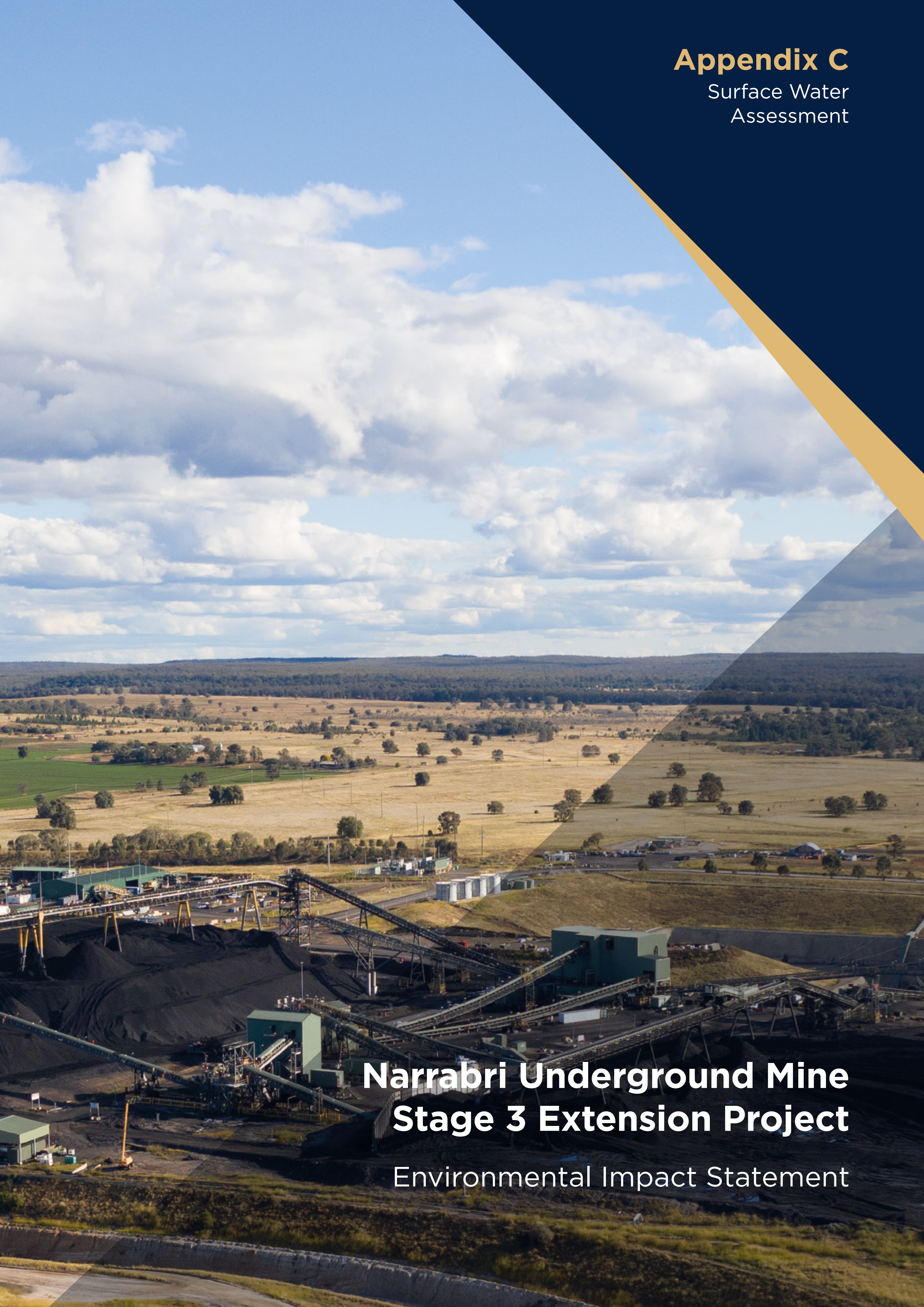
Appendix C

Surface Water Assessment



Narrabri Underground Mine Stage 3 Extension Project

Environmental Impact Statement

Narrabri Underground Mine Stage 3 Extension Project

Surface Water Assessment

Narrabri Coal Operations Pty Ltd

0189-13-E9, 6 October 2020

Report Title	Narrabri Underground Mine Stage 3 Extension Project – Surface Water Assessment
Client	Narrabri Coal Operations Pty Ltd
Report Number	0189-13-E9

For and on behalf of
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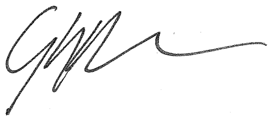

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Glossary

Term	Definition
AGE	AGE Consulting Pty Ltd
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZG	Australian & New Zealand Guidelines for Fresh and Marine Water Quality
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AWBM	Australian Water Balance Model
BCD	Biodiversity Conservation Division
BOM	Bureau of Meteorology
Ca	Calcium
CHPP	Coal Handling Preparation Plant
Dams Safety Act	Dams Safety Act 2015
DECC	Department of Environment and Climate Change
DEM	digital elevation model
DGS	Ditton Geotechnical Services Pty Ltd
DPIE	NSW Department of Planning, Industry and Environment
DSNSW	Dams Safety NSW
EC	Electrical Conductivity
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPA	Environment Protection Authority
EPL	environmental protection licence
FMP	floodplain management plan
Ha	hectares
HDPE	High density polyethylene
kL/ROM tonne	kilolitres per ROM tonne
Km	kilometres
km^2	square kilometres
L/s	litres per second
M	metre
m/s	metres per second
Mdb	Murray Darling Basin
Mg	Magnesium
mg/L	milligrams per litre
ML	Mining Lease
ML/day	megalitres per day
ML/yr	megalitres per year
MLA	Mining Lease Application
MF	Microfiltration
Mm	millimetres
Mtpa	million tonnes per annum
Na	Sodium
NCOPL	Narrabri Coal Operations Pty Ltd

Term	Definition
NRRWSP	Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016
NSW	New South Wales
NPUWSP	Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012
OEH	Office of Environment and Heritage
POEO Act	Protection of the Environment Operations Act 1997
Resource Strategies	Resource Strategies Pty Ltd
RO	Reverse Osmosis
ROM	run-of-mine
SEARs	Secretary's Environmental Assessment Requirements
TARP	Trigger Action Response Plan
TDS	Total Dissolved Solids
The Manual	Floodplain Development Manual
the Objectives	NSW Water Quality and River Flow Objectives
the Project	Narrabri Underground Mine Stage 3 Extension Project
TOC	total organic carbon
Total N	Total nitrogen
Total P	Total phosphorus
TSS	total suspended solids
UG demand	Underground demand
WAL	water access licence
WM Act	Water Management Act 2000
WSP	water sharing plan
Zn	Zinc
µS/cm	micro Siemens per centimetre
%	percent

1 Introduction

1.1 BACKGROUND

The Narrabri Mine is located approximately 25 kilometres (km) south east of Narrabri and approximately 60 km north west of Gunnedah within the Narrabri Shire Council Local Government Area of New South Wales (NSW) (Figure 1.1). The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (NCOPL).

NCOPL is seeking a new Development Consent under the State Significant Development provisions of Part 4 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Narrabri Underground Mine Stage 3 Extension Project (the Project). This Surface Water Assessment forms part of the Environmental Impact Statement (EIS) which has been prepared to accompany the Development Application for the Project, with reference to the surface water components of the Secretary's Environmental Assessment Requirements (SEARs) (Section 2).

This Surface Water Assessment has been peer reviewed by Emeritus Professor Thomas McMahon, and the peer review letter can be found in Attachment 6 of the EIS.

1.2 PROJECT DESCRIPTION

The Project involves an extension to the south of the approved underground mining area to gain access to additional coal reserves within Mining Lease Applications (MLAs) 1 and 2 (Figure 1.2), an extension of the mine life to 2044 and development of supporting surface infrastructure (Figure 1.3). Run-of-mine (ROM) coal production would occur at a rate of up to 11 million tonnes per annum (Mtpa), consistent with the currently approved limit. A detailed description of the Project is provided in Section 2 in the Main Report of the EIS.

A description of the Project water management system is provided in Section 5. The Project area is the area encompassed by the existing Narrabri Mine Mining Lease (ML) 1609 and MLAs 1 and 2.

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 (Ditton Geotechnical Services Pty Ltd [DGS], 2020) (Appendix A of the EIS);
- Groundwater Assessment (AGE Consulting Pty Ltd [AGE], 2020) (Appendix B of the EIS);
- Biodiversity Development Assessment Report (Resource Strategies Pty Ltd [Resource Strategies], 2020) (Appendix D of the EIS);
- Agricultural Impact Statement (2rog Consulting Pty Ltd, 2020) (Appendix G of the EIS); and
- Geochemistry Assessment (Geo-Environmental Management Pty Ltd, 2020) (Appendix N of the EIS).

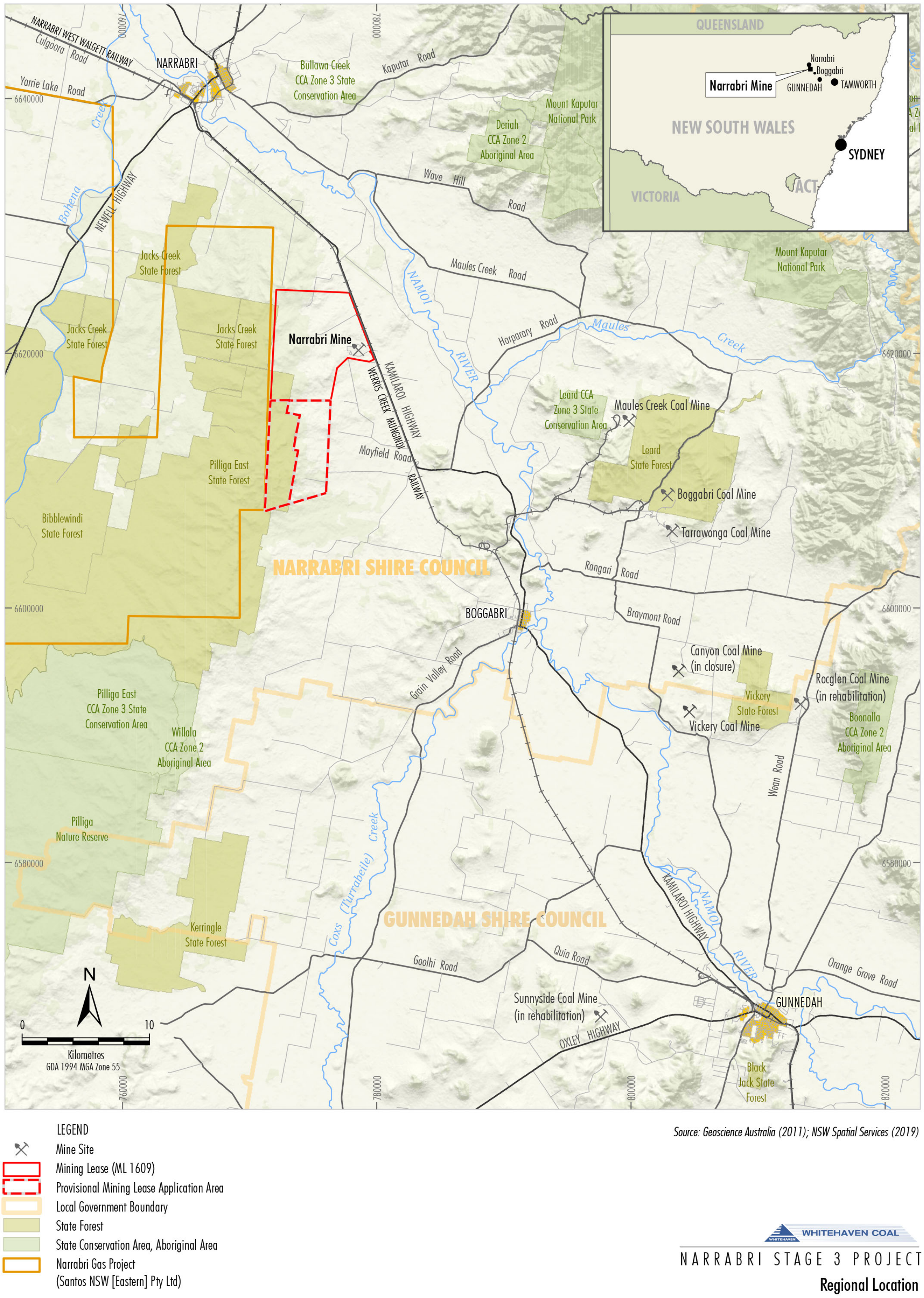


Figure 1.1 – Narrabri Mine regional locality map (Source: Resource Strategies, 2020)

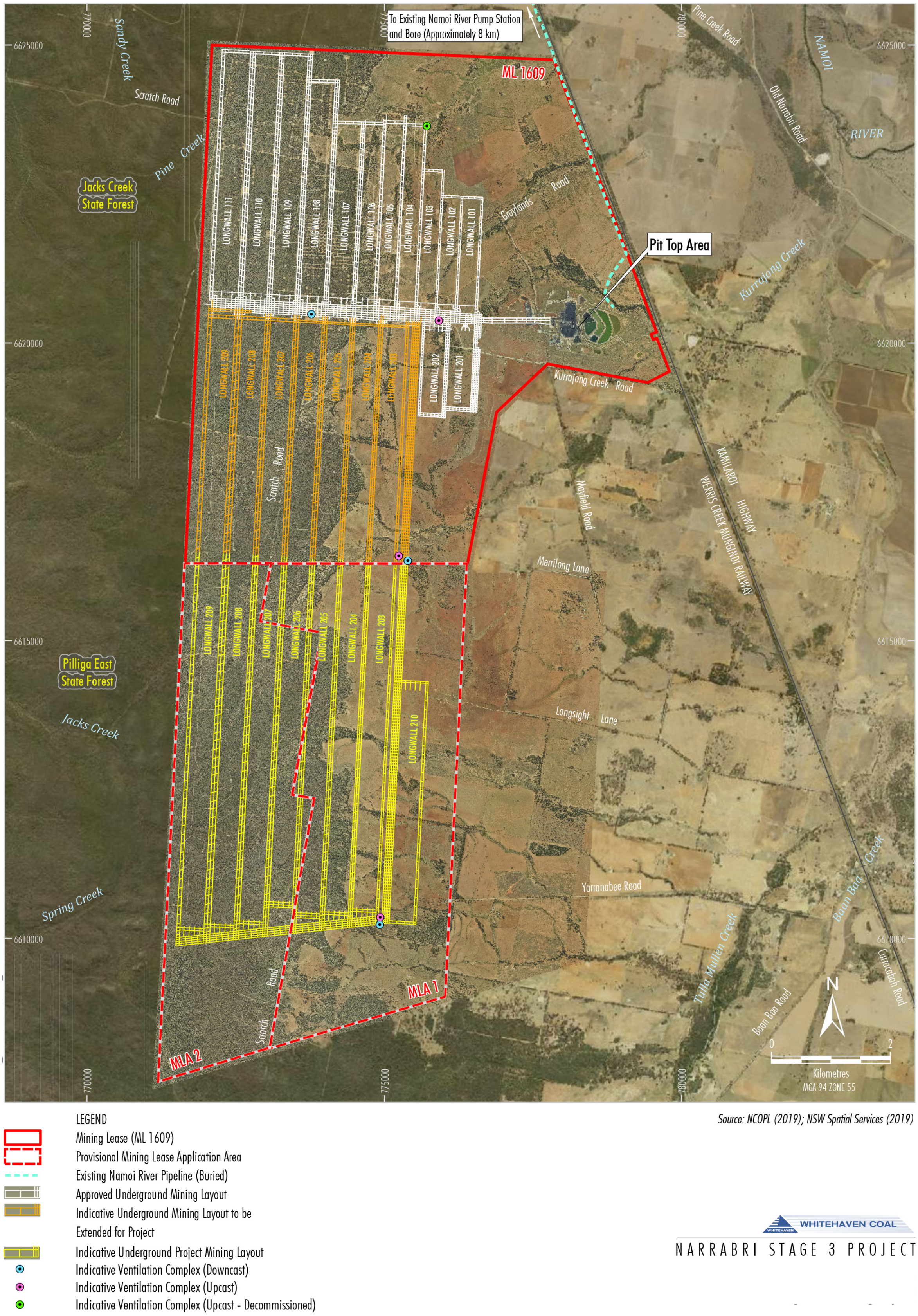


Figure 1.2 – Project General Arrangement – Indicative Underground Mining Layout (Source: Resource Strategies, 2020)

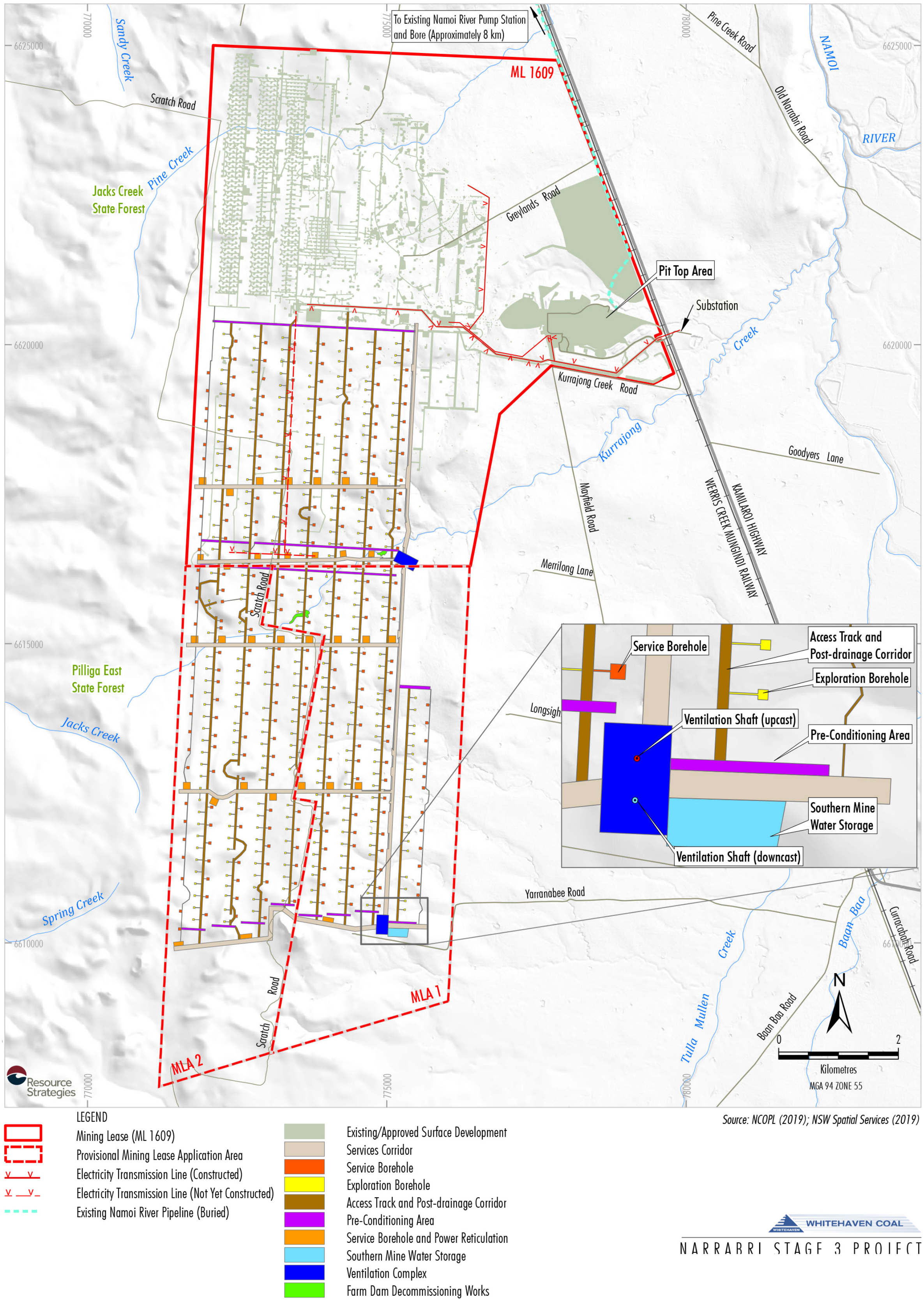


Figure 1.3 - Project General Arrangement - Indicative Surface Development Footprint (Source: Resource Strategies, 2020)

1.4 REPORT STRUCTURE

This report includes a further ten sections:

- Section 2 provides a summary of the relevant SEARs;
- Section 3 outlines the key legislation and guidelines relevant to the assessment;
- Section 4 describes the existing surface water environment including the local drainage characteristics and background water quality;
- Section 5 outlines the existing/approved site water management system;
- Section 6 describes the Project site water management system;
- Section 7 presents the methodology and results of a numerical simulation of the site water balance, including both calibration against historical site data, and the predicted performance of the proposed site water management system;
- Section 8 describes the potential surface water resource impacts of the Project and provides an assessment of the likely magnitude of these impacts;
- Section 9 documents the proposed licensing, management and mitigation measures for the Project;
- Section 10 is a summary of the findings of the Surface Water Assessment; and
- Section 11 is a list of references.

2 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 SEARs. This Surface Water Assessment, which forms part of the EIS, addresses the SEARs concerning surface water.

The key issues identified in the SEARs relating to surface water are provided in Table 2.1, which also identifies the relevant section(s) where the issues have been addressed in this report. Table 2.1 also includes the requirements of the Department of Environment and Energy (now the Department of Agriculture, Water and Environment) (Attachment 3 of the SEARs) (including the advice from the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development [IESC]) and the recommendations of the Mining and Petroleum Gateway Panel (Attachment 4 of the SEARs).

This report addresses the surface water aspects of these SEARs. The groundwater aspects are addressed in the Groundwater Assessment prepared for the Project (AGE, 2020).

Table 2.1 - Coverage of SEARs for the Project – Surface Water

Relevant requirement	Report/EIS section
NSW Department of Planning, Industry and Environment (DPIE)	
The EIS must include an assessment of: • *an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the Mining & Petroleum Gateway Panel's requirements (see Attachment 4) and (Commonwealth) Department of Environment and Energy requirements under the Environment Protection and Biodiversity Conservation Act 1999 (see Attachment 3);*	Section 8, Groundwater Assessment and Agricultural Impact Statement
• *an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, groundwater dependent ecosystems, water-related infrastructure, and other water users;*	Section 8 and Groundwater Assessment
• *an assessment of potential flooding and ponding impacts of the development;*	Sections 8.1 and 8.5
• *a detailed site water balance, including a description of site water demands, water disposal methods (including the location, volume, and frequency of any water discharges and management of discharge water quality), water supply arrangements, water supply and transfer infrastructure and water storage structures; and*	Sections 6 and 7
• *a detailed description of the proposed water management system (including sewerage), beneficial water re-use program and all other proposed measures to monitor and mitigate surface water and groundwater impacts;*	Sections 6 and 9 and Groundwater Assessment

Relevant requirement	Report/EIS section
Department of Agriculture, Water and Environment (Attachment 3 of the SEARs)	
The EIS must include a detailed water assessment. The water assessment must be undertaken in accordance with the IESC Information Guidelines (http://iesc.erlvirurlrnerll.yov.Clu/publiGCllions/information-guidelines-independent-expertscientific- committee-advice-coal-seam-gas) and provide the information outlined in these guidelines including:	This report and the Groundwater Assessment
Confirm the distribution of GOE[1]s (sic) in the region and the depth to groundwater in areas of potential GOE's (sic).	Groundwater Assessment and Biodiversity Development Assessment Report
Conduct a detailed cumulative impact assessment of potential risks to groundwater and surface water ecosystems of the Namoi River catchment that may be impacted by the project.	
Include an assessment of GOEs (sic) as outlined in Paragraph 18 of the IESC advice.	
The EIS should provide surface water modelling which considers water loss from surface waters due to groundwater drawdown, cracking and ponding.	Sections 7 and 8
Include a surface water assessment in accordance with Paragraph 17 of the IESC advice. Include a quantitative site-specific water balance modelling approach as per the recommendations provided in Paragraph 14 of the IESC advice	This report
The EIS should derive site-specific water quality guidelines and provide more information on how they plan to monitor impacts. For example, the parameters and frequency of monitoring should be detailed.	Section 9.3
Mining & Petroleum Gateway Panel's requirements (Attachment 4 of the SEARs)	
The panel requires a landscape management plan to be prepared as part of the EIS detailing how surface cracking and altered drainage patterns will be managed as subsidence occurs. This plan must include detailed mapping of potential BSAL currently not verified	Sections 9.2 and Agricultural Impact Statement
The panel requires a landscape management plan to be prepared as part of the EIS detailing how altered drainage patterns resulting in soil saturation for extended periods will be managed as subsidence occurs	Section 9.2 and Agricultural Impact Statement
The Panel requires more geological detail and baseline data acquisition in any upgraded groundwater model that is to be used in an EIS. Also, any future groundwater flow modelling should include cumulative impact studies of the nearby (proposed) Santos Coal Seam Gas Project. Additional studies are required to more fully identify and evaluate cracking formed from the effects of mining and the possible loss of water in ephemeral streams due to surface cracking.	Sections 8.1 and 8.7, Subsidence Assessment and Groundwater Assessment

[1] GOE assumed to refer to groundwater dependent ecosystems (GDE)

Relevant requirement	Report/EIS section
Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development Advice	
Key potential impacts from this project are: … • *surface water losses and altered stream-flow regimes (e.g. Kurrajong Creek) through surface fracturing, cracking and ponding along drainage lines above the proposed longwalls; and*	Sections 8.1, 8.2, and 8.3
• *cumulative impacts created by the multiple competing demands for water in an already heavily used system.*	Sections 8.6, 8.7 and 8.8
The IESC has identified areas in which additional work is required to assess the materiality of impacts, as detailed in this advice. These are summarised below. • *Surface water modelling informed by baseline stream gauging is required to assess water loss from surface waters due to groundwater drawdown and from cracking and ponding, under a range of climatic scenarios. Additional mitigation measures may be necessary, such as revising the mine layout to reduce subsidence-related strains and stresses experienced at the surface and retiring water licenses to account for the increased loss of surface water through cracking and ponding.*	Section 8.2.2
• *Surface and groundwater quality monitoring is needed, including information on parameters measured and frequency of monitoring, on which to base site-specific water quality guidelines.*	Section 9.3 and Groundwater Assessment
• *A detailed assessment of potential risks to groundwater and surface water ecosystems of the Namoi catchment and a cumulative impact assessment will be required.*	Sections 8.3 and 8.7
f. The influence of faults has not been discussed. The EIS should consider the behaviour of faults, as either barriers, conduits or both. Their potential impacts on the connectivity between groundwater and surface water also need to be considered.	Groundwater Assessment
n. Regional and site-specific data and information on surface-groundwater interactions and GDEs should be provided in the EIS.	Groundwater Assessment
7. Subsidence modelling should be better integrated with the groundwater model. Fracture networks may provide tortuous connection pathways between surface water and groundwater and may modify infiltration rates and water fluxes. Such connections have implications for: a. surface waters, where part or all of creek flows could be re-routed into open cracks and below surface pathways; and	Sections 8.2.2 and 8.4 and Groundwater Assessment
Surface waters 11. No investigations have been undertaken to assess the likely impacts of subsidence and groundwater drawdown on surface waters. Without such analyses, it is not possible to comment on the likelihood and significance of impacts on surface water resources.	Section 8.1

Relevant requirement	Report/EIS section
Surface and receiving waters 16. The Trigger Action Response Plan (TARP) for the existing mine could not be located. However, surface water compliance criteria for the existing mine are stated as being based on the Catchment Action Plan for the Namoi River. Clarification is required as to whether baseline values for water quality (physical-chemical parameters and contaminants) have been established for the existing mine which gained approval in 2011.	Sections 4.5 and 9.1
17. A surface water assessment is needed which: a. includes baseline and event-based monitoring of water quality parameters over a sufficient time period to enable the derivation of appropriate site-specific water quality guideline values. The parameters monitored, frequency of monitoring and actual monitoring data are required;	Sections 4.5 and 9.1
b. uses a risk-based approach to identify key surface waters that might be impacted (e.g. through direct and indirect discharges, subsidence fracturing, ponding or erosion), and considers how the proposal may alter the duration of low- and zero-flow days and potentially impact on instream biota. The proposed development area is drained by ephemeral streams whose flow regime is likely to be altered by subsidence and, potentially, groundwater drawdown. Altered flow regimes will affect the capacity of these ephemeral streams to provide habitat for aquatic species (review in Stubbington et al., 2017) or support the important ecosystem services provided by these types of surface waters (Datry et al., 2018);	Section 8.8.1 and Groundwater Assessment and Biodiversity Development Assessment Report
c. identifies the existing (baseline) hydrological regime of all watercourses within the potential zone of hydrological impacts based on selected site-specific monitoring;	Section 4.5.2
d. uses appropriate surface water quantity and quality data consistent with the ANZG (2018) guidelines for aquatic ecosystem protection to inform impacts and risks; and	Section 3.5 and 4.5.2
e. informs appropriate mitigation strategies (e.g. timing and methods for re-establishing drainage lines to minimise erosion, and actions to be taken when there is a suspected exceedance of a guideline value).	Sections 5.11 and 9.2
Cumulative Impacts 19. A detailed assessment of potential risks to groundwater and surface water ecosystems of the Namoi catchment will be required in the EIS. As the region has one of the highest levels of groundwater extraction in the Murray-Darling Basin (Department of Primary Industries, 2017), a cumulative impact assessment will be required, taking into account overlap in groundwater drawdown with the Narrabri Gas Project, potentially other coal mines to the east of the project, and other water users.	Sections 8.3 and Groundwater Assessment

In addition, this Surface Water Assessment addresses the key surface water-related issues identified in the government agency correspondence relating to SEARs. These key issues are provided in Table 2.2, which also identifies the relevant section(s) where the issues have been addressed in this report.

Table 2.2 - Coverage of other government agency requirements for the Project – Surface Water

Relevant requirement	Report/EIS section
NSW Environment Protection Authority (EPA)	
Water management: The EIS needs to demonstrate that the site will not pollute waters. This includes appropriate management of pollutants generated through coal contact water, sediment-laden water from exposed areas of the site and other activities including any groundwater extraction from the underground mine.	Sections 6 to 8
Impacts related to the following environmental issues need to be assessed, quantified and reported on: • ***Water and Soils*** *including site water balance and sediment and erosion controls during construction and operation phases*	Sections 6 to 8
The EIS must demonstrate how the proposed development will meet the requirements of section 120 of the POEO Act.	Sections 7 to 9
The EIS must include a water balance for the development including water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-use options.	Section 7
If the proposed development intends to discharge waters to the environment, the EIS must demonstrate how the discharge(s) will be managed in terms of water quantity, quality and frequency of discharge and include an impact assessment of the discharge on the receiving environment. This should include:	
• *Description of the proposal including position of any intakes and discharges, volumes, water quality and frequency of all water discharges.*	Sections 6 and 7
• *Description of the receiving waters including upstream and downstream water quality as well as any other water users.*	Section 4
• *Demonstration that all practical options to avoid discharge have been implemented and environmental impact minimised where discharge is necessary.*	Sections 6 and 7
The EIS must refer to Water Quality Objectives for the receiving waters and indicators and associated trigger values or criteria for the identified environmental values of the receiving environment. This information should be sourced from the ANZECC (2000) Guidelines for Fresh and Marine Water Quality (http://www.environment.gov.au/water/policy-programs/nwqms/).	Section 3.5
The EIS must describe how stormwater will be managed in all phases of the project, including details of how stormwater and runoff will be managed to minimise pollution. Information should include measures to be implemented to minimise erosion, leachate and sediment mobilisation at the site. The EIS should consider the guidelines *Managing urban stormwater: soils and construction*, vol. 1 (Landcom 2004) and vol. 2 (A. Installation of services; C. Unsealed roads; D. Main Roads; E. Mines and quarries) (DECC, 2008).	Sections 3.6, 6 and 7

Relevant requirement	Report/EIS section
The EIS must describe any water quality monitoring programs to be carried out at the project site. Water quality monitoring should be undertaken in accordance with the *Approved Methods for the Sampling and Analysis of Water Pollutant in NSW* (2004) which is available at http://www.epa.nsw.gov.au/resources/legislation/approvedmethods-water.pdf.	Sections 4.5 and 9.3
NSW Office of Environment and Heritage (now the DPIE - Biodiversity Conservation Division [BCD])	
The EIS must map the following features relevant to water and soils including: a. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method). b. Wetlands as described in s4.2 of the Biodiversity Assessment Method. c. Proposed intake and discharge locations.	Sections 4 and 7 and Biodiversity Development Assessment Report
The EIS must describe background conditions for any water resource likely to be affected by the project, 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 http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters. d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Sections 3.5, 4, 6 and 7 and Groundwater Assessment
The EIS must assess the impacts of the project on water quality, including: a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the project protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. b. Identification of proposed monitoring of water quality. c. Consistency with any relevant certified Coastal Management Program (or Coastal Zone Management Plan).	Sections 8 and 9 and Groundwater Assessment

Relevant requirement	Report/EIS section
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 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, 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.	Sections 7, 8 and 9 and Biodiversity Development Assessment Report
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). d. Flood hazard.	Sections 3.7, 4.6 and 8.5
The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP, flood levels and the probable maximum flood, or an equivalent extreme event.	Section 8.5
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 14 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Section 8.5
Modelling in the EIS must consider and document: a. Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies. b. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood, or an equivalent extreme flood. c. 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, hazard categories and hydraulic categories. d. Relevant provisions of the NSW Floodplain Development Manual 2005.	Section 8.5

Relevant requirement	Report/EIS section
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. Consistency with any Rural Floodplain Management Plans. d. Compatibility with the flood hazard of the land. e. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. f. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. g. 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. h. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the NSW SES and Council. i. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and Council. j. 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 NSW SES. k. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Section 8.5
Narrabri Shire Council	
a. A Water Balance is to be provided for the project (expansion and intensification) to demonstrate sufficient water supply can be made available for the development and to enable assessment of the impacts of any proposed measures.	Section 7
b. The stormwater generation shall be considered as part of the EIS, including potential erosion and sediment generation. Measures shall be included in the development to mitigate any adverse impacts from stormwater, erosion and sedimentation both on and off site.	Sections 6, 7 and 8.1
NSW Department of Industry	
The SEARS should include: • *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.*	Sections 7.5.2 and 9.4
• *A detailed and consolidated site water balance.*	Section 7

Relevant requirement	Report/EIS section
• *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 and Groundwater Assessment
• *Proposed surface and groundwater monitoring activities and methodologies.*	Section 9.3 and Groundwater Assessment
• *Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the 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 and Groundwater Assessment
NSW Health	
In the preparation of the EIS, proponents should consider and provide discussion, and by no means an exhaustive list;	
• *An assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources;*	Section 8 and Groundwater Assessment
• *An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users;*	Section 8 and Groundwater Assessment
• *An assessment of the potential flooding and ponding impacts of the development;*	Sections 8.1, 8.2.2 and 8.5
• *A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures;*	Section 7
• *A detailed description of the proposed water management system (including sewerage), beneficial water re-use program and all other proposed measures to mitigate surface water and groundwater impacts;*	Section 6

3 Relevant legislation and guidelines

3.1 OVERVIEW

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

- *Water Management Act 2000* (WM Act) and associated water sharing plans (WSPs), which relate to the:
  - taking of waters from the Namoi Regulated River Water Source;
  - taking of waters from the Namoi Unregulated and Alluvial Water Source; and
  - capture of clean water runoff;
- *Protection of the Environment Operations Act 1997* (POEO Act), which sets the limits on pollutant loads from the mine water management systems and sets clear minimum standards for environmental performance;
- *Dams Safety Act 2015* (Dams Safety Act), which relates to the design, construction, monitoring and management requirements of any declared dams on the site or in the surrounding area;
- NSW Government Water Quality and River Flow Objectives, which provide information on the environmental values of receiving waters and the definition of protection level based on ecosystem condition;
- Managing Urban Stormwater Soils and Construction – Volume 2E Mines and Quarries, (Department of Environment and Climate Change [DECC], 2008) and Managing Urban Stormwater, Soils and Construction, (Landcom, 2004), which provides guidelines on suitable management measures for erosion and sediment control;
- Flood Prone Land Policy (outlined in the Floodplain Development Manual [NSW Government, 2005]);
- NSW State Rivers and Estuaries Policy (NSW Water Resources Council, 1993); and
- Significant impact guidelines 1.3: Coal seam gas and large coal mining developments—impacts on water resources (Commonwealth of Australia, 2013) (Significant Impact Guidelines).

