MALABAR COAL

MAXWELL PROJECT

APPENDIX C

Surface Water Assessment

Surface Water Assessment
Maxwell Project

Malabar Coal Limited

1383-02-J5, 9 July 2019

Report Title	Surface Water Assessment Maxwell Project
Client	Malabar Coal Limited PO Box R864 Royal Exchange NSW 1225
Report Number	1383-02-J5

Revision Number	Report Date	Report Author	Reviewer
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Glossary

Term	Definition
AGL	AGL Energy Limited
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS/NZS	Australian Standard/New Zealand Standard
AWBM	Australian Water Balance Model
BOM	Commonwealth Bureau of Meteorology
BSAL	Biophysical Strategic Agricultural Land
CHPP	coal handling and preparation plant
CL	Coal Lease
DES	Queensland Department of Environment and Science
DGV	default guideline value
DoI-Water	Department of Industry – Water
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EL	Exploration Licence
EMU	Extraction Management Unit
EP&A Act	NSW Environmental and Planning and Assessment Act 1979
EPL	Environment Protection Licence
ESD	ecologically sustainable development
FRMS&P	Floodplain Risk Management Study and Plan
FSL	full supply level
ha	hectare
HEC-RAS	Hydrologic Engineering Centre River Analysis System
HGL	Hydrogeological Landscapes Study
HRRWSP	Water Sharing Plan for the Hunter Regulated River Water Source 2016
HUAWSP	Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009
km	kilometres
km^2	square kilometres
kt/yr	kilotonnes per year
LIDAR	Light Detection and Ranging
m	metre
mAHD	metres Australian Height Datum

Term	Definition
m/s	metres per second
m^3/s	cubic metres per second
MEA	mine entry area
mg/L	milligrams per litre
ML	megalitres
ML/d	megalitres per day
ML/yr	megalitres per year
mm	millimetres
mm/hr	millimetres per hour
mm/month	millimetres per month
Mtpa	million tonnes per annum
MOL	maximum operating level
NATA	National Association of Testing Authorities
NTU	Nephelometric Turbidity Units
OPSIM	A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project
PMF	probable maximum flood
RHDHV	Royal HaskoningDHV
ROM	Run-of-mine
SEARs	Secretary's Environmental Assessment Requirements
SILO	Scientific Information for Land Owners
SRLUP	Strategic Regional Land Use Plan
t/yr	tonnes per year
TDS	total dissolved solids
TSS	total suspended solids
w/w	weight/weight
WAL	water access licence
WMS	Water management system
WSP	Water Sharing Plan
WTF	Water Treatment Facility
µS/cm	microSiemens

1 Introduction

1.1 BACKGROUND

Maxwell Ventures (Management) Pty Ltd, a wholly owned subsidiary of Malabar Coal Limited (Malabar), is seeking consent to develop an underground coal mining operation, referred to as the Maxwell Project (the Project).

The Project is in the Upper Hunter Valley of New South Wales (NSW), east-southeast of Denman and south-southwest of Muswellbrook (Figure 1.1).

Underground mining is proposed within Exploration Licence (EL) 5460, which was acquired by Malabar in February 2018. Malabar also acquired existing infrastructure within Coal Lease (CL) 229, Mining Lease (ML) 1531 and CL 395, known as the "Maxwell Infrastructure". The Project would include the use of the substantial existing Maxwell Infrastructure, along with the development of some new infrastructure (see Figure 1.2).

This surface water assessment forms part of an Environmental Impact Statement (EIS) which has been prepared to accompany a Development Application for the Project in accordance with Part 4 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act).

1.2 PROJECT DESCRIPTION

The Project would involve an underground mining operation that would produce high quality coals over a period of approximately 26 years.

At least 75% of coal produced by the Project would be capable of being used in the making of steel (coking coals). The balance would be export thermal coals suitable for the new generation High Efficiency, Low Emissions power generators.

The Project would involve extraction of run-of-mine (ROM) coal, from four seams within the Wittingham Coal Measures using the following underground mining methods:

- underground bord and pillar mining with partial pillar extraction in the Whynot Seam; and
- underground longwall extraction in the Woodlands Hill Seam, Arrowfield Seam and Bowfield Seam.

The substantial existing Maxwell Infrastructure would be used for handling, processing and transportation of coal for the life of the Project. The Maxwell Infrastructure includes an existing coal handling and preparation plant (CHPP), train load-out facilities and other infrastructure and services (including water management infrastructure, administration buildings, workshops and services).

A mine entry area would be developed for the Project in a natural valley in the north of EL 5460 to support underground mining and coal handling activities and provide for personnel and materials access.

ROM coal brought to the surface at the MEA would be transported to the Maxwell Infrastructure area. Early ROM coal would be transported via internal roads during the construction and commissioning of a covered overland conveyor system. Subsequently, ROM coal would be transported to the Maxwell Infrastructure area via the covered overland conveyor system.

The existing product coal stockpile area at the Maxwell Infrastructure would be extended to allow for better management of different product coal blends. An additional ROM stockpile would also be developed adjacent to the CHPP to cater for delivery of ROM coal via the covered overland conveyor.

The Project would support continued rehabilitation of previously mined areas and overburden emplacements areas within CL 229, ML 1531 and CL 395. The volume of the East Void would be reduced through the emplacement of reject material generated by Project coal processing activities and would be capped and rehabilitated at the completion of mining.

A detailed description of the Project is provided in the main document of the EIS.

1.3 RELATED STUDIES

The studies undertaken for the EIS, which are to be read in conjunction with this assessment, include the following:

- subsidence assessment (Appendix A of the EIS) (Mine Subsidence Engineering Consultants, 2019);
- groundwater assessment (Appendix B of the EIS) (HydroSimulations, 2019);
- geomorphology assessment (Appendix D of the EIS) (Fluvial Systems, 2019);
- biodiversity development assessment report (Appendix E of the EIS) (Hunter Eco, 2019);
- geochemistry assessment (Appendix P of the EIS) (Geo-Environmental Management, 2019); and
- agricultural impact statement (Appendix Q of the EIS) (2rog Consulting, 2019).

1.4 REPORT STRUCTURE

This report includes a further eight sections:

- Section 2 provides an overview of the regulatory framework;
- Section 3 describes the existing surface water environment;
- Section 4 describes the proposed surface water management system;
- Section 5 provides a description of the site water balance model used to simulate the performance of the water management system of the life of the Project;
- Section 6 presents the results of the site water balance assessment;
- Section 7 describes the predicted behaviour of the final voids;
- Section 8 assesses the potential impacts of the Project on surface water resources;
- Section 9 outlines the proposed mitigation and management measures to minimise surface water impacts;
- Section 10 presents a summary of the conclusions of the surface water impact assessment; and
- Section 11 provides a list of references.

LEGEND
- Mining Operation
- Proposed Mining Operation
- Bureau of Meteorology Weather Station
- Railway
- Local Government Boundary
- State Forest
- National Parks and Wildlife Service Estate
- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Indicative Extent of Underground Development

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services and Innovation (2019); Office of Environment and Heritage NSW (2019); Bureau of Meteorology (2019)

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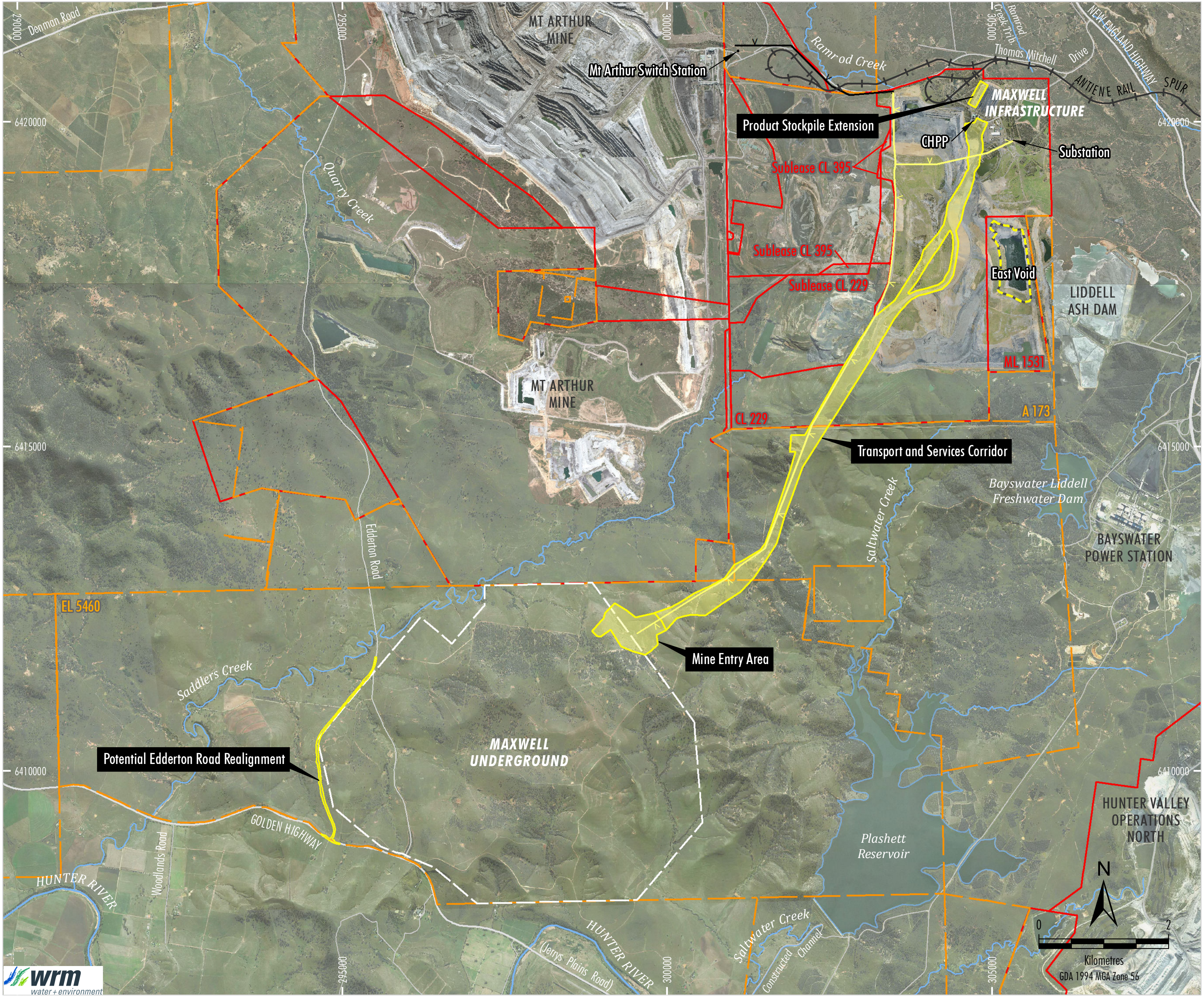
Regional Location

Figure 1.1



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Extent of Underground Development
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Proposed 66 kV Power Supply
- Proposed Ausgrid 66 kV Power Supply Extension#

Subject to separate assessment and approval.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019) Orthophoto Mosaic: 2018, 2016, 2011

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Project General Arrangement

Figure 1.2

SHM-18-03 Maxwell_EIS_App SWA_202B

2 Regulatory framework

2.1 REGULATORY DOCUMENTS

The following legislation, plans, policies and regulations are potentially relevant to the Project for surface water management:

- Upper Hunter Strategic Regional Land Use Plan (SRLUP), which considers potential impacts on agricultural land;
- the Water Management Act 2000 (WM Act), including the Water Sharing Plan for the Hunter Regulated River Water Source 2016 (HRRWSP) and Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (HUAWSP) with respect to:
  - the taking of waters from the Hunter River Regulated Water Source;
  - the taking of waters from the Hunter River Unregulated and Alluvial Water Source;
  - the capture of clean water runoff; and
  - the use of the final voids at the Maxwell Infrastructure as a water storage.
- the Protection of the Environment Operations Act 1997, relevant to the Environment Protection Licence (EPL) that may be required;
- Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002, with respect to managing cumulative salinity in the Hunter River;
- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) and using the ANZECC Guidelines and Water Quality Objectives in NSW (NSW Department of Environment and Conservation [DEC], 2006) with respect to defining the environmental values of receiving waters and the definition of protection level based on ecosystem condition;
- Dams Safety Act 1978 and/or Dams Safety Act 2015 with respect to the design, construction, monitoring and management requirements of any prescribed dams on the site or in the surrounding area, including Plashett Reservoir;
- Managing Urban Stormwater Soils and Construction - Volume 2E Mines and Quarries, (NSW Department of Environment and Climate Change [DECC], 2008) and Managing Urban Stormwater, Soils and Construction, (Landcom, 2004) with respect to the design of erosion and sediment control measures;
- NSW Flood Prone Land Policy; and
- Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources (Significant Impact Guidelines) (Commonwealth of Australia, 2013).

The design of infrastructure for the Project has considered the requirements of the above legislation, plans, policies and regulations. Further discussion on the regulatory framework with respect to surface water is provided in the following sections.

2.2 UPPER HUNTER STRATEGIC LAND USE PLAN

The SRLUP aims to identify, map and protect valuable residential and agricultural land from the impacts of mining. Implementation of the policy includes the Gateway process to closely examine the potential impacts of new mining proposals on strategic agricultural land and equine and viticulture critical industry clusters.

There is approximately 72 hectares (ha) of verified biophysical strategic agricultural land (BSAL) within the Project area. Malabar lodged an application for a Gateway Certificate to the Mining and Petroleum Gateway Panel (Gateway Panel) in relation to the Project on 23 August 2018. A Conditional Gateway Certificate was issued on 20 December 2018.

The Gateway Panel's recommendations relating to surface water have been considered in this assessment.

2.3 WATER MANAGEMENT ACT

2.3.1 Water Access Licences

Water Access Licences (WALs) would be required for any water taken from the Hunter River and used for the Project.

Additionally, any water occurring naturally on or below the surface of the ground which is taken by the Project would be required to be the subject of a WAL unless it is subject to an exemption.

2.3.2 Water supply works approval

All dams, pipes, pumping stations and other water supply works which would ordinarily require water supply works approvals under the WM Act would be exempt if a project approval is granted under Part 4 of the EP&A Act (see section 4.41 of the EP&A Act). The impact and environmental issues relating to these elements are included in this assessment.

2.3.3 Excluded works

Item 12 of Schedule 4 of the Water Management (General) Regulation, 2018 provides access licence exemptions in relation to water take from or by means of an 'excluded work' as defined in Schedule 1.

Items of relevance to the Project in Schedule 1 of the Water Management (General) Regulation, 2018 are as follows:

> *1 Dams solely for the control or prevention of soil erosion:*
>
> *(a) from which no water is reticulated (unless, if the dam is fenced off for erosion control purposes, to a stock drinking trough in an adjoining paddock) or pumped, and*
>
> *(b) the structural size of which is the minimum necessary to fulfil the erosion control function, and*
>
> *(c) that are located on a minor stream.*
>
> …
>
> *3 Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream.*

2.3.4 Water Sharing Plans

NSW Water Sharing Plans (WSPs) establish rules for sharing water between the environmental needs of the river or aquifer and water users, and between different types of water use such as town supply, rural domestic supply, stock watering, industry and irrigation.

Department of Industry – Water (DoI – Water) are progressively developing WSPs for rivers and groundwater systems across NSW following the introduction of the WM Act. The purpose of the plans is to protect the health of rivers and groundwater, while also providing water users with perpetual WALs, equitable conditions, and increased opportunities to trade water through separation of land and water.

The WSPs relevant to this assessment include the:

- Water Sharing Plan for the Hunter Regulated River Water Source 2016 (HRRWSP); and
- Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009 (HUAWSP).

2.3.4.1 Water Sharing Plan for the Hunter Regulated River Water Source 2016

The HRRWSP commenced on 1 July 2016 and applies for a period of 10 years to 30 June 2026.

The Hunter River water source is located in the central eastern area of NSW and drains an area of some 17,500 square kilometres (km^2). The Hunter River rises in the Mount Royal Range north east of Scone and travels approximately 450 kilometres (km) to the sea at Newcastle. The Hunter River is regulated from Glenbawn Dam to Maitland, a distance of about 250 km. Glennies Creek is regulated by Glennies Creek Dam, which also provides water to the lower reaches of the Hunter River.

The HRRWSP applies to rivers regulated by Glenbawn and Glennies Creek Dams. The water source is divided into five management zones. These are:

- Hunter River from Glenbawn Dam to Goulburn River Junction (Management Zone 1A);
- Hunter River from Goulburn River Junction to Glennies Creek Junction (Management Zone 1B);
- Hunter River from Glennies Creek Junction to Wollombi Brook Junction (Management Zone 2A);
- Hunter River from Wollombi Brook Junction to downstream extent of the Hunter River (Management Zone 2B); and
- Glennies Creek (Management Zone 3).

The Project is located within Management Zone 1B of the HRRWSP.

The HRRWSP allows for the extraction of water from the Hunter River without a WAL to provide basic landholder rights, which include domestic and stock rights, as well as Native Title rights.

All water extraction that is not for basic landholder rights must be authorised by a WAL. Each WAL specifies a share component. The share components of specific purpose licences, such as town water supply, stock and domestic are expressed as megalitres per year (ML/yr). The share components of high security, general security and supplementary WALs are expressed as a number of unit shares. Table 2.1 shows the categories of WALs in the HRRWSP and their total share components at the commencement of the WSP.

Table 2.1 – Hunter Regulated River Water Source share components for different licence categories

Water Access Licence Category	Total Share Component				
	Zone 1A	Zone 1B	Zone 2A	Zone 2B	Zone 3
Domestic & stock (ML/yr)	672	101	27	855	181
General security (units shares)	46,925	29,475	3,053	43,298	5,793
High security (units shares)	5,128	5,128	2,809	6,971	1,650
Supplementary water (units shares)	4,441	40,166	505	3,289	117
Local water utility (unit shares)	5,800	32	-	-	5,000
Major utility (units shares)	-	36,000	-	-	-

Malabar currently owns one high security (WAL769) and six general security Water Access Licenses (WAL771, WAL1143, WAL1220, WAL1066, WAL31439 and WAL31440) totalling 1,123 units from the Hunter River.

2.3.4.2 Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009

The HUAWSP commenced on 1 August 2009 and applies for a period of 11 years to 31 July 2020.

In total there are 39 water sources covered by the HUAWSP and nine of these are further sub-divided into management zones. Saddlers Creek (including the associated alluvial aquifers) is contained within the Jerrys Management Zone of the Hunter Extraction Management Unit (EMU). The alluvial aquifers associated with the Hunter River are contained within the Upstream Glennies Creek Management Zone (alluvial water source 1) of the Hunter Regulated River Alluvium EMU.

The total licensed water entitlement within the Jerrys Management Zone has a share component of 2,861 ML/yr. The total licensed entitlement within the Hunter Regulated River Alluvium has a share component of 15,193 ML/yr.

2.4 NSW FLOOD PRONE LAND POLICY

The NSW Government's Flood Prone Land Policy is directed at providing solutions to existing flooding problems in developed areas, and ensuring that new developments are compatible with the flood hazard and do not create additional flooding problems in other areas. Under the Flood Prone Land Policy, the management of flood prone land remains the responsibility of local government. To facilitate this, the Government has published the "*Floodplain Development Manual: The Management of Flood Liable Land*", NSW Government, April 2005 (the Manual), to provide guidance to Councils in the implementation of the Flood Prone Land Policy, and provide funding in support of floodplain management programs.

Muswellbrook Shire Council has developed a draft flood study (Worley Parsons, 2014) in accordance with the Manual to define the flood prone areas along the Hunter and Goulburn Rivers. The study includes the Hunter River within the vicinity of the Project but does not include Saddlers Creek. Flood risk management studies have yet to be prepared to define the flood planning area for the shire. However, Council's existing Development Control Plan and the Local Environment Plan (2009) include measures to manage development within flood prone land, which may be updated once these flood risk management studies have been completed.

2.5 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Development Applications under Part 4 of the EP&A Act must be accompanied by an EIS prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs). This impact assessment, which forms part of the EIS, addresses the SEARs concerning surface water. Table 2.2 lists the SEARs that are relevant to this assessment and the sections of this report where those SEARs are addressed.

This report addresses the surface water aspects of these SEARs. The groundwater aspects are addressed in the Groundwater Assessment prepared for the EIS (HydroSimulations, 2019).

Table 2.2 - Secretary's Environmental Assessment Requirements

Requirement	Report Section
NSW Planning and Environment	
Water	
• an assessment of the likely impacts of the development on the quantity and quality of existing surface and groundwater resources including an assessment of existing connectivity between surface water, alluvial and Permian aquifers and how that could be impacted by the development;	Section 8
• an assessment of the likely impacts of the development on watercourses, riparian land, water-related infrastructure, and other water users (private bores and groundwater dependent ecosystems);	Section 8
• an assessment of the likely impacts of the development on a water resource in relation to coal seam gas development and large coal mining development under the Environment Protection and Biodiversity Conservation Act 1999 (see Attachment 4);	Section 8
• a detailed site water balance, including a description of site water demands, water disposal method (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Sections 5 and 6
• identification of any licensing requirement of other approvals under the Water Act 1912 and/or Water Management Act 2000;	Section 8.6
• demonstration that water take for the construction and operation of the proposed development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo;	Section 8.6
• an assessment of any likely flooding impacts of the development;	Section 8.2

Requirement	Report Section
• a salinity investigation study;	Section 6.3.4
• the measures which would be put in place to control sediment runoff and avoid erosion;	Section 9.1.5
NSW Planning & Environment - Resources Regulator (f) Mine layout and scheduling, including maximising opportunities for progressive final rehabilitation. The final rehabilitation schedule should be mapped against key assumptions (eg. production milestones) of the mine layout sequence, before being translated to indicative timeframes throughout the Project life. The mine plan should maximise opportunities for progress rehabilitation;	Section 4
(g) Inclusion of a drawing at an appropriate scale identifying key attributes of the final landform, including final landform contours and the location of the proposed final land use(s);	Section 7.2
(m) Where a void is proposed to remain as part of the final landform, include: (iii) Outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required (sic) be implemented to minimise associated impacts to the environment and downstream water users.	Section 7.8
NSW EPA • Impacts on water quality and site wide water management.	Section 8
NSW Office of Environment and Heritage 9 The EIS must map the following features relevant to water and soils including: a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map). b. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method). c. Wetlands as described in s4.2 of the Biodiversity Assessment Method. d. Groundwater. e. Groundwater dependent ecosystems. f. Proposed intake and discharge locations.	Section 6 of the EIS and Biodiversity Development Assessment Report
10 The EIS must describe background conditions for any water resource likely to be affected by the development, including: a. Existing surface and groundwater. b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. 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. d. Indicators and guideline values/criteria for the environmental values identified at(c) in accordance with the ANZECC (2000) & ANZG (2018) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government	Section 3
11 The EIS must assess the impact of the development on water quality, including: a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently	Section 8

Requirement		Report Section
	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. b. Identification of proposed monitoring of water quality.	
12	The EIS must assess the impact of the development on hydrology, including: a. Water balance including quantity, quality and source. b. Effects to downstream rivers, wetlands, estuaries, marine waters and floodplain areas. c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems. d. 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 (e.g. river benches). e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water. f. 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. g. Identification of proposed monitoring of hydrological attributes.	Section 8
13	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 b. Flood planning area, the area below the flood planning level. c. Hydraulic categorisation (floodways and flood storage areas).	Section 3.7
14	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 3.7
15	The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behaviour for a range of design events as identified in 11[sic]) 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.	Section 3.7
16	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. b. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories. c. Relevant provisions of the NSW Floodplain Development Manual 2005.	Section 8.2
17	The EIS must assess the impacts on the proposed development on flood behaviour, including: a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. 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.	Section 8.2

Requirement	Report Section
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. 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 consequence of flooding.	
Muswellbrook Shire Council	
2. Surface water and groundwater considerations • The project is situated in the Saddlers Creek catchment. The Department of Primary Industries Salinity Study 'Hydrogeological Landscapes Study' (HGL's) identified Saddlers Creek and the adjacent catchments as having high salt loads, saline discharge areas and soils and water with high Electro Conductivity readings. Accordingly, Council requests the impact of the project on and offsite be considered in the preparation of any EIS. To identify any such impacts a Salinity Investigation Study and Management Plan should be undertaken in relation to the project and should consider the sites geology, soils, vegetation, surface and groundwater. Council would also have a interest in the methodology proposed to manage groundwater seepage into the mine, the above ground control of water to avoid on and off-site contamination and how it is intended to be disposed.	Sections 6.3 and 8.6
12. Cumulative regional impacts of water, road and rail networks • The project will utilise water resources, putting pressure on availability of raw water for other industries. Mines have demonstrated an ability to out compete other sectors to buy water allocations, an unintended consequence being a difficulty for new non-coal related industries and businesses to establish in the Shire. This in turn makes it difficult to achieve the desired outcomes of the Hunter Regional Plan 2036 and Upper Hunter Diversification Action Plan. The EIS should address what impact the water requirements of this project will have on the amount of water that will be available for non-coal related uses under the water sharing plans applying in the region.	Section 8.8

Requirement	Report Section
<u>Department of Industry - Water</u>	
• The identification of an adequate and secure water supply for the life of the project. This includes confirmation that water can be sourced from an appropriately authorised and reliable supply. This is also to include an assessment of the current market depth where water entitlement is required to be purchased.	n/a
• A detailed and consolidated site water balance.	Section 6
• Assessment of impacts on surface and ground water 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 8
• Proposed surface and groundwater monitoring activities and methodologies.	Section 9.1
• Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the DPI Water Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans (available at https://www.industry.nsw.gov.au/water).	Section 8.6

3 Existing surface water environment

3.1 REGIONAL DRAINAGE NETWORK

The regional drainage network in the vicinity of the Project is shown in Figure 1.1. The Project is located in the Hunter River catchment. The Hunter River has a catchment area of approximately 13,400 km^2 to Jerrys Plains, which is immediately downstream of the Maxwell Underground. The catchment extends some 110 km to the north and 140 km to the west and includes the major tributaries of the Pages River, Dart Brook and the Goulburn River.

The Hunter River is a regulated river supplying water from Glenbawn Dam to a range of industrial and agricultural users as well as town water supplies. Glenbawn Dam is located on the upper headwaters of the Hunter River.

Two major tributaries, Glennies Creek and Wollombi Brook, drain into the Hunter River some 10 km downstream of the Maxwell Underground. The total catchment area of the Hunter River to Singleton, located 30 km downstream, which includes these two tributaries, is 16,400 km^2.

3.2 LOCAL DRAINAGE NETWORK

Figure 3.1 shows the topography and the location of tributaries draining the study area.

3.2.1 Maxwell Infrastructure

The Maxwell Infrastructure is located in the upper headwaters of the following Hunter River tributaries:

- Ramrod Creek;
- Bayswater Creek;
- Saltwater Creek; and
- Saddlers Creek.

The northern areas of Maxwell Infrastructure historically drained to the Ramrod Creek catchment. Ramrod Creek drains into the Hunter River 10 km to the north-west of the study area immediately downstream of Muswellbrook.

The eastern areas of the existing Maxwell Infrastructure historically drained to or previously drained to Bayswater Creek (prior to mining operations). The Bayswater Creek catchment at the Maxwell Infrastructure encompasses previously mined areas that do not drain off-site. The lower reaches of Bayswater Creek drains into Lake Liddell and the headwater dams upstream of the ash dam on land owned by AGL Macquarie Pty Limited, a subsidiary of AGL Energy Limited (AGL).

The southern areas of Maxwell Infrastructure are located within the pre-mine Saltwater Creek and Saddlers Creek catchments. The Saddlers Creek and Saltwater Creek catchments at Maxwell Infrastructure no longer drain off-site. Saltwater Creek drains into Plashett Reservoir on land owned by AGL. Saddlers Creek drains to the Hunter River.

Prior to the commencement of mining in the area, Saddlers Creek had a catchment of about 97.1 km^2.

