NARRABRI MINE

GROUNDWATER MANAGEMENT PLAN

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WHC_PLN_NAR_GROUNDWATER MANAGEMENT PLAN

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1. Introduction

1.1 Background

The Narrabri Mine is an existing underground coal mining operation situated in the Gunnedah Coalfield, approximately 25 kilometres (**km**) southeast of Narrabri and approximately 60 km northwest of Gunnedah, within the Narrabri Shire Council (**NSC**) Local Government Area, in New South Wales (**NSW**). It is operated by Narrabri Coal Operations Pty Ltd (**NCOPL**), on behalf of the Narrabri Mine Joint Venture[1], which consists of two Whitehaven Coal Limited's (**WHC**) wholly owned subsidiaries, and other joint-venture partners.

The Narrabri Underground Mine Stage 3 Extension Project (**Stage 3**) involves a southern extension to the previously approved Stage 2 mining area (approximately 609 hectares (ha) of additional surface development footprint) to gain access to additional areas of coal reserves within Mining Lease Application (**MLA**) 1 and 2, an increase in the mine life to 2044, and the development of supporting surface infrastructure[2].

1.2 Purpose and scope

This Groundwater Management Plan (**GWMP** or **Plan**) has been developed in accordance with the Stage 3 Extension Project State Significant Development (**SSD**) 10269 Conditions of Consent (**CoC**) B36(e)(iv), the applicable Commonwealth and NSW State regulatory framework for groundwater management, the requirements of the Water Group within the Department of Planning and Environment (**DPE Water**) and the requirements of the Environment Protection Authority (**EPA**).

As required by CoC B38, NCOPL will implement the GWMP as approved by the Planning Secretary. In accordance with CoC B37, NCOPL will not commence construction until this Plan is approved by the Planning Secretary.

This GWMP forms Attachment 4 of the Narrabri Mine Water Management Plan (**WMP**), developed in accordance with CoC B35 to CoC B38.

1.3 Objectives

The objectives of this Plan are to:

- provide details of the relevant statutory requirements, including any relevant approval, licence or lease conditions;
- describe the measures to be implemented to ensure compliance with the water management performance measures in accordance with CoC B34;
- provide baseline data for groundwater levels, yield, quality and supply for other water users;
- detail the potential impacts to groundwater and groundwater users as a result of the development;
- provide a detailed description of the groundwater management system;
- provide details of the proposed metering, monitoring and modelling measures;
- detail the groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts (or trends) associated with the development;

[1] For full details on the joint venture ownership, refer to the introduction of the Environmental Management Strategy.

[2] For full detail on the background of the Narrabri Mine, refer to the overarching WMP.

- provide a program to monitor and evaluate:
  - compliance with the relevant performance measures;
  - water loss/seepage from water storages into the groundwater system;
  - groundwater inflows, outflows and storage volumes, to inform the Site Water Balance (**SWB**);
  - the hydrogeological setting of any nearby alluvial aquifers and the likelihood of any indirect impacts from the development;
  - the effectiveness of the groundwater management system; and
  - a monitoring program for groundwater dependent ecosystems (GDEs) which may be impacted by the development.
- detail a trigger action response plan (**TARP**) to respond to any exceedances of the relevant performance measures and groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development; and
- describe the regular review of the groundwater model for the Narrabri Mine.

1.4 Regulatory requirements

In accordance with CoC E5(b), Appendix A provides a summary of the relevant regulatory requirements relating to groundwater and outlines the section of the GWMP in which each of these conditions have been addressed.

In accordance with CoC E5(c), Appendix B provides a summary of the relevant commitments or recommendations within the EIS relating to groundwater and outlines the section of the GWMP in which each of these commitments have been addressed. These relevant commitments or recommendations include those as amended or added to by the:

- Applicant's Submission Report submitted 31 May 2021;
- Applicant's Amendment Report submitted 31 May 2021; and
- Applicant's final Biodiversity Development Assessment Report dated September 2021.

A detailed overview of the statutory requirements relating to water management is described in section 3 of the WMP.

1.5 Definitions

The terminology used within this GWMP are defined in the WMP.