The design of the existing and proposed site water management system has considered the requirements of the above legislation, plans, policies and guidelines. Further discussion on the regulatory framework with respect to surface water is provided in the following sections.

3.2 WATER MANAGEMENT ACT 2000

The WM Act establishes licensing regimes for the management of water resources in NSW. The licensing and approvals provisions of the WM Act apply to water sources that are the subject of a WSP.

With respect to surface water, the Project is located in the Lower Namoi River Water Source and Eulah Creek Water Source under the WM Act, as identified in the *Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016* (NRRWSP) and *Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources 2012* (NPUWSP), respectively. The WM Act is therefore relevant to the Project.

3.2.1 Water Sharing Plans

3.2.1.1 Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016 (NRRWSP)

The NRRWSP, which is made under section 50 of the WM Act.

The NRRWSP area is shown on Figure 3.1. The NRRWSP area comprises two water sources in the Namoi River catchment. The Lower Namoi Water Source (in which the Project is located) is located downstream of Keepit Dam.

The NRRWSP allows for some extraction of water from the river and groundwater without a water access licence (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 3.1 shows the categories of access licences in the Lower Namoi Water Source and their total share components in the NRRWSP (as given in the 1 July 2020 version).

The WALs held by NCOPL within the Lower Namoi River Water Source are given in Section 5.6.

Table 3.1 – Lower Namoi River water source share components for different licence categories

Access Licence Category	Lower Namoi River Water Source Share Component	Total Share Component in the NRRWSP Water Sources
Domestic and Stock Access (ML/yr)	1,998	2,088
Regulated River (High Security) Access (Unit Shares)	3,904	3,984
Regulated River (General Security) Access (Unit Shares)	245,074	256,528
Supplementary WALs (Unit Shares)	115,479	115,479
Local Water Utility (ML/yr)	2,271	2,786

3.2.1.2 Water Sharing Plan for the Namoi and Peel Unregulated Water Sources 2012 (NPUWSP)

The NPUWSP, which is made under section 50 of the WM Act, commenced on 4 October 2012 and the current version is dated 1 July 2020. The NPUWSP area comprises 30 water sources in the Namoi River catchment. The water sources of the Namoi Unregulated Rivers Extraction Management Unit of the Namoi Unregulated and Alluvial Water Sources, including the Eulah Creek Water Source (in which the Project is located), are shown in Figure 3.2.

The NPUWSP identifies the requirements for water from these water sources for basic landholder rights (Division 2) and for extraction under access licences (Division 3). The amounts of water specified in the NPUWSP represent the estimated water requirements of persons entitled to basic landholder rights in these water sources and the total volumes or unit shares specified in the share components of all access licences in these water sources.

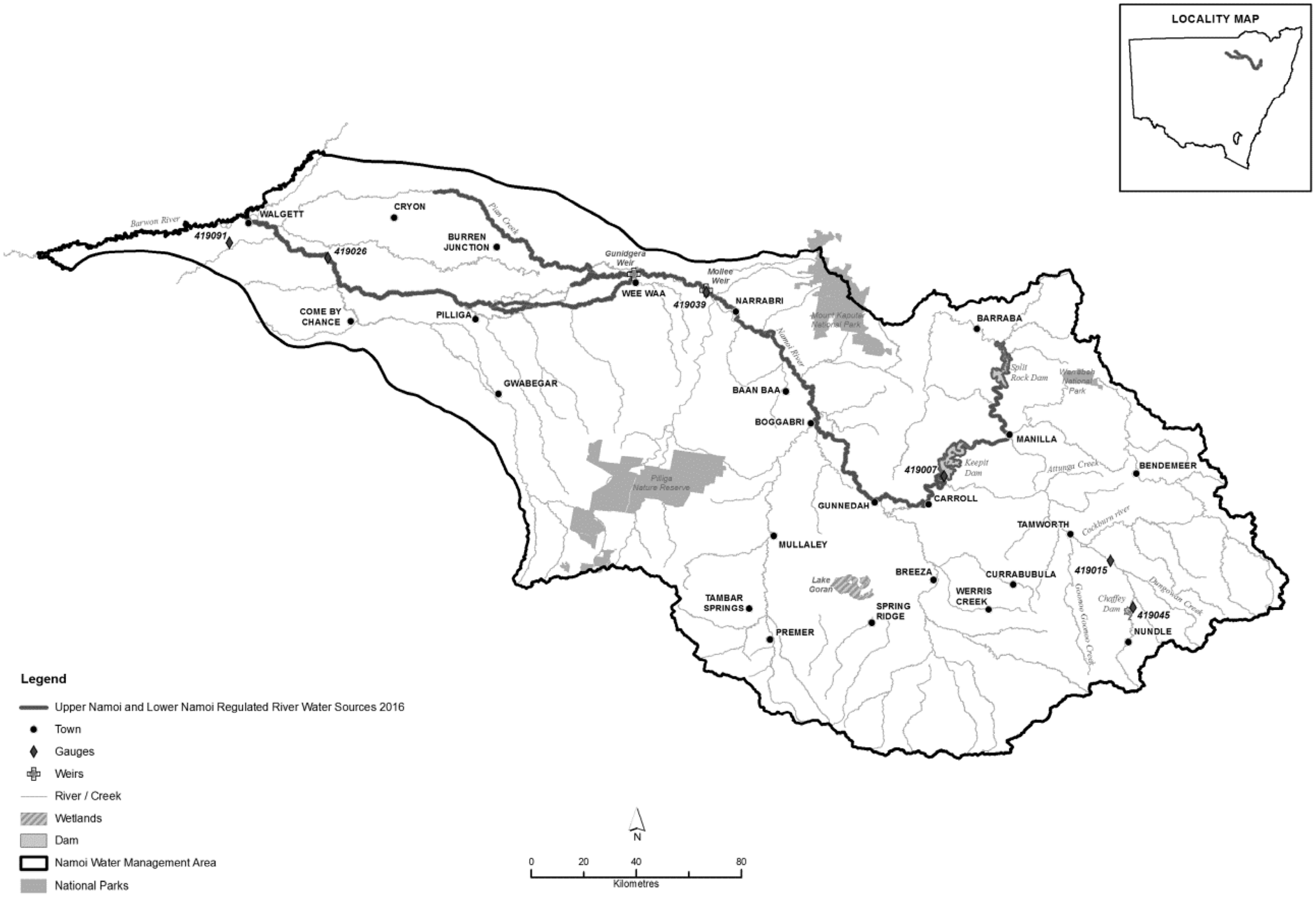


Figure 3.1 – Upper and Lower Namoi regulated water sources (Source: NRRWSP)

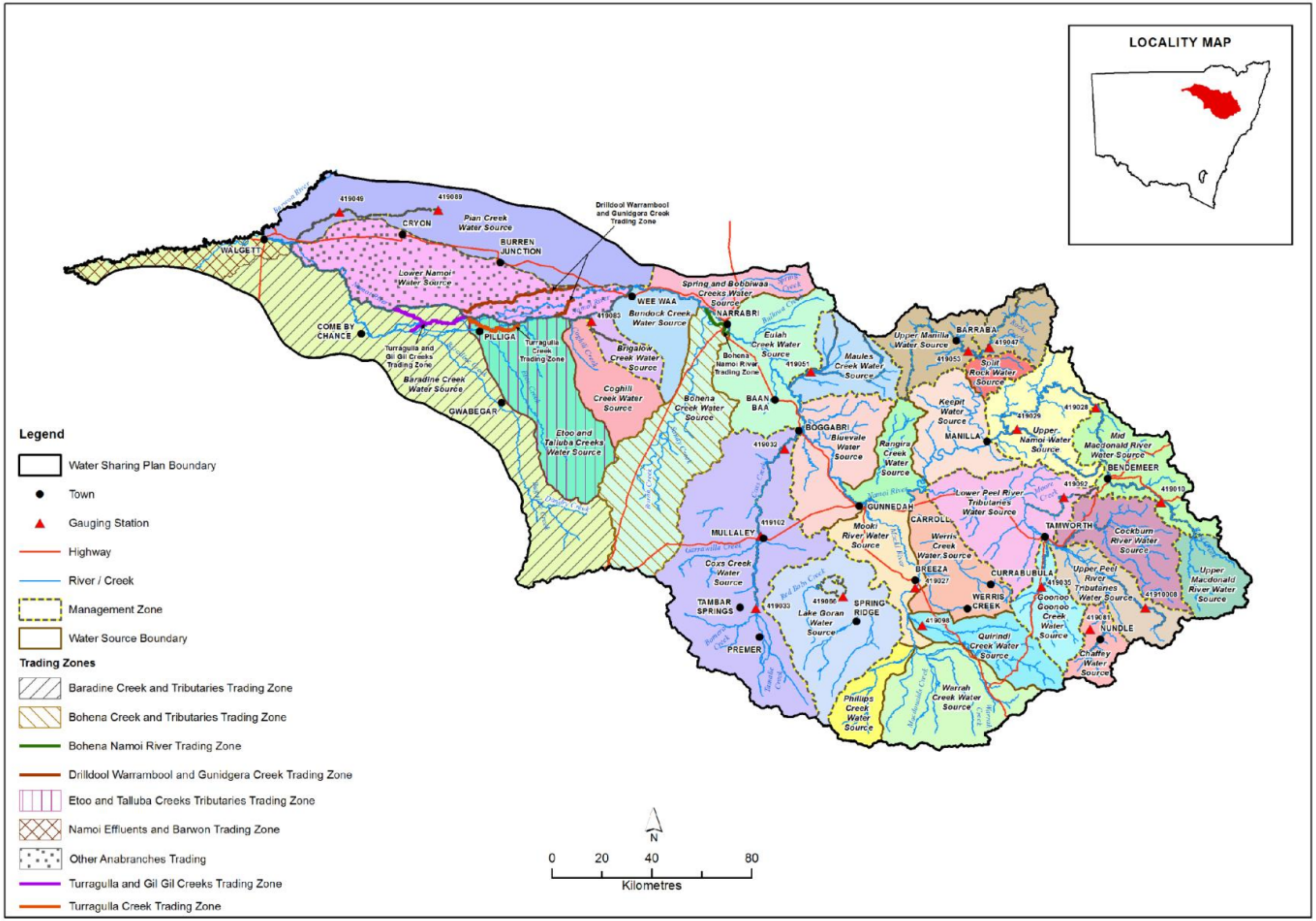


Figure 3.2 – Namoi and Peel unregulated water sources (Source: NPUWSP)

For basic landholder rights (Division 2), the NPUWSP provides 28.4 ML/yr for stock and domestic purposes in the Eulah Creek water source from a total share across the entire plan area of 2,480.2 ML/yr. The requirement for water under harvestable rights in these water sources is equal to the total amount of water that owners or occupiers of landholdings are entitled to capture and store, pursuant to a harvestable rights order made under Division 2 of Part 1 of Chapter 3 of the WM Act.

The order by which a harvestable rights area is constituted must specify the method for calculating the maximum harvestable right volume for works constructed or used in exercise of harvestable rights on landholdings in the area by reference to a proportion (not being less than 10 percent [%]) of the average regional overland flow waters for that area. A harvestable rights assessment for the Project is presented in Section 8.6.

Table 3.2 shows the share components for water extraction under access licences (Division 3) in the Eulah Creek Water Source and their total share components in the NPUWSP (as given in the 1 July 2020 version). The actual volumes of water available for extraction in these water sources at any time will depend on factors such as climatic variability, access licence priority and the rules in the NPUWSP.

Table 3.2 - Eulah Creek water source share components for different licence categories (Division 3)

Access Licence Category	Eulah Creek Water Source Share Component	Total Share Component in the NPUWSP Water Sources
Domestic and Stock Access (ML/yr)	35	993
Unregulated River Access (Unit Shares)	2,034	153,386
Unregulated River (Special Additional High Flow) Access (Unit Shares)	0	729
Aquifer Access Licences (Unit Shares)	0	4,968
Aquifer (General Security) Access (Unit Shares)	0	2,311
Local Water Utility (ML/yr)	0	8,333

3.2.2 Excluded works

Item 12 of Schedule 4 of the Water Management (General) Regulation 2018 provides WAL 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.*

The Project water management dams are considered to be excluded works under item 3, Schedule 1 of the Water Management (General) Regulation, 2018 (Section 8.6).

3.2.3 Other Water Management Act 2000 Approvals

A water use approval under section 89, a water management work approval under section 90 or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act would not be required if a Development Consent is granted under Part 4 of the EP&A Act (see Section 4.41 of the EP&A Act).

3.3 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The POEO Act is the key piece of environment protection legislation administered by the EPA. The POEO Act enables the government to set protection of the environment policies that provide environmental standards, goals, protocols and guidelines. The POEO Act also establishes a licensing regime for pollution generating activities in NSW. Under section 48, an environment protection licence (EPL) is required for "scheduled activities", which includes coal mining. NCOPL currently holds EPL 12789 for operations at Narrabri Mine.

Table 3.3 shows the EPL 12789 water quality limits for wet weather releases from the Narrabri Mine sediment dams.

Table 3.3 – EPL 12789 wet weather water quality releases limits

Pollutant	Units	Limit
Oil and grease	mg/L	10
pH		6.5 – 8.5
Total suspended solids	mg/L	50

Note: mg/L = milligrams per litre.

EPL 12789 also states that the total suspended solids (TSS) concentration limit (Table 3.3) specified may be exceeded for water releases provided that:

a) the discharge occurs solely as a result of rainfall measured at the premises that exceeds 38.4 millimetres (mm) over any consecutive 5 day period immediately prior to the discharge occurring; and
b) all practical measures have been implemented to dewater all sediment dams within 5 days of rainfall such that they have sufficient capacity to store run off from a 38.4 mm, 5 day rainfall event.

The 38.4 mm rainfall event referred to above equates to the 5 day 90th percentile rainfall depth for Gunnedah sourced from Table 6.3a in Landcom (2004).

In addition, EPL 12789 allows for excess filtered water to be transferred via the approved Namoi River pipelines to the Namoi River for controlled release to the Namoi River. EPL 12789, includes the following water quality release criteria:

- 50th percentile of all samples (volume based) are below 250 mg/L of Total Dissolved Solids (TDS);
- 100th percentile of all samples (volume based) are below 350 mg/L of TDS; and
- pH values of all sampled water to be between 6.5 and 8.5.

3.4 DAMS SAFETY ACT 2015

The Dams Safety Act establishes the role of the Dams Safety NSW (DSNSW) to ensure the safety of dams in NSW, including surveillance of declared dams. The DSNSW is empowered with various enabling functions under the Dams Safety Act and the *Mining Act 1992*. The DSNSW has a general responsibility for the safety of all dams, and a special responsibility for declared dams. Determination of whether a dam is a declared dam is based on an assessment of its consequence category, which considers potential downstream impacts of dam failure.

The DSNSW has declared all of the dams located in the Pit Top Area rail loop (Dams A1, A2, A3, B, C and D) with a significant consequence category under the Dams Safety Act.

3.5 NSW WATER QUALITY AND RIVER FLOW OBJECTIVES

The NSW Government have published online the NSW Water Quality and River Flow Objectives (the Objectives). The Objectives are the agreed environmental values and long-term goals for NSW's surface waters. They set out:

- the community's values and uses for rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water); and
- a range of water quality indicators to help assess whether the current condition of our waterways supports those values and uses.

The Objectives are consistent with the agreed national framework for assessing water quality set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australia and New Zealand Environment and Conservation Council [ANZECC] and Agriculture and Resource Management Council of Australia and New Zealand [ARMCANZ], 2000) (the ANZECC/ARMCANZ Guidelines). The ANZECC/ARMCANZ Guidelines provide an agreed framework to assess water quality in terms of whether the water is suitable for a range of environmental values (including human uses). The Objectives provide environmental values for NSW waters and the ANZECC/ARMCANZ Guidelines provide the technical guidance to assess the water quality needed to protect those values. Note that the ANZECC/ARMCANZ Guidelines have been superseded by the national Water Quality Guidelines and Australian & New Zealand Guidelines for Fresh and Marine Water Quality (ANZG) (2018).

The Objectives include the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses.

Specific environmental values for uncontrolled streams in the Namoi River catchment including the Project area are protection of:

- aquatic ecosystems;
- visual amenity;
- primary contact recreation;
- secondary contact recreation;
- livestock water supply;
- irrigation water supply;
- homestead water supply;
- drinking water at point of supply - disinfection only;
- drinking water at point of supply - clarification and disinfection;
- drinking water at point of supply - groundwater; and
- aquatic foods (cooked).

River flow objectives are:

- protect pools in dry times;
- protect natural low flows;
- protect important rises in water levels;
- maintain wetland and floodplain inundation;
- manage groundwater for ecosystems; and
- minimise effects of weirs and other structures.

Default trigger values for water quality indicators relevant to the various environmental values from the Namoi River Water Quality and River Flow Objectives[2] are shown in Table 3.4.

3.6 MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION

Managing Urban Stormwater: Soils and Construction (Landcom, 2004) provides guidance on best practice management measures for erosion and sediment control during construction and other land disturbance activities. A specific volume (2E: Mines and Quarries) provides specific advice on appropriate measures and design standards for mining operations. The design of erosion and sediment control measures for the Narrabri Mine has been based on the recommended approaches and design criteria from these documents.

Erosion and Sediment Control Plans for the Narrabri Mine, which utilise these guidelines, is provided in the Water Management Plan (NCOPL, 2013) and the Extraction Plan Water Management Plan LW107 to LW110 (NCOPL, 2017).

3.7 NSW STATE RIVERS AND ESTUARIES POLICY

The NSW State Rivers and Estuaries Policy (NSW Water Resources Council, 1993) contains state-wide objectives for the protection and enhancement of watercourses. The proposed surface water management should be consistent with the NSW State Rivers and Estuaries Policy objectives.

3.8 NSW FLOOD PRONE LAND POLICY

The Floodplain Development Manual (NSW Government, 2005) (the Manual) has been prepared in support of the Flood Prone Land Policy. The primary objective of the policy is to develop sustainable strategies for managing human occupation and use of the floodplain using risk management principles. The Manual provides a framework for implementing the policy to achieve the policies primary objective. It also outlines processes for ensuring these needs are addressed through the development of floodplain management plans (FMPs).

The Office of Environment and Heritage (OEH) (now the Department of Planning, Industry and Environment [DPIE] – Biodiversity Conservation Division [BCD]) has developed a FMP for the Upper Namoi Valley Floodplain in pursuance of section 50 of the WM Act.

FMP’s for the local tributaries that cross the existing Narrabri Mine or MLAs 1 and 2 have not been developed to date.

[2] https://www.environment.nsw.gov.au/ieo/Namoi/index.htm

Table 3.4 - Water quality trigger values

Parameter	Unit	Trigger Value						
		Irrigation	Livestock Drinking	Ecosystem[1]	Recreation	Homestead Water Supply	Drinking Water for Disinfection	Aquatic Foods
pH	pH	6.0 - 9.0	-	6.5 - 8.0	5.0 - 9.0	6.5 - 8.5	6.5 - 8.5	-
Electrical Conductivity (EC) (uncompensated)	µS/cm	1,000[2]	-	-	-	-	-	-
EC (25C)	µS/cm	-	-	30 - 350	-	-	<1500	-
Dissolved Oxygen (% Saturation)	%	-	-	90 - 110	-	-	-	-
Total Dissolved Solids (TDS)	mg/L	-	2,000[2]	-	1,000	<500 - 1000	-	-
Turbidity	NTU[7]	-	-	2 - 25	6	5	-	-
Calcium (Ca)	mg/L	-	1000	-	-	-	-	-
Sodium (Na)	mg/L	115[3]		-	300	-	-	-
Magnesium (Mg)	mg/L	-	2,000[4]	-	-	-	-	-
Sulphate as SO_4	mg/L	-	1000	-	400	-	-	-
Chloride as Cl	mg/L	175[3]	-	-	400	-	-	-
Aluminium	mg/L	5[6]	5	-	0.2	-	-	-
Arsenic	mg/L	0.1[6]	0.5[2]	0.013[2, 5]	0.05	-	-	-
Barium	mg/L	-	-	-	1	-	-	-
Beryllium	mg/L	0.1[6]	-	-	-	-	-	-
Cadmium	mg/L	0.01[6]	0.01	0.0002[5]	0.005	-	-	-
Chromium	mg/L	0.1[6]	1	0.001[5]	0.05	-	-	-
Cobalt	mg/L	0.05[6]	1	-	-	-	-	-
Copper	mg/L	0.2[6]	0.4[2]	0.0014[5]	1	-	-	0.005
Iron	mg/L	0.2[6]	-	-	0.3	-	-	-
Lead	mg/L	2[6]	0.1	0.0034[5]	0.05	-	-	-
Manganese	mg/L	0.2[6]	-	1.9[5]	0.1	-	-	-
Mercury	mg/L	0.002[6]	0.002	0.0006[5]	0.001	-	-	0.001
Nickel	mg/L	0.2[6]	1	0.011[5]	0.1	-	-	-
Selenium	mg/L	0.02[6]	0.02	0.011[5]	0.01	-	-	-
Vanadium	mg/L	0.1[6]	-	-	-	-	-	-
Zinc (Zn)	mg/L	2[6]	20	0.008[5]	5	-	-	0.005

Parameter	Unit	Trigger Value						
		Irrigation	Livestock Drinking	Ecosystem[1]	Recreation	Homestead Water Supply	Drinking Water for Disinfection	Aquatic Foods
Ammonia	mg/L	-	-	0.013	-	-	-	-
Total phosphorus (Total P)	mg/L	0.05[6]	-	0.02	-	-	-	-
Total nitrogen (Total N)	mg/L	5[6]	-	0.25	-	-	-	-
NOx	mg/L	-	-	0.015	-	-	-	-
Nitrate-N	mg/L	-	400	0.7[5]	10	-	-	-
Nitrite-N	pH	-	30	-	1	-	-	-

Source: *Namoi River Water Quality and River Flow Objectives* (https://www.environment.nsw.gov.au/ieo/Namoi/index.htm.
Notes: - No Trigger Value recommended

[1] Upland River

[2] Lowest recommended value

[3] Sensitive crops

[4] Cattle (insufficient information on other livestock)

[5] 95% of species protected

[6] Long term Trigger Value

[7] NTU = Nephelometric Turbidity Units

3.9 SIGNIFICANT IMPACT GUIDELINES 1.3: COAL SEAM GAS AND LARGE COAL MINING DEVELOPMENTS—IMPACTS ON WATER RESOURCES

In June 2013, the Federal Government enacted changes to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), to provide that 'water resources' are a matter of national environmental significance in relation to coal seam gas and large coal mining development. This change is referred to as the 'water trigger'. In December 2013, the Department of the Environment and Energy released guidelines for proponents of coal seam gas and large coal mining projects to assess the potential for significant impacts on water resources.

The Project was deemed a 'controlled action' on 30 September 2019 (including water resources) (EPBC 2019/8427). The elements of the Project which require EPBC Act approval (i.e. "the Action") exclude the approved Narrabri Mine, which was previously referred in 2009 and determined to be "a controlled action" (EPBC 2009/5003) (last varied on 19 March 2020).

4 Existing surface water environment

4.1 RAINFALL AND EVAPORATION

Daily rainfall data has been recorded at Narrabri Mine Pit Top Area since April 2008. Figure 4.1 shows a comparison of average monthly rainfalls recorded at the site against monthly average rainfall obtained from the SILO Data Drill service (Jeffrey et al., 2001) for the site over the common period between April 2008 and March 2020. Figure 4.1 shows the general trend in monthly rainfall between the two datasets is the same. The monthly SILO data is generally slightly lower than the site monthly data but is sufficient to provide a reasonable representation of the long-term rainfall at Narrabri Mine, and has been adopted for this study.

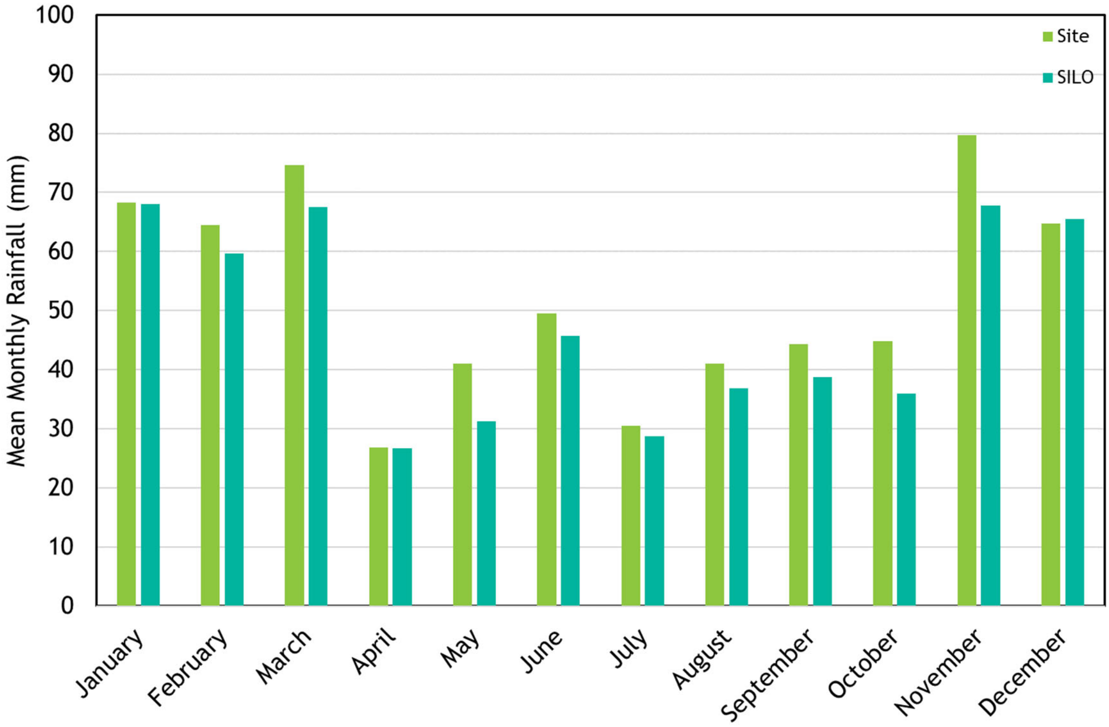


Figure 4.1 – Narrabri Mine rainfall and SILO rainfall monthly mean rainfall comparison, April 2008 to March 2020

Table 4.1 shows the long-term seasonal variation in average monthly rainfall and potential evaporation (determined using the FAO-56 Penman Monteith equation) for the Narrabri Mine based on 131 complete years (1889 to 2020) of interpolated data from the SILO Data Drill. The recorded Bureau of Meteorology (BOM) rainfall averages at the Boggabri Post Office (BOM Station 5007) over the period 1884 to 2020 is also shown for comparison. The Boggabri Post Office rainfalls, which have not been corrected for missing data, closely resemble the SILO Data.

The mean and median annual rainfalls at the Narrabri Mine are estimated at 603 mm and 597 mm, respectively. The annual rainfalls can vary considerably from year to year. Based on the 131 years of record, the 10% and 90% annual rainfalls are estimated at 368 mm and 810 mm, respectively. Of note, only 205 mm was recorded at the Narrabri Mine during 2019, which is the lowest annual rainfall over the 131 year period. In fact, it is over 100 mm lower than the previous lowest annual rainfall.

Table 4.1 – Mean monthly and annual rainfall and potential evaporation at the Narrabri Mine based on SILO Data Drill and mean monthly rainfall at Boggabri PO

Month	Mean rainfall at Boggabri PO (mm)	SILO Data	
		Mean rainfall (mm)	Mean potential evaporation (mm)
January	72	78	200
February	64	59	166
March	47	51	152
April	33	35	105
May	41	43	74
June	44	47	53
July	41	42	58
August	38	37	77
September	38	38	106
October	50	50	148
November	59	59	174
December	62	65	199
Annual	590	603	1,502

Note: Mean annual value will not necessarily equal the total of mean monthly values due to rounding.

The mean monthly rainfalls vary during the year from a low of 35 mm in April to a high of 78 mm in January. The summer average monthly rainfalls (59 mm to 78 mm) are generally higher than the equivalent winter month rainfalls (37 mm to 47 mm).

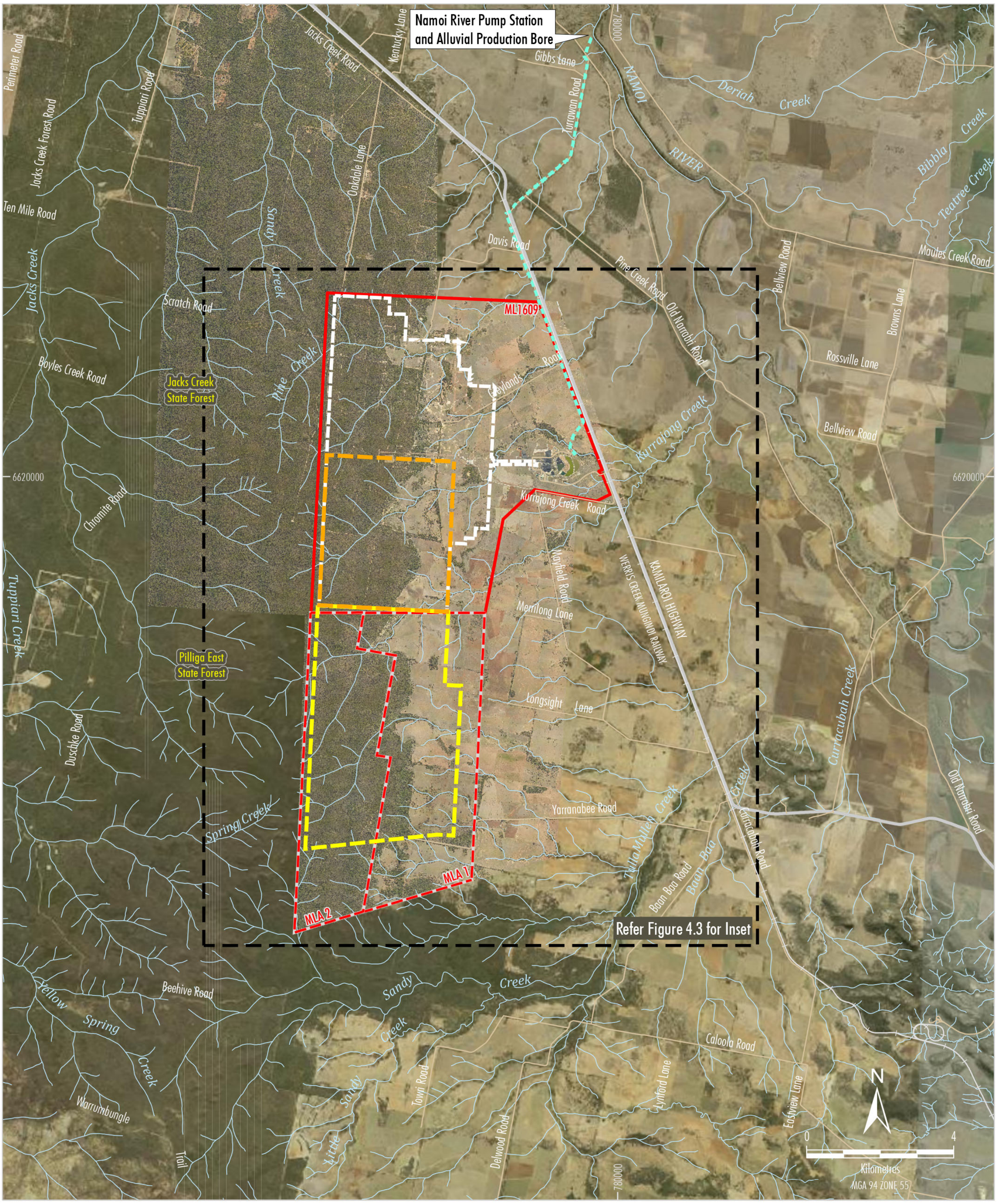
The mean and median annual potential evaporation is estimated at 1,502 mm and 1,499 mm, respectively. Evaporation varies seasonally, with high evaporation rates occurring in the months between October and March. The values in Table 4.1 indicate that the potential evaporation rate during the summer months is greater (up to almost 3 to 4 times) than the evaporation rate during the winter months. In addition, average potential evaporation exceeds average rainfall for all months of the year.

4.2 REGIONAL DRAINAGE

The Project is located in the Namoi River catchment and within the tributary catchments of Kurrajong Creek, Pine Creek and Tulla Mullen Creek (Figure 4.2 and Figure 4.3). The Namoi River flows in a north-westerly direction at a distance of approximately 4 km to 5 km to the north and east of the Project area (Figure 1.1).

The Namoi River stretches for over 350 km, with a catchment extending from the Great Dividing Range in the east to Walgett in the west where the Namoi River discharges into the Barwon River. Some of the Namoi River's major tributaries include the Peel River, Mooki River, Manilla River, Coxs Creek, Baradine Creek and Pian Creek. It has a total catchment area of approximately 42,000 square kilometres (km^2) to Walgett.

The Namoi River catchment has been used extensively for agricultural activities for over 100 years. It is one of Australia's most developed irrigation areas, supporting significant cotton and broad acre cropping (mainly sorghum, sunflower and wheat) as well as other crops, and some sheep and cattle grazing.