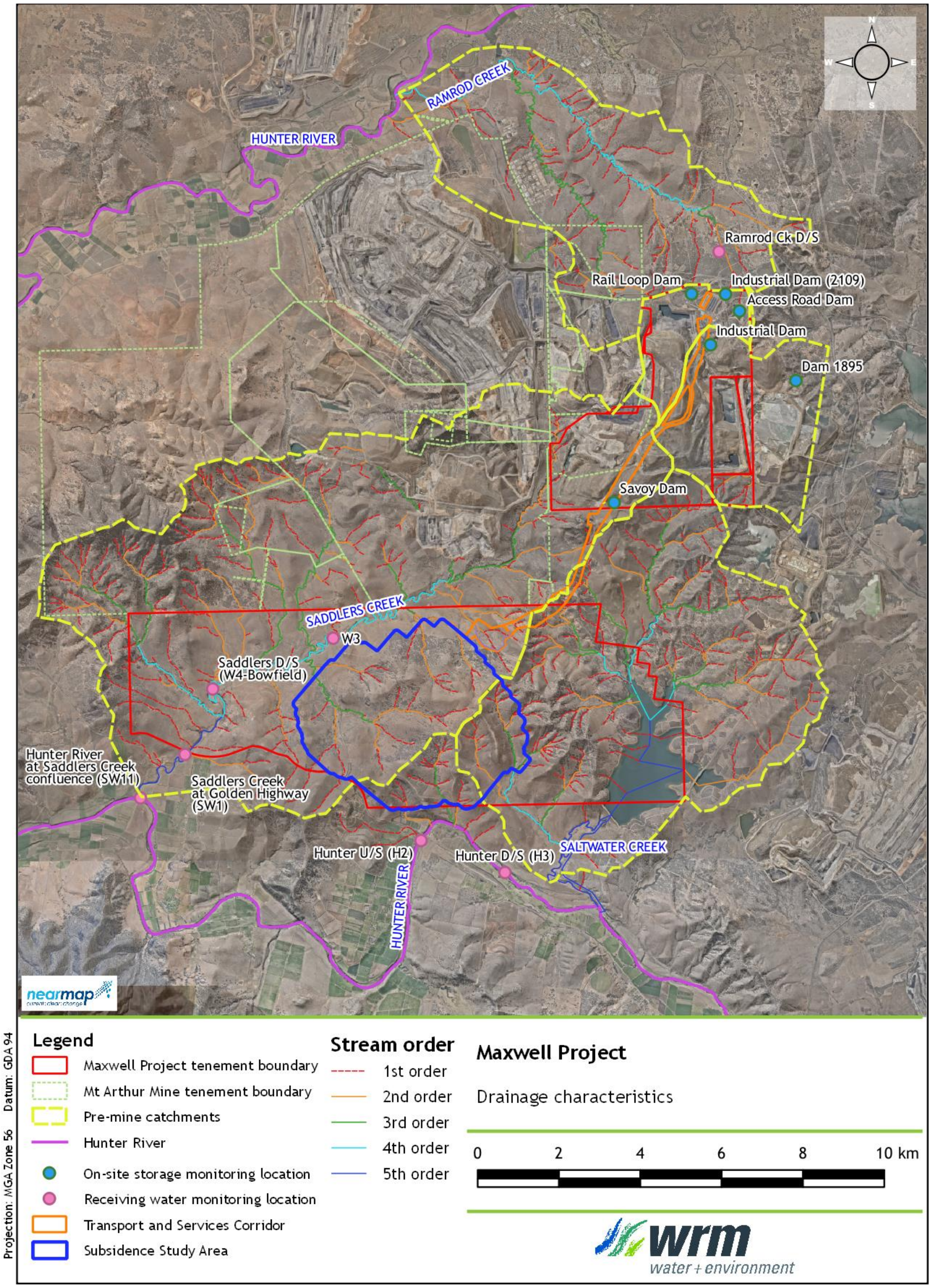


Figure 3.1 – Topography and drainage characteristics of the study area

3.2.2 Maxwell Underground

The main drainage feature in the vicinity of the Maxwell Underground is Saddlers Creek, located to the north and west. The thalweg of the Saddlers Creek channel is 240 metres (m) north of Maxwell Underground at its closest point. Under the Strahler stream classification system (Strahler, 1957), Saddlers Creek is a fourth and fifth order watercourse.

Approximately 14.3 km^2 of the pre-mining catchment is currently being mined at Mt Arthur Mine (including within sub-lease CL 229) and no longer drains to the Saddlers Creek catchment. It is understood that almost all of the Saddlers Creek catchment within Mt Arthur Mine leases to the north of Saddlers Creek will be mined.

Figure 3.2 shows a photograph of Saddlers Creek at the Edderton Road crossing. Saddlers Creek flows intermittently, within a generally well defined channel that has a thick covering of long grass across a broad base. There are several pools on the base that would hold water for a period following rainfall. The channel banks are well defined but have little remnant vegetation. Erosion is evident along several sections of the stream bank which appear to be caused by a combination of the loss of vegetation and the highly dispersive soils. Erosion resulting from stock access is also evident.

Figure 3.2 – Saddlers Creek at Edderton Road

The channel meanders across a small floodplain with a relatively tight geometry. There are several oxbows adjacent to the main channel indicating that the channel has actively eroded in the past.

Several first (minor), second (minor), third (non-minor) and fourth order (non-minor) gullies drain into Saddlers Creek across the Maxwell Underground area. The gullies have similar characteristics to Saddlers Creek in that they have a relatively broad base with active areas of bank erosion indicative of the dispersive soils. The gullies are generally devoid of remnant vegetation. As part of historic agricultural activities in the area, contour banks have been constructed across much of land within the Maxwell Underground area to divert overland flows to these gullies. The gullies are therefore carrying much higher catchment flows than under pre-disturbance conditions.

The eastern side of the Maxwell Underground area drains via first order (minor), second order (minor) and third order (non-minor) gullies directly to Saltwater Creek downstream of Plashett Reservoir. The pre-mine and pre-power station catchment area of Saltwater Creek to its confluence with the Hunter River is 53.2 km^2. Plashett Reservoir is a 65,000 megalitre (ML) storage that captures some 40.9 km^2 (77%) of the Saltwater Creek catchment and serves as an off-river water storage for Bayswater Power Station, along with supplying water to the Jerrys Plains township. It receives pumped inflows from the Hunter River and is designed to spill infrequently. That is, Saltwater Creek downstream of Plashett Reservoir receives runoff from only 23% of the original catchment.

Two minor gullies and one non-minor gully also drain directly to the Hunter River upstream of the Saltwater Creek confluence.

3.3 FARM DAMS

There are 41 existing farm dams on land owned by Malabar in the vicinity of the Project, none of which are prescribed dams under the Dams Safety Act 1978. These farm dams are mostly less than 1 ML in capacity located at the end of contour banks and appear to act as sediment sumps.

The total capacity of the existing farm dams within the Maxwell Underground area is estimated to be less than 50 ML.

3.4 RAINFALL AND EVAPORATION

3.4.1 Local climate data

Table 3.1 shows summary details of the Commonwealth Bureau of Meteorology (BOM) rainfall recording stations with a significant period of record in the vicinity of the Project. The locations of the various stations are shown in Figure 1.1.

Table 3.1 – BOM rainfall stations in the vicinity of the Project

Station No.	Station name	Elevation (m)	Latitude (°S)	Longitude (°E)	Opened	Closed
061053	Muswellbrook (Lower Hill St)	143	32.26	150.88	1870	January 2013
061086	Jerrys Plains Post Office	87	32.50	150.91	1884	April 2014
061016	Denman (Palace Street)	105	32.39	150.69	1883	-*

* The BOM reports this station as “Open”, however the last reading was in September 2014.

Table 3.2 shows mean monthly rainfalls for the three rainfall stations shown in Figure 1.1. Note that the mean monthly values have been calculated over varying periods, depending on the length of the available record. The mean annual rainfall in the area of interest ranges from 592 to 645 millimetres (mm), with maximum monthly rainfalls occurring during the summer months.

Table 3.2 also shows mean monthly evaporation (based on a Class A evaporation pan) for 10 years of data recorded at Jerrys Plains Post Office (Station No. 061086), located approximately 7 km south-southwest of the Project. Mean annual evaporation is 1,641 mm, which is more than double the mean annual rainfall.

Figure 3.3 shows the annual distribution of average monthly rainfall and evaporation at the Jerrys Plains Post Office. Mean evaporation is higher than mean rainfall for all months.

Table 3.2 - Mean monthly rainfall and evaporation

Month	Mean Monthly Rainfall (mm)			Mean Monthly Evaporation (mm)
	Muswellbrook (Lower Hill St) (061053)	Jerrys Plains Post Office (061086)	Denman (Palace Street) (061016)	Jerrys Plains Post Office (061086) [10 years data]
January	69.8	77.1	72.2	220
February	66.6	73.1	66.5	170
March	52.8	59.7	54.2	155
April	43.2	44.0	40.1	120
May	41.5	40.7	36.3	90
June	51.3	48.1	42.4	60
July	44.2	43.4	38.8	71
August	38.6	36.1	34.7	81
September	40.5	41.7	38.9	111
October	48.6	51.9	48.0	164
November	56.1	61.9	55.5	195
December	67.0	67.5	64.6	205
Total	**620**	**645**	**592**	**1,641**

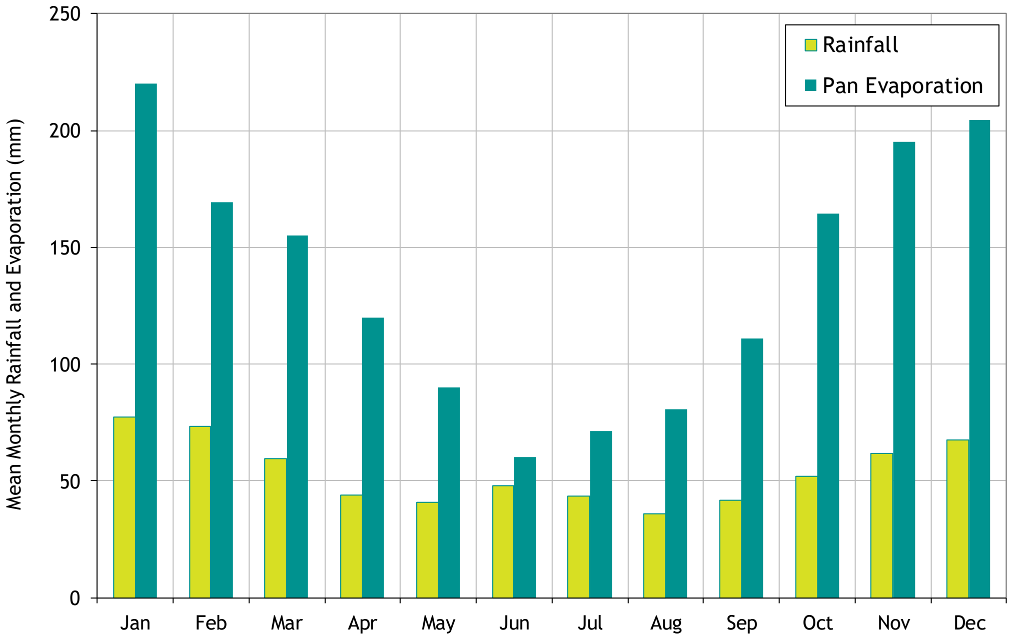


Figure 3.3 - Distribution of monthly rainfall and evaporation (Jerrys Plains Post Office)

3.4.2 Scientific Information for Land Owners climate data

The local rainfall stations datasets are missing some data, and only extend to 2014. In order to extend the rainfall dataset for the simulation of the site water balance over the widest range of locally relevant climatic conditions, a synthetic dataset was also obtained for the Project from the Queensland Department of Environment and Science (DES) Scientific Information for Land Owners (SILO) climate database.

SILO Data Drill accesses grids of data "*derived by interpolating the BOM's station records. Interpolations are calculated by splining and kriging techniques. The data in the Data Drill are all synthetic; there are no original meteorological station data left in the calculated grid fields. However, the Data Drill does have the advantage of being available for any set of coordinates in Australia*" (Jeffrey et al. 2001).

Key advantages of the Data Drill climate data include its length (129 years of paired rainfall and evaporation), and also that it has been adjusted to remove accumulated totals over multiple days and to fill periods of missing data using rainfall from nearby stations.

A comparison of mean monthly rainfall for the Data Drill data and the Muswellbrook (Lower Hill St) station over the period 1889 to 2012 (the period of coincident rainfall) is presented in Table 3.3, which shows that the simulated rainfall data set is within a few percent of the recorded data.

Table 3.3 – Mean monthly rainfall comparison – Data Drill vs Muswellbrook (mm/month)

Month	Muswellbrook (Lower Hill St) (061053)	SILO Data Drill
Jan	69.8	72.7
Feb	66.6	67.1
Mar	52.8	56.8
Apr	43.2	41.8
May	41.5	38.5
Jun	51.3	48.1
Jul	44.2	44.2
Aug	38.6	37.1
Sep	40.7	42.8
Oct	48.6	49.4
Nov	56.1	56.1
Dec	67.0	62.4
TOTAL	**620**	**617**

Table 3.4 shows mean monthly evaporation (based on Class A pan evaporation) recorded at Jerrys Plains Post Office (BoM Station No. 061086), located 7 km south of the Project, as well as Morton's Lake evaporation obtained from SILO Data Drill for the Project. Factored values (based on the appropriate pan and areal evapotranspiration factors) are also shown in Table 3.4.

Comparison of the data shows that the factored pan evaporation is slightly higher than factored Morton's Lake evaporation. As SILO Data Drill provides long-term evaporation data, paired with the rainfall data, it has been adopted for use in the water balance model.

Table 3.4 – Mean monthly evaporation comparison – Data Drill vs Jerrys Plains (mm/month)

Month	Jerrys Plains Post Office (061086) [10 years data]	Factored	SILO Data Drill	Factored
Jan	220	198	188	185
Feb	170	156	152	148
Mar	155	144	135	132
Apr	120	104	91	89
May	90	75	59	57
Jun	60	46	40	39
Jul	71	56	48	47
Aug	81	68	73	72
Sep	111	98	105	103
Oct	164	151	144	141
Nov	195	179	166	163
Dec	205	182	190	186
TOTAL	**1,641**	**1,457**	**1,391**	**1,363**

3.5 WATER QUALITY AND QUANTITY

3.5.1 Environmental values of receiving waters

The ANZECC and ARMCANZ have prepared a guideline for water quality management for use throughout Australia and New Zealand based on the philosophy of ecologically sustainable development (ESD). The guideline is called the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) and is often referred to as the 'ANZECC guideline'. A revision of the guidelines is currently underway and partially complete as part of the 2018 update (Australian and New Zealand Guidelines [ANZG], 2018). Where appropriate, the updated guidelines have been reviewed and considered.

The NSW Department of Environment and Climate Change and Water has prepared a website entitled NSW Water Quality and River Flow Objectives that provides guidance to technical practitioners in the application of the ANZECC guidelines in NSW.

The guideline defines the 'environmental values' of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem. The environmental values of the receiving waters of the Hunter River and Saddlers Creek for which water quality objectives are set are regarded as:

- aquatic ecosystem;
- visual amenity;
- secondary contact recreation;
- primary contact recreation (assess opportunities to achieve as a longer term objective, 10 years or more);
- livestock water supply;
- irrigation water supply;

- homestead water supply;
- drinking water; and
- aquatic foods (cooked).

The ANZECC guidelines specify three levels of protection, from stringent to flexible, corresponding to whether the condition of the particular ecosystem is:

- of high conservation value;
- slightly to moderately disturbed; or
- highly disturbed.

The receiving waterways adjacent to the study area are regarded as slightly to moderately disturbed. The water quality trigger values of four objectives (aquatic ecosystem, livestock water supply, irrigation and drinking water supply) that are identified as most relevant to this study are shown in Table 3.5.

3.5.2 Baseline water quality data

3.5.2.1 Regional water quality

Water quality data for Electrical Conductivity (EC) is available for the Hunter River at Liddell Gauging Station (210083) for the period February 1991 to April 2019. The Liddell Gauging Station (210083) is located about 9 km downstream of the study area. Figure 3.4 shows the relationship between daily stream flow and EC at the Liddell Gauging Station (210083). The logarithmic trend line for flows above 1,000 megalitres per day (ML/d) is also shown. There is a strong relationship between flow rate and EC, with high flows (associated with floods) measuring lower EC values. There is a broad scatter of EC for low flows below 1,000 ML/d. Higher EC values would tend to occur when there are limited releases from Glenbawn Dam and the majority of flow is being generated from the downstream catchments.

Table 3.5 – Water quality guideline values

Parameter	Unit	Guideline value				
		Irrigation	Livestock Drinking	Eco-system	Recreational	Drinking
pH	pH	-	-	6.5 - 8.5	5.0-9.0	6.5 - 8.5
EC (25°C)	µS/cm	1,000 *a	-	25-2200	-	<1,500
DO (% Saturation)	%	-	-	85-110	-	>80
Total Dissolved Solids (TDS)	mg/L	-	2,000*a	-	1,000	1,000
Turbidity	NTU	-	-	6-50	6	-
Calcium (Ca)	mg/L	-	1000	-	-	-
Sodium (Na)	mg/L	115*c		-	300	-
Magnesium (Mg)	mg/L	-	2,000*b	-	-	-
Sulphate as SO_4	mg/L	-	1000	-	400	-
Chloride as Cl	mg/L	175*c	-	-	400	-
Arsenic	mg/L	0.1*f	0.5	0.013*ae	0.05	0.01
Barium	mg/L		-	-	1	2
Cadmium	mg/L	0.01*f	0.01	0.0002*e	0.005	0.002
Chromium	mg/L	0.1*f	1	0.001*e	0.05	0.05
Copper	mg/L	0.2*f	0.4*a	0.0014*e	1	2
Iron	mg/L	0.2*f	-	-	0.3	-
Lead	mg/L	2*f	0.1	0.0034*e	0.05	0.01
Manganese	mg/L	0.2*f	-	1.9*e	0.1	0.5
Nickel	mg/L	0.2*f	1	0.011*e	0.1	0.02
Zinc (Zn)	mg/L	2*f	20	0.008*e	5	-
Mercury	mg/L	0.002*f	0.002	0.0006*e	0.001	0.001
Ammonia	mg/L	-	-	0.9	0.01	-
Total Phosphorus	mg/L	0.05*f	-	0.025	-	-
Total nitrogen	mg/L	5	-	0.35	-	-
Nitrate-N	mg/L	-	400	0.7*e	10	50
Nitrite-N	mg/L		30		1	3

Notes: No guideline value recommended.
NTU = Nephelometric Turbidity Units.
mg/L – milligrams per litre.
µS/cm – microSiemens per centimetre.
*a Lowest recommended value.
*b Cattle (insufficient information on other livestock).
*c Sensitive crops.
*d Upland River.
*e 95% of species protected.
*f Long term guideline value.

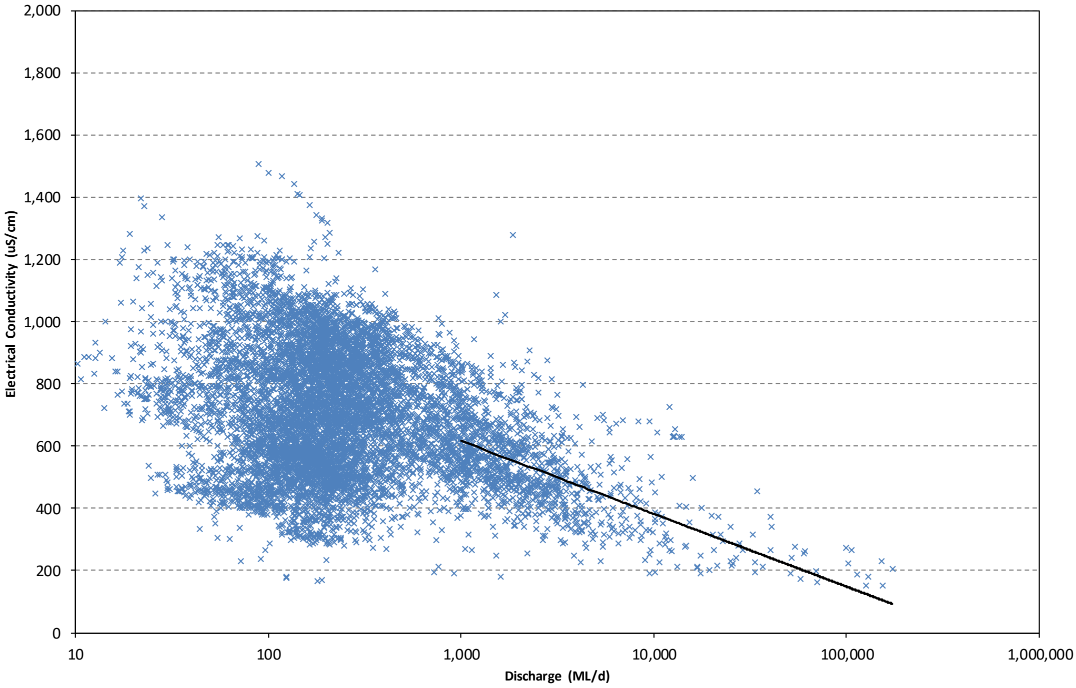


Figure 3.4 - Stream flow and electrical conductivity relationship for the Hunter River at Liddell Gauging Station (210083)

Water quality in the Hunter River has been monitored at three locations in the vicinity of the Project by Anglo American plc (Anglo American) and Malabar since 2008. The locations of the water sampling locations are shown in Figure 3.1. A summary of water quality for the Hunter River is given in Table 3.6.

The 80th percentile value represents 80% of samples are below the given value, and similarly, the 20th percentile value represents 20% of samples are below the given value. The sampling results show the following:

- Hunter River flow is slightly alkaline with median pH ranging from 8.1 to 8.4;
- Hunter River median EC ranges from 735 to 817 µS/cm and is typically below the ANZECC and ARMCANZ default guidelines values (DGVs) for irrigation, livestock drinking water and aquatic ecosystem protection, however the 80th percentile value for the upstream site (H2) exceeds the guideline value for irrigation;
- Hunter River TDS concentrations are well below the ANZECC and ARMCANZ DGVs; and
- Recorded total suspended solids (TSS) concentrations for the Hunter River are low.

Table 3.6 - Hunter River water quality

Parameter		Hunter River (2008 to 2015)		Hunter River (2012 to 2018)
		H2	H3	SW11
pH	20%ile	8.1	8.1	8.0
	Median	8.3	8.4	8.1
	80%ile	8.4	8.5	8.2
	N	31	31	69
EC (μS/cm)	20%ile	629	624	497
	Median	817	812	735
	80%ile	1,024	982	935
	N	31	31	70
TDS (mg/L)	20%ile	420	420	289
	Median	550	540	406
	80%ile	690	660	489
	N	31	31	69
TSS (mg/L)	20%ile	10	11	8
	Median	20	19	14
	80%ile	40	39	29
	N	31	31	69
Calcium (mg/L)	20%ile	34	33	32
	Median	47	45	42
	80%ile	52	54	49
	N	11	11	70
Chloride (mg/L)	20%ile	79	73	49
	Median	108	103	101
	80%ile	167	166	147
	N	11	11	70
Iron (filterable) (mg/L)	20%ile	0.05	0.05	0.05
	Median	0.05	0.05	0.05
	80%ile	0.05	0.05	0.07
	N	11	11	70
Iron (total) (mg/L)	20%ile	0.38	0.39	0.26
	Median	1.17	0.64	0.53
	80%ile	1.89	2.07	1.48
	N	11	11	70

Parameter		Hunter River (2008 to 2015)		Hunter River (2012 to 2018)
		H2	H3	SW11
Sulphur as SO4 (mg/L)	20%ile	27	28	20
	Median	33	33	31
	80%ile	39	39	40
	N	11	11	70
Magnesium (mg/L)	20%ile	25	25	21
	Median	32	34	30
	80%ile	42	44	40
	N	11	11	70

N = Number.

3.5.2.2 Maxwell Underground catchments - Saddlers Creek

Anglo American has previously monitored background water quality in Saddlers Creek between 1998 and 2014. Since acquiring the EL 5460 and the Maxwell Infrastructure, Malabar has continued to monitor background quality in Saddlers Creek. BHP has also monitored Saddlers Creek between 2007 and 2019.

The locations of the water sampling locations are shown in Figure 3.1. A summary of water quality for Saddlers Creek is given in Table 3.7. Note that sampling at the Hunter River sites only commenced in August 2012.

- Saddlers Creek flow is slightly alkaline with median pH ranging from 7.4 to 8.3;
- Saddlers Creek EC and TDS concentrations are very high and substantially exceed ANZECC and ARMCANZ DGVs for irrigation, livestock drinking water and aquatic ecosystem protection with median EC values ranging from 5,280 to 7,510 µS/cm; and
- Recorded TSS concentrations for Saddlers Creek are low (in both datasets).

Table 3.7 - Saddlers Creek water quality

Parameter		Saddlers Creek				
		W3	W4	SW1	SW02	SW03
pH	20%ile	7.9	8.1	7.8	7.1	7.7
	Median	8.0	8.2	8.3	7.4	7.9
	80%ile	8.2	8.4	8.4	7.9	8.1
	N	178	59	39	78	137
EC (µS/cm)	20%ile	6,144	3,968	1,458	4,622	3,378
	Median	7,295	6,880	5,365	7,510	5,280
	80%ile	8,470	8,614	7,206	8,600	7,530
	N	178	59	40	78	137

Parameter		Saddlers Creek				
		W3	W4	SW1	SW02	SW03
TDS	20%ile	3,960	2,640	838	4,402	2,104
(mg/L)	Median	4,764	4,530	3,130	6,280	3,300
	80%ile	5,515	5,584	3,942	7,212	4,694
	N	176	57	39	78	137
TSS	20%ile	5	4	5	5	5
(mg/L)	Median	14	6	7	10	5
	80%ile	38	10	18	24	11
	N	178	59	39	77	137
Calcium	20%ile	76	43	21	-	-
(mg/L)	Median	100	58	46	-	-
	80%ile	110	73	65	-	-
	N	59	19	40	-	-
Chloride	20%ile	1,374	743	316	-	-
(mg/L)	Median	1,880	1,730	1,305	-	-
	80%ile	2,318	2,298	1,810	-	-
	N	59	19	40	-	-
Iron (filterable)	20%ile	0.05	0.05	0.05	0.05	0.05
(mg/L)	Median	0.05	0.05	0.08	0.05	0.05
	80%ile	0.12	0.14	0.22	0.50	0.06
	N	59	19	40	78	137
Iron (total)	20%ile	0.13	0.11	0.09	0.30	0.10
(mg/L)	Median	0.41	0.33	0.36	0.62	0.20
	80%ile	0.94	0.76	2.25	0.92	0.33
	N	58	19	40	9	35
Sulphur as SO4	20%ile	348	150	84	-	-
(mg/L)	Median	520	237	168	-	-
	80%ile	614	333	311	-	-
	N	59	19	40	-	-
Magnesium	20%ile	236	93	42	-	-
(mg/L)	Median	319	195	147	-	-
	80%ile	354	252	208	-	-
	N	59	19	40	-	-

3.5.2.3 Downstream of Maxwell Infrastructure

A summary of the water quality sampling in the catchments downstream of Maxwell Infrastructure is given in Table 3.8. Maxwell Infrastructure does not discharge water to any of these catchments. Rather the catchments are mostly undisturbed with small areas of previously rehabilitated mining areas. BHP has also monitored Ramrod Creek between 2007 and 2018.

The following is of note:

- runoff is generally saline with median EC ranging from 1,520 to 6,410 µS/cm. The EC of Bayswater Creek and Ramrod Creek is measured in dams, which would elevate recorded levels compared to streamflow;
- median pH is slightly alkaline ranging from 7.6 to 9.2; and
- TSS is generally low.

Table 3.8 - Downstream Maxwell Infrastructure water quality

Parameter		Bayswater Creek (1895)	Ramrod Creek (2221)	Ramrod Creek SW09 (BHP)	Ramrod Creek SW12 (BHP)
pH	20%ile	8.5	6.0	7.7	7.7
	Median	8.6	7.6	8.0	7.9
	80%ile	8.9	8.0	8.3	8.1
	N	47	52	33	137
EC (µs/cm)	20%ile	5,874	1,240	4,138	4,504
	Median	6,410	1,520	6,260	5,120
	80%ile	7,232	3,464	7,062	5,766
	N	47	52	33	137
TSS (mg/L)	20%ile	5	5	5	5
	Median	5	6	8	12
	80%ile	8	36	22	38
	N	47	52	31	137

3.5.2.4 Maxwell Infrastructure dams

Malabar (and previously Anglo American) monitor water quality in all water storages at Maxwell Infrastructure. A summary of the water quality tested in the various water storages at Maxwell Infrastructure is given in Table 3.9. The summary is based on monthly samples collected between August 2014 and March 2019. The results indicate that water stored in the Maxwell Infrastructure water management dams has similar water quality characteristics to the natural catchments with runoff that is saline and slightly alkaline.

Table 3.9 – Maxwell Infrastructure dam water quality

Parameter		Rail Loop Dam (2114)	Access Road Dam (2081)	Industrial Dam (1969)	Savoy Dam (1609)
pH	20%ile	7.9	8.0	8.0	8.2
	Median	8.1	8.1	8.2	8.3
	80%ile	8.2	8.3	8.3	8.5
	N	55	56	55	54
EC (µs/cm)	20%ile	2,760	6,270	5,878	7,464
	Median	5,100	6,865	6,220	7,760
	90%ile	6,536	8,180	6,530	10,480
	N	55	56	55	54
TSS (mg/L)	20%ile	5	5	5	5
	Median	10	6	7	5
	90%ile	14	12	12	8
	N	55	56	55	54

3.5.3 Baseline water quantity data

3.5.3.1 Hunter River

Figure 3.5 shows the flow-duration relationship for the recorded Hunter River flows, closest to Maxwell Underground, at the Liddell Gauging Station (210083). The Liddell Gauging Station (210083) is located approximately 9.0 km downstream of Maxwell Underground and has an upstream catchment area of 13,400 km^2. Data has been collected at the Liddell Gauging Station (210083) since 1969. The flow-duration relationship indicates that flow is non-zero all of the time, which is characteristic of regulated river systems. The median flow is about 240 ML/d and flows exceed 1,000 ML/d some 16% of the time. The volumetric runoff coefficient (rainfall to runoff relationship) of the Hunter River flows to the Liddell Gauging Station (210083) is approximately 4.4%.

3.5.3.2 Saddlers Creek

Figure 3.6 shows the flow-duration relationship for the recorded flows in Saddlers Creek at the Bowfield Gauge (GS210043). Bowfield Gauge is located at the same site as W4, shown in Figure 3.1. Stream water level was recorded at this station between 1956 and 1981. However, very few stream gaugings greater than 10 ML/d were taken to derive an accurate relationship between water level and stream flow. As such, there is likely to be a high level of uncertainty associated with the data in Figure 3.6. Notwithstanding, the figure shows that Saddlers Creek is intermittent, with flow recorded 55% of the time, and is dry 45% of the time.

Extended periods of baseflow are evident indicating that the system is fed by groundwater flows. The median (non-zero) flow is 0.22 ML/d and the highest recorded daily flow over the period of record was 1,137 ML/d.

Malabar installed a new stream gauging station on Saddlers Creek on 12 September 2018 at the location shown on Figure 3.1. Figure 3.7 shows the recorded water level and streamflow at 5-minute recording intervals at the new gauging station between September 2018 and April 2019. The data shows that there was only been a single recorded flow event since the gauge was installed.

A comparison of the recorded peak daily flow rate and the daily rainfall total over the entire period is presented in Figure 3.8, and shows the following:

- The single recorded flow occurred after 66 mm of rainfall fell in a single day. The flow event lasted for around 48 hours.
- During the recording period, daily rainfall totals of less around 25 mm are insufficient to cause a measurable surface flow in Saddlers Creek at the gauging station.

