NARRABRI MINE

EXTRACTION PLAN
WATER MANAGEMENT PLAN

LW 203 – LW 206

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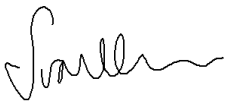
Senior Environmental Manager	S. van der Meulen Onward Consulting		10 February 2023
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Acronyms and abbreviations

Acronym	Description
µS/cm	microSiemens per centimetre
AHD	Australian Height Datum
AIP	NSW Aquifer Interference Policy
AoD	Angle of Draw
CF	Cut and flit
Cwlth	Commonwealth
DGS	Ditton Geotechnical Services
DPE	The NSW Department of Planning and Environment
EC	electrical conductivity
EIS	Environmental Impact Statement
EP 203-206	Extraction Plan for LW 203 to LW 206
EP-WMP	Extraction Plan - Water Management Plan (this document)
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
EPL	Environment Protection License
GAB	Great Artesian Basin
GDE	groundwater dependent ecosystem
ha	hectare
IEA	Independent Environmental Audit
km	kilometre
LiDAR	light detection and ranging
LW	longwall panel
m	metre
MDB	Murray Darling Basin
mg/L	milligram per litre
Mining Act	*Mining Act 1992* (NSW)
ML	mining lease; megalitre
mm	millimetre
mm/m	millimetre per metre
MOD 5	Modification 5
MOD 7	Modification 7
Mtpa	million tonnes per annum
NCOPL	Narrabri Coal Operations Pty Ltd
NSW	New South Wales
PED	personal emergency device (communications system)

Acronym	Description
POEO Act	*Protection of the Environment Operations Act 1997*
QA/QC	Quality assurance / quality control
ROM	run of mine
SoC	Statement of Commitment
SSGV	Site specific guideline value
TARP	trigger action response plan
TDS	total dissolved solids
TSS	total suspended solids
U95%CL	upper 95 % confidence level
VWP	vibrating wire piezometer
WAL	water access licence
WHC	Whitehaven Coal Limited
WM Act	*Water Management Act 2000*
WSP	water sharing plan
XL	Cross section cross-line across the longwall panels

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1. Introduction

1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield. It 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 in New South Wales (**NSW**). The Narrabri Mine includes an underground coal mine, a coal handling and preparation plant and associated rail siding and surface infrastructure.

The Narrabri Mine is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture, which consists of two Whitehaven Coal Limited (**WHC**) wholly owned subsidiaries, and other joint-venture partners[1]. The underground mine is covered by Mining Lease (**ML**) 1609 which covers an area of 5,298 hectares (**ha**) for the predominant purpose of mining for coal from the Hoskissons Coal Seam.

Stage 1 of the Narrabri Mine was approved in November 2007 under Part 3A of the *Environmental Planning and Assessment Act 1979* (**EP&A Act**). Construction of the mine and supporting infrastructure commenced in 2008, with production using a continuous miner commencing in 2010. Following the approval of the Stage 2 Environmental Assessment (R.W Corkery & Co., 2009) (the **EA**) and the issue of the Stage 2 Project Approval 08_0144 (**Project Approval**) in July 2010, and *Environmental Protection and Biodiversity Conservation Act 1999* **(EPBC Act)** approval (**2009/5003**) in January 2011, the Narrabri Mine was converted to an 8 million tonnes per annum (**Mtpa**) run of mine (**ROM**) longwall mining operation, which commenced in 2012.

The Project Approval has subsequently been modified on a number of occasions. The environmental assessment for Modification 5 (Resource Strategies, 2015) (**MOD 5**), approved in December 2015, changed the mine geometry by reducing the number of longwall (**LW**) panels from 26 to 20, increased some LW panel widths and increased the production to 11 Mtpa of ROM coal until July 2031.

Modification 7, the most recent modification of the Project Approval, was approved on 23 November 2021. The environmental assessment for Modification 7 (Resource Strategies, 2021) (**MOD 7**) describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels Cut and Flit (**CF**) 201 to CF 205. There is no change to the previously approved longwall panels LW 203 to LW 209. The bord and pillar mining will occur concurrently with existing longwall operations for a period of approximately five years, with the maximum ROM coal production rate remaining within the approved limit of 11 Mtpa.

1.2 Purpose and scope

This Extraction Plan - Water Management Plan (**EP-WMP** or **Plan**) for Longwall (**LW**) 203 to LW 206 has been prepared in accordance with Schedule 3 Condition 4(h) of the Project Approval and the Department of Planning and Environment (**DPE**) *Draft Extraction Plan Guideline* (DPE 2022).

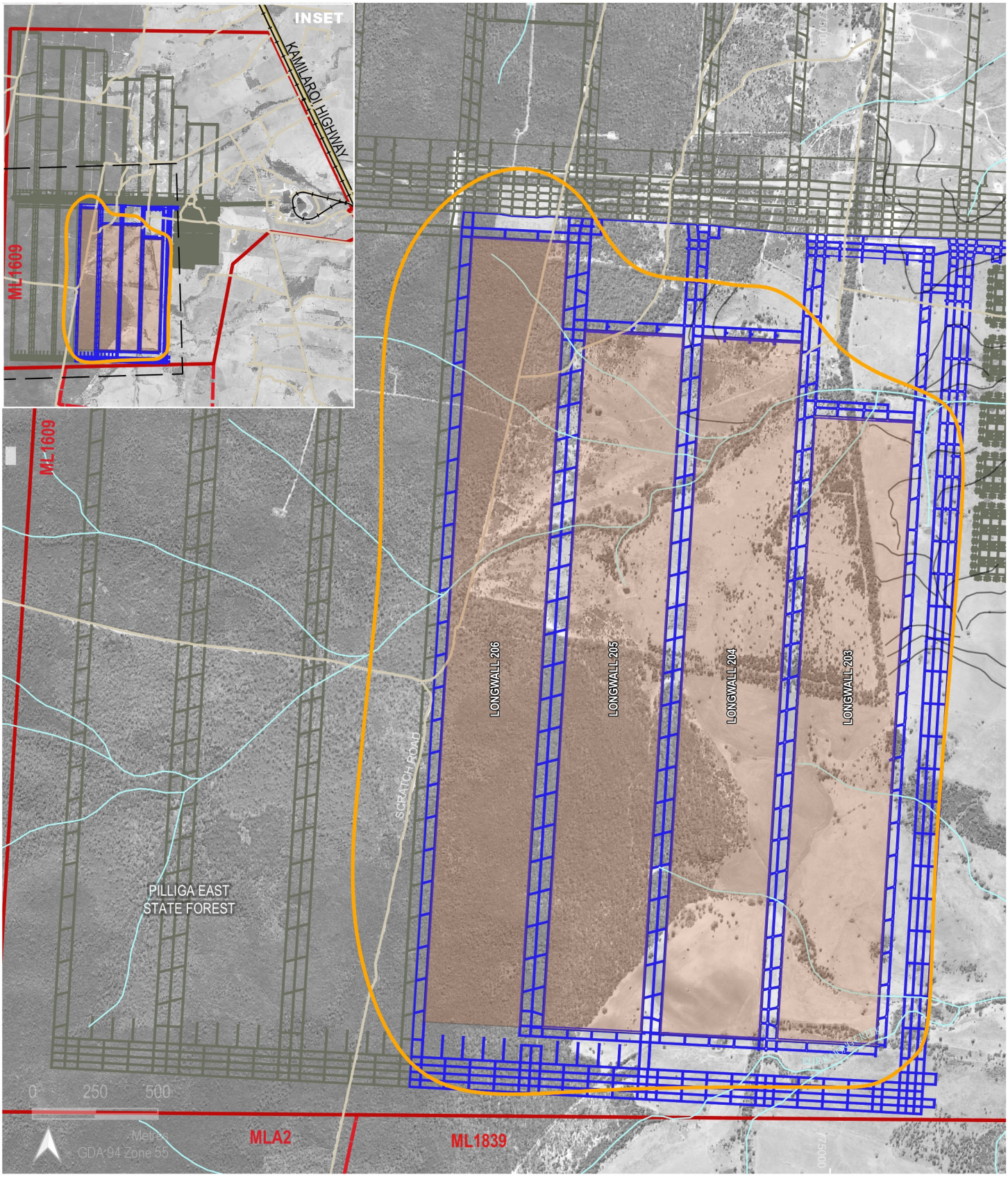
The EP-WMP sets out the objectives, performance measures and management actions required to manage the potential impacts from subsidence on watercourses and aquifers above LW 203 to LW 206 (the **Extraction Plan Area**[2]). This Plan forms Appendix A of the Extraction Plan for LW 203 to LW 206 (**EP 203-206**).

[1] For full details on the joint venture ownership, refer to the introduction of the Extraction Plan.

[2] The area located within the 45° Angle of Draw (**AoD**) as shown on Figure 1-1.

The Ditton Geotechnical Services Pty Ltd (**DGS**) *Mine Subsidence Assessment Report for LW 203 to LW 206* (DGS 2022) (**Mine Subsidence Assessment Report**) has been used as a basis for developing the performance measures and management actions in response to the predicted impacts on watercourses and aquifers within the Extraction Plan Area. The Mine Subsidence Assessment Report is presented in full as Appendix J to EP 203-206.

The Extraction Plan Area and underground mining layout for LW 203 to LW 206 is presented in Figure 1-1. A detailed description of the underground mining method is provided within EP 203-206.



WHITEHAVEN COAL

ONWARD CONSULTING

LEGEND

- ML1609
- ML1839
- MLA2
- Underground mining layout
- Longwalls 203 to 206
- Proposed longwall voids (LW203-206)
- 45 degree angle of draw
- Road
- Watercourse
- Contour bank

NARRABRI MINE

FIGURE 1-1

Extraction Plan Area and Underground Mining Layout for LW 203 to LW 206

1.3 Objectives

The objectives of this EP-WMP are to:

- provide details of the relevant statutory requirements, including any relevant approval, licence or lease conditions;
- provide baseline data for surface water flows and quality in watercourses and other water bodies, groundwater levels, yield and quality in the Extraction Plan Area;
- provide a description of the management of potential impacts and/or environmental consequences of the proposed second workings on watercourses and aquifers;
- provide a surface water monitoring program that:
  - monitors for potential impacts to surface water take, stream flows and quality, riparian vegetation health and channel stability; and
  - evaluates the effectiveness of management actions.
- provide a groundwater monitoring program that:
  - monitors for potential impacts to groundwater resources or quality, groundwater bores on privately-owned land, groundwater inflows to underground workings and groundwater dependent ecosystems (**GDEs**); and
  - evaluates the effectiveness of management actions.
- provide triggers to inform additional and/or adaptive management actions;
- describe the protocol for managing and reporting any incident, non-compliance or exceedance of any impact assessment criteria or performance criteria, complaint, or failure to comply with other statutory requirements;
- detail the regulatory reporting requirements;
- describe the protocol for periodic review of this Plan; and
- identify the roles and responsibilities for implementation of this Plan.

1.4 Statutory requirements

1.4.1 Relevant legislation

Environmental Planning and Assessment Act 1979

The EP&A Act provides the statutory basis and framework for planning and environmental assessment in NSW. The EP&A Act includes provisions to ensure that the potential environmental impacts of a development are assessed and considered by consent authorities prior to granting development approval. The original approvals for the Narrabri Mine were obtained under the Part 3A, 'Major Projects' provisions of the EP&A Act. While Part 3A has since been repealed, it remains applicable to NCOPL under transitionary provisions.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (**POEO Act**) regulates pollution from a facility or activity through the placement of conditions in an environment protection licence (**EPL**). Activities requiring an EPL are listed in Schedule 1 of the POEO Act and include mining for coal and coal works.

The POEO Act provides the statutory framework for managing water pollution in NSW. It is supported by the *Protection of the Environment Operations (General) Regulation 2021,* which among other functions prescribes certain matters for the purposes of the definition of water pollution.

It is an offence under section 120 of the POEO Act to pollute waters. However, section 121 and section 122 of the POEO Act provides a defence against prosecution under section 120 where the pollution was regulated by an EPL or regulation which was not contravened.

Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)

The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance, which include a water resource associated with a large coal mining development (the water trigger).

Mining Act 1992

The *Mining Act 1992* (**Mining Act**) regulates the licensing, land access, and operations for coal mines operating in NSW. Under the Mining Act, all resource activities must be licensed, including exploration activities.

Water Management Act 2000

The NSW *Water Management Act 2000* (**WM Act**) provides for the protection, conservation and ecologically sustainable development of the water sources of the State. The WM Act includes the concept of “no more than minimal harm” for both the granting of water access licences (**WALs**) and the granting of approvals. The WM Act licensing regimes for the management of water resources apply to water sources that are the subject of a Water Sharing Plan (**WSP**).

All surface water and groundwater associated with the Narrabri Mine, including extraction from the Namoi River, is governed by the WM Act. The following WSPs are relevant to the Narrabri Mine:

- Water Sharing Plan for the Upper Namoi and Lower Namoi Regulated River Water Sources 2016 (Lower Namoi Regulated River Water Source);
- Water Sharing Plan for the Namoi and Peel Unregulated Rivers Water Sources 2012;
- Water Sharing Plan for the NSW Murray Darling Basin (**MDB**) Porous Rock Groundwater Sources 2020 – Gunnedah-Oxley Basin MDB Groundwater Source (Gunnedah Oxley Basin MDB [Other] Management Zone);
- Water Sharing Plan for the NSW Great Artesian Basin (**GAB**) Groundwater Sources 2020 – Southern Recharge Groundwater Source; and
- Water Sharing Plan for the Namoi Alluvial Groundwater Sources 2020 – Upper Namoi Zones 2, 4 and 5 and the Lower Namoi Groundwater Sources.

The current WALs held by NCOPL for surface water and groundwater sources are listed in Table 1-1.

Table 1-1 Existing surface and groundwater licences

Works approval	WAL	Water source	Nominal allocation (units/yr)
Surface water			
90CA802130	6762	Lower Namoi Regulated River Water Source (high security)	20
90CA802130	2728	Lower Namoi Regulated River Water Source (general security)	10
90CA802130	20152		600
90CA802130	2671		48
Groundwater			
90WA812891	12833	Upper Namoi Zone 5 Namoi Valley (Gins Leap to Narrabri) Groundwater Source	67
90WA812891	20131		150
90WA812891	12822		43
90WA822539	29549	Gunnedah - Oxley Basin Murray Darling Basin Groundwater Source	818
90WA822539	43017		403
90WA822539	15922	Southern Recharge Water Source	248

1.4.2 Statutory approvals

Project Approval

This Plan has been developed in accordance with Schedule 3 Condition 4 of the Project Approval which requires NCOPL to prepare an Extraction Plan for all second workings within the area of the Approved Mine Plan (Appendix H to EP 203-206) to the satisfaction of the Secretary.

In accordance with Schedule 4 Condition 4(h), the Extraction Plan must include a Water Management Plan which has been prepared in consultation with the Environment Protection Authority (**EPA**) and DPE Water, which provides for the management of potential environmental consequences of the proposed second workings on watercourses and aquifers.

Schedule 3 Condition 4(b) of the Project Approval requires the Extraction Plan and its sub plans to be approved by the Secretary prior to NCOPL carrying out any of the second workings covered by EP 203-206.

The EP-WMP must include detailed performance indicators for each relevant performance measure conditioned under Schedule 3 Condition 1. In accordance with Schedule 3 Condition 1, NCOPL must ensure that the development does not cause any exceedances of the performance measures detailed in Table 1-2.

Project Approval Schedule 6 Condition 2 lists the requirements for the preparation of management plans which must be prepared in accordance with any relevant guidelines and include details of the relevant approval, licence or lease conditions. Attachment 1, Table A1-1 provides a summary of the Project Approval conditions relevant to this Plan and outlines the section of the EP-WMP in which each of these conditions have been addressed. Table A1-2 provides the relevant Statement of Commitments (**SoCs**) and a cross reference table to where these commitments have been addressed.

Table 1-2 Subsidence impact performance measures

Feature	Performance Measures
Water Resources	
Great Artesian Basin	The Proponent shall ensure that, within 5 years of the date of this approval, any loss of water flow into the Great Artesian Basin aquifers (equal to the maximum predicted impact, or the measured impact of the project, whichever is the greater), is managed, licensed or offset (including the possibility of injection of raffinate) to the satisfaction of DPE Water.
Biodiversity	
Flora and Fauna	The Proponent shall ensure that clearing and disturbance of vegetation above the mining area is minimised, to the satisfaction of the Secretary.

Environment protection licence

NCOPL is the holder of EPL 12789, which includes conditions relating to surface water, groundwater, erosion and sediment control and associated water management infrastructure.

EPBC Act Approval

The Narrabri Mine was granted EPBC 2009/5003 in 2011 issued under the EPBC Act (last varied on 24 March 2021).

EPBC 2009/5003 prescribes conditions to minimise potential impacts on EPBC Act listed threatened species and communities within the mine site. Condition 3 of EPBC 2009/5003 states that in order to minimise potential impacts on EPBC Act listed threatened species and communities within the mine site, prior to any Works commencing and in accordance with the NSW Director General's Assessment Report and approval conditions (26 July 2010), the person undertaking the action must develop and implement an Extraction Plan.

Mining lease

NCOPL are the holder of ML 1609 issued under the Mining Act 1992 in January 2008. As the holder of a mining lease, NCOPL must take all reasonable measures to prevent, or if that is not reasonably practicable, to minimise, harm to the environment caused by activities under the mining lease.

1.5 Risk assessment

A subsidence risk assessment has been undertaken to identify the risks associated with subsidence at the Narrabri Mine. It builds on previous risk assessments completed for LW 101 to LW 110 and Panels 201 to 202 and is presented as Appendix I to EP 203-206. The updated risk assessment for LW 203 to LW 206 identified one high-risk item (i.e. Mayfield GG1) above LW 205. All other risks within the Extraction Plan Area have been assessed as low to moderate.

The potential environmental impacts and consequences relevant to surface water and groundwater management are further discussed in section 3 and section 5.

1.6 Preparation and consultation

Consultation with the EPA and DPE Water was undertaken for the preparation of this EP-WMP in accordance with Schedule 3 Condition 4(h) of the Project Approval. The draft EP-WMP (Revision A) was provided to the EPA and DPE Water on 8 November 2022.

Attachment 2 provides evidence of the consultation process, including a cross reference table addressing the comments received, and detailing the section of the Plan where these comments have been addressed (Table A2-1).

1.7 Access to information

In accordance with Schedule 6 Condition 10 of the Project Approval, the approved Extraction Plan and all appendices, audits and reports, and summaries of all monitoring data (where relevant) will be made publicly available on the WHC website. All information will be kept up to date.

Note that any printed copies of this EP-WMP are uncontrolled.

2. Baseline surface water and groundwater data

2.1 Surface water

2.1.1 Surface water resources

LW 203 to LW 206 are primarily located in the Kurrajong Creek catchment which is a sub-catchment of the Namoi River as shown in Figure 2-1. The Namoi River flows in a north-westerly direction and is located approximately 5 km north and east of the Extraction Plan Area.

The headwaters of Kurrajong Creek and Kurrajong Creek Tributary 1 rise in the Pilliga East State Forest to the west of the Extraction Plan Area. The watercourses travel north-east towards the Namoi River, converging downstream of the Narrabri Mine Pit Top. Kurrajong Creek discharges to Tulla Mullen Creek, a tributary of the Namoi River, approximately 5 km downstream (north-east) of the Narrabri Mine Pit Top.

Kurrajong Creek traverses the southern boundary of LW 203 and is a third order stream[3] within the vicinity of LW203-206. The Kurrajong Creek catchment area to the eastern extent of LW 203 is approximately 21.9 km^2. Kurrajong Creek Tributary 1, a third order stream, flows south-west to north-east above LW 203 to LW 206. The catchment area of Kurrajong Creek Tributary 1 to the eastern extent of the Extraction Plan Area is approximately 12.6 km^2.

Kurrajong Creek has an average gradient of 1.2 % to the eastern extent of LW203 while Kurrajong Creek Tributary 1 has an average gradient of 0.97 %.