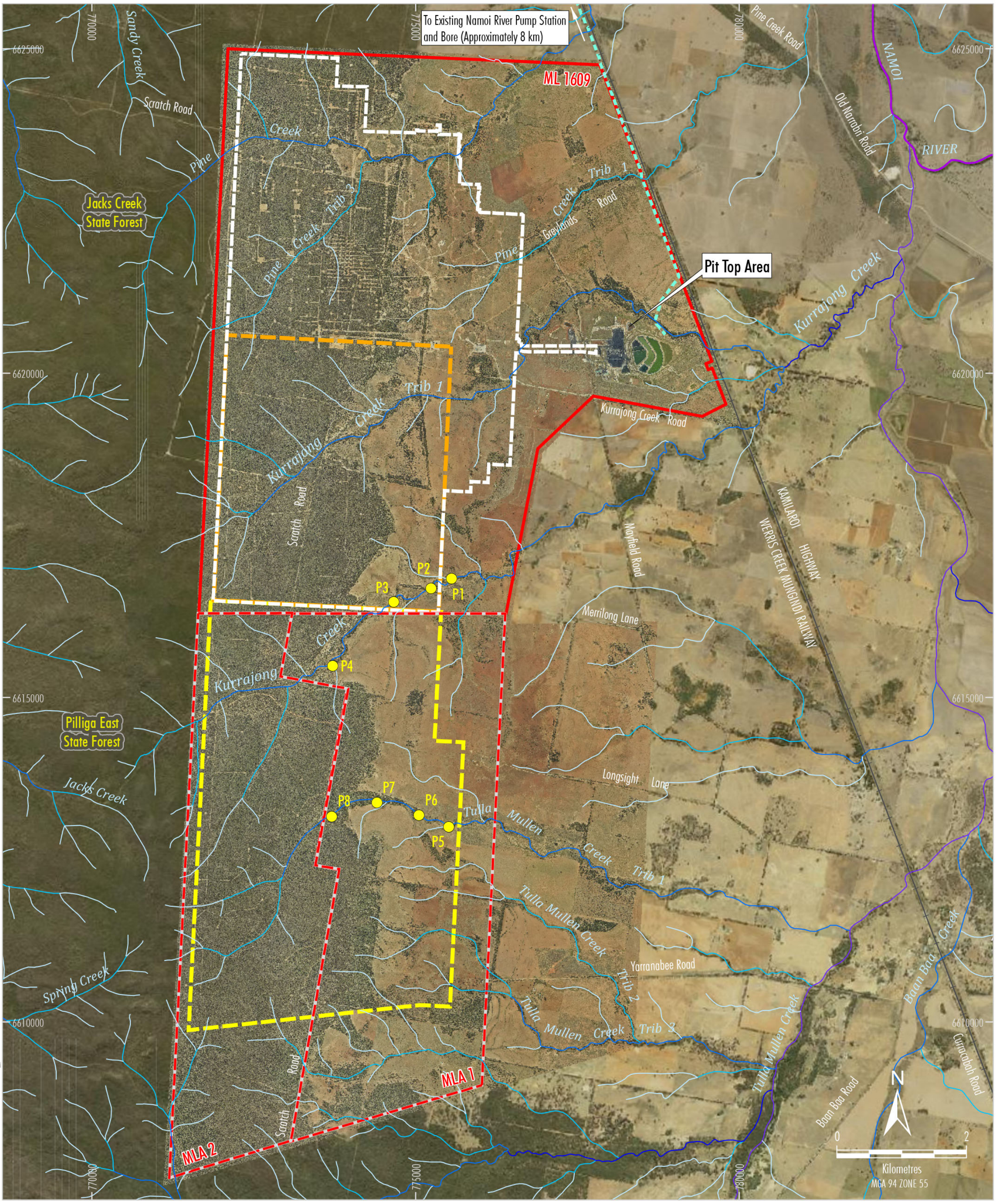
LEGEND
- Mining Lease (ML 1609)
- Provisional Mining Lease Application Area
- Existing Namoi River Pipeline (Buried)
- Approved Underground Mine Footprint
- Underground Mine Footprint to be Extended for Project
- Project Underground Mine Footprint

Source: NCOPL (2019); NSW Spatial Services (2019); WRM (2019)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Figure 4.2 – Local watercourse and drainage features across ML 1609 and MLAs 1 & 2



LEGEND

- Mining Lease Boundary (ML 1609)
- Provisional Mining Lease Application Area
- Existing Namoi River Pipeline (Buried)
- Approved Underground Mine Footprint
- Underground Mine Footprint to be Extended for Project
- Project Underground Mine Footprint
- Photo Location

Strahler Stream Order: 1, 2, 3, 4, 5, 9

Source: NCOPL (2019); NSW Spatial Services (2019); WRM (2020)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Figure 4.3 - Local watercourse and drainage features across ML 1609 and MLAs 1 & 2

There are a number of major storages in the Namoi River catchment, namely the Keepit, Chaffey and Split Rock dams located on the Namoi, Peel and Manilla Rivers, respectively, which provide water for the licensed water users in the region.

4.3 LOCAL DRAINAGE

The approved Narrabri Mine (ML 1609) is located within the catchments of Kurrajong and Pine Creeks, as shown in Figure 4.2. Pine Creek and its tributaries traverse through the northern part of ML 1609, before entering the Namoi River 4.7 km downstream of the Turrawan stream gauging station. The Project would not change the approved potential impacts to Pine Creek and its tributaries.

MLAs 1 and 2 are located in the Kurrajong Creek and Tulla Mullen Creek tributary catchments as shown in Figure 4.3. Both of these tributaries drain to Tulla Mullen Creek to the east of the Project. These creeks are all ephemeral with minimal to no baseflow. Several farm dams are located across the drainage lines. Descriptions of these catchments is given below.

Figure 4.3 also shows the Strahler stream order of the creeks defined using the methodology described in Schedule 2 of the Water Management (General) Regulation 2018. The Strahler system is based on the confluence (joining) of streams of the same order. A first (1^{st}) order stream has no other streams flowing into it. When two streams with different orders join, the resulting stream has the same order as the highest order of the two joining streams. For example, when a 1^{st} and second (2^{nd}) order stream join, the resulting stream is 2^{nd} order. When two streams with the same order join, the resulting stream has the next highest order than the joining streams.

4.3.1 Kurrajong Creek

Kurrajong Creek originates to the west of the Project within the Pilliga East State Forest (see Figure 4.3). It drains in a north easterly direction across the Project area. Across the Project area, the main Kurrajong Creek channel is a third (3^{rd}) order watercourse under the Strahler stream ordering system. The catchment area of Kurrajong Creek to the eastern Project area boundary is 15.8 km^2.

Figure 4.4 and Figure 4.5 provide photographs of the Kurrajong Creek channel at four locations. The locations of the photographs are shown in Figure 4.3. A description of the creek channel at each photograph location is given in Table 4.2.

Of particular note is the difference in channel shape downstream of and across the Project area. There is a 4 metre (m) drop separating the downstream incised channel and the upstream ill-defined channel. This drop, or headcut, is located between P1 and P2 immediately downstream of MLAs 1 and 2 (see Figure 4.6). The drop is associated with historical headward erosion of the channel bed (i.e. not due to the existing Narrabri Mine) and would likely continue to progress upstream with successive flood events.

A review of available historical aerial imagery (Google Earth) would suggest that there has been no material upstream movement of the head cut between 2007 and 2019. However, the channel has widened between these dates. It is expected that both lateral erosion and potentially headward erosion will continue at this location if not controlled.

Upstream of location P4, the stream has similar channel characteristics to location P3 but has a bed slope of approximately 1.1%. The upper reach drains through the Pilliga East State Forest.

Note also that it was very dry at the time of the site inspection (November 2019) with little evidence of in-channel ponding. However, a review of the lidar topography of the channels suggest that numerous small water holes have potential to exist along the channels.

Figure 4.4 – Photographs of Kurrajong Creek, Locations P1 and P2

Figure 4.5 – Photographs of Kurrajong Creek, Locations P3 and P4

Table 4.2 – Kurrajong Creek channel descriptions

Location	Description
P1	• *Located downstream of the mining area and about 100 m downstream of a channel headcut (looking downstream).* • *Creek channel is incised with vertical banks about 0.8 m deep and about 10 m wide.* • *Bed slope approximately 0.41%.* • *Bed material consists of coarse sand.* • *Right bank floodplain consists of a 20 m wide lower bench about 1 m above the channel bank followed by a 40 m wide bench about 1 m higher.* • *Left bank floodplain rises at a consistent 10% gradient to an upper terraced located about 4 m above the channel.*
P2	• *Located at the downstream edge of Longwall 203 (looking upstream).* • *Creek channel consists of a broad flow path with no recognised low flow channel.* • *Bed slope approximately 0.43%.* • *Left and right bank floodplains rise at a consistent 5% gradient.* • *Bed material consists of a sandy loam with intermittent sand deposition.* • *Intermittent scour is evident on some outside bends.*
P3	• *Located at the downstream edge of Longwall 204 (looking upstream).* • *Creek channel consists of a broad flow path with a minor low flow channel.* • *Bed slope approximately 0.8%.* • *Left and right bank floodplains rise at a consistent 10% gradient.* • *Bed material consists of a sandy loam.* • *Grassed channel indicating it may retain water following rainfall.*
P4	• *Located at the downstream edge of Longwall 206 (looking upstream at an in-channel dam).* • *Creek channel and floodplain similar to location P3.* • *Bed slope approximately 0.94%.* • *Farm dam includes spillway on right hand side of channel, which appears stable at the upper end but erosion is evident at the lower end as it drains back into the channel.* • *Bed material consists of a sandy loam.* • *Upper catchment wholly within the Pilliga East State Forest.*

Figure 4.6 – Kurrajong Creek head cut located between P1 and P2

4.3.2 Tulla Mullen Creek Trib1

Tulla Mullen Creek Trib1 (tributary) also originates to the west of the Project within the Pilliga East State Forest (see Figure 4.3). It drains in a northeasterly and then easterly direction across the MLA 1 and MLA 2 areas before it drains into Tulla Mullen Creek upstream of the Kamilaroi Highway. Tulla Mullen Creek Trib1 channel is a 1st order watercourse under the Strahler stream ordering system as it drains into the most western longwall panel (Longwall 209). It becomes a 3rd order watercourse as it crosses Longwall 207. The catchment area of Tulla Mullen Creek Trib1 to the downstream Project boundary is 8.2 km^2.

Figure 4.7 and Figure 4.8 show photographs of the Tulla Mullen Creek Trib1 channel at four locations. The locations of the photographs are shown in Figure 4.3. A description of the tributary channel at each photograph location is given in Table 4.3.

4.3.3 Minor tributaries

A number of 1st and 2nd order watercourses drain to Kurrajong Creek and the Tulla Mullen Creek tributaries across the Project area. These tributaries are generally steeper than the main channels of Kurrajong Creek and Tulla Mullen Creek Trib1. They are also generally without an incised channel but drain as broad overland flows or broad V-shaped valleys. Many of these minor tributary catchments contain contour banks that direct runoff to the tributary channels. It would appear that the contour banks have been installed to both minimise surface erosion and to direct runoff to farm dams for agricultural purposes.

Figure 4.7 – Photographs of Tulla Mullen Creek Trib1, Locations P5 and P6

Figure 4.8 – Photographs of Tulla Mullen Creek Trib1, Locations P7 and P8

Table 4.3 – Tulla Mullen Creek Trib1 channel descriptions

Location	Description
P5	• *Located approximately at the centre of Longwall 210 (looking upstream).* • *Creek channel consists of a low flow channel some 2 m wide that meanders through a terrace elevated about 0.5 m to 1 m above the base of the lower flow channel.* • *The lower terrace is about 25 m to 30 m wide with banks sloping up at gradients exceeding 10%.* • *Bed slope approximately 0.96%.* • *Bed material consists of a sandy loam with no obvious sediment deposition.* • *Lower terraces are vegetated with mature trees.*
P6	• *Located between Longwall 210 and Longwall 203 (looking upstream).* • *Creek channel is generally V-shaped channel with a 2 m wide base.* • *The left-hand floodplain consists of a 30 m wide high level bench that is about 1 m above the channel bed.* • *The right-hand floodplain rises at a gradient of over 20% to an upper level terrace that is about 2 m above the channel bed. Inundation of the upper terrace would only occur during rare flood events if at all.* • *Bed slope approximately 1.0%.* • *Bed material consists of a sandy loam with a covering of grass.*
P7	• *Located approximately at the centre of Longwall 204 (looking upstream).* • *Creek channel generally V-shaped with a 2 m wide base.* • *Channel banks rise at gradients exceeding 15%.* • *Bed slope approximately 1.1%.* • *Bed material consists of a sandy loam.* • *Black pine located within the channel indicating sandy soils.*
P8	• *Located at Longwall 205.* • *Creek channel generally V-shaped with a 1 m wide base.* • *Bed slope approximately 1.2%.* • *Channel banks rise at gradients exceeding 20%.* • *Bed material consists of a sandy loam with a covering of woody debris.* • *Upper catchment wholly within the Pilliga East State Forest.*

4.3.4 Existing subsidence impacts

The surface water impacts in Pine Creek Trib1 and Pine Creek associated with existing subsidence (e.g. ponding) above Longwalls 101 to 109 are generally consistent with the predicted impacts (WRM, 2015), with maximum ground subsidence depths up to approximately 2.75 m.

4.4 FARM DAMS

There are 129 farm dams in the Project area, none of which are declared dams under the Dams Safety Act.

There are 176 existing farm dams on contiguous land owned by NCOPL within and in the vicinity of the Project area (Figure 4.9), none of which are declared dams under the Dams Safety Act. These farm dams are mostly less than 1 ML in capacity.

For the purpose of restoring flow in watercourses within and in the vicinity of the Project area, NCOPL has indicated that some of the existing farm dams within land owned by NCOPL would be decommissioned. The two farm dams located on Kurrajong Creek would be decommissioned as part of the Project and other farm dams would be decommissioned (subject to obtaining relevant approvals).

4.5 SURFACE WATER QUALITY

4.5.1 Regional water quality

Basic water quality indicators such as EC, turbidity, TSS, and nutrients were monitored on a monthly basis for the five-year Namoi Water Quality Project study, starting in July 2002. Residues of herbicides and insecticides were also measured. The study found the following:

- The majority of sites had median EC results that did not meet the ANZECC and ARMCANZ default trigger values for the protection of aquatic ecosystems of south-eastern Australia. Median EC values were below 650 micro Siemens per centimetre (µS/cm) below Boggabri, which is suitable for irrigation water.
- Median total phosphorus and total nitrogen in excess of the ANZECC and ARMCANZ default trigger values in conjunction with low flows were also experienced.
- All sites in the Namoi river basin were found to have high enough total phosphorus concentration present to encourage algae growth.

Water quality of the Namoi River is generally characterised by moderate alkalinity and elevated EC relative to the default trigger values for ecosystem protection in upland rivers (>150 m altitude) in the ANZECC/ARMCANZ Guidelines. EC values in the Namoi River at Gunnedah (Station 419001) have ranged between 200 µS/cm and 900 µS/cm every year since 2001 and there is no significant trend to the data (Advisian, 2018).

4.5.2 Background and receiving water quality

Surface water quality monitoring has been undertaken by NCOPL at ten sites on the watercourses draining the Narrabri Mine since July 2007 in accordance with the Water Management Plan (NCOPL, 2013) and the Extraction Plan Water Management Plan LW107 to LW110. In addition, NCOPL established surface water monitoring sites on Tulla Mullen Creek Trib1 and Trib2 in 2017 (UT1DS and UT2DS) and another on Kurrajong Creek Trib 1 (KC1TOP) to establish background water quality in the MLA 1 and MLA 2 areas. Figure 4.10 shows these surface water monitoring locations.

Sampling has been undertaken during or immediately following flow events, for EC, pH, TSS, oil and grease and total organic carbon (TOC). Note that there is minimal disturbance due to the existing Narrabri Mine operations within the catchment areas draining to monitoring sites KCUS, KCDS, KC1US, KC2US, UT1DS and UT2DS other than minor disturbance for exploration works. Monitoring sites KC1DS and KC2DS are downstream of the Pit Top Area and may be affected if there are discharges of disturbed runoff from the sediment dams at the Narrabri Mine. Monitoring locations PC1 and PC are located downstream of longwall panel subsidence and gas pre-drainage drill sites. Limited data is available at KC1TOP, PCUS and PC3US due to the difficulty of access and the very short window of opportunity to collect samples due to the sites being at the top of the catchment.

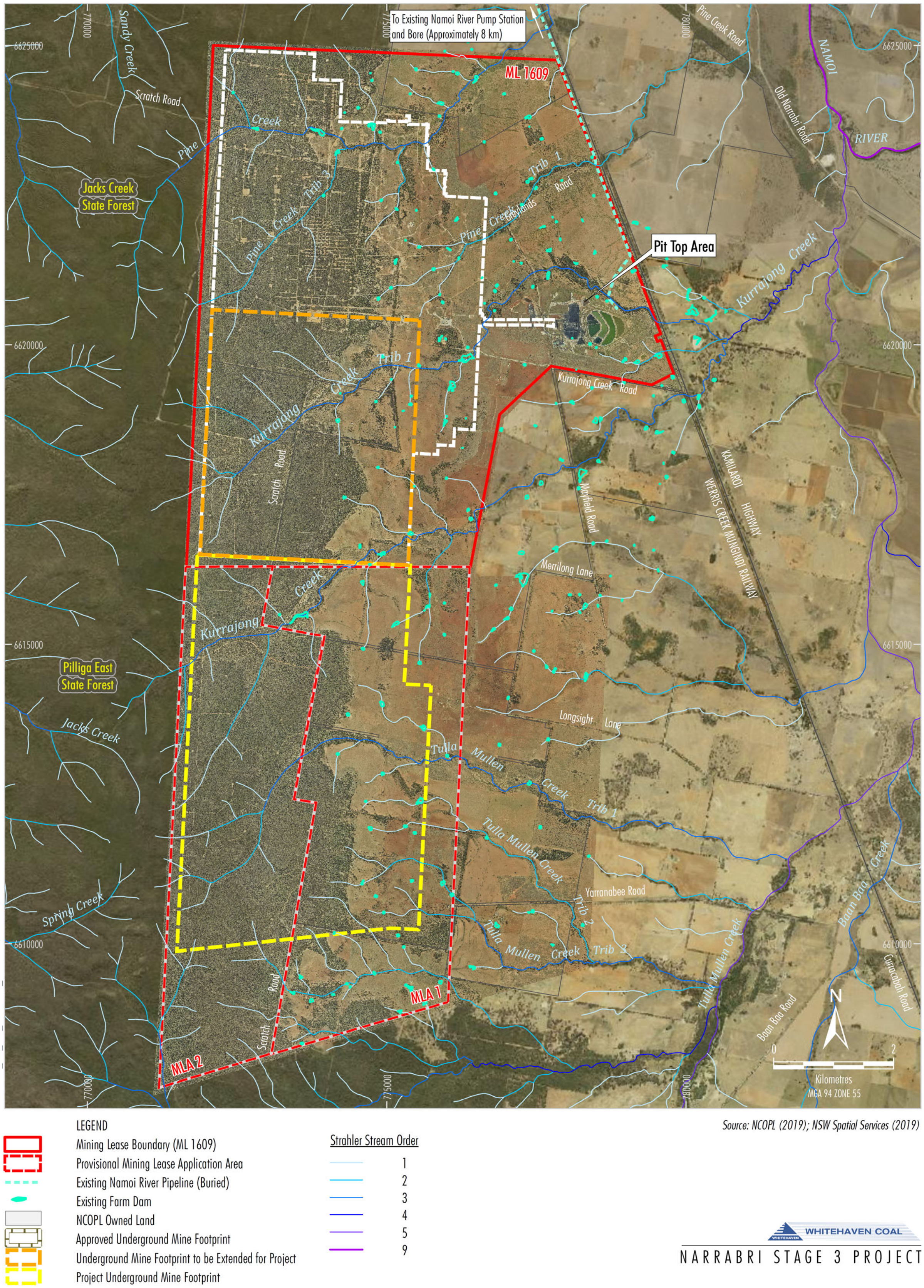


Figure 4.9 – Existing farm dams located within and in the vicinity of the Project

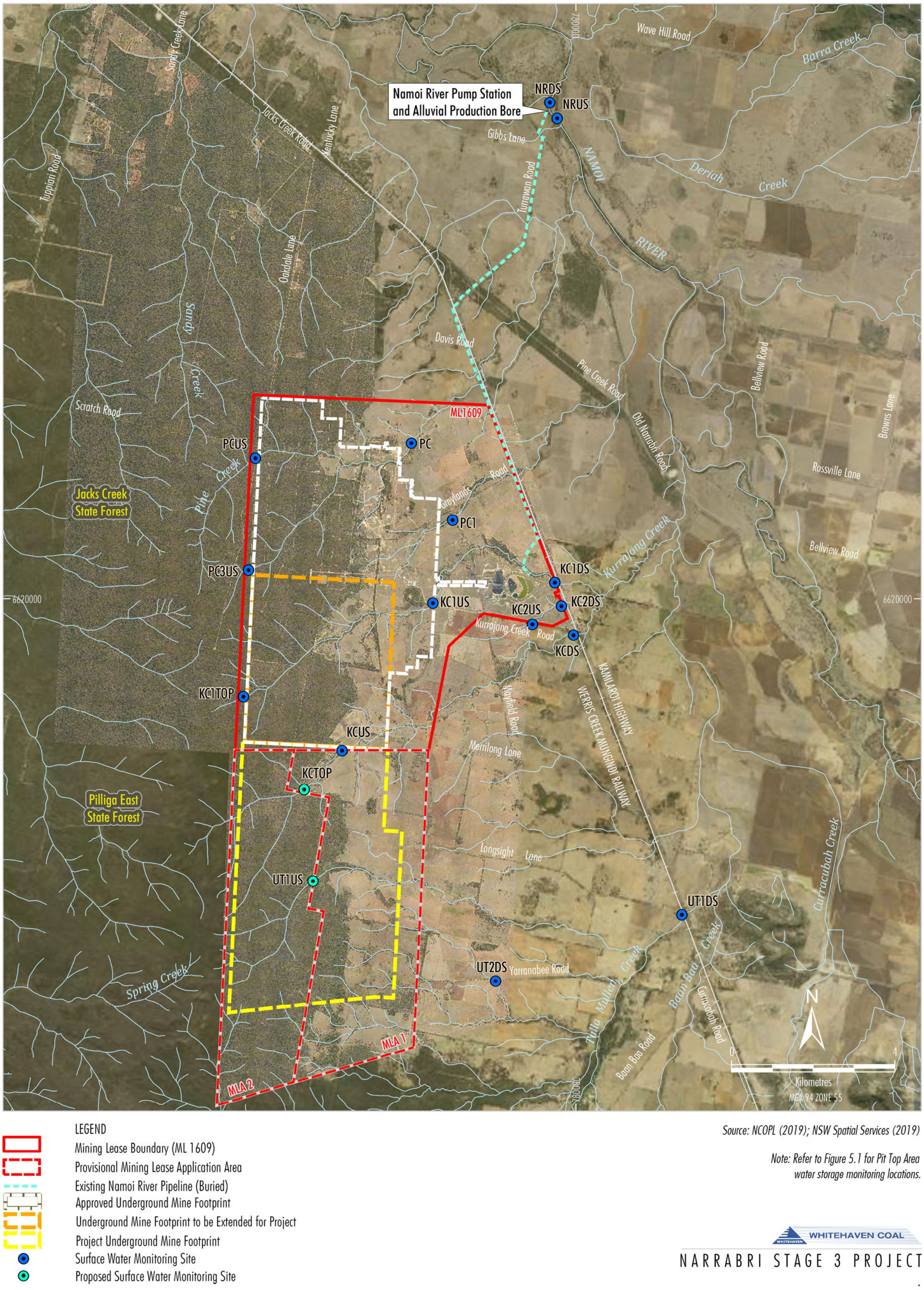


Figure 4.10 – Narrabri Mine receiving water monitoring locations

Table 4.4 shows the recorded surface water quality monitoring data with the Namoi River Water Quality and River Flow Objectives 'Ecosystem' trigger values (Table 3.4). The surface water quality in the watercourses draining the Project area can be characterised as follows:

- slightly alkaline, with median laboratory measured pH values ranging from 7.0 to 7.7 (within the 'Ecosystem' trigger value range);
- fresh, with median EC values ranging from approximately 63 µS/cm to 207 µS/cm (within the 'Ecosystem' trigger values range);
- variable levels of TSS, with median values ranging from approximately 20 mg/L to 132 mg/L;
- not affected by oil and grease contamination; and
- exhibiting low levels of TOC, with median values ranging from approximately 10 mg/L to 15.5 mg/L.

Water quality samples collected at all background and receiving water quality monitoring sites during the January 2020 runoff events were also analysed for dissolved and total metals. No previous water quality samples at any monitoring sites were analysed for metals, hence limited, if any, conclusions can be drawn regarding metal concentrations from the single available sample. However, it appears that dissolved metal concentrations at more than half of the monitoring sites exceeded the Namoi River Water Quality and River Flow Objectives 'Ecosystem' trigger values (Table 3.4) for Iron, Chromium, Copper and Zinc. Concentrations for all other heavy metal toxicants were below the *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values.

The differences in water quality between undisturbed monitoring locations (KCUS, KC1US and KC2US) and those located downstream of the Narrabri Mine (KCDS, KC1DS, KC2DS, PC and PC1) is small. Further, there has not been an increasing (or decreasing) trend in recorded water quality over the life of the Narrabri Mine.

4.5.3 Narrabri Mine water storage water quality

Water quality monitoring has been undertaken by NCOPL in the water storages at the Narrabri Mine (refer Figure 5.1 and Section 5.3) from August 2010 in accordance with the Water Management Plan (NCOPL, 2013) and the Extraction Plan Water Management Plan LW107 to LW110. Sampling has typically been undertaken on a monthly basis, with some sediment dams sampled during wet weather discharge events as well. Samples are tested for EC, pH, TSS, oil and grease and TOC.

Table 4.5 and Table 4.6 show the recorded dam water quality monitoring data, with the *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values (Table 3.4) and EPL 12789 release limits (Table 3.3). Strategies for managing water in these dams is described in Section 5.

Table 4.5 indicates that water in the Pit Top Area runoff, mine and brine dams typically exceeds the 'Ecosystem' trigger values for EC and pH and the EPL 12789 release limits for pH and TSS. Filtered and raw water dams typically exceed the 'Ecosystem' trigger values for EC and pH and the EPL 12789 discharge limit for pH.

Table 4.6 indicates that water in sediment dams SD1, SD2, SD3, SD4 and SD6 typically exceeds the 'Ecosystem' trigger values for pH and EC. SD4 and SD6 typically exceed the EPL 12789 discharge limits for pH and SD3, SD4 and SD6 for EC.

It is of note that SD5[3] is typically within the 'Ecosystem' trigger values for EC, and below the EPL 12789 release limits for pH, TSS and oil and grease. This is expected as SD5 collects runoff from a rehabilitated disturbance area.

[3] SD5 is a decommissioned sediment dam that is no longer part of the Narrabri Mine water management system.

Table 4.4 - Comparison of background and receiving water quality (July 2007 to March 2020) with *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values

Water Quality Parameter		Sampling Site										WQO Trigger Value*a
		Kurrajong Creek						Pine Creek		Tulla Mullen Creek		
		KCUS	KCDS	KC1US	KC1DS	KC2US	KC2DS	PC	PC1	UT1DS	UT2DS	
pH	20th %ile	7.1	7.1	7.1	7.1	6.7	6.8	6.9	7.2	-	-	6.5 - 8.0
	Median	7.4	7.4	7.3	7.5	7.0	7.1	7.2	7.4	7.7	7.1	
	80th %ile	7.6	7.6	7.6	7.7	7.3	7.4	7.4	7.7	-	-	
	N	50	39	32	54	47	47	56	55	1	1	
Electrical Conductivity (µs/cm)	20th %ile	72.0	121.0	83.0	114.0	45.4	71.2	58.0	59.0	-	-	30 - 350
	Median	206.5	203.0	125.0	171.0	63.0	95.0	90.5	99.0	148	54	
	80th %ile	490.2	440.4	192.0	322.6	85.2	162.4	148.0	160.0	-	-	
	N	50	39	32	54	47	47	56	55	1	1	
Total Suspended Solids (mg/L)	20th %ile	25.0	16.8	18.6	21.2	8.2	16.0	16.8	31.6	-	-	NA
	Median	132.0	64.0	54.0	57.0	26.0	30.5	82.0	74.0	20	124	
	80th %ile	373.0	241.2	192.6	121.4	46.8	94.2	206.0	205.6	-	-	
	N	48	39	32	54	47	44	55	55	1	1	
Oil and Grease (mg/L)	20th %ile	<5	<5	<5	<5	<5	<5	<5	<5	-	-	NA
	Median	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
	80th %ile	<5	<5	<5	<5	<5	<5	5.4	<5	-	-	
	N	48	37	30	51	45	44	55	55	1	1	
Total Organic Carbon (mg/L)	20th %ile	7.0	7.0	8.0	9.0	9.0	12.0	7.4	7.0	-	-	NA
	Median	10.0	10.0	11.0	11.0	12.0	15.0	10.0	10.0	10	15	
	80th %ile	13.0	14.2	12.0	15.0	16.0	20.0	14.0	14.0	-	-	
	N	46	35	30	51	44	43	53	51	1	1	

*a Namoi River Water Quality and River Flow Objectives (https://www.environment.nsw.gov.au/ieo/Namoi/index.htm) 'Ecosystem' trigger values (Table 3.4).

N = Number of samples. NA = No WQO trigger value provided for this parameter

Table 4.5 - Comparison of Pit Top Area runoff/mine, brine, raw and filtered dam water quality (August 2010 to March 2020) with *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values and EPL 12789 discharge limits

Water Quality Parameter		Dam										WQO Trigger Value*a	EPL 12789 Limit
		Pit Top Area runoff/Mine						Brine		Filtered	Raw		
		A1	A2	A3	SB1	SB2	SB3	B2	C	B1	D		
pH	20th %ile	8.9	9.0	8.9	9.0	9.1	9.2	9.2	9.3	8.4	8.4	6.5 - 8.0	6.5 - 8.5
	Median	9.2	9.2	9.2	9.3	9.5	9.5	9.6	9.7	8.6	8.6		
	80th %ile	9.4	9.5	9.5	9.6	9.8	9.9	9.9	9.9	8.8	8.7		
	N	111	96	93	117	93	86	98	79	93	105		
EC (µs/cm)	20th %ile	2,510	6,890	7,890	2,572	1,378	3,452	12,540	2,520	410	398	30 - 350	NA
	Median	7,030	8,270	8,910	6,800	2,830	7,060	14,500	24,000	587	634		
	80th %ile	8,650	15,600	14,860	8,606	4,360	10,440	25,620	33,780	833	834		
	N	111	96	93	117	93	89	98	79	93	105		
TSS (mg/L)	20th %ile	9.4	17.2	18.4	19.0	11.0	17.4	20.8	34.6	5.0	7.0	NA	50.0
	Median	19.0	41.0	46.5	56.0	24.0	46.0	45.0	60.0	5.0	18.0		
	80th %ile	33.6	95.6	131.6	107.0	47.6	134.4	118.2	139.8	7.6	32.0		
	N	103	94	92	116	88	88	98	79	93	100		
Oil and Grease (mg/L)	20th %ile	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	NA	10.0
	Median	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
	80th %ile	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
	N	96	85	81	103	92	89	87	69	81	91		
TOC (mg/L)	20th %ile	5.0	6.0	8.0	3.0	11.0	14.4	16.0	16.0	1.2	3.0	NA	NA
	Median	8.0	10.0	20.0	10.5	23.0	32.5	30.0	65.0	3.0	5.0		
	80th %ile	14.0	44.8	86.4	31.0	36.0	68.0	88.8	212.0	6.0	9.0		
	N	107	90	87	116	91	88	89	71	92	105		

*a Namoi River Water Quality and River Flow Objectives (https://www.environment.nsw.gov.au/ieo/Namoi/index.htm) 'Ecosystem' trigger values (Table 3.4).
N = Number of samples. NA = No WQO trigger value provided for this parameter

Table 4.6 - Comparison of sediment dam water quality (August 2010 to March 2020) with *Namoi River Water Quality and River Flow Objectives* 'Ecosystem' trigger values and EPL 12789 discharge limits

Water Quality Parameter		Dam						WQO Trigger Value[*b]	EPL Limit
		SD1	SD2	SD3	SD4	SD5 [a]	SD6		
pH	20th %ile	8.0	7.9	8.0	8.4	7.9	8.8	6.5 - 8.0	6.5 - 8.5
	Median	8.3	8.3	8.5	8.9	8.3	9.0		
	80th %ile	8.8	8.9	9.0	9.4	8.7	9.5		
	N	87	85	90	84	98	88		
EC (μs/cm)	20th %ile	322.8	222.6	345.4	473.0	176.0	1,224.0	30 - 350	NA
	Median	440.0	278.0	480.5	889.0	261.0	1,440.0		
	80th %ile	721.0	452.0	779.0	1,690.0	485.0	2,168.0		
	N	87	85	90	83	98	88		
TSS (mg/L)	20th %ile	11.0	10.0	8.8	10.0	11.6	18.0	NA	50.0
	Median	29.0	25.0	26.0	31.5	35.0	43.0		
	80th %ile	80.0	123.0	84.0	108.2	87.2	147.2		
	N	82	76	85	82	94	85		
Oil and Grease (mg/L)	20th %ile	<5	<5	<5	<5	<5	<5	NA	10.0
	Median	<5	<5	<5	<5	<5	<5		
	80th %ile	<5	<5	<5	<5	<5	<5		
	N	87	83	90	83	97	87		
TOC (mg/L)	20th %ile	10.0	7.0	8.0	6.6	9.0	15.0	NA	NA
	Median	13.5	10.0	12.0	9.0	12.0	23.0		
	80th %ile	20.0	15.2	17.2	13.4	20.0	42.2		
	N	86	85	90	84	98	88		

[*] SD5 is a decommissioned sediment dam that is no longer part of the Narrabri Mine water management system.
[*b] Namoi River Water Quality and River Flow Objectives (https://www.environment.nsw.gov.au/ieo/Namoi/index.htm) 'Ecosystem' trigger values (Table 3.4).
N = Number of samples. NA = No WQO trigger value provided for this parameter

4.6 FLOODING

4.6.1 Namoi River

The OEH (now the DPIE – BCD) has developed the FMP for the Upper Namoi Valley Floodplain in pursuance of Section 50 of the WM Act. The Project (with the exception of the existing/approved Namoi River pump station, alluvial production bore and the pipeline) is located outside the plan area defined within the FMP. The Project (with the exception of the existing/approved Namoi River pump station, alluvial production bore and the pipeline) is also located at least 20 m in elevation above the Namoi River floodplain and as such the Namoi River would not inundate the Project site under any circumstance.