2. Baseline data

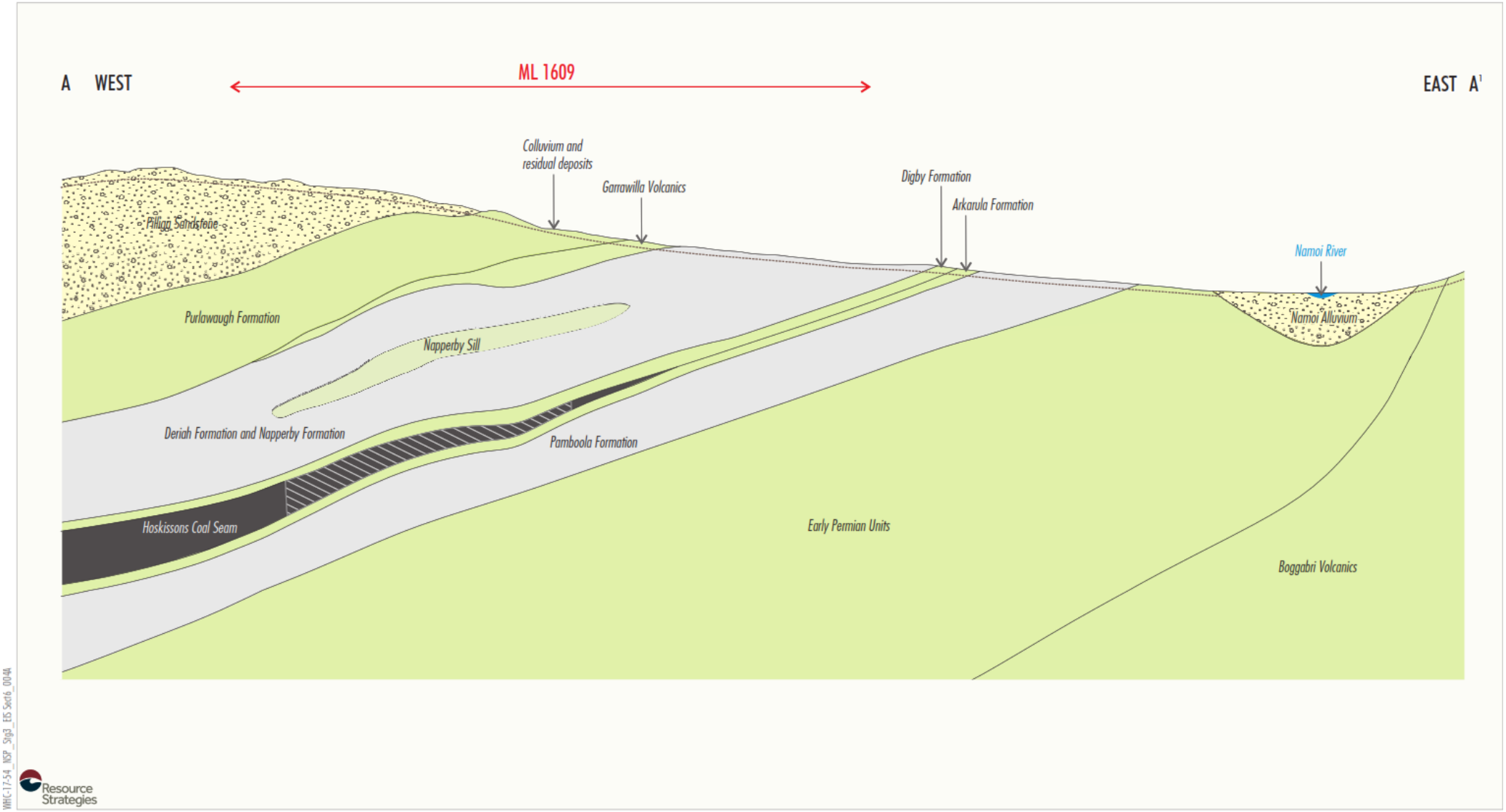
2.1 Groundwater regime

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.

A conceptual geological cross-section showing the main stratigraphic units occurring in the vicinity of the mine is provided in Figure 2-1.