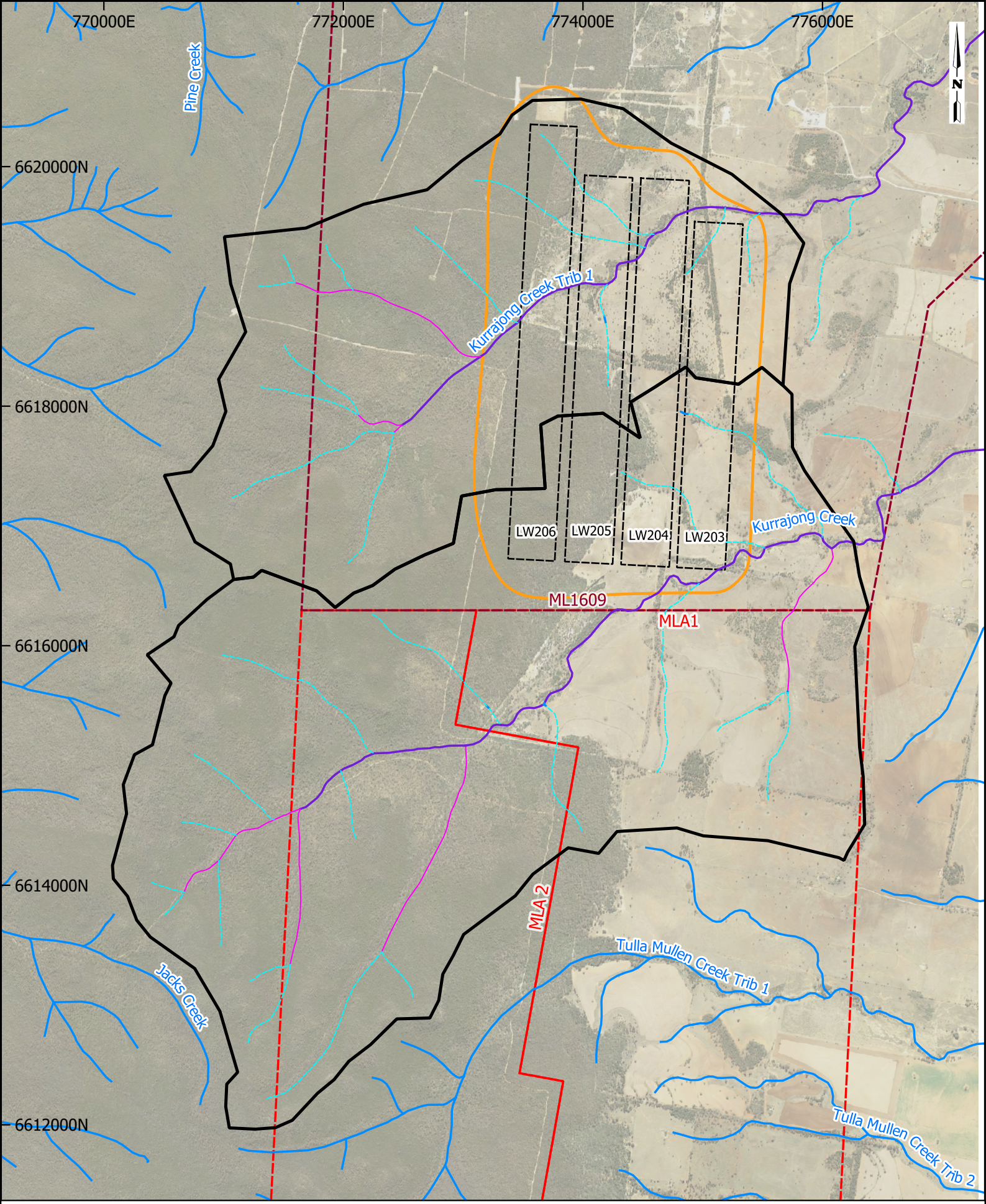
Kurrajong Creek is ill-defined to the downstream boundary of LW 203; consisting of a broad flow path with minor low flow channel. The bed material is comprised of sandy loam with scattered dryland vegetation. Immediately downstream of the eastern extent of LW 203, the watercourse is comprised of a broad flow path with no evident low flow channel. The bed material consists of sandy loam with intermittent sand deposition. Scouring was evident on some outside bends of the watercourse in this reach (WRM, 2020).

A four metre (**m**) high headcut is located downstream of the eastern extent of LW203, separating the downstream incised channel and the upstream ill-defined channel. The headcut is the result of historical headwater erosion of the channel bed rather than a result of Narrabri Mine activities and will likely to progress further upstream with successive flood events unless otherwise appropriately managed (WRM, 2020).

Downstream of the headcut, Kurrajong Creek is incised with a channel width of approximately 10 m wide and vertical banks approximately 0.8 m deep. The bed material in this reach consists of coarse sand with no in-stream vegetation (WRM, 2020).

Several minor (first and second order) watercourses drain to Kurrajong Creek and Kurrajong Creek Tributary 1 (Figure 2-1). These watercourses are generally steeper than the main channel of Kurrajong Creek and drain as broad overland flow or broad v-shaped valleys with no incised channel. Contour banks have been constructed at a number of these minor watercourses to minimise surface erosion and to direct rainfall runoff to agricultural farm dams (WRM, 2020).

[3] Strahler stream order classification scheme (Strahler, 1952).



LEGEND

- LW203-206 (Proposed)
- Extraction Plan Area
- First Order Stream
- Second Order Stream
- Third Order Stream
- Minor Watercourse
- Catchment Boundary
- Mining Lease
- Mining Lease Application

FIGURE 2-1: Extraction Plan Area surface water resources

ATC WILLIAMS

0 500 1000 1500 2000

Metres

CRS: GDA94 / MGA Zone 55
Aerial: Google 2018

File: Synergy\116100\06\Data and Calcs\Baseplan_116100-06.qgz

2.1.2 Surface water flows

Based on the period of monitoring and the number of event-based samples collected during this period, the percentage of time for which there was ponded water and/or surface water flow at each monitoring site shown in Figure 2-2 has been estimated. It is noted that other factors may have prohibited event-based sampling i.e., access restrictions. As such, the number of samples collected may not accurately represent the number of flow events during the monitoring period. Table 2-1 presents the period of monitoring, number of sampling events and estimated frequency of ponded water and/or surface water flow over the period of monitoring at each site.

Table 2-1 Frequency of ponded/flowing water

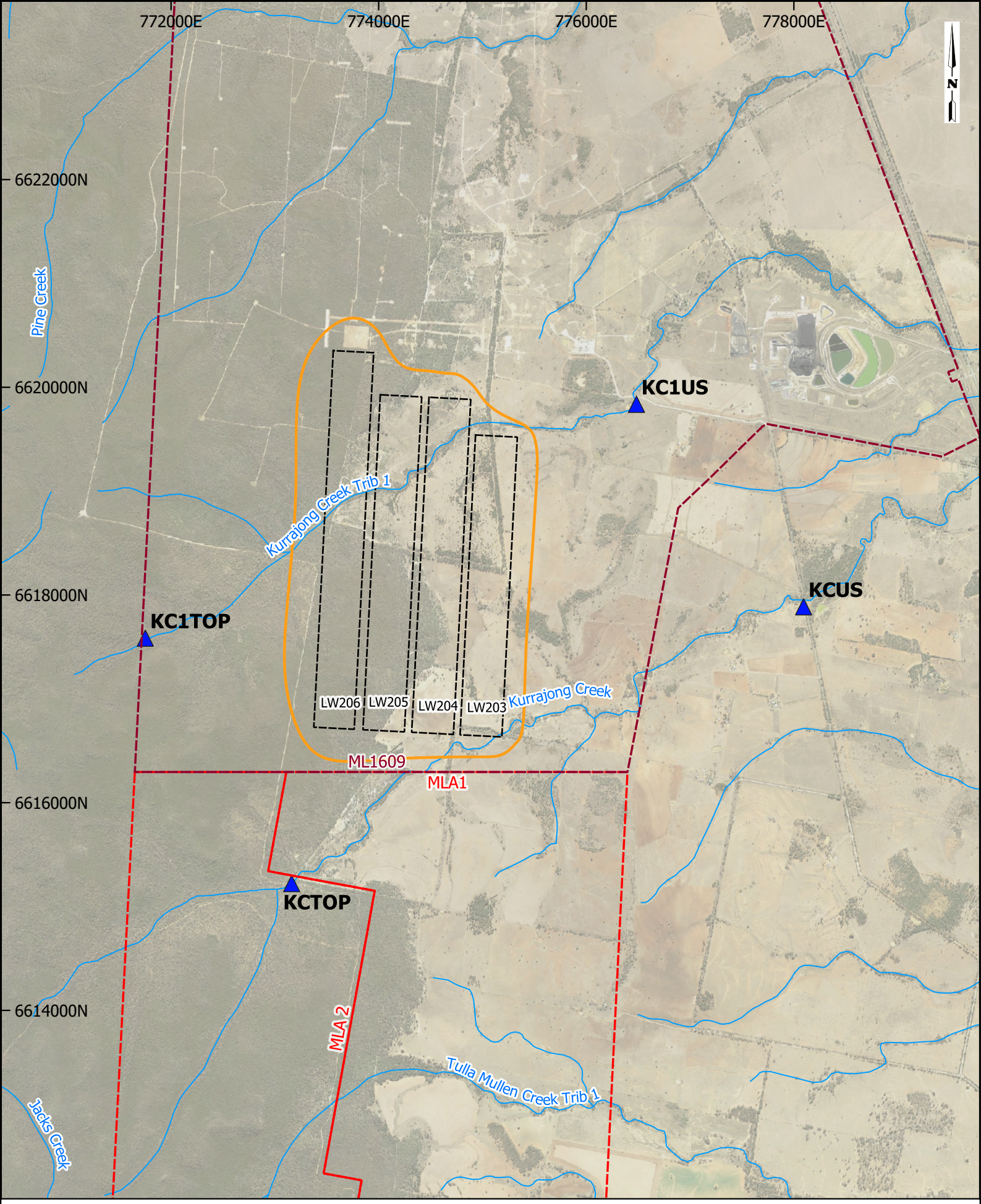
Watercourse	Site	Monitoring period (No. of days)	Number of days samples collected	Frequency of days with ponded/flowing water
Kurrajong Creek	KCTOP	1,625	0	0%
	KCUS	5,246	63	1.2%
Kurrajong Creek Tributary 1	KC1TOP	5,246	0	0%
	KC1US	5,246	41	0.8%

The data presented in Table 2-1 indicates that the watercourses within and adjacent to the Extraction Plan Area are highly ephemeral, particularly at headwater sites. Ponded and/or flowing water was present at downstream monitoring sites on Kurrajong Creek and Kurrajong Creek Tributary 1 approximately 1.2% and 0.8% of sampling occasions respectively over the duration of monitoring.

2.1.3 Surface water quality

In accordance with the Site WMP, event-based water quality sampling is undertaken during flow events as practical. Baseline surface water quality monitoring has been undertaken by NCOPL at sites within and adjacent to the Extraction Plan Area since July 2007. The locations of the monitoring sites relevant to the Extraction Plan Area are shown in Figure 2-2. It is noted that additional monitoring sites are located outside of the Extraction Plan Area and are detailed in the Site WMP.

To provide an indication of baseline water quality conditions within and adjacent to the Extraction Plan Area, water quality data for the period of record has been compared to the ANZECC & ARMCANZ (2000) and ANZG (2018) default trigger guidelines for the protection of aquatic ecosystems, consistent with the Namoi River catchment water quality objectives (NSW Government, 2006). Additionally, the Namoi River catchment water quality objectives for visual amenity have been considered. The default guideline values and water quality objectives are summarised in Table 2-2.



LEGEND

- LW203-206 (Proposed)
- Mining Lease
- Mining Lease Application
- Extraction Plan Area
- Watercourse
- Water Quality Monitoring Site

FIGURE 2-2: Surface water quality monitoring sites

ATC WILLIAMS

0 500 1000 1500 2000

Metres

CRS: GDA94 / MGA Zone 55
Aerial: Google 2018

File: Synergy\116100\06\Data and Calcs\Baseplan_116100-06.qgz

Table 2-2 Kurrajong Creek (KCUS) water quality summary

Parameter	ANZECC & ARMCANZ (2000) and ANZG (2018) Default Guideline Values		Namoi River Catchment Water Quality Objectives (NSW Government, 2006)
	Aquatic Ecosystems (95%ile level of species protection)	Upland Rivers (NSW)	Visual amenity
pH (pH units)	-	6.5 - 8	-
EC (µS/cm)	-	350	-
TSS (mg/L)	-	-	-
Grease and Oil (mg/L)	-	-	Oils and petrochemicals will not be noticeable as a visible film on the water, nor will they be detectable by odour.
TOC (mg/L)	-	-	-

Table 2-3 and Table 2-4 presents a summary of the water quality monitoring data recorded at KCUS in Kurrajong Creek and KC1US in Kurrajong Creek Tributary 1.

Where default guideline values for aquatic ecosystems and/or upland rivers were available, the monitoring results were compared with these default guideline values, and the percentage of exceedances reported.

Table 2-3 Kurrajong Creek (KCUS) water quality summary

Parameter (mg/L unless otherwise stated)	Default guideline value	KCUS*				Exceedances %
		No. of samples	Min	Median	Max	
pH	6.5 - 8.0	63	6.64	7.41	8.18	3%
EC (µS/cm)	350	63	33	195	1,280	32%
TSS	-	63	2	98	2,180	-
Grease & Oil	-	61	2	5	11	-
TOC	-	59	5	10	22	-

**July 2007 to December 2021*

Table 2-4 Kurrajong Creek Tributary 1 (KC1US) water quality summary

Parameter (mg/L unless otherwise stated)	Default guideline value	KC1US*				Exceedances %
		No. of samples	Min	Median	Max	
pH	6.5 - 8.0	41	6.7	7.35	8.2	2%
EC (µS/cm)	350	41	54	116	1,300	2%
TSS	-	41	8	62	2,760	-
Grease & Oil	-	39	2	5	11	-
TOC	-	39	5	11	21	-

**July 2007 to December 2021*

The data presented in Table 2-3 and Table 2-4 show that the default guideline values for pH and EC are, at times, naturally exceeded at monitoring sites KCUS and KC1US in Kurrajong Creek and Kurrajong Creek Tributary 1 respectively. Site specific guideline values (**SSGVs**) have been derived for KCUS and KC1US as detailed in Section 6.1.2.

2.1.4 Other water users

A total of 17 farm dams used for livestock watering are located within or directly adjacent to the Extraction Plan Area (DGS, 2022). The farm dams are mostly less than 1 ML in capacity and have not been declared as dams under the Dams Safety Act (WRM, 2020).

2.2 Groundwater

2.2.1 Groundwater regime

The Narrabri Mine is located within the Mullaley Sub-basin, which forms part of the larger Gunnedah Basin. The western half of the mining lease is also located on the eastern margin of the Surat Basin. In general, the Surat and Gunnedah Basin stratigraphic units are characterised by a dip to the west at an angle of less than 10 degrees and outcrops to along the Namoi River valley.

The main stratigraphic units occurring in the vicinity of the Narrabri Mine are the:

- Gunnedah Basin Units inclusive of:
  - the Napperby Formation and Digby Formations of Triassic age; and
  - Permian coal measures within the Black Jack Group including the Hoskissons Coal Seam, Arkarula Formation and Pamboola Formations (which are locally characterised by an east [shallowest] to west [deepest] dip).
- Surat Basin Units of Jurassic age, which include the Pilliga Sandstone, Purlawaugh Formation and Garrawilla Volcanics; and
- Quaternary alluvium which consists of unconsolidated clays, silts, sands and gravels associated with the Namoi River and its associated tributaries.

Of the units listed above, only the Namoi River alluvium and Pilliga Sandstone are considered regionally significant aquifers ("highly productive" under the Aquifer Interference Policy [**AIP**][4]). The Namoi River alluvium is present at outcrop approximately 5.5 km east of the EP area and not present within the EP area. Whilst the remaining units may support minor extractions for stock and domestic purposes, they are relatively low-yielding aquifers ("less productive" unit under the AIP). A conceptual geological cross-section showing the main stratigraphic units occurring in the vicinity of the mine is provided in Figure 2-3.

Only the Pilliga Sandstone, Pulawaugh Formation and occasionally the Garawilla Volcanics outcrop or sub-outcrop above the EP long wall panels (i.e. LW 203-206).

2.2.2 Groundwater levels

NCOPL has historically undertaken monitoring of groundwater levels in the Namoi Alluvium, Pilliga Sandstone, Purlawaugh Formation, Garrawilla Volcanics, Napperby Formation, Digby Formation, Hoskissons Coal Seam, Arkarula Formation, Pamboola Formation and various older units.

Regional groundwater level contours for the Namoi Alluvium indicate that groundwater flows generally south to north along the Namoi River, consistent with topography and flow direction of the river. Intensive groundwater use for irrigation results in seasonal water table drawdown in excess of 15 m in areas of the Namoi Alluvium.

Regional groundwater flow directions in the Pilliga Sandstone are towards the north-west, show little or no temporal variation, and do not appear to be affected by climate, Narrabri Mine dewatering and other extraction.

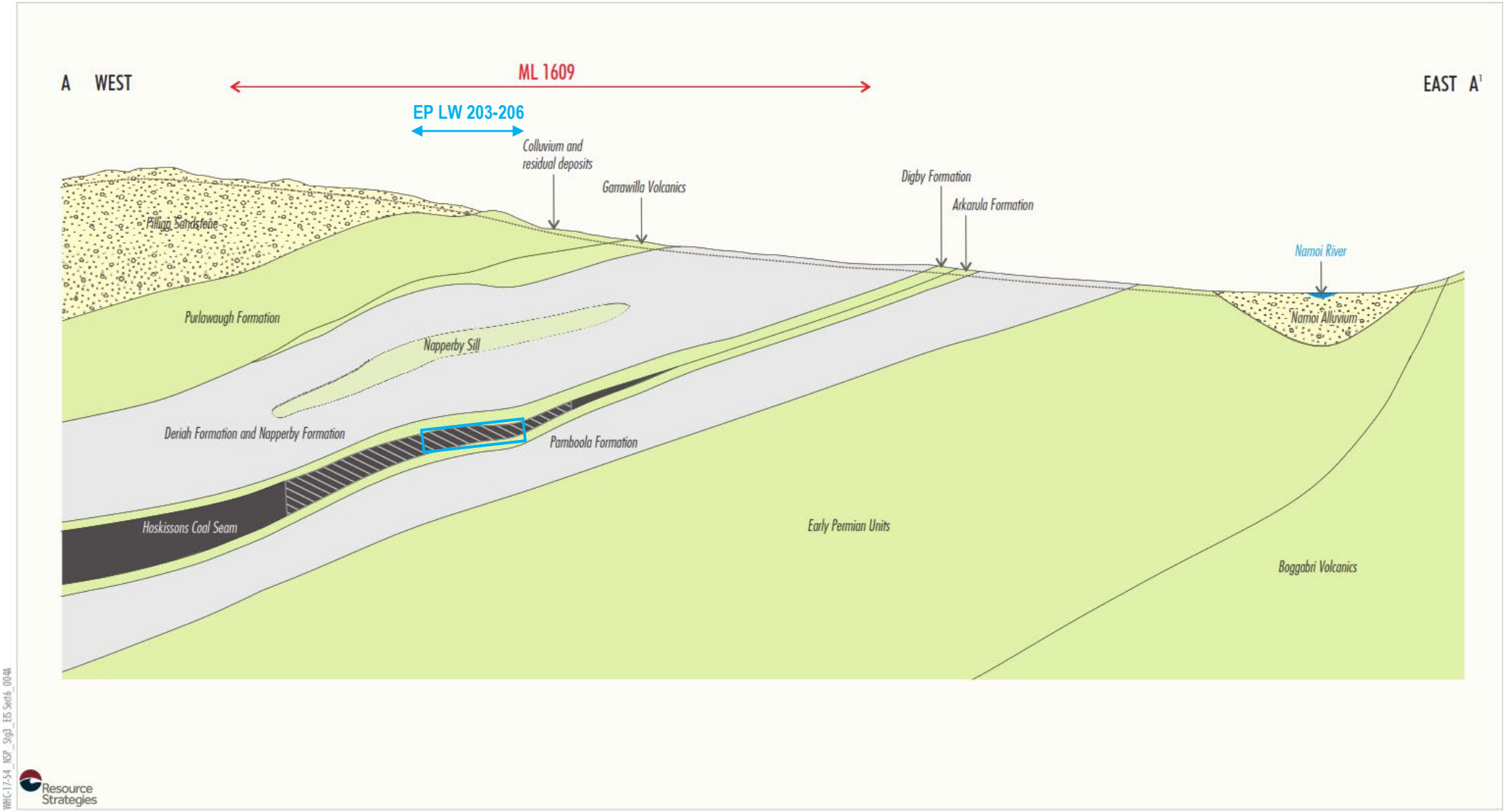
Deeper units show varying levels of response to the Narrabri Mine operations, from little or no response in the Purlawaugh Formation, to substantial depressurisation in the Hoskissons Coal Seam, as will be expected given the nature of mining operations.

Recharge to the hydrostratigraphic units occurs through diffuse rainfall recharge and limited seepage through the non-perennial Kurrajong Creek and its tributaries when flowing. No aquifer discharge occurs above the Extraction Plan Area related to baseflow since groundwater levels are generally deep and well below the non-perennial tributaries associated with the Extraction Plan Area. Accordingly, no alluvium is present along these creeks and are either entirely disconnected (or possibly only very occasionally connected) to the Namoi Alluvium. No high priority GDEs occur within the Extraction Plan Area as described in the Stage 3 Groundwater Impact Assessment (AGE, 2020a). The Mayfield Spring (a potential groundwater feature) occurs approximately 1 km south of the Extraction Plan Area.

Groundwater level baseline data for the monitoring bores associated with the Extraction Plan Area (P7 to P11) is shown in Figure 2-4.

[4] A 'highly productive' source is defined by the AIP as a groundwater source which has been declared in regulations and datasets, based on the following criteria:

- has a total dissolved solids **(TDS)** concentration less than 1,500 milligrams per litre (mg/L); and
- contains water supply works that can yield water at a rate greater than 5 litres per second (L/s).