4.6.2 Local tributaries

FMPs for the local tributaries that cross the Project site have not previously been developed. A flood study of Kurrajong Creek Trib 1 (WRM, 2007) was prepared as part of the Narrabri Mine Stage 1 Environmental Assessment to assess the potential impacts of the Pit Top Area. This assessment found that the infrastructure developed for Stage 1 was located outside the 100-year average recurrence interval flood extent except for a small section of rail adjacent to the Kamilaroi Highway. The impact of the constriction caused by the Pit Top Area was not significant.

The Project would not include significant changes to the Pit Top Area and none of the infrastructure proposed as part of the Project would significantly impact on the flow of water in any of the local tributaries (i.e. because the surface infrastructure has been sited to avoid and minimise impacts on local tributaries), with the exception of mine subsidence, which is assessed in Section 8.1. The proposed surface infrastructure is presented in Figure 1.3.

5 Existing/approved site water management

5.1 OVERVIEW

The water management system is managed in accordance with the Water Management Plan (NCOPL, 2013) and the Extraction Plan Water Management Plan LW107 to LW110 (NCOPL, 2017). The water management strategy for the Narrabri Mine is based on the containment and re-use of mine water and diversion of upstream water around the Pit Top Area.

The existing/approved Narrabri Mine water management system includes:

- up-catchment diversion structures;
- raw water storage dams (D and Containment Bund);
- mine water storage dams (A1 to A3);
- pit top area storages (SB1 to SB4);
- a filtered water storage dam (B1);
- brine storage dams (B2, C and BR1 to BR5);
- sediment dams (SD1 to SD4 and SD6 to SD8);
- water treatment facilities;
- the Namoi River pump station, alluvial production bore and pipeline; and
- other water transfer infrastructure (i.e. tanks, pumps and pipelines).

Existing/approved water management dams at the Pit Top Area are shown on Figure 5.1.

The water management system is progressively developed subject to its ongoing performance, prevailing climatic conditions and actual underground mine inflows.

5.2 SURFACE WATER TYPES

For the purposes of existing site water management, the surface water generated at the Narrabri Mine is divided into seven types based on water quality:

- 'Raw' – raw water imported to the Narrabri Mine from external sources (e.g. the Namoi River).
- 'Clean'– surface runoff from the Narrabri Mine site areas unaffected by mining operations.
- 'Rehabilitated Mine Area Runoff' – runoff from rehabilitated mine areas that have established stable vegetation cover. This runoff is expected to have similar water quality characteristics to clean water and is therefore managed as undisturbed area runoff and not captured in the water management system.
- 'Filtered' – water treated by the RO or MF plants, suitable for use in the underground workings or controlled release to the Namoi River in accordance with Condition 11, Schedule 4 of Project Approval (08_0144) or provided to other water users in the Project area for beneficial reuse.
- 'Disturbed Area Runoff' – surface runoff water from Narrabri Mine site areas that are disturbed by mining operations. This runoff may contain silt and sediment, but does not contain other pollutants (e.g. chemicals, hydrocarbons). This water can be released from site in accordance with EPL 12789, if required.

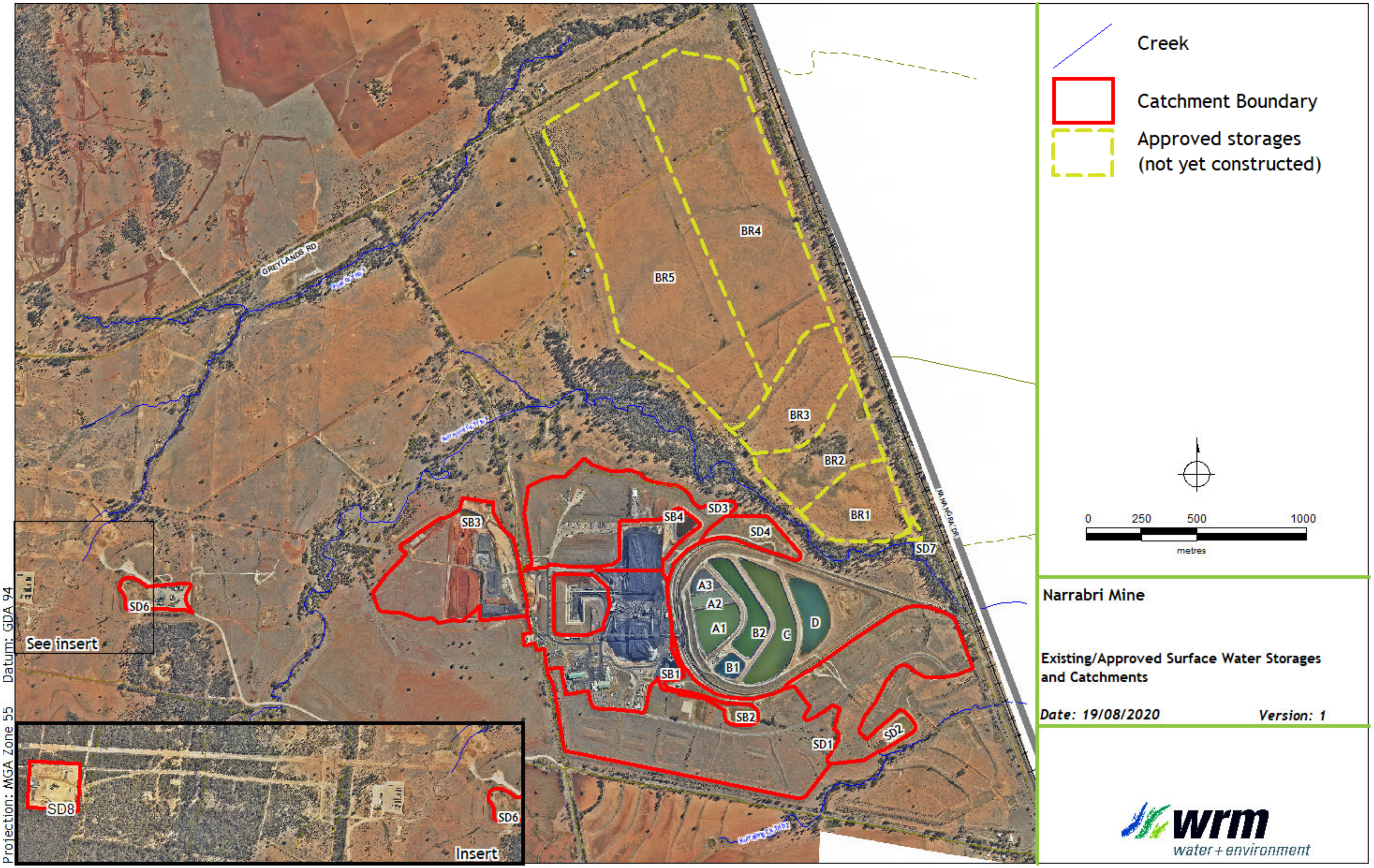


Figure 5.1 - Existing/approved Pit Top Area water storages and catchments

- 'Mine' – water pumped from the underground workings containing elevated concentrations of TDS.
- 'Pit Top Area Runoff' – surface water from the Narrabri Mine site areas affected by mining operations and potentially contain silt/sediment and other pollutants (e.g. chemicals and hydrocarbons). Pit Top Area runoff water areas include coal stockpile areas, service ponds and fuel storage areas. Pit Top Area runoff water is managed to avoid its discharge from the Narrabri Mine.
- 'Brine' – waste or concentrate produced by the RO plants containing high concentrations of TDS.

5.3 WATER STORAGES

Figure 5.1 shows the existing/approved dams at the Narrabri Mine, and Table 5.1 provides a summary of the key characteristics of each dam including the current storage volume as of 31 March 2020.

Note that the catchment area of SB3 shown in Figure 5.1 represents the entire reject emplacement area (some 25 hectares [ha]). The reject emplacement area is managed such that the maximum catchment area draining to SB3 at any time is limited to approximately 10 ha, with runoff from rehabilitated or undisturbed areas bypassing SB3.

5.4 WATER DEMAND AND SUPPLY

Water is required for underground mining, in the Coal Handling Preparation Plant (CHPP), washdown requirements, dust suppression, drilling and potable water supply.

The main water sources for the Narrabri Mine are:

- groundwater inflows into the underground workings;
- captured runoff from disturbed areas;
- raw water imported to site from the Namoi River pump station and/or alluvial production bore via the pipeline; and
- potable water trucked to site by a licensed contractor, as required.

The existing water treatment facilities treat groundwater inflows and disturbed area runoff to produce filtered water and a brine waste product. The filtered water is used in underground mining operations, transferred to the Namoi River for controlled release or provided to other water users in the Project area for beneficial reuse. To date, all filtered water has been used in underground mining operations.

Brine (generated from the water treatment facilities) is approved to be used for dust suppression and/or stored in Brine Storage Ponds at the Pit Top Area. Towards the end of mining, brine is approved to be re-injected into the longwall goaf through the disused goaf gas drainage holes.

Groundwater inflows are also used for dust suppression.

Disturbed area runoff and groundwater inflows are used in the CHPP.

Raw water is used to supplement underground mining and CHPP demand and to supply a separate water treatment facility used to produce potable water. If required, potable water can also be transported via truck to the Narrabri Mine by a licensed contractor to supplement the potable water supply from the water treatment facility.

Table 5.1 – Existing/approved water storages at the Narrabri Mine

Water Storage	Water Type Stored	Capacity (ML)	Catchment Area (ha)	Stored volume 31 March 2020 (ML)
A1	Mine/Pit Top Area Runoff	127.6	3.6	118.1
A2	Mine/Pit Top Area Runoff	30.0	1.2	30.0
A3	Mine/Pit Top Area Runoff	32.0	1.1	32.0
B1	Filtered	39.4	1.9	32.1
B2	Brine	158.0	5.8	43.7
C	Brine	208.9	8.5	126.8
D	Raw	136.8	5.4	98.2
SB1	Pit Top Area Runoff	20.7	29.6	19.3
SB2	Pit Top Area Runoff	38.5	1.9	8.6
SB3	Pit Top Area Runoff	22.0	12.0	0.0
SB4	Pit Top Area Runoff	25.0	6.8	0.0
SD1	Disturbed Area Runoff	3.1	43.4	0.0
SD2[2]	Disturbed Area Runoff	52.1	26.3	0.0
SD3	Disturbed Area Runoff	6.3	25.9	0.0
SD4[2]	Disturbed Area Runoff	30.2	4.5	0.0
SD6	Disturbed Area Runoff	5.8	4.6	0.0
SD7[1,2]	Disturbed Area Runoff	-[3]	-[3]	-
SD8[2]	Disturbed Area Runoff	1.3	5.0	0.0
Containment Bund	Raw	40.1	11.1	0.0
BR1[1]	Brine	470	8.5	-
BR2[1]	Brine	748	13.7	-
BR3[1]	Brine	898	16.2	-
BR4[1]	Brine	950	55	-
BR5[1]	Brine	950	55	--

1 Not currently constructed.
2 EPL 12789 surface water discharge location.
3 SD7 will be sized once the areas and footprints of BR1, BR2, BR3, BR4 and BR5 are confirmed.

5.5 MINE DEWATERING

Groundwater inflows to the underground workings are pumped to a sump in the box cut before being transferred to the site water management system.

Water pumped from the underground into the box cut sump consists of both returned underground mine filtered water and groundwater inflows. The ratio between the two is important to calculate for both licensing and water management purposes.

To delineate the fractions of underground dewatering made up by return underground mine filtered water usage and groundwater inflows, the following assumptions are adopted:

- Water enters the underground workings via:
  - underground filtered water demand;
  - longwall emulsion; and
  - groundwater inflows.
- Water is lost from the underground workings via:
  - increase in coal moisture from in-situ to ROM coal;
  - vent humidity extraction; and
  - underground dewatering.

The underground mine filtered demand returning to the box cut sump via underground dewatering is calculated as follows:

- Underground demand return = [underground filtered water demand + longwall emulsion] – [increase in coal moisture + vent humidity extraction].
- If the above result returns a negative number (i.e. losses exceed inflows) then there is no underground demand return for that day.
- The increase in coal moisture is based on an increase of 2% by mass from in-situ to ROM coal.
- The vent humidity extraction is assumed to be 133 ML/yr (0.37 megalitres per day [ML/day]) based on calculations by NCOPL.

Groundwater inflows are unlikely to be lost to coal wetting or vent extraction. Therefore, all groundwater inflows would flow to the box cut sump via underground dewatering, and the estimated volume of groundwater inflows flowing the box cut sump can be calculated as follows:

- Groundwater inflows = [Recorded box cut sump flowmeter volume] – [Calculated underground demand return].

The total amount of groundwater extracted is then equal to the groundwater inflows plus the gas drainage extraction. Figure 5.2 shows the estimated historical groundwater extraction at Narrabri Mine since operations commenced.

5.6 NAMOI RIVER PUMP STATION, ALLUVIAL PRODUCTION BORE AND PIPELINE

A pump station and production bore have been developed at (and adjacent to, in the case of the bore) the Namoi River to allow for supplementary water supply to the Narrabri Mine. The construction and operations of two approved buried pipelines between the Narrabri Mine and the Namoi River is approved as part of the Narrabri Mine. One pipeline has been constructed to date, and the second approved pipeline may be constructed as part of the Project.

In accordance with NCOPL operational procedures, makeup water is preferentially taken from the Namoi River (Lower Namoi Regulated River Water Source in the NRRWSP) in accordance with WALs held by NCOPL.

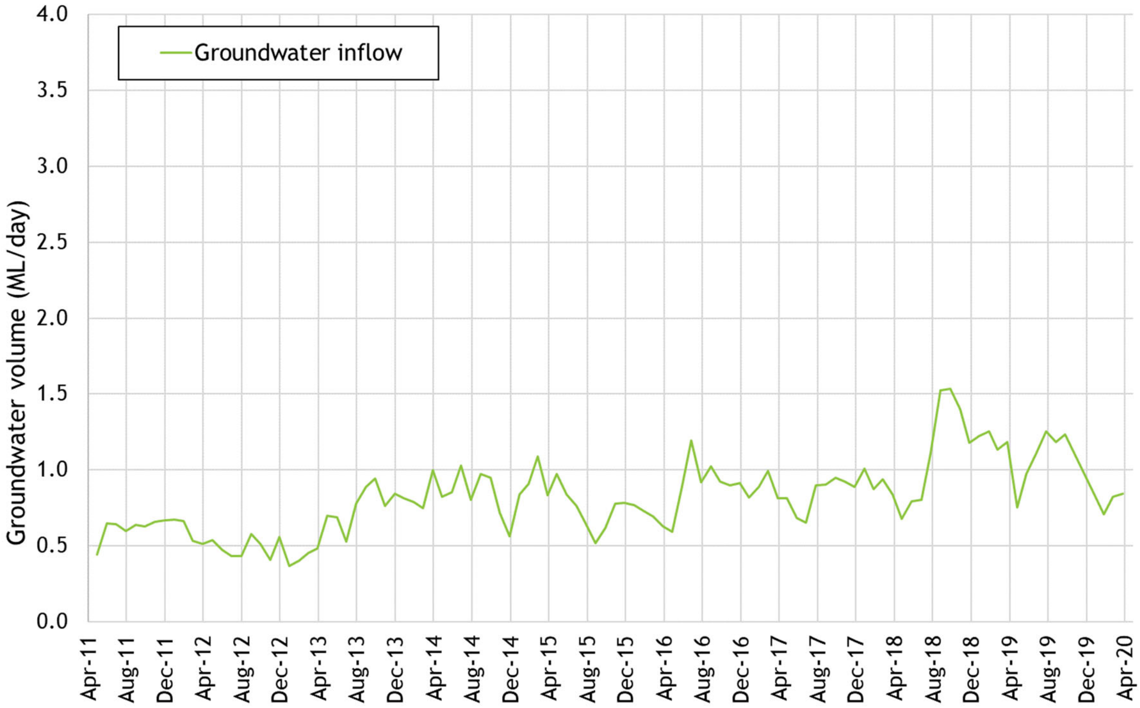


Figure 5.2 – Estimation of groundwater inflows

When low or no flow conditions in the Namoi River prevent the extraction of water from the river, groundwater is extracted from NCOPL's bore to provide a supplementary water supply. The production bore has been constructed to allow groundwater extraction from the Namoi alluvium (Upper Namoi Zone 5 Namoi Valley [Gins Leap to Narrabri] Groundwater Source in the NUAWASP), in accordance with WALs held by NCOPL (or transferred to NCOPL from other Whitehaven operations).

The current WALs held by NCOPL for extraction from the pump station and production bore are listed in Table 5.2.

5.7 CONTROLLED RELEASES

Under some wet climate conditions, the Narrabri Mine has the potential to receive groundwater and surface water inflows in excess of its consumption requirements.

The Narrabri Mine allows for excess filtered water to be transferred via the approved Namoi River pipelines to the Namoi River for controlled release to the Namoi River at the pump station in accordance with EPL 12789 (refer to Section 3.3). To date, no water has been released to the Namoi River.

NCOPL would also investigate options for the beneficial re-use of excess filtered water with other water users in the Project area (e.g. mining operations, irrigation) or passing the water to local landholders.

5.8 BRINE DISPOSAL STRATEGY

Brine stored in the brine storages at the end of mining is approved to be re-injected into the longwall goaf through the disused goaf gas drainage holes.

Table 5.2 – Existing surface and groundwater licences for extraction from the pump station and production bore

Works Approval	Water Access Licence	Water Source	Nominal Allocation (units/yr)
Surface Water			
90CA802130	20152	Lower Namoi Regulated River Water Source (General security)	600
90CA802130	2728	Lower Namoi Regulated River Water Source (General security)	10
90CA802130	6762	Lower Namoi Regulated River Water Source (High security)	20
90CA802130	2671	Lower Namoi Regulated River Water Source (General security)	48
Groundwater			
90WA812891	12833	Upper Namoi Zone 5 Namoi Valley (Gins Leap to Narrabri) Groundwater Source	67
90WA812891	20131	Upper Namoi Zone 5 Namoi Valley (Gins Leap to Narrabri) Groundwater Source	150
90CA807255*	12822	Upper Namoi Zone 5 Namoi Valley (Gins Leap to Narrabri) Groundwater Source	43
90WA822539	29549	Gunnedah - Oxley Basin Murray Darling Basin (Mdb) Groundwater Source	818
90WA822539*	43017	Gunnedah - Oxley Basin Murray Darling Basin Groundwater Source	403
90WA822539	15922	Southern Recharge Water Source	248

* NCOPL has submitted applications to Water NSW for the formal registration of these licences.

5.9 SITE WATER MANAGEMENT SYSTEM

The operation of the existing/approved site water management system is shown schematically in Figure 5.3, and can be summarised as follows:

- Pit Top Area runoff is collected in SB1, SB2, SB3 and SB4. Water collected in these water storages is pumped to A1 for reuse or treatment in the RO plant. Pit Top Area runoff is transferred from A1 to the reclaim tanks at the box cut for use in the CHPP, dust suppression (surface trucks and ROM and product coal stockpiles) and washdown bay.
- SB1 has a permanent automatic pump, but all other Pit Top Area runoff water storages are dewatered as required using mobile diesel pumps. Any overflow from SB1 drain to SB2. Some overflows from SB1 are to be expected, as it is undersized for the catchment area draining to it. SB2 was constructed to account for the lack of capacity in SB1. Any overflows from SB2 drain to SD2, which forms part of the disturbed area runoff management system.

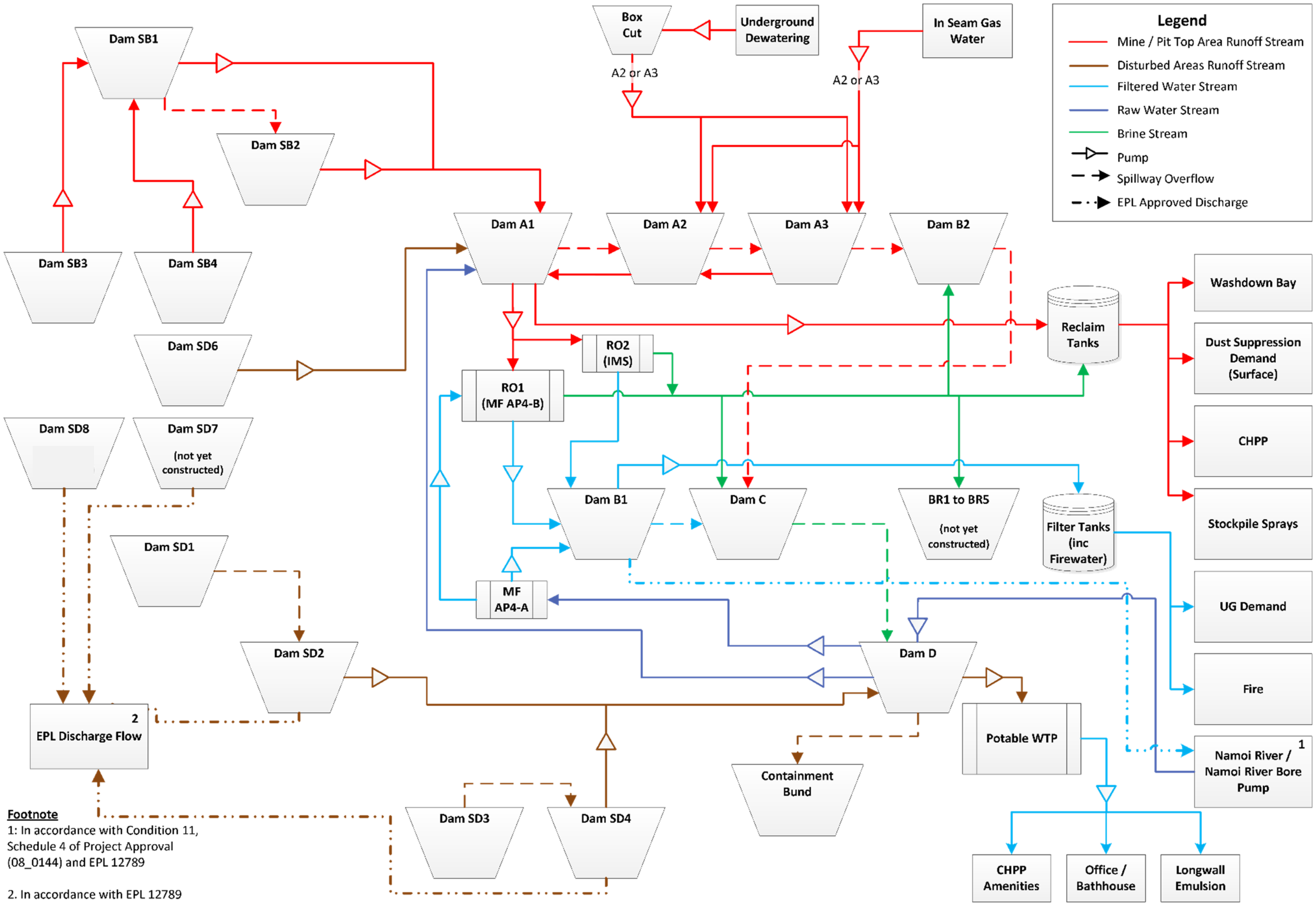


Figure 5.3 - Existing/approved site water management system schematic

- Underground process water and groundwater entering the underground workings are pumped to the box cut sump, then transferred to A2 or A3 for Pit Top Area runoff use or treatment in the RO plants. Gas drainage water is also pumped from the bores into A2 or A3 when required.
- Demands for Pit Top Area runoff at Narrabri Mine are obtained from A1 (via the reclaim tank at the box cut).
- Disturbed area runoff is collected in sediment dams SD1, SD2, SD3, SD4, SD6, SD7 and SD8. Four of these dams (SD2, SD4, SD7 and SD8) are EPL 12789 surface water discharge points. Note that SD7 has not yet been constructed.
- There are two RO plants currently operating at the Narrabri Mine (RO1 and RO2). Both RO plants source feed water from A1. The original RO plant (RO1) began operating in June 2012. The RO1 plant maximum feed flowrate is 16 litres per second (L/s) (approximately 1.4 ML/day), however when backwashing and 'clean-in-place' operations are taken into account, the RO1 plant unit feed flowrate averages out at approximately 8 L/s (0.7 ML/day) over a 24-hour period (based on available RO1 plant monitoring data). The RO1 plant product permeate[4] (clean)/concentrate (brine) split is approximately 70%/30%, respectively.
- The RO2 unit (also referred to as the IMS RO plant) was commissioned in August 2017. The maximum feed flowrate for the RO2 plant is approximately 1.6 ML/day, however the long-term average feed flowrate based on available data is approximately 0.65 ML/day. The RO2 plant product permeate (clean)/concentrate (brine) split is approximately 80%/20%, respectively.
- NCOPL has advised that if necessary, the RO1 and RO2 units can be operated to treat a combined maximum of 2.5 ML/day for an extended period of time. To date, the RO plants have not been required to treat such a volume of water, hence the recorded site data giving a combined long-term treatment capacity of 1.35 ML/day for the two plants.
- Brine from the RO plant is currently stored in C and B2, but has also been stored in A2 and A3 in the past. Additional brine storages (BR1 to BR5) will be constructed to contain excess brine if and when they are required.
- A MF plant treats raw water from D and discharged to B1 to assist in satisfying demands for filtered water.
- Filtered water from the RO and MF plants is pumped into B1, and then transferred to the filtered water storage tanks at the box cut, for use underground and for firewater purposes. Any treated water in excess of Narrabri Mine requirements will be piped to the Namoi River for release in accordance with Condition 11, Schedule 4 of Project Approval (08_0144) and EPL 12789.
- Dam D receives water from the Namoi River pump station and production bore and is used to supply the potable water treatment plant, or for shandying with water in A1 prior to treatment in the RO plant. Water from D can also be treated by the MF plant and discharged to B1 to assist in satisfying demands for filtered water. Water from the Namoi River is sourced as required to supply deficits in the mine site water demands.
- Sewage is treated in an on-site sewage treatment plant which is serviced by a licensed contractor.

[4] Permeate was previously referred to in "raffinate" in previous environmental assessment documentation.

5.10 HISTORICAL BEHAVIOUR OF THE SITE WATER MANAGEMENT SYSTEM

Figure 5.4 and Figure 5.5 show the historical behaviour of the site water management system, including site water inventory and recorded water usage and underground dewatering.

Key operational changes in the water management system since operations commenced include:

- The CHPP was commissioned in August 2011 and commenced operation in mid-2012.
- Longwall mining commenced in October 2012 and the RO1 plant commenced operations in June 2012.
- A2 and A3 were used to store brine from the RO1 plant until July 2014, when lining of Dam C was completed, Dam C became the primary brine storage. The contents of A2 and A3 were transferred into Dam C in September 2014.
- Prior to January 2012 all gas drainage water was stored in B2. From January 2012 onwards gas drainage water has been deposited in A1 to A3.
- An additional package RO plant was operated between October 2013 and September 2014. The package RO plant treated water from A1, A2 and B2. Some of the brine stored in A2 and A3 was transferred into B2 for treatment using the package RO plant. This explains the decrease in brine inventory and corresponding increase in mine/Pit Top Area runoff inventory between September and November 2013.
- When the package RO plant had treated the water stored in B2 in November 2015, high density polyethylene (HDPE) lining of B2 commenced and was completed in August 2016.
- The IMS RO2 plant was commissioned in August 2017, and includes its own pre-treatment systems.

5.11 MINING AREA WATER MANAGEMENT

The Extraction Plan Water Management Plan provides for the management of the potential surface water impacts associated with the mining area. A summary of the surface water management measures outlined in the Extraction Plan Water Management Plan is provided in Table 5.3.

The Extraction Plan Water Management Plan also includes a Trigger Action Response Plan (TARP) which includes trigger and response actions for mitigation of impacts to the natural environment as a result of mining (e.g. surface water quality; stream morphology).

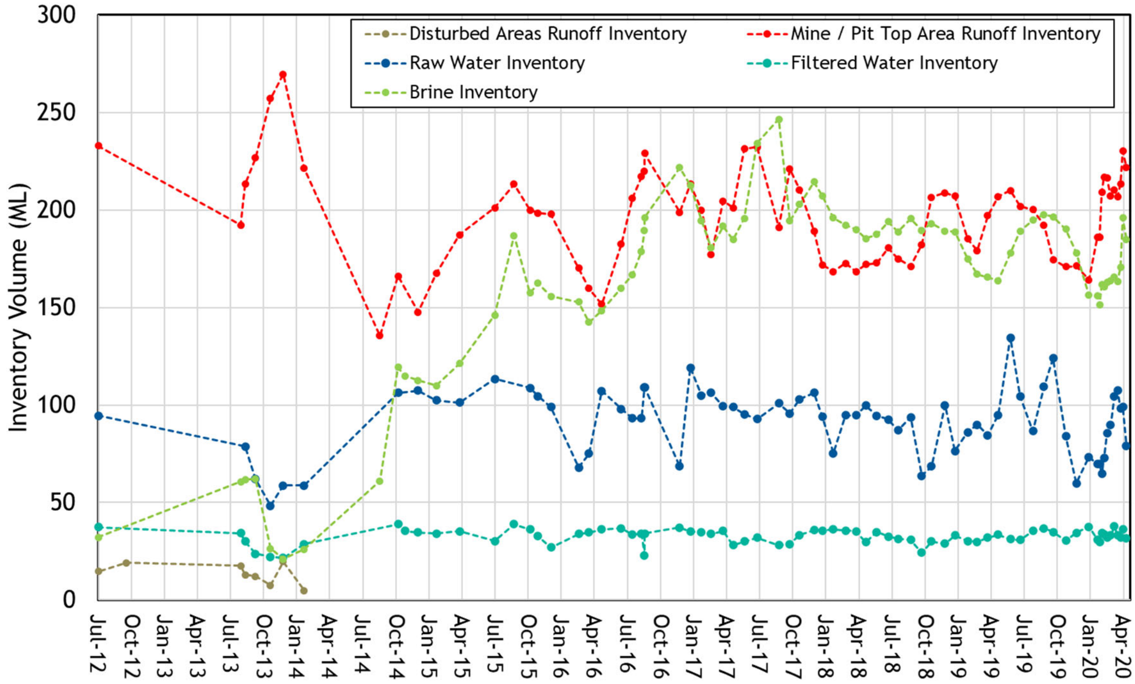


Figure 5.4 – Historical behaviour of site water inventory, July 2012 to March 2020

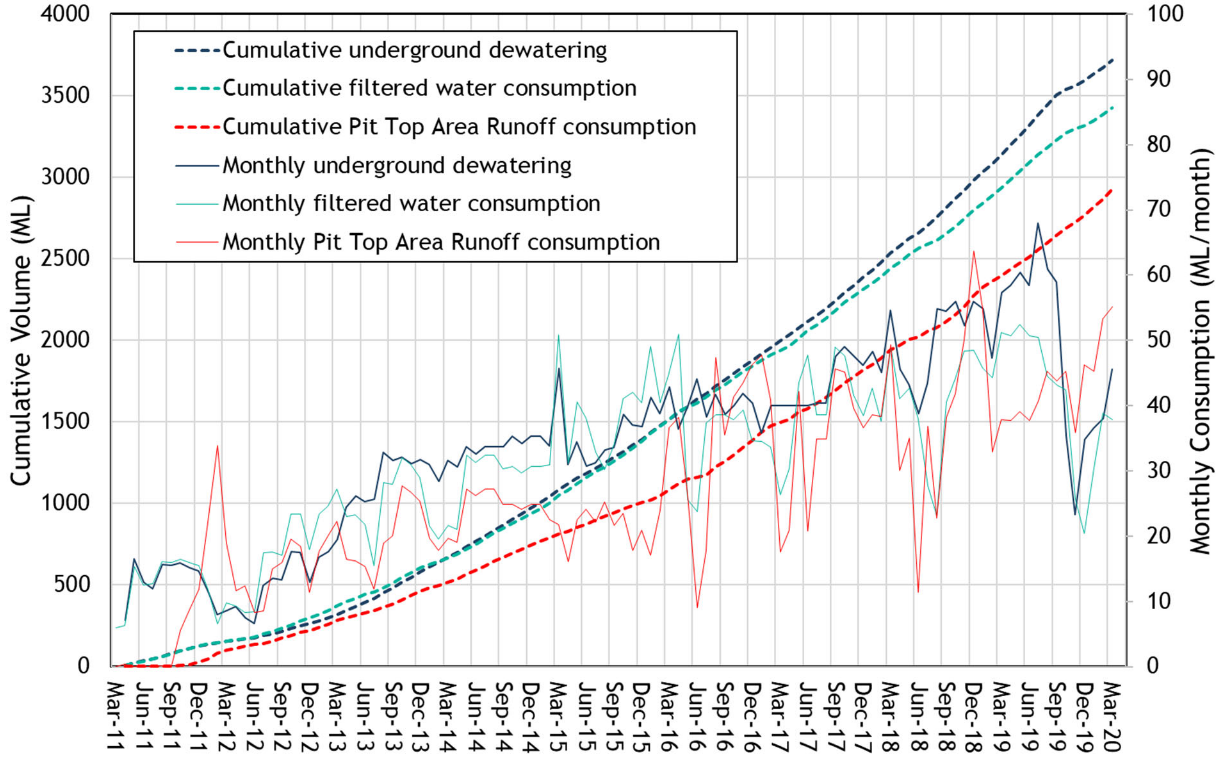


Figure 5.5 – Historical water consumption and underground dewatering (cumulative), April 2011 to March 2020

Table 5.3 – Summary of Extraction Plan Water Management Plan surface water management measures

Aspect	Management Measure
Surface Cracking and Surface Uplift	• *Smaller cracks (less than 100 mm) allowed to fill by natural erosive forces.* • *Remedial works to be conducted for larger cracks (greater than 100 mm) or persisting cracks such as ripping of ground cover on both sides of the crack. If required following these remedial works, suitable stockpiled subsoil would be used to fill cracks.*
Slope Stability and Erosion	• *Any "non-natural" or erosion deemed to be in excess of natural rates of erosion to be repaired and remedial measures (e.g. check dams or drop structures) undertaken (if required).*
Ponding	• *Ponding areas located in areas with no significant vegetation and the water quality of the ponded water is non-saline to be allowed to self-correct.* • *Ponding areas located in areas with significant vegetation to be assessed and remedial measures (e.g. drainage) developed and implemented in consultation with a geomorphologist.*
Surface Infrastructure Development Areas	• *A ground disturbance protocol to be prepared in consideration of the Managing Urban Stormwater: Soils and Construction manual (Landcom, 2004) before surface development.* • *The ground disturbance protocol to include strategies to minimise impacts, including:* ○ Minimise surface development area; ○ Avoid drainage lines wherever possible; ○ Implement erosion control measures for roadways (e.g. drainage socks along table drains, rock check dams to slow down runoff); ○ Implement erosion control measures for disturbed slopes (e.g. silt fences along contours); and ○ Schedule works for dry periods where possible.

6 Project site water management system

6.1 OVERVIEW

The Project would involve the use of the existing/approved water management infrastructure with minor augmentations and extensions, including the progressive developments of pumps, pipelines, water storage and other water management infrastructure.