WRHC-17-54_NSP_Stg3_EIS Sect6_0044

Source: AGE (2020)

LEGEND
- Highly Productive Aquifer
- Minor Aquifer (Less Productive)
- Aquitard/Poor Aquifer
- Target Coal Seam
- Underground Mining Area

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FIGURE 2-1
Conceptual Geological Cross-Section

A conceptual hydrogeological model of the existing groundwater regime was developed for the Stage 3 EIS based on a review of the available baseline groundwater data and relevant Water Sharing Plans (**WSP**).

The key 'highly productive' aquifers in the vicinity of the Narrabri Mine are:

- Jurassic-aged Pilliga Sandstone; and
- alluvium associated with the Namoi River.

A 'highly productive' source is defined by the Aquifer Interference Policy (**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**).

Other units present in the vicinity of the mine are considered to be 'less productive' aquifers, as they don't meet the appropriate criteria for TDS and/or yield to be considered 'highly productive'.

2.1.1 Pilliga sandstone

The Pilliga Sandstone is the youngest consolidated formation in the immediate vicinity of the mine and outcrops across the western half of the mining lease. The Pilliga Sandstone is an important regional aquifer dominated by well sorted, fine to coarse-grained sandstones that are typically highly porous and permeable and producing high yields of good quality groundwater.

The sandstone thickness varies from zero at the mapped limit of the formation to approximately 80 m to 120 m at the western margin of the mining lease. The sandstone continues to thicken further west, reaching thicknesses greater than 500 m.

The Pilliga Sandstone above the underground mining area forms part of the Southern Recharge Groundwater Source within the *WSP for the NSW Great Artesian Basin Groundwater Sources 2020*. However, recharge to the Great Artesian Basin (**GAB**) in the vicinity of the mine is low (less than 5 millimetres per year [**mm/year**]) and therefore is not a significant recharge zone for the GAB. Recharge to the Pilliga Sandstone primarily occurs in the Warrumbungles area, where higher rainfall results in estimated recharge rates in excess of 40 mm/year.

2.1.2 Alluvial groundwater system, Colluvium and Regolith

The Namoi River is a major watercourse that flows in a north-westerly direction approximately 4 to 5 km to the north and east of the Narrabri Mine. The alluvial sediments associated with the Namoi River are subdivided into two formations, although they are not always distinguishable. The Gunnedah Formation occurs towards the base of the alluvium, which typically comprises well sorted sand and gravel interbedded with clay, and is, therefore, the target for most water supply bores in the region. The overlying Narrabri Formation typically comprises extensive overbank clays with fewer sand/gravel units, suggesting generally lower permeability and aquifer potential.

The Namoi River alluvium is generally thickest (greater than 100 m) to the east of the Namoi River and thins towards the edges of mapped alluvium and along the tributaries.

The Namoi River alluvium to the east of the site forms part of the Upper Namoi Zone 5, Namoi Valley (Gin's Leap to Narrabri) Groundwater Source (Zone 5) within the *WSP for the Namoi Alluvial Groundwater Sources Order 2020.*

DPE Water has mapped areas of the alluvium associated with the Namoi River and its tributaries as a 'highly productive' groundwater source under the AIP. To the west of the 'highly productive' alluvium associated with the Namoi River are areas of undifferentiated Quaternary colluvium and residual soils (or regolith). Both the colluvium and regolith cover, where present, are thought to be relatively thin and dominated by low permeability clay strata, which are the result of weathering and decomposition of the underlying consolidated strata.

Alluvium to the south of the Narrabri Mine associated with the Tulla Mullen Creek is not mapped as 'highly productive' and has been formed from a different depositional environment to the Namoi River alluvium (i.e. Quaternary piedmont deposits).

2.1.3 Other units

Underlying the Pilliga Sandstone are the Jurassic-aged Purlawaugh Formation and Garrawilla Volcanics that form part of the Southern Recharge Groundwater Source within the *WSP for the NSW Great Artesian Basin Groundwater Sources 2020.* However, unlike the Pilliga Sandstone, these units are considered 'less productive' under the AIP. Like other generally low hydraulic units within the region, sandstone units are occasionally present in the Purlawaugh Formation and can support minor extraction for stock and domestic purposes.

The Purlawaugh Formation has lower hydraulic conductivity than the Pilliga Sandstone and acts as an aquitard.