Source: AGE (2020)

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FIGURE 2-3
Conceptual Geological Cross-Section and Approximate Extraction Plan Area

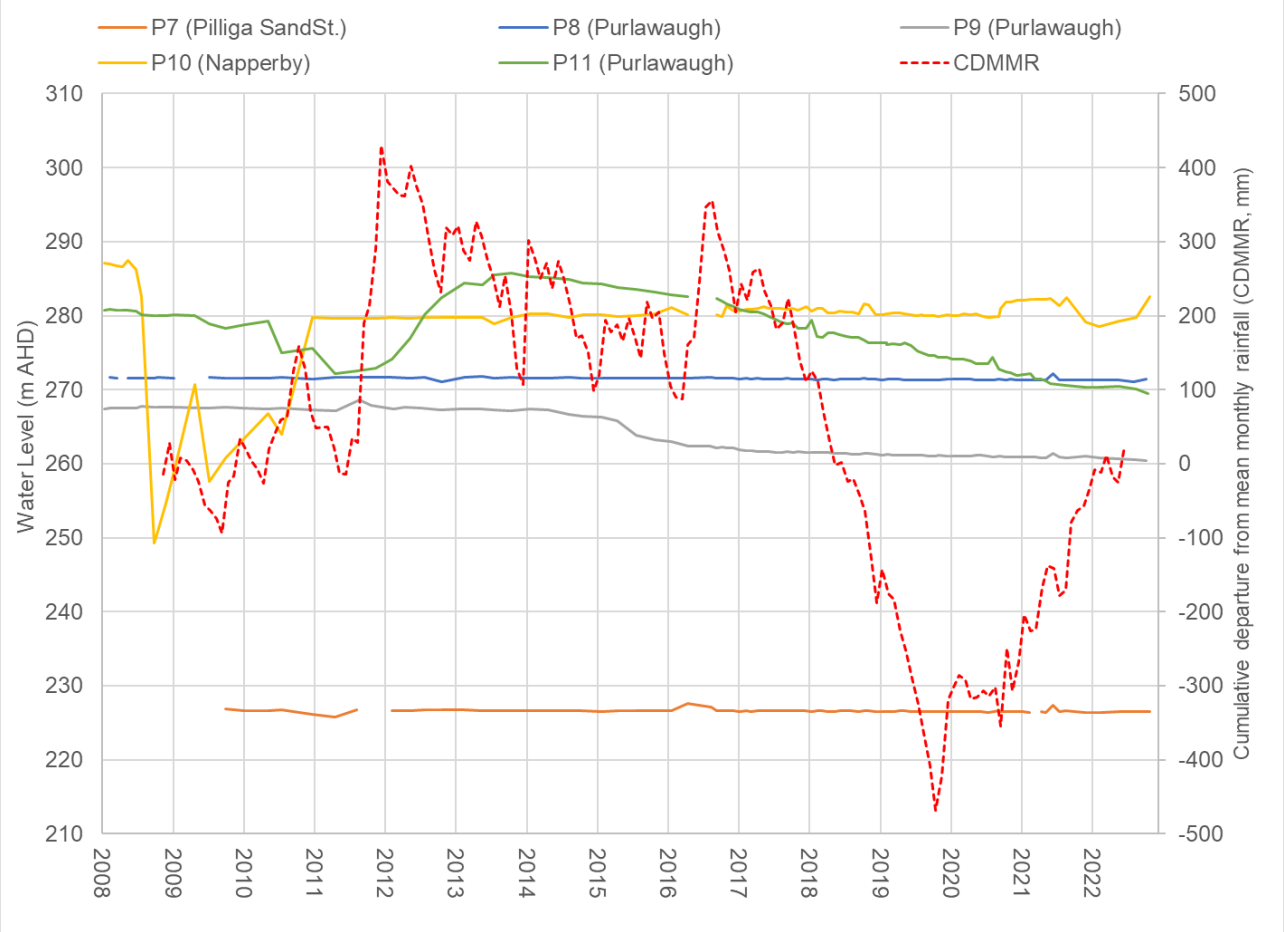


Figure 2-4 Baseline groundwater level data for bores P7 to P11

2.2.3 Groundwater quality

Both the Namoi Alluvium and the Pilliga Sandstone are characterised by relatively low salinity and variability. The median electrical conductivity (**EC**) for both aquifers is less than 700 microSiemens per centimetre (**µS/cm**), suggesting the water is relatively fresh.

The Garrawilla Volcanics has an EC of approximately 2,630 µS/cm, suggesting brackish to moderately saline groundwater. In addition, median EC values for the Purlawaugh and Napperby Formations suggest moderately saline conditions on average but show a high degree of variability and relatively fresh water in some cases, suggesting that potentially useful freshwater aquifers can be encountered within these formations.

Data for the Hoskissons Coal Seam suggest moderately saline conditions based on the median EC value of 6,180 µS/cm, whilst data for the two deepest units monitored within the mining lease, the Arkarula and Pamboola Formations, suggest median EC values in excess of 15,000 µS/cm. The relatively high salinity values recorded in samples taken from the Arkarula Formation may reflect the depth of this unit and the lack of any known outcrop areas. Residence times with the strata may therefore be substantial resulting in relatively high salinity groundwater.

Table 2-5 provides a summary of the field EC data by hydrostatic unit.

Table 2-5 Summary statistics, field EC data by hydrostratigraphic unit

Formation	No. bores	No. tests	Field EC (µS/cm)					
			Mean	Min	25%	50%	75%	Max
Alluvium	9	92	2,292	597	704	853	5,860	7,050
Pilliga Sandstone	4	93	1,410	129	256	393	2,900	5,440
Purlawaugh Formation	4	181	8,343	293	674	4,880	18,960	34,900
Garrawilla Volcanics	9	360	4,606	274	1379	2,630	4,158	20,200
Napperby Formation	9	438	9,632	1,020	3,083	7,040	17,628	33,100
Hoskissons Coal Seam	1	5	5,580	1,410	4,070	6,180	7,490	8,750
Arkarula Formation	1	15	19,230	1,140	15,915	23,770	25,015	25,420
Pamboola Formation	3	174	14,785	1,050	3,468	17,175	25,025	27,340

2.2.4 Groundwater yields

The Narrabri Hydrogeological Sheet (1:250 000) (NSW Water Resources Commission) indicates that the site is mapped primarily as Jurassic sediments (Purlawaugh Formation), which are rarely considered as aquifers and have yields generally less than 0.5 L/s. This map also identifies a small area in the south-east portion of ML 1609 as part of the Gunnedah Basin sequence, with low yields similar to the Purlawaugh Formation. The geological unit in the Narrabri area with the highest potential yields is the Garrawilla Volcanics of the *NSW GAB Groundwater Sources Southern Recharge Groundwater Source*. However, this formation is not regionally extensive and not considered a highly productive groundwater source.

2.2.5 Groundwater use

There are more than 2,200 bores in the regional context, comprising approximately 1,500 water supply bores and approximately 700 bores drilled for non-water supply purposes (e.g. monitoring, exploration or dewatering). Registered water supply bores in the broader region are located predominantly within the Namoi alluvium and include a number of bores used for irrigation purposes that tap into the 'highly productive' Namoi Alluvium aquifer.

Closer to the site, however, groundwater use is less prevalent and less intensive. Privately-owned registered water supply bores in the immediate vicinity of the mine are predominantly used for stock and domestic purposes, which reflects the lack of highly productive formations immediately to the east (outside the extent of Namoi alluvium), and lack of development to the west (i.e. within the Pilliga East State Forest).

Groundwater is also extracted from NCOPL's existing alluvial bore located adjacent to the Namoi River when required (e.g. when supply from the underground mining area is insufficient to meet water demands, and sufficient allocation from the Namoi River [i.e. utilising NCOPL's existing Namoi River pump] is unavailable).

The existing alluvial bore is located within the Upper Namoi Zone 5 groundwater source (within the *WSP for the Namoi Alluvial Groundwater Sources 2012*), and water is extracted in accordance with the relevant Water Access Licence (**WAL**) held by NCOPL and the rules prescribed in the WSP.

3. Subsidence impacts and potential environmental consequences

3.1 Subsidence predictions

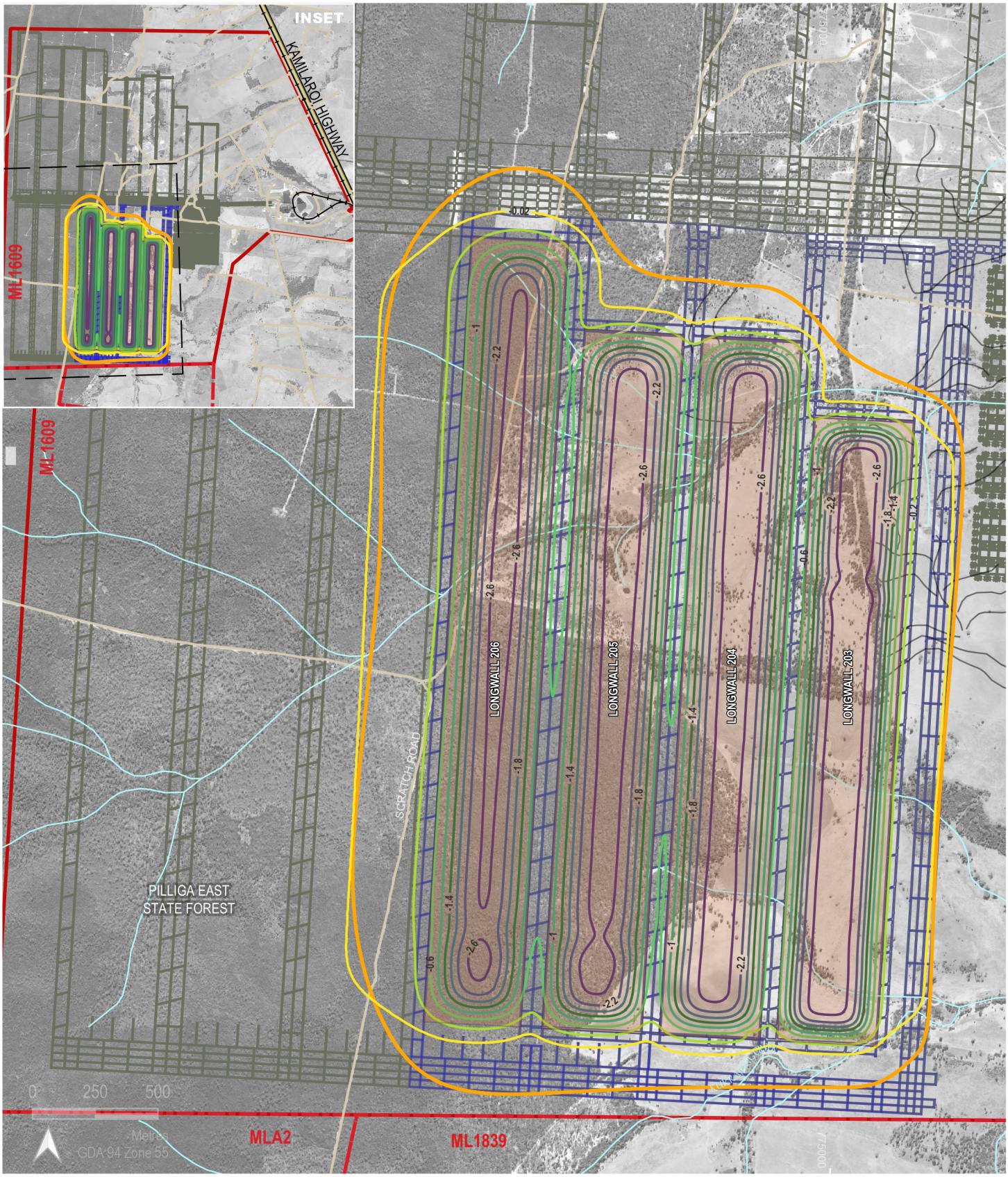
Subsidence predictions for the Extraction Plan Area were assessed and are presented in the Mine Subsidence Assessment Report. The Mine Subsidence Assessment Report details the potential impacts to natural, man-made and Aboriginal heritage features within the Extraction Plan Area based on the predictions of conventional and non-conventional subsidence. The predictions include a review of the subsidence effects measured above previously undermined LW 101 to LW 109.

The predicted maximum subsidence estimates for the Extraction Plan Area are summarised in Table 3-1 and shown on Figure 3-1.

Table 3-1 Maximum final subsidence effect predictions

LW	Cover depth (m)	Subsidence (m)	Tilt (mm/m)	Tensile strain (mm/m)	Compressive strain (mm/m)
203	200-208	2.63 - 2.80	34 - 54	15 - 32	16 - 35
204	230-242	2.72 - 2.80	29 - 47	11 - 26	12 - 27
205	248-282	2.75 - 2.80	24 - 39	9 - 19	9 - 21
206	280-311	2.75 - 2.80	20 - 33	7 - 15	7 - 16

Source: adapted from Table 4 (DGS, 2021)



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LEGEND

- ML1609
- ML1839
- MLA2
- Underground mining layout
- Longwalls 203 to 206
- Proposed longwall voids (LW203-206)
- 45 degree angle of draw
- Roads
- Watercourse
- Contour bank

Subsidence contours (m)

- -0.02
- -0.2
- -0.6
- -1
- -1.4
- -1.8
- -2.2
- -2.6

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FIGURE 3-1

Predicted Subsidence Contours
for LW 203 to LW 206

3.1.1 Subsidence cracking

Based on the predicted range of maximum transverse tensile strains for the proposed longwall panels (i.e. 7 mm/m to 32 mm/m), surface crack widths are estimated to range from approximately 210 millimetres (**mm**) to 330 mm in cohesionless soils and from approximately 420 mm to 650 mm in cohesive soils or shallow rock (Table 3-2). Cracks usually develop within several days after a longwall face has retreated beneath a given location, with some of the cracks closing in the compression zone in the middle of the fully developed subsidence trough, together with new cracks developing in the tensile zones along and inside the panel sides approximately two to three weeks later.

Surface crack widths are upper 95% confidence level (**U95%CL**) values (to the nearest 10 mm), which means they may be exceeded 5% of the time (by definition) due to adverse topographic or geological conditions. Whilst this effect is unlikely to occur above LW 203 to LW 206 generally, crack widths may exceed the predicted range near the crests of steep creek banks or elevated ridges. The steep rocky slopes above LW 204 and LW 205 are considered likely to be impacted by surface cracking more than 300 mm wide. Based on the above, it is estimated that approximately 0.02 km^2 to 0.04 km^2 of the surface will be crack affected. This represents 0.13% to 0.27% of the extracted longwall area.

Based on reference to the Australian Coal Industry's Research Program (2003), surface cracks will likely develop by the time the longwall face has retreated past a given location for a distance equal to one to two times the cover depth (i.e. ranging from 170 m to 840 m, based on cover depths at the Narrabri Mine).

Detail on steep slopes and sub surface cracking relevant to the Extraction Plan Area is presented in the Extraction Plan – Land Management Plan.

Table 3-2 Predicted maximum crack width in flat terrain

LW	Cross section cross-line (XL)	Panel width [W] (m)	Cover depth [H] (m)	Panel W/H	Effective bay length* (m)	Predicted maximum tensile strain (mm/m)		Predicted U95%CL crack width (mm)	
						Mean	U95%	Sand or Loam	Clay or Rock
203	6	402.8	208	1.94	10.4	15	29	300	600
	7	402.8	200	2.01	10.0	15	31	310	620
	8	402.8	204	1.97	10.2	16	32	330	650
204	6	402.8	232	1.74	11.6	12	24	280	560
	7	402.8	242	1.66	12.1	11	23	280	560
	8	402.8	230	1.75	11.5	13	26	300	600
205	6	399.7	248	1.61	12.4	10	20	250	500
	7	399.7	282	1.42	14.1	9	17	240	480
	8	399.7	275	1.45	13.8	9	19	260	520
206	6	395.3	280	1.41	14.0	8	15	210	420
	7	395.3	311	1.27	15.6	7	14	220	440
	8	395.3	304	1.3	15.2	8	15	230	460

Source: DGS, 2022 (Table 7)
* - max (H/20, 10m)

3.1.2 Ponding

The Mine Subsidence Assessment Report predicts a maximum panel subsidence of up to 2.8 m, which may result in closed form depressions forming in some of the central areas of the longwall panels with flatter surface gradients and disrupt natural drainage pathways to watercourses and farm dams. Analysis of the pre- and post-mining surface levels suggests that ponding (if it occurs) is likely to develop along Kurrajong Creek and its tributaries.

A total of six potential ponding locations have been assessed within the Extraction Plan Area. Five of the potential ponding areas already exist along the watercourses and dams. Existing (pre-mining) and post-mining pond depths are estimated to range from 0.1 m to 4.7 m. Pond depths are estimated to increase by up to 1.3 m or decrease by up to 0.04 m.

The maximum changes in pond area (where positive represents an increase in pond area) are estimated to range from -0.42 ha to 2.92 ha. The maximum changes in pond volume (where positive represents an increase in pond volume) are estimated to range from -0.23 megalitres (**ML**) to 20.6 ML[5]. The largest ponding increases are estimated over LW 203 and LW 205.

Overall, the existing ponds are expected to extend laterally from the watercourses for distances ranging from 50 m to 410 m. Existing ponded areas extend up to 270 m, indicating a potential lateral increase of up to 140 m.

3.2 Predicted subsidence impact on surface water and groundwater

3.2.1 Surface water flows

River flow objectives

The Kurrajong Creek and Kurrajong Creek Tributary 1 are classified as uncontrolled streams of the Namoi River catchment (NSW Government, 2006). NSW Government (2006) defines uncontrolled streams as largely natural and typically ephemeral. The River Flow Objectives for uncontrolled streams in the Namoi River catchment (NSW Government, 2006), which are applicable to watercourses within and adjacent to LW203-206, are to:

- protect pools in dry times;
- protect natural low flows;
- maintain natural rates of change in water levels;
- maintain wetland and floodplain inundation;
- maintain natural flow variability; and
- manage groundwater for ecosystems.

These objectives have been considered in the development of the Trigger Action Response Plans (**TARP**) detailed in section 7. The TARPs have been designed to assess performance against the prescribed watercourse measures for Kurrajong Creek and Kurrajong Creek Tributary 1.

[5] The actual ponding depths, areas and volumes will also depend upon several other factors, such as rain duration, surface cracking and effective percolation rates of the surface soils along the creeks/drainage lines.

Potential impacts on streamflow due to surface cracking

The watercourses within the Extraction Plan Area are ephemeral and are likely to only flow during periods of high or extended rainfall. During high rainfall periods, the majority of surface water runoff will flow as streamflow within the watercourse, with negligible flow diverted to the underlying strata. During periods of low flow, a portion of surface water flow is expected to be diverted to the underlying strata. However, given the highly ephemeral nature of the watercourses, low flow periods are expected to be rare. As such, redirection of surface flow within the Extraction Plan Area is expected to have negligible effect on local watercourses and is unlikely to have discernible impacts on catchment-wide surface water resources and ecosystems.

Cracking of a watercourse bed will likely result in redirection of surface flow to the underlying strata. Where surface flow is diverted to the subsurface fracture network, there is potential that the redirected flow will re-emerge further downstream of the longwall panels. Fracturing within the Extraction Plan Area is expected to be discontinuous and unlikely to result in direct hydraulic connection to the underground mine workings. Additionally, there is potential that, following major flow events, cracks in watercourses with cohesionless bed material (i.e., sand) may self-seal due to sediment deposition (DGS, 2022).

Potential impacts on streamflow due to groundwater drawdown and baseflow reduction

Baseflow contribution to the watercourses within the Extraction Plan Area has not been observed. Given the highly ephemeral nature of the Extraction Plan Area watercourses, it is expected that baseflow contribution will be negligible.

Additionally, the groundwater model predictions indicate that the Project will result in negligible impact to baseflow in the Namoi River and associated tributaries. As such, groundwater drawdown associated with mining of LW 203 to LW 206 is not expected to result in an impact to surface water flow within the Extraction Plan Area.

3.2.2 Potential impacts on overland flow, ponding and flooding

The predicted maximum panel subsidence of up to 2.8 m may result in notable depressions forming in areas of naturally low gradients. These depressions are likely to result in a reduction in overland flow to downstream watercourses and farm dams. Where surface depressions naturally exist along Kurrajong Creek and Kurrajong Creek Tributary 1, there is potential for increased ponding and further reduction in streamflow to downstream reaches.

DGS (2022) have identified 5 existing (P13, P14.1, P14.2, P14.3, P15) and 1 potential (P16) ponding location within and adjacent to Kurrajong Creek Tributary 1. These ponds have the potential to increase in dimension as a result of subsidence, further disrupting flows to natural drainage channels and/or dams located downstream. Existing and post-mining pond depths are estimated to range from 0.1 to 4.7 m. The maximum changes in pond area (where positive represents an increase in pond area) are estimated to range from -0.42 ha to 2.92 ha. The changes in pond volume (where positive represents an increase in pond volume) are estimated to range from -0.23 to 20.6 megalitres.

It is noted that the ponded areas are expected to accumulate sediment over time thereby reducing, to some extent, impacts to overland flow (DGS, 2022).

While subsidence associated with mining of LW 203 to LW 206 may result in localised areas of increased ponding, due to the ephemeral nature of the watercourses it is unlikely to result in significant changes to flooding in the Extraction Plan Area.

3.2.3 Potential impacts to farm dams and contour banks

There are 17 farm dams used for livestock watering are located within or directly adjacent to the Extraction Plan Area. The farm dams are predicted to be impacted by tensile and compressive strains ranging from 3 mm/m to 20 mm/m (DGS, 2022). Based on the predicted phases of tensile and compressive strain development, the Mine Subsidence Assessment Report estimates that breaching of the dam walls or water storage areas may occur. For all farm dams located within the Extraction Plan Area, a loss or increase of water storage area may occur as a result of the predicted mining-induced tilt. The Mine Subsidence Assessment Report estimates that maximum tensile crack widths of 30 mm to 400 mm may occur within the base or walls of the farm dams.

A number of contour banks, constructed to manage overland flow and reduce erosion and sedimentation transport, are present in the Extraction Plan Area. The contour banks are typically constructed with low longitudinal gradients (i.e., less than 0.5 %). Based on the subsidence predictions associated with mining LW 203 to LW 206, impacts to contour banks may occur resulting in the contour banks no longer performing as designed. Where impacts to contour banks occur, there is potential for re-direction of overland flow, concentration of overland flow and increased erosion (WRM, 2020).

Where required, remediation of farm dams and contour banks will be undertaken by NCOPL as described in the Extraction Plan - Built Features Management Plan.

3.2.4 Potential impacts to slope instability and erosion

Based on the subsidence predictions associated with mining LW 203 to LW 206, differential ground movement and/or instability may occur resulting in an increase in the gradients of local watercourses and overbank areas. This may result in increased flow velocity and subsequently influence rates of erosion and sediment transport. The effects of differential ground movement or instability are most likely to be observed immediately downstream of the chain pillars. Where increased erosion and sediment transport occurs, there is potential that downstream landforms/geomorphology and surface water quality may be affected.

3.2.5 Potential impacts to surface water quality

Increased erosion due to subsidence effects has the potential to result in sediment transport and increased total suspended solids and turbidity concentrations in downstream watercourses. Where increased ponding occurs as a result of subsidence, the ponded water that resides on or flows over saline soils may result in an increase in salinity concentrations in downstream watercourses.

Where surface cracking occurs, diverted flow may be conveyed via the dilated strata and remerge further downstream in the watercourse as surface flow. This may result in isolated, episodic increases in salinity and dissolved metals at locations in Kurrajong Creek and Kurrajong Creek Tributary 1 where flow re-emergence occurs.