The objectives and design criteria of the Project site water management system would be to:

- protect the integrity of local and regional water resources;
- separate runoff from undisturbed and mining-affected areas;
- design and manage the system to operate reliably throughout the life of the Project in all seasonal conditions, including both extended wet and dry periods;
- provide water for use in mining and CHPP operations that is of sufficient volume and quality, including during periods of extended dry weather;
- provide sufficient storage capacity in the system to store, treat and discharge runoff as required, including during periods of extended wet weather; and
- maximise the re-use of water on-site.

6.2 WATER STORAGES

The Project would continue to use existing water storages described in Section 5.3.

NCOPL would progressively construct the approved brine storage ponds (BR1 to BR5) (Section 5.3) or a combination thereof, as required. The brine storage ponds would be constructed with a low permeability lining.

An additional mine water storage would be constructed south of Longwall 210 (the Southern Mine Water Storage) (Figure 1.3). This mine water storage would be a 'turkey nest' style storage used to store mine water dewatered from of the southern longwall panels, prior to transfer to the Pit Top Area, as required.

A pipeline between the Southern Mine Water Storage area and the Pit Top Area would be installed to facilitate transfer of water. The pipeline would be installed within services corridors and other cleared areas.

For each of the ventilation shaft and service borehole pads, sediment dams would typically be constructed. These sediment dams would typically be lined with a low permeability HDPE liner. Each ventilation shaft and service borehole pad would be designed and constructed such that any overflow from sediment basins or sumps would be retained on the pad itself (i.e. no runoff would be discharged to local drainage or impact on undisturbed vegetation). The sediment dams would be progressively constructed and decommissioned as the ventilation shaft or service boreholes are developed and decommissioned over the Project life.

For the exploration boreholes, pre-conditioning areas and gas management areas, short-term sediment management measures in accordance with *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004) would be implemented to minimise potential water quality impacts.

Drilling process water would be stored in temporary in-ground or above-ground sumps would be constructed within the drill pad area.

6.3 WATER DEMAND AND SUPPLY

The Project would not change the existing water demand types at the Narrabri Mine (i.e. underground mining operations, CHPP operations, washdown usage, dust suppression on roads, stockpile dust suppression, and other minor non-potable uses).

The main water sources for the Project would also not change from the existing/approved Narrabri Mine:

- groundwater inflows to underground workings (mine water);
- catchment runoff and infiltration;
- supplementary licensed extraction from the Namoi River and/or Namoi River alluvium (raw water) (Section 5.3); and
- potable water transported to site.

The Project would include the continued use of water treatment facilities (and/or other suitable water treatment technologies) to treat water for supply to underground mining operations and potable water. The capacity of the water treatment facilities would be reviewed as part of the periodic site water balance reviews and the capacity of the water treatment facilities may be adjusted as necessary.

6.4 CONTROLLED RELEASES

In the event that excess water accumulates in the Project water management structures, filtered water that meets the relevant water quality criteria in EPL 12789 would be pumped to the Namoi River for release consistent with approved Narrabri Mine (Section 4.3).

In addition, NCOPL would investigate options for the beneficial re-use of excess filtered water with other water users in the Project area (e.g. mining operations, irrigation) or passing the water to local landholders.

Consideration would also be given to the injection of excess mine water into the longwall goaf through the disused goaf gas drainage holes or via the underground infrastructure. Any beneficial re-use of excess filtered water or underground injection of excess mine water would be undertaken in accordance with an updated Water Management Plan.

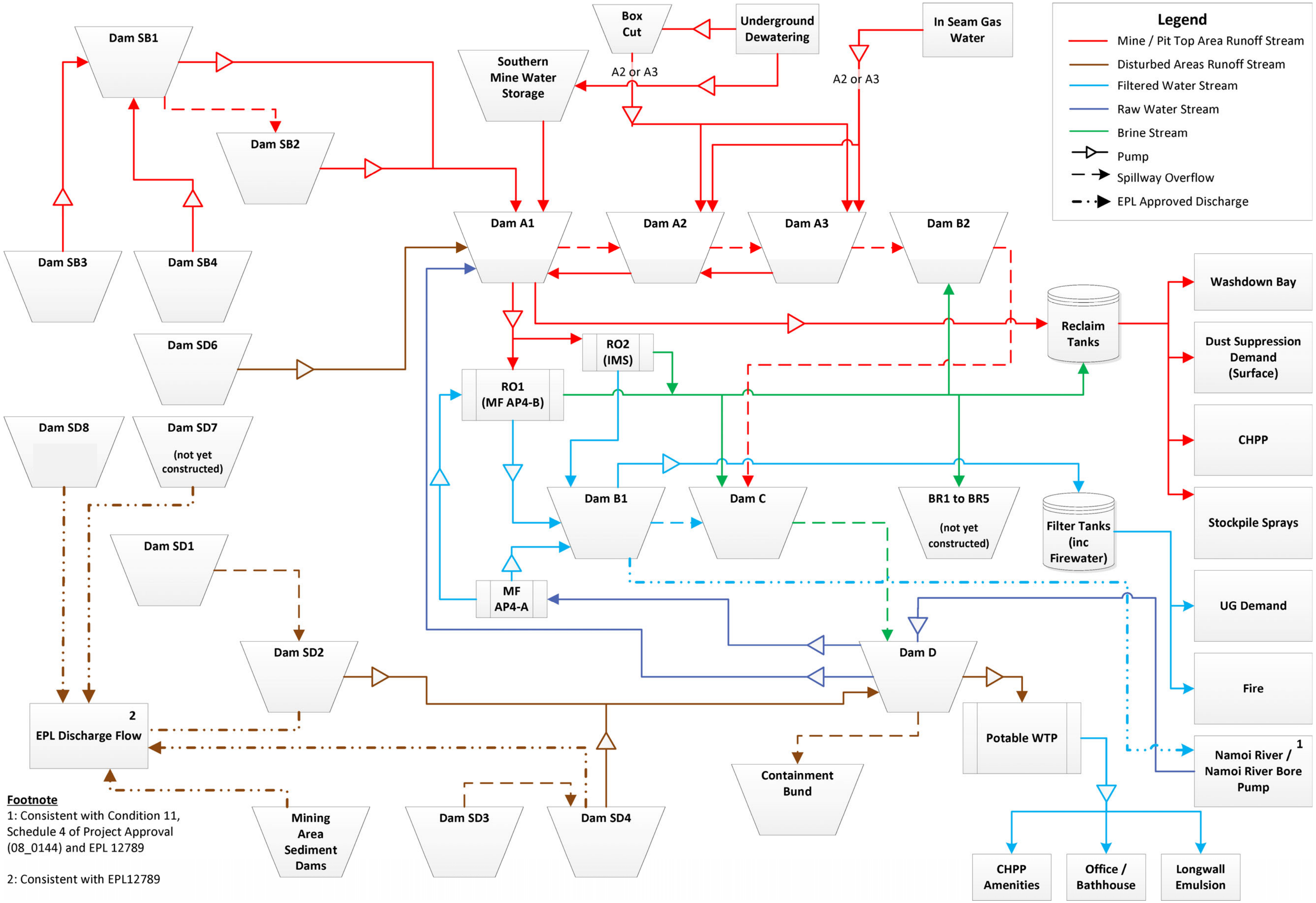
6.5 BRINE DISPOSAL STRATEGY

Consistent with the approved Narrabri Mine, the brine stored within the brine storage ponds would be re-injected into the longwall goaf through the disused goaf gas drainage holes towards the completion of mining. Progressively re-injecting brine into the goaf of the completed longwall panels would ultimately result in the removal of all brine within the brine storage ponds.

In the event of a spontaneous combustion event in the underground mine during the Project life, NCOPL would investigate the feasibility of transferring water stored on-site water management system to assist extinguish the spontaneous combustion event. NCOPL would complete relevant assessments and seek relevant approvals prior to transferring water to the underground.

6.6 WATER MANAGEMENT SCHEMATIC

The Project site water management system schematic water is shown on Figure 6.1. The only change to existing/approved Narrabri Mine site water management system schematic is the addition of the Southern Mine Water Storage and additional sediment dams for the ventilation shaft and service borehole pads.



Footnote

1: Consistent with Condition 11, Schedule 4 of Project Approval (08_0144) and EPL 12789

2: Consistent with EPL12789

Figure 6.1 - Project site water management schematic

7 Water balance modelling

7.1 METHODOLOGY

A computer-based operational simulation model (Goldsim) (Goldsim Technology Group, 2018) 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 Goldsim model was selected for use due to the complex nature of the mine water balance, which is influenced by groundwater inflows, water treatment plant operation, site water demands and runoff from surface water catchments. The Goldsim model allows all operating rules to modelled in full detail. In particular the model allows the operation of the water treatment plant and brine dams to be easily investigated and optimised. The Goldsim 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 7.1.

The water balance model was calibrated by comparing predicted dam volumes and salinity against recorded data for the period July 2012 to March 2020. The calibrated model was then modified to reflect the proposed conditions to assess the impacts of the Project.

7.2 WATER BALANCE MODEL CONFIGURATION

7.2.1 Rainfall and evaporation

The rainfall and evaporation data obtained from the SILO Data Drill for the Narrabri Mine (Section 4.1) were used in the Goldsim model. The SILO Data Drill climate data in the model currently extends from 1 January 1889 to 20 January 2020. For rainfall runoff modelling (AWBM), potential evapotranspiration was calculated using FAO-56 Penman Monteith equation (see Table 4.1). Evaporation from the water storages was determined using the Morton's wet-environment areal potential evapotranspiration. Both datasets were obtained from the SILO data drill service. Evaporation from brine storages was reduced by 20% based on the results of the water balance model calibration.

Table 7.1 – 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 underground	Dust suppression demand
	Washdown usage
	Underground water usage
	Entrainment of water in co-disposed rejects

7.2.2 Catchment runoff

The Australian Water Balance Model (AWBM) (Boughton, 1993) was used to convert rainfall to runoff for three catchment types defined for the Narrabri Mine; natural/revegetated, hardstand/industrial and stockpile catchments areas. Table 7.2 summarises the AWBM parameters used in the Goldsim model. The AWBM parameters were initially obtained from the guidance provided in Boughton (2003), and the parameters were then adjusted as part of the water balance model calibration to match observed site water inventories (see Section 7.3).

Table 7.2 - Adopted rainfall-runoff parameters - AWBM model

Parameter	Natural/ revegetated	Hardstand/ industrial	Stockpiles
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
C1	15.0	3.0	7.5
C2	75.0	7.5	25.0
C3	150.0	15.0	45.0
C_{AVG}	99.4	10.1	31.3
K_{BASE}	1.0	1.0	1.0
K_{SURF}	0.0	0.0	0.0
BFI	0.0	0.0	0.0
Long term volumetric runoff coefficient	8.5%	42.5%	22.9%

7.2.3 Salt generation parameters

Table 7.3 outlines the salinity parameters adopted in the Goldsim model. The salinity parameters were initially selected based on observed salinity values in site storages and then adjusted as part of the calibration process (Section 7.3) to match with observed salinity in the water management system.

A factor of 0.6 has been adopted to represent the relationship between TDS and EC for the Project. There is currently no site data available to confirm the accuracy of the adopted TDS to EC conversion factor. The Australian Drinking Water Guidelines (NHMRC, 2011) state that the relationship is dependent on both chemistry and temperature and factors of between 0.50 and 0.64 are used across Australia. The adopted conversion value is considered reasonable and has no impact on the outcomes of the water balance model.

Table 7.3 - Adopted salinity parameters

Runoff/Water Type	Adopted TDS (mg/L)	EC (µS/cm)
Natural catchments	200	333
Stockpile catchments	4,500	7,500
Industrial catchments	2,000	3,333
Groundwater/Gas Drainage Water		
Prior to July 2014	3,000	5,000
After July 2014	6,000	10,000
Namoi River/Bore Imported Water	400	666
Reverse Osmosis Permeate	300	500

Note that the adopted salinity of groundwater and gas drainage water changes over time, as the groundwater encountered in the early years of the Narrabri Mine was not as saline as the groundwater currently being extracted.

7.2.4 Water storage stage-storage-surface area data

The water storages at the Project were represented in the Goldsim model based on the survey and design data provided by NCOPL.

7.2.5 Other key assumptions

The following key assumptions were made in both the calibration (Section 7.3) and forecast (Section 7.4) water balance models:

- A percentage of the Pit Top Area runoff used in the CHPP, washbay, stockpile sprays and surface dust suppression returns to the water management system via SB1. The water balance model assumes that 22% of this Pit Top Area runoff would drain to SB1, SB3 and SB4 and be recycled into the site water management system.
- The salinity of Pit Top Area runoff recycle water increases by 25% due to contact with coal in the CHPP and stockpiles.
- A constant longwall emulsion demand of 6.33 ML/yr (0.0175 ML/day) was adopted in the model, based on advice from NCOPL.
- A constant vent humidity loss of 133 ML/yr (0.37 ML/day) has been adopted in the water balance model.
- ROM coal moisture was assumed to increase by 2% from underground water interacting with the coal.
- The assumptions and formula given in Section 5.5 were used in the water balance model to determine the fraction of groundwater inflows included in underground dewatering volumes.
- The salinity of recycled underground filtered water increases by a factor of 2.5 due to having been in contact with the coal seams (calibration factor based on recorded data).

7.3 WATER BALANCE MODEL CALIBRATION

7.3.1 Methodology

The water balance AWBM model parameters and salinities were calibrated in the water to match observed water levels and salinity at the Narrabri Mine site water management system over the period July 2012 to March 2020.

AWBM parameters for natural, hardstand and stockpile catchments were initially selected based on the guidance provide in Boughton (2003). The AWBM parameters (namely the soil moisture storage depths C1, C2 and C3) were then adjusted to produce runoff volumes that matched the observed site inventory in all dams for which data was available. Initially, salinity parameters were derived based on observed salinities in dams, and then adjusted to ensure the recorded salinities in individual dams, and the overall salt load in the inventory could be replicated by the model.

As all water imports, demand usage and water movements on site are metered (and included in the calibration model as time series data), the AWBM soil moisture storage parameters and salinity values can be calibrated with confidence.

The calibration water balance model was configured to reflect the existing/approved water management schematic shown in Figure 5.3. Recorded site rainfall was used in the model calibration.

The calibration water balance model was also configured to represent the changes to the water management system that occurred during the calibration period including the following:

- transferral of water from A2 and A3 to B2 and C in 2013 and 2014;
- RO plant operation (i.e. source of feed water, destination of brine and waste);
- permanent RO1 plant operation;
- temporary RO plant operation;
- IMS RO2 plant operation;
- longwall changeover periods; and
- gas drainage water management.

Recorded Narrabri Mine site data was incorporated into the water balance model for the following components of the site water management system:

- underground dewatering volumes;
- Pit Top Area runoff water use;
- filtered water use;
- potable water use;
- raw water imports;
- RO plant feed and production volumes; and
- ROM coal production.

7.3.2 Results summary

Figure 7.1 and Figure 7.2 show a comparison of predicted and observed site water and salt inventories at the Narrabri Mine over the calibration period. Calibration plots for individual dams are provided in Appendix A.

Due to irregular dam water level measurements, the contents of the Pit Top Area runoff dams SB1, SB2 and SB3 have not been included in the inventory plots shown in Figure **7.1** and Figure 7.2, and no individual calibration plots have been produced for these dams. The volumes of water held in these dams at any time are typically small and have little bearing on the overall site inventory. Further, the water balance model includes the regular pumping out of these dams to prevent overflows, and hence the contribution of these dams to overall site inventory over the calibration period is adequately represented.

The calibration results show that the water balance model adequately matches the trends in the observed data, for both site water and salt inventories. The calibration is considered acceptable, particularly considering the complex nature of the Narrabri Mine site water management system, and the numerous variations to the operation of the system during the calibration period.

The water balance model calibration identified that the contribution of runoff from the surface water catchments to the site water balance is relatively minor. The percentage contribution of runoff from each landuse to the total volume of water at the mine over the calibration period is as follows:

- Natural catchments: 3.9%;
- Stockpile catchments: 2.4%; and
- Industrial catchments: 1.5%.

These percentages are low when compared to the contribution from other sources:

- Direct rainfall onto the surfaces of dams: 12.6%;
- Imports from the Namoi River pump and alluvial bore: 37.8%; and
- Groundwater extracted from the underground mine: 41.7%.

The above percentage contributions clearly show that groundwater extraction from the underground mine is the main driver of the site water balance.

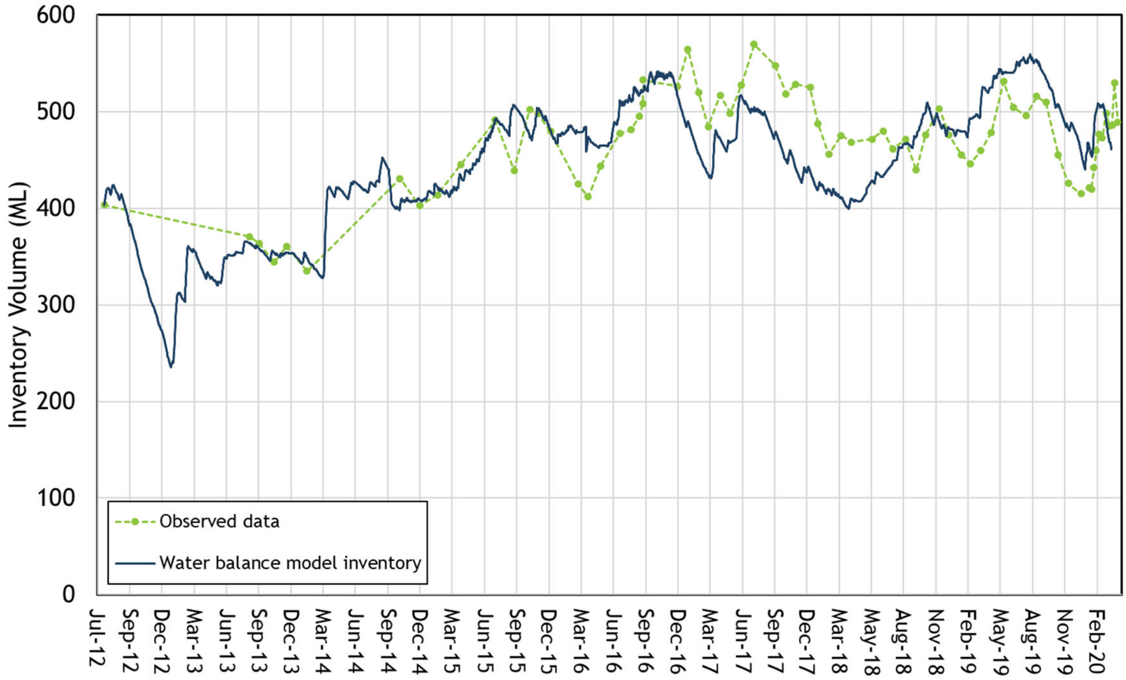


Figure 7.1 – Water balance model calibration results, total site water inventory

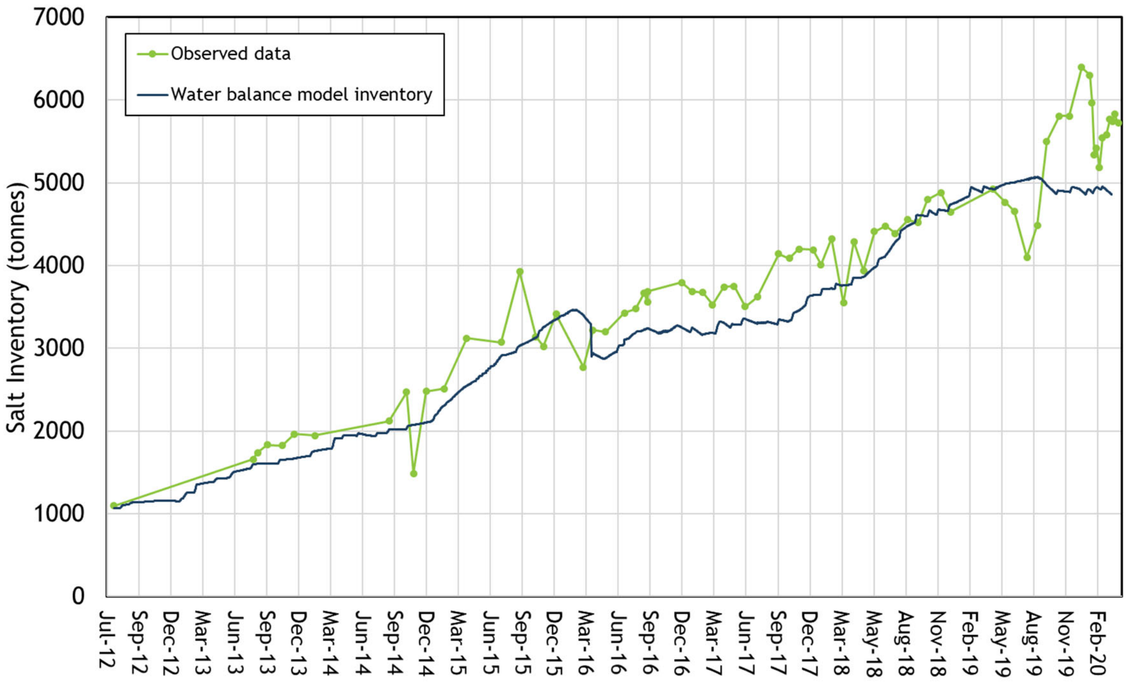


Figure 7.2 – Water balance model calibration results, total site salt inventory

7.4 FORECAST WATER BALANCE MODELLING

7.4.1 Methodology

In order to undertake forecasting simulations of the behaviour of the water management system over the future 24 years of mine operations, for a range of climatic conditions, the calibrated water balance model was configured to run 131 simulations of a 24 year (mine life) period, using the 131 years of available SILO Data Drill historic climate data. In order to achieve 131 simulations of 24 years, historical climate data was looped within the model to ensure the full range of climatic conditions was applied to all stages of the Project. For example, for the model realisation that commences in the year 2000, the historical data from 1889 to 1883 is added to provide a complete 24 year simulation period. The 24 year forecast simulation period commences on 1 April 2020 and ends on 1 November 2043.

The forecast simulation begins in January 2020, and the Project operations commence in January 2022. It is necessary to include the two-year interim period of operations within the forecast modelling period to understand the potential behaviour of the mine water management system between January 2020 and January 2022, and the resulting initial conditions at the start of the Project. The stored water volumes in the rail loop dams at January 2020 were used as the initial conditions at the start of each simulation.

Key elements of the forecast water balance model are discussed in more detail below.

7.4.2 Project production schedule

Table 7.4 outlines the ROM production schedule for the Project based on the proposed mining schedule.

Table 7.4 – Project ROM coal production schedule

Year	ROM coal production (Mtpa)	Year	ROM coal production (Mtpa)
2022	7.7	2034	8.3
2023	7.1	2035	9.4
2024	6.6	2036	8.1
2025	10.9	2037	9.2
2026	10.9	2038	9.2
2027	9.4	2039	7.7
2028	10.8	2040	8.4
2029	9.0	2041	7.5
2030	10.4	2042	9.1
2031	8.4	2043	6.1
2032	10.3	2044	1.3
2033	9.4		

7.4.3 Predicted groundwater inflows

The Groundwater Assessment prepared by AGE (2020) provides predicted groundwater inflows for the Project. Figure 7.3 shows the AGE (2020) predicted groundwater inflows. The AGE (2020) predicted groundwater inflows have been adopted for use in forecast water balance modelling for the Project.

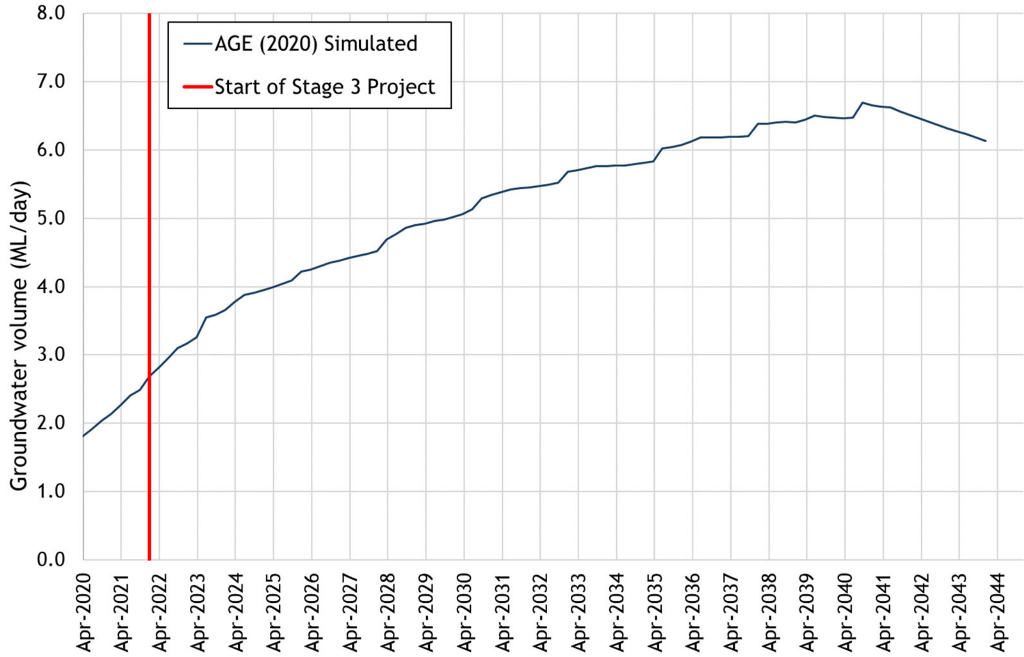


Figure 7.3 – AGE (2020) predicted Project groundwater inflows

The following are of note:

- The AGE (2020) predicted daily groundwater inflow rate for March 2020 is 1.80 ML/day, 0.96 ML/day higher than the estimated actual groundwater inflow for March 2020 (refer Figure 5.2). The AGE (2020) predicted groundwater inflows are therefore conservative for the purposes of assessing the water management system's ability to contain and treat mine affected water.
- AGE (2020) predicts groundwater inflows of about 2.7 ML/day at the start of the Project (January 2022).
- Groundwater inflows are predicted to increase steadily, reaching a peak of 6.69 ML/day in September 2040, before reducing to 6.14 ML/day by the end of 2044.
- Groundwater inflows to the existing Narrabri Mine have typically been less than 1.5 ML/day.

7.4.4 Water demands

The key water demand assumptions used in the forecast water balance model are described below:

- A demand of 0.33 ML/day was adopted for the ROM and product coal stockpile sprays based on the available Narrabri Mine site data:
    - Brine would be used in the ROM and product coal stockpile sprays as a first priority, followed by mine/Pit Top Area runoff water from A1.
- A surface dust suppression demand of 0.21 ML/day was adopted based on available Narrabri Mine site data.
- ROM and product coal stockpile sprays and surface dust suppression would only be operated on non-rain days.
- A Pit Top Area runoff demand (CHPP and washdown) of 0.039 kilolitres per ROM tonne (kL/ROM tonne) was adopted based on available Narrabri Mine site data.

- As per the calibration model, 22% of Pit Top Area runoff water use is recycled via Dam SB1.
- An underground filtered water demand of 0.064 kL/ROM tonne was adopted based on recorded underground filtered water use and ROM coal production.
- Pit Top Area runoff and underground filtered water demands are calculated by the water balance model based on the ROM coal production schedule.
- Longwall emulsion demand, vent humidity loss and increase in coal moisture were kept as per Section 5.5.

Figure 7.4 compares the predicted site demands with the predicted groundwater inflows described in Section 7.4.3. Inflows are predicted to exceed demands in every year of mining, with releases of filtered water required to manage the surplus onsite. The predicted water surplus ranges from -0.75 ML/day (i.e. a water deficit) to 5.6 ML/day.

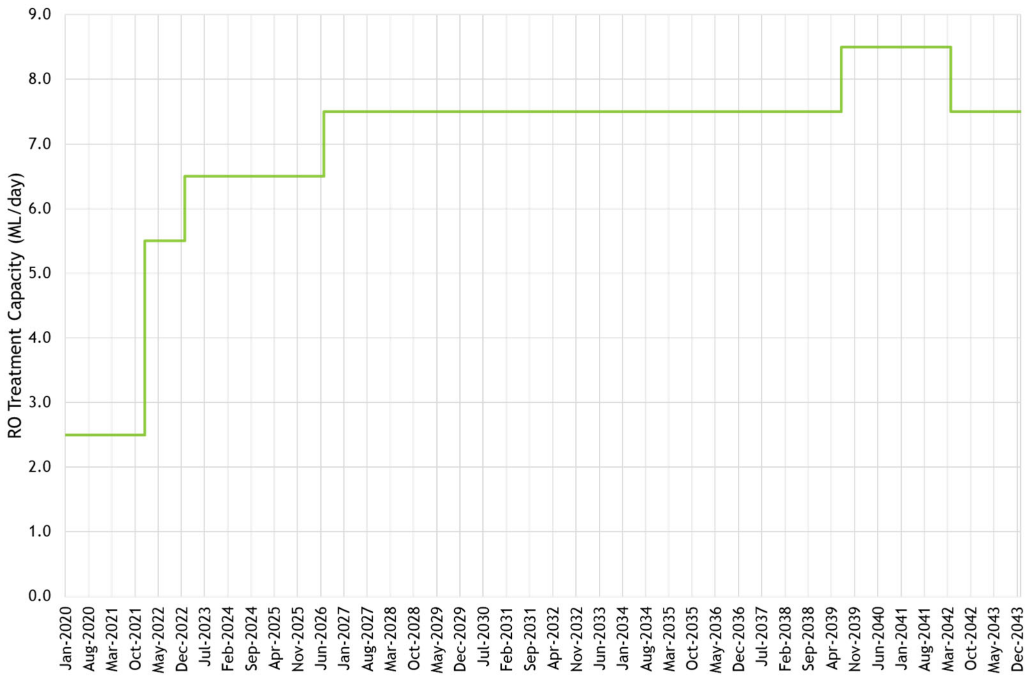


Figure 7.4 – Comparison of predicted site water demands and inflows and predicted surplus

7.4.5 Management of A1 water levels

The forecast site water balance model is configured such that the RO plants operate to maintain the volume of water stored in A1 between 30% (38 ML) and 40% (51 ML) of the dam capacity (128 ML).

This set point provides sufficient capacity to allow the Pit Top Area runoff storages (SB1, SB2, SB3, SB4 and SD6) to be pumped out following rainfall events to prevent overflows from these storages to the environment.

7.4.6 Pumping out of SB1, SB2, SB3, SB4 and SD6

The configuration and assumed operation of SB1, SB2, SB3, SB4 and SD6 is as follows:

- SB1 is pumped into A1, and overflows to SB2:
  - SB1 is pumped out whenever more than 2 ML of water accumulates;
- SB2 is pumped into A1, and SB2 overflows to SD1 and then SD2:
  - SB2 is pumped out whenever more than 2 ML of water accumulates in the dam;

- SD6 is pumped into A1:
    - SD6 is assumed to be pumped out completely following rainfall events;
- Pumping from SB1, SB2 and SD6 into A1 ceases when the volume of water stored in A1 is greater than 119 ML (93% full); and
- SB3 and SB4 are pumped into SB1, and overflow to SD3 and then SD4:
    - Pumping of SB3 maintains its water level between 4 ML and 5 ML;
    - Pumping of SB4 maintains its water level between 18 ML and 20 ML; and
    - Pumping from SB3 and SB4 into SB1 stops if SB2 volume is greater than 25 ML (65%).

7.4.7 Additional brine storage dams

The forecast water balance modelling suggests that the approved but not constructed brine storages BR1, BR2, BR3 and BR4 would be required. However, if groundwater inflows significantly exceed the adopted groundwater inflows estimates, the additional approved brine storage (i.e. BR5) may also be required.

The forecast modelling has been used to predict the required timing (i.e. commissioning) and storage volume for BR1, BR2, BR3 and BR4. The adopted dates of commissioning for these additional brine storages are based on the predicted groundwater inflows (Section 7.4.3):

- BR1: Commissioned in January 2022 (at commencement of the Project);
- BR2: Commissioned March 2023;
- BR3: Commissioned July 2026;
- BR4: Commissioned July 2030; and
- BR5: Commissioned July 2035.

The need for brine storages (i.e. BR1 to BR5), and timing of commissioning would be assessed against the actual groundwater inflows and site water system performance over the life of Narrabri Mine (i.e. actual need and, therefore, timing of commissioning of these storages would be regularly reviewed).

7.4.8 RO water treatment plant capacity

The capacity of the RO plants at the Project would be increased or decreased as required to treat the volumes of mine water and Pit Top Area runoff generated. An assumed time series for the RO treatment capacity available at the Project during the Project mine life has been developed and incorporated into the water balance model. The proposed RO treatment capacity for the Project is shown in Figure 7.5, and ranges from approximately 2.5 ML/day to 8.5 ML/day. It has been assumed that the RO treatment plant would have the ability to treat water with salinity of up to 12,500 µS/cm, with a recovery rate of 75%.

7.4.9 Releases of treated water to the Namoi River

The water balance model includes the ability for excess filtered water to be released from the mine site to the Namoi River. Water releases to the Namoi River are able to be made from the start of the Project (i.e. 1 January 2022). Releases of filtered water in the water balance model commence when:

- The volume of water stored in B1 (filtered water) exceeds 35 ML (89% capacity); and
- The volume of water stored in D (raw water) exceeds 70 ML.

Releases of filtered water cease when the volume of water stored in B1 is reduced to 27.6 ML (70% capacity). These trigger limits for releases were set to prevent B1 from overflowing into B2, and overwhelming the brine storages (B2 and C) within the rail loop.

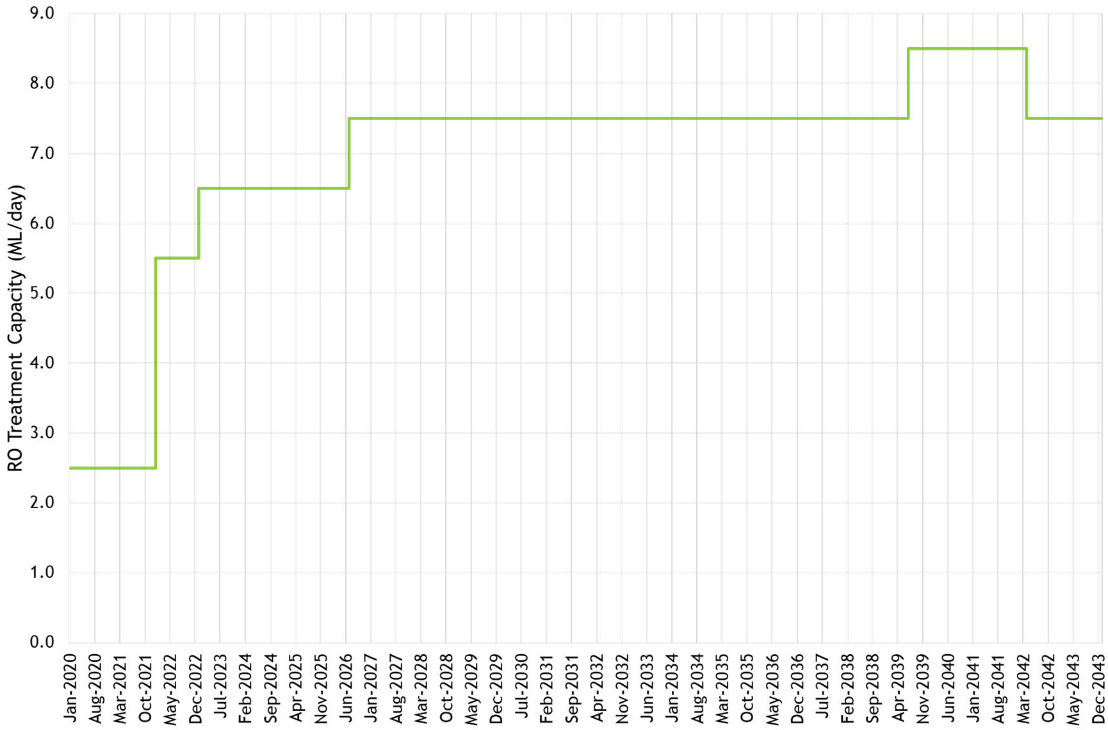


Figure 7.5 – Adopted RO treatment capacity for forecast water balance modelling

The model allows for up to 6 ML/day (approximately 2190 ML/year) of filtered water to be released to the Namoi River.