Triassic-aged units in the vicinity of the mine include the Napperby Formation and Digby Formation, which form part of the Gunnedah-Oxley Basin Murray Darling Basin (**MDB**) Groundwater Source within the *WSP for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*. The Gunnedah-Oxley Basin MDB Groundwater Source also encompasses late Permian units including the Hoskissons Coal Seam (i.e. the Narrabri Mine coal resource). Triassic and Permian units in the vicinity of the mine are also identified as 'less productive' units under the AIP.

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 should be expected given the nature of mining operations.

Detailed baseline data on groundwater levels is presented in Appendix C.

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 2-1 provides a summary of the field EC data by hydrostatic unit.

Table 2-1 Summary statistics, field EC data by hydrostratigraphic unit

Formation	No of bores	No of tests	Field EC (µS/cm)					
			Mean	Min	25%	50%	75%	Max
Alluvium	9	92	2292	597	704	853	5860	7050
Pilliga Sandstone	4	93	1410	129	256	393	2900	5440
Purlawaugh Formation	4	181	8343	293	674	4880	18960	34900
Garrawilla Volcanics	9	360	4606	274	1379	2630	4158	20200
Napperby Formation	9	438	9632	1020	3083	7040	17628	33100
Hoskissons Coal Seam	1	5	5580	1410	4070	6180	7490	8750
Arkarula Formation	1	15	19230	1140	15915	23770	25015	25420
Pamboola Formation	3	174	14785	1050	3468	17175	25025	27340

Results of the initial Stage 3 bore census (ENRS 2020) indicate that privately-owned water supply bores in the vicinity of the mine and surrounds have a wide range of salinity. Groundwater quality was tested in the field as part of the third Stage 3 bore census at 26 privately owned bores (AGE 2021). The EC ranged from 521 µS/cm to 22,680 µS/cm.

Detailed baseline data on groundwater quality is presented in Appendix C.

2.4 Groundwater yield

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.

2.5 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. Refer to section 3.3.1 of the Site Water Balance (**SWB**) (Attachment 1 of the WMP).

3. Implementation and management

3.1 Groundwater inflows

The predicted annual groundwater volumes (water take) for each groundwater source over the life of mine (based on the Stage 3 EIS groundwater modelling) is presented in Table 3-1. Details of the current groundwater WALs held by NCOPL are summarised in Table 3-2

At the end of mining, relevant entitlements will be surrendered to account for groundwater take post-mining in accordance with the AIP.

Table 3-1 Predicted annual groundwater volumes per water source

Year	Total (ML/year)	*NSW Murray-Darling Basin Porous Rock Groundwater Sources Order 2020* (ML/year)	*NSW Great Artesian Basin Groundwater Sources 2020* (ML/year)	*Namoi Alluvial Groundwater Sources Order 2020* (ML/year)	*Upper and Lower Namoi Regulated River Water Source* (ML/year)
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
2032	2029	1991	29	0	9
2033	2096	2053	32	0	11
2034	2112	2064	34	0	14
2035	2188	2134	36	1	17
2036	2259	2199	37	2	21
2037	2279	2216	36	3	24
2038	2337	2267	38	4	28
2039	2365	2290	40	4	31
2040	2406	2310	42	10	44
2041	2404	2310	42	10	42
2042	2332	2242	42	8	40
2043	2265	2170	42	9	44

Table 3-2 Current Water Access Licence entitlements

Water Sharing Plan	Water source (Management Zone)	Licence category	WAL number	Nominated works	Allocation (Unit Shares)	Entitlement (Unit Shares) held by NCOPL	Peak volume requiring licensing during mining (ML/year[1])	Peak volume requiring licensing post-mining (ML/year[1])	Estimated year to exceed entitlement
Groundwater									
NSW Murray-Darling Basin Porous Rock Groundwater Sources Order 2020	Gunnedah Oxley Basin MDB Groundwater Source	Aquifer	WAL 29549	90WA822539	818	1,221	2,310	2,310	2023
			WAL 43017[2]	- [2]	403				
NSW Great Artesian Basin Groundwater Sources 2020	GAB Southern Recharge Groundwater Source	Aquifer	WAL 15922	90WA822539	248	248	42	88	NA
Namoi Alluvial Groundwater Sources Order 2020	Upper Namoi Zone 5 Groundwater Source	Aquifer	WAL 12833	90WA812891	67	260	10	64	NA
			WAL 20131		150				
			WAL 12822		43				
	Lower Namoi Groundwater Source	Aquifer	-	-	Nil	Nil	0	1	> 2149

3.1.1 Water licensing

NCOPL holds sufficient licences to cover the predicted licensing requirements, with the exception of the following water sources:

- Gunnedah Oxley Basin MDB Groundwater Source regulated by the *WSP for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020*; and
- Lower Namoi Groundwater Source regulated by the *WSP for the Namoi Alluvial Groundwater Sources 2020*.