3.2.6 Groundwater inflows

The predicted annual groundwater volumes (water take) for each groundwater source over the life of mine based on the updated groundwater model used in the Stage 3 Environmental Impact Assessment (**EIS**) groundwater modelling (AGE, 2020a) are presented in Table 3-3. Details of the current groundwater allocations held by NCOPL are summarised in the overarching Site WMP.

The period of mining LW 203 to LW 206 is marked in bold in Table 3-3. It is important to note that the predicted inflows for this period represents the total predicted mine inflow to all panels, whilst the majority of this inflow will be to panels currently under production (i.e. LW 203 to LW 206) some inflow will also be derived from previously mined areas and pre-drainage of areas yet to be mined.

Table 3-3 Predicted annual groundwater volumes per water source

Water Year	Total (ML/year)	*NSW Murray-Darling Basin Porous Rock Groundwater Sources Order 2020*	*NSW Great Artesian Basin Groundwater Sources 2020*	*Namoi Alluvial Groundwater Sources Order 2020*	*Upper and Lower Namoi Regulated River Water Source*
2022	1099	1093	6	0	0
2023	**1284**	**1277**	**7**	**0**	**0**
2024	**1420**	**1409**	**10**	**0**	**1**
2025	**1491**	**1478**	**12**	**0**	**1**
2026	**1578**	**1563**	**14**	**0**	**1**
2027	1631	1613	16	0	2
2028	1760	1738	19	0	3
2029	1815	1790	21	0	4
2030	1901	1871	24	0	6
2031	1981	1946	28	0	7

Source: AGE (2020a)

3.2.7 Predicted groundwater impacts

Overall, the assessment of groundwater impacts for the approved mine plan (and discussed in detail) is primarily based on predictions from the numerical model of the groundwater system around the Narrabri Mine developed for the Stage 3 EIS (AGE, 2020a) and predicted impacts specific to the Extraction Plan Area as outlined in the Mine Subsidence Assessment Report. The following impacts are relevant to the Extraction Plan Area:

- connective cracking is estimated to range from 151 m to 257 m above panels LW 203 to LW 206, which equates to 64% to 87% of the overlying cover depth (DGS, 2022);
- direct hydraulic connection to the mine workings due to sub-surface fracturing is estimated to encroach within 27 m to 55 m depth below the surface, with the closest value occurring above the proposed LW 203;
- overall groundwater inflow predictions are presented in Table 3-3;
- similarly, and as per the predictions made in AGE (2020a), drawdown of more than 2 m (i.e. the AIP threshold) is not predicted in any existing privately-owned water supply bores thought to extract water from either the Pilliga Sandstone or Namoi Alluvium aquifers as a result of the EP 203-206;
- no directly related impacts on GDEs from the Extraction Plan Area is expected and the following should be noted:
  - impacts on GDEs and other receptors outside of the mine footprint and Extraction Plan Area are monitored and managed in accordance with the revised Stage 2 WMP; and
  - no high priority GDEs or alluvial aquifer systems occur within the Extraction Plan Area;
- dewatering leading to drawdown in overlying strata above the LW 203 to LW 206 exacerbated by fracturing due to collapse into the goaf;
- dewatering impacts will continue to develop in each of the “less productive” hydrostratigraphic units in which impacts have already been observed namely the Digby Formation, Napperby Formation, Garrawilla Volcanics and Purlawaugh Formation; and
- the potential for impact on the identified local groundwater users, as a result of the overall approved mine plan is covered in the Site GWMP.

Given the above, no changes to the existing groundwater monitoring or management measures as approved for the existing Narrabri Mine are proposed for conducting secondary workings within the Extraction Plan Area.

4. Performance measures and indicators

Performance measures for watercourses are listed in Schedule 3 Condition 1 of the Project Approval and presented in Table 4-1.

Table 4-1 Subsidence performance measures and performance indicators for water resources

Feature	Subsidence Performance Measures	Subsidence Performance Indicators
Great Artesian Basin	The Proponent shall ensure that, within 5 years of the date of this approval, any loss of water flow into the Great Artesian Basin aquifers (equal to the maximum predicted impact, or the measured impact of the project, whichever is the greater), is managed, licensed or offset (including the possibility of injection of raffinate) to the satisfaction of DPE Water.	Groundwater volumes extracted from Great Artesian Basin water source are measured and reported annually against licensed groundwater extraction volume.

NCOPL will ensure sufficient water entitlements are held in WALs to account for the maximum predicted take for each water source, including the associated WAL dealings prior to take occurring.

Based on the predicted subsidence impacts in the Mine Subsidence Assessment Report and the proposed remediation measures, it is considered that the performance measures for water resources within the Extraction Plan Area will be achieved during and following mining of LW 203 to LW 206.

5. Management measures

In accordance with Schedule 2 Condition 1 of the Project Approval, NCOPL will implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation activities at the Narrabri Mine.

NCOPL will implement the management measures detailed in the following sections to ensure compliance with the performance measures listed in Table 1-1 and Table 4-1.

5.1 Remediation of surface cracks and ponding

5.1.1 Surface cracking

NCOPL will conduct remediation of surface cracking where crack width is more than 50 mm. A preliminary assessment will be undertaken to minimise the environmental impact of remediation actions. Prior to any remediation, NCOPL will undertake a review of environmental impacts (including impacts to biodiversity values) that may result from the remediation at the specific location and consider whether remediation will create an increased impact (e.g. clearing native vegetation to enable machinery access or major drainage works that will cause a greater impact from excavation). If the assessment concludes that there may be the potential to increase impacts on biodiversity, alternative methods of remediating the crack are warranted (e.g. without machinery).

After surface cracks have been remediated, NCOPL will conduct an inspection within three months to identify if further remediation is required.

5.1.2 Ponding

The standard management measures for the remediation of subsidence induced ponding are:

- ponding located in areas where vegetation is not affected, will be allowed to self-correct;
- ponding located in areas with affected vegetation, or if ponding significantly alters or affects flows, will be assessed and remedial actions (that present the lowest environmental impact) developed in consultation with a geomorphologist; and
- if Endangered Ecological Communities are impacted, or downstream water quality analysis indicates a change in EC trends, the ponding will be assessed, and remediation options will be developed to afford the maximum practical protection to the affected feature.

Remediation of ponding is further detailed in the Land Management Plan (Appendix B to EP 203-206).

5.2 Steep slopes

Appropriate impact management strategies for the farm dams and soil contour banks are described in the Extraction Plan - Land Management Plan.

5.3 Erosion

The classification system for gully erosion will be commensurate with the depth and width as presented in Table 5-1.

Table 5-1 Gully erosion rating

Gully depth	Associated rating
Cracks	A
<0.5 m deep, <0.5 m wide	B
0.5 – 1 m deep, <1 m wide	C
>1 m deep, >1.5 m wide	D

For gully erosion rated A or B, management measures are commensurate with the measures for surface crack remediation as detailed in section 5.1.1.

For gully erosion rated C or D, the following measures may be considered:

- grade banks to stop the upslope concentration of flow and stabilise through revegetation:
  - graded bank diversionary structures may need to be installed on a suitable grade to ensure flows that are diverted away from the gullies with consideration of ground surface, soil type and design flows; and
  - sow perennial pasture species in accordance with the Rehabilitation Management Plan.
- fill using rocks or rubble sourced from site or reshape using an excavator, or a combination of both. After filling, it is recommended that they be dressed with topsoil to encourage rapid establishment of vegetation; or
- diversion banks to convey flows to a safe disposal area where water will naturally spread and not concentrate into erosive volumes and velocities. Where safe disposal areas are not available, the construction of a suitable drop structure to safely convey diverted flows into creek lines will need to be considered.

Depending on the nature of the soils and the availability and quality of topsoil, consideration will be given to the use of soil ameliorants to improve the soil structural stability. This will improve rehabilitation and revegetation outcomes. Soils may respond particularly well to the use of gypsum to address the highly dispersible soils. Temporary sediment fencing will be installed below any areas to be disturbed and be maintained until such time as disturbed areas have revegetated. Erosion and sediment controls will be implemented in accordance with the Erosion and Sediment Control Plan which forms part of the Site WMP.

5.4 Farm dams and contour banks

Appropriate impact management strategies for the farm dams and soil contour banks are described in the Built Features Management Plan (Appendix E to EP 203-206).

6. Subsidence impact monitoring

6.1 Surface water monitoring methods

6.1.1 Monitoring standards

Surface water monitoring at Narrabri Mine will be undertaken in accordance with the Australian Standard for Water Quality Sampling *AS/NZS 5667.1:1998* and the *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW* (EPA, 2022). Laboratory analysis will be undertaken by a laboratory which has the relevant accreditation by the National Association of Testing Authorities (NATA). Quality assurance and quality control (**QA/QC**) for water quality monitoring will be undertaken in accordance with the *Australian and New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG, 2018).

6.1.2 Site-specific guideline values

In order to reflect local conditions, SSGVs have been derived from historical data for monitoring sites KCUS and KC1US, located downstream of the Extraction Plan Area and upstream of the Narrabri Mine. The SSGVs have been defined as the 90th (referred to as Stage 1) and 95th percentile (referred to as Stage 2) of the baseline water quality data recorded at these sites. As limited water quality data is available for monitoring sites KC1TOP and KCTOP, site specific guideline values were unable to be derived for these sites. These sites will continue to be monitored when feasible in order to provide reference site data for comparison to KCUS and KC1US data in the event of a trigger exceedance.

As constituent values may at times naturally exceed the derived SSGV of the baseline water quality data, an exceedance of a SSGV is not considered as immediate evidence of an impact, rather the SSGVs are proposed as performance indicators to initiate investigation into potential changes in water quality characteristics which may result in impacts to aquatic ecosystems at monitored surface water sites.

Table 6-1 presents the SSGVs derived for KCUS and KC1US. It is noted that KC1US overlies the eastern edge of CF 201 (cut and flit panel) and therefore may be impacted by mining related effects associated with CF 201. Potential subsidence effects related to mining of CF 201 and associated monitoring and management measures are described in the *Panels 201 – 202 Extraction Plan Water Management Plan* (Whitehaven, 2022).

Table 6-1 Site specific guideline values – water quality

Parameter (mg/L unless otherwise stated)	KCUS		KC1US	
	Stage 1	Stage 2	Stage 1	Stage 2
pH (pH units)	6.5 - 8	6.5 - 8	6.5 - 8	6.5 - 8
EC (µS/cm)	721	847	210	220
TSS	708	860	653	1018
TOC	15	17	16	17

Note: a minimum of 62 baseline values were used to derive the SSGVs for KCUS and a minimum of 41 baseline values for KC1US

The proposed impact assessment criteria (Trigger Stage 2) for surface water quality recorded at each monitoring site are as follows:

- Field pH values exceed the upper or lower pH trigger values (pH 6.5 – 8.0) for three consecutive events at a monitoring site.

OR

- Recorded EC, TSS or TOC value exceeds the 90th percentile baseline value for three consecutive events at the same monitoring site.

OR

- Recorded EC, TSS or TOC value exceeds the 95th percentile baseline value at a monitoring site in one event.

6.1.3 Surface water monitoring program

A surface water monitoring program will be implemented to monitor the impacts of subsidence effects during the extraction of LW 203 to LW 206. The surface water monitoring program is summarised in Table 6-2.

Table 6-2 Surface water monitoring program

Location	Parameters	Monitoring frequency
KC1TOP, KC1US, KCTOP, KCUS	Field analysis: • pH • EC • turbidity • DO • temperature Laboratory analysis: • pH • EC • TDS • TSS • turbidity • TOC • Oil & grease • Metals and metalloids: aluminium, arsenic, cadmium, chromium, copper, lead, nickel, selenium, zinc, iron, molybdenum, antimony, mercury, cobalt	Quarterly, in the event of flow during the quarter
	Visual inspection to record streamflow characteristics: • no ponding/flow • ponded water • trickle flow • flowing water	

6.1.4 Streamflow monitoring

As stated in Table 6-2, visual inspections will be undertaken at surface water monitoring sites in Kurrajong Creek and Kurrajong Creek Tributary 1 in order to record the presence of ponded water and surface water flow at each monitoring site. This will aid in providing an improved understanding of watercourse hydrology within the Extraction Plan Area and in interpreting water quality and erosional effects.

NCOPL will investigate alternatives to measuring or predicting creek flows for the purpose of supporting water take licensing, to improve understanding of the hydrology, and to interpret water quality and erosion observations. An assessment will be conducted by a surface water specialist prior to any surface cracking occurring within the Extraction Plan Area to consider alternative methodologies to measure and/or predict creek flows. Following the assessment, the appropriate method (if feasible) for formally recording creek flow conditions, and contingency measures will be incorporated into the Site WMP.

An approach for quantifying losses of stream flow from surface cracking and ponding for a range of climatic scenarios will be established and included in the Site WMP following the assessment. The aim of this monitoring is to determine the requirement for a WAL under the *WSP for the Namoi and Peel Unregulated Rivers Water Sources 2012*.

6.1.5 Watercourse monitoring program

Monthly visual inspections behind the longwall face (i.e. during active subsidence) will be conducted to determine surface crack locations, depth and width, the extent of any ponding, and erosion/sedimentation. Surface cracks with widths more than 50 mm will be remediated within two months of being identified. Where this occurs, appropriate management measures will be implemented as detailed in section 5.1.1. Significant vegetation present at ponding locations, that may require monitoring, will be recorded and monitored in accordance with the Extraction Plan - Biodiversity Management Plan.

The reaches of Kurrajong Creek and Kurrajong Creek Tributary 1 which overlie the active subsidence zone will be visually inspected to identify surface cracking of the watercourses and/or increased ponding, erosion and sedimentation. Visual inspections of the full reach of the watercourses will also be conducted to monitor for erosion and ponding. The visual inspections will be conducted prior to mining (baseline) and quarterly for a period of two years. If vegetation is present within areas of ponding, vegetation monitoring will be conducted in accordance with the Extraction Plan - Biodiversity Management Plan.

Channel geomorphology surveys will be undertaken to define the main geomorphic zones and to document changes in channel cross-section, bed erosion and deposition following commencement of mining. Geomorphic zones will be defined during the baseline survey with consideration to stream order, dominant channel bed material, bed stability, channel geometry and other relevant features. A reach of at least 100 m in length will be surveyed for each geomorphic zone with at least four cross-sections surveyed at equal intervals across the reach. The main geomorphic zones and survey locations, including the 100m reaches and channel cross sections will be determined during the baseline surveys conducted prior to secondary workings. Channel dimensions and flow characteristics (i.e., channel width, depth, area, bank full level, bed erosion and deposition) will be recorded annually and following a significant rainfall event.

Two to three reaches each at least 100 m in length within a relevant control zone (i.e., Tulla Mullen Creek Tributary 1) will also be surveyed to provide information on natural channel variability that occurs between survey periods. These control surveys will provide an indication of natural variability due to rainfall events that can be used to indicate if changes in channel dimensions and flow characteristics for watercourses overlying LW 203 to 206 are mining-induced (e.g., changes to channel area and bed slope, erosion of channel banks and bed and/or or sediment deposition). Permanent pegs will be established at each cross-section such that

the results of the surveys conducted following commencement of mining are able to be directly compared to the results of the baseline survey.

Creek line surveys will be undertaken annually. Restriction of flows and hence restriction of fish passage will be assessed following a rainfall event to facilitate appropriate restorative measures (if required).

Remote light detection and ranging (**LiDAR**) and multi-spectral imaging will be used to provide a quantitative comparison of landscape condition and vegetation cover above LW 203 to LW 206 to that of control sites. The control sites will be established within zones where subsidence impacts are not predicted to occur and where similar topographical and vegetative conditions are present. If changes to landscape condition and/or vegetative cover are noted, targeted field surveys will be conducted to confirm the nature and extent of change and to identify appropriate management measures.

A summary of the watercourse monitoring program is provided in Table 6-3.

Table 6-3 Extraction Plan Area watercourse subsidence monitoring program

Aspect/feature	Frequency	Method and analysis	Parameters
Surface cracking and ponding			
Surface cracking	During active subsidence, monthly and following a significant rainfall event (defined as a rainfall event >38.4 mm over 5 consecutive days).	Visual inspections directly behind the longwall face to: • Identify areas of surface cracking and ponding. • Identify erosion/potential erosion. • Record nature and extent of sedimentation (location, extent, depth, sediment calibre). • Identify a decline in riparian vegetation health in ponded areas. • Determine appropriate management response.	• Surface crack GPS location, depth, width and length. • Ponding GPS location, width, depth, area, presence of vegetation. • Bed and bank stability. • Erosion and potential for erosion (e.g., knickpoints, head cuts). Vegetation health is to be monitored in accordance with the Extraction Plan - Biodiversity Management Plan.
Watercourses and ponding	Baseline and then quarterly during active subsidence	Visual inspection and photographs within the active subsidence zone to: • Identify areas of ponding, including vegetation. • Identify erosion/potential erosion. • Record nature and extent of sedimentation (location and approximate extent/depth). • Determine appropriate	• Ponding GPS location, width, depth, area, presence of vegetation. • Bed and bank stability. • Watercourse erosion and potential for erosion (e.g., knickpoints, head cuts).

Aspect/feature	Frequency	Method and analysis	Parameters
		management response.	
Remote sensing			
Topography and landscape morphology	Baseline then every 3 years (triennially).	LiDAR over entire site.	• High resolution topography. • Creek line slope and volumes.
Vegetative cover characteristics and erosion monitoring	Baseline and then annually.	Multi-spectral imaging.	• Vegetative biomass and cover (pasture). • Erosion.
Creek line surveys			
Geomorphic survey	Baseline and then annually for a period of 2 years following longwall mining.	In watercourses with a predicted risk of altered bed slopes following subsidence and likely effects of increased channel gradients (e.g. upstream and downstream of chain pillars)	• Mapping and description. • Survey (100 m reach).
Channel survey	Baseline and then annually for a period of 2 years following longwall mining.	• Effectiveness of gully erosion stabilisation methods. • Cross-section diagrams.	• Identification of ponding - GPS location, width, depth, area, significant vegetation. • Channel parameters. • Advancement of gully erosion.
Direct field survey	Following changes detected during remote sensing.	• Field inspection. • Sampling/testing as required.	Determined during field survey.

6.2 Groundwater monitoring methods

NCOPL has a groundwater monitoring program in place across the mine site that incorporates the collection of water quality and water level data from a network of groundwater monitoring bores. The Narrabri Mine groundwater monitoring network is presented in the latest revision of the Site WMP (not yet approved) and is shown in Figure 6-1 below.

As shown in Figure 6-2 and listed in Table 6-4, a sub-set of the overall site groundwater monitoring network proximal to longwall panels LW 203 to LW 206 has been selected to provide early warning of any impacts which may occur during mining of these panels. Proposed trigger criteria at each location are tabulated in Table 6-4 and Table 6-5.

The methodology for deriving the groundwater level trigger criteria as presented in Table 6-5 includes:

- The ‘maximum life of mine’ predicted drawdown will be used as the Stage 1 trigger value applied throughout the life of mine.

- The Stage 2 drawdown trigger equates to the Stage 1 trigger value plus 15% to compensate for model uncertainty.
- For the Pilliga Sandstone monitoring bores, trigger values will be Stage 1 (>5 m drawdown from baseline level) and Stage 2 (>10 m drawdown from baseline level).

6.2.1 Additional groundwater monitoring locations

It is recommended in the Mine Subsidence Assessment Report, that installation of a multi-level Vibrating Wire Piezometer (**VWP**) and a deep wireline extensometer is considered. Since the Mine Subsidence Assessment Report indicates that the direct hydraulic connection to the mine workings due to sub-surface fracturing is estimated to be the closest above proposed mine panel LW 203 (within 27 m), it is recommended that the multi-level VWP and wireline extensometer be located towards the southern drainage line above LW 203. The proposed depths of the monitoring locations are listed in Table 6-4.

In addition, a VWP and a deep and shallow standpipe monitoring bore cluster are proposed to be installed along Kurrajong Creek east of longwall panel LW 203 and as presented in the Stage 3 Groundwater Impact Assessment (AGE, 2020a). These bores are further discussed in the response to submission and clarification requests[6]. The proposed monitoring locations form part of six additional sites (AGE, 2020a). The proposed depths of the monitoring locations are listed in Table 6-4.

The additional groundwater monitoring bores will be installed prior to the commencement of secondary workings.