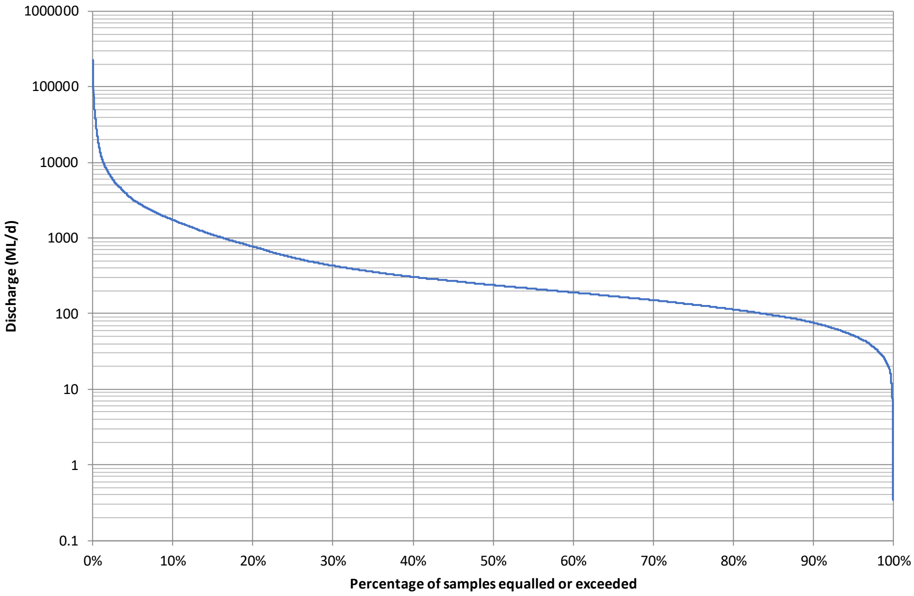


Figure 3.5 – Recorded flow-duration relationship for the Hunter River at Liddell Gauging Station (210083) (1969-2019)

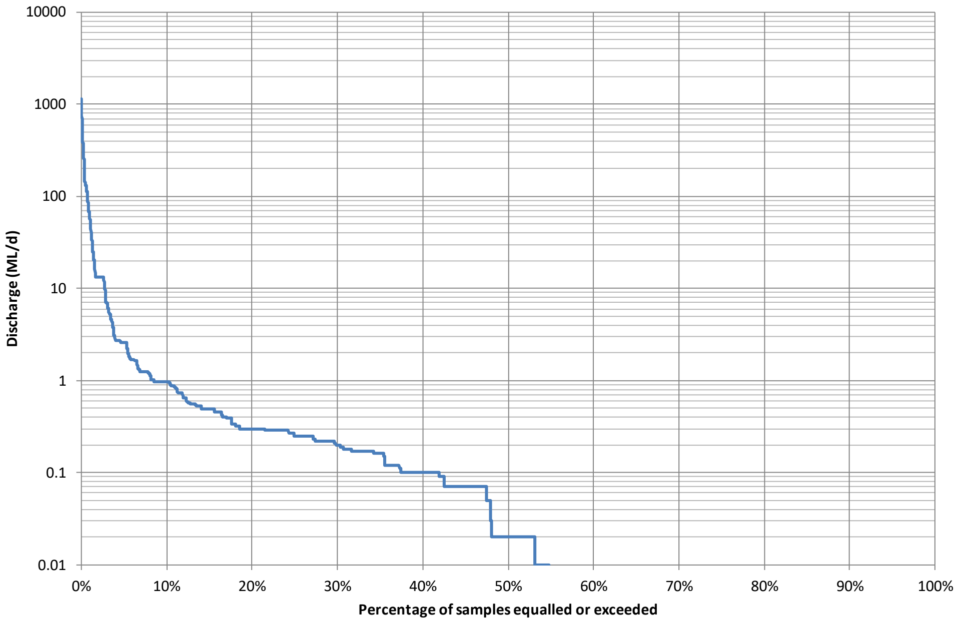


Figure 3.6 – Derived flow-duration relationship for Saddlers Creek at Bowfield (1956-1981)

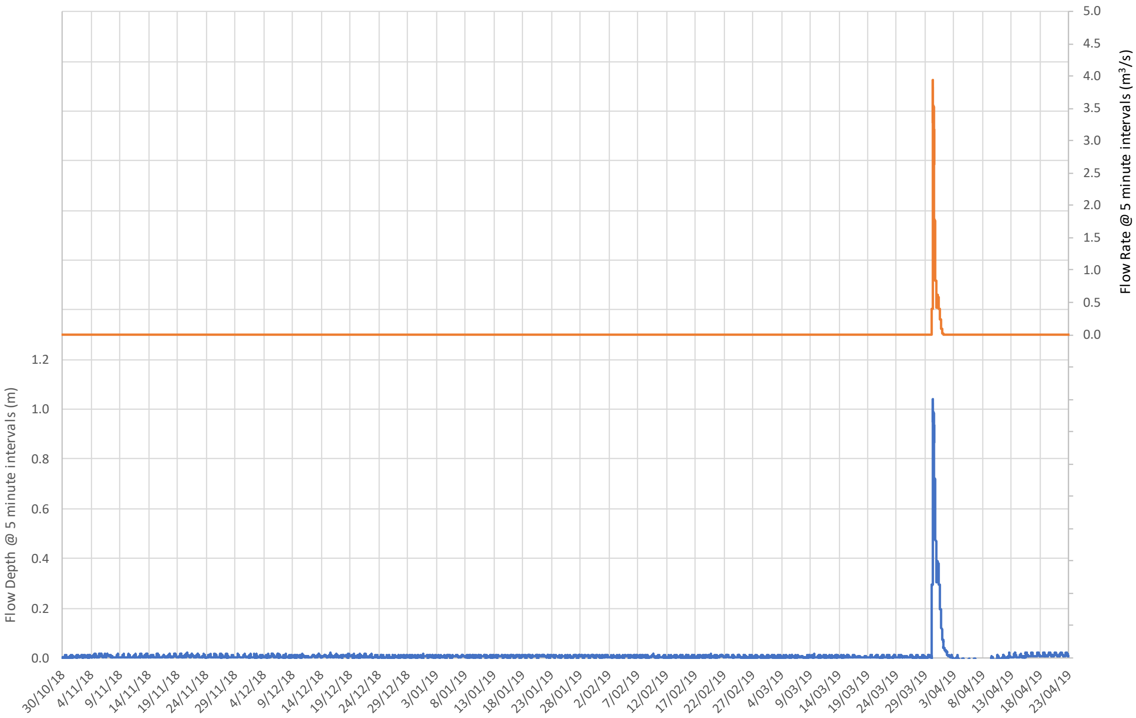


Figure 3.7 – Saddlers Creek water level and streamflow at new stream gauge (Sept-18 to Apr-19) – 5 minute recording intervals

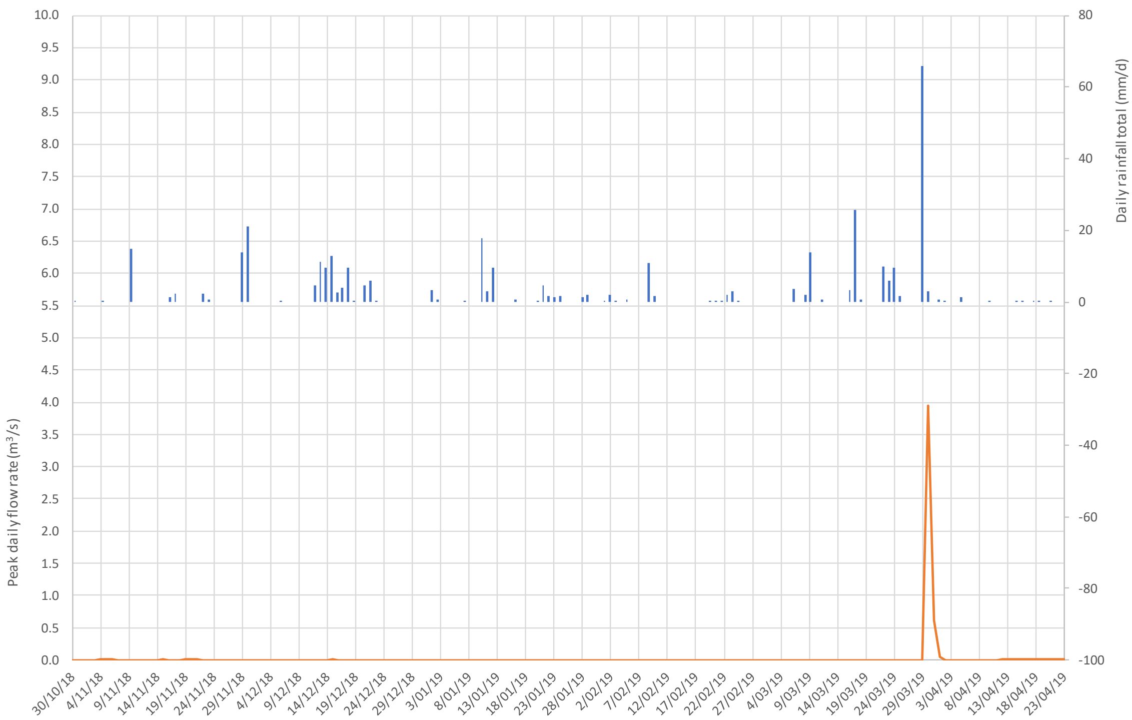


Figure 3.8 – Saddlers Creek peak daily flow rate and rainfall at new stream gauge (Sept-18 to Apr-19)

3.6 EXISTING WATER MANAGEMENT SYSTEM

Figure 3.9 shows the locations of the major water management storages and the previously mined areas at Maxwell Infrastructure; East Void, North Void and South Void.

Details of the existing and proposed water management systems are provided in Section 4.

Table 3.10 shows details of the main water management storages at Maxwell Infrastructure. These dams are connected by a pipe network, which enables a transfer of water.

The Access Road Dam is a prescribed dam listed under Schedule 1 of the Dams Safety Act 1978, which requires the proponent (Malabar) monitor and manage the dam to ensure it is safe to the downstream community.

Table 3.10 – Details of existing Maxwell Infrastructure water management storages

Storage name	Storage type	Storage capacity (ML)	Catchment
Access Road Dam	Mine affected water dam	750	Ramrod Creek
Industrial Dam	Mine affected water dam	750	East Void
Rail Loop Dam	Mine affected water dam	18	Ramrod Creek
Savoy Dam	Mine affected water dam	140	Saddlers Creek

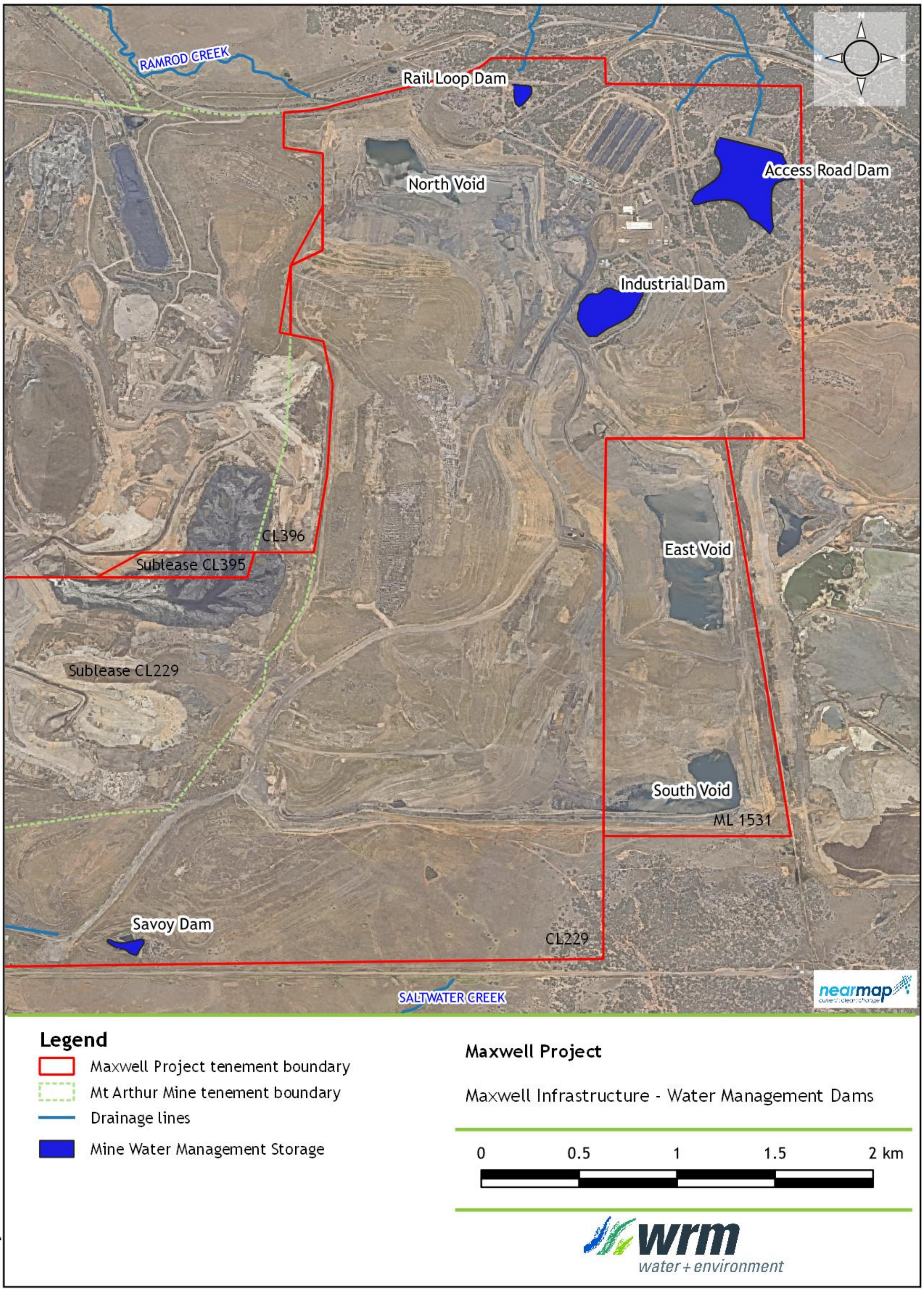


Figure 3.9 – Maxwell Infrastructure - Water Management Dams

3.7 FLOODING

The proposed Project surface infrastructure and the estimated limit of subsidence has been located outside the predicted probable maximum flood (PMF) extent of the Hunter River and Saddlers Creek.

Flood modelling of Saddlers Creek has been undertaken to define the location of the Maxwell Underground and Maxwell Infrastructure. Design flood discharges, flood levels and flood extents were estimated for Saddlers Creek across the Maxwell Underground area for pre-mine conditions to ensure a conservative assessment was undertaken. These conditions assume that both Maxwell Infrastructure (previously Drayton Mine) and BHP's Mt Arthur Mine were not built and the entire catchment drains to Saddlers Creek. This assessment would over-estimate the extent of flooding under existing conditions as existing mining has reduced the contributing catchment area.

A Floodplain Risk Management Study and Plan (FRMS&P) of the Hunter River between Muswellbrook and Denman was undertaken by Royal HaskoningDHV (RHDHV, 2018) for Muswellbrook Shire Council in 2018. The FRMS&P included modelling of the PMF extent along the Hunter River adjacent to the Project and is considered in Section 3.7.3.2.

3.7.1 Project Infrastructure and Maxwell Infrastructure

Surface infrastructure proposed to be constructed for the Project includes (as shown in Figure 3.10):

- Infrastructure at the mine entry area;
- Transport and services corridor (including a covered overland conveyor system to transport coal from the mine entry area to the existing CHPP for processing);
- Site access road;
- Power transmission infrastructure; and
- Water management infrastructure (including pump, pipelines, water storages and water treatment facilities).

As described in the Subsidence Assessment (MSEC, 2019), the extent of the subsidence study area (as shown in Figure 3.10) has been calculated by combining the areas bounded by the following limits:

- 26.5° angle of draw from the extents of the proposed panels and longwalls in each seam; and
- predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of the proposed panels and longwalls in all seams.

3.7.2 Estimation of discharges

The XP-RAFTS rainfall runoff routing model was used to estimate PMF design discharges along Saddlers Creek across the Project area and surrounds for pre-mine conditions. XP-RAFTS model is proprietary software that is widely used throughout Australia for flood studies.

Discharges were estimated at the upstream location where Saddlers Creek north of the Maxwell Underground (Location A shown in Figure 3.10) and at a further two points along Saddlers Creek (Locations B and C shown in Figure 3.10) using design rainfalls obtained from BOM (2006). The XP-RAFTS model consisted of three sub-areas representing the catchments draining to location A, B and C. XP-RAFTS model parameters adopted for the PMF design event are as follows:

- catchment Manning's 'n' = 0.07;
- catchment slope = 1%;
- percentage impervious – 0%;

- initial rainfall loss = 15mm;
- continuing rainfall loss = 3 millimetres per hour (mm/hr);
- channel velocity = 0.75 metres per second (m/s); and
- channel routing storage coefficient = 0.25.

Details of the XP-RAFTS model estimate for the PMF design event are provided in Table 3.11.

Table 3.11 - Saddlers Creek PMF design discharges, XP-RAFTS model

Parameter	Location A	Location B	Location C
Catchment Area (km^2)	33.2	50.4	76.9
PMF (m^3/s)	460	680	990

Note: m^3/s = cubic metres per second.

3.7.3 Estimation of flood levels

3.7.3.1 Saddlers Creek

The Hydrologic Engineering Centre River Analysis System (HEC-RAS) hydraulic model was used to estimate design flood levels along Saddlers Creek at Maxwell Underground under pre-mining conditions. The model consists of 112 cross-sections, extracted from a digital elevation model of the area. The locations of the model cross-sections are shown in Figure 3.10. Figure 3.11 shows a representative cross-section of Saddlers Creek (XS 70).

A Manning's 'n' value (representing the hydraulic roughness of the waterway) of 0.08 was adopted for the main channel and 0.1 for the floodplain of Saddlers Creek. This is a conservatively high estimate of roughness, given the existing channel vegetation, to provide conservatively high flood levels and flood extent.

The downstream boundary condition for the HEC-RAS model was based on a normal depth calculation, using the average longitudinal bed slope of Saddlers Creek in the area of interest of approximately 0.4%. This represents the scenario where there is no coincident flooding in the Hunter River at the time of a Saddlers Creek flood event. The top of bank of the Hunter River at the Saddlers Creek confluence is some 25 m below the minimum elevation of where mining would commence and therefore would not impact on the Project.

Estimated design flood levels along Saddlers Creek are shown in Table 3.12. Figure 3.10 shows the estimated extent of flooding for the PMF event.

3.7.3.2 Hunter River

The PMF extent from the FRMS&P (RHDHV, 2018) has been overlain on Figure 3.10, showing the following:

- The extent of conventional subsidence (20 mm subsidence contour) lies outside of the Hunter River PMF extent; and
- The PMF extent at the Saddlers Creek confluence is generally only slightly larger than the Saddlers Creek PMF flood extent. This confirms the assumption that coincident Hunter River flooding would not impact on the Project area.

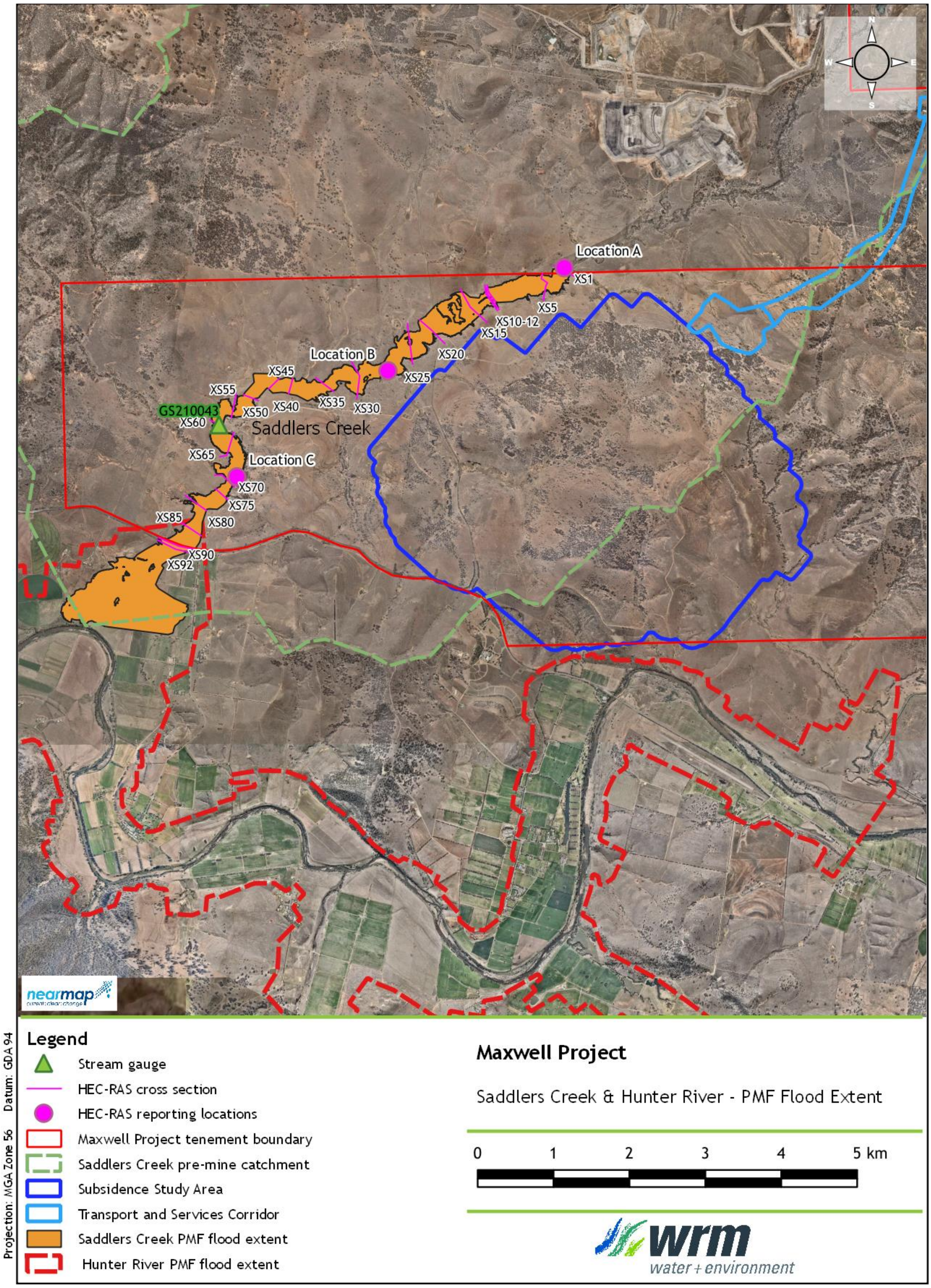


Figure 3.10 – Saddlers Creek & Hunter River – PMF Flood Extent

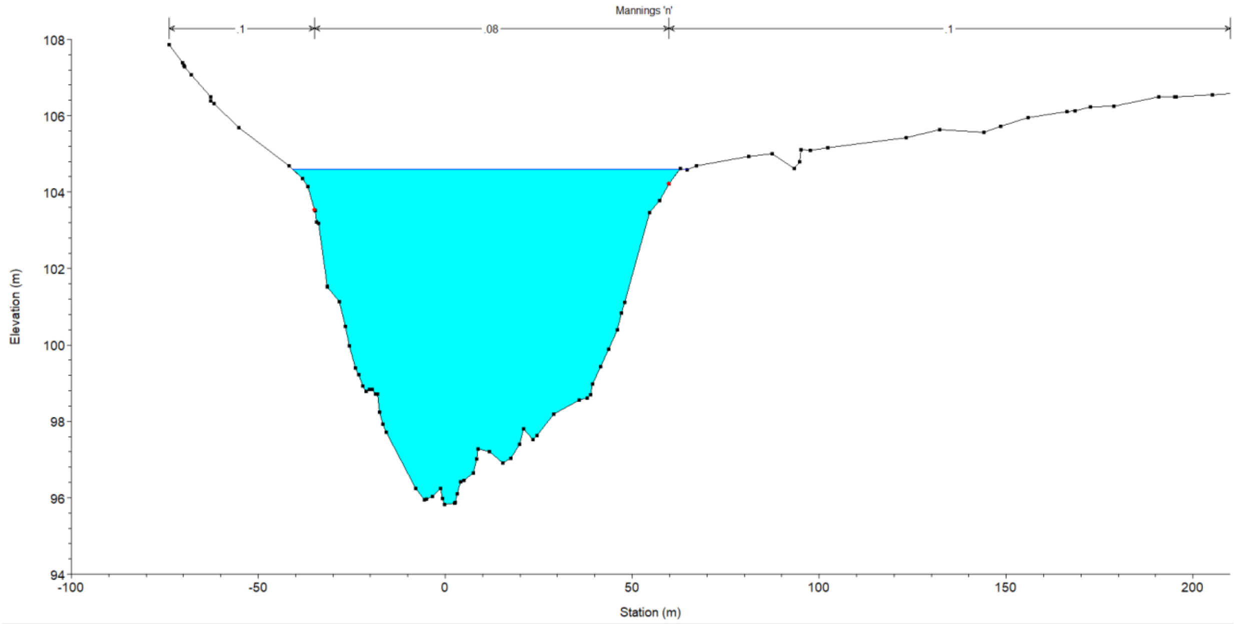


Figure 3.11 – Saddlers Creek HEC-RAS model (XS70) - PMF level

Table 3.12 - Saddlers Creek peak flood levels, PMF

Cross-Section	Peak Flood Level (mAHD)
	PMF
XS1	136.00
XS5	134.13
XS10	130.12
XS11	129.57
XS12	128.69
XS15	126.92
XS20	122.60
	Edderton Road
XS25	118.96
XS30	115.35
XS35	113.98
XS40	112.13
XS45	111.45
XS50	110.05
XS55	107.50
XS60	106.55
XS65	105.52
	Bowfield Gauge
XS70	104.60
XS75	103.54
XS80	103.11
XS85	101.7
XS90	100.38
	Golden Highway
XS92	99.75

Note: mAHD = metres Australian Height Datum.

4 Proposed surface water management system

4.1 OVERVIEW

4.1.1 Maxwell Infrastructure

The existing water management system at Maxwell Infrastructure (as described in Section 3.6) would be used to support the mining operations at Maxwell Underground. This would include the following activities:

- Processing of ROM coal at the existing CHPP at Maxwell Infrastructure;
- Emplacement of coarse rejects and tailings and brine within the East Void;
- Rehabilitation activities within CL 229, ML 1531 and CL 395, including the rehabilitation of reject and tailings emplacement areas;
- Storage of excess water within the North Void and the South Void; and
- Management of the existing water storages (Access Road Dam, Industrial Dam, Rail Loop Dam and Savoy Dam) to support operations and protect the receiving environment.

The conceptual mine plan layout and water management infrastructure at Maxwell Infrastructure is shown in Figure 4.1 to Figure 4.3 for the following stages:

- Stages 1 and 2 (first stage of Maxwell Infrastructure rehabilitation complete);
- Stages 3 and 4 (final drainage layout partially complete); and
- Stage 5 (final drainage layout complete).

BHP holds a sublease area over part of CL 229. The land within the sublease is subject to an agreement between Malabar and BHP that provides for the ongoing management activities to this area including overburden emplacement, water management, spontaneous combustion management and the development of rehabilitation and the final landform.

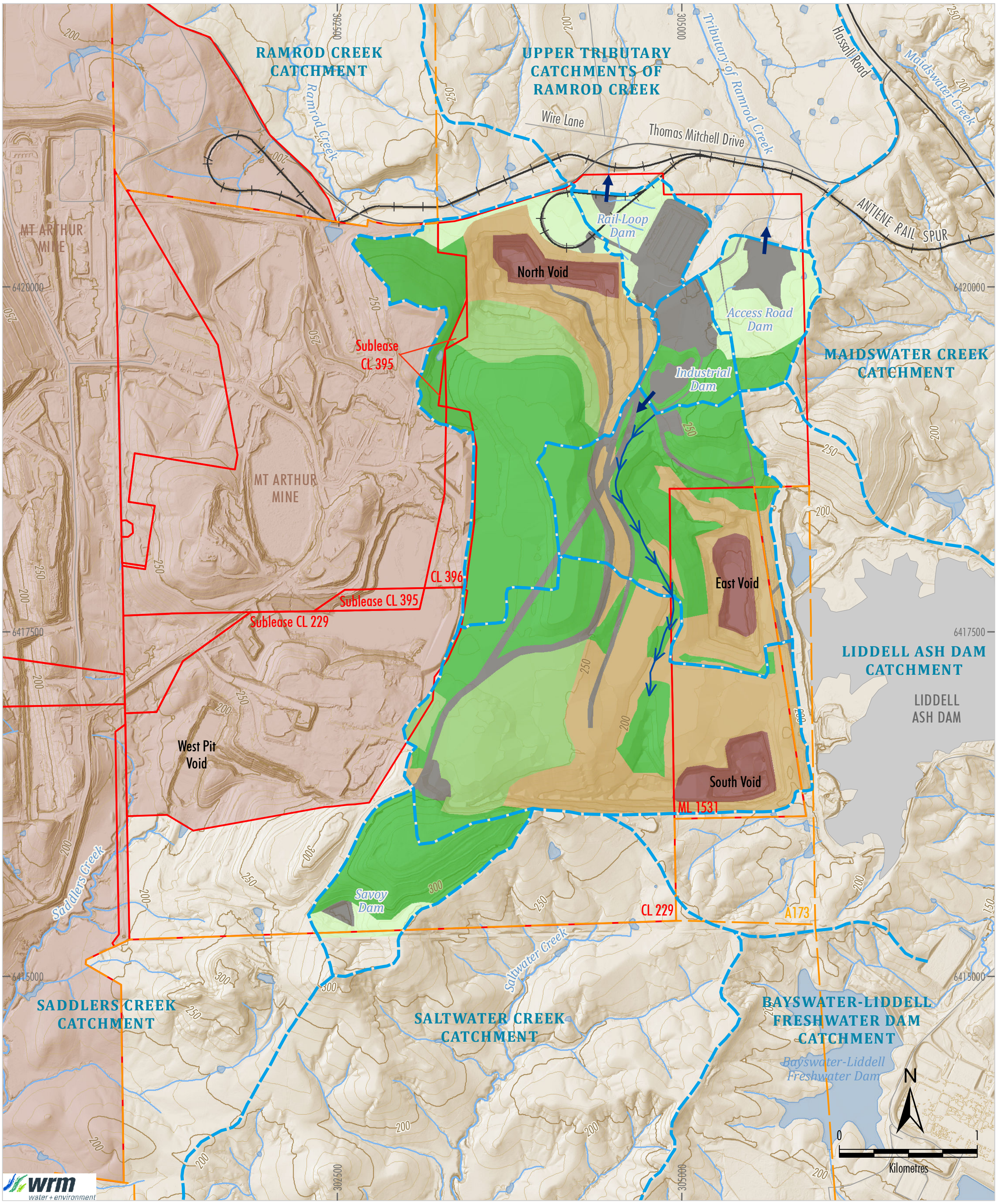
Under the existing sublease agreement and associated schedules, BHP is obliged to manage the area to achieve agreed final landform outcomes and manage the rehabilitation of any land that is disturbed by their activities in the sublease area. This is also stipulated in the Project Approval conditions for the Mt Arthur Mine.