It is noted that excess filtered water could also be provided for beneficial reuse to other water users in the Project area (e.g. mining operations, irrigation) or passing the water to local landholders.

7.5 RESULTS

The calibrated model was used to forecast the behaviour of the Project site water balance over the life of the Project. The model was used to simulate 131 realisations of the future mine operations, allowing the future behaviour of the water management system to be assessed for a range of climatic conditions.

In interpreting the results of the forecast water balance simulation, it should be noted that the results provide a statistical analysis of the water management system's performance over the forecast period, based on different climatic conditions. The 50th percentile represents the median results, the 20th percentile exceedance represents dry conditions and the 80th and 99th percentile exceedance results represent wet and extremely wet conditions. There is a 60% chance that the result would fall within the 20th and 80th percentiles and a 98% chance the result would fall between the 1st and 99th percentiles Each model realisation is dependent on adjacent realisations because the process relies on looping the same rainfall and evaporation dataset offset by one year. However, the percentiles provide a reasonable estimate of the range of expected results that could occur.

Importantly, a percentile trace shows the percentile chance of a particular value on each day, and does not represent continuous results from a single model realisation (e.g. the 50th percentile trace does not represent the model time series for median climatic conditions).

Predicted 20th, median, 80th and 99th percentile inventory and overflow values are shown for a variety of storages. The plots reflect the likelihood of the stored or overflow volume being at or above this value on any given day. For instance, 80% of stored volumes are expected to be at or below the 80th percentile value.

7.5.1 Water management system performance

The forecast water balance model was used to predict the likely site water inventory for Pit Top Area runoff/mine water, brine, disturbed runoff, raw and filtered water. The results have been used to assess whether the Project water management system is adequate and in particular whether the water management infrastructure (dams/pumps and pipes) are capable of preventing uncontrolled overflows from the brine and mine storages.

Figure 7.6 and Figure 7.7 show the predicted stored volumes probability plots for the mine/Pit Top Area runoff storages (A1, A2, A3, SB1, SB2, SB3, SB4, SD6 and Box Cut Sump) and the brine storages (B2, C and the additional storages [BR1, BR2, BR3 and BR4 when they are commissioned]), respectively. Table 7.5 is a summary of the predicted inventories for all water streams at the Narrabri Mine. The following are of note:

- The mine/Pit Top Area runoff storage volumes generally vary between 100 ML and 250 ML over the life of the Project.
- There is a 1% chance that the stored volume in the mine/Pit Top Area runoff storages would reach 269 ML, which is less than the combined maximum storage volume of A1, A2, A3, SB1, SB2, SB3, SB4 and SD6 (301.6 ML).
- There is a less than 1% chance of an uncontrolled release to the environment occurring from SB2, SB3 or SB4.
- There is a 2% chance of overflows of Pit Top Area runoff water from A1 into B2 over the life of the Project.
- There is a 2% chance of an overflow of brine occurring from C into D (raw water storage) in August 2021 (prior to commissioning of BR1 in January 2022). There is a less than 1% chance of C overflowing into D following the construction of BR1.
- There is a 2% chance of Dam D overflowing to the containment bund in August 2021 (prior to commissioning of BR1 in January 2022). There is a less than 1% chance of D overflowing to the containment bund following the construction of BR1.
- The containment bund is not predicted to overflow to the environment.
- There is a 1% chance that the volume of brine stored in the brine storage dams (B2, C, BR1, BR2, BR3, BR4 and BR5) would reach a maximum of up to 4,023 ML in 2042, before reducing to about 3,895 ML at the end of the Project life.
- No overflows are predicted from the additional brine storage dams.

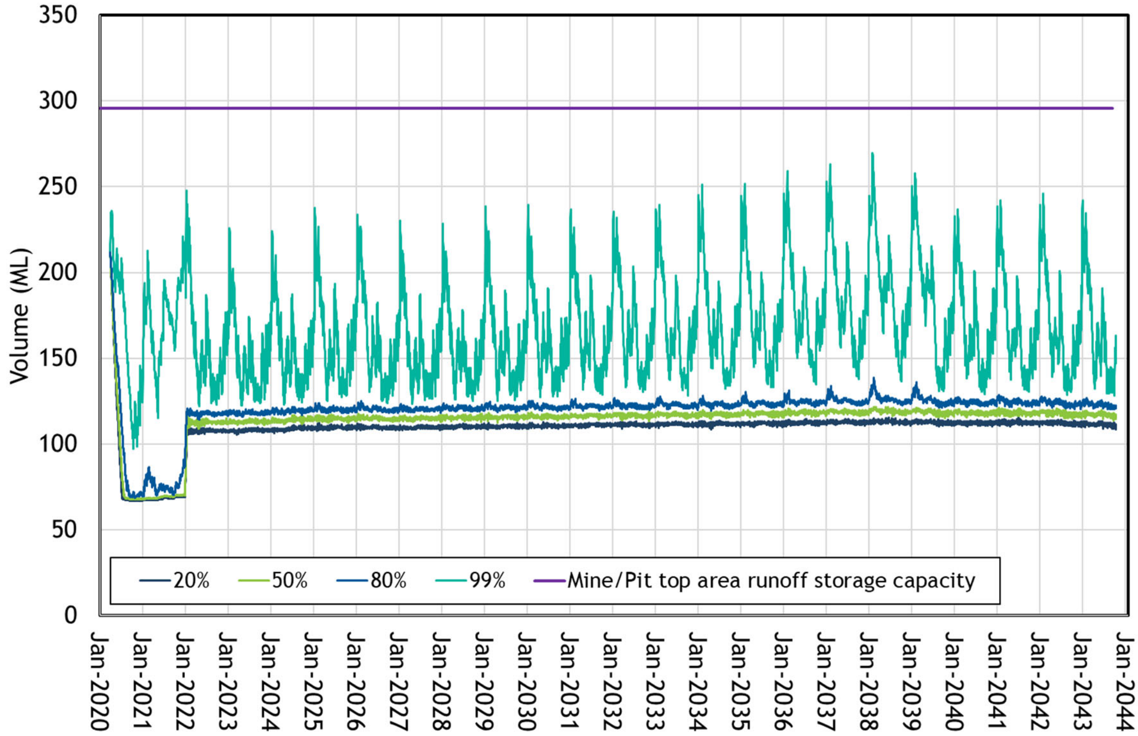


Figure 7.6 – Predicted storage inventory in the mine/Pit Top Area runoff storages (A1, A2, A3, SB1, SB2, SB3, SB4, SD6 and Box Cut Sump)

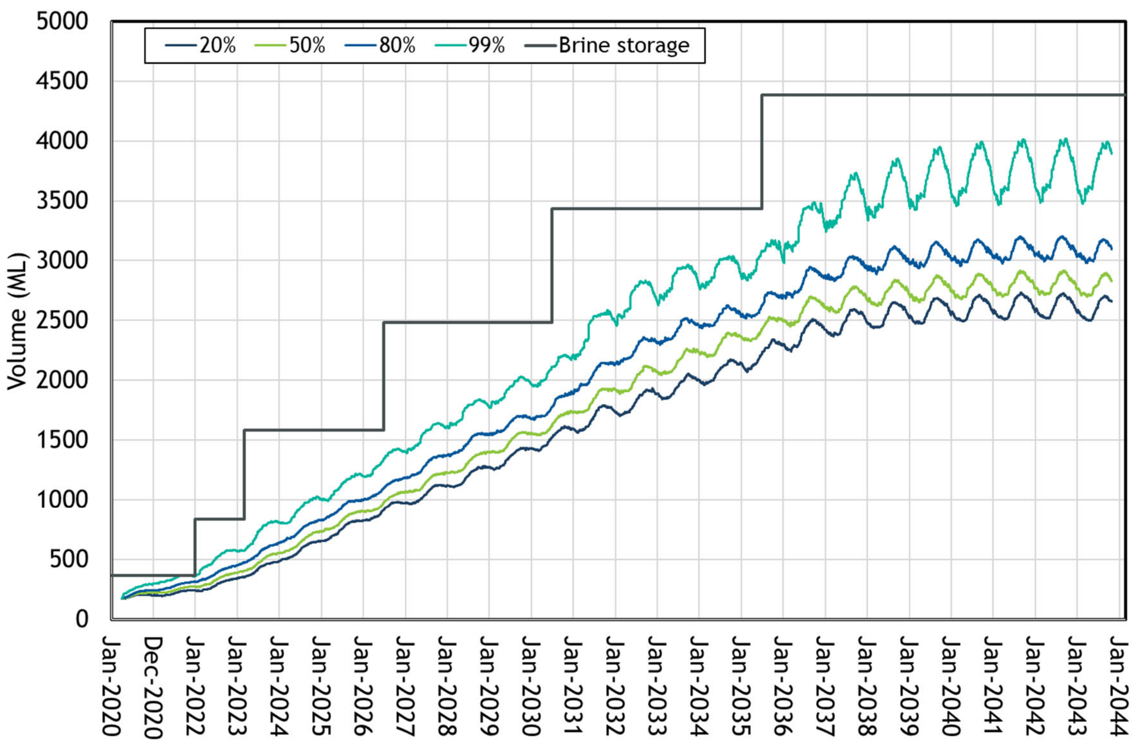


Figure 7.7 – Predicted storage inventory in the brine storage dams (B2, C, BR1, BR2, BR3, BR4 and BR5)

Table 7.5 - Forecast water inventory results

Year	Pit Top Area runoff/mine volume (ML)			Brine volume (ML)			Sediment dam volume (ML)			Filtered water volume (ML)			Raw water volume (ML)		
	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile	20th%ile	Median	80th%ile
2020	67.0	68.0	69.4	200.4	221.2	241.0	3.0	11.1	30.4	1.2	1.3	1.9	57.2	82.3	111.4
2021	69.1	70.1	87.2	241.6	274.4	315.4	8.5	17.5	49.4	1.9	1.9	1.9	2.1	25.8	92.1
2022 *	107.7	112.5	117.8	340.2	391.0	452.7	9.7	18.6	41.1	20.5	25.9	30.5	79.7	79.9	81.4
2023	107.8	113.5	118.1	485.6	553.7	638.9	9.2	17.2	38.2	22.2	27.0	32.4	79.7	79.9	81.7
2024	109.0	114.7	119.9	655.6	731.7	831.5	8.7	18.1	38.3	20.2	25.5	30.9	79.7	79.9	81.4
2025	109.4	113.8	119.4	825.4	900.3	1,000.0	8.4	17.6	38.2	21.8	27.4	31.4	79.7	79.9	81.6
2026	108.6	114.5	119.5	976.0	1,063.0	1,187.0	8.7	17.5	38.4	21.9	27.5	32.9	79.7	79.9	81.6
2027	109.0	113.0	120.4	1,123.0	1,229.0	1,376.0	8.7	17.1	38.4	22.4	28.7	34.0	79.7	79.9	81.7
2028	109.4	114.0	119.8	1,270.0	1,401.0	1,554.0	8.9	18.1	38.2	22.9	28.5	34.2	79.7	79.9	81.4
2029	110.1	115.2	120.8	1,430.0	1,557.0	1,680.0	8.9	18.1	38.2	21.5	28.3	34.7	79.7	79.9	81.6
2030	110.6	115.5	121.7	1,593.0	1,725.0	1,896.0	8.9	17.5	38.4	23.1	28.8	34.4	79.7	79.9	81.6
2031	111.0	116.3	120.7	1,737.0	1,927.0	2,136.0	9.0	17.3	38.4	23.4	30.2	34.9	79.7	79.9	81.7
2032	111.2	116.5	121.7	1,885.0	2,077.0	2,311.0	9.3	18.1	38.2	23.4	29.0	33.6	79.7	79.9	81.4
2033	112.2	117.6	122.1	2,003.0	2,232.0	2,458.0	8.9	18.1	38.2	22.4	29.0	35.2	79.7	79.9	81.6
2034	112.0	117.7	123.9	2,140.0	2,363.0	2,544.0	8.9	17.5	38.4	22.6	28.6	34.4	79.7	79.9	81.6
2035	111.5	116.4	121.7	2,301.0	2,493.0	2,703.0	9.0	17.3	38.4	26.3	31.5	35.6	79.7	79.9	81.7
2036	112.8	118.5	124.2	2,426.0	2,608.0	2,853.0	9.3	18.1	38.2	26.1	30.4	34.5	79.7	79.9	81.4
2037	113.4	118.3	125.1	2,488.0	2,673.0	2,942.0	8.9	18.1	38.2	26.1	30.4	35.0	79.7	79.9	81.5
2038	112.5	118.7	124.4	2,536.0	2,720.0	2,989.0	8.9	17.5	38.4	27.2	32.2	35.0	79.7	79.9	81.5
2039	112.4	117.3	122.3	2,558.0	2,746.0	3,024.0	9.0	17.3	38.4	24.8	30.7	36.3	79.7	79.9	81.7
2040	111.9	116.6	123.0	2,575.0	2,762.0	3,032.0	9.3	18.1	38.2	26.2	32.0	35.2	79.7	79.9	81.4
2041	111.9	117.6	123.6	2,592.0	2,771.0	3,051.0	8.9	18.1	38.2	24.4	31.1	34.5	79.7	79.9	81.5
2042	111.4	116.6	121.0	2,578.0	2,762.0	3,045.0	8.9	17.5	38.4	24.4	31.6	36.8	79.7	79.9	81.5
2043	111.3	117.3	122.6	2,659.0	2,826.0	3,101.0	10.8	21.5	47.0	26.4	35.3	38.6	79.7	80.0	82.0

* Project commencement is Year 2022.

7.5.2 Raw water supply

The forecast supply of raw water from the Namoi River pump station and/or alluvial production bore is shown in Figure 7.8. The water balance model predicts that small amounts of raw water would be imported to the Narrabri Mine in 2021 and 2022. No external raw water is predicted to be required at the Narrabri Mine in 2020 and between 2023 and 2043 as groundwater inflows would exceed the site demands.

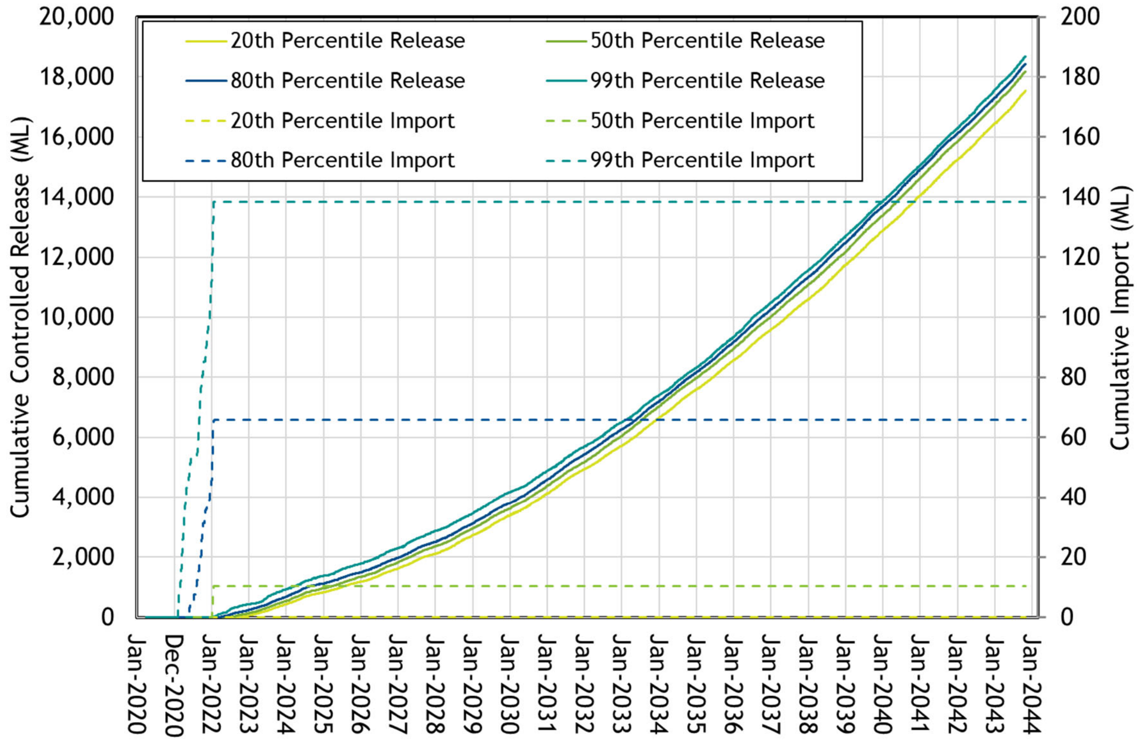


Figure 7.8 – Predicted cumulative controlled releases and water imports

Notwithstanding the above, the NCOPL would maintain existing WALs for the extraction of water from the Namoi River pump station and/or alluvial production bore (Section 5.6). No additional WALs would be required.

7.5.3 Controlled releases

Figure 7.8 shows the forecast volume of excess filtered water that may be released to the Namoi River within the forecast period. The following are of note:

- Controlled releases generally track the groundwater inflows. There is very little variation in controlled releases between the 80th percentile and 99th percentile plots due to the system being groundwater dependent and not rainfall dependent.
- Rainfall and climatic conditions influence the timing of releases. If wet climatic conditions are experienced, controlled releases would occur earlier in the Project. If dry climatic conditions are experienced, controlled releases of filtered water are delayed.
- There is a 1% chance that up to 438 ML of water would need to be released to the Namoi River in 2022.
- There is a 50% chance that up to 144 ML of water would need to be released to the Namoi River in 2022.

As described in Section 6.4, NCOPL would also investigate options for the beneficial re-use of excess filtered water with other water users in the Project area (e.g. mining operations, irrigation) or passing the water to local landholders.

7.5.4 Brine disposal

Consistent with the approved Narrabri Mine, the brine stored within the brine storage ponds would be re-injected into the longwall goaf through the disused goaf gas drainage holes towards the completion of mining.

The predicted volumes and salinity of brine stored in the brine storage ponds at the completion of mining are:

- 20 percentile – 2,657 ML (67,770 mg/L);
- 50 percentile – 2,832 ML (64,110 mg/L);
- 80 percentile – 3,098 ML (58,767 mg/L); and
- 99 percentile – 3,895 ML (46,004 mg/L).

7.5.5 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.

8 Assessment of impacts

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

- potential impact of mine subsidence on the local waterway geomorphology;
- potential impacts on local stream flows due to catchment excision and subsidence-related ponding;
- potential impacts on regional stream flows;
- potential impacts on water quality;
- potential impacts on the flood regime;
- consideration of water licensing requirements; and
- potential cumulative impacts of the Project.

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

8.1 SUBSIDENCE IMPACTS ON WATERWAYS

An assessment of the potential subsidence impacts on watercourses due to the existing/approved Narrabri Mine was previously undertaken by WRM (2015). As the Project would not involve any changes to the approved Longwalls 101 to 111, the potential subsidence impacts on the watercourses above these longwall panels (i.e. Pine Creek and its tributaries) described in WRM (2015) would also be unchanged by the Project. The Project is also seeking no change to the approved Longwalls 201 and 202.

The Project would however include changes to Longwalls 203 to 209, as well as an additional longwall panel (Longwall 210) and therefore the potential subsidence impacts on the following watercourses above these longwall panels have been considered:

- Kurrajong Creek (3rd order watercourse);
- Tulla Mullen Creek Trib1 (3rd order watercourse); and
- other minor 1st and 2nd order watercourses.

The potential subsidence impacts on Kurrajong Creek Trib 1 described in WRM (2015) would also not significantly change as a result of the Project.

All of the watercourses are ephemeral.

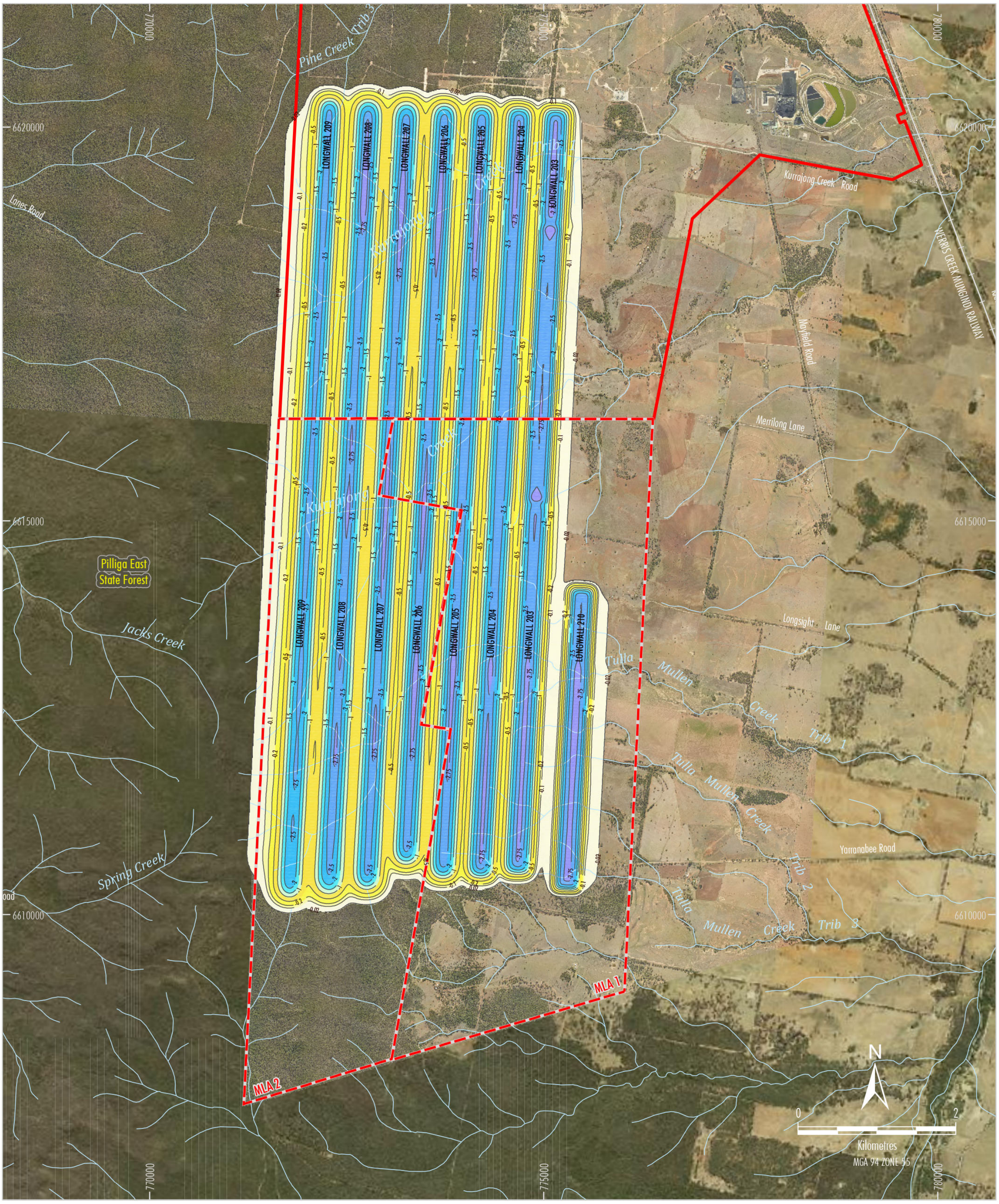
8.1.1 Overview of predicted subsidence impacts

Longwall mining typically results in subsidence, which leads to progressive development of shallow, trough-like depressions on the surface above each extracted longwall panel. The trough-like depressions have gentle grades and develop relative to the natural surface.

The depressions on the surface develop as the roof strata above the coal seam progressively collapse to fill the void created by the extraction of coal in the area behind the longwall. As the roof collapses into the mined area (referred to as the 'goaf'), the fracturing and settlement of rocks progresses upwards through the overlying strata and results in sagging and bending of the near surface layers.

Surface subsidence develops progressively on the surface in a wave across the active longwall panel that travels at the same rate as the longwall.

DGS (2020) developed estimates of ground subsidence associated with the proposed longwall mining operation (Figure 8.1). The estimates were based on several empirical and calibrated analytical models of overburden and chain pillar behaviour developed in NSW Coalfields but adjusted to match measured subsidence observed at the existing/approved Narrabri Mine.



LEGEND

Mining Lease (ML 1609)

Provisional Mining Lease Application Area

-0.02 -0.1 -0.2 -0.5 -1 -1.5 -2 -2.5 -2.75 -3

Subsidence (m)

Source: NCOPL (2020); NSW Spatial Services (2019); Ditton Geotechnical Services (2020)

WHITEHAVEN COAL

NARRABRI STAGE 3 PROJECT

Figure 8.1 – Predicted subsidence depths (Source: DGS, 2020)

Figure 8.1 shows a digital elevation model (DEM) of the predicted longwall subsidence contours for the Project (DGS, 2020). The post subsidence DEM was then inspected to identify areas of potential stream geomorphological impacts, including ponding and potential for erosion. Details of the impacts for each creek system are given below.

DGS (2020) found the following with respect to mine subsidence impacts on the waterways that occur in the Project area.

- Surface cracking and shearing ranging in width from 100 mm to 400 mm could occur with occasional (<5% probability) wider cracks up to approximately 390 mm in sand or loam, and up to approximately 780 mm in clay or rock.
- Surface gradients are likely to increase or decrease by up to 2.5% (±1.5°) along creeks.
- Direct hydraulic connection to the surface, due to continuous sub-surface fracturing above the panels, is considered unlikely to possible to occur.
- The Geology and Geometry Pi-Term Models predict 'discontinuous', or B-Zone, sub-surface fracturing is likely to interact with surface cracks (D-Zones) where cover depths are <300 m above the 306 m wide panels and <390 m above the wider longwalls. Creek flows could be temporarily re-routed into open cracks to below-surface pathways and re-surface downstream of the mining extraction limits in the mining area.
- General and localised slope instability along minor cliff faces and steep rocky slopes are considered very unlikely due to the predicted cracking and tilting caused by Longwalls 203 to 210.
- A total of 18 potential ponding locations are assessed. The majority of potential ponding areas already exist and would develop further along the watercourses and likely to remain 'in-channel'. The maximum change in pond depths are estimated to range from -0.1 m to 0.9 m (average of 0.6 m).
- 41 farm dams would be located within the angle of draw of the proposed Longwalls 203 and 210 and are likely to be impacted by mine subsidence. There are nine dams that may have their inflows affected by upstream ponding due to the proposed longwalls.

DGS (2020) presents comprehensive estimates of the predicted mine subsidence impacts.

8.1.2 Kurrajong Creek

Figure 8.2 shows longitudinal profiles along the Kurrajong Creek centre line for existing and post mining subsidence conditions. The location of the headcut (Section 4.3.1) is also shown. A visual interpretation of the potential impacts of the predicted subsidence along Kurrajong Creek and in particular the locations of predicted ponding, are shown in Figure 8.3. The locations and extent of the existing ponding, which is generally associated with existing farm dams, is also shown.

The following are of note:

- Major changes in channel geomorphology due to changes in channel location (avulsions) are unlikely as the pre- and post-subsidence channels are located within well-confined valleys.
- Some of the minor (1st order) channels may drain into the creek at alternate locations and cause localised bank scour, particularly above Longwalls 207 and 209.
- Minor increases in channel erosion would be expected on the downstream side of each chain pillar due to the increased channel slope.
- Additional in-channel ponding is expected to occur above all longwall panels upstream of each chain pillar. The ponded areas are expected to accumulate sediment over time.

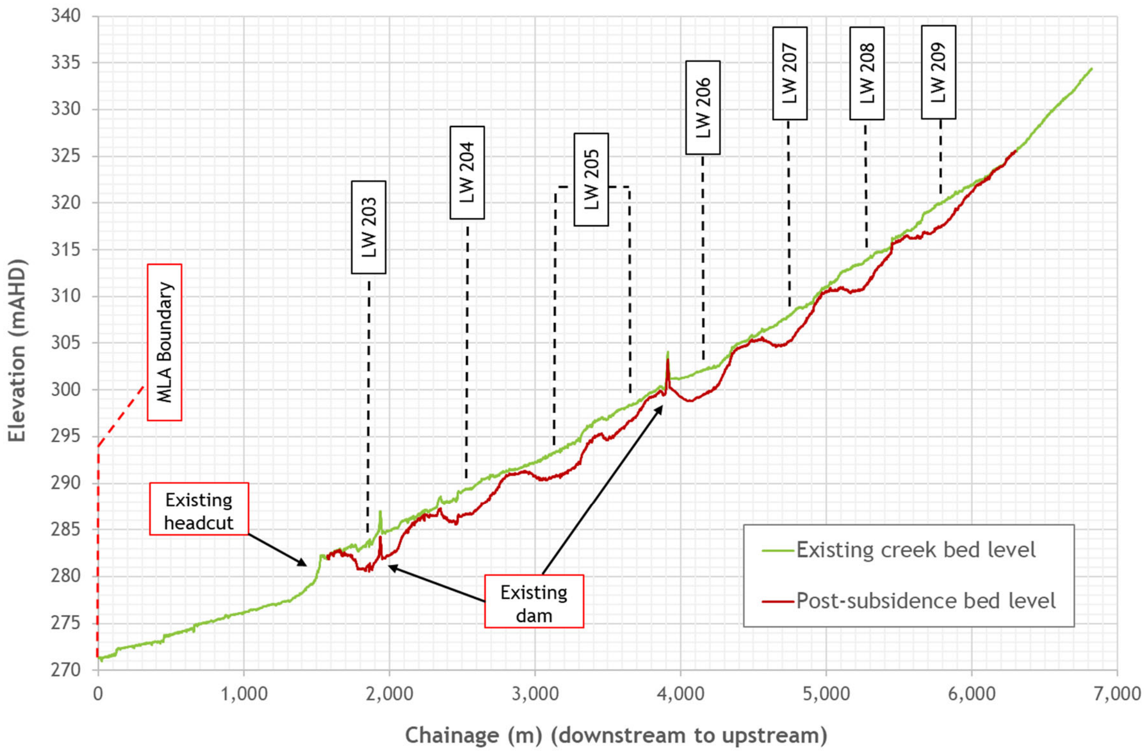


Figure 8.2 – Longitudinal profile of Kurrajong Creek channel bed

- The existing farm dam above Longwall 203 is generally unaffected with little change to the extent of ponding or storage volume. However, NCOPL has indicated that this farm dam would be decommissioned (Section 4.4).
- Additional ponding is predicted at the existing farm dam located above Longwall 206. Again, NCOPL has indicated that this farm dam would be decommissioned (Section 4.4). The extent of ponding in this area is predicted to reduce once the dam has been removed.
- Additional ponding is located upstream of a farm dam located on the 1st order watercourse that drains along the chain pillar between Longwalls 203 and 204. This dam should be removed if the additional ponding impacts on existing vegetation.
- Numerous contour banks above Longwalls 203 and 204 would be impacted by subsidence. Some contour banks would ultimately drain in two directions, causing contour banks to silt up and overtop, potentially resulting in minor downstream erosion by the concentration of flow.
- Overbank ponding is expected to the south of Kurrajong Creek along Longwall 203. There is no vegetation within the ponded area. It is expected that this ponded area would fill with silt over time.
- The hydraulic and geomorphic characteristics of the channel at the existing headcut located downstream of the mining area is expected to be unchanged by the Project. As a result, the Project is not expected to exacerbate erosion at the headcut. A review of the longitudinal profile in Figure 8.2 suggests that, if the headward erosion was to continue, the lowering of the bed due to Longwall 203 may in fact reduce further bed incision because the lowered bed level is similar to the incised bed level.