6.2.2 Monitoring bores impacted by subsidence

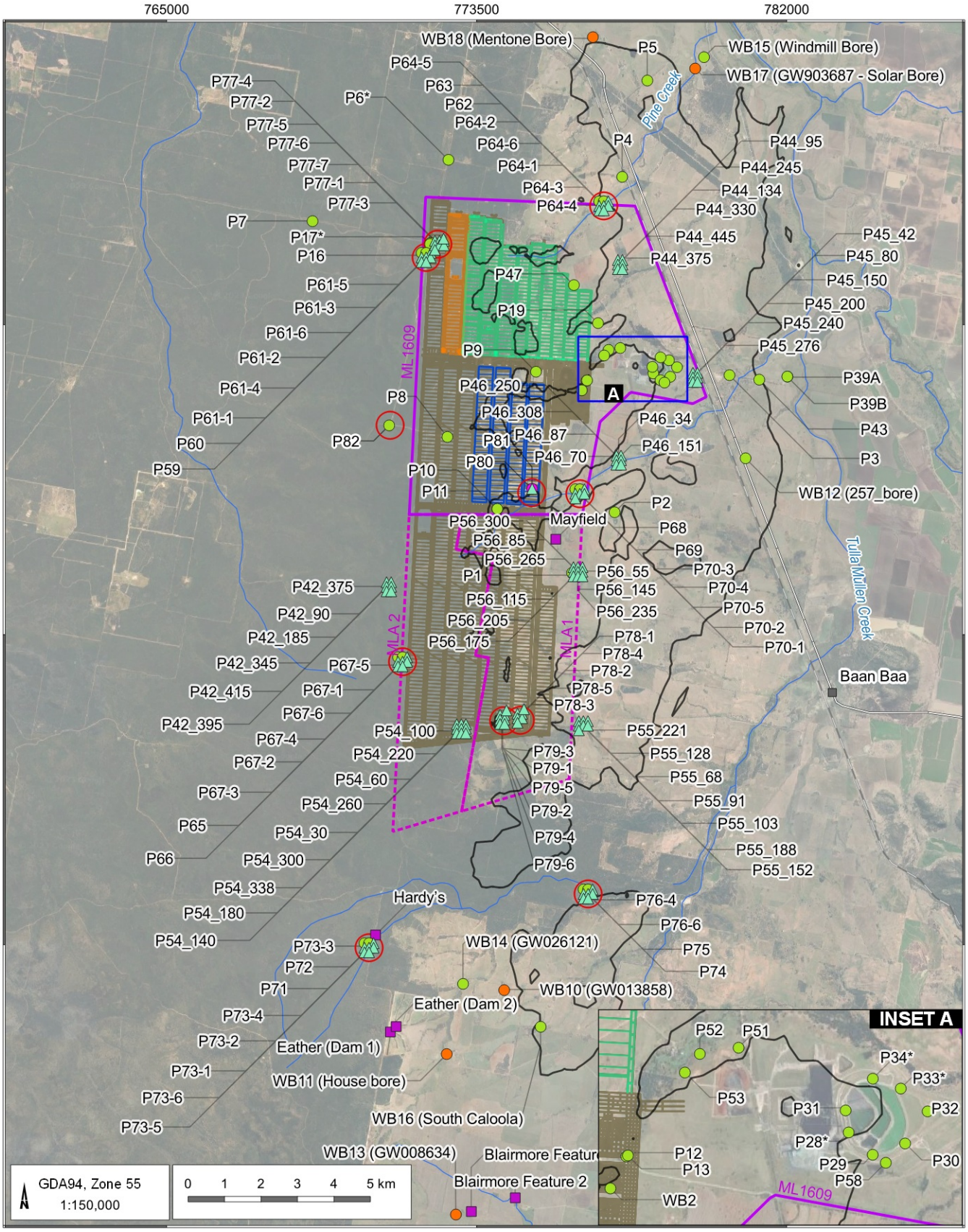
The monitoring locations located over the proposed longwall limits, i.e the proposed additional LW 203 VWP, P9, P10, P11 and the two old production wells, might be subject to failure due to subsidence and fracturing (also refer to DGS, 2022). Where groundwater monitoring points are identified as having been impacted by subsidence, NCOPL will undertake to reinstate or correct the monitoring point where possible. DPE Water will be notified within two weeks of identification of detection of the impacted bore. A determination of the appropriate action for reinstatement or correction of the groundwater bore will be determined in consultation DPE Water. Impacted monitoring locations will be rectified within three months of detection (where possible).

Additional monitoring bores may be required to replace the function of impacted monitoring bores, if necessary. Groundwater monitoring bore P8 is located 1.2 km outside the limits of longwall mining (3.75 times the cover depth) and has a ‘low’ risk of being impacted by horizontal bedding shear movements.

6.2.3 Groundwater monitoring program

Table 6-6 defines the parameters and sampling frequency for each sampling location.

[6] Whitehaven Coal Narrabri Coal Operations Pty Ltd (21 July 2021). Narrabri Underground Mine Stage 3 Extension Project – IESC and DPIE-Water Responses and Groundwater Monitoring Clarifications



LEGEND

- Populated place
- Road
- Rail
- Drainage
- Maximum 2m drawdown contour (alluvium/regolith)
- Mining Lease (1609 Area)
- MLA boundaries (MLA1 & MLA2)
- Current mining
- Mined/Goaf
- Underground panels (LW203 - LW206)
- Proposed new groundwater monitoring sites

GWMP locations

- VWPs
- Standpipe
- Standpipe (Stock and domestic)
- Geotechnical bore
- GDEs/Springs

Narrabri LW203-206 EP GWMP (NAR5002.001)

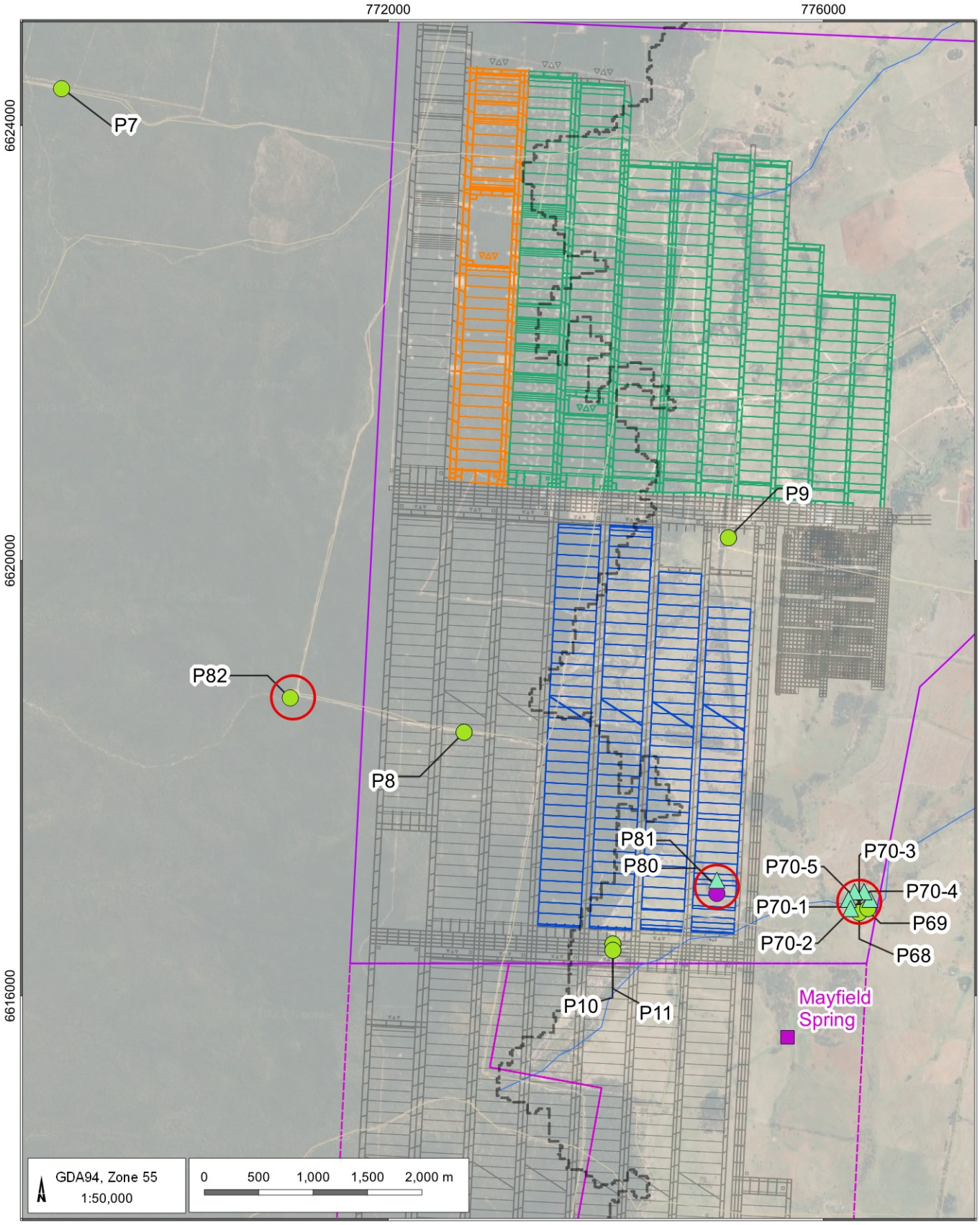
Site GWMP overarching groundwater monitoring network

AGE

DATE 09/02/2023

FIGURE No: **6-1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\NAR5002.001 Narrabri LW203-206 EP_GWMP\3_GIS\Workspaces\001_Deliverable1\01_NAR5002.001_Site GWMP overarching groundwater monitoring network.qgs



LEGEND

- Drainage
- Pilliga Sandstone boundary
- Mining Lease (ML1609)
- MLA boundaries (MLA1 & MLA2)
- Underground mine workings
- Current mining
- Mined/Goaf
- Underground panels (LW203 - LW206)

Proposed new groundwater monitoring sites

GWMP locations

- Standpipe
- VWPs
- Geotechnical bore
- GDEs/Springs

Narrabri LW203-206 EP GWMP (NAR5002.001)

Groundwater monitoring map specific to mine Panels LW203 - LW206

AGE

DATE 10/02/2023

FIGURE No: **6-2**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\NAR5002.001 Narrabri LW203-206 EP_GWMP\3_GIS\Workspaces\001_Deliverable1\02_NAR5002.002_Groundwater monitoring map specific to EP LW203-LW206 and Pilliga Sandstone monitoring locations.qgs

Table 6-4 Summary of the site-specific LW 203 to LW 206 groundwater monitoring site types and assessment criteria

Location ID	Type	Coordinates (MGA55)		Bore Depth (m)	Screen Interval (m bgl)	Formation	Monitoring Purpose	Trigger criteria	
		Easting	Northing					Level	Quality
P7	Standpipe	768998	6624338	90	78-90	Pilliga Sandstone	level and quality	Refer to Table 6-5 [4]	2,327[1]
P8	Standpipe	772697	6618421	65	57-63	Purlawaugh Formation	level and quality	Refer to Table 6-5 [4]	5,970 [2]
P9	Standpipe	775127	6620209	30	24-30	Purlawaugh Formation	level and quality	Refer to Table 6-5 [4]	20,330 and 21,190 [3]
P10	Standpipe	774063	6616444	130	118-130	Napperby Formation	level and quality	Refer to Table 6-5 [4]	8,894 and 9,426 [3]
P11	Standpipe	774066	6616447	50	44-50	Purlawaugh Formation	level and quality	Refer to Table 6-5 [4]	6,052 and 6,546 [3]
P70_1, * P70-2, * P70-3, * P70-4 *, and P70-5 *	VWP	776329	6616863	~140	~5 ~41 ~83 ~125 ~135	Colluvium /Garrawilla Napperby Basalt Sill Digby Hoskissons (thinned out)	level	TBC**	None set, VWP
P68 (shallow) *	Standpipe	776329	6616863	~8	~4 - 6	Uppermost consolidated strata / alluvium / colluvium	level and quality	TBC**	TBC**
P69 (deep) *	Standpipe	776329	6616863	~45	~40	Napperby	level and quality	TBC**	TBC**
LW203 VWP (P80) *** P80_1 P80_2 P80_3 P80_4 P80_5	VWP	775019	6616999	~188	32 80 132 162 188	Garrawilla Napperby Basalt Sill Napperby Base Sill Digby	Level	TBC**	None set, VWP
LW203 extensometer (P81) ***	Extensometer	775019	6617032	~270	To be confirmed	To be confirmed	Displacement	TBC**	None set, wireline extensometer
P82**	Standpipe	771100	6618737	~110	100-108	Pilliga Sandstone	level and quality	TBC**	TBC**

Notes: [1] Converted from TDS trigger using equation 4.6 (ANZECC, 2000). ANZG (2018) Irrigation

[2] Electrical conductivity (EC) [uS/cm] - ANZG (2018) livestock drinking water (beef cattle)

[3] Electrical conductivity (EC) [uS/cm] - Tier 1 and Tier 2 control charting method (DES 2021)

[4] Water level trigger values have been developed for monitoring locations with sufficient pre-mining baseline data based on the maximum predicted drawdown generated from the recalibrated numerical groundwater model (AGE 2020).

* Additional proposed multi-level VWPs and shallow/deep standpipes as per the Stage 3 Groundwater Impact Assessment (AGE, 2020a). Narrabri Underground Mine Stage 3 Extension Project – IESC and DPIE-Water Responses and Groundwater Monitoring Clarifications.

** Groundwater level and quality triggers to be determined when six to eight data sets are available.

*** Geotechnical calibration boreholes (installation above LW 203) (DGS, 2022)

Table 6-5 Groundwater level triggers for life of mine

Monitoring Bore (Geological unit)	Trigger levels (mAHD)	
	Stage 1	Stage 2
P7 (Pilliga Sandstone)	221.81*	216.81*
P8 (Purlawaugh)	269.63	267.49
P9 (Purlawaugh)	262.16	258.45
P10 (Napperby)	245.70	215.46
P11 (Napperby)	264.03	256.52

Note:

* the Stage 1 (>5 m below baseline level) and Stage 2 (>10 m below baseline level) triggers have been applied to the Pilliga Sandstone bore

Table 6-6 EP 203-206 groundwater monitoring program

Monitoring focus	Monitoring type	Monitoring parameters	Frequency
Groundwater	VWPs Sites: P70	Pressure data	Continuous VWP sensor with quarterly download of data
Groundwater	Standpipes Sites: P7, P8, P9, P10, P11, P68, P69, P82	• Water level • Field EC and pH • Laboratory analysis: ▪ physical parameters (e.g. alkalinity, ED, TDS, TSS and pH); ▪ cations (e.g. calcium, magnesium, sodium and potassium); ▪ anions (e.g. carbonate, bicarbonate, sulphate and chloride); ▪ dissolved metals (e.g. aluminium, antimony, arsenic, boron, cobalt, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, selenium and zinc); and ▪ nutrients (e.g. ammonia, nitrate, phosphorous and reactive phosphorous).	• Quarterly for water level, EC and pH • Annually for all other parameters
Groundwater	Monitoring of water quality entering the underground mine workings (i.e. in the mine water collection system via the monitoring at the box cut sump)	• TDS • pH • temperature	Continuous
Groundwater	Monitoring of water quality entering the underground mine workings (i.e. within longwall panels)	• EC • TDS	Initial 6 month period and annually thereafter
Groundwater	Mine water pumping inflow and outflow	• Discharge rate	Weekly meter read
Subsidence (subsurface cracking)	Subsidence calibration borehole P80 (deep borehole piezometers, shallow standpipe piezometers) and geotechnical borehole P81 (deep wireline extensometer) above LW 203^.	• Pressure data • Displacement	Continuous

Monitoring focus	Monitoring type	Monitoring parameters	Frequency
GDEs	Site visits to Mayfield Spring	• Site photographs (x4) and observations of: ▪ Flow rates ▪ Surface conditions ▪ Surface water levels and field water quality (EC and pH) in any standing pools	Annually

6.2.4 Mine inflow rates and quality

Daily recording of mine water inflows and outflows will be conducted to record potential sudden inflows as subsidence develops (as a result of groundwater inflow or connection to surface water flows). In consideration of the sensitivity analysis conducted on the groundwater model (HydroSimulations, 2015) and the potential variability of mine inflows (on a daily basis compared to the weighted average annual inflow of the model), an observed inflow rate 100% in excess[7] of the predicted base case mean monthly inflow rate at any stage during the EP 203-206 operational period sustained for three consecutive weeks where a significant rainfall event[8] has occurred during this period, will trigger an investigation and preparation of a response plan as detailed in section 7.

The volumes extracted from the LW203 to LW 206 mine workings will be transferred through the box cut sump and pumped flows measured from this location. These volumes are included as part of the monitoring network and are reported in the Annual Review. This forms the largest portion of flow that contributes to Narrabri Mine's licenced groundwater extraction volume.

NCOPL will conduct EC and TDS monitoring to identify relationships between measured EC and TDS in mine water and groundwater in the Hoskissons Seam and adjoining aquifers. EC and TDS will be monitored via:

- routine monitoring data from the box-cut;
- groundwater collected within the longwall panels i.e. targeting the Hoskissons Seam; and
- monitoring bores associated in adjoining aquifers i.e. Garrawilla, Napperby, Purlawaugh and Watermark.

The groundwater collected within the longwall panels will be sampled monthly for an initial 6-month period to collect adequate baseline data. Following this, the groundwater collected within the longwall panels will be sampled annually.

The relationship between EC and TDS will be analysed during the annual hydrogeologist review (refer to section 9.3). Mine inflow water quality monitoring will be monitored as described in Table 6-6.

6.2.5 Bore and gas drainage water extraction

The groundwater volumes extracted from bores and gas drainage activities will be measured using flow meters on the pumping equipment. This water contributes to Narrabri Mine's total licenced extraction volume. The volumes extracted from each location will be recorded and included in the Annual Review where flows warrant installation of flow meters, as flows from vertical gas bores are usually very low to insignificant.

[7] 'Day to day inflow rates may be highly variable as the longwall retreats and subsidence develops. A fracture zone may be intercepted which contributes increased inflow for a short period of time (days to weeks), but then inflow would be expected to return to the long term average. The groundwater model also assessed variability in parameters, including hydraulic conductivity, to examine potential variability in impact on groundwater (groundwater level drawdown and inflow rate) compared to the base case. The adoption of a 100% trigger level for variation in inflow rates is based on these two considerations.'

[8] defined as a rainfall event >38.4 mm over 5 consecutive days.

6.2.6 Impacts to licensed users

Due to the generally high groundwater salinities and low bore yields, there is very limited existing groundwater abstraction in the immediate mining area other than for coal mine dewatering. No private bore exists within the immediate area of LW203-206. Management and monitoring of privately-owned water supply bores is outlined in the Site WMP.

6.2.7 Groundwater quality criteria

Due to the generally high naturally occurring groundwater salinity in the area, there is limited existing groundwater abstraction in the immediate mining area other than for coal mine dewatering. Some local bores, however, target relatively permeable horizons within the Napperby Formation and the Garrawilla Volcanics which can support stock & domestic extractions. Irrigated agriculture utilises groundwater in the Namoi River Alluvium. Where suitable, the guideline water quality objectives for stock drinking water (beef cattle) and long-term irrigation are adopted. The selected trigger criteria applied for the selected monitoring bores are summarised in Table 6-4 and the trigger selection criteria explained and presented in detail in the latest revision of the Site WMP (not yet approved).

6.2.8 Groundwater level criteria

The groundwater level trigger values for each monitoring point are summarised in Table 6-5 and the detailed methodology and selected trigger criteria applied are presented in the latest revision of the Site WMP (not yet approved). Measured water levels at each monitoring location will be assessed annually against the derived water level trigger values.

6.2.9 Mayfield Spring

The monitoring of the Mayfield Spring will include an annual evaluation to observe any changes to surface conditions (e.g. vegetation), flow rates, water level and/or water quality (EC and pH). Four photographs will be taken at each site comprising upstream, downstream, at the left bank and at the right bank. The location, direction and date of each photograph taken will be recorded. The monitoring results will then be used to determine if there are any potential impacts occurring to the site as a result of mining operations.

If potential impacts are observed, NCOPL will engage a suitable qualified hydrogeologist to undertake further assessment.

7. Contingency response

In the event that a non-compliance against a performance measure and/or impact assessment criteria has occurred, or is likely to occur, NCOPL will:

1. Report the non-compliance as soon as practicable to the relevant agencies as required under the Project Approval and relevant legislation in accordance with section 8.
2. Identify and implement an appropriate course of action with respect to the non-compliance in consultation with a suitably qualified person/s and relevant agencies.
3. Review the effectiveness of the EP-WMP management measures in accordance with section 9.4.

In addition, a Trigger Action Response Plan (Table 7-1 and Table 7-2) has been developed to identify, assess and respond to triggers and to manage risks associated with meeting the water performance measures and/or impact assessment criteria.

Table 7-1 Trigger action response plan surface water

<table>
<tr><th>Method</th><th>Status</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td colspan="5">Water quality watercourse</td></tr>
<tr><td rowspan="2">To identify potential surface water quality impacts as a result of mining activities (e.g. via run off, subsidence cracking, ponding, erosion, changes in water course morphology).

Sites:
• KC1TOP, KC1US, KCTOP, KCUS.

Parameters:
• Field - EC, pH
• Laboratory - TSS, TOC

Frequency:
• Quarterly.
• During flow event (as practical).

Analysis:
• Comparison of water quality records during operations with the SSGVs for KCUS and KC1US.</td><td>Normal</td><td>The water quality trigger levels are not exceeded and performance measures met.</td><td>None required.</td><td>• Continue to implement surface water management measures in accordance with this Plan.
• Continue routine surface water monitoring and evaluation of results.</td></tr>
<tr><td>Level 1</td><td>• Less than pH 6.5 or greater than pH 8.0 for one monitoring event.
• EC, TSS and TOC exceeding Stage 1 trigger for one monitoring event.
<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Trigger</th><th colspan="4">Monitoring location</th></tr>
<tr><th>KCUS</th><th>KC1US</th><th>KCTOP</th><th>KC1TOP</th></tr>
<tr><td>EC (µs/cm)</td><td>Stage 1</td><td>721</td><td>210</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td></tr>
<tr><td>Total suspended solids (mg/L)</td><td>Stage 1</td><td>708</td><td>653</td></tr>
<tr><td>Total organic carbon (TOC)</td><td>Stage 1</td><td>15</td><td>16</td></tr>
</table></td><td>Conduct preliminary quality assurance of data to confirm an exceedance.</td><td>For a single exceedance, the exceedance will be recorded, with no further contingency or notification measures required. If pH or a Stage 1 trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented.</td></tr>
</table>

<table>
<tr><th>Method</th><th>Status</th><th>Trigger</th><th>Action</th><th>Response</th></tr>
<tr><td></td><td>Level 2</td><td>

Less than pH 6.5 or greater than pH 8.0 for three consecutive monitoring events.
EC, TSS and TOC exceeding Stage 1 trigger for the same parameter exceeded at the same location for three consecutive monitoring events.
EC, TSS and TOC exceeding Stage 2 trigger for one monitoring event.

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2">Trigger</th><th colspan="4">Monitoring location</th></tr>
<tr><th>KCUS</th><th>KCIUS</th><th>KCTOP</th><th>KC1TOP</th></tr>
<tr><td rowspan="2">EC (µs/cm)</td><td>Stage 1</td><td>721</td><td>350</td><td rowspan="6">N/A</td><td rowspan="6">N/A</td></tr>
<tr><td>Stage 2</td><td>847</td><td>220</td></tr>
<tr><td rowspan="2">Total suspended solids (mg/L)</td><td>Stage 1</td><td>708</td><td>653</td></tr>
<tr><td>Stage 2</td><td>860</td><td>1,018</td></tr>
<tr><td rowspan="2">Total organic carbon (TOC)</td><td>Stage 1</td><td>15</td><td>16</td></tr>
<tr><td>Stage 2</td><td>17</td><td>17</td></tr>
</table>
</td><td>

Conduct preliminary quality assurance of data to confirm an exceedance.
Environmental Superintendent to implement contingency and notification measures as per section 8.