4.1.2 Maxwell Underground

Maxwell Underground is located entirely within EL 5460, and would include the following surface water-related activities:

- underground bord and pillar mining with partial pillar extraction in the Whynot Seam;
- underground longwall extraction in the Woodlands Hill Seam, Arrowfield Seam and Bowfield Seam; and
- development and use of a mine entry area and associated infrastructure, including multiple water storages and a Water Treatment Facility (WTF).

The conceptual layout and water management infrastructure for Maxwell Underground are shown in Figure 4.4.



LEGEND

- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Catchment Boundary
- Key Surface Water Drain
- Overflow Direction

Land Use

- Natural/Undisturbed
- Existing Rehabilitation
- Rehabilitated Spoil
- Spoil
- Void
- Industrial/Hardstand

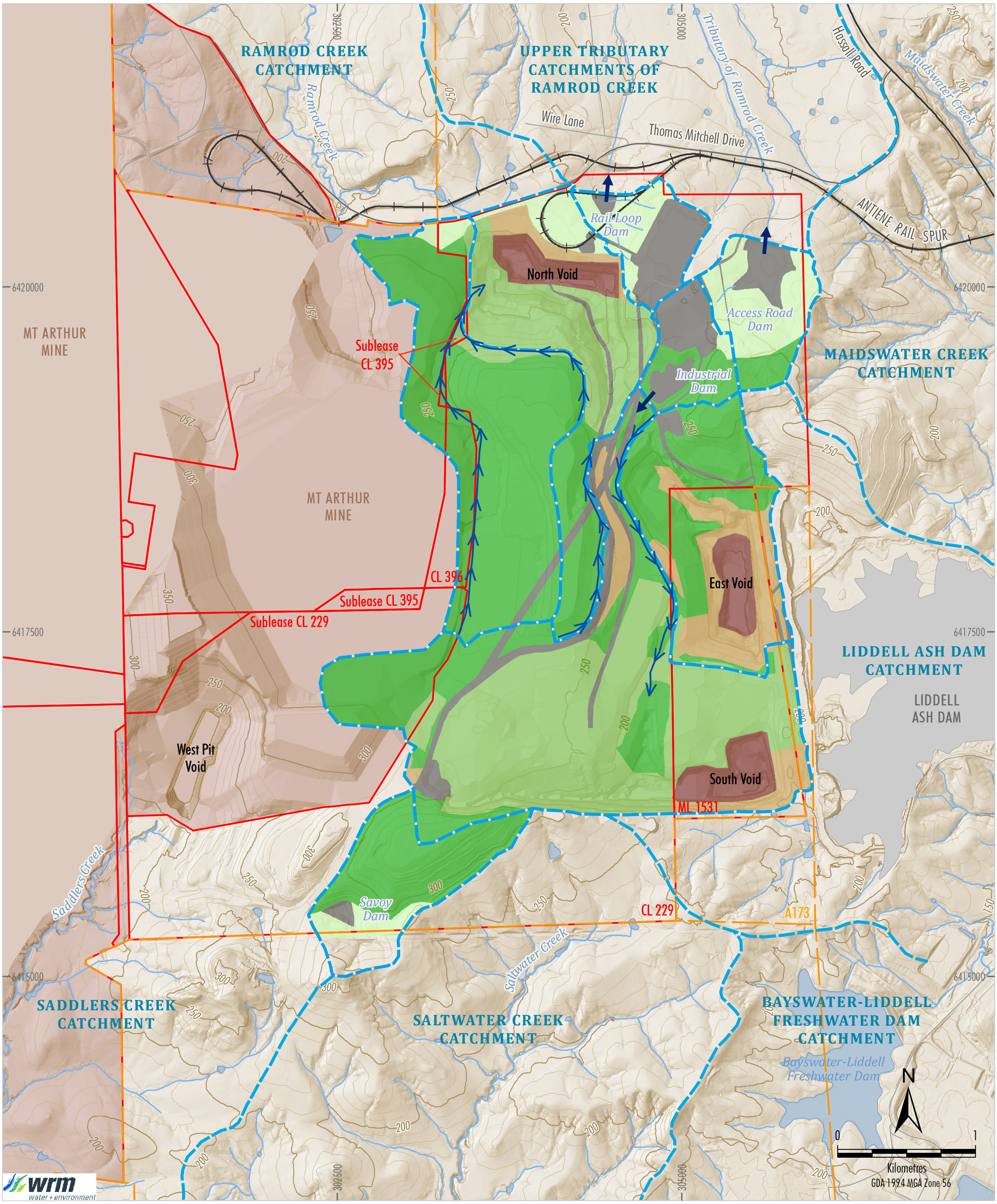
Source: © NSW Department of Planning and Environment (2019); Department of Finance, Services & Innovation (2019)

MALABAR COAL

MAXWELL PROJECT

Conceptual Mine Plan - Maxwell Infrastructure - Stages 1 and 2

Figure 4.1



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Catchment Boundary
- Key Surface Water Drain
- Overflow Direction

Land Use
- Natural/Undisturbed
- Existing Rehabilitation
- Rehabilitated Spoil
- Spoil
- Void
- Industrial/Hardstand

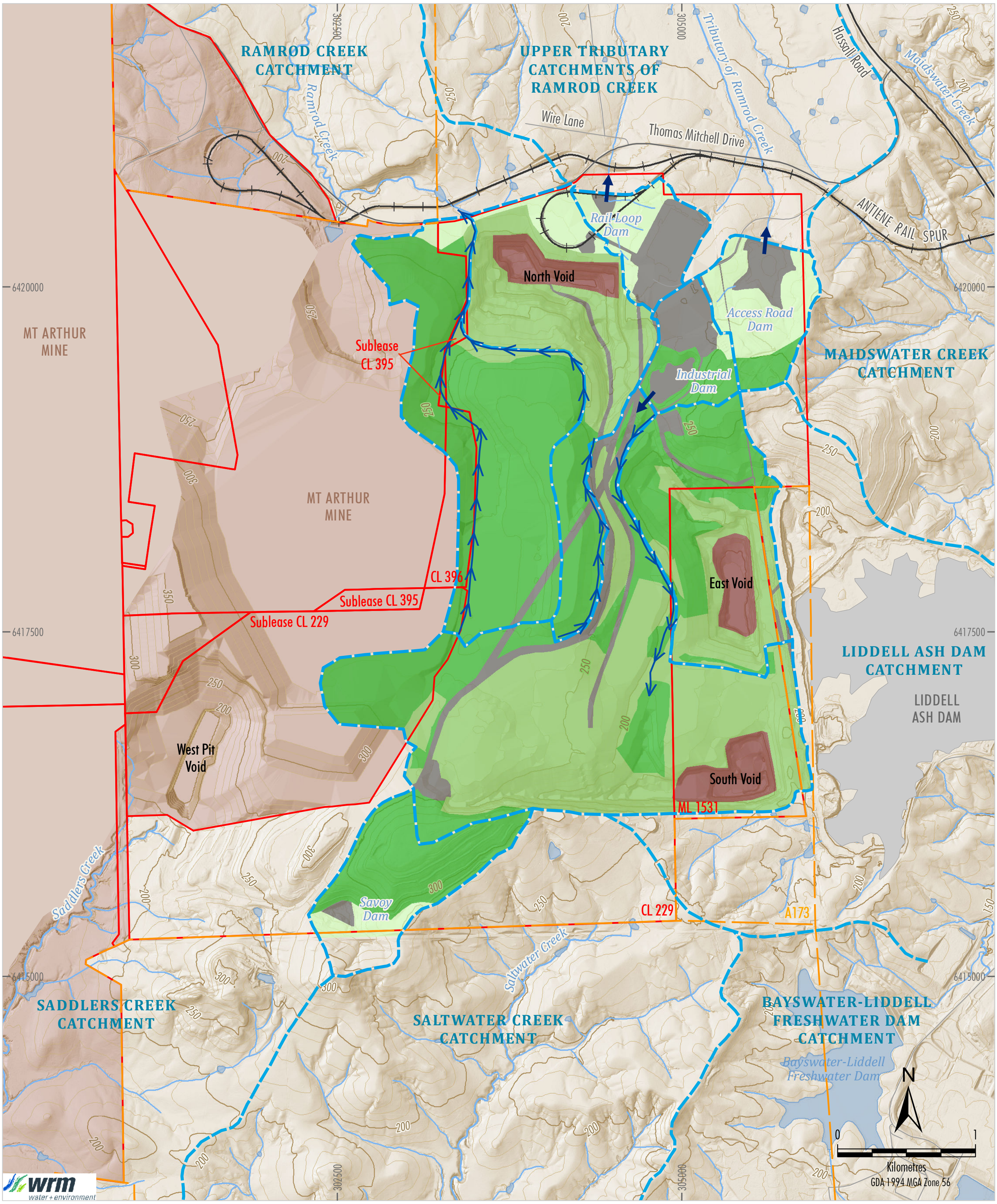
Source: © NSW Department of Planning and Environment (2019); Department of Finance, Services & Innovation (2019); Hunter Valley Energy Coal Pty Ltd (2017)

MALABAR COAL

MAXWELL PROJECT

Conceptual Mine Plan
- Maxwell Infrastructure
- Stages 3 and 4

Figure 4.2



LEGEND

Railway
Exploration Licence Boundary
Mining and Coal Lease Boundary
Catchment Boundary
Key Surface Water Drain
Overflow Direction

Land Use

Natural/Undisturbed
Existing Rehabilitation
Rehabilitated Spoil
Void
Industrial/Hardstand

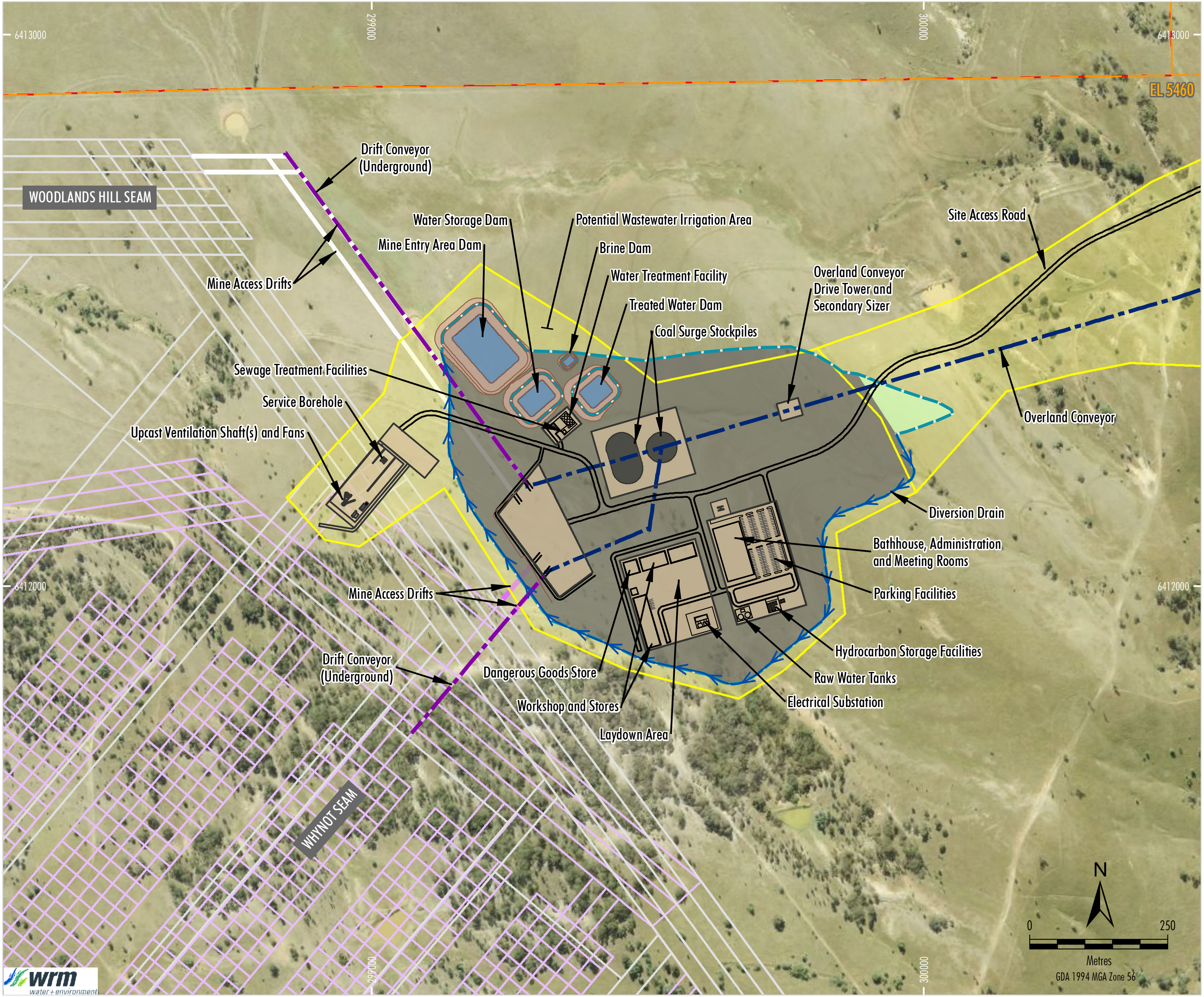
Source: © NSW Department of Planning and Environment (2019); Department of Finance, Services & Innovation (2019); Hunter Valley Energy Coal Pty Ltd (2017)

MALABAR COAL

MAXWELL PROJECT

Conceptual Mine Plan - Maxwell Infrastructure - Stage 5

Figure 4.3



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Indicative Underground Mining Layout
Indicative Surface Development Area
Indicative Surface/Overland Conveyor Location
Indicative Underground Conveyor Location
Catchment Boundary
Key Surface Water Drain
Land Use
Undisturbed
Industrial

Note: Runoff from the transport and services corridor and ventilation fan site would not be captured in the mine water management system. These areas would be managed with appropriate sediment controls in accordance with Section 8.2 of the Blue Book (Landcom, 2004).

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); GHD (2018)
Orthophoto: NSW Department of Finance, Services & Innovation (2018)

MALABAR COAL
MAXWELL PROJECT
Indicative Mine Entry Area Layout

Figure 4.4

wrm water + environment
SHM-18-03 Maxwell_EIS_App SWA_206B

4.2 SURFACE WATER MANAGEMENT STRATEGY

Land disturbance associated with the Project has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from operational areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants compared to natural runoff. The surface water management principles are based on the categorisation of water generated within Project areas based on water quality, and include:

- A mine water management system to collect and use water that may contain high TDS (salt) concentrations, generally through coming into contact with coal such as runoff from the coal stockpile. Mine water would primarily be used to satisfy on site demand for coal washing.
- A tailings water management system to manage the inflows to and outflows from the CHPP and tailings emplacement area (East Void).
- A clean water management system to divert water undisturbed by mining, or from fully rehabilitated areas, around the mine entry area and existing disturbed areas of the Maxwell Infrastructure.
- A dirty water management system to separate potentially sediment-laden runoff from disturbed areas from clean area runoff and collect it in sediment dams for treatment.
- A hydrocarbon water management system for water that has come in contact with oils, greases and chemicals.

4.3 SURFACE WATER MANAGEMENT

4.3.1 Mine water management system

The proposed mine water management system for the Project is summarised below:

- Water collected in the previously mined areas within Maxwell Infrastructure would be pumped to Access Road Dam to supply site water demands, including the CHPP.
- Excess mine affected water would be pumped to South Void for temporary storage, where it can be pumped back as required. The South Void would be the main storage for excess water for the Project.
- Rail Loop Dam, which collects mine affected runoff from the Maxwell Infrastructure facilities and coal stockpiles, would be pumped to the Access Road Dam.
- Water Storage Dam acts as the primary water storage at the mine entry area. It would supply the proposed WTF, and receive water pumped from the underground mining operations. It would have the ability to transfer water to/from South Void at Maxwell Infrastructure.
- Runoff from the mine entry area would be captured within the Mine Entry Area Dam (MEA Dam), and pumped to Water Storage Dam.
- The proposed WTF would operate as follows:
    - Feed water supplied from Water Storage Dam.
    - Treated water pumped to Treated Water Dam prior to it being used in the underground.
    - Brine pumped to the Brine Dam.
- Brine would eventually be pumped from Brine Dam to a separate impoundment area within East Void.

4.3.2 Tailings water management system

Rejects and tailings generated at the CHPP would be deposited in East Void. Decant water recovered from the tailings (30% of tailings moisture) would be recycled within the site water management system and returned for consumption in the CHPP. The remaining 70% of tailings moisture and the moisture within the coarse rejects would evaporate or become entrained.

The tailings emplacement within East Void would be kept separate from the brine water impoundment area.

4.3.3 Clean water management system

A series of dams and drains would be constructed to divert clean water around the mine entry area in order to minimise clean water capture as shown in Figure 4.4.

4.3.4 Dirty water management system

Surface runoff from disturbance areas that drain off-site would be managed by the dirty water management system to reduce sediment loads. As the majority of the catchments at Maxwell Infrastructure and mine entry area drain internally to site storages, this would mainly comprise the transport and services corridor and upcast ventilation shaft site (including shafts, associated fans and ancillary infrastructure).

4.3.5 Hydrocarbon water management system

The Maxwell Infrastructure site facilities and the proposed mine site facilities at the mine entry area may produce runoff that contains hydrocarbons. These areas include:

- the vehicle and equipment wash-down area;
- workshop;
- fuel, oil and grease storages; and
- refuelling bays.

Runoff from these areas would be managed as follows:

- Runoff would drain to a triple interceptor (or similar) to reduce hydrocarbons to acceptable levels before draining to the downstream dams. The oily fraction would enter a containment system for removal as necessary.
- Storage tank areas would have an impermeable surface and bunding in accordance with Australian Standard (AS) 1940:2017: The storage and handling of flammable and combustible liquids.
- All oil, grease, fuel and hydrocarbon products would be securely stored.
- Refuelling, oiling and greasing would take place in designated areas only.

In the event of a spill, the contaminated soil at the site of the spill would be collected and transported to a licensed waste disposal facility or remediated safely on-site.

4.3.6 Potable water

Potable water at Maxwell Infrastructure is supplied via a pipeline from Muswellbrook Shire Council. The current supply arrangement is proposed to continue for the Project. Potable water requirements at the mine entry area and Maxwell Underground would be sourced from the existing Maxwell Infrastructure potable water supply, and transported by truck to the Maxwell Underground facilities, within potable water standard requirements.

4.4 WATER MANAGEMENT STORAGES

Table 4.1 shows details of the water management storages within the Project area. The catchment areas and land use draining to the various dams and voids are given in Section 5.3.2. The dams are connected by a pipe network, which enables the transfer of water according to mine operational requirements. The operational rules of the various storages, including the sources of water pumped to and from each storage are given in Section 5.4.

The operating rules have been developed to either maintain a storage volume to enable supplies to be met or to prevent uncontrolled spills from occurring. The limits were approximated through modelling and are generally based on the receiving storages ordering water to meet demand or to minimise the risk of uncontrolled spills.

4.4.1 Access Road Dam

Access Road Dam is an existing mine affected water storage at Maxwell Infrastructure, with a capacity of 750 ML, that is used to supply water for dust suppression, industrial wash down and as the primary water supply to the CHPP.

It can receive pumped inflows from Industrial Dam, Rail Loop Dam, along with decant returns from East Void and South Void.

4.4.2 Industrial Dam

Industrial Dam is an existing mine affected water storage at Maxwell Infrastructure, with a capacity of 750 ML, that can be used as a back up to the Access Road Dam to supply water to the CHPP, dust suppression and industrial wash down.

4.4.3 Rail Loop Dam

Rail Loop Dam is an existing mine affected water storage at Maxwell Infrastructure, with a capacity of 18 ML, which captures mine affected runoff from the existing site facilities and coal stockpiles. The Rail Loop Dam has an automatic pump back system to the Industrial Dam.

4.4.4 Savoy Dam

Savoy Dam is an existing dam at Maxwell Infrastructure, with a capacity of 140 ML, which primarily captures runoff from a rehabilitated catchment. If required, water can be pumped back to South Void.

4.4.5 Mine Entry Area Dam

MEA Dam is a proposed mine affected water storage within the mine entry area, with a proposed capacity of 110 ML, that would be used to capture runoff from the mine entry area, as well as overflows from Water Storage Dam and Brine Dam.

It would be kept empty through pumping water to the Water Storage Dam.

4.4.6 Water Storage Dam

Water Storage Dam is a proposed mine affected water storage within the mine entry area, with a proposed capacity of 17 ML, that would be used to store underground dewatering water, provide feed water to the proposed WTF as well as have the ability to transfer water to/from South Void at Maxwell Infrastructure.

4.4.7 Treated Water Dam

Treated Water Dam is a proposed dam within the mine entry area, with a proposed capacity of 15 ML, that would be used to store treated water from the proposed WTF, to supply the underground water demands.

4.4.8 Brine Water Dam

Brine Water Dam is a proposed dam within the mine entry area, with a proposed capacity of 4 ML, that would be used to store brine from the proposed WTF. The brine would then be pumped to a segregated area within East Void.

4.4.9 South Void

South Void would function as the primary mine water storage for the Project, and would store excess mine water generated within the water management system.

The capacity of South Void includes both the open void component, as well as available storage volume within the in-pit spoil. Based on advice from HydroSimulations, a spoil storativity factor of 20% was adopted. That is, 20% of the spoil volume is available to store water.

Based on the mined pit shell geometry and latest LiDAR information, a composite storage curve has been developed for South Void which includes both the open void and the spoil pore volume up to a level of 175 mAHD (i.e. the full supply level [FSL]).

For the purposes of this Surface Water Assessment, it has been assumed that water is able to rapidly infiltrate into the in-pit spoil and utilise available pore volume.

4.4.10 North Void

North Void would function as the secondary mine water storage for the Project, and would store any mine water in excess of the South Void storage capacity.

As per South Void, the capacity of North Void includes both the open void component, as well as available storage volume within the in-pit spoil.

4.4.11 East Void

East Void would receive emplaced CHPP waste (coarse rejects and tailings) as well as excess brine generated by the WTF (in an isolated cell).

As per South Void and North Void, the capacity of East Void includes both the open void component, as well as available storage volume within the in-pit spoil.

Table 4.1 - Existing and proposed storage details

Storage name	Storage type	Storage capacity (ML)	Stored volume @ Jan-19	Overflows to catchment
Existing dams/voids (Maxwell Infrastructure)				
Access Road Dam	Mine affected water dam	750	208	Ramrod Creek
Industrial Dam	Mine affected water dam	750	386	East Void
Rail Loop Dam	Mine affected water dam	18	-	Ramrod Creek
Savoy Dam	Mine affected water dam	140	6	Saddlers Creek
South Void	Pit void	17,700 (open void to 175 mAHD) 30,935 (composite to 175 mAHD)	2,410 (open void) 5,530 (composite)	-

Storage name	Storage type	Storage capacity (ML)	Stored volume @ Jan-19	Overflows to catchment
North Void	Pit void	17,390 (open void to 175 mAHD) 30,800 (composite to 175 mAHD)	3,610 (open void) 5,680 (composite)	-
East Void (existing)	Pit void	23,730 (open void to 175 mAHD) 35,590 (composite to 175 mAHD)	5,680 (open void) 9,020 (composite)	-
East Void (final)	Pit void/rejects co-disposal storage	5,900 (open void to 175 mAHD) 12,650 (composite to 175 mAHD)	-	-
Proposed dams (Maxwell Underground)				
MEA Dam	Mine affected water dam	110	-	Saddlers Creek
Water Storage Dam	Mine affected water dam	17	-	MEA Dam
Treated Water Dam	Treated water storage	15	-	Saddlers Creek
Brine Dam	Mine affected water dam	4	-	MEA Dam

4.5 PROPOSED FINAL LANDFORM

4.5.1 Maxwell Infrastructure

Figure 4.3 shows the configuration and the major drainage catchments of the indicative final landform at Maxwell Infrastructure. This would include the rehabilitation of all major infrastructure and the final capping and rehabilitation of the East Void reject co-disposal storage.

A key feature of the final landform is the diversion of the western rehabilitated area past North Void and into a tributary of Ramrod Creek. This proposed diversion drain would be constructed around the commencement of Stage 5 as part of the establishment of the long-term drainage plan.

The design of the final landform may be refined prior to the completion of mining once there is a better understanding of the overburden material characteristics.

4.5.2 Mine Entry Area, Transport and Services Corridor and Maxwell Underground

The surface facilities associated with mine entry area and transport and services corridor would be decommissioned when they are no longer required or at the end of the Project life where no further ongoing beneficial use is identified.

At closure, works would include the decommissioning of infrastructure, the sealing of mine entrances and rehabilitation of any disturbed areas.

5 Water balance model configuration

5.1 OVERVIEW

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps a complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 5.1.

Table 5.1 - Simulated inflows and outflows to the water management system

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows to existing voids	Dust suppression demand
Groundwater inflows to underground	Washdown usage
	Underground water usage
	Entrainment of water in co-disposed rejects

5.2 SIMULATION METHODOLOGY AND MODEL STAGING

The Project water management system would change over the 26-year Project life, including changes in catchment areas, production profile and site water demands. The water balance model has been run on a daily time step for a 27-year period, corresponding to an initial construction phase followed by a 26-year period of operation. To represent the progressive rehabilitation of the Maxwell Infrastructure over time, the site water balance was modelled in five discrete stages, as shown in Table 5.2.

The first stage of rehabilitation activities at Maxwell Infrastructure would be completed during the initial construction phase. From Stage 2, drainage works would be undertaken to work towards the final landform configuration. However, the western rehabilitation area would continue to drain into North Void until Stage 5, when a diversion drain would be constructed to divert the western rehabilitation area past North Void and into a tributary of Ramrod Creek.

There would also be a continual reduction in East Void capacity due to the rejects/co-disposal deposition between over the life of the Project.

Table 5.2 – Application of representative mine stages

Stage	Representative mine configuration	Production throughput (Mtpa ROM)	No. of model years
1	First Stage Rehabilitation Complete	0	1
2	First Stage Rehabilitation Complete	0.5 to 7.0	7
3	Final Landform Drainage Partially Complete	6.0 to 7.9	7
4	Final Landform Drainage Partially Complete	5.2 to 6.7	7
5	Final Landform Drainage Complete	3.0 to 5.5	5

Note: Mtpa = million tonnes per annum.

The model has been run over multiple climate sequences, each referred to as a "realisation". Each realisation is based on a 27-year sequence extracted from the historical rainfall data. The first realisation was based on rainfall data from 1889 to 1915. The second used data from 1890 to 1916 and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record. Statistical analysis of the results from all realisations provides a probability distribution of key hydrologic parameters.

5.3 CATCHMENT YIELD

5.3.1 Catchment yield parameters

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (Kbase, Ksurf and BFI).

Catchments across the site have been characterised into the following land use types:

- Natural/undisturbed, representing areas in their natural state;
- Industrial area, hardstand and roads;
- Spoil dump, representing uncompacted dumped overburden material;
- Rehabilitated spoil, representing spoil that is rehabilitated over the life of the Project;
- Existing rehabilitation representing established rehabilitated spoil areas; and
- Void areas.

The adopted AWBM parameters for each catchment types are summarised in Table 5.3. Catchment runoff yield parameters from previous investigations at the former Drayton Mine (WRM, 2015) have been adopted for current investigations. These parameters were previously calibrated to the total site water inventory at the former Drayton Mine using known site performance and operations from January 2007 to May 2011. They have also been verified against observed inventory at Maxwell Infrastructure between 2016 and 2018.

The calibrated parameters have been applied to both the Maxwell Infrastructure and Maxwell Underground catchments.