For the predicted licensing requirements in the Lower Namoi Groundwater Source, NCOPL will seek and obtain the appropriate entitlements on the open market in accordance with the appropriate trading rules of the *WSP for the Namoi Alluvial Groundwater Sources Order 2020*. Based on recent water trading statistics, there is sufficient market depth in the Lower Namoi Groundwater Source to accommodate the very small allocation required.

Based on recent water trading statistics, there is sufficient market depth in Gunnedah Oxley MDB Groundwater Source to secure the additional entitlement. Additional entitlements for the Gunnedah Oxley Basin MDB Groundwater Source may also be obtained via the controlled allocation order process. Under section 65 of the *Water Management Act 2000,* the Minister for Water can make a controlled allocation order to make new entitlements available in water sources with unassigned water. Controlled allocation orders relevant to the Gunnedah Oxley Basin MDB Groundwater Source have been made in 2013, 2014, 2017 and 2020. There is approximately 181,528 megalitre per year **(ML/year**) of unassigned water in the Gunnedah Oxley Basin MDB Groundwater Source.

Water licence transfer strategy

To address the identified shortfall in the Gunnedah-Oxley Basin MDB Groundwater Source, allocation may also be transferred from other WHC operations to meet the operational requirements. NCOPL will conduct an annual assessment to validate actual groundwater take and predicted future water take. The assessment will consider available water take entitlement and any need to transfer entitlement from other WHC mining operations.

The aim of the assessment will be to ensure that cumulative impacts are taken into account if transferring entitlement between other WHC sites during operation and post mining, and to demonstrate that there is a viable pathway to obtain the necessary entitlement from any allocation surplus. NCOPL must ensure sufficient water entitlement is held in a WAL or WALs to account for the maximum predicted take for each water source prior to take occurring. The assessment will:

- consider the availability of entitlement from other WHC mine sites;
- account for peak water take for Stage 3; and
- consider the operational and post-operational take in each year until post-operational groundwater equilibrium is reached.

By doing this, NCOPL will identify if mine operations may significantly limit the availability of any WHC allocation surplus for transfer that may still require entitlement to address ongoing impacts at a particular mine. The assessment will be based on the other mine sites closing at the currently approved mine life date and will also re-evaluate the availability of entitlement should any of these operations have their mine life extended, while taking into account post operational requirements in accordance with the AIP.

3.2 Groundwater drawdown

Sub-surface fracturing can cause significant changes in hydraulic properties, and potentially provide pathways for groundwater movement. Discontinuous fracturing will normally be expected to occur above the mining area, causing an increase in rock mass storage capacity and horizontal permeability, without direct hydraulic connection to the workings. Groundwater levels will be lowered in the medium to long terms as a consequence of these impacts.

Drawdown greater than 2 m within the 'highly productive' Pilliga Sandstone is constrained to small areas close to the western boundary of the mining lease, due to the intervening 'less productive' formations between the Pilliga Sandstone and the Hoskissons Coal Seam (e.g. the Purlawaugh formation). Impacts are predicted to occur post-mining due to the high level of inertia (time-lag) in groundwater systems that are poorly connected to surficial recharge sources.

Substantial drawdown (or depressurisation in confined aquifers) is predicted in the groundwater systems of the 'less productive' Permian-aged porous rock in the near vicinity of the site. Recovery of the groundwater water table and pressures within the porous rock groundwater system is predicted to occur over many decades following the cessation of mining.

Privately-owned bores predicted to experience greater than 2 m drawdown are listed in section 4.6.3.

3.3 Alluvial groundwater system discharge

During operations, net discharge from other groundwater systems to the Quaternary alluvium is predicted to reduce by up to approximately 0.22 ML/day (or 80 ML/year), compared with the baseline model prediction for net discharge to the alluvium of around 15 ML/day (or 5,475 ML/year). Net discharge reduction will increase to a maximum of approximately 0.66 ML/day (or 240 ML/year) around 150 years after mining ceases, before returning to equilibrium.