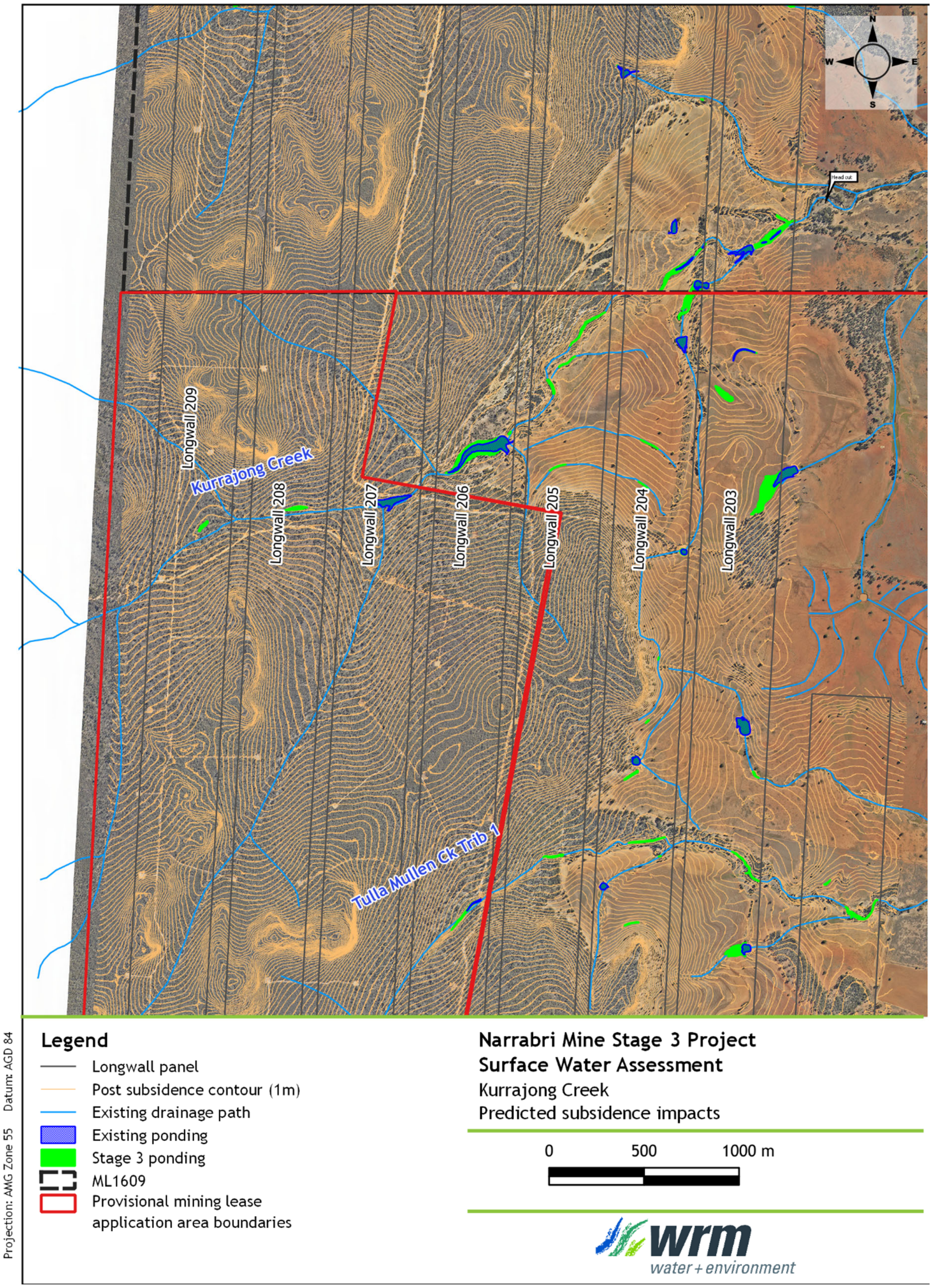


Figure 8.3 – Predicted subsidence impacts, Kurrajong Creek

8.1.3 Tulla Mullen Creek Trib1

Figure 8.4 shows longitudinal profiles along the Tulla Mullen Creek Trib1 centre line for existing and post mining subsidence conditions. A visual interpretation of the potential impacts of the predicted subsidence along Tulla Mullen Creek Trib1 and in particular the locations of predicted ponding, are shown in Figure 8.5. The locations and extent of the existing ponding, which is generally associated with farm dams, is also shown.

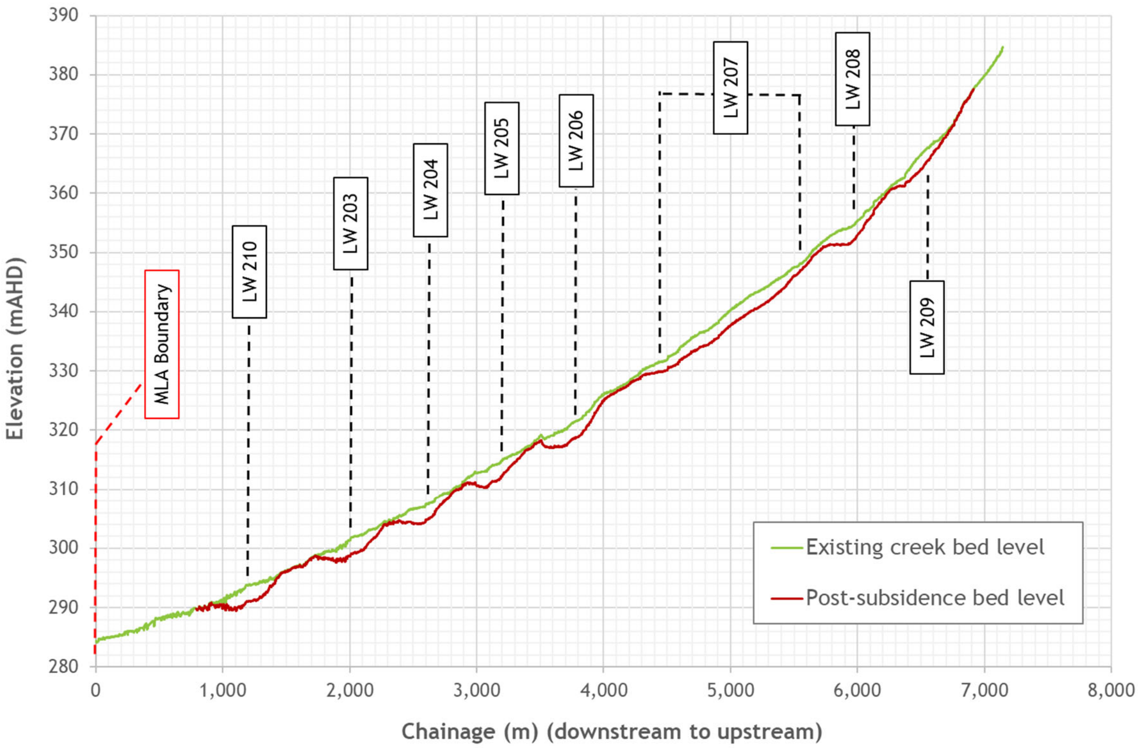
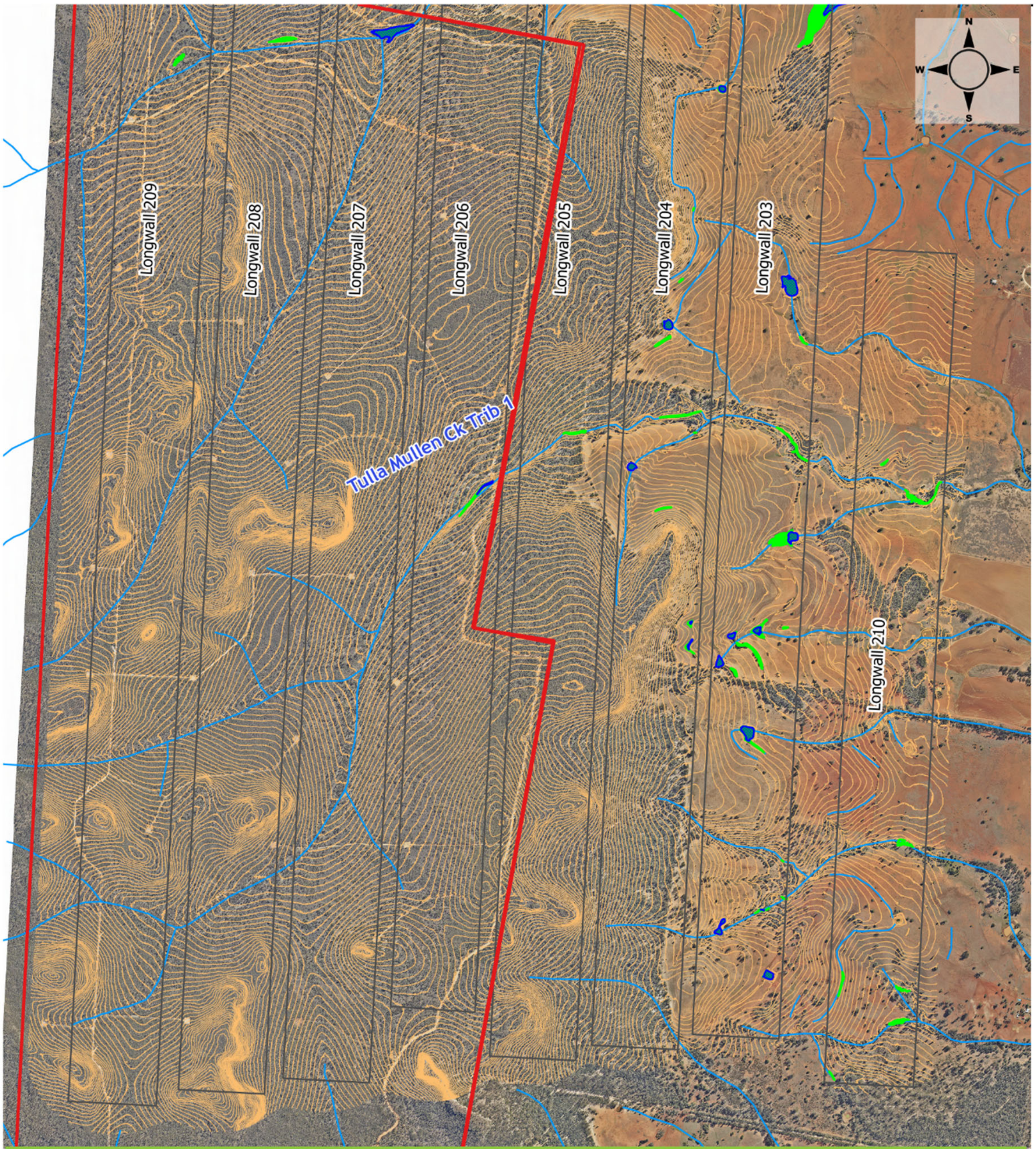


Figure 8.4 – Longitudinal profile of Tulla Mullen Creek Trib1 channel bed

The following are of note:

- Major changes in channel geomorphology due to changes in channel location (avulsions) are unlikely as the pre- and post-subsidence channels are located within well confined valleys.
- Minor increases in channel erosion would be expected on the downstream side of each chain pillar due to the increased channel slope.
- Additional in-channel ponding is expected to occur above all longwall panels upstream of each chain pillar. The additional ponding is minor given the confined nature of the channel. The ponded areas are expected to accumulate sediment over time.
- An existing farm dam located on the 1st order watercourse that drains to the south of Tulla Mullen Creek Trib1 across Longwall 203 would experience additional ponding. The additional ponding only impacts on cleared agricultural land.
- Numerous contour banks above Longwalls 203 and 210 would be impacted by subsidence. Some contour banks would ultimately drain in two directions, causing contour banks to silt up and overtop, potentially resulting in minor downstream erosion by the concentration of flow.



Projection: AMG Zone 55 Datum: AGD 84

Legend

- Longwall panel
- Post subsidence contour (1m)
- Existing drainage path
- Existing ponding
- Stage 3 ponding
- ML1609
- Provisional mining lease application area

Narrabri Mine Stage 3 Project
Surface Water Assessment
Tulla Mullen Creek Tributary 1
Predicted subsidence impacts

0 500 1000 m

wrm water + environment

Figure 8.5 – Predicted subsidence impacts, Tulla Mullen Creek Trib1

8.2 IMPACT ON LOCAL CATCHMENT FLOWS

8.2.1 Catchment excision

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

Although the Project would not change the catchment flowing to the existing/approved Pit Top Area water management system, there would be a reduction associated with the proposed Southern Mine Water Storage (approximate 4.6 ha). There would be minor changes associated with the ventilation shaft and service borehole pad sediment dams. However, these catchment impacts would be minor and temporary (as this infrastructure is progressively constructed and rehabilitated after use is completed).

Table 8.1 shows the pre-mining catchment areas for the impacted creeks to the downstream Project area boundary, the catchment excised by the existing Narrabri Mine infrastructure and the estimated incremental reduction in catchment area for the Project. As shown, the incremental change in catchment area due to the Project is minor and would not have a measurable impact on catchment flows.

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

Watercourse	Predevelopment catchment area (ha)	Reduction in catchment area due to the Project from pre-mine (ha)			Reduction in catchment area due to the Project from pre-mine (%)
		Existing/ Approved Narrabri Mine	Incremental Change due to Project	Total	
Pine Creek	6,800	0	0	6,800.0	0
Kurrajong Creek	5,500	247.3	0	5,252.7	4.50
Tulla Mullen Creek	10,700	0	4.6	10,695.4	0.04

8.2.2 Mine subsidence

Subsidence was predicted to increase the surface area of depressions in drainage lines from 8.3 ha (existing case) to 16.7 ha (impacted case) (see Figure 8.3 and Figure 8.5). The removal of the existing farm dams associated with Kurrajong Creek and Kurrajong Creek Trib 1 would reduce the surface area under the impacted case to 13.2 ha. Sediment loads were not estimated. However, sediment is likely to fill the subsidence areas incrementally over the life of the Project 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 remediation or infilling, would be 41.8 ML without the removal of the farm dams and 24.5 ML when the dams are removed. This volume is negligible when compared to the expected mean annual runoff volume for Kurrajong Creek and Tulla Mullen Creek Trib 1 to the eastern boundary (combined) of 1,230 ML (determined using the mean annual rainfall in Table 4.1 and the volumetric runoff coefficient for natural catchments given in Table 7.2).

Further to this, the additional in-stream storage is not expected to impact on the low and medium flows or flow regime of the watercourses. First, the watercourses are highly ephemeral with no baseflow observed under existing conditions. The downstream vegetation would be adapted to these conditions. Figure 8.3 and Figure 8.5 show that the instream depressions are widely distributed throughout the two catchments with many small side tributaries contributing to instream flows downstream of the depressions. As such, the frequency of no flow days is unlikely to change.

In addition, DGS (2020) determined that a direct hydraulic connection to the surface due to mine subsidence is unlikely to possible. In the event that direct hydraulic connection was to occur, there is potential for the diversion of flows into the underlying strata. In times of high flow, the majority of the runoff would flow over the drainage line beds and would not be diverted into the underlying strata. In times of low flow, however, surface water flows could be diverted into the underlying strata. Given the highly ephemeral nature of the drainage lines, the potential diversion of flows into the underlying strata during low flow events would be negligible.

Given the above, a more detailed impact assessment on the flow regime (including modelling and collection of detailed monitoring and hydrographic data) is not warranted.

8.3 IMPACT ON NAMOI RIVER FLOWS

The potential impact of the Project on baseflow in the Namoi River and its tributaries has been assessed by AGE (2020). The assessment concluded that there would be negligible changes to baseflow during the Project life. Baseflow impacts to the Namoi River and its tributaries of up to approximately 200 ML/yr are predicted to be lost post-mining (AGE, 2020). The Namoi River would not be subject to direct subsidence effects (DGS, 2020).

Flows in the Namoi River are regulated by releases from the upstream Chaffey, Split Rock and Keepit dams. Mean flow rates in the Namoi River at Gunnedah (upstream of the Project) are maintained at about 1,900 ML/day. In the context of the Namoi River regulated system, a baseflow loss of 200 ML/yr (or approximately 0.03% of the mean Namoi River flow) is minor. Hence, the Project would not measurably affect baseflow in the Namoi River post mining.

During operations, the water balance modelling showed that there could be releases of filtered water of up to 6 ML/day (Section 7.5.3), which is insignificant in comparison to the regulated flows of 1,900 ML/day. Hence, the Project would not measurably affect low flows in the Namoi River during mining.

The reduction in Namoi River flows due to catchment incision is insignificant, given the catchment area of the Namoi River is 24,500 km^2.

8.4 IMPACT ON SURFACE WATER QUALITY

The water balance model indicates that the likelihood of an uncontrolled release of mine/Pit Top Area runoff water is very low (less than 1%), and that no brine would be released from the Project. The sediment dams at the Project would continue to be dewatered following runoff events, and would only overflow within the EPL 12789 limits for wet weather discharges. Therefore, the Project water management system is unlikely to result in adverse impacts to water quality due to uncontrolled releases of water.

The filtered water that is proposed to be released to the Namoi River would be treated by RO, and would comply with the release criteria outlined in EPL 12789. The controlled release of treated water would not adversely impact on water quality in the Namoi River.

The NCOPL would prepare and implement a Permeate Discharge Control and Monitoring Plan to monitor potential Namoi River water quality impacts associated with the controlled release of treated water.

The surface cracking associated with mine subsidence would expose soils to short term erosion during the first flush, which may temporarily increase turbidity and TSS in the local waterways. It is expected that turbidity and TSS would revert back to background conditions for subsequent flow events as the cracks fill in and repair. As a result, water quality impacts associated with mine subsidence is not expected to be long term or significant.

Services corridors, access tracks and other infrastructure would utilise fords or culverts to traverse drainage lines in accordance with the Fisheries NSW *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013).

8.5 FLOODING

8.5.1 Namoi River

A FMP for the Upper Namoi Valley Floodplain has been developed in pursuance of Section 50 of the WM Act. The Project (with the exception of the existing/approved Namoi River pump station, alluvial production bore and the pipeline) is located outside the plan area defined within the FMP.

Given the nature of the existing/approved Namoi River pump station, alluvial production bore and the pipeline (i.e. mostly underground with minimal above-ground components), the impact on the Namoi River floodplain is considered to be negligible. Irrespective of the above, the Project would not change the existing/approved Namoi River pump station, alluvial production bore and the pipeline.

In addition, the Project Pit Top Area is located at least 20 m in elevation above the Namoi River floodplain and as such the Namoi River would not inundate the Project Pit Top Area under any circumstance, which is consistent with WRM (2007).

Given the above, the Project is not expected to have any significant impact on Namoi River flooding.

As a component of the original SEARs for the Project, OEH (now within the DPIE – BCD) requested flood modelling be undertaken as part of the EIS. NCOPL wrote to DPIE via letter on 26 July 2019 regarding the requirement for flood modelling, and DPIE responded via letter on 27 August 2019 confirming that flood modelling was not required for the EIS.

8.5.2 Local tributaries

FMPs for the local tributaries that cross the Project area have not previously been developed. A flood study of Kurrajong Creek Trib1 (WRM, 2007) was prepared as part of the Narrabri Mine Stage 1 Environmental Assessment to assess the potential impacts of the Pit Top Area. This assessment found that the infrastructure developed for Stage 1 was located outside the 100 year average recurrence interval flood extent except for a small section of rail adjacent to the Kamilaroi Highway. The impact of the constriction caused by the Pit Top Area was not significant.

The Project would not include changes to the Pit Top Area and no significant infrastructure is proposed as part of the Project (Figure 1.3) that would significantly impact on the flow of water in any of the local tributaries, with the exception of mine subsidence.

The local waterways subject to mine subsidence are well confined. As a result, there would be no significant changes to the flooding behaviour along any of the local waterways.

8.6 WATER LICENSING CONSIDERATIONS

8.6.1 Water Sharing Plan for the Namoi and Peel Unregulated Water Sources 2012

The Project is located wholly within the Eulah Creek water source within the NPUWSP.

The water management system for the Project has been designed to minimise the capture of clean runoff wherever possible.

Licensing considerations for the Project water storages are summarised in Table 8.2. The Project water storages 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 – Summary of water licensing requirements for the Project water storages

Water Storage	Water Type Stored	Water Licensing Requirements
A1	Mine/Pit Top Area Runoff	Nil - turkey's nest
A2	Mine/Pit Top Area Runoff	Nil - turkey's nest
A3	Mine/Pit Top Area Runoff	Nil - turkey's nest
Southern Mine Water Storage[1]	Mine	Nil - turkey's nest
B1	Filtered	Nil - turkey's nest
B2	Brine	Nil - turkey's nest
C	Brine	Nil - turkey's nest
D	Raw	Nil - turkey's nest
SB1	Pit Top Area Runoff	Nil - excluded work
SB2	Pit Top Area Runoff	Nil - excluded work
SB3	Pit Top Area Runoff	Nil - excluded work
SB4	Pit Top Area Runoff	Nil - excluded work
SD1	Disturbed Area Runoff	Nil - excluded work
SD2	Disturbed Area Runoff	Nil - excluded work
SD3	Disturbed Area Runoff	Nil - excluded work
SD4	Disturbed Area Runoff	Nil - excluded work
SD6	Disturbed Area Runoff	Nil - excluded work
SD7[1]	Disturbed Area Runoff	Nil - excluded work
SD8	Disturbed Area Runoff	Nil - excluded work
Surface infrastructure sediment dams[1]	Disturbed Area Runoff	Nil - excluded work
Containment Bund	Raw	Nil - turkey's nest
BR1[1]	Brine	Nil - turkey's nest
BR2[1]	Brine	Nil - turkey's nest
BR3[1]	Brine	Nil - turkey's nest
BR4[1]	Brine	Nil - turkey's nest
BR5[1]	Brine	Nil - turkey's nest

[1] Not currently constructed.

Notwithstanding the above, where appropriate, NCOPL may rely on its harvestable right entitlement for Project water storages (subject to incorporation in the Water Management Plan). 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 on minor streams. A dam can capture up to 10% of the average regional rainfall runoff for their landholding without requiring a licence. According to the Water NSW calculator, the maximum harvestable right for the Project area is 0.065 ML per ha. The landholding area required for the purposes of the harvestable right calculation is the NCOPL's contiguous landholding shown on Figure 4.9 which is 8,723.6 ha. Based on the NCOPL's contiguous landholding and the harvestable rights multiplier value of 0.065 ML/ha for the relevant area, the total harvestable right for the Project is 567 ML.

8.6.2 Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016

NCOPL currently owns WALs under the NRRWSP (Section 5.6). Based on the forecast raw water supply required from the Namoi River pump station (Section 7.5.2), no additional WALs under the NRRWSP would be required.

NCOPL holds sufficient WALs under the NRRWSP to account for the predicted Namoi River baseflow losses (AGE, 2020). At the completion of the Project, relevant WALs under the NRRWSP would be surrendered to account for predicted Namoi River baseflow loses post-mining.

8.7 CUMULATIVE IMPACTS

There are currently numerous mines operating in the Namoi River catchment. The nearest mine to the Project is the Maules Creek Coal Mine which is located approximately 25 km to the east (Figure 1.1). With respect to cumulative impacts on water supply, any take of water from the Namoi River, whether it be for industrial or agricultural use, is managed through the NRRWSP. 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.

The Narrabri Gas Project proposed by Santos NSW (Eastern) Pty Ltd would be located to the west of the Project and would also be located in the Namoi River catchment. The Narrabri Gas Project (State Significant Development 6456) was approved by the Independent Planning Commission of NSW on 30 September 2020. The Narrabri Gas Project EIS (Santos NSW (Eastern) Pty Ltd, 2017) concluded that the Narrabri Gas Project would have low risk of surface water impacts with the implementation of the proposed management measures.

As described in Sections 8.3, 8.4 and 8.5, the Project is not expected to have significant catchment flows, surface water quality and flooding.

Given the above, the Project is unlikely to result in any cumulative impacts to surface water resources.

8.8 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

A description of the key considerations of the Project with respect to the Significant Impact Guidelines (Commonwealth of Australia, 2013) (Section 3.8) can be found below.

8.8.1 Potential Impacts on Hydrological Characteristics

The Significant Impact Guidelines (Commonwealth of Australia, 2013) provide the following guidance on potential impacts of an action on hydrological characteristics:

> *A significant impact on the hydrological characteristics of a water resource may occur where there are, as a result of the action:*
>
> *a) changes in the water quantity, including the timing of variations in water quantity*
> *b) changes in the integrity of hydrological or hydrogeological connections, including substantial structural damage (e.g. large scale subsidence)*
> *c) changes in the area or extent of a water resource where these changes are of sufficient scale or intensity as to significantly reduce the current or future utility of the water resource for third party users, including environmental and other public benefit outcomes.*

Sections 8.1, 8.2 and 8.3 demonstrate that the Project would not have a significant impact on the hydrological characteristics of the waterways. The volumes of surface depressions are small in comparison to the mean annual runoff volume for the impacted waterways.

The highly ephemeral nature of the waterways, the broad distribution of waterways and depression zones suggest that there would not be an impact on the number of no or low flow days.

8.8.2 Potential Impacts on Water Quality

The Significant Impact Guidelines (Commonwealth of Australia, 2013) provide the following guidance on potential impacts of an action on water quality:

A significant impact on a water resource may occur where, as a result of the action:

- *a) there is a risk that the ability to achieve relevant local or regional water quality objectives would be materially compromised, and as a result the action:*
  - *i. creates risks to human or animal health or to the condition of the natural environment as a result of the change in water quality*
  - *ii. substantially reduces the amount of water available for human consumptive uses or for other uses, including environmental uses, which are dependent on water of the appropriate quality*
  - *iii. causes persistent organic chemicals, heavy metals, salt or other potentially harmful substances to accumulate in the environment*
  - *iv. seriously affects the habitat or lifecycle of a native species dependent on a water resource, or*
  - *v. causes the establishment of an invasive species (or the spread of an existing invasive species) that is harmful*
  - *vi. to the ecosystem function of the water resource, or*
- *b) there is a significant worsening of local water quality (where current local water quality is superior to local or regional water quality objectives), or*
- *c) high quality water is released into an ecosystem which is adapted to a lower quality of water.*

On the basis of the water balance modelling, the Project site water management system is unlikely to result in adverse impacts to the receiving water quality due to uncontrolled releases of water during the Project, as there is a less than a 1% chance of an uncontrolled release of water from the mine/Pit Top Area runoff dams, and no predicted releases or overflows from the brine storage dams (Section 8.4).

The filtered water that is proposed to be released to the Namoi River would be treated by RO, and would comply with the release criteria outlined in EPL 12789. If released in compliance with the existing EPL 12789 criteria, there would be no adverse impact on water quality in the Namoi River (Section 8.4).

8.8.3 Consideration of Cumulative Impacts

The Significant Impact Guidelines (Commonwealth of Australia, 2013) require the action to be:

considered with other developments, whether past, present or reasonably foreseeable developments.

Cumulative impacts of the Project with the Narrabri Gas Project was considered in Section 8.7. It was concluded that the Project is unlikely to result in any cumulative impacts to surface water resources.

8.9 CONSIDERATION OF CLIMATE CHANGE

Climate change is predicted to affect rainfall and other climatic variables, of which any predicted changes in rainfall are likely to have the most significant effect on groundwater by affecting recharge rates. Two sources of projected changes in rainfall have been reviewed:

- NSW/ACT Regional Climate Modelling (NARCliM) for the New England and North West Region (OEH, 2014); and

- Climate Change in Australia Technical Report (CCiA) produced by the CSIRO and BoM covering Australia's National Resource Management (NRM) regions, including the 'Eastern Australia' region (CSIRO and BoM, 2015).

Table 8.3 presents the median projection for change in rainfall from these sources for 2030 and longer-term projections for 2070 and 2090.

Rainfall projections are somewhat similar, at least on an annual basis, for 2030, but quite variable for the 2070-2090 forecast. NARCliM projections suggest a wetter climate, while CCiA projections suggest a drier climate.

Table 8.3 - Climate change projections - percentage change in rainfall

Period	NARCliM Projections		CSIRO Projections		
	2020-2039	2060-2079	2030[1]	2090[1]	2090[2]
Summer	-3.3%	+9.8	-2.0	-2.0	4.0
Autumn	+14.9%	+16.8	-4.0	-7.0	-8.0
Winter	-7.6%	-0.7	-3.0	-10.0	-16.0
Spring	+2.6%	-0.7	-2.0	-10.0	-16.0
Annual	+1.6%	+7.7	-1.0	-7.0	-10.0

1 Emissions under the RCP4.5 scenario which assumes a slow reduction in emissions that stabilises carbon dioxide (CO_2) concentration at about 540 parts per million (ppm) by 2100.

2 Emissions under the RCP8.5 scenario which assumes an increase in emissions leading to a CO_2 concentration of about 940 ppm by 2100.

The implications of climate change predictions on water management are unlikely to be significant over the Project life (i.e. to 2044) because they are small relative to high natural climatic variability.

9 Management, monitoring and licensing

The potential impacts of the Project on surface water resources can generally be managed and mitigated through the implementation of the Project water management system (Sections 5 and 6). An overview of the key management measures, monitoring and licensing for the Project is provided below.

9.1 WATER MANAGEMENT PLAN

The Water Management Plan and the Extraction Plan Water Management Plan LW107 to LW110 outlines the water management system and water management strategy for the Narrabri Mine (Section 5). The Water Management Plan includes:

- Site Water Balance;
- Erosion and Sediment Control Plan;
- Surface Water Monitoring Plan; and
- a Surface and Groundwater Response Plan in the form of a TARP.

The existing Water Management Plan is also required to include a Permeate Discharge and Transfer Control and Monitoring Plan prior to commencing controlled releases to the Namoi River.

The Water Management Plan would be reviewed and revised to incorporate the Project. The Water Management Plan would describe the operational site water management system and would include provisions for review of the site water balance, erosion and sediment controls, water monitoring and management. The existing Water Management Plan would also be revised to incorporate any proposed beneficial re-use of excess filtered water or underground injection of excess mine water.

Review and progressive refinement of the site water balance would continue to be undertaken on an annual basis over the life of the Project to record the status of inflows (water capture), storage and consumption (e.g. usage, return water from co-disposal areas, dust suppression and filtered water releases or beneficial reuse) and to optimise water management performance. The results of site water balance reviews would be reported in the Annual Review.

The Erosion and Sediment Control Plan would be reviewed and updated for the Project and would identify activities that could cause soil erosion and generate sediment and describe the specific controls (including locations, function and structure capacities) to minimise the potential for soil erosion and transport of sediment off-site.

The Surface Water Monitoring Plan would be reviewed and updated for the Project. A recommended monitoring program is provided in Section 9.3.

Prior to commencing controlled releases to the Namoi River, NCOPL would prepare and implement a Permeate Discharge Control and Monitoring Plan to monitor potential Namoi River water quality impacts associated with the controlled release of treated water.

The Surface and Groundwater Response Plan and TARPs would be reviewed and updated for the Project. The Surface and Ground Water Response Plan would describe any additional measures and procedures that would be implemented over the life of the Project to respond to any potential exceedances of surface water related criteria and contingent mitigation, compensation, and/or offset options if downstream private surface water users or riparian vegetation are adversely affected by the Project.

9.2 STREAM IMPACT MANAGEMENT

The Extraction Plan Water Management Plan (NCOPL, 2017) provides for the management of the potential surface water impacts associated with the mining area (including TARPs) (Section 5.11). Where applicable, these management actions and TARPs would continue to be implemented for the Project, and extended to cover the 200 series longwall panels.

9.3 SURFACE WATER QUALITY MONITORING

The existing surface water monitoring program outlined in the Water Management Plan is generally considered adequate for the Project. The background monitoring locations in the surface water monitoring program would be expanded to include two additional sites within the Project longwall subsidence area (i.e. KCTOP and UT1US). The locations of existing and proposed receiving surface water monitoring locations are shown in Figure 4.10. In addition, the existing water storage monitoring program would be expanded to include the Southern Mine Water Storage.

The suite of monitoring parameters would remain as per the approved Water Management Plan with the addition of total alkalinity, sulphate, arsenic, cobalt, molybdenum, antimony and selenium. Geo-Environmental Management (2020) recommended that these parameters be added to surface water monitoring program due to the enrichment and/or expected solubility of the identified elements in Project waste materials (ROM coal, coarse rejects, mine waste).

The frequency of monitoring would remain as per the approved Water Management Plan.

In addition, prior to commencing controlled releases to the Namoi River, a Permeate Discharge Control and Monitoring Plan would be prepared to monitor potential Namoi River water quality impacts associated with the controlled release of treated water.

9.4 LICENSING

The existing WALs held by NCOPL (Section 5.6) would be maintained, and are considered adequate for the Project surface water requirements.

10 Summary and conclusions

10.1 OVERVIEW

NCOPL is seeking a new Development Consent under the State Significant Development provisions of Part 4 of the EP&A Act for the Project.

This report has investigated the potential impacts of the Project on surface water resources, in particular the impact of the Project on the site water management system and downstream water quality, and the impact of the Project on stream geomorphology due to subsidence.

10.2 SITE WATER MANAGEMENT SYSTEM

The existing Narrabri Mine site water management system and Water Management Plan are considered robust and adequate for the Project. No major changes to the existing water management system are required for the Project.

Water balance modelling undertaken for the Project indicates that there is less than a 1% chance of an uncontrolled release of mine/Pit Top Area runoff water from the water management system to the receiving environment in any year of the Project. The water balance model predicts that there would be no releases or overflows of brine from the site water management system.

The water balance modelling indicates that there would be an excess of water produced at the mine during the Project. The Project water demands would therefore likely be satisfied by water captured in the site water management system and dewatered from the underground mine.

The site water balance would be revisited on an annual basis to compare the actual behaviour of the Narrabri Mine site water management system to the predicted outcomes of this study.

10.3 WATER QUALITY

On the basis of the water balance modelling, the Project site water management system is unlikely to result in adverse impacts to the receiving water quality due to uncontrolled releases of water during the Project, as there is a less than a 1% chance of an uncontrolled release of water from the mine/Pit Top Area runoff dams, and no predicted releases or overflows from the brine storage dams.

The filtered water that is proposed to be released to the Namoi River would be treated by RO, and would comply with the release criteria outlined in EPL 12789. If released in compliance with the existing EPL 12789 criteria, there would be no adverse impact on water quality in the Namoi River.

10.4 IMPACT ON CATCHMENT FLOWS

The Project would not increase the size of the catchments diverted to the water management system beyond the catchments already approved as part of the Water Management Plan, with the exception of the Southern Water Management Dam and the ventilation shaft and service borehole pad sediment dams. The impact of the ventilation shaft and service borehole pad sediment dams, Southern Water Management Dam (approximately 4.6 ha) and the existing water management dams (237 ha) on local waterways or the Namoi River would be negligible.

The potential reduction in catchment flows due to mine subsidence is also expected to be minor and would reduce as the subsidence areas silt up over time.

The proposed releases of filtered water from the Narrabri Mine into the Namoi River are unlikely to have any discernible impact on the Namoi River flow regime given that the river is regulated by releases from upstream dams.

10.5 IMPACT ON STREAM GEOMORPHOLOGY

Two 3rd order watercourses that would be impacted by the Project include Kurrajong Creek and Tulla Mullen Creek Trib1. A number of 1st and 2nd order watercourses are also potentially impacted. All of the creeks are ephemeral.

The following are of note:

- Major changes in channel geomorphology due to changes in channel location (avulsions) are unlikely as the pre and post subsidence channels are located within well confined valleys for both 3rd order watercourses.
- Some of the minor (1st order) channels may drain into Kurrajong Creek at alternate locations and cause localised bank scour, particularly above Longwalls 207 and 209 within the Pilliga East State Forest.
- Minor increases in channel erosion would be expected on the downstream side of each chain pillar due to the increased channel slope.
- Additional in-channel ponding is expected to occur above all longwall panels upstream of each chain pillar. The ponded areas are expected to accumulate sediment over time.
- There are two farm dams located on Kurrajong Creek, which would be decommissioned as part of the Project (Section 4.4). The removal of these dams would mitigate any ponding impact associated with mine subsidence at these locations.
- Numerous contour banks above Longwalls 203 and 210 would be impacted by subsidence. Some contour banks would ultimately drain in two directions, causing contour banks to silt up and overtop, potentially resulting in minor downstream erosion by the concentration of flow.