Table 5.3 - Adopted AWBM parameters

Parameter	Natural/ undisturbed	Industrial/ hardstand	Spoil	Spoil Rehab	Rehab	Void
A1	0.2	0.1	0.2	0.2	0.1	0.2
A2	0.4	0.9	0.8	0.8	0.9	0.8
A3	0.4	-	-	-	-	-
C1	40	4.08	13	13	7.7	3
C2	85	12.96	48	48	77	11.75
C3	145	-	-	-	-	-
C_{avg}	100	12.07	41	41	70.1	10
BFI	0	0	0.85	0.85	0.15	0
K_{base}	1	1	0.7	0.7	0.98	1
K_{surf}	1	1	0.7	0.7	0.98	1
Cv*	6.6%	36.0%	17.3%	17.3%	11.0%	39.5%

**Long term volumetric runoff coefficient*

5.3.2 Catchment areas

5.3.2.1 Catchment and land use areas - Stages 1 and 2 drainage configuration

Table 5.4 shows the predicted catchment areas and land disturbance types that drain to the various water storages at Maxwell Infrastructure and the mine entry area based on the landform shown in Figure 4.1 and Figure 4.4. This landform represents the proposed disturbance footprint at Project commencement.

Table 5.4 - Storage catchment areas – Stages 1 and 2

Storage	Contributing catchment (ha)					
	Natural/ Udisturbed	Industrial/ hardstand	Spoil/ Rehab Spoil	Rehab	Void	TOTAL
Maxwell Infrastructure						
Access Road Dam	40.8	14.1	-	10.1	-	65.0
Rail Loop Dam	21.2	29.8	-	-	-	51.0
Industrial Dam	1.9	26.1	-	17.7	-	45.7
Savoy Dam	11.8	2.7	-	68.3	-	82.8
North Void	22.7	10.3	104.5	176.3	22.3	336.1
East Void	-	25.3	66.9	121.0	17.9	231.1
South Void	-	24.8	261.6	86.0	24.6	397.0
Mine Entry Area						
MEA Dam	-	37.3	-	-	-	37.3
Water Storage Dam	-	0.5	-	-	-	0.5
Treated Water Dam	-	0.4	-	-	-	0.4
Brine Dam	-	0.1	-	-	-	0.1

5.3.2.2 Catchment and land use areas - Stages 3 and 4 drainage configuration

Table 5.5 shows the predicted catchment areas and land disturbance types that drain to the various water storages at Maxwell Infrastructure and the mine entry area based on the Stage 3 landform, as shown in Figure 4.2 and Figure 4.4. Drainage works would be undertaken during Stages 3 and 4 to work towards the final landform configuration. However, the western rehabilitation area would continue to drain into North Void during this period.

Table 5.5 - Storage catchment areas – Stages 3 and 4

Storage	Contributing catchment (ha)					
	Natural/ undisturbed	Industrial/ Hhrdstand	Spoil/ Rehab Spoil	Rehab	Void	TOTAL
Maxwell Infrastructure						
Access Road Dam	40.8	14.1	-	10.1	-	65.0
Rail Loop Dam	21.2	29.8	-	-	-	51.0
Industrial Dam	1.9	26.1	-	17.7	-	45.7
Savoy Dam	11.8	2.7	-	68.3	-	82.8
North Void (incl. western rehab)	22.7	15.5	104.5	257.7	22.3	422.7
East Void	-	7.8	58.5	84.2	17.9	168.4
South Void	-	37.1	269.9	114.0	24.6	445.6
Mine Entry Area						
MEA Dam	-	37.3	-	-	-	37.3
Water Storage Dam	-	0.5	-	-	-	0.5
Treated Water Dam	-	0.4	-	-	-	0.4
Brine Dam	-	0.1	-	-	-	0.1

5.3.2.3 Catchment and land use areas - Stage 5 drainage configuration

Table 5.6 shows the predicted catchment areas and land disturbance types that drain to the various water storages at Maxwell Infrastructure and the mine entry area based on Stage 5 (final drainage layout), as shown in Figure 4.3 and Figure 4.4. The proposed drainage works required to progress to the final drainage layout would occur at the start of Stage 5. This is primarily associated with the diversion of the western rehabilitation area past North Void and into a tributary of Ramrod Creek.

The catchment and land use breakdown presented in Table 5.6 and Figure 4.3 has been applied from Stage 5, as well as for the final void analysis.

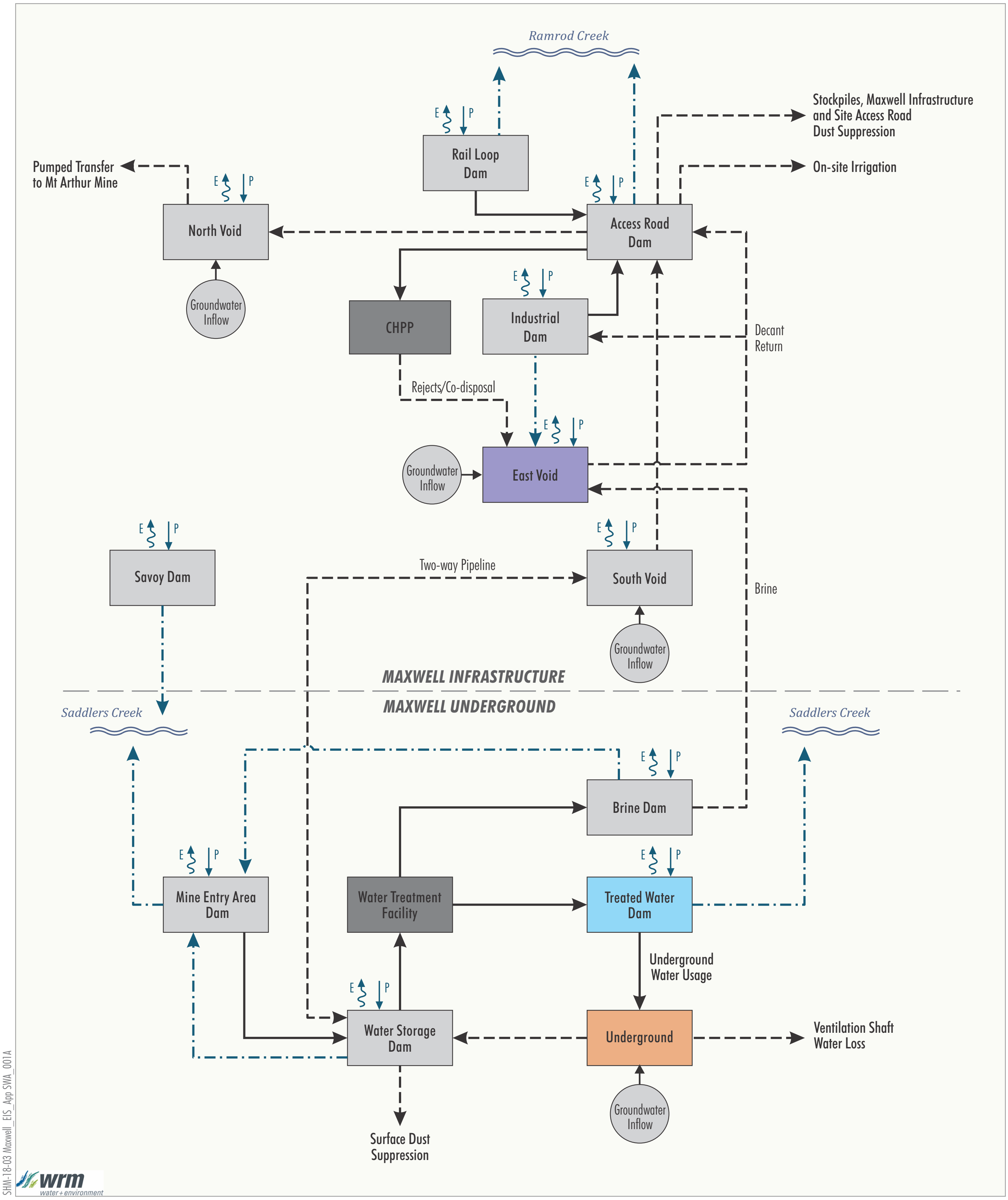
Table 5.6 - Storage catchment areas – Stage 5

Storage	Contributing catchment (ha)					
	Natural/ undisturbed	Industrial/ Hhrdstand	Spoil/ Rehab Spoil	Rehab	Void	TOTAL
Maxwell Infrastructure						
Access Road Dam	40.8	14.1	-	10.1	-	65.0
Rail Loop Dam	21.2	29.8	-	-	-	51.0
Industrial Dam	1.9	26.1	-	17.7	-	45.7
Savoy Dam	11.8	2.7	-	68.3	-	82.8
North Void	16.8	11.9	95.3	35.3	22.3	181.6
East Void	-	7.8	58.5	84.2	17.9	168.4
South Void	-	37.1	269.9	114.0	24.6	445.6
Mine Entry Area						
MEA Dam	-	37.3	-	-	-	37.3
Water Storage Dam	-	0.5	-	-	-	0.5
Treated Water Dam	-	0.4	-	-	-	0.4
Brine Dam	-	0.1	-	-	-	0.1

5.4 CONCEPTUAL WATER MANAGEMENT SYSTEM CONFIGURATION AND SCHEMATIC

A conceptual water management system layout for the Project has been developed based on the water management principles described in Section 4.2 and presented in Figure 4.1 to Figure 4.4. A schematized plan for the modelled Project's water management system configuration is shown in Figure 5.1.

A summary of the modelled water management system operating rules is provided in Table 5.7.



LEGEND

- E Evaporation
- P Precipitation/Catchment Runoff
- Gravity Driven
- Pumped/Siphoned
- Overflow
- Reverse Osmosis Treated Water Dam
- Underground Mine
- Mine Affected Water Storage
- Rejects/Co-disposal Storage

NOTES

Overflow Direction: Good engineering practice is to include a stabilised spillway as a contingency for dam safety. This arrow does not indicate that these discharges (overflows) will occur. The arrow is to show the direction of water flow (by gravity) should the dam water level exceed the dam spillway level.

Seepage between voids/storages may occur through previously emplaced waste rock, including seepage between voids and native water storages.

Water management system would change if Malabar pursue an alternative management option for excess water (refer excess water management hierarchy in Section 3.9.3).

MALABAR COAL

M A X W E L L   P R O J E C T

Indicative Water Management Schematic

Figure 5.1

Table 5.7 – Maxwell Project – modelled water management system configuration

Item	Node Name	Operating Rules
1.0	***External Water Supply***	
1.1	External water supply	• There is no proposed external water supply to Maxwell Infrastructure or Maxwell Underground other than potable water
2.0	***Supply to Demands***	
2.1	CHPP	• Primary supply from Access Road Dam • Co-disposed reject stream directed to East Void – 70% moisture entrained, 30% available for decant (refer to Section 5.6.1)
2.2	Dust suppression	• Demand supplied from Access Road Dam
2.3	Maxwell Underground Water Treatment Facility (WTF)	• Feed water supplied from WSD • Treated water supplied to underground operations via the Treated Water Dam • Brine sent to Brine Dam, before being pumped to the East Void
3.0	***Operation of mine affected water dams/voids***	
3.1	North Void	• Existing void that functions as a surplus water storage • Receives groundwater inflows (refer to Section 5.5.2)

3.2	East Void	• Existing void
		• Receives rejects from CHPP, progressively reducing capacity for water storage
		• Receives the following transfers:
		  ○ The co-disposed reject stream from the CHPP
		  ○ Brine transferred from Brine Dam
		• Decant return water pumped to Access Road Dam, up to Access Road Dam high alarm of 480 ML. Supplies Access Road Dam as required (at a higher preference than South Void)
		• Receives groundwater inflows (refer to Section 5.5.2)

3.3	South Void	• Existing void • Receives dewatering from WSD • Supplies Access Road Dam as required (at a lower preference than East Void) • Receives groundwater inflows (refer to Section 5.5.2)

3.4	Access Road Dam	• Existing dam
		• Supplies CHPP makeup demand
		• Supplies dust suppression demand
		• Demands water from the following storages, up to a high alarm volume of 480 ML:
		  ○ Rail Loop Dam
		  ○ Industrial Dam
		  ○ East Void
		  ○ South Void
		• Overflows to Ramrod Creek catchment

3.5	Rail Loop Dam	• Existing dam • Transfers to Access Road Dam, and is maintained empty

Item	Node Name	Operating Rules
		• Overflows to Ramrod Creek catchment
3.6	Savoy Dam	• Existing dam • Pumped transfer to South Void • Overflows to Saddlers Creek catchment
3.7	Industrial Dam	• Existing dam • Pumped transfer to Access Road Dam • Overflows to East Void
3.8	Water Storage Dam (WSD)	• Proposed dam • Receives pumped transfer of groundwater inflows (dewatered) from the underground operations • Receives pumped transfer from MEA Dam • Supplies feed water to the WTF as required • Supplies water to dust suppression demand • Transfers water to/from South Void as required • Overflows to MEA Dam
3.9	Mine Entry Dam (MEA Dam)	• Proposed dam • Captures surface runoff from MEA area • Transfers water to WSD, and is maintained empty • Overflows to Saddlers Creek catchment
3.10	Treated Water Dam (TWD)	• Proposed dam • Stores treated water from the WTF for use within the underground • Overflows to MEA Dam
3.11	Brine Dam	• Proposed dam • Stores brine from the WTF, and then transfers to East Void • Overflows to MEA Dam
4.0	***Operation of Maxwell Underground***	
4.1	Maxwell Underground	• Receives groundwater inflows (see Section 5.5.1) • Treated water is supplied to the underground from TWD for equipment cooling and dust suppression • Groundwater inflows (dewatered) from the underground to maintain operations are pump transferred to WSD
5.0	***Miscellaneous***	• All storages and voids receive local catchment runoff and lose water through evaporation

5.5 WATER SOURCES

5.5.1 Groundwater inflows to Maxwell Underground

Estimated groundwater inflows for Maxwell Underground over the Project life were developed by HydroSimulations and are summarised in Figure 5.2.

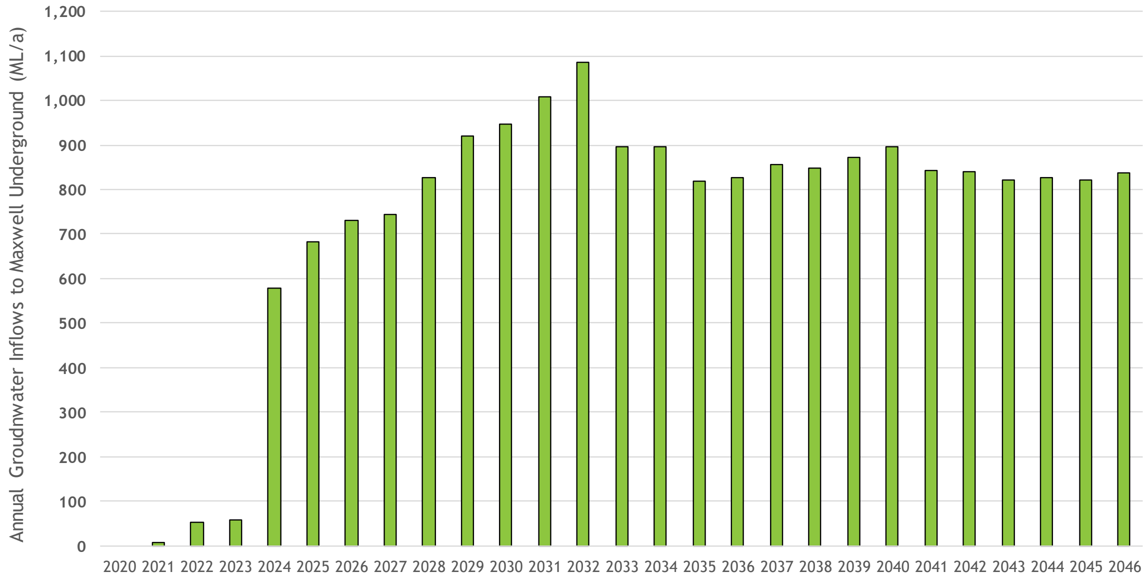


Figure 5.2 – Annual groundwater inflows – Maxwell Underground

5.5.2 Groundwater inflows to Maxwell Infrastructure voids

Analysis by HydroSimulations (2019) indicates that groundwater inflows to the Maxwell Infrastructure voids would be negligible over the life of the Project. Rather, the voids would typically lose water to the surrounding spoil until it re-saturates. Water would flow to the voids when the head in the spoil is greater than the water level in the voids, and vice versa.

In order to capture the gain/loss of water between the voids and the spoil, the storage capacity of the spoil pore space has been incorporated in the storage curves for the voids.

5.6 SITE WATER DEMANDS

5.6.1 Coal handling and preparation plant (CHPP)

The projected annual coal production schedule for the Project is summarised in Table 5.8. The key parameters for the CHPP water balance are shown in Table 5.9.

The CHPP water demand is sourced from the Access Road Dam. Consistent with previous investigations (WRM, 2015), it is assumed that 30% of the co-disposed rejects (sand and fine) moisture would be decanted from East Void and returned to the CHPP (via Access Road Dam). The remaining 70% would evaporate or become entrained within the co-disposed rejects solids matrix.

The estimated gross and net annual CHPP makeup requirement for each year is provided in Table 5.10 and shown on Figure 5.3.

Table 5.8 - Annual CHPP production profile

Project year	Total ROM (kt/yr) (wet)	Plant Feed (kt/yr) (air-dried)	Plant Bypass (kt/yr) (air-dried)	Total Product (kt/yr) (wet)
0	-	-	-	-
1	467	396	47	307
2	1,608	1,268	259	1,157
3	2,009	1,815	95	1,433
4	7,969	7,099	487	5,909
5	7,865	7,041	449	5,772
6	7,230	6,549	326	5,305
7	6,950	6,265	353	5,250
8	7,385	6,659	372	5,569
9	7,360	6,592	413	5,685
10	5,933	5,278	367	4,610
11	7,828	6,918	530	6,165
12	7,918	6,097	1,438	6,696
13	6,560	3,723	2,521	5,950
14	6,189	3,571	2,308	5,569
15	5,993	3,146	2,552	5,480
16	6,658	3,345	2,980	6,124
17	5,209	2,665	2,283	4,796
18	5,993	3,092	2,600	5,497
19	6,403	3,108	2,964	5,912
20	6,002	3,625	2,065	5,419
21	5,669	3,708	1,675	5,076
22	5,079	3,525	1,278	4,471

Project year	Total ROM (kt/yr) (wet)	Plant Feed (kt/yr) (air-dried)	Plant Bypass (kt/yr) (air-dried)	Total Product (kt/yr) (wet)
23	4,326	2,893	1,197	3,854
24	5,461	3,584	1,590	4,892
25	4,782	3,245	1,282	4,255
26	3,020	2,393	459	2,615

kt/yr = kilotonne per year.

Table 5.9 - Key CHPP water balance parameters

Parameter	Value
Moisture contents (% w/w)	
ROM coal	8.0
Product coal	8.8 - 9.7
Rejects (coarse)	35
Rejects (sand)	70
Rejects (fine)	70
Solids partition (%)	
Rejects (coarse)	70
Rejects (sand)	10
Rejects (fine)	20

Table 5.10 - Annual estimated CHPP water usage

Project year	Gross CHPP consumption (ML/yr)	Net CHPP consumption (ML/yr)
0	-	-
1	122	91
2	348	259
3	459	343
4	1,678	1,259
5	1,704	1,278
6	1,556	1,166
7	1,402	1,055
8	1,495	1,124
9	1,389	1,046
10	1,099	828
11	1,389	1,047

Project year	Gross CHPP consumption (ML/yr)	Net CHPP consumption (ML/yr)
12	1,046	792
13	576	443
14	560	428
15	480	369
16	510	393
17	394	304
18	463	356
19	451	345
20	502	381
21	522	397
22	508	383
23	401	303
24	488	370
25	450	341
26	345	261

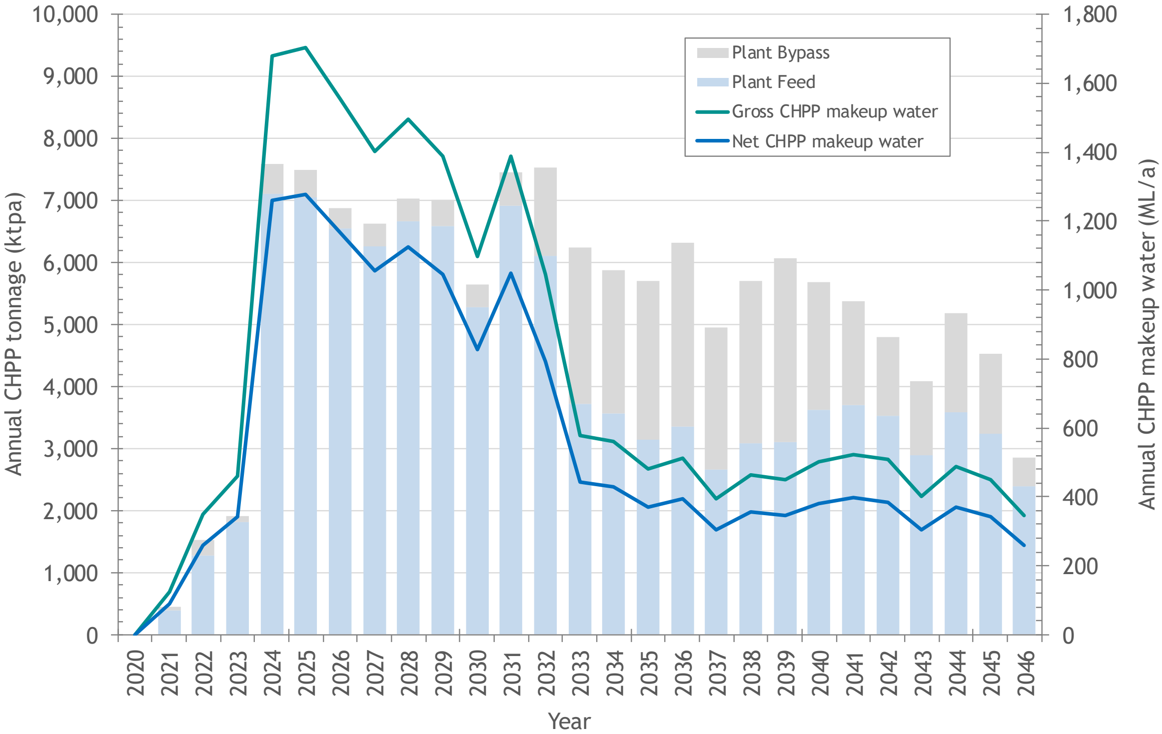


Figure 5.3 - Estimated gross and net annual CHPP makeup water requirements

5.6.2 Dust suppression and washdown usage

Table 5.11 shows the predicted dust suppression water requirements for each year of the Project life. This estimate includes water for dust suppression and washdown usage.

Dust suppression water demand and washdown would be sourced from both Access Road Dam and Water Storage Dam.

Table 5.11 - Projected dust suppression and washdown usage

Project year	Usage (ML/yr)	Project year	Usage (ML/yr)
0	-	14	21.7
1	16.3	15	21.0
2	56.3	16	23.3
3	7.0	17	18.2
4	27.9	18	21.0
5	27.5	19	22.4
6	25.3	20	21.0
7	24.3	21	19.8
8	25.8	22	17.8
9	25.8	23	15.1
10	20.8	24	19.1
11	27.4	25	16.7
12	27.7	26	10.6
13	23.0		

5.6.3 Underground water use

Table 5.12 shows the predicted underground water requirements for each year of the Project life. The underground water requirement would be supplied from the Treated Water Dam.

Table 5.12 - Projected underground usage

Project year	Usage (ML/yr)	Project year	Usage (ML/yr)
0	-	14	433
1	33	15	419
2	113	16	466
3	141	17	365
4	558	18	419
5	551	19	448
6	506	20	420
7	486	21	397
8	517	22	356

Project year	Usage (ML/yr)	Project year	Usage (ML/yr)
9	515	23	303
10	415	24	382
11	548	25	335
12	554	26	211
13	459		

5.7 REJECTS EMPLACEMENT

The co-disposed reject stream would be deposited within the East Void and therefore the available storage capacity within the East Void would reduce over the Project life. The reduction in East Void storage capacity has been calculated based on the following information:

- Stage 1 landform digital elevation model (to establish initial storage capacity).
- Annual co-disposed reject volumes.

A summary of the predicted East Void storage volume over time is presented in Figure 5.4.

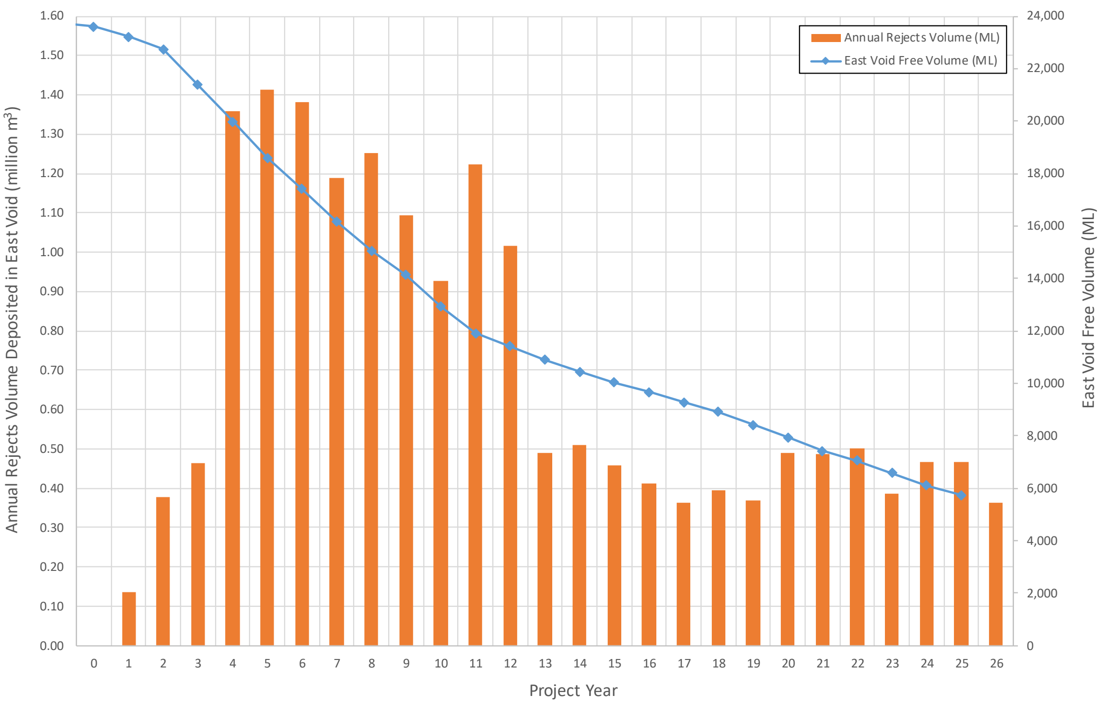


Figure 5.4 - Annual deposited rejects volume and East Void free capacity

5.8 PROPOSED WATER TREATMENT FACILITY CIRCUIT

The typical salinity of the water stored at Maxwell Infrastructure is around 8,000 µS/cm. However, the water supply to the underground operations is required to be less than 3,100 µS/cm.

As there is no external water supply to the Project, a WTF is proposed to supply the underground water demand. The conceptual configuration of the WTF circuit is described as follows:

- The WTF would be supplied from Water Storage Dam, which primarily stores dewatered groundwater inflows from the underground operations.
- Treated water would be sent to the Treated Water Dam, where it would be available for use in the underground.
- The brine stream would be sent to Brine Dam, where it would be transferred to East Void for final storage. For operational water quality management purposes, the brine would be kept in a separate storage cell within East Void to maintain separation with the co-disposed rejects decant water.

Preliminary sizing of the WTF throughput has been based on the predicted maximum annual underground demand of 558 ML/yr (or 1.53 ML/d). Based on a WTF efficiency of 75%, the WTF feed capacity would need to be approximately 2.1 ML/d, with the following configuration:

- Feed water rate: 2.10 ML/d @ 8,000 µS/cm.
- Treated water rate: 1.58 ML/d @ 2,000 µS/cm.
- Brine production rate: 0.52 ML/d @ 26,200 µS/cm

5.9 UNDERGROUND WATER BALANCE

Groundwater is extracted via the underground workings, and water pumped from the underground is made up of both recovered WTF treated water and groundwater inflows. To delineate the fractions of underground dewatering made up by recovered WTF treated water and groundwater inflows, the following assumptions have been made:

- Water enters the underground workings via:
  - underground treated water demands;
  - longwall emulsion; and
  - groundwater inflows.
- Water is lost from the underground workings via:
  - increase in coal moisture from *in-situ* coal to ROM coal;
  - vent humidity extraction; and
  - underground dewatering (pumped to the Water Storage Dam at the mine entry area).

Groundwater inflow is unlikely to be measurably lost to coal wetting or vent extraction. Therefore, all groundwater inflow has been assumed to report to Water Storage Dam via underground dewatering. Therefore, the underground treated water returning to the Water Storage Dam via underground dewatering is calculated as follows:

- Underground demand return = [underground treated water demand + longwall emulsion] – [increase in coal moisture + vent humidity extraction].
- If the above result returns a negative number (i.e. losses exceed flows) then there is no underground demand return for that period.

The following data and assumptions have been used for these calculations:

- The groundwater inflows presented in Section 5.5.
- The increase in coal moisture is estimated on an assumed 2%w/w increase in moisture between *in-situ* coal and ROM coal.
- The maximum annual vent humidity extraction volume has been based on estimated vent humidity extraction volumes from an operating underground mine in the region, and scaled to reflect the proposed extraction rates for the Project.
- A notional longwall emulsion usage has been benchmarked against the estimated usage at the aforementioned operating underground mine.

Based on the above assumptions, the estimated annual underground return volumes are provided in Table 5.13, which shows the following:

- For the first 3 years (and final year) of the Project, there would be nil underground treated water returned to the water management system. All of the water inputs from treated water and longwall emulsion would be consumed by the increase in coal moisture and vent extraction losses. The net underground dewatering volume would equal the groundwater inflow.
- In all other years, the UG treated water return varies between 49 – 290 ML/yr. This is in addition to the groundwater dewatering, which varies between 657 – 1,351 ML/yr.
- The underground dewatering annual volumes (which include the groundwater inflows and UG treated water return) vary between 37 – 1,612 ML/yr.