</td><td>

Hydrologist (or similar specialist) to review sampling and climate data and compare to upstream value to confirm likely mining impact or otherwise. If mine related, undertake physical inspection of affected surface and creeks to identify potential source of water quality degradation.
Implement appropriate management or contingency response (i.e. repair of subsidence cracking, remediation of ponding, erosion control works and rehabilitation).

</td></tr>
<tr><td colspan="5">Vegetation health (ponding)</td></tr>
<tr><td>To ensure that surface water ponding does not result in adverse impacts to vegetation health.

Sites:
P13-P16 and other ponded areas identified above LW203-206, as necessary (identified through visual inspection and survey, see ‘Changes to Watercourse Morphology’ TARP).
Parameters:
Ponding - GPS location, width, depth, area, significant vegetation.
Vegetation monitoring in accordance with the Extraction Plan - Biodiversity Management Plan.
Frequency:
As per ‘Changes to Watercourse Morphology’ TARP
Annual multi-spectral imaging.</td><td>Normal</td><td>No adverse impacts on vegetation observed.</td><td>None required.</td><td>Continue to implement surface water management measures in accordance with this Plan.
Continue routine surface water ponding monitoring and evaluation of results.</td></tr>
<tr><td></td><td>Level 1</td><td>Adverse impacts on vegetation identified.</td><td>Record visual observations, including photographs.</td><td>Investigate options to dewater the ponded area to limit further impacts on vegetation health and implement identified adaptive management measures.</td></tr>
</table>

Method	Status	Trigger	Action	Response
• LiDAR survey every three years. • Vegetation monitoring in accordance with the Extraction Plan - Biodiversity Management Plan. **Analysis**: • Assessment of changes in topography and associated potential ponding. • Vegetation health assessment in accordance with the Extraction Plan - Biodiversity Management Plan.	**Level 2**	Significant impacts to vegetation identified (e.g. canopy dieback, tree death).	Record visual observations, including photographs.	• If vegetation will be at risk, undertake a geomorphological assessment to determine options to have the subsidence ponded area freely drain. • Undertake survey to identify vegetation community and impacted area. The disturbance will be recorded in the site clearing register.
Changes in watercourse morphology				
To identify subsidence effects to the morphology of creeks. This may occur in the channel and/or floodplain. **Sites:** • Reaches of Kurrajong Creek Tributary 1 and Kurrajong Creek which traverse the Extraction Plan Area. **Parameters:** • Channel width, depth, area and bank full level. • Erosion and sediment deposition. • Extent of ponding. **Frequency:** • During active subsidence (within the active subsidence zone) - monthly and following a significant rainfall event (defined as a 5-day 90th percentile rainfall event, equal to 38.4 mm over 5 consecutive days). • Creek line - baseline and quarterly for a period of two years during mining. • Geomorphology and channel survey – baseline and annually for two years. • Field survey if changes detected following remote sensing. **Analysis:** • Comparison of baseline, during mining and post-mining conditions.	**Normal**	No identified impacts on water course morphology.	None required.	• Continue to implement surface water management measures in accordance with this Plan. • Continue routine creek line monitoring program and evaluation of results.
	Level 1	Identified changes in channel cross-section, bed erosion, incision and deposition identified.	Record observations, including photographs.	• Contract a qualified geomorphologist to develop an action plan which may involve further monitoring or remediation (with consideration given to application of the River Style Framework for classifying channel condition and recovery). • Implement geomorphology action plan. • Implement contingency measures and notify relevant stakeholders.
	Level 2	Further monitoring identifies remediation works are not performing (i.e. ineffective control measure).	Record observations, including photographs.	• As for Level 1 • If implemented erosion control measures are found to be ineffective, identify cause and rectify or replace with effective measures. Continue monitoring.

Table 7-2 Trigger action response plan groundwater

Method	Status	Trigger	Action	Response
Groundwater levels (non Pilliga Sandstone bores)				
To provide baseline water level data and to identify water level impacts in comparison to predicted drawdown considering natural variations. To verify that impacts on aquifers are consistent with model predictions. **Sites:** • P8, P9, P10 and P11. **Parameters:** • Water level. **Frequency:** • Quarterly manual monitoring of groundwater levels and automatic groundwater level monitoring via VWPs (downloaded quarterly).	**Normal**	Routine monitoring indicates water level below trigger levels.	None required	Continue routine groundwater monitoring and evaluation of results.
	Level 1	One exceedance above a Stage 1 trigger (Table 6-5).	Conduct preliminary quality assurance of data to confirm an exceedance.	The exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented.
	Level 2	Three consecutive exceedances above a Stage 1 trigger OR one exceedance above a Stage 2 trigger (Table 6-5).	• Conduct preliminary quality assurance of data to confirm an exceedance. • Environmental Superintendent to implement contingency and notification measures as per section 8.	• Engage hydrogeologist to undertake assessment and report on any identified changes/likely causes and recommendations. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.
Groundwater levels (Pilliga Sandstone bores only)				

Method	Status	Trigger	Action	Response
To provide baseline water level data and to identify water level impacts in comparison to predicted drawdown considering natural variations. To verify that impacts on aquifers are consistent with model predictions. **Sites:** • P7 **Parameters:** • Water level. **Frequency:** • Quarterly manual monitoring of groundwater levels and automatic groundwater level monitoring via VWPs (downloaded quarterly).	**Normal**	Routine monitoring indicates water level below trigger levels.	• None required	• Continue routine groundwater monitoring and evaluation of results.
	Level 1	Stage 1 (>5m below baseline level) (Table 6-5)	• Conduct preliminary quality assurance of data to confirm an exceedance. • Environmental Superintendent to implement contingency and notification measures as per section 8.	• Engage hydrogeologist to undertake assessment and report on any identified changes/likely causes and recommendations. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations. Recommendations should be clear and detailed mitigation actions should consider: ▪ review and calibration of numerical model and update predictions; ▪ review allocated licensed units; ▪ consider adjusting mine plan (i.e. reduce mining heights to that originally approved for Stage 2). This would reduce the vertical fracturing and extent of depressurisation into the Pilliga Sandstone; ▪ report in Annual Review; and ▪ review and if necessary revise the EP-WMP.

Method	Status	Trigger	Action	Response
	Level 2	Stage 2 (>10 m below baseline level) (Table 6-5)*	• Conduct preliminary quality assurance of data to confirm an exceedance. • Determine if an incident has occurred. • Environmental Superintendent to implement contingency and notification measures as per section 8.	• The decline beyond the Level 1 trigger will be assessed by a hydrogeologist as soon as it is confirmed that the trend continues beyond the Level 1 trigger. The investigation will confirm if the bore trigger is isolated or of regional scale west of the mine panels as a result of mining. • Assess risk of environmental harm, take all preventative measures to prevent or minimise environmental harm. • Submit a detailed report to the relevant Government agencies within seven days. • Priority actions will include groundwater isolation contingency plans or modification of mining operations based on the risk to the environment and likelihood of a repeat incident. • Monitor the implementation of actions to ensure they have been effective. • Review and if necessary revise the EP-WMP.
Groundwater quality				
To assess performance of water management infrastructure. **Sites:** • P7, P8, P9, P10 and P11. **Parameters:** • EC and pH **Frequency:** • Quarterly	**Normal**	Routine monitoring indicates water quality below the EC or pH trigger value (Table 6-4).	No action	Continue routine groundwater monitoring and evaluation of results.
	Level 1	Routine monitoring indicates water quality exceeds the EC or pH trigger value (single exceedance) (Table 6-4).	Conduct preliminary quality assurance of data to confirm an exceedance.	For a single exceedance, the exceedance will be recorded, with no further contingency or notification measures required. If a water level trigger is exceeded at the same location for three consecutive sampling events, then the actions required for Level 2 will be implemented.

Method	Status	Trigger	Action	Response
	Level 2	Routine monitoring indicates water quality exceeds the EC or pH trigger value over three consecutive monitoring events (Table 6-4).	• Conduct preliminary quality assurance of data to confirm an exceedance. • Environmental Superintendent to implement contingency and notification measures as per section 8.	• Engage hydrogeologist to undertake assessment and report on any identified changes/likely causes and recommendations. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations.

Note: * Level 2 at >10m drawdown in the Pilliga Sandstone would account for the fact that drawdown will be 10 m greater than what has been predicted in the Stage 2 Mod 5 approval.

8. Incidents and non-compliance

8.1 Incident notification

An incident is defined under the Project Approval as *a set of circumstances that causes or threatens to cause material harm, and/or breaches or exceeds the limits of performance measures/criteria*. Material harm to the environment is defined under the Project Approval as *involving actual or potential harm to the health or safety of human beings or to the environment that is not trivial.* This definition excludes "harm" that is authorised under the Project Approval or any other statutory approval (e.g., the Environmental Protection License [**EPL**]).

In the event of any exceedance of the performance criteria, NCOPL will advise the Secretary and any other relevant agencies as soon as practicable after becoming aware of the incident, in accordance with Schedule 6 Condition 4. Within 7 days of the event, NCOPL will also provide the Secretary and any relevant agencies a detailed report which will:

- describe the date, time and nature of the exceedance/incident;
- identify the cause (or likely cause) of the exceedance/incident;
- describe what action has been taken to date; and
- describe the proposed measures to address the exceedance/incident.

Notifications to the EPA will be made by contacting the Environment Line on 131 555 and written details of the notification will be provided within 7 days of the date on which the incident occurred.

Incident reporting and emergency response is further described in NCOPLs Environmental Management Strategy.

8.2 Non-compliance notification

In accordance with Schedule 6 Condition 2, where a non-compliance with a statutory requirement/s or an exceedance of the relevant criteria or performance measures has occurred, NCOPL will, at the earliest opportunity, take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur. Once this has been achieved, all reasonable and feasible options for remediation (where relevant) will be considered.

In accordance with Schedule 6 Condition 4, within seven days of becoming aware of a non-compliance, NCOPL will notify DPE of the non-compliance[9]. The notification will be made in writing via the Major Projects website and identify the development (including the development application number and name), set out the condition or requirement that the development is non-compliant with, why it does not comply and the reasons for the non-compliance (if known) and what actions have been, or will be, undertaken to address the non-compliance.

NCOPL will implement any reasonable remediation measures as directed by the Secretary, to the satisfaction of the Secretary.

[9] A non-compliance which has been notified as an incident under section 8.1 does not need to also be notified as a non-compliance under section 8.2.

9. Reporting, evaluation and review

9.1 Data quality assurance plan

9.1.1 Data collection

The following data quality assurance/quality control (**QA/QC**) procedures will be followed during groundwater level, groundwater quality, and mine inflow data collection.

Groundwater level monitoring

- The primary instrumentation that requires QA/QC checks include steel tapes and electric tapes used to measure groundwater levels. These are to be checked for any defaults before every monitoring event. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks, and possible stretch.
- The electric tape is to be recalibrated annually (or more frequently if it is used often) or if the tape has been subjected to abnormal stress that may have caused it to stretch. Cunningham and Schalk (2011) provides more guidance on the use of electrical measuring tapes.
- Pressure transducers used to monitor water levels will be assessed by QA/QC procedures as specified by the vendor and as described in Cunningham and Schalk (2011). Additionally, calibration and maintenance information of specific brands of pressure transducers are provided by the manufacturers and will be consulted.
- The procedure to identify any anomalies and/or outliers is to be followed to validate and justify abnormal data entries. Continuous decline in levels is to be validated against potential default equipment, changes in monitoring bore construction due to subsidence, changes in levels due to climate, changes in level due to mining and changes in level due to agricultural use. Groundwater level hydrographs will be developed for each monitoring point to identify any outliers in the data collected. If such outliers are identified in the monitoring data, these will be highlighted appropriately and excluded from comparisons with trigger elevations.
- The methods for analysis of groundwater level data are summarised in Figure 9-1. The flowchart outlines the pre-processing steps, including QA/QC undertaken for groundwater level data analysis.
- As indicated in Figure 9-1, manual standing water levels and electronic pressure logger/VWP data will be converted to a reduced water level with respect to Australian Height Datum (**m AHD**). Pressure logger data will be adjusted to remove the effects of barometric pressure changes where required.

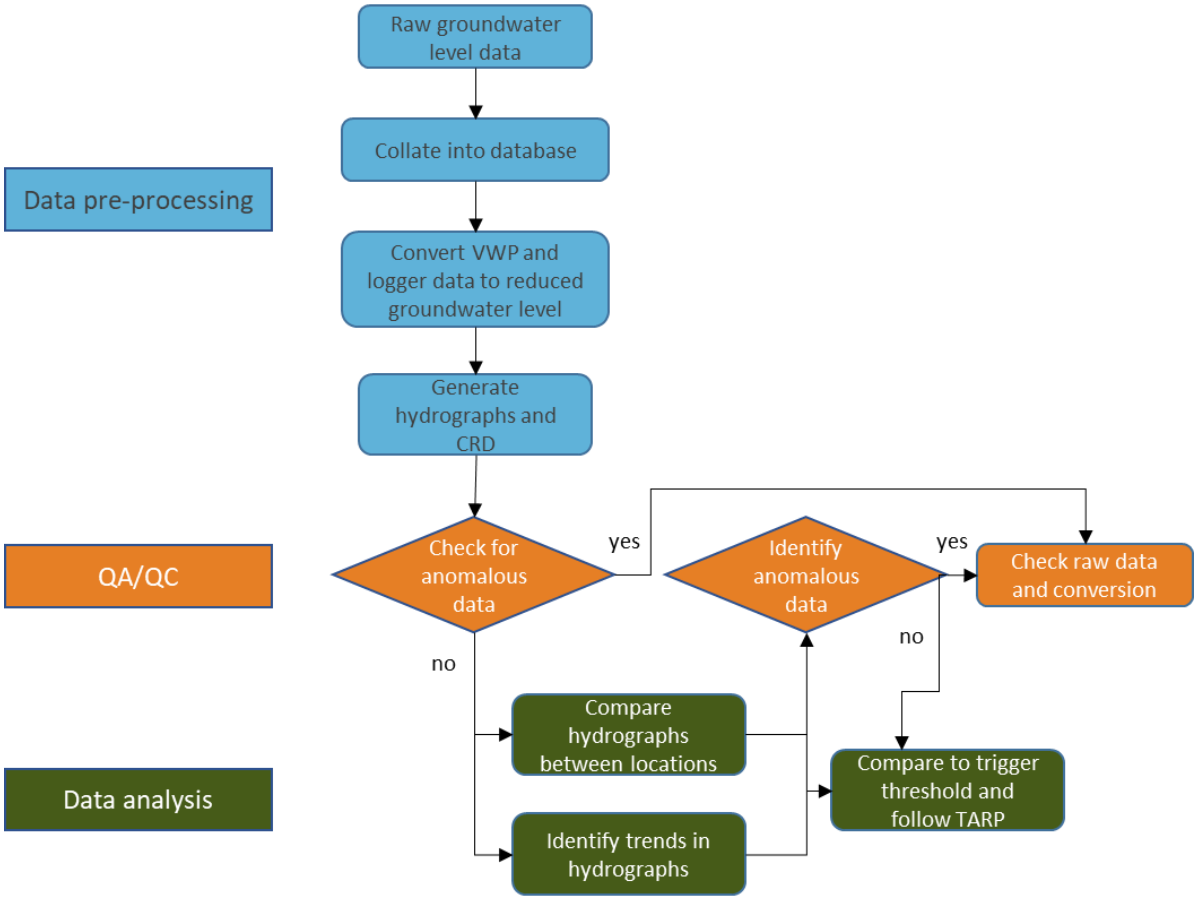


Figure 9-1 Groundwater level data pre-processing and analysis flowchart

Groundwater quality monitoring

Field:

The following field sampling QA/QC procedures will be applied in order to prevent cross-contamination and preserve sample integrity:

- samples are to be collected in clearly labelled bottles with appropriate preservation solutions;
- samples are to be delivered to the laboratories within the specified holding times; and
- pH and EC/TDS (salinity are also measured in the field with calibrated field measurement equipment and then compared against laboratory data).

In addition, a duplicate sample is collected in the field to assess sampling and laboratory analysis accuracy.

Laboratory:

The laboratories conduct their own internal QA/QC program to assess the repeatability of the analytical procedures and instrument accuracy. These programs include analysis of laboratory sample duplicates, spike samples, certified reference standards, surrogate standards/spikes, and laboratory blanks.

Data:

The selected groundwater monitoring bores will have water samples collected for water quality analysis and field pH and EC measurements. The methodology for analysis of groundwater quality data is summarised in Figure 9-2. Similar to the water level flowchart (Figure 9-1), this flowchart outlines the pre-processing, including QA/QC, as well as the steps that will be undertaken for groundwater quality data analysis.

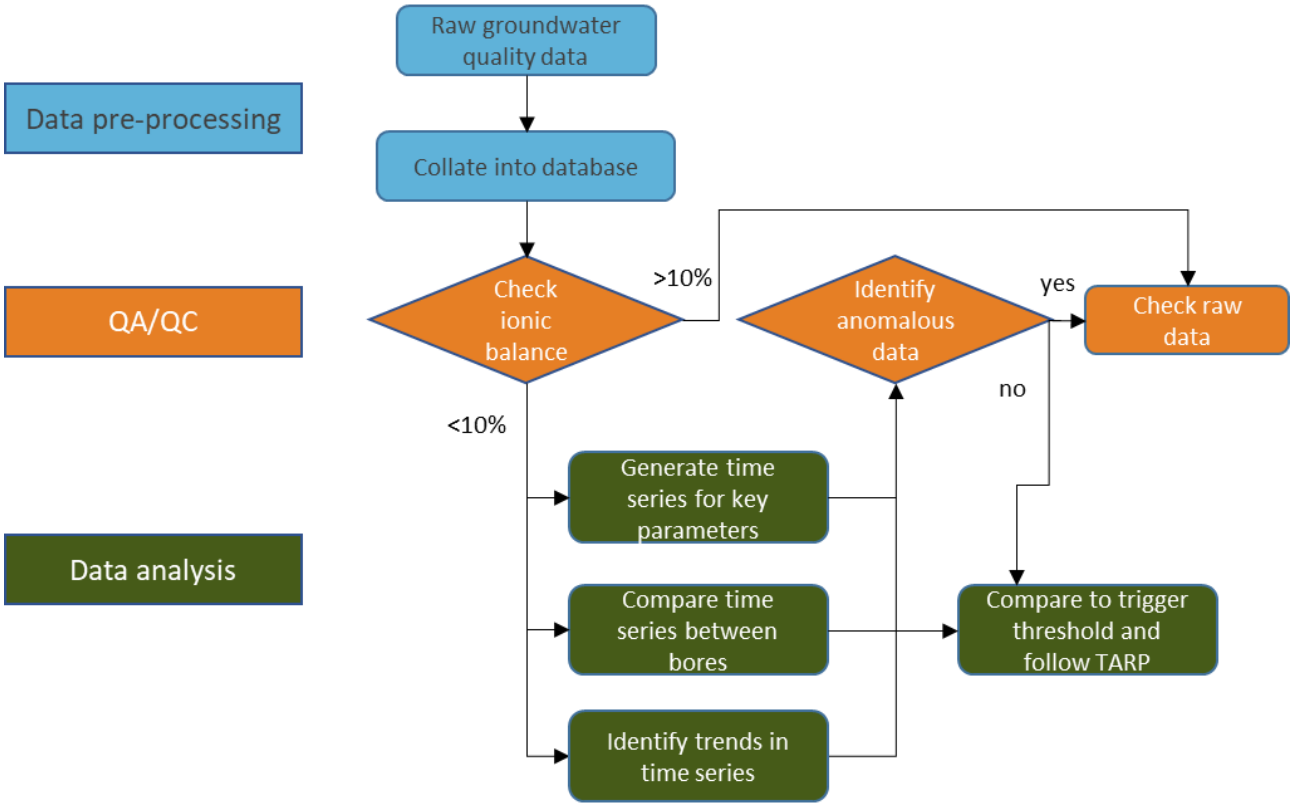


Figure 9-2 Groundwater quality data pre-processing and analysis procedures

9.1.2 Data analysis

All data on groundwater levels, groundwater quality, and data quality control is to be provided in a csv format to accompany the release of Annual Reviews.

9.2 Further development of the groundwater model

The numerical model developed for the Stage 3 EIS (AGE, 2020a) will be used as a management tool for the periodic review and validation of predicted groundwater impacts through the life of mine. NCOPL will update the model every five years in consultation with DPE Water and to the satisfaction of the Secretary.

NCOPL has implemented a comprehensive monitoring program to investigate the subsidence impacts as they develop over the Extraction Plan Area as presented in section 6.2.3. Where monitored seasonal groundwater levels (pressure) vary significantly from baseline levels and modelled levels in the environmental assessment,

the groundwater model will be used to determine the likely source of the discrepancy and to what extent the secondary workings within the Extraction Plan Area is influencing groundwater levels.

The groundwater level and quality information collected, together with the mine water inflows and outflows, will show changes in surface or groundwater flow entering the mine for comparison to and updating of the groundwater model. Hydrogeological data is reviewed continuously as and when field data is obtained and included in the annual monitoring report.

DGS (2022) recommended that the groundwater response to mining above mined LW 109 to LW 111 continue to be periodically reviewed to confirm the assessed fracture zones for LW 203 to LW 206 are still reasonable. Mining of panel LW109 started in January 2020 and completed in November 2021 and LW 110 started in December 2021 and currently in progress.

The NCOPL numerical groundwater model is currently in a recalibration stage (November 2022 to February 2023).