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

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Appendix A Water Balance Model Calibration Results

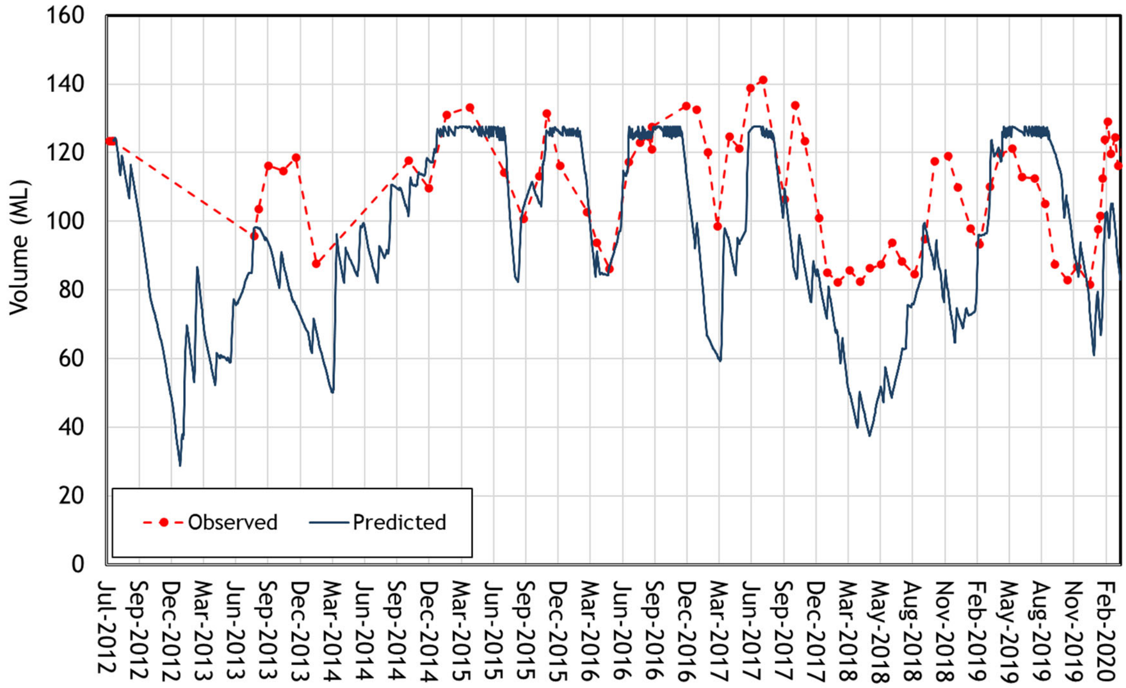

Figure A 1 - Observed and predicted volume in Dam A1, July 2012 to March 2020

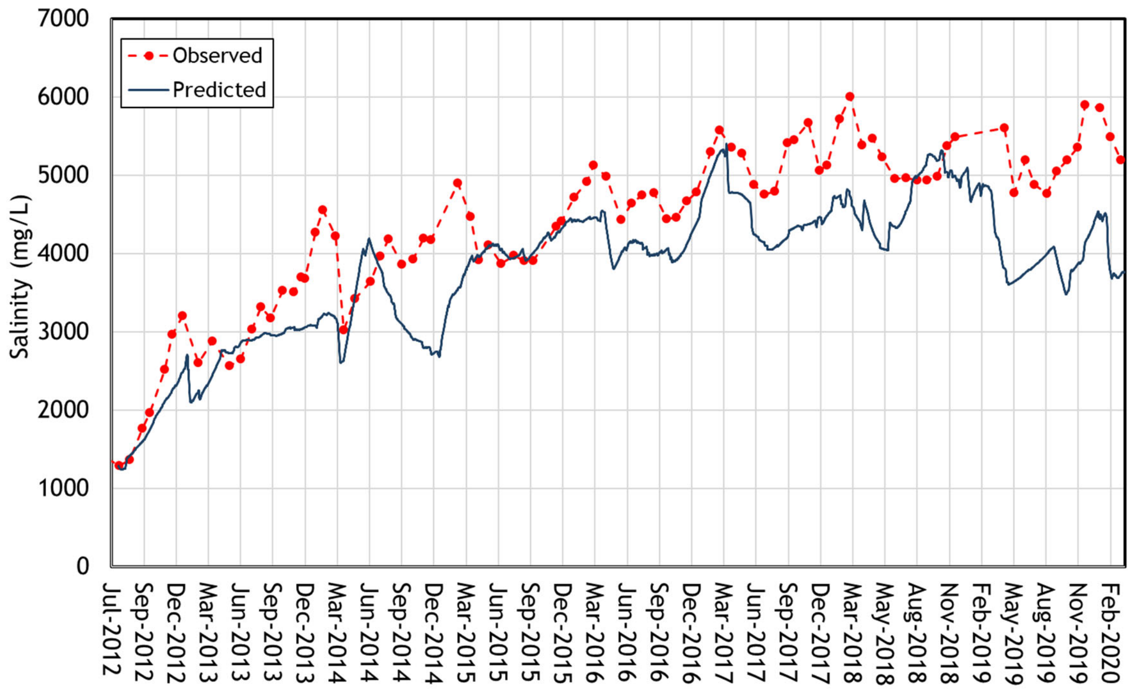

Figure A 2 - Observed and predicted salinity in Dam A1, July 2012 to March 2020

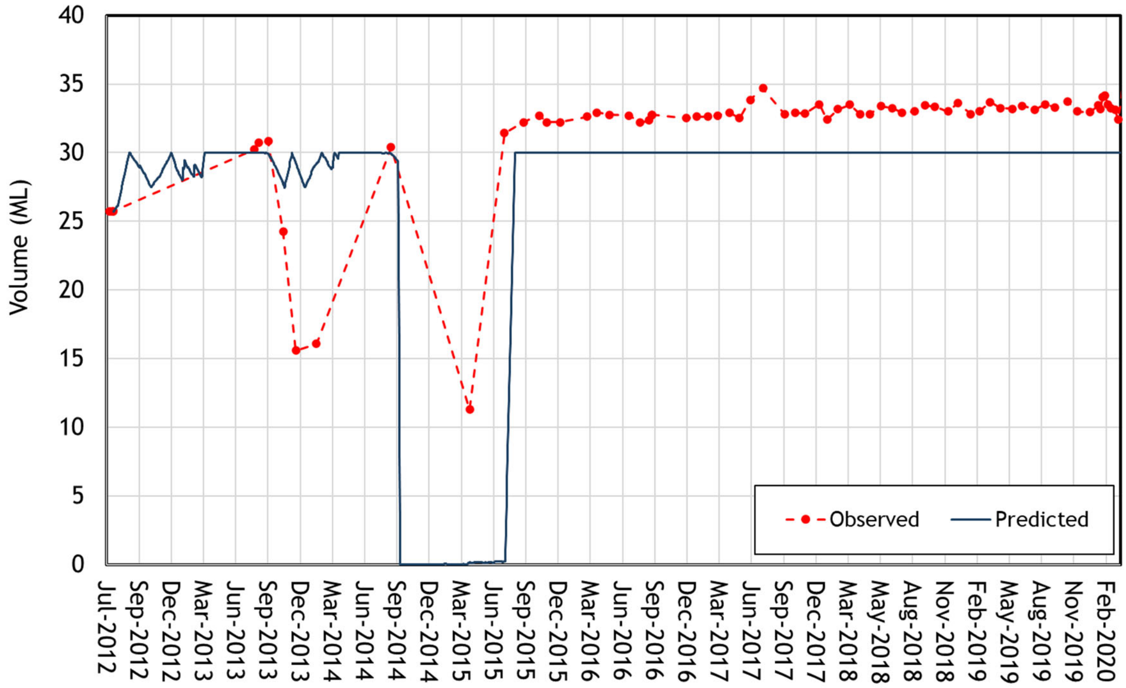

Figure A 3 - Observed and predicted volume in Dam A2, July 2012 to March 2020

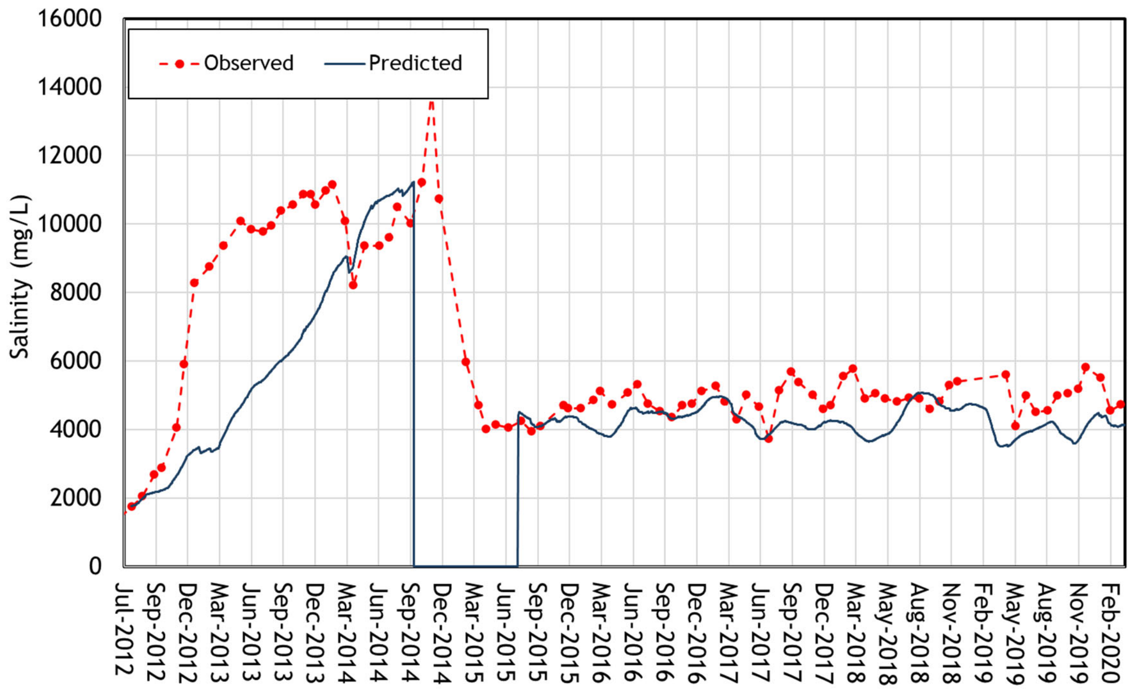

Figure A 4 - Observed and predicted salinity in Dam A2, July 2012 to March 2020

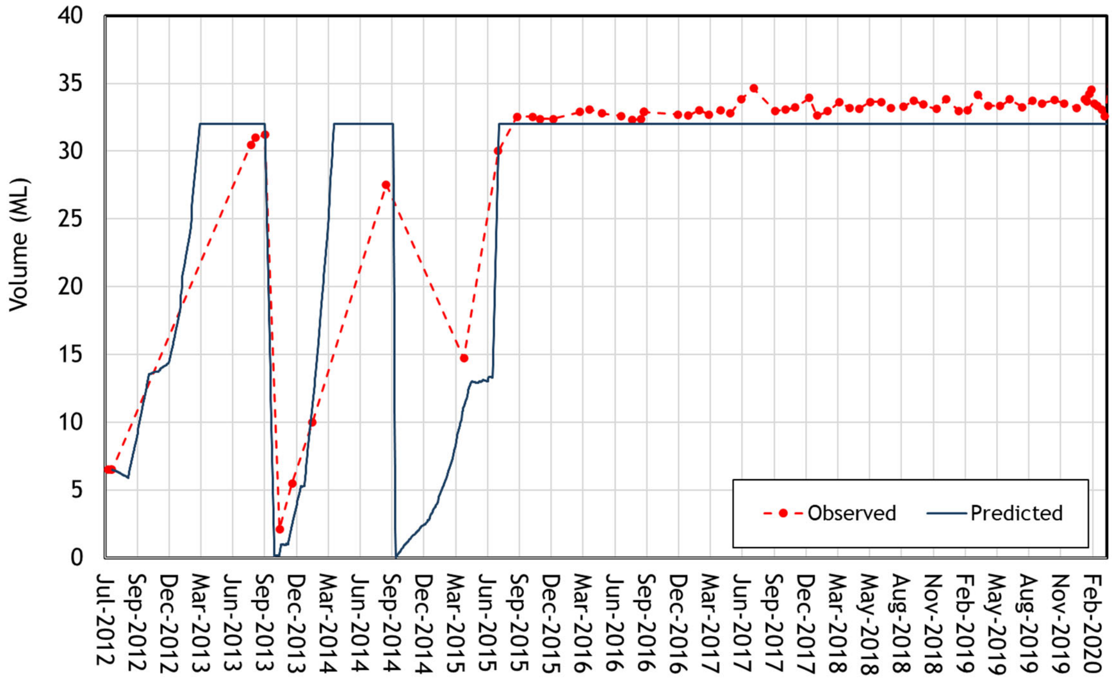

Figure A 5 - Observed and predicted volume in Dam A3, July 2012 to March 2020

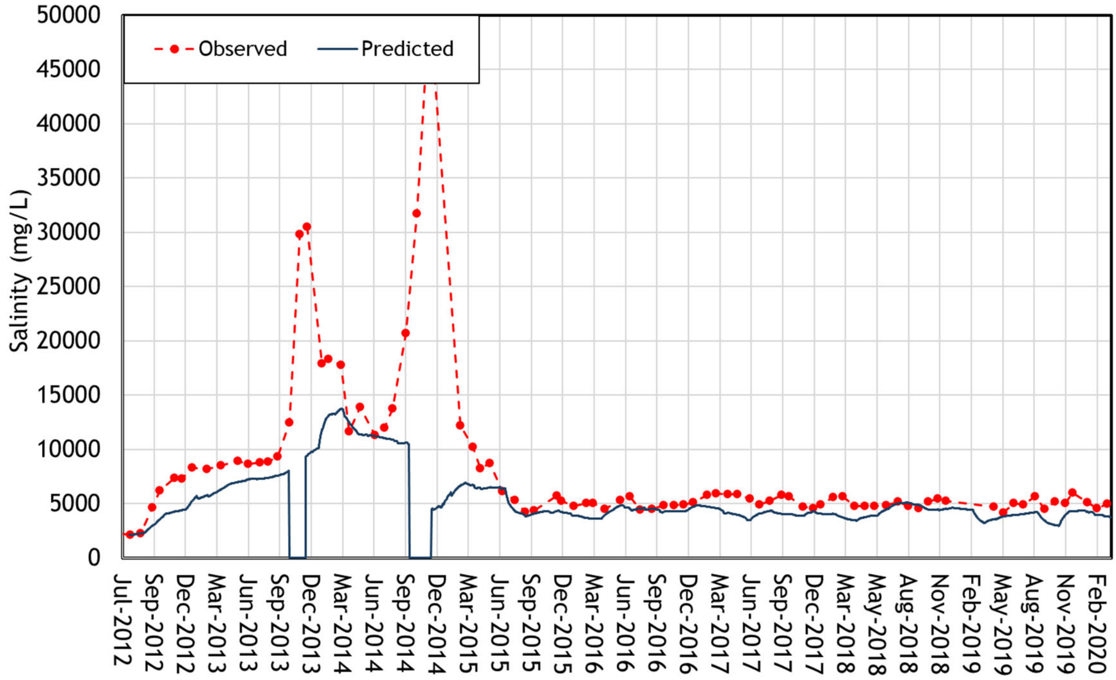

Figure A 6 - Observed and predicted salinity in Dam A3, July 2012 to March 2020

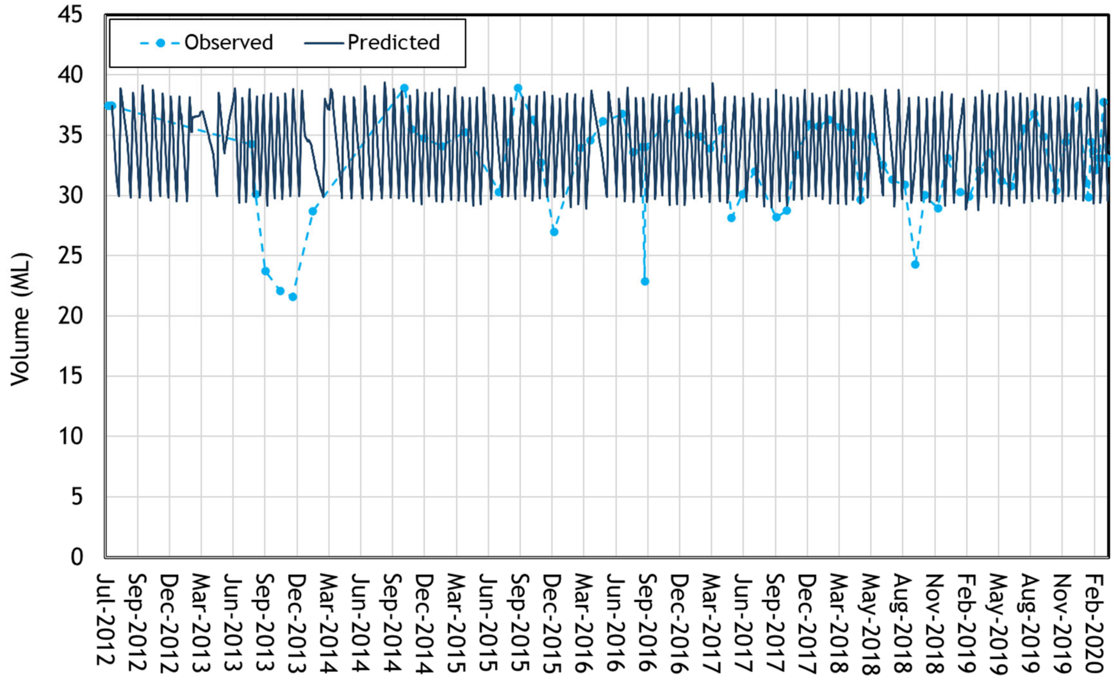

Figure A 7 - Observed and predicted volume in Dam B1, July 2012 to March 2020

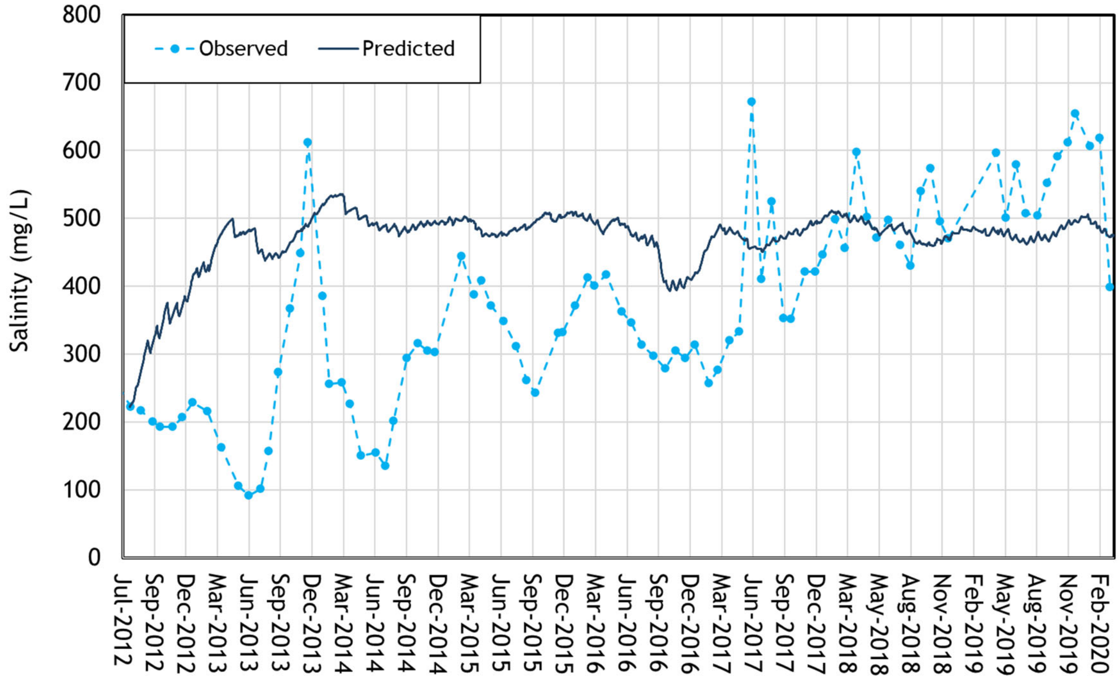

Figure A 8 - Observed and predicted salinity in Dam B1, July 2012 to March 2020

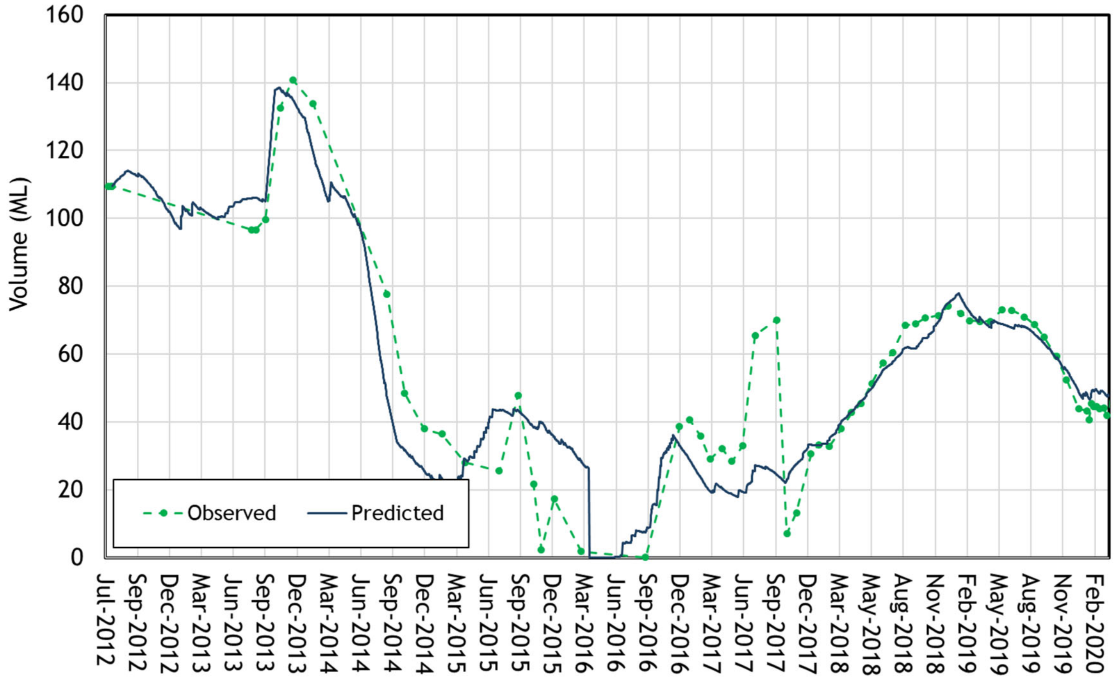

Figure A 9 - Observed and predicted volume in Dam B2, July 2012 to March 2020

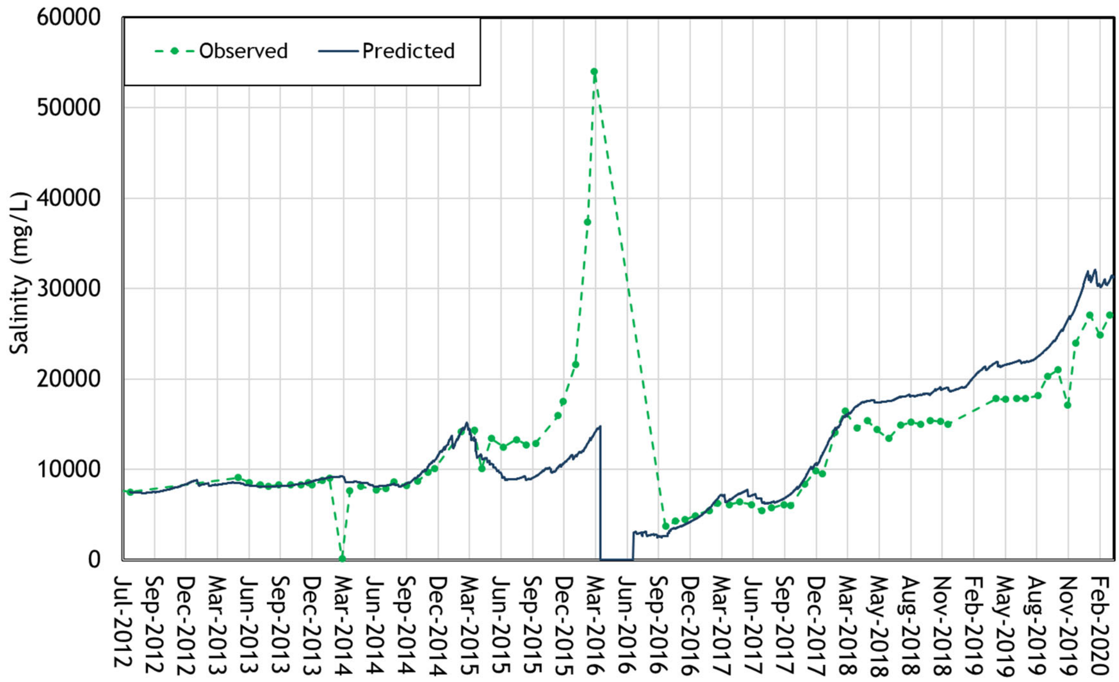

Figure A 10 - Observed and predicted salinity in Dam B2, July 2012 to March 2020

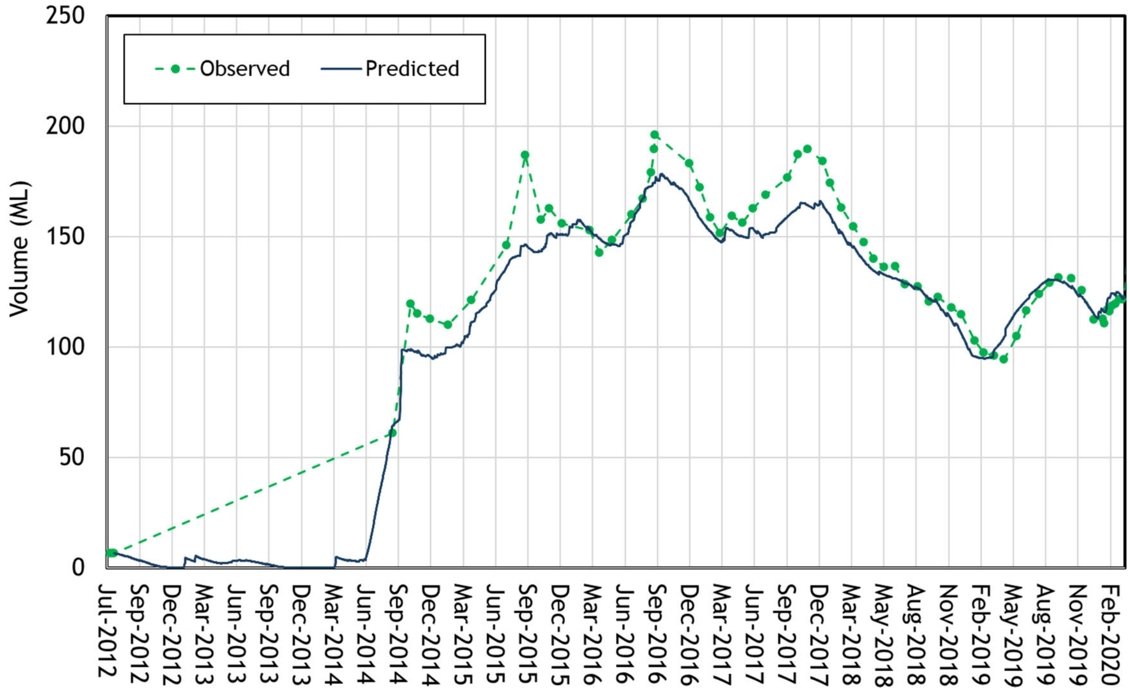

Figure A 11 - Observed and predicted volume in Dam C, July 2012 to March 2020

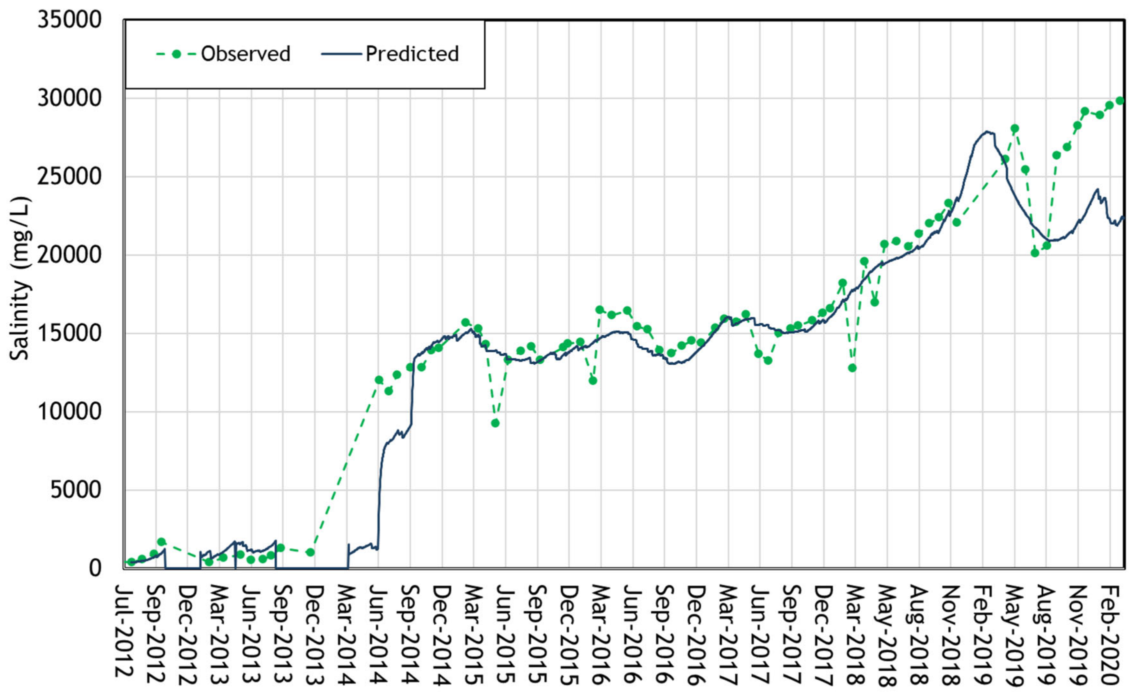

Figure A 12 - Observed and predicted salinity in Dam C, July 2012 to March 2020

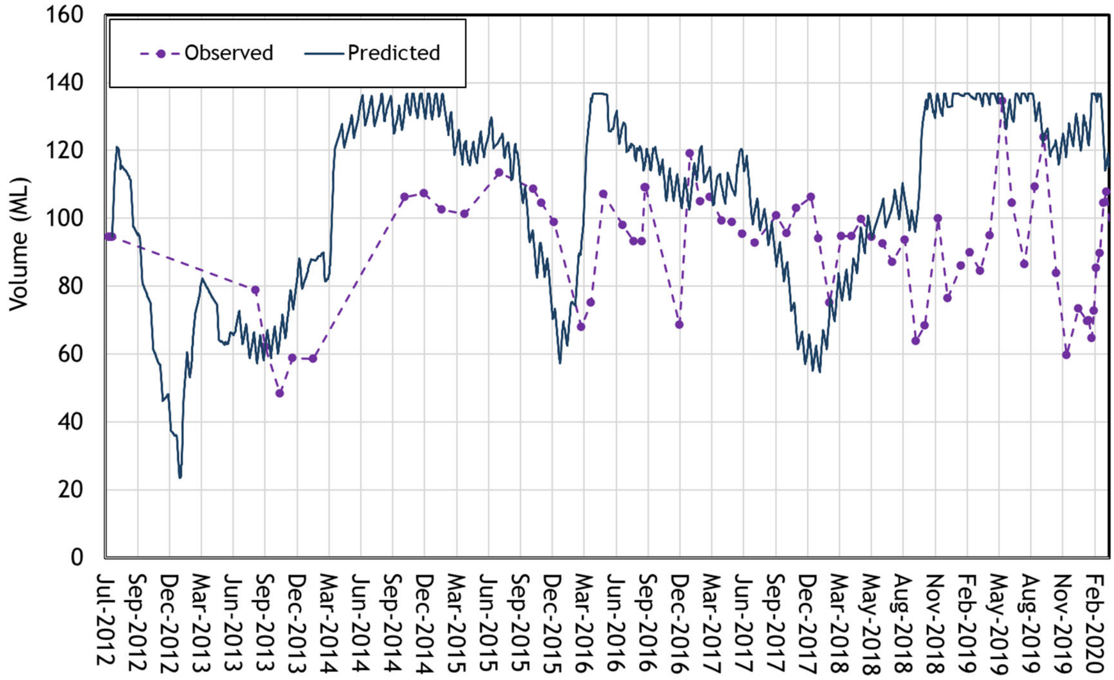

Figure A 13 - Observed and predicted volume in Dam D, July 2012 to March 2020

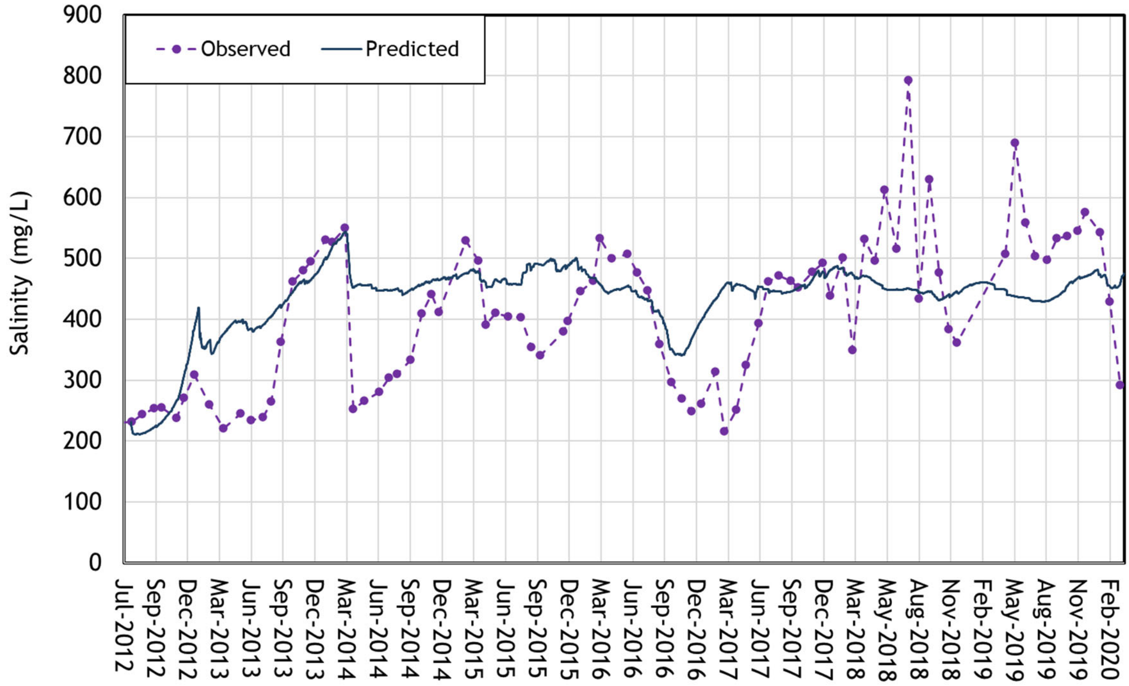

Figure A 14 - Observed and predicted salinity in Dam D, July 2012 to March 2020