Table 5.13 – Estimated annual underground water balance

Project year	Inputs				Outputs				
	Groundwater inflow (ML/yr)	Treated water (ML/yr)	Longwall emulsion (ML/yr)	TOTAL INPUTS (ML/yr)	Groundwater dewatering (ML/yr)	Increase in coal moisture (ML/yr)	Vent extraction (ML/yr)	UG treated water return (ML/yr)	TOTAL OUTPUTS (ML/yr)
1	37	33	10	**79**	37	9	33	***0***	**79**
2	73	113	10	**196**	73	32	90	***0***	**196**
3	584	141	10	**735**	584	40	110	***0***	**735**
4	657	558	10	**1,225**	657	159	118	***290***	**1,225**
5	804	551	10	**1,364**	804	157	118	***285***	**1,364**
6	1,023	506	10	**1,539**	1,023	145	118	***253***	**1,539**
7	1,096	486	10	**1,592**	1,096	139	118	***239***	**1,592**
8	1,351	517	10	**1,878**	1,351	148	118	***261***	**1,878**
9	1,315	515	10	**1,840**	1,315	147	118	***260***	**1,840**
10	1,278	415	10	**1,704**	1,278	119	177	***129***	**1,704**
11	1,242	548	10	**1,800**	1,242	157	177	***224***	**1,800**
12	1,278	554	10	**1,843**	1,278	158	177	***229***	**1,843**
13	1,278	459	10	**1,748**	1,278	131	177	***161***	**1,748**
14	1,278	433	10	**1,722**	1,278	124	177	***142***	**1,722**
15	1,278	419	10	**1,708**	1,278	120	177	***132***	**1,708**
16	1,278	466	10	**1,754**	1,278	133	177	***166***	**1,754**
17	1,278	365	10	**1,653**	1,278	104	177	***93***	**1,653**
18	1,242	419	10	**1,671**	1,242	120	177	***132***	**1,671**
19	1,242	448	10	**1,700**	1,242	128	177	***153***	**1,700**

Project year	Inputs				Outputs				
	Groundwater inflow (ML/yr)	Treated water (ML/yr)	Longwall emulsion (ML/yr)	TOTAL INPUTS (ML/yr)	Groundwater dewatering (ML/yr)	Increase in coal moisture (ML/yr)	Vent extraction (ML/yr)	UG treated water return (ML/yr)	TOTAL OUTPUTS (ML/yr)
20	1,169	420	10	**1,599**	1,169	120	177	***133***	**1,599**
21	1,132	397	10	**1,539**	1,132	113	177	***116***	**1,539**
22	1,096	356	10	**1,461**	1,096	102	177	***87***	**1,461**
23	1,059	303	10	**1,372**	1,059	87	177	***49***	**1,372**
24	1,023	382	10	**1,415**	1,023	109	177	***106***	**1,415**
25	986	335	10	**1,331**	986	96	177	***72***	**1,331**
26	950	211	10	**1,171**	950	60	161	***0***	**1,171**

UG = underground.

5.10 WATER QUALITY MODELLING

The water balance model has been configured to use salinity as an indicator of water quality. This has been achieved by assigning representative EC values to runoff from catchments and other sources of water.

The representative salinity for runoff from the various catchment types are largely based on information provided in previous studies and by the Project groundwater consultant. The adopted EC values are shown in Table 5.14, with discussion relating to the source of the proposed values.

Table 5.14 – Adopted salinity concentrations

Water source / land use	EC (µs/cm)	Comment
Groundwater inflows to the Maxwell Underground and existing voids	7,500	Adopted "typical" groundwater quality based on HydroSimulations (2019)
Natural/undisturbed	267	Based on previous water balance modelling
Industrial/hardstand	2,667	Based on previous water balance modelling
Spoil	2,667	Based on previous water balance modelling
Rehab	1,333	Based on previous water balance modelling
Void	5,333	Based on previous water balance modelling

Salt is lost from the system through the product coal, coarse rejects and fine rejects streams. The amount of salt lost varies depending on the EC of the feed water supply to the CHPP water circuit. Salt is also lost through dust suppression.

5.11 MODEL CALIBRATION

Calibration of the water balance model was undertaken over the period January 2017 to December 2018, for which stored water volumes onsite were available and there were no active operations at the mine. It was assumed that there were no changes to site catchments over this period, any transfers of water between the storages or voids, or water consumption at Maxwell Infrastructure.

The previously modelled AWBM parameters (as per Section 5.3.1) were used for this assessment, as well as recorded daily site rainfall data. Note that this assessment only considered the stored volume within the open void, and did not include any allowance for water stored within the in-pit spoil.

The modelled combined inventory for North Void, East Void and South Void were compared to the recorded combined void inventory, as shown in Figure 5.5. To achieve the calibration shown in Figure 5.5, an additional inflow to the voids of around 6.1 ML/d to the voids was required.

Based on discussions with Hydrosimulations, it is our understanding that the source of this additional inflow is seepage from the in-pit spoil, with some small contribution from external groundwater inflows. Modelling of seepage between the voids and the in-pit spoil has been undertaken by HydroSimulations (2019) in consideration of the outcomes of this calibration.

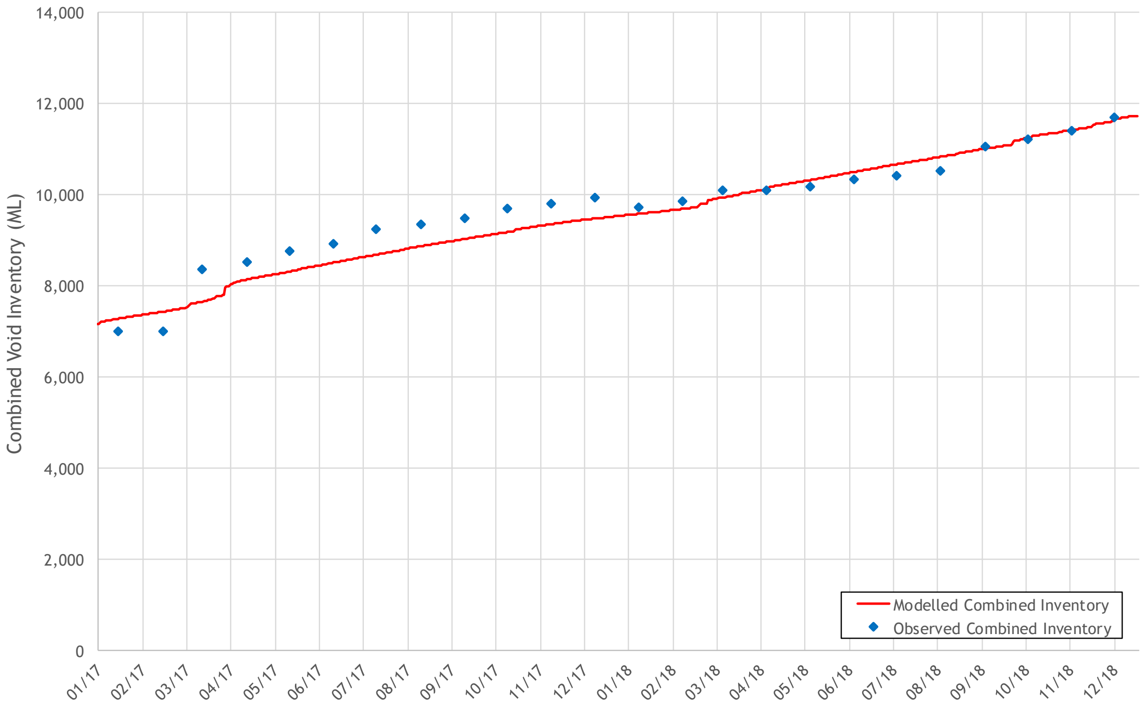


Figure 5.5 – Model calibration – combined void volumes over 2017/18

6 Water management system assessment

6.1 OVERVIEW

The water balance model was used to assess the performance of the Project water management system, using the following key performance indicators:

- overall water balance – the average inflows and outflows of the water management system based on all model realisations (Section 6.3.1);
- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory (Section 6.3.2);
- uncontrolled spillway discharges – the risk and associated volumes (and salt loads) of uncontrolled discharge from the mine affected water storages and sediment dams to the receiving environment (Section 6.3.3); and
- salinity investigation study – the average salt loads in and out of the water management system based on all model realisations (Section 6.3.4).

The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance under very wet, very dry and average climatic conditions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/runoff, groundwater inflows, etc.).

6.2 INTERPRETATION OF MODEL RESULTS

In interpreting the results of the site water balance, it should be noted that the results provide a statistical analysis of the water management system's performance over the 27 years of mine life, based on 103 realisations with different climatic sequences.

The model results are presented as a probability of exceedance. For example, the 10^{th} percentile represents a 10% probability of exceedance and the 90^{th} percentile results represent a 90% probability of exceedance. There is an 80% chance that the result would lie between the 10^{th} and 90^{th} percentile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is that available storage capacity would be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1 percentile storage volume would be exceeded, which would correspond to very wet climatic conditions. For off-site site water supply volumes (for example), where the risk is that insufficient water would be available, there is only a small chance that more than the 1 percentile water supply volume would be required. This would correspond to very dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50^{th} percentile trace does not represent the model time series for median climatic conditions.

6.3 WATER BALANCE MODEL RESULTS

6.3.1 Overall water balance

Water balance results for all of the 103 model realisations are presented in Table 6.1, averaged over each model phase. The results presented in Table 6.1 are the average of all realisations and would include wet and dry periods distributed throughout the Project life.

Rainfall yield for each year is affected by the variation in climatic conditions within the adopted climate sequence.

It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff;
- Evaporation; and
- Uncontrolled discharges.

Table 6.1 – Average annual water balance – all realisations

Component	Process	Average annual volume (ML/yr) per model stage				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Inflows	Catchment runoff & direct rainfall	1,635	1,579	1,643	1,708	1,634
	UG Groundwater inflows	0	408	939	851	829
	Total inflows	**1,635**	**1,987**	**2,582**	**2,559**	**2,463**
Outflows	Evaporation	797	722	739	818	921
	Dust suppression	0	26	25	21	16
	Net CHPP demand	0	727	755	332	307
	Vent/Moisture losses	0	170	301	297	265
	Spillway overflows - offsite	1	1	0	0	0
	Total outflows	**798**	**1,646**	**1,820**	**1,468**	**1,509**
	Change in volume	**837**	**341**	**762**	**1,091**	**954**

6.3.2 Mine affected water inventory

6.3.2.1 South Void

The South Void functions as the primary mine water storage for the Project. To prevent potential interaction between stored mine water and the surrounding groundwater system, a maximum operating level (MOL) of 174 mAHD has been set for South Void. This is 1 m below the FSL of 175 mAHD.

Water is transferred to North Void when the water level exceeds the MOL.

Figure 6.1 shows the forecast water level in South Void over the 27-year forecast. The model results show the following:

- For the 10th percentile results (wet climatic conditions), the water level in South Void reaches the MOL of 174 mAHD by Year 2043.
- For the 50th percentile results (median climatic conditions), the water level in South Void reaches the MOL of 174 mAHD by Year 2046 (around 6 months prior to the end of the simulation).
- For the 90th percentile results (dry climatic conditions), the peak water level in South Void reaches around 168 mAHD by the end of the simulation.

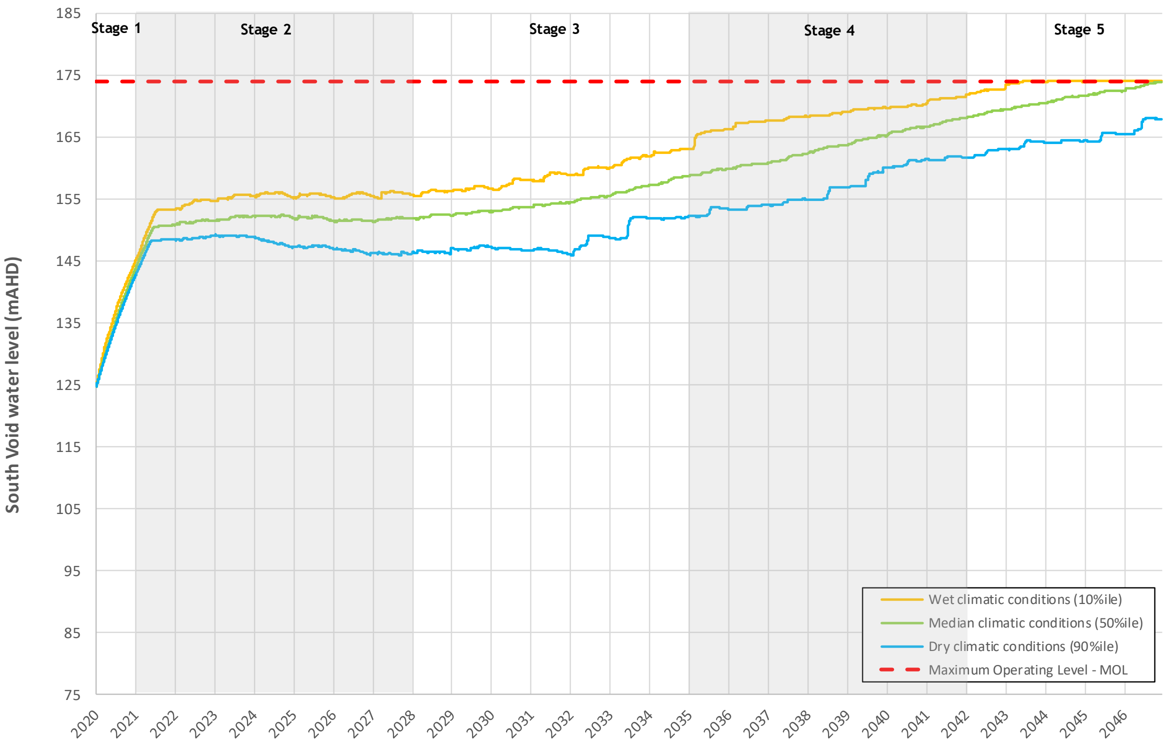


Figure 6.1 - Forecast mine water level - South Void

6.3.2.2 North Void

North Void functions as the secondary mine water storage for the Project. The FSL of North Void is 210 mAHD. Similar to South Void, to prevent potential interaction between stored mine water and the surrounding groundwater system, a MOL of 175 mAHD has been set for North Void.

Figure 6.2 shows the forecast water level in North Void over the 27-year forecast. The model results show the following:

- For the 10th percentile results (wet climatic conditions), the peak water level in North Void reaches around 150 mAHD by the end of the simulation.
- For the 50th percentile results (median climatic conditions), the peak water level in North Void reaches around 140 mAHD by the end of the simulation.
- For the 90th percentile results (dry climatic conditions), the peak water level in North Void reaches 135 mAHD by the end of the simulation.
- The model results show that water levels within North Void are well below the MOL under all climatic conditions.

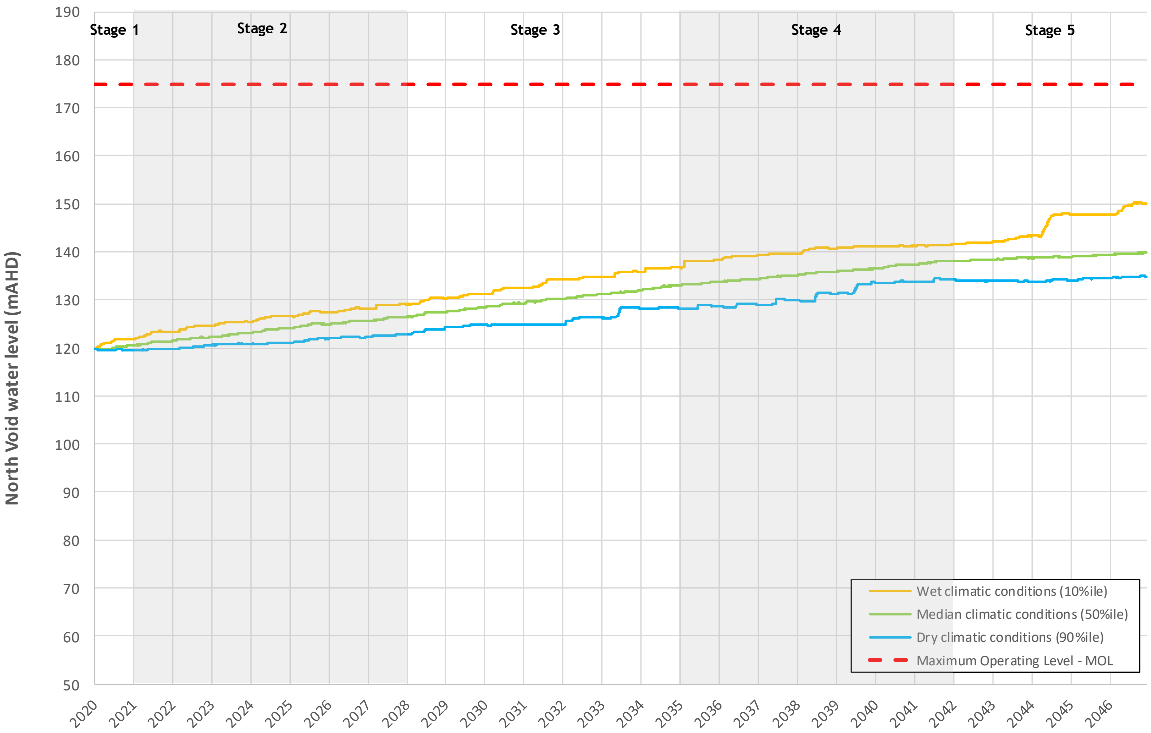


Figure 6.2 – Forecast mine water level – North Void

6.3.3 Uncontrolled spillway discharges

The water balance model was used to assess the risk of uncontrolled off-site spills from the water management system. The dams that could potentially overflow directly to the receiving environment include:

- Rail Loop Dam (to Ramrod Creek);
- Access Road Dam (to Ramrod Creek);
- MEA Dam (to Saddlers Creek);
- Treated Water Dam (to Saddlers Creek); and
- Savoy Dam (to Saddlers Creek).

There were no modelled overflows from MEA Dam, Treated Water Dam and Savoy Dam during any of the model realisations over the life of the Project.

There is a 1% probability (in any one year) that Rail Loop Dam and Access Road Dam could overflow to Ramrod Creek. The predicted overflow volume ranges from 20 to 30 ML. However, overflows from these storages would only occur during extreme rainfall events. The water within the dams during these events would be heavily diluted by catchment inflows and any overflows would be further diluted by significant flows in Ramrod Creek.

6.3.4 Salinity investigation study

Salt inputs to the Project include salts in the groundwater inflows, catchment runoff and direct rainfall. Salt outputs from the Project include salts which are lost through the process plant in the waste material, site demands (including dust suppression) and dam overflows. Salt inflows from direct rainfall were assumed to be zero.

Figure 6.3 shows a schematic diagram of the salt inputs and outputs from the Project. Table 6.2 shows the average annual salt balance for the Project. The results indicate the following:

- the largest contributor to the Project salt load is from groundwater inflows to the underground, however catchment runoff inflows also contribute significant salt load to the Project; and
- net loss from the CHPP demand contribute the greatest salt loss from the Project.

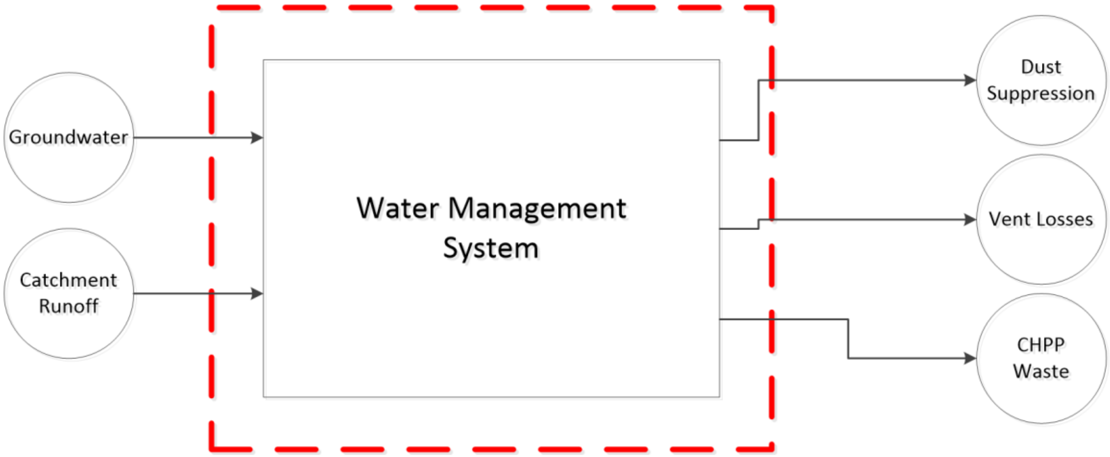


Figure 6.3 - Project surface water salt load schematic

Table 6.2 – Average annual salt balance – all realisations

Component	Process	Average annual load (t/yr) per model stage				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
Inflows	Catchment runoff & direct rainfall	2,044	2,090	2,134	2,144	1,990
	UG Groundwater inflows	0	2,293	5,281	4,787	4,664
	Total salt input	**2,044**	**4,383**	**7,415**	**6,931**	**6,654**
Outflows	Evaporation	0	0	0	0	0
	Dust suppression	0	118	83	68	49
	Net CHPP demand	0	4,607	4,372	2,182	1,851
	Vent/Moisture losses	0	957	1,693	1,672	1,490
	Spillway overflows - off-site	3	1	0	0	0
	Total salt output	**3**	**5,683**	**6,148**	**3,922**	**3,390**
	Change in salt load	**2,041**	**-1,300**	**1,267**	**3,009**	**3,264**

t/yr = tonnes per year.

6.4 ADAPTIVE MANAGEMENT OF THE WATER MANAGEMENT SYSTEM

The model results presented above represent the application of the adopted water management system rules over the Project life, regardless of climatic conditions. In reality, there are numerous options for adaptive management of the water management system to accommodate climatic conditions. For example, when excess water is available on site, it may be possible to increase the application of water for dust suppression or share excess water with other users. These alternative management approaches would be used to reduce the risks to the Project associated with climatic variability.

7 Final void behaviour

7.1 OVERVIEW

Water levels in the final voids would vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater. A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term water level behaviour of the final voids. The historical rainfall and evaporation sequences (129 years) were repeated 5 times to create a long-term climate record.

A linearly varying depth-dependent storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void - 0.5.
- 10m from top of void - 0.95.
- Top of void - 1.0.

The volume of water in the voids is calculated at each time step as the sum of direct rainfall to the void surface, catchment runoff, and groundwater inflows, less evaporation losses.

7.2 FINAL VOID CONFIGURATION

The final void configuration and contributing catchment areas are shown in Figure 7.1 and summarised in Table 7.1. As described in Section 4.5, this would include the rehabilitation of all major infrastructure and the final capping and rehabilitation of the East Void reject co-disposal storage.

A key feature of the final landform is the diversion of the western rehabilitated area past North Void and into a tributary of Ramrod Creek. This proposed diversion drain would be constructed in Stage 5 as part of the establishment of the final drainage plan.

The design of the final landform may be refined prior to the completion of mining once there is a better understanding of the overburden material characteristics.

Table 7.1 – Contributing catchment to final voids

Final void	Contributing catchment (ha)
North Void	181.6
East Void	168.4
South Void	445.6

7.3 STAGE-STORAGE CHARACTERISTICS

The stage-storage curve for North Void, East Void and South Void have been estimated from the final landform terrain model provided by Malabar, and include an allowance for the storage of water within the in-pit spoil pores. Refer to Section 4.4 for further details on the development of the void storage curves.

The adopted geometries of the final voids are summarised in Table 7.2.

Table 7.2 – Modelled final void geometry

Final void	Depth (m)	Target maximum water level (mAHD)	Surface overflow level to the receiving environment/void (mAHD)	Overflows to
South Void	101	175	177	East Void
North Void	157	175	210	Ramrod Creek
East Void	25	175	175	Liddell Ash Dam

7.4 INITIAL CONDITIONS

The starting water level for the post-mining simulation has been based on the modelled 50th percentile water level from the operational water balance model. These are shown in Section 6.3.2, and summarised as follows:

- South Void: 172 mAHD.
- North Void: 140 mAHD.
- East Void: 150 mAHD (based on final landform).

7.5 FINAL VOID RUNOFF SALINITY

The adopted salinity concentrations for the final void catchment are as follows:

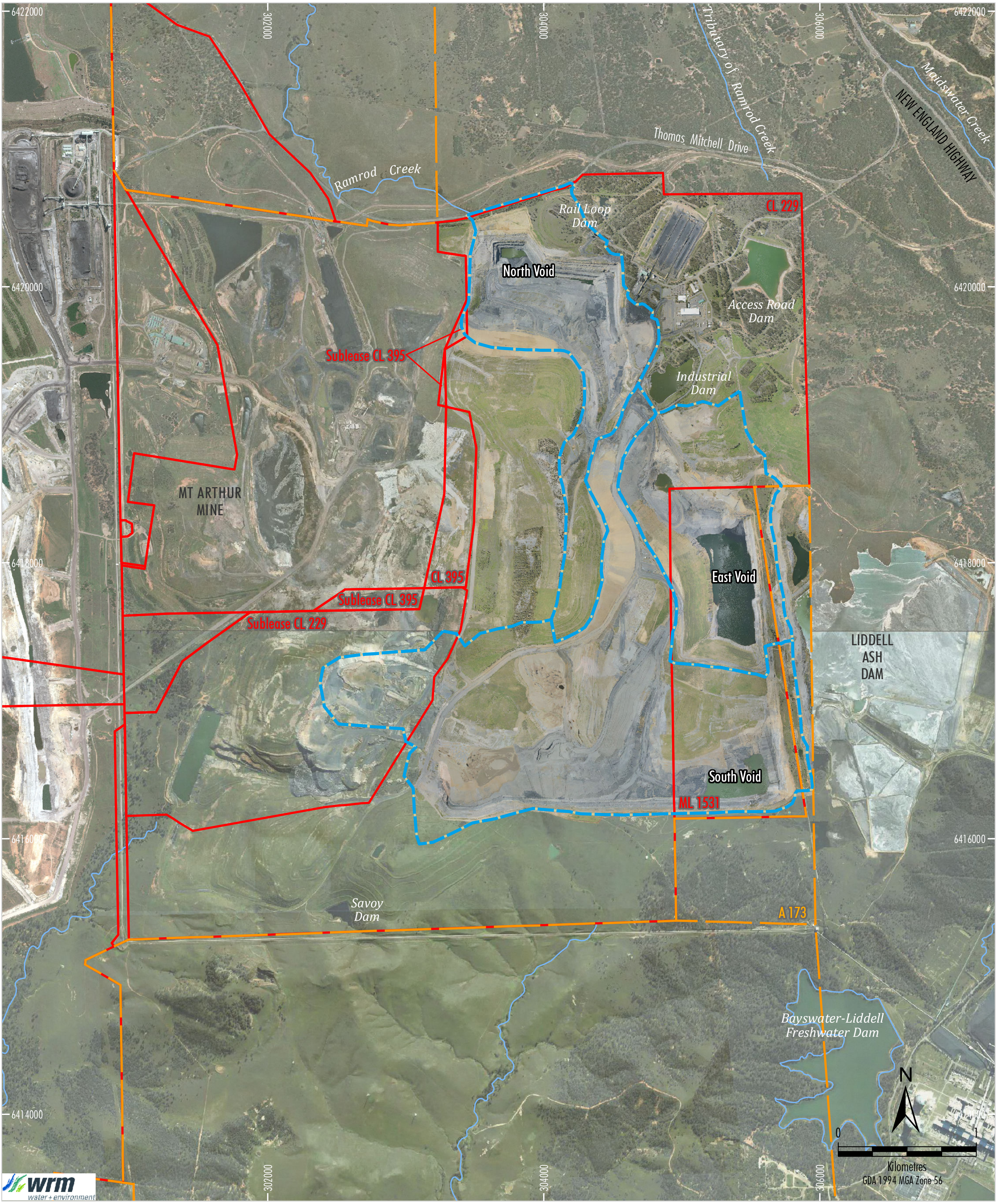
- Mining pit floor: 5,333 µS/cm.
- Spoil: 2,666 µS/cm.
- Rehabilitated landform: 1,333 µS/cm.

The adopted runoff salinity for the final void assessment is applied at a fixed concentration and does not include any allowance for decay in runoff salinity over time.

7.6 EQUALISATION OF WATER LEVELS BETWEEN VOIDS

The three voids at Maxwell Infrastructure are located within a larger mined pit shell, separated by backfill spoil at varying levels. As part of the final void modelling assessment, we have assumed water levels within each void would eventually equalise over time.

While the rate of movement of water between the voids is uncertain, we expect that the levels in each void would eventually equalise, and continue to do so whenever there is a differential in head between the individual voids. For the purposes of this assessment, we have assumed that the rate of transfer between voids is 1 ML/d.



LEGEND
Exploration Licence Boundary
Mining and Coal Lease Boundary
Catchment Boundary

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019) Orthophoto Mosaic: 2018, 2016, 2011

MALABAR COAL

MAXWELL PROJECT

Final Void Configuration - Maxwell Infrastructure

Figure 7.1

7.7 GROUNDWATER INFLOWS

Initial pit lake equilibrium levels were determined based on direct rainfall to the void surface and catchment runoff, less evaporation losses. These pit lake levels were then implemented in the recovery groundwater model using a series of constant heads over time (HydroSimulations, 2019).

The recovery groundwater modelling predicts that net groundwater inflows to the voids at the predicted equilibrium level would be negligible (HydroSimulations, 2019). Accordingly, further refinement of the final void modelling was not required.