9.3 Annual hydrogeologist review

As part of the annual monitoring program, NCOPL will commission an experienced hydrogeologist to collate and review the monitoring data collected. The hydrogeologist will provide the findings in an Annual Hydrogeologists Report, including a summary of the mine's environmental performance over the preceding year in relation to groundwater inflows, groundwater levels (including early warning of groundwater level impact) and groundwater quality, and compare observed groundwater quality and groundwater levels to the trigger values presented in section 6.2.7 and 6.2.8.

The review will also include:

- compare any observed impacts with those predicted in the groundwater modelling and, if significant variation is found between predicted impacts and observed operational monitoring data, then notification of proposed remediation will be submitted to DPE Water;
- revise trigger levels as additional monitoring information becomes available and, if required, the GWMP will be updated to reflect any changes to site-specific trigger levels listed in section 6.2;
- identify relationships between measured EC and TDS in mine water and groundwater in the Hoskissons Seam and adjoining aquifers from the collection of adequate samples over time and evaluating this data for comparison (i.e. trends);
- implement procedures from ANZG (2018) to establish, update and report on site-specific baseline status, variability and the early detection of state trends and change against trigger values for each water-quality objective using control charts and with uncertainty estimated from quality control measures;
- a comparison to climate trends and surface water monitoring results to identify changes in the surface water and groundwater interactions (e.g. comparison of groundwater levels to rainfall and estimated recharge); and
- establish and assess the ongoing suitability of appropriate factors for converting EC to TDS for each sampling site with consideration of the influence of major ionic composition.

If required, the review will also make use of the Santos Gas Project Pilliga Sandstone monitoring data if the newly proposed P82 and the existing P7 monitoring bores exceed the trigger value/s. Detailed investigations

will then be conducted as required. It is assumed that the Santos data will be readily available from their website.

9.4 Annual Review

In accordance with Schedule 6 Condition 6, NCOPL will review the performance of its environmental management for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Secretary. The Annual Review will at minimum provide information regarding the effectiveness of the management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact on water.

Further, the Annual Review requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

NCOPL will include maps, hydrographs, and/or other visual tools within the Annual Review to present the groundwater monitoring results with reference to the NSW Government *Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical guideline.* (DPE, 2022). The results will display both recent and historical datasets (including baseline). In addition, all data on groundwater levels, quality, and data quality control will be provided separately to DPE Water in csv format to accompany the Annual Review.

The Annual Review may also make recommendations for any additions, changes, or improvements to NCOPLs environmental management procedures.

The Annual Review will be made available on the WHC website.

9.5 Independent environmental audits

Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, NCOPL will commission and pay the full cost of an Independent Environmental Audit (**IEA**) of the development (Stages 1 and 2), to be conducted in accordance with the requirements of Schedule 6 Condition 7.

The audit team will be led by a suitably qualified auditor and the IEA will be conducted by suitably qualified, experienced and independent team of experts whose appointment has been endorsed by the Secretary.

9.6 Management plan review and evaluation

As required by Schedule 6 Condition 3 of the Project Approval, within three months of any of the following:

- completion of an IEA (as required by Schedule 6 Condition 7);
- submission of an Incident Report (as required by Schedule 6 Condition 4);
- submission of an Annual Review (as required by Schedule 6 Condition 6); and

- any modification to the conditions of the Project Approval (unless the conditions require otherwise).

NCOPL will then review, and if necessary, revise this EP-WMP. This is to ensure that the strategies, plans and programs are updated on a regular basis, and incorporate any recommended measures to improve the environmental performance of the Narrabri Mine operations.

Condition 3 of Schedule 6 further states that if the review determines that this EP-WMP requires revision, then this will be completed to the satisfaction of the Secretary. A dedicated review register will be maintained which will provide the details of the review of all relevant strategies, plans and programs that need to be reviewed as required by Schedule 6 Condition 3 of the Project Approval. The revision status of this EP-WMP is indicated in section 14.

9.7 Improvement measures

Project Approval Schedule 6 Condition 2(f) requires this Plan to include a program to investigate and implement ways to improve the environmental performance of the development over time. Improvement measures may be investigated through review of the following:

- monitoring data, and any assessment of trends;
- audit outcomes, including audits of water management measures; and
- incident reports, including any community complaints.

Reasonable and feasible improvement measures will be implemented and documented as a management measure in a revision to the Plan as described in section 9.6.

In accordance with Schedule 6 Condition 2(g) a protocol for periodic review of this Plan has been addressed under section 9.6.

10. Complaints management

Any complaints received in relation to water will be managed in accordance with the complaints management protocol as follows:

- Publicly advertised telephone complaints line, 1800WHAVEN, will be in place to receive complaints.
- Each complaint received will be recorded in a Complaints Register, which will include the following details:
  - date and time of complaint;
  - method by which a complaint was made;
  - personal details the complainant wishes to provide or, if no such details are provided, a note to that effect;
  - nature of the incident that led to the complaint;
  - action taken by NCOPL in relation to the complaint (i.e., any required remedial actions), including any follow-up contact with the complainant; and
  - if no action was taken, the reason why no action was taken.
- The Environmental Superintendent will be responsible for ensuring that an initial response is provided within 24 hours of receipt of a complaint (except in the event of complaints recorded when the mine is not operational or outside of usual business hours).
- Once the identified measures are undertaken, the Environmental Superintendent will sign off on the relevant complaint within the Complaints Register.
- If necessary, follow-up monitoring will take place to confirm the source of the complaint is adequately mitigated.
- A summary of the complaints will be maintained by NCOPL and made available to the Community Consultative Committee, the complainant (on request) and on the WHC website. A summary of complaints received every 12 months will be provided in the Annual Review.

In the event that any complainant considers that NCOPL has not adequately addressed their concerns, the NCOPL representative will convene additional meetings with the complainant.

11. Plan implementation

11.1 Roles and responsibilities

During the operational phases of the development, the Narrabri Mine will be managed by the General Manager who will have overall responsibility for ensuring contractors, employees and service providers comply with all laws, regulations, licences, and approvals. Table 11-1 outlines the roles and responsibilities applicable to this EP-WMP.

Table 11-1 Roles and responsibilities

Roles	Responsibilities
General Manager	• Ensure that adequate resources are available to NCOPL personnel to facilitate the completion of their responsibilities under this EP-WMP.
Mine Manager	• Ensure all contractors, sub-contractors and service-personnel are appropriately qualified, competent, and licensed to undertake the required work under this EP-WMP and have a good environmental performance record. • Ensure the subsidence monitoring program is implemented and adhered to.
Environmental Superintendent	• Ensure that all environmental monitoring and reporting is undertaken in accordance with this EP-WMP and various approval requirements, and is checked, processed, and filed appropriately. • Communicate with statutory agencies and departments, public authorities and the community. • Advise on matters identified in all approval, permit, licence, and consent documents and ensure all operations are conducted in compliance with those conditions, and all other environmental obligations. • Liaise with stakeholders regarding subsidence impact management. • Authorise changes to this EP-WMP.
Surface Operations Manager	• Provides notification to all mine personnel advising of potential subsidence hazards and impacts.
Civil Services Coordinator	• Manages the condition and safety of roads and tracks around the mine site. • Remediates subsidence impacts to maintain trafficability of access roads and tracks. • Maintains access to critical infrastructure and facilitates inspections and remedial works. • Designs and installs PED cables (personal emergency device communications system).
Technical Services Manager	• Decommissions Surface to in-seam (SIS) drainage sites and structures prior to subsidence impacts.
Registered Mine Surveyor	• Ensure that all subsidence monitoring is carried out in accordance with the Subsidence Monitoring Program to the accuracy required, within the specified timeframes and are checked, processed and filed appropriately.

12. References

Australasian Groundwater and Environmental Consultants Pty Ltd (2020a). *Groundwater Assessment Narrabri Mine Stage 3 Extension Project.* Prepared for Narrabri Coal Operations Pty Ltd.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE 2020b) Narrabri Coal Operations *Groundwater Model Calibration Report – document G1972E*.

ANZECC & ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

ANZG (2018). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines.

Department of Planning and Environment (October 2022). *Extraction Plan Guideline.*

Ditton Geotechnical Services (2022). *Mine Subsidence Assessment for Longwalls LW203 to LW206 at the Narrabri Underground Mine.* Prepared for Narrabri Coal Operations Pty Ltd.

EPA (2022). *Approved Methods for the Sampling and Analysis of Water Pollutants in NSW*. Prepared by the NSW Environment Protection Authority (EPA), January.

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NSW Department of Planning and Environment (January 2022). *Guidelines for Groundwater Documentation for SSD/SSI Projects. Technical guideline*.

NSW Department of Planning, Industry and Environment (November 2021). *Project Approval Narrabri Coal Project – Stage 2*

NSW Government (2006). *NSW Water Quality and River Flow Objectives – Namoi River*. Available at https://www.environment.nsw.gov.au/ieo/Namoi/index.htm.

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Strahler, A.N. (1952). "Dynamic Basis of Geomorphology", *Bulletin of the Geological Society of America*, no. 63, pp. 923–938.

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Whitehaven Coal Narrabri Coal Operations Pty Ltd (21 July 2021). *Narrabri Underground Mine Stage 3 Extension Project – IESC and DPIE-Water Responses and Groundwater Monitoring Clarifications*.

Whitehaven (2022). *Narrabri Mine Extraction Plan Water Management Plan Panels 201 – 202*.

13. Glossary

Term	Definition
Active subsidence	The period of time that movement of the ground can occur after underground mining.
Angle of Draw (AoD)	The angle with the vertical, made by a straight line extending away from the limits of extraction at seam level to the ground surface, spanning the horizontal distance in which subsidence may occur.
Chain pillar	The pillar(s) of coal left between adjacent longwall panels. This forms a barrier that allows the goaf to be sealed off and facilitates tailgate roof stability.
Compressive strain	A decrease in the distance between two points on the surface. This can cause shear cracking or steps at the surface if > 3 millimetres per metre (mm/m).
Cover depth	The depth of coal seam from the ground surface (metres).
Department	Planning and Assessment Group within the NSW Department of Planning and Environment (DPE).
Development	The Stage 2 development described in the EA as modified by the Project Approval.
Environmental consequences	The environmental consequences of subsidence impacts including: damage to built features; loss of surface flows to the subsurface; loss of standing pools; adverse water quality impacts; development of iron bacterial mats; cliff falls; rock falls; damage to Aboriginal heritage sites; impacts to aquatic ecology; ponding.
Extraction Plan Area	The area predicted to be affected by the proposed secondary extraction of the approved longwall panels LW 203 to LW 206.
First workings	Development of the main headings and gate roads to establish access to the coal in the mining area.
Goaf	The mined-out area into which the immediate roof strata breaks.
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Incident	A set of circumstances that causes or threatens to cause material harm to the environment, and/or breaches or exceeds the limits of performance measures/criteria in the Project Approval.
Material harm	Material harm to the environment is defined in section 147 of the POEO Act.
Mining Operations	The extraction, processing, and transportation of coal on the site, including the formation of mine access drifts and associated surface infrastructure such as gas and water drainage facilities.
MOD 5	Reduced the number of longwall panels from 26 to 20; increased the longwall panel widths for LW 107 to LW 120 from approximately 295 m to approximately 400 m; extended the western footprint approximately 60 m; and increased the maximum ROM coal processing rate from 8 Mtpa to 11 Mtpa.
MOD 7	Describes the change in mining method within the extent of the previously approved LW 201 and LW 202 and allows for up to 0.7 Mtpa via bord and pillar extraction at pillar reduction panels CF 201 to CF 205.
Narrabri Mine	The development approved under Project Approval 05_0102 and Project Approval 08_0144.
Pollution incident	Has the same meaning as in the POEO Act.
Project Approval	Development consent (PA 08_0144) issued on 26th July 2010 under Section 75J of *the Environmental Planning and Assessment Act 1979* by the Department of Planning & Infrastructure (as modified).
Raffinate	Treated process water from the Water Conditioning Plant.

Term	Definition
Rehabilitation	The treatment or management of land disturbed by the project for the purpose of establishing a safe, stable and non-polluting environment including the remediation of impacts.
Remediation	Activities associated with partially or fully repairing or rehabilitating the impacts of the project or controlling the environmental consequences of this impact.
Second workings	Extraction of coal from longwall panels, mini-wall panels, or pillar extraction.
Secretary	Planning Secretary under the EP&A Act, or nominee
Stage 1	The project approval granted by the Minister Planning for the Narrabri Coal Project, dated 14 November 2007.
Stage 2	Narrabri Mine Stage 2 approved under Project Approval 08_0144.
Statement of Commitments	The Proponent's revised commitments in Appendix 3 of the Project Approval, dated May 2010.
Subsidence	The totality of subsidence effects, subsidence impacts and environmental consequences of subsidence impacts.
Subsidence effects	Deformation of the ground mass due to mining, including all mining-induced ground movements, such as vertical and horizontal displacement, tilt, strain and curvature.
Subsidence impacts	Physical changes to the ground and its surface caused by subsidence effects, including tensile and shear cracking of the rock mass, localised buckling of strata caused by valley closure and upsidence and surface depressions or troughs.
Tailgate	Refers to the tunnels or roadways down the side of a longwall block which provides a ventilation pathway for bad or dusty air away from the longwall face. It is usually located on the side of the longwall panel adjacent to extracted panels or goaf.
Tensile strain	An increase in the distance between two points on the surface. This is likely to cause cracking at the surface if it exceeds 2 mm/m. Tensile strains are usually associated with convex (hogging) curvatures near the sides (or ends) of the panels.
the Proponent	Narrabri Coal Operations Pty Ltd
Tilt	The rate of change of subsidence between two points (A and B), measured at set distances apart (usually 10m). Tilt is plotted at the mid-point between the points and is a measure of the amount of differential subsidence.
Upsidence	Relative vertical upward movements of the ground surface associated with subsidence.
Vertical subsidence	Vertical downward movements of the ground surface caused by underground coal mining.
Watercourse	A river, creek or other stream, including a stream in the form of an anabranch or tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events: In a natural channel, whether artificially modified or not, or in an artificial channel that has changed the course of the stream. It also includes weirs, lakes and dams.

14. Review history

Revision	Comments	Author	Authorised by	Date

Attachment 1 Compliance conditions relevant to this Plan

Table A1-1 Project Approval conditions relevant to this Plan

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 2 Condition 1	The Proponent shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the project.	Section 5
Schedule 2 Condition 11	With the approval of the Secretary, the Proponent may submit any management plan or monitoring program required by this approval on a progressive basis. ***Note**: The conditions of this approval require certain strategies, plans, and programs to be prepared for the project. They also require these documents to be reviewed and audited on a regular basis to ensure they remain effective. However, in some instances, it will not be necessary or practicable to prepare these documents for the whole project at any one time, particularly as these documents are intended to be dynamic and improved over time. Consequently, the documents may be prepared and implemented on a progressive basis, subject to the conditions of this approval. In doing this however, the Proponent will need to demonstrate that it has suitable documents in place to manage the existing operations of the project.*	There is no staging of the EP-WMP
Schedule 3, Condition 4 (h)	The Proponent shall prepare and implement Extraction Plans for any second workings to be mined to the satisfaction of the Secretary. Each Extraction Plan must: include a: • Water Management Plan, which has been prepared in consultation with EPA and DPE Water, which provides for the management of the potential impacts and/or environmental consequences of the proposed second workings on surface water resources, groundwater resources and flooding, and which includes:	Section 1.4.2 Section 1.6
	▪ surface and groundwater impact assessment criteria, including trigger levels for investigating any potentially adverse impacts on water resources or water quality;	Section 6.1.2 Section 6.2.7 Section 6.2.8
	▪ a program to monitor and report groundwater inflows to underground workings; and	Section 6.2.4
	▪ a program to manage and monitor impacts on groundwater bores on privately-owned land;	Section 6.2.6
	***Notes**:* *Management plans prepared under condition 4(h) should address all potential impacts of proposed underground coal extraction on the relevant features. Other similar management plans required under this approval (eg under conditions 13 and 23 of schedule 4 or condition 3 of schedule 5) are not required to duplicate these plans or to otherwise address the impacts associated with underground coal extraction.*	
Schedule 3 Condition 5	The Proponent shall ensure that the management plans required under condition 4(h) above include:	

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
	(a) an assessment of the potential environmental consequences of the Extraction Plan, incorporating any relevant information that has been obtained since this approval;	Section 3
	(b) a detailed description of the measures that would be implemented to remediate predicted impacts; and	Section 5
	(c) a contingency plan that expressly provides for adaptive management.	Section 7
Schedule 6, Condition 2	The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include:	
	(d) detailed baseline data;	Section 2
	(e) a description of:	
	• the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 1.4
	• any relevant limits or performance measures/criteria;	Section 4 Section 6.1.2 Section 6.2.7 Section 6.2.8
	• the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures	Section 4
	(f) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria:	Section 5 Section 6
	(g) a program to monitor and report on the:	
	• impacts and environmental performance of the project;	Section 6
	• effectiveness of any management measures (see (c) above);	
	(h) a contingency plan to manage any unpredicted impacts and their consequences;	Section 7
	(i) a program to investigate and implement ways to improve the environmental performance of the project over time;	Section 9.7
	(j) a protocol for managing and reporting any;	
	• incidents;	Section 8.1
	• complaints;	Section 10
	• non-compliances with statutory requirements; and	Section 8.2
	• exceedances of the impact assessment criteria and/or performance criteria; and	
	(k) a protocol for periodic review of the plan.	Section 9.6

Project Approval 08_0144 conditions		Document reference
Condition	**Requirement**	
Schedule 6 Condition 3	Within 3 months of the submission of an:	Section 9.6
	(a) audit under condition 7 of Schedule 6;	
	(b) incident report under condition 4 of Schedule 6; and	
	(c) annual review under condition 5 of Schedule 6; and	
	(d) any modification to the conditions of this approval (unless the conditions require otherwise),	
	the Proponent shall review, and if necessary revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.	
Schedule 6 Condition 4	The Proponent shall notify the Secretary in writing via the Major Projects website and any other relevant agencies of any incident associated with the project as soon as practicable after the Proponent becomes aware of the incident. Within 7 days of the date of the incident, the Proponent shall provide the Secretary and any relevant agencies with a detailed report on the incident.	Section 8
Schedule 6 Condition 5	The Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this approval, and to the satisfaction of the Secretary.	Section 1.7 Section 9.4
Schedule 6 Condition 6	By the end of March each year, the Proponent must submit a review of the environmental performance of the project for the previous calendar year to the satisfaction of the Secretary.	Section 9.4
Schedule 6 Condition 7	Prior to 13 September 2010, and every 3 years thereafter, unless the Secretary directs otherwise, the Proponent shall commission and pay the full cost of an Independent Environmental Audit of the project (Stages 1 and 2).	Section 9.5
Schedule 6 Condition 10	The Proponent shall: (a) make copies of the following publicly available on its website: • the documents referred to in Condition 2 of Schedule 2; • all current statutory approvals for the project; • all approved strategies, plans and programs required under the conditions of this approval; • a comprehensive summary of the monitoring results of the project, reported in accordance with the specifications in any conditions of this approval, or any approved plans and programs; • a complaints register, updated on a monthly basis; • minutes of CCC meetings; • the annual reviews of the project; • any independent environmental audit of the project, and the Proponent's response to the recommendations in any audit; • any other matter required by the Secretary; and	Section 1.7 Section 9.4 Section 9.5 Section 10
	(b) keep this information up-to-date, to the satisfaction of the Secretary.	Section 1.7

Table A1-2 Relevant SoCs

SoC requirements		WMP reference
SoC	**Summary of the requirement**	
5.4	Undertake a detailed condition assessment of the 3rd order waterways within the predicted subsidence zone to enable assessment of changes post mining.	Section 2.1.1
5.5	Inspect local drainage lines above the active and completed longwall panels. Monitoring should assess any restriction of flows and hence restriction of fish passage to facilitate appropriate restorative measures.	Section 6.1
5.6	Undertake water quality sampling from watercourses within the impact zone to determine any impacts on sediment loading and other parameters including salt loads	Section 6.1.3
5.10	In the event of erosion within Mine Site watercourses, stabilise the damaged or eroded banks in accordance with an Erosion and Sediment Control Plan.	Section 5.3
5.11	Establish survey lines along ephemeral drainage gullies and along gully crests and monitor during and after mining of each longwall panel to identify any signs of cracking or ‘upsidence’.	Section 6.1
5.14	Sample ponded water to determine if there is any increase in salinity.	Refer to the Site WMP
5.15	Inspect the watercourses over the subsidence zone to identify the location and extent of ponding.	Section 6.1
5.16	For ponding where there is little or no vegetation of conservation significance, monitor the location and extent of ponding.	Section 6.1
12.12	Minimise erosion on the Mine Site as a consequence of subsidence.	Section 5.3

Attachment 2 Consultation records

DOC22/989569-5
15 November 2022

Mr Brent Baker
Manager HSE – Narrabri Coal Operations
Whitehaven Coal Limited
10 Kurrajong Creek Rd,
Baan Baa NSW 2390
Email: BrentBaker@whitehavencoal.com.au

No Comment to Post Approval Advice Request

Dear Mr Baker

Thank you for the request for advice from Public Authority Consultation (PAE-50414707), requesting input from the NSW Environment Protection Authority (EPA) on the draft (Revision A) Extraction Plan - Water Management Plan for the Narrabri Coal Mine Stage 2 Project (PA 08_0144) at 10 Kuarrjong Creek Road, Baan Baa NSW 2390.

The NSW Environment Protection Authority (EPA) does not endorse or approve plans prepared for the purpose of project approvals and does not make representations in relation to the adequacy or completeness of any plans prepared for the purpose of project approval.

In view of these factors, the EPA has no comments to provide on this project and no follow-up consultation is required.

If you have any questions about this request, please contact Mr Lindsay Fulloon on (02) 6773 7000 or via email at info@epa.nsw.gov.au.

Yours sincerely

LINDSAY FULLOON
Manager Regulatory Operations

Department of Planning and Environment

Our ref: OUT23/150

Brent Baker
10 Kurrajong Creek Rd,
Baan Baa NSW 2390 Australia

Email: [redacted]

23 January 2023

Subject: **Narrabri Mine – Extraction Plan LW203-LW206 – Consultation Request**

Dear Brent Baker

I refer to your request for advice sent on 9 November 2022 to the Department of Planning and Environment (DPE) Water about the above matter.