A proportion of groundwater discharging to the Quaternary alluvium would ultimately discharge to the Namoi River. During operations, net discharge from the Quaternary alluvium to the Namoi River is predicted to reduce by up to approximately 0.08 ML/day (or 28 ML/year), compared with the baseline model predictions for net discharge to the river of around 13 ML/d (or 4,745 ML/year). Net discharge reduction will increase to a maximum of approximately 0.39 ML/day (or 142 ML/year) around 150 years after mining ceases, before returning to equilibrium.

3.4 Groundwater users

Groundwater modelling conducted for the Stage 3 EIS indicates that:

- predicted drawdowns at all bores accessing 'highly productive' aquifers (i.e. the Namoi Alluvium and Pilliga Sandstone) are within the AIP minimal harm impact criterion (i.e. less than 2 m drawdown); and
- nine privately-owned stock and domestic water supply bores accessing 'less productive' aquifers are predicted to experience drawdowns exceeding the AIP minimal harm impact criterion (i.e. more than 2 m drawdown) as listed in Table 3-3.

Table 3-3 Private bores predicted to experience more than 2 m drawdown

Bore	Property name	Formation	Predicted maximum cumulative drawdown (m)	Water column length (m)	Percentage reduction in water column (%)	Timing of maximum drawdown (year)
WB10 (GW013858)	Nindethana (east)	Napperby Formation	10.93	17.71	62%	2055
WB11 (House Bore)	Towri	Garrawilla Volcanics	2.72	17.6	15%	2360
WB12 (257_Bore)	Wilga	Arkarula Formation/Pamboola Formation	12.61	36.5	35%	2043
WB 13 (GW008634)	South End	Garrawilla Volcanics/Napperby Formation	0.86 - 3.35	62.8	4-17%	2113
WB 14 (GW026121)	Nindethana (west)	Garrawilla Volcanics	4.57	4-8	57 - 100%	2191
WB15 (Windmill Bore)	Riverview	Napperby Formation	4.61	8.70	54%	2050
WB16 (South Caloola)	South Caloola	Napperby Formation	5.46	4.71	100%	2067
WB17 (GW903687-Solar Bore)	Turra	Napperby Formation	5.62	11.3	50%	2050
WB18 (Mentone Bore)	Mentone	Napperby Formation	13.11	6.5	100%	2050

Impairment of supply is only expected at six of the nine bores since the predicted drawdown represents a relatively minor proportion of the standing water column observed in the other three bores and hence the yield of these bores may not be significantly impaired. Additionally, due to the slow rates of anticipated groundwater drawdown, many of these impacts are not expected to occur for decades. Consistent with their use for stock and domestic purposes, none of the bores are associated with WALs with licensed extraction quantities.

For all private bores predicted to be drawn down more than 2 m, NCOPL will:

- conduct a groundwater yield test;
- conduct annual groundwater level and quality monitoring;
- monitor any drawdown as it develops; and
- implement 'make good' measures which may include:
  - deepening the affected groundwater bore;
  - constructing a new groundwater bore;
  - providing an alternative water supply of suitable quality and quantity; and/or
  - compensation, to the satisfaction of the Planning Secretary in accordance with CoC B28 to B30.

In accordance with CoC B31, NCOPL will complete all compensatory water supply measures required under CoC B27 to CoC B30 within two years of the date of commencement of the development. In accordance with CoC B32, if NCOPL and a landowner cannot agree on whether the loss of water is to be attributed to the development or the measures to be implemented under CoC B28 to CoC B31, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution.

CoC B27 states that prior to the commencement of development under the CoC, NCOPL must notify owners of licensed privately-owned groundwater bores that are predicted to have a drawdown of more than 2 m as a result of the development. This notification must set out the terms whereby NCOPL proposes to give effect to landowner entitlements and NCOPLs responsibilities under conditions B28 to B32 (i.e. a 'make good' agreement).

NCOPL has committed to make good measures at all privately owned bores where the AIP's 2 m minimal impact criterion may be exceeded. Make good provisions and contingency measures will be applied in accordance with the terms of any formal make-good agreement.