7.8 MODEL RESULTS

Figure 7.2, Figure 7.3, Figure 7.4 and Figure 7.5 show the simulated long-term water levels in the final voids. The model results show the following:

- The water level within all three voids reach equilibrium between 160 mAHD and 165 mAHD after 100 years and generally remains at these levels throughout the remainder of the simulation.
- The maximum modelled water level in North Void is around 9 m below the target maximum water level (175 mAHD) and around 44 m below the North Void overflow level.
- The maximum modelled water level in East Void is around 9 m below the target maximum water level and the East Void overflow level (both 175 mAHD).
- The maximum modelled water level (after equalisation) in South Void around 9 m below the target maximum water level (175 mAHD) and around 11 m below the South Void surface overflow level.

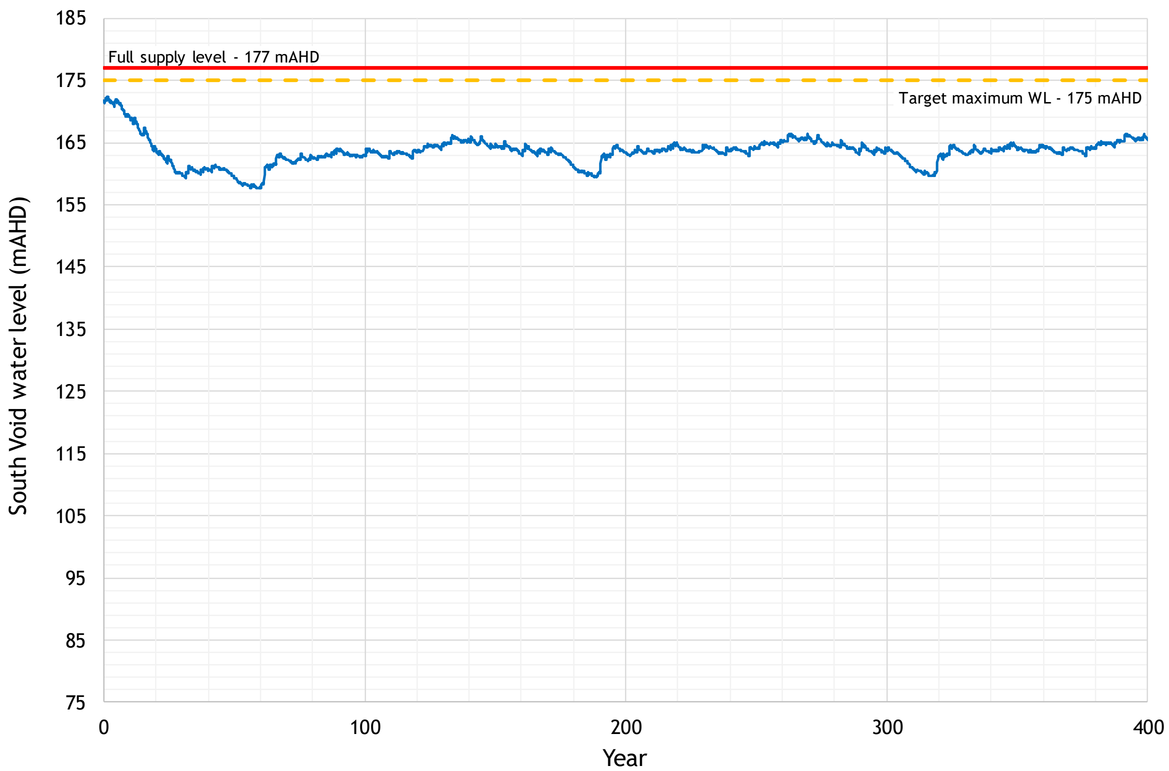


Figure 7.2 – Final void water levels – South Void

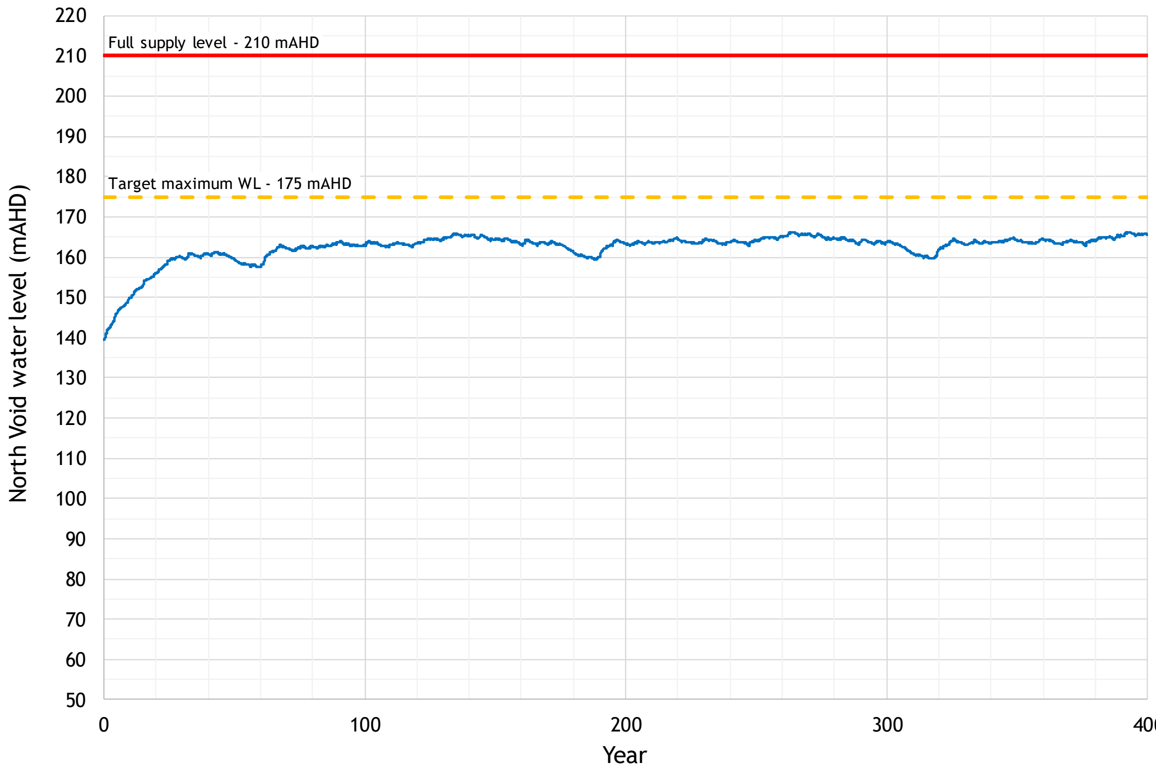


Figure 7.3 - Final void water levels - North Void

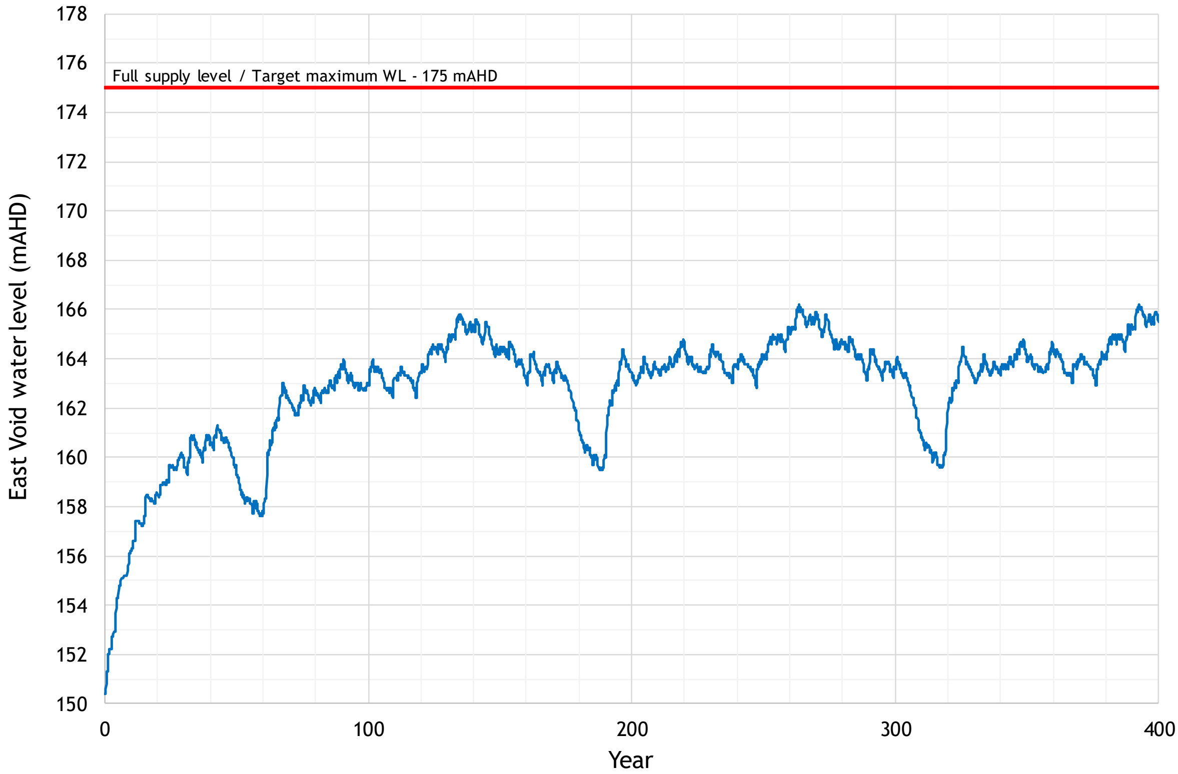


Figure 7.4 - Final void water levels - East Void

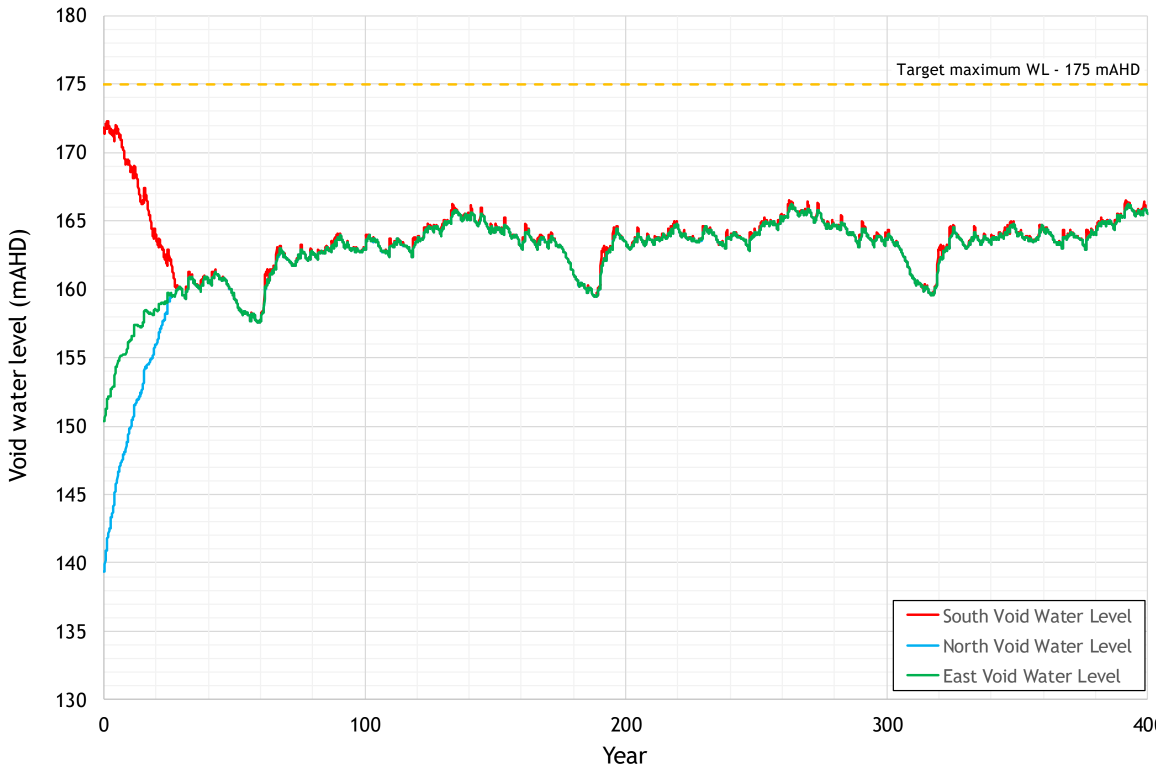


Figure 7.5 – Final void water levels – All voids

The final void modelling indicates that the expected water levels are below the target maximum water level (175 mAHD) FSLs for each void, and the voids would remain as long-term groundwater sinks (HydroSimulations, 2019). As there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline or approach hypersaline conditions over the 400-year simulation.

8 Impact assessment

8.1 POTENTIAL IMPACTS

The potential impacts of the Project on the local and regional water sources include:

- potential impacts on the flood regime;
- potential impacts on local stream flows due to catchment excision and subsidence related ponding;
- potential impact on Saddlers Creek and Hunter River baseflow;
- potential impacts on regional stream flows and water allocations; and
- potential impacts on local and regional water quality.

These potential impacts are assessed in the following sub-sections.

8.2 FLOODING

The NSW Office of Environment and Heritage requires the EIS to determine design flood levels and assess flood behaviour for a range of events up to and including the PMF.

Section 3.7 shows that the proposed the predicted extent of conventional subsidence and the mine entry area are located outside the extent of flood prone land from both Saddlers Creek and the Hunter River. The extent of flood prone land has been defined using the PMF in accordance with the NSW Flood Prone Land Policy.

It has been demonstrated in Figure 3.10 that the extent of subsidence of the Maxwell Underground and the infrastructure in the mine entry area and transport and services corridor are located outside of both the Saddlers Creek and Hunter River PMF extent. Therefore, the Project would have no impact on the flood behaviour of the PMF event, or any lesser events.

8.3 LOSS OF CATCHMENT FLOWS DUE TO CATCHMENT EXCISION

As an underground mine, the Project would result in limited catchment excision. In addition, the requirement to develop new infrastructure for the Project has been limited through the use of the substantial existing Maxwell Infrastructure. Notwithstanding, the Project would result in a reduction in catchment flows due to the catchment excised within the mine water management system.

The existing reduction in catchment associated with the voids and dams at the Maxwell Infrastructure area would also continue to reduce the flows draining to local waterways relative to pre-mining conditions.

The mine entry area at the Maxwell Underground area is located within the Saddlers Creek catchment. The Maxwell Infrastructure area is located within the upper headwater catchments of Ramrod Creek, Bayswater Creek, Saltwater Creek and Saddlers Creek.

Table 8.1 shows the pre-mining catchment areas for the impacted creeks, the catchment excised by the existing Maxwell Infrastructure and the estimated incremental reduction in catchment area for the Project. The pre-mining catchment is based on the 1:25,000 topographic maps prior to the commencement of mining on both the former Drayton Mine and the Mt Arthur Mine and works on the adjoining AGL-owned land.

Table 8.1 - Changes in local creek catchment area due to the Project

Catchment	Pre-development catchment area (ha) [a]	Reduction in catchment area due to the Project from pre-mine (ha)		
		Existing Maxwell Infrastructure	Incremental Change due to Project	Total
Saddlers Creek	9,714	173 [b]	38 [c]	211
Saltwater Creek	5,315	0	0	0
Bayswater Creek	13,430	586	0	586
Ramrod Creek	3,975	439	0	249[d]

[a] approximate catchment only
[b] excludes catchment associated with West Pit Void on the sublease CL 229
[c] additional 38 ha due to the catchment boundary for the mine entry area
[d] catchment area to North Void diverted around by Stage 5.

8.3.1 Saddlers Creek

The catchment draining to Saddlers Creek has been reduced by the South Void and Savoy Dam at the Maxwell Infrastructure area and this would be unchanged by the Project (i.e. it is a residual impact associated with previous mining activities). The mine entry area at the Maxwell Underground area would be rehabilitated post mining so there would be no additional long-term impact on Saddlers Creek flows post mining.

The Saddlers Creek catchment flows are impacted by the operations at the Mt Arthur Mine.The *Mt Arthur Coal Open Cut Mine Modification Environmental Assessment Surface Water Assessment* (Appendix C) (Gilbert & Ass, 2013) concluded the maximum reduction in catchment to Saddlers Creek would be 940 ha during the operational phase and this reduces to 550 ha at the completion of mining. The cumulative impact of the Project and the Mt Arthur Mine on the Saddlers Creek catchment would therefore be 12% during the operational phases of both mining operations (0.3% incremental change due to the Project). The cumulative impact would reduce to 8% post-mining. The Project would have no incremental contribution to cumulative impacts post-mining, once the mine entry area is rehabilitated.

There are no licensed water users on Saddlers Creek that could be impacted by the reduction in catchment flows.

8.3.2 Saltwater Creek

The catchment of Saltwater Creek would not materially change as a result of the Project. It is noted that Plashett Reservoir on AGL-owned land already has a significant impact on Saltwater Creek catchment flows. The Saltwater Creek catchment is 5,321 ha, 77% of which currently drains to Plashett Reservoir. Any releases from Plashett Reservoir are made to a low flow constructed channel and not directly to the legacy Saltwater Creek channel. As a result, the only flows draining to Saltwater Creek under existing conditions is the catchment downstream of Plashett Reservoir.

8.3.3 Bayswater Creek

The catchment draining to Bayswater Creek has been reduced by the East Void at the Maxwell Infrastructure area and this would be unchanged by the Project (i.e. it is a residual impact associated with previous mining activities). Bayswater Creek downstream of Maxwell Infrastructure contains Lake Liddell and the Liddell Power Station, as well as, the established coal mines Hunter Valley Operations and the Greater Ravensworth Area Operations. Very little of the catchment exists in its pre-mining state.

8.3.4 Ramrod Creek

The catchment draining to Ramrod Creek has been reduced by North Void and Access Road Dam on the Maxwell Infrastructure area. The loss of catchment associated with North Void would be unchanged by the Project (i.e. it is a residual impact associated with previous mining activities). However, as much of the upstream catchment as possible would be diverted around the North Void prior to the completion of mining. The Access Road Dam would also be removed or rehabilitated to minimise the impact of the loss of catchment.

8.4 LOSS OF STREAM BASEFLOW

The potential impact of the Project on baseflow in Saddlers Creek and the Hunter River has been undertaken by HydroSimulations (2019). The assessment concluded the following:

- Zero impact on baseflow in Saddlers Creek; and
- A maximum baseflow reduction of 0.55 ML/yr in the Hunter River.

In the context of the Hunter River regulated system, a baseflow loss of 0.55 ML/yr is negligible. Hence, the Project would not measurably affect baseflow in the downstream waterways.

8.5 LOSS OF CATCHMENT FLOWS DUE TO MINE SUBSIDENCE

The Hunter River and Saddlers Creek are located outside the Maxwell Underground area and would not be subject to direct subsidence effects (MSEC, 2019). Notwithstanding, potential subsidence impacts on the unnamed drainage lines draining to Saddlers Creek and Saltwater Creek are considered below.

8.5.1 Increased Ponding

The Geomorphology Assessment (see Appendix D of the EIS) found that subsidence was predicted to increase the surface area of depressions in drainage lines from 8.9 ha (existing case) to 12.9 ha (impacted case). A further 2.5 ha of the depressions present under the existing case were predicted to become deeper under the impacted case. The Geomorphology Assessment also found that the in-channel subsided areas would naturally fill with sediment over time. Sediment loads were not estimated. However, sediment is likely to fill the subsidence areas incrementally over the 26 year Project life and therefore the maximum increase in surface ponding would be associated with one or two panels only or a fraction of this increase.

Notwithstanding, if it is assumed that the surface depressions increase by 0.5 m, the total volume of water retained in the local waterways by the additional surface depressions, assuming no infilling, would be 32 ML. Given that the average annual flows recorded at the Bowfield stream gauge (GS210043) on Saddlers Creek is 1,000 ML, the potential reduction in flows due to subsidence is negligible.

8.5.2 Surface Fracturing

Some fracturing of exposed bedrock and bedrock beneath the soil beds of drainage lines is predicted to occur as a result of the Project (MSEC, 2019). Rock slabs have been identified along the drainage lines in four locations within the Maxwell Underground area (Fluvial Systems, 2019). MSEC (2019) describe that fracturing could develop in three of these rock slabs that are located directly above the proposed mining panels.

The drainage lines within the Maxwell Underground area are typically ephemeral and, therefore, surface water flows only occur during and for short periods after rainfall events. In times of heavy rainfall, the majority of the runoff would flow over the natural surface soil beds and would not be diverted into the dilated strata below (MSEC, 2019). In times of low flow, however, surface water flows could be diverted into the dilated strata below the beds where the bedrock is shallow or exposed (MSEC, 2019).

Given the ephemeral nature of the drainage lines overlying the Maxwell Underground, the potential diversion of flows into the underlying strata during low flow events would be negligible.

8.6 WATER LICENSING CONSIDERATIONS

8.6.1 Hunter Unregulated and Alluvial Water Sharing Plan

The Project is located wholly within the extent of the HUAWSP. The Maxwell Underground is located within the Jerrys Water Source and the Maxwell Infrastructure is located on the boundary of the Muswellbrook Water Source and Jerrys Water Source.

The water management system for the Project has been designed to minimise the capture of clean runoff wherever possible. The diversion drain at the mine entry area would be constructed to divert clean water runoff that would have drained into the mine entry area.

Licensing considerations for the existing Maxwell Infrastructure dams and the Project dams are summarised in Table 8.2. The MEA Dam at the Maxwell Underground area and the existing dams at the Maxwell Infrastructure area are solely for the capture, containment and recirculation of mine affected water consistent with best management practice to prevent the contamination of a water source. These types of dams are “excluded works” and are exempt from the requirement for water supply works approvals and WALs. Therefore, the water captured in these dams would not be subject to licencing.

Table 8.2 – Water licensing considerations for water management storages

Storage name	Storage type	Storage capacity (ML)	Water Licensing Requirements
Access Road Dam	Mine affected water dam	750	Nil - excluded work
Industrial Dam	Mine affected water dam	750	Nil - excluded work
Rail Loop Dam	Mine affected water dam	18	Nil - excluded work
Savoy Dam	Mine affected water dam	140	Nil - excluded work
MEA Dam	Mine affected water dam	110	Nil - excluded work
Water Storage Dam	Mine affected water dam	17	Nil – turkey’s nest
Treated Water Dam	Treated water dam	15	Nil – turkey’s nest
Brine Water Dam	Brine dam	4	Nil – turkey’s nest

Under the WM Act, landholders in rural areas are permitted to collect a proportion of the rainfall runoff on their property and store it in one or more dams up to a certain size. This is known as a 'harvestable right'. A dam can capture up to 10 percent of the average regional rainfall runoff for their landholding without requiring a licence. The landholding area required for the purposes of the harvestable right calculation is the Project’s contiguous landholding (6,839 ha). Based on the Project’s contiguous landholding and a harvestable rights multiplier value of 0.07 ML/ha for the relevant area, the total harvestable right for the Project is 479 ML.

There are currently 41 farm dams on these holdings. The capacity of these farm dams has been estimated to be less than 50 ML, well below the harvestable right.

8.6.2 Hunter Regulated River Water Sharing Plan

Malabar currently owns one high security (WAL769) and six general security Water Access Licenses (WAL771, WAL1143, WAL1220, WAL1066, WAL31439 and WAL31440) totalling 1,123 units from the Hunter River. These licences are not required for water supply as part of the Project.

8.7 SURFACE WATER QUALITY

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. As an underground mine, the Project would involve minimal surface disturbance and therefore has limited potential for water quality impacts. By implementing an effective water management system, as described in Section 4, the Project would not result in adverse impacts on the receiving waters.

Key elements of the proposed water management system for the mine entry area include:

- minimise the surface development extent;
- divert runoff from undisturbed catchments away from surface development areas, wherever possible, using surface drains;
- runoff from the mine entry area would be collected within the MEA Dam for recycling on-site and would not be released from the site; and
- the development of an erosion and sediment control plan to manage runoff during the construction phase to manage runoff from the disturbed areas peripheral to the mine entry area, including the transport and services corridor and ventiliation shaft site.

Areas within the extent of conventional subsidence have the potential for increased sediment loads in Saddlers Creek and Saltwater Creek. The Geomorphology Assessment (see Appendix D of the EIS) recommended measures to reduce the risk of knickpoint formation and stream channel alignment change, and therefore reduce the potential for increased in-stream sediment, through a process of adaptive management. Under this process: (i) regular monitoring would detect if and where the threat occurs, (ii) an assessment would be made to determine the potential consequences of the observed threat, and then, (iii) appropriate control works would be put in place.

Details of the proposed mine water management system at the Maxwell Infrastructure area are provided in Section 4. Water balance modelling has been undertaken to demonstrate that the operation of the mine water management system would minimise the risk of controlled or uncontrolled releases from the Maxwell Infrastructure area.

The water balance modelling indicates that there is a very low (1%) probability (in any one year) that Rail Loop Dam and Access Road Dam could overflow to Ramrod Creek. However, overflows from these storages would only occur during extreme rainfall events and the water within the dams during these events would be heavily diluted by catchment inflows. In addition, any overflows would be further diluted by significant flows in Ramrod Creek.

Hence, the Project would not adversely affect surface water quality in downstream receiving waters including downstream water-dependent fauna and flora and therefore having no detrimental impact on the water quality objectives given in Section 3.5.1.

8.8 CUMULATIVE IMPACTS

There are currently numerous mines and power generation infrastructure operating in the Hunter River catchment, both upstream and downstream of the Project. With respect to cumulative impacts on water supply, any take of water from the Hunter River, whether it be for industrial or agricultural use, is managed through the HRRWSP. The water sharing rules in this plan are designed to provide for the environmental needs of the river, as well as directing how water would be allocated and shared among different water users. The plan has considered the cumulative impacts of all water users in the catchment to ensure the environmental needs of the catchment are satisfied. The Project would comply with the provisions of this plan and the available WALs, if required, to minimise the cumulative impacts.

There would be some continued loss of catchment and reduction in flow associated with the final voids on the Maxwell Infrastructure area. These catchment areas have been reduced as far as practical to minimise the impact. There would be no long-term additional impact on the loss of catchment flows due to activities associated with the Project.

8.9 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Based on the detailed assessment presented above, and in consideration of the Significant Impact Guidelines, the Project would not result in significant changes to the quantity or quality of water available to third party uses or the environment.

Accordingly, the Project would not have a significant impact on surface water resources on a local, regional, state or national scale.

9 Mitigation and management measures

The site water management system described in Section 4 and assessed in Section 6 has been developed to mitigate the potential impact of the Project on downstream water quality. However, there remains a residual impact associated with the loss of catchment due to the previous mining activities at the Maxwell Infrastructure. There are also potential residual impacts associated with subsidence as described in the Geomorphology Assessment (Appendix D of the EIS). Recommended measures to monitor these impacts and strategies to mitigate the impacts, if required, are outlined below.

9.1 SURFACE WATER MONITORING PLAN

Surface water monitoring for the Project would be undertaken to demonstrate compliance with regulatory requirements, as well as improve the understanding and efficiency of the site water management system. The proposed monitoring program for the Project addresses the following issues:

- water quality – to understand the quality of water stored on-site and demonstrate no adverse impact on receiving waters;
- water balance – to understand the volumes of water associated with key processes on-site and comply with conditions of WALs;
- system integrity – to ensure that the site water management system is operating as intended and minimising safety and environmental risks;
- erosion and sediment control - to demonstrate compliance of the erosion and sediment control system with EPL conditions; and
- stream health monitoring - to ensure that the condition of the drainage lines external to the approved disturbance boundary is not impacted by the Project.

The proposed monitoring locations are shown in Figure 9.1. A summary of the proposed surface water monitoring program is provided in Table 9.1. Table 9.1 also shows the trigger levels to undertake investigative or corrective action under the Surface Water Response Plan (see Section 9.2).

9.1.1 Water quality monitoring

Surface water quality monitoring and sample collection, storage and transportation would be undertaken in accordance with the procedures outlined in the relevant sections of the Australian Standard for Water Quality Sampling Australian and New Zealand Standard (AS/NZS) 5667.1-1998. Laboratory analysis would be undertaken by a laboratory which has relevant accreditation by the National Association of Testing Authorities (NATA), Australia.

Water quality samples would be collected by both field testing using hand held probes that have been regularly maintained and calibrated and laboratory analysis.

Table 9.3 shows the suite of water quality parameters for laboratory analysis. Samples for laboratory analysis from the surface water quality monitoring program are collected to the Approved Water Sampling Methods: AS/NZS 5667.1 and AS/NZS 5667.6. Additional surface water sampling is undertaken following events if recorded rainfall at the site exceeds 25 mm over a 24 hours period. Event sampling is undertaken at all regular monitoring sites plus additional sites at the frequencies summarised in Table 9.1. The results would be reported in the Annual Review.

9.1.2 Water quality guideline values

Table 9.2 shows the proposed preliminary criteria for surface water quality which would be used as guideline values for assessing the surface water impacts at the downstream monitoring locations from Project.

Exceedance of the guideline values would initiate an investigation to assess whether the identified exceedance has potentially been caused by the Project.

The approach to the selection of water quality guideline values is as described in the ANZECC guidelines (ANZECC & ARMCANZ, 2000 / ANZG, 2018) , regarding the determination of appropriate guideline values: "*For physical and chemical stressors and toxicants in water and sediment, our preferred approach to derive guideline values is to use local field and/or laboratory-effects data. But these are expensive to collect so guideline values are usually derived – initially at least – using reference-site data.*" As no laboratory-effects data is available, local field data has been used as a basis for the selection of the guideline values. The 80th percentile recorded baseline values shown for Saddlers Creek in Table 9.2 are based on monitoring data from May 1998 to June 2015.