The Department of Planning and Environment- Water makes a number of recommendations to improve the monitoring, management and reporting of surface and groundwater for the project. Further while it appears that groundwater triggers in the Water Management Plan (WMP) have been exceeded, we are not aware of the required responses being carried out.

Please note our detailed advice is in Attachment A.

Should you have any further queries in relation to this submission please do not hesitate to contact DPE Water Assessments at water.assessments@dpie.nsw.gov.au

Yours sincerely,

Mitchell Isaacs
Chief Knowledge Officer
Department of Planning and Environment: Water

Attachment A

Detailed advice regarding the Narrabri Mine - Extraction Plan LW203-LW206

1.0 Water Take and Licensing

1.1 Recommendation

That the proponent develops a methodology to determine surface water take due to subsidence related cracking prior to any surface cracking occurring.

1.2 Recommendation

That the proponent ensures sufficient water entitlement is held in a water access licence to account for the maximum water take for each water source prior to take occurring.

1.3 Explanation

Ensuring a suitable and approved methodology is in place to quantify surface water take prior to the take occurring is critical to inform water licence requirements at the site. It is understood the methodology is to be investigated within 12 months of the commencement of the Extraction Plan, however the proponent needs to ensure this is in place prior to any water take occurring.

2.0 Groundwater impact monitoring and management

2.1 Recommendation

That the Water Management Plan of the Extraction Plan be amended to:

- establish groundwater level triggers for monitoring bores of the GAB, including the Pilliga Sandstone within the GAB Southern Groundwater Recharge water source. This will require extending the monitoring network to more locations and requires consideration of timeline of impact through early indicators. A specific performance measure utilising a tiered approach is recommended for the Pilliga Sandstone as follows:
    - Tier 1 > 5m drawdown in the Pilliga Sandstone - all future westward panels revert back to original longwalls panels and reduce mining heights to that originally approved for Stage 2. This would reduce the vertical fracturing and extent of depressurisation into the Pilliga Sandstone.
    - Tier 2 at >10m drawdown in the Pilliga Sandstone - a cessation of mining further panels westward beneath the GAB or limit mining to first workings only. This would account for the fact that drawdown has doubled from that predicted for Stage 3 approval and that peak drawdowns are still yet to eventuate due to the lag in groundwater flow and any cumulative impact yet to be realised from other approved projects.
- establish performance targets to monitor, evaluate and report on high priority GDEs,
- ensure mitigation strategies for aquifer impacts are consistent with those approved in existing development consents, and
- modify the frequency of measuring the metered mining inflow and outflow from monthly to weekly and adjusting the response plan to excessive inflow from 3 consecutive months to 3 consecutive weeks.

2.2 Explanation

The Extraction Plan (EP) does not sufficiently define a process to manage and constrain groundwater related impacts to limits consistent with that presented at the approval assessment stage. This applies in particular to the protection of the Great Artesian Basin (GAB) and 'high priority' groundwater dependent ecosystems.

There is evidence of declining groundwater level trends in the aquifers of the GAB beyond that which was presented for the initial Stage 2 development consent and an increased risk that depressurisation impacts will exceed that presented for the Stage 3 approval. DPE Water seeks the establishment of thresholds, reporting processes and timeline development to ensure the project operates within impacts forecast at development consent, and the mitigation strategies put forward by the proponent will be enacted upon should impacts beyond that presented for approval eventuate.

The EP describes that CSIRO (2007), SCT (2008) and Tametta (2013) model results all indicate full depressurisation of the overburden, however the EP recommends the reader to consider these estimates as likely to give conservative results for estimating depressurisation. This indicates a potential for excessive aquifer depressurisation in the GAB Pilliga Sandstone both on and off lease.

Permitting excessive water level declines in the GAB conflicts with the Great Artesian Basin Strategic Management Plan 2019 to which the NSW Government is a signatory. This GAB Plan contains objectives for the protection of the GAB including:

> *" ...that industry measures are put in place to minimise impacts from mining and other resource extraction on groundwater recharge and Basin groundwater dependent ecosystems, including springs."*

Additionally, the NSW Aquifer Interference Policy (AIP) defines Level 1 impacts for the GAB Southern and Eastern Recharge Groundwater Sources including:

> *"a cumulative pressure level decline of not more than 15m, allowing for typical climatic "post-water sharing plan variations'.*

There are stratigraphic units that make up the GAB Southern Recharge Groundwater Source, where collectively the predicted drawdowns from the Narrabri Coal Project will exceed 15m (Purlawaugh Formation and Garrawalla Volcanics). However, it is the shallower Pilliga Sandstone that is the primary aquifer for management and protection and is the focus of this review. The groundwater impact assessment for the Stage 2 approval stated the Pilliga Sandstone would not be impacted by depressurisation. However, the assessment for the Stage 3 approval informed of cumulative drawdowns of up to 5m in two isolated sections of the Pilliga Sandstone. The stage 3 impacts are deemed to be appropriate to define trigger limits and response protocols.

The tiered performance measure approach recommended above was put forward by the proponent to address the uncertainty in subsidence related impacts when obtaining development consent but has not been carried forward into the Extraction Plan.

Mitigation strategies for impacts to aquifers greater than that predicted were presented in the EA that supported the Mod 5 application. Mitigation strategies were presented in a tiered order of increasing impact and included:

(i) grading of cracks;
(ii) decreasing mining widths and heights, and
(iii) leaving a barrier or limit mining to first working (ref: Mod 5 Appendix A Section 9.3.10).

However, the current Extraction Plan only brings forward the remediation option to remediate cracks and is silent on the other mitigation strategies to manage impacts as put forward for obtaining development consent.

2.3 Recommendation

That the Water Management Plan of the Extraction Plan be amended to include the requirement for regular InSAR subsidence reports and to interpret those in association with groundwater level monitoring.

2.4 Explanation

InSAR subsidence reports provide data to support subsidence impact interpretations.

2.5 Recommendation

That Annual Review reports prepared for this project be amended to:

- improve the presentation of the monitoring data and the use of maps, hydrographs and other visual tools reported in the Annual Review. The data should display recent and historical datasets (incl baseline).The SSD groundwater guidelines (https://water.dpie.nsw.gov.au/science-data-and-modelling/groundwater-management-and-science/groundwater-document-library) should be consulted to that effect.
- include documentation of quality assurance and controls.

2.6 Explanation

Comprehensive reporting and data presentation assists in ensuring information is available, accurate and easy to understand.

2.7 Recommendation

That the proponent ensures Trigger Action Response Plans are adhered to for groundwater drawdown limits.

2.8 Explanation

A comparison of groundwater levels reported in Narrabri Coals Annual Review documents against the groundwater level triggers shown in Table 6-5 of the WMP, indicates the occurrence of groundwater level declines below nominated trigger levels (see Table below). This included three consecutive readings which according to the WMP should include the following 2 actions:

- *engage hydrogeologist to undertake and report on any identified changes/likely causes and recommendations, and*
- *implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendation.*

There is no evidence that these actions have occurred or been reported on.

Location ID	Bore depth (m bgl)	Screen Depth (m bgl)	Formation	Ground surface elevation (m AHD)	Sept 2008 water level (m bgl)	Aug 2021 water level (m bgl)	Oct 2021 water level (m bgl)	Jan 2022 water level (m bgl)	Sept 2008 water level (m AHD)	Aug 2021 water level (m AHD)	Oct 2021 water level (m AHD)	Jan 2022 water level (m AHD)	Extraction Plan 'Life of Mine' lowest groundwater level trigger (m AHD)
P8	65	57-63	Purlawaugh	322.09	50.53	50.78	50.8	50.75	271.56	271.31	271.29	271.34	269.6
P9	30	24-30	Purlawaugh	287.46	19.66	26.23	26.31	26.7	267.8	261.23	261.15	260.76	262.4
P10	130	118-130	Napperby	269.2	20.03	21.2	20.13	23.42	249.17	248	249.07	245.78	251.8
P11	50	44-50	Napperby	303.01	22.91	29.57	32.4	32.68	280.1	273.44	270.61	270.33	272.9

End Attachment A

Table A2-1 DPE Water consultation recommendations

Consultation feedback	Outcome	Document reference
1.0 Water Take and Licensing		
1.1 Recommendation That the proponent develops a methodology to determine surface water take due to subsidence related cracking prior to any surface cracking occurring.	Section 6.1.4 has been updated to state: "An assessment will be conducted by a surface water specialist prior to any surface cracking occurring within the Extraction Plan Area to consider alternative methodologies to measure and/or predict creek flows."	Section 6.1.4 of the EP-WMP
1.2 Recommendation That the proponent ensures sufficient water entitlement is held in a water access licence to account for the maximum water take for each water source prior to take occurring.	Noted. No update required as commitment has already been included in Section 4 of the Plan.	Section 4 of the EP-WMP
2.0 Groundwater impact monitoring and management		
2.1 Recommendation That the Water Management Plan of the Extraction Plan be amended to: • Establish groundwater level triggers for monitoring bores of the GAB, including the Pilliga Sandstone within the GAB Southern Groundwater Recharge water source. This will require extending the monitoring network to more locations and requires consideration of timeline of impact through early indicators. A specific performance measure	As presented in Table 6-4 of the EP-WMP, four monitoring bores (P8, P9, P10 and P11) from the current Narrabri Mine groundwater monitoring network have been included in the EP-WMP monitoring program. In addition, the Subsidence Assessment Report (DGS, 2022) proposed an additional VWP (P80) and a wireline extensometer (P81) be installed above LW 203 at its southern limit. Given the Pilliga Sandstone Formation is not present above LW203 to LW206, monitoring locations in the Pilliga Sandstone were not included in Revision A of the EP-WMP. However, in response to DPE Water Recommendation 2.1, NCOPL propose to install an additional standpipe within the Pilliga Sandstone formation west of the planned longwall panels (P82) which has also been included in the EP-WMP monitoring program (Table 6-4). Furthermore, the revised Site WMP (which describes the overall site groundwater monitoring network) (not yet approved) includes two existing standpipes (P6 and P7) and two existing VWPs (P42_90 and P54_30) that are currently monitoring the Pilliga Sandstone. The	Section 6.2, Table 6-4, Table 6-5, Section 9.3 of the EP-WMP

Consultation feedback	Outcome	Document reference
utilising a tiered approach is recommended for the Pilliga Sandstone as follows: ▪ Tier 1 >5 m drawdown in the Pilliga Sandstone – all future westward panels revert back to original longwalls panels and reduce mining heights to that originally approved for Stage 2. This would reduce the vertical fracturing and extent of depressurisation into the Pilliga Sandstone. ▪ Tier 2 at >10 m drawdown in the Pilliga Sandstone – a cessation of mining further panels westward beneath the GAB or limit mining to first workings only. This would account for the fact that drawdown has doubled from that predicted for Stage 3 approval and that peak drawdowns are still yet to eventuate due to the lag in groundwater flow and any cumulative impact yet to be realised from other approved projects.	existing monitoring bore P7 has also been in included in Revision 0 of the EP-WMP (Table 6-4 and Table 6-5). Stage 1 and Stage 2 groundwater level trigger criteria have been established for all monitoring bores (see Table 6-5 of EP-WMP) which require response actions to be undertaken in accordance with the TARP in section 7. The Stage 1 and Stage 2 triggers for the Pilliga Sandstone bores follow the tiered approach for trigger levels as recommended under Recommendation 2.1. However, the performance measures/response actions have not been adopted as they are not practicable. Refer to the TARP in section 7 for reasonable and feasible response actions. The method for deriving the Stage 1 and Stage 2 trigger criteria for all bores is documented in section 6.2 of the EP-WMP. In terms of the broader monitoring context, the revised Site WMP also recommends the drilling and installation of additional VWPs P61_1, P67_1, P70, P73_1 and P77_1. With the exception of P70, each of these VWPs are located to the west of the Pilliga Sandstone outcrop and include monitoring at shallow depths (including in the Pilliga Sandstone) to identify impacts through early indicators for groundwater drawdown. NCOPL are also proposing three additional standpipes (P68 shallow and P69 deep and P82 [mentioned above]). These standpipes have also been included in the EP-WMP groundwater monitoring program as well as VWPs P70 and P73 (Table 6-4). NCOPL will make use of the Santos Pilliga Sandstone monitoring data if the newly proposed P82 and the existing P7 monitoring bores exceed the trigger value/s. Detailed investigations will then be conducted as required. It is assumed that the Santos data will be readily available from their website. Note: Groundwater level triggers will not apply to the Santos bores, however the bores will provide background monitoring data for reference purposes only.	
• establish performance targets to monitor, evaluate and report on high priority GDEs,	As stated in section 3.2.7, no directly related impacts to GDEs from the Extraction Plan Area are expected and no high priority GDEs or alluvial aquifer systems occur within the Extraction Plan Area. Impacts on GDEs and other receptors outside of the mine footprint and Extraction Plan Area will be monitored and managed in accordance with the revised Stage 2 WMP (not yet approved).	Section 3.2.7, Section 6.2.3, Section 6.2.9 of the EP-WMP

Consultation feedback	Outcome	Document reference

	Notwithstanding the above, the groundwater monitoring program (Table 6-6) includes a commitment to conduct annual site visits to the Mayfield Spring which includes collecting data for the following parameters:
	• Site photographs (x4) and observations of:
	  ▪ Flow rates
	  ▪ Surface conditions
	  ▪ Surface water levels and field water quality (EC and pH) in any standing pools.
	
	Section 6.2.9 has been added to the EP-WMP which establishes performance criteria, monitoring and evaluation of Mayfield Spring.	

• ensure mitigation strategies for aquifer impacts are consistent with those approved in existing development consents, and	The revised subsidence predictions report for LW 203-206 (DGS, 2022) states the following mitigation strategies for sub-surface cracking: “The practical options available for controlling sub-surface fracturing are limited to: • Monitor rainfall deficit and underground water makes or changes to ventilation during longwall mining to detect surface to seam connectivity. • Repair surface cracks after active subsidence is complete. • Install further borehole extensometers and piezometers to monitor the height of fracturing development for multiple 400 m wide longwalls after supercritical conditions develop (most of the subsurface fracturing prediction models consider impacts due to one or two longwalls only).” Therefore, the above measures represent the most current and appropriate management strategies as recommended in the subsidence prediction report for LW 203-206 (DGS, 2022). These measures have been included in section 5.2 of the EP-Land Management Plan.	Section 5.2 of the EP-LMP
• modify frequency of measuring the metered mining inflow and outflow from monthly to weekly and adjusting the response plan to excessive inflow from 3 consecutive months to 3 consecutive weeks.	The monitoring frequency for mine water inflow and outflow in Table 6-6 (section 6.2.3) has been amended to state “weekly meter read”. Section 6.2.4 has also been updated to state: “an observed inflow rate 100% in excess of the predicted base case mean monthly inflow rate at any stage during the EP 203-206 operational period sustained for three consecutive weeks where a	Section 6.2.3, Section 6.2.4 of the EP-WMP

<table>
<tr><th>Consultation feedback</th><th>Outcome</th><th>Document reference</th></tr>
<tr><td></td><td>significant rainfall event has occurred during this period, will trigger an investigation and preparation of a response plan as detailed in section 7.”

Note: a significant rainfall event is defined as a rainfall event >38.4 mm over 5 consecutive days.</td><td></td></tr>
<tr><td>2.3 Recommendation

That the Water Management Plan of the Extraction Plan be amended to include the requirements for regular InSAR subsidence reports and to interpret those in association with groundwater level monitoring.</td><td>NCOPL have an established remote sensing monitoring program in place which consists of annual multi spectral imaging and triennial LiDAR surveys to detect changes in landform. If changes in landform are detected, targeted field surveys will be conducted to examine the cause of change, followed by the implementation of appropriate management measures.

The surface zones subject to impact monitoring are described in the below table.
<table>
<tr><th>Surface zone</th><th colspan="2">Definition</th></tr>
<tr><td>Longwall</td><td>Zone of maximum subsidence.</td><td>>2 m predicted subsidence.</td></tr>
<tr><td>Transition</td><td>Zone of maximum stress and tilt.</td><td>0.1 – 1.5 m predicted subsidence.</td></tr>
<tr><td>Pillar</td><td colspan="2">Zone above the pillar with minimal subsidence.</td></tr>
<tr><td>Control</td><td colspan="2">Zones of no impact located outside of any predicted subsidence zone.</td></tr>
</table>
It would be very difficult to differentiate between ground deformation caused by subsidence and ground deformation caused by groundwater drawdown within the Extraction Plan Area (i.e. 45º AoD).

Section 6.2 of the EP-LMP describes the remote sensing monitoring program applicable to the entire mine site. Table 6-3 in the EP-WMP also describes the remote sensing monitoring program that is applicable to monitoring watercourses.</td><td>Table 6-3 of the EP-WMP
Section 6.2 of the EP-LMP</td></tr>
<tr><td>2.5 Recommendation</td><td>NCOPL will include maps, hydrographs, and/or other visual tools within the Annual Review to present the groundwater monitoring results. The results will display both recent and historical datasets</td><td>Section 9.4 of the EP-WMP</td></tr>
</table>

Consultation feedback	Outcome	Document reference
That Annual Review reports prepared for this project be amended to: • improve the presentation of the monitoring data and the use of maps, hydrographs and other visual tools reported in the Annual Review. The data should display recent and historical datasets (incl baseline). The SSD groundwater guidelines (https://water.dpie.nsw.gov.au/science-data-and-modelling/groundwatermanagement-and-science/groundwater-document-library) should be consulted to that effect. • include documentation of quality assurance and controls.	(including baseline). In addition, all data on groundwater levels, quality, and data quality control will be provided separately to DPE Water in csv format to accompany the Annual Review.	
2.7 Recommendation That the proponent ensures Trigger Action Response Plans are adhered to for groundwater drawdown limits.	The Trigger Action Response Plan in section 7 (Table 7-2) details the monitoring bores that have a groundwater level trigger. If routine monitoring indicates the groundwater level exceeds the trigger level over three consecutive monitoring events (Level 2 trigger), NCOPL will ensure the actions of conducting preliminary quality assurance of data to confirm the exceedances and the implementation of the contingency and notification measures as per section 8 are executed. Responses to the exceedances include: • Engage hydrogeologist to undertake assessment and report on any identified changes/likely causes and recommendations. • Implement contingency responses as agreed with government agencies and in accordance with hydrogeologist recommendations. In addition, and in response to DPE Water Recommendation 2.1, an additional component has been included in the TARP specific to the Pilliga Sandstone monitoring bores. In response to DPE Water's 2.8 Explanation regarding historical groundwater level declines below the EP-WMP nominated trigger levels (for bores P9, P10 and P11), NCOPL have conducted a review of	Section 6.2, Table 6-5, Section 7 of the EP-WMP

Consultation feedback	Outcome	Document reference

the trigger levels with a summary of the identified issues and recommendations presented in the below table.

Issue	Recommendations
The pre-mining baseline data used to derive groundwater level triggers, for some of the monitoring bores, (i.e. P10) shows fluctuating trends.	The pre-mining water level for P10 was adjusted from 278.1 mAHD to 271.99 mAHD using the average pre-mining data (i.e. pre-2012).
The heads predicted in the model simulations are regionally based, some discrepancies may occur due to the model grid construction process and real collar elevations.	The level trigger determination process should account for discrepancies. The drawdown will be subtracted from pre-mining baseline heads to derive triggers presented in the head (mAHD) and modelled predicted heads not used directly.
The numerical groundwater model derives regional impacts (as per the AIP), mine inflow rates, overall (regional) groundwater management options and model uncertainty. Not all observations applied in the numerical model calibrate 100%; some are slightly over-predicted, and some are slightly under-predicted but overall, the model achieved reasonable calibration targets in line with the Australian Model Guidelines[10]. The application of annual trigger levels was implemented following consultation with NRAR in	A single Stage 1 and Stage 2 trigger level for the life of mine period (i.e. 2031 for Stage 2) will be implemented. The proposed methodology is described in section 6.2 of the EP-WMP.

[10] The objective of the calibration being to replicate observed groundwater levels, net baseflow gains and mine inflows in accordance with Australian Groundwater Modelling Guidelines (Barnett et al. 2012). The transient calibration achieved a 5.0% scaled root mean square (SRMS) error, which is well within acceptable limits (i.e. <10%), recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). More importantly, the model was able to replicate the observed depressurisation of the Permian strata occurring above the existing underground mining area, and average inflows into the existing underground mining area (AGE, 2020b).

Consultation feedback	Outcome		Document reference
	2021 regarding revision 3 of the Stage 2 WMP. However, monitoring and assessing against a yearly trigger has since been concluded by NCOPL to be impracticable based on the intent of the groundwater model and ability to calibrate to this accuracy (as stated above). In accordance with the Statement of Commitments within the Project Approval (PA 08_0144), the groundwater model will be recalibrated 12 months (2013), 3 years (2015) and 5 years (2017) after the commencement of longwall extraction. Recalibration will then occur every 5 years thereafter (2022, 2027 and 2032), and at least 12 to 18 months prior to the cessation of mining. The current recalibration time frame is 5 years; this means that small changes in mining may result in the over or under-prediction of groundwater levels in certain monitoring bores if the actual mining differs from the mine plan used in the preceding model calibration exercise. This is a further reason why annual trigger levels are difficult to manage, and exceedance of predicted levels may occur.		
	The NCO numerical groundwater model is currently in a recalibration stage (Nov 2022 to February 2023).	The objective is to adjust the groundwater level triggers to align with the 2023 calibrated numerical groundwater model where necessary. The Stage 1 and Stage 2 trigger levels for the EP-WMP monitoring bores have been derived from the 2023 recalibrated model (Table 6-5 of EP-WMP).	

Consultation feedback	Outcome	Document reference
	With consideration of the above, an adjustment of the trigger values has been conducted as part of the 2023 numerical groundwater model calibration. The method used to derive the trigger values is detailed in section 6.2 of the EP-WMP. The revised groundwater level trigger vales are presented in Table 6-5 of the EP-WMP.	