Ongoing groundwater monitoring described in section 4, as well as any updates to the groundwater model, will be used to confirm the predicted drawdown at these bores.

3.5 Namoi Alluvial bore

Water will be extracted from NCOPL's existing alluvial bore located adjacent to the Namoi River during periods when supply from the underground mining area is insufficient to meet the mine water demand, and sufficient allocation from the Namoi River (i.e. utilising NCOPL's Namoi River pump) is unavailable. NCOPL's bore is located within the Upper Namoi Zone 5 Groundwater Source (within the *WSP for the Namoi Alluvial Groundwater Sources Order 2020*).

Water will be extracted in accordance with the licensed entitlements allocated under the relevant WALs held by NCOPL (section 3.3.1 of the SWB [Attachment 1 of the WMP]) and the rules prescribed in the WSP. Therefore, minimal impacts to the groundwater source and other users are predicted as a result of the ongoing use of the alluvial bore by NCOPL.

3.6 Groundwater quality

Mine dewatering activities will create hydraulic gradients towards the mine; therefore, any contamination or poor-quality groundwater generation will likely flow to the underground mine workings and be transferred to the site water management system. The mined area will remain as a local groundwater sink in the long-term and groundwater from the surrounding groundwater system will continue to flow towards the area after mining has ceased.

Disposal of brine into the underground workings has been assessed in the Stage 3 EIS Groundwater Assessment. The volume of brine to be reinjected will be negligible in the context of the overall pore space available in the goaf (i.e. less than 2%), and flows from the surrounding groundwater system will dilute the brine. Therefore, underground disposal of brine is not predicted to influence the quality of the surrounding groundwater system.

In accordance with CoC B36(e)(iv), NCOPL will monitor the impact of any brine re-injection into the goaf on salt concentrations in surrounding aquifers, for a period of 10 years following any such reinjection or such other period as required by the Planning Secretary.

The monitoring program detailed in section 4.5 will be updated prior to the end of mine life (i.e. prior to post mining) to include the monitoring of brine re-injection, including establishment of trigger values for identifying and investigating potentially adverse groundwater impacts and trends.

3.7 Groundwater dependent ecosystems

The magnitude of predicted drawdown at 'high priority' GDEs will be significantly less than the estimated seasonal water table variation, and the drawdown will occur at a very slow rate. Minor changes to the groundwater regime may not have any adverse impacts on facultative GDEs that utilise groundwater as required (i.e. opportunistically); however, these ecosystems can dieback if reduced access to groundwater is prolonged, or if the change is too rapid that the trees are not able to adapt. No GDEs where predicted maximum drawdowns exceed 5 m (a threshold mentioned by the Independent Expert Scientific Committee **(IESC)** as being of interest [IESC and DPIE–Water 2021]) are mapped in areas overlying the longwall panels. Maximum impacts of more than 5 m are predicted at a small number of GDE sites to the east and south-east of the mine.

Three springs are identified as being potentially significant. The Mayfield Spring lies immediately to the east of the mine and has historically been used for stock-watering. The other two springs are the Hardys Spring and Eather Spring, located approximately 3.5 km and 5.5 km south of MLAs 1 and 2, respectively. Maximum drawdowns of less than 5 centimetres (**cm**) are predicted at all three springs. It is therefore considered unlikely that discharge from these springs will be significantly affected.

Post-closure re-injection of relatively small amounts of brine into goaf areas is not expected to impact water quality in adjacent units or at GDEs which are located at surface between 165 m and 400 m above the coal seams. Section 4.2.3 and section 4.5 detail the monitoring program for the GDE sites.

4. Groundwater monitoring

The Narrabri Mine groundwater monitoring program (section 4.5) provides for the collection of water quality and water level data. As groundwater monitoring considers local variations whenever possible, NCOPL utilises an analysis of historical data to determine the suitability of groundwater for a particular purpose at a monitoring location. Continued monitoring also provides for the ongoing collection of data to inform management decisions in relation to potential groundwater impacts arising from operations.