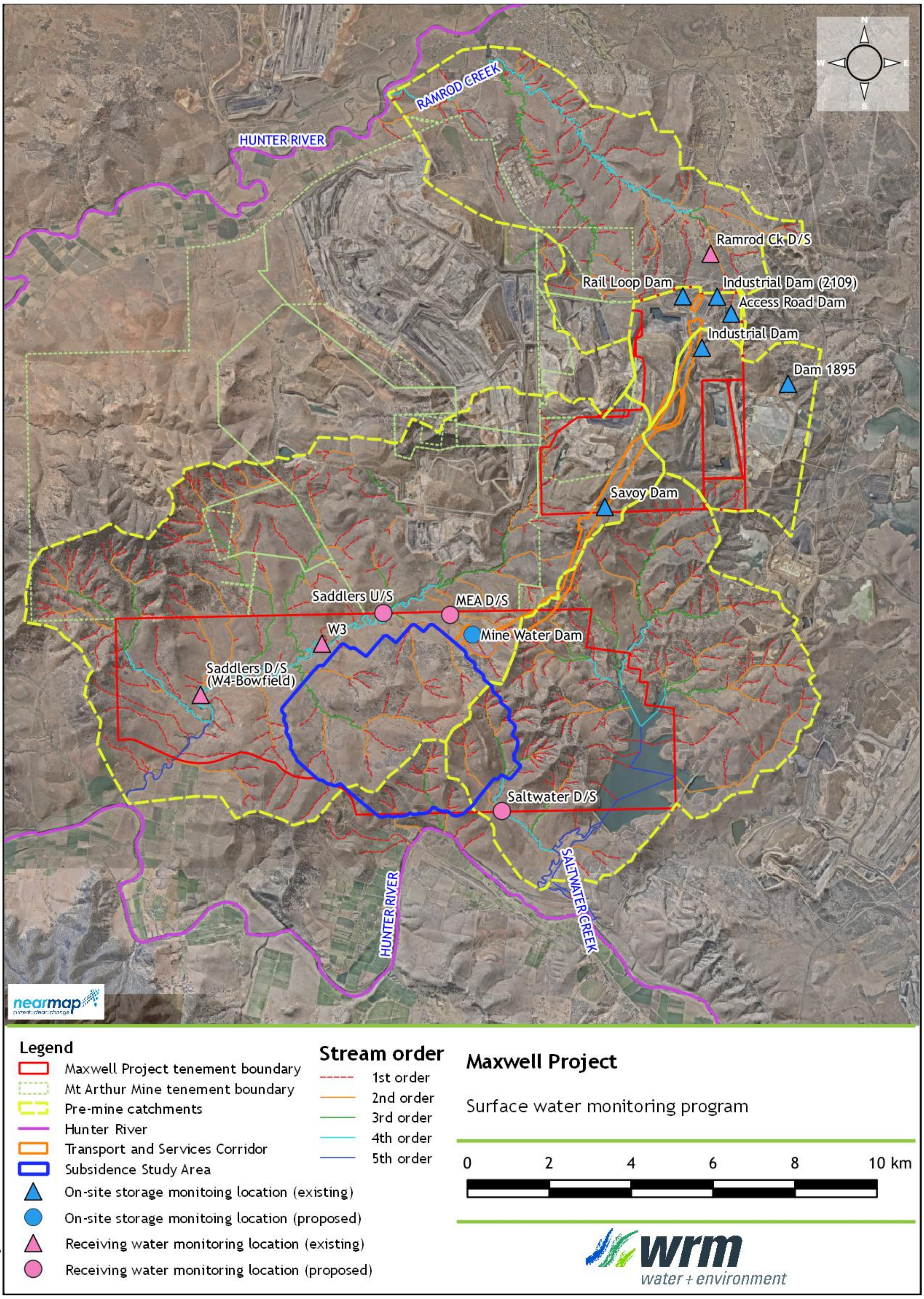


Figure 9.1 – Existing and proposed surface water monitoring locations

Table 9.1 – Surface water monitoring summary

Issue	Monitoring Location	Monitored Parameter	Monitoring Frequency	Trigger Event/Comment
Water quality	Saddlers U/S	Water level (gauge plate), pH, EC, Turbidity (Field) + Lab analysis suite (Table 9.3)	Following 25 mm/d of rain	Upstream Baseline Data
	Saddlers D/S (W4) MEA D/S Saltwater D/S Ramrod D/S (2221)	Water level (gauge plate), pH, EC, Turbidity (Field) + Lab analysis suite (Table 9.3)	Following 25 mm/d of rain	Exceedance of water quality trigger values (see Table 9.2)
	Mine water storages - (MEA Dam, South Void, East Void, North Void. Access Road Dam, Rail Loop Dam)	Water level (gauge plate), pH, EC, Turbidity (Field) + Lab analysis suite (Table 9.3)	Monthly	Stored volume greater than 50% full and water quality parameter outside range of historical values by >20% (after at least 1 year data).
	WTF Dams - Water Storage Dam, Treated Water Dam	pH, EC Lab analysis suite (Table 9.3)	Monthly	Internal use for WTF operations
Water Balance	On-site	Rainfall	Continuous	Internal use for water balance and not reported
	On-site	Weather forecast	Daily	Forecast heavy rainfall
	External water supply	Raw water volume	Daily	Pro-rata use exceeds licensed volume by >10%.
	CHPP	CHPP water consumption	Daily	Internal use for water balance and not reported
	Mine water storages/ water truck fill points	Total water volume for dust suppression	Daily	Internal use for water balance and not reported
	Mine water storages	Stored volume	Monthly or following 25 mm/d of rain.	Stored volume exceeds maximum operating volume of 50 ML
	Major pipelines	Pumping volume	Daily	Internal use for water balance and not reported
System integrity	Pumps and pipelines	Inspection for leaks / damage / correct operation	Monthly	Observed damage, major leaks or inoperable

Issue	Monitoring Location	Monitored Parameter	Monitoring Frequency	Trigger Event/Comment
	Dams	Inspection of embankment and spillway	Annually	Embankment or spillway damage and structural failure
Erosion & sediment control	Diversion drains	Inspection for erosion damage or sediment accumulation	Monthly or following 25 mm/d of rain	Drain inoperable due to erosion of sediment accumulation
Stream Health Monitoring	Saddlers U/S, W3, Saddlers D/S	Photographic monitoring of Creek for vegetation and erosion/sedimentation.	Quarterly	>10% loss of revegetation species. Erosion or sedimentation characteristics obviously degrading

U/S = upstream, D/S = downstream.

Table 9.2 - Preliminary guideline values for water quality assessment

Parameter	Unit	ANZECC default guideline value				Recorded baseline data (80%ile)	Preliminary guideline value	Comment
		Irrigation	Livestock drinking	Eco-system*a	Recreational	Saddlers Creek*b	Saddlers Creek	
pH	pH	6.0 - 9.0	-	6.5 - 8.0	6.5 - 8.5	8.0 - 8.5	6.5-8.5	Lower bound based on ANZECC guideline for ecosystem protection, upper bound based on baseline data.
EC	µS/cm	Site dependent	-	35-350	-	7,584	7,600	Baseline data adopted. Rounded up to nearest hundred.
TDS	mg/L	-	2,000*a	-	1,000	4,890	4,900	Baseline data adopted. Rounded up to nearest hundred.
Turbidity	NTU	-	-	2-25	-	-	-	To be derived based on TSS/Turbidity relationship
TSS	mg/L	-	-	-	-	38	50	DECC 2008 guidelines adopted

Notes: - No guideline value recommended.
*a Upland River
*b At surface water monitoring location W1

Table 9.3 - Surface water quality - laboratory analysis suite

Parameter
TDS
TSS
Turbidity
EC
Sodium
Magnesium
Potassium
Calcium
Chloride
Sulphate
Bicarbonates

9.1.3 Water balance monitoring

Storage volume and water quality data would be collected from the various water storages to assist in the verification/calibration of the site water balance and salt balance at the Project and to minimise the risk of an uncontrolled spill from the dams.

The site water balance would be reviewed annually and updated as additional and/or newer information becomes available with the progression of the underground operations. Recording the following parameters would assist in validating the assumptions of the water balance model, particularly the AWBM runoff parameters:

- site rainfall;
- dam and void water levels (to be converted to volumes using stage-storage characteristics);
- volume estimates for volume of any off-site discharges;
- pump rates between storages, particularly major pipelines between the mine entry area and Maxwell Infrastructure;
- actual demand rates for CHPP makeup water (and losses), dust suppression and vehicle washdown during operation of the mine;
- general mine site water management practices; and
- the personnel responsible for ensuring the monitoring of these parameters.

9.1.4 System integrity monitoring

Regular monitoring of infrastructure such as pumps, pipelines and dams would be undertaken to monitor whether they are working effectively.

A dam at Maxwell Infrastructure is currently listed with the Dam Safety Committee under the provisions of the Dams Safety Act 1978 and Dams Safety Act 2015, that being the Access Road Dam. As required by the listing of this dam with the Dam Safety Committee, an annual surveillance report is undertaken and submitted. In addition to this report, detail on the status of this dam and a summary of the surveillance report is included in the Annual Review for the Maxwell Infrastructure.

9.1.5 Erosion and sediment control monitoring and maintenance

An erosion and sediment control plan would be developed to manage runoff during the construction phase and to manage runoff from the disturbed areas peripheral to the mine entry area (i.e. transport and services corridor). Site drainage and sediment control structures would be inspected regularly (monthly or following rainfall greater than 25 mm in 24 hours) to check for scouring of diversion drains (and their outlets) and accumulation of sediment in sediment traps (including sediment fences, sediment basins, etc.).

Regular inspections of control structures would be undertaken to ensure they are functioning as designed and required. Maintenance activities would be undertaken in accordance with Section 8.2 of the Blue Book (Landcom, 2004) and would include:

- ensuring proper drainage of the site, including:
  - cleaning catch drains, diversion banks, table drains, and drop-down structures that have become blocked with sediment;
  - checking that drains are operating as intended and any damaged works are repaired where necessary;
- keeping all control structures in good, working condition, ensuring:
  - recent works have not resulted in the diversion of sediment-laden water away from their intended destination;
  - removing accumulated sediment from basins/drains (if required); and
  - checking that rehabilitated lands have established sufficient ground cover.

9.1.6 Stream health monitoring

The extent of riparian vegetation and extent of erosion and sedimentation deposits would be used as an indicator of stream health.

Monitoring is undertaken quarterly by taking photographs at each of the Saddlers Creek surface water monitoring sites. The photographs would be taken at the same location (identified by GPS or permanent photographic ID post) and taken of the relevant bed and bank features looking upstream and downstream. These photographs are documented with the person completing the survey, location, direction and date as well as a log of erosional and depositional features at each location.

The Subsidence Monitoring Program (Appendix A of the EIS), outlines the requirements to monitor the local gullies crossing extent of conventional subsidence. Monitoring would be undertaken as each longwall panel crosses the waterways and then subsequent to the next runoff events.

9.2 SURFACE WATER RESPONSE PLAN

The Surface Water Response Plan identifies proposed actions to be taken if the monitoring program identifies the occurrence of a trigger event (see Table 9.2). The general protocol for response to trigger events is outlined in Table 9.4.

Specific actions to respond to trigger events identified in the Surface Water Management Plan are identified in Figure 9.2 to Figure 9.6.

Table 9.4 – Trigger Event Response Protocol

Step	Procedure
1	Confirm the timing of the event
2	Confirm the general location of the event
3	Confirm the climatic conditions at the time of the event (where relevant)
4	Identify any potential contributing factors
5	Assess the monitoring results and other available information for any anomalies or causes (obtain specialist advice if required)
6	Develop appropriate mitigation and management strategies
7	Consult and seek approval of strategies from Regulatory Authorities where necessary
8	Implement the mitigation and management strategies
9	Review of follow up results
10	Report to the appropriate regulatory authorities

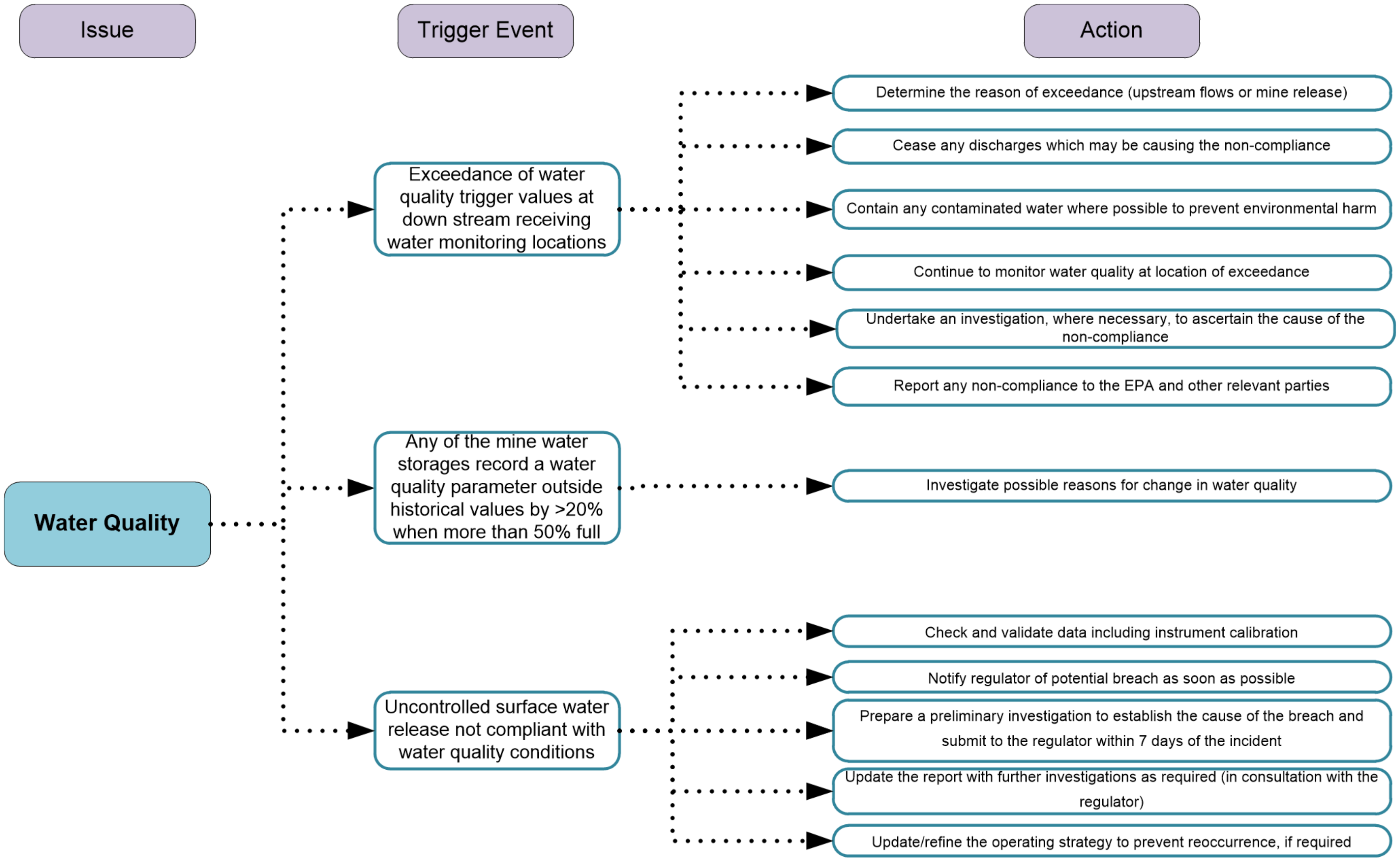


Figure 9.2 – Surface water trigger action response plan – water quality

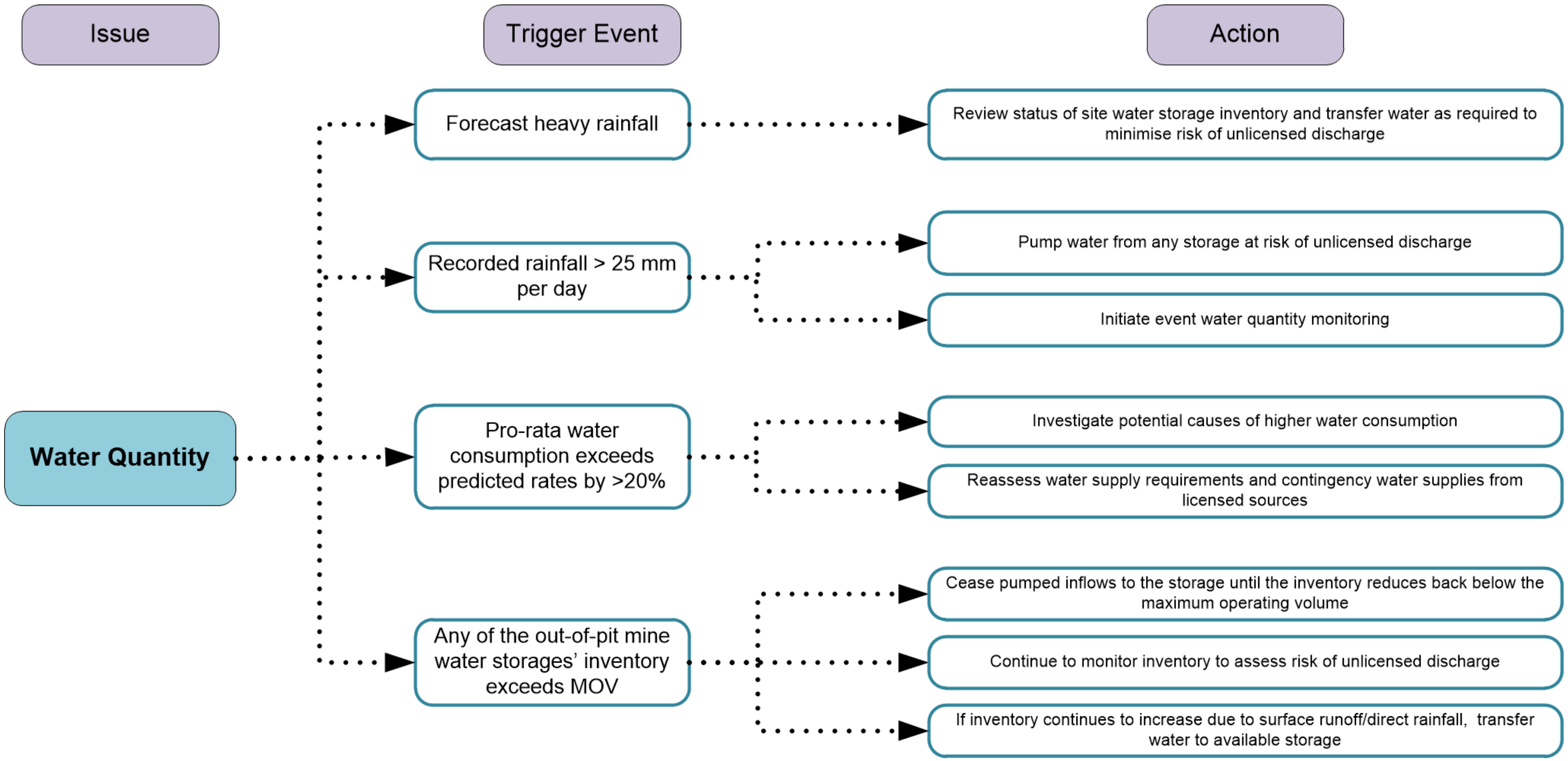


Figure 9.3 - Surface water response actions - water quantity

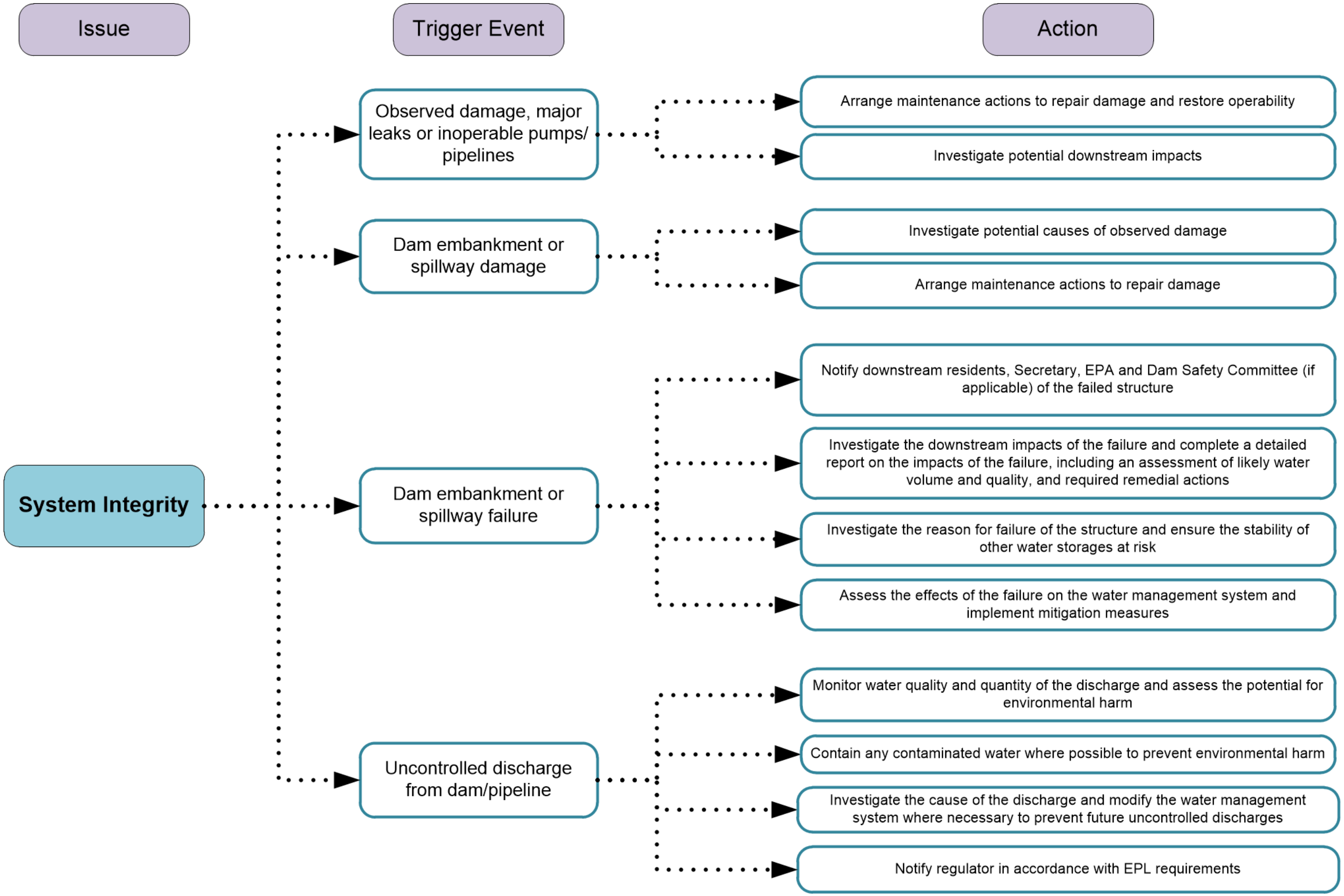


Figure 9.4 - Surface water response actions - system integrity

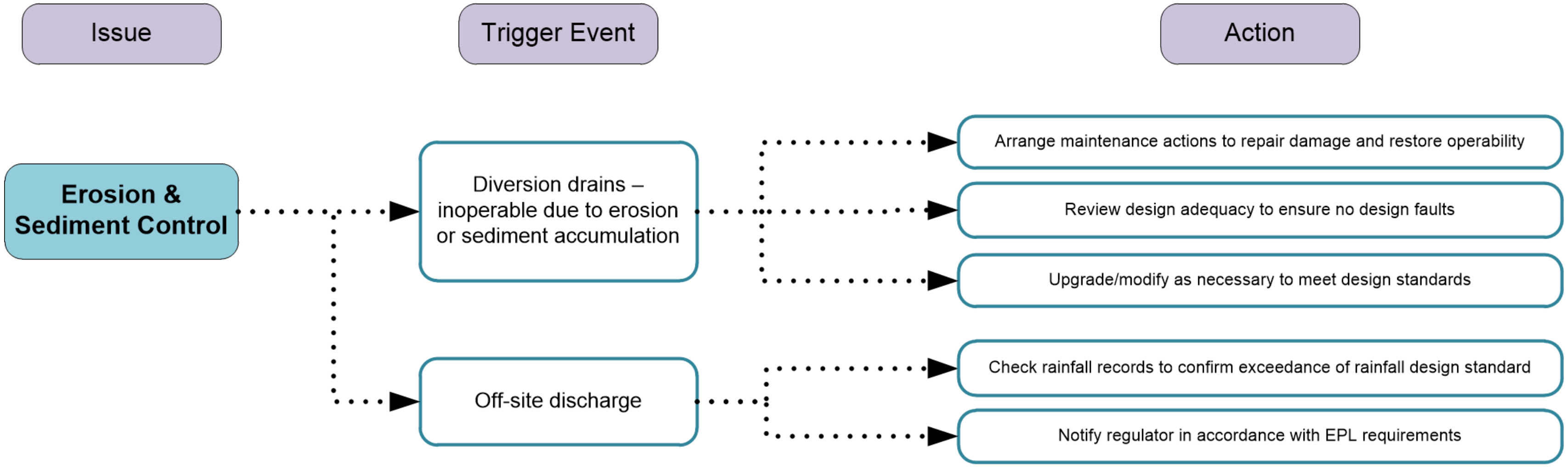


Figure 9.5 - Surface water response actions - erosion and sediment control

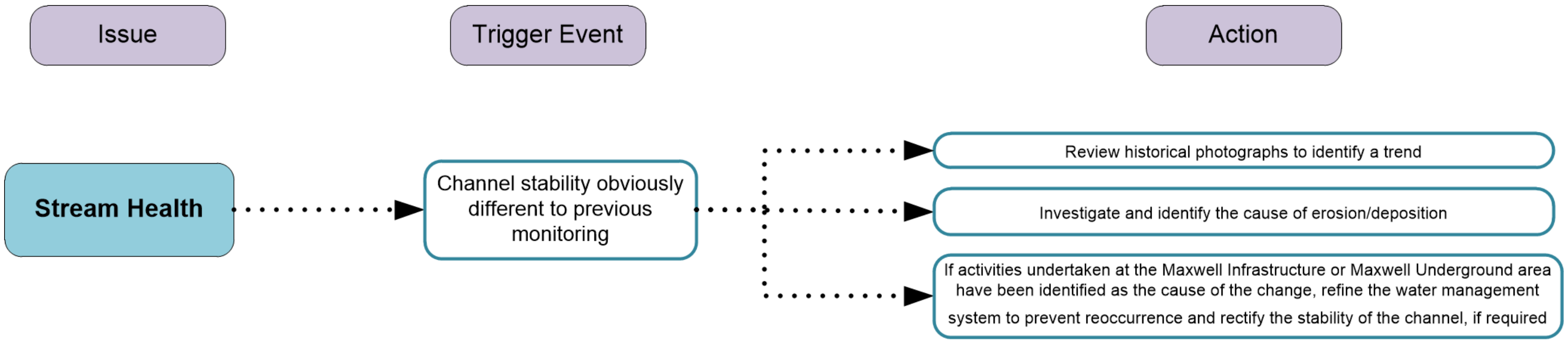


Figure 9.6 - Surface water response actions - stream health

10 Conclusions

A summary of the surface water impact assessment of the Project is as follows:

- The extent of subsidence associated with the Maxwell Underground and the infrastructure in the mine entry area and services corridor are located outside of both the Saddlers Creek and Hunter River PMF extent.
- The catchment draining to Saddlers Creek has been reduced by the South Void and Savoy Dam at the Maxwell Infrastructure area and this would be unchanged by the Project (i.e. it is a residual impact associated with previous mining activities). The mine entry area at the Maxwell Underground area would be rehabilitated post mining so there would be no additional long-term impact on Saddlers Creek flows post mining.
- The cumulative impact of the Project and the Mt Arthur Mine on the Saddlers Creek catchment would be 12% during the operational phases of both mining operations (0.3% incremental change due to the Project). The cumulative impact would reduce to 8% post-mining. The Project would have no incremental contribution to cumulative impacts post-mining, once the mine entry area is rehabilitated. There are no licensed water users on Saddlers Creek that could be impacted by the reduction in catchment flows.
- The loss of catchment to Saltwater Creek, Bayswater Creek and Ramrod Creek would be unchanged by the Project. As much of the upstream catchment of Ramrod Creek as possible would be diverted around North Void prior to completion of mining. The Access Road Dam would also be removed or rehabilitated to minimise of the existing loss of catchment.
- The total volume of water retained in the local waterways by the additional surface depressions due to mine subsidence, assuming no infilling, is estimated to be 32 ML. Given that the average annual flows recorded at the Bowfield stream gauge on Saddlers Creek is 1,000 ML, the potential reduction in flows due to subsidence is negligible.
- Given the ephemeral nature of the drainage lines overlying the Maxwell Underground, the potential diversion of flows into the underlying strata during low flow events would be negligible.
- There is a very low probability that Rail Loop Dam and Access Road Dam could overflow to Ramrod Creek. However, overflows from these storages would only occur during extreme rainfall events and the water within the dams during these events would be heavily diluted by catchment inflows. In addition, any overflows would be further diluted by significant flows in Ramrod Creek. Hence, the Project would not adversely affect surface water quality in downstream receiving waters including downstream water-dependent fauna and flora and therefore having no detrimental impact on the water quality objectives.
- The water balance modelling shows that there is sufficient capacity within the voids at Maxwell Infrastructure to accommodate the water generated by the Project.

- The final void modelling indicates that the expected water levels are below the target maximum water level (175 mAHD) FSLs for each void, and the voids would remain as long-term groundwater sinks.
- There would be some continued loss of catchment and reduction in flow associated with the final voids on the Maxwell Infrastructure area. These catchment areas have been reduced as far as practical to minimise the impact. There would be no long-term additional impact on the loss of catchment flows due to activities associated with the Project.

Overall, the assessment has found that the Project will not have a material impact on the environmental values of the receiving surface waters.

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