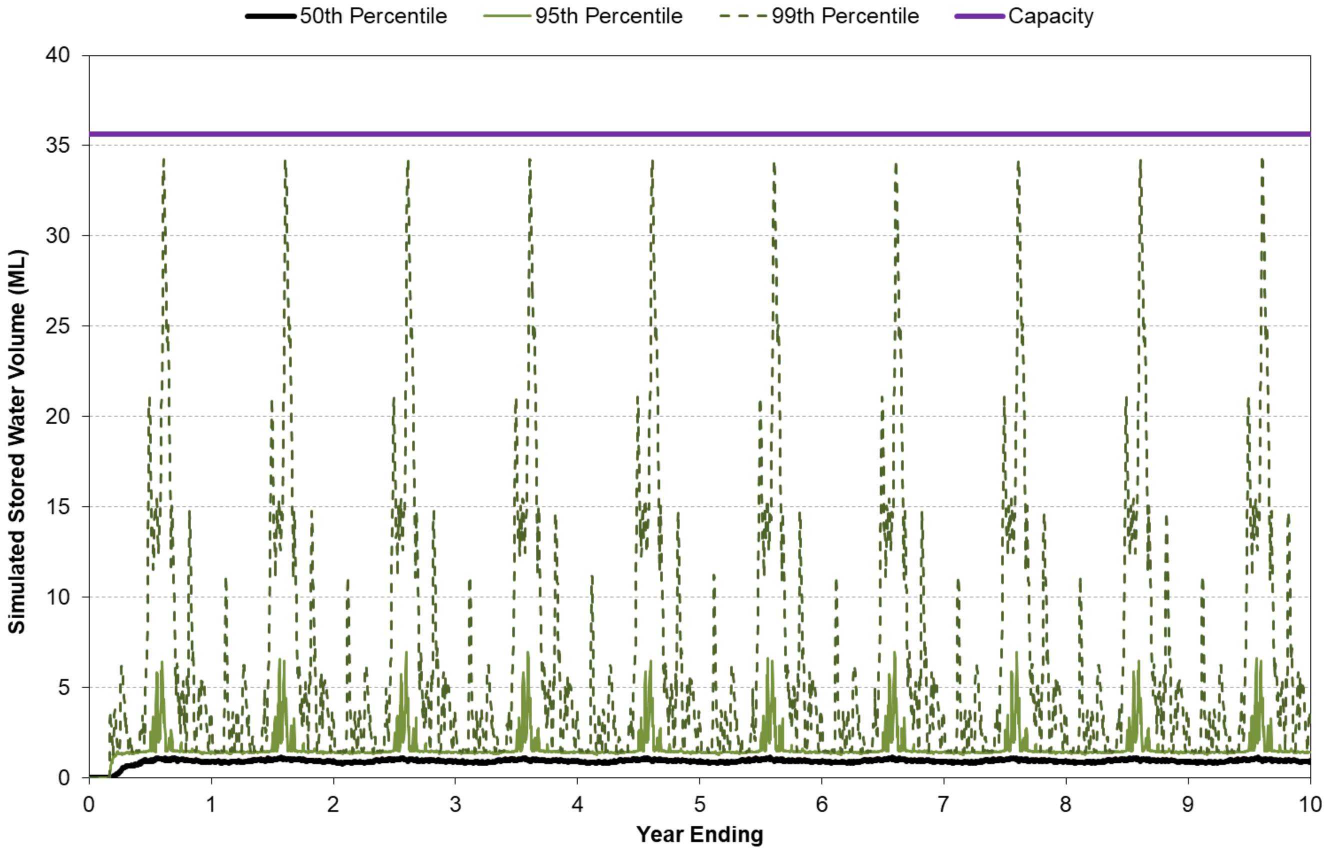


Figure C5 Simulated Stored Water Volume in CWF3

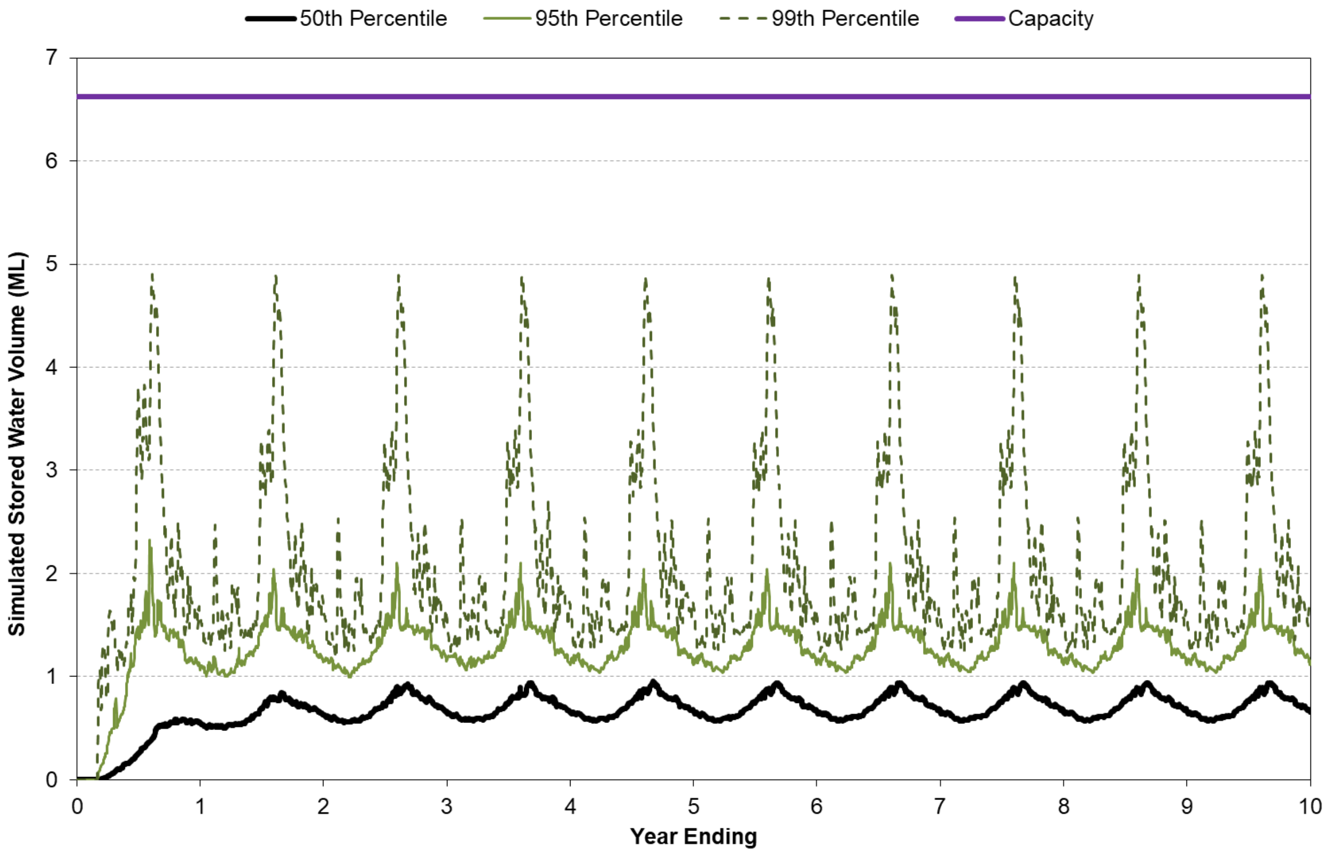


Figure C6 Simulated Stored Water Volume in CWF4

ATTACHMENT D Independent Peer Review

wrm
water + environment

1575-01-A

Janet Krick
Senior Environmental Planner
EMM Consulting
Via email: jkrick@emmconsulting.com.au

21 August 2019

Subject: McPhillamys Gold Project, Mine Development Surface Water Assessment – Independent Peer Review

Dear Janet,

As requested, I have undertaken a review of the surface water assessment report for the McPhillamys Gold Project undertaken by Hydro Engineering Consulting Pty Ltd (HEC) (Revision F dated 15 August 2019).

I reviewed an initial draft of the report and concluded that the approach and methodology of the study was appropriate and consistent with industry standards. My feedback on the draft report was predominantly related to providing further detail and explanation of the study method and results. HEC have considered my comments in the preparation of their final report.

Please do not hesitate to contact me if you have any queries.

For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

Level 9, 135 Wickham Terrace, Spring Hill
PO Box 10703, Brisbane Adelaide St Qld 4000

Tel 07 3225 0200
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