Key components of the groundwater monitoring program include:

- measurement of water levels in seepage, standpipe, and production bores;
- water quality sampling of seepage, standpipe and production bores;
- continuous measurement of water levels at the VWPs;
- continuous monitoring of water quality entering the underground mine workings;
- manual reading of the volume of groundwater pumped to surface from the box cut;
- water level and quality analysis at affected bores (more than2m predicted drawdown) in accordance with the 'make good' agreement (refer to section 3.4 and section 4.2.4); and
- photographs and site observations at identified springs and high priority GDE sites.

4.1 Existing monitoring network

The existing groundwater monitoring network includes groundwater quality sampling and field data collection from 45 individual monitoring locations comprising:

- 32 standpipe piezometers of which:
  - 21 are for general water quality and water level monitoring purposes; and
  - 11 are for monitoring of seepage around water management infrastructure.
- 7 vibrating wire piezometer locations (multi-level) with 4 individual sensors for water level monitoring; and
- one spring (Mayfield) for water quality and water monitoring.

Utilising this data, impact assessment criteria (trigger values) have been adopted (section 4.6) for:

- mine water inflow volume/rate;
- groundwater quality; and
- groundwater levels.

The groundwater monitoring network (including the additional groundwater monitoring locations described in the following sections) is shown on Figure 4-1 and is detailed in Table D-1, Appendix D. It is noted that as mining progresses, a number of the monitoring locations in Table D-1 will become obsolete due to undermining. As this occurs, NCOPL will assess the monitoring requirements and locations for replacement and revise this Plan accordingly (refer to section 4.4).

4.2 Additional monitoring network

4.2.1 New Quaternary Alluvium bores

NCOPL will establish additional bores at six new monitoring locations. Each location will comprise:

- two shallow standpipe monitoring bores monitoring groundwater levels and water quality in the Quaternary Alluvium and the immediately underlying bedrock; and
- a nested VWP facility including monitoring of all groundwater levels in consolidated units from the Hoskissons Coal Seam to the ground surface (VWPs to provide an 'early warning' of potential impacts).

The new monitoring bore locations are shown in Figure 4-1 (i.e. locations located upstream and downstream of the mine on Pine Creek, Kurrajong Creek, and Tulla Mullen/Sandy Creeks (or tributaries). Following commencement of the Stage 3 development, the monitoring bores described above will be installed. Bores P62 to P64, P68 to P70, P71 to P73 and P74 to P76 will be used as primary early warning monitoring bores for groundwater drawdown (refer to section 4.6.3). Trigger levels will be established for these bores according to the maximum predicted drawdown at these locations and following the collection of baseline data over six to eight monitoring events.

Indicative bore depths are based on the middle of the geology layers and are included in Table D-1, Appendix D. These depths are to be confirmed during drilling and inspection of bore logs. Once the bore details are confirmed, Table D-1 in Appendix D will be updated accordingly.

Surface water levels and field water quality parameters in any standing pools at the six locations will also be monitored (refer to section 4.2.3).

NCOPL will also assess the feasibility of using helium gas, or other tracers/indicators to investigate seam to surface connectivity above selected longwall panels.

4.2.2 Multilevel piezometer nests

NCOPL are required to install three multilevel piezometer nests in accordance with CoC B36(e)(iv) and as described in the IAPUM advice (IAPUM 2021):

- one additional multilevel piezometer nest at the northern end of longwall 111 (P77) on the centreline of the longwall and directly east of existing monitoring site P17;
- two nests within the extension mine area along the centreline of the first two longwalls to be mined (i.e. longwall 301 [P78] and longwall 302 [p79]), 300 m from their southern limit; and
- monitoring depths are to be in the middle of each of the main formations.

The locations of the additional VWPs are shown on Figure 4-1.

Following commencement of the Stage 3 development, the additional VWP bores described above will be installed. The indicative depths are based on the middle of the geology layers and are included in Table D-1, Appendix D. This Plan will be updated to confirm the new bore locations and details as presented in Table D-1, Appendix D. These depths are to be confirmed during drilling and inspection of bore logs. Additionally, the number of VWP sensors per bore will be limited based on diameter and other construction constraints and the number of sensors is to be confirmed with the VWP installation contractor.

4.2.3 Groundwater features

NCOPL are required to monitor at a number of potential 'high priority' GDE sites which have a predicted drawdown in excess of the relevant AIP threshold. These areas are predominantly located within the *Gunnedah Oxley Basin MDB Groundwater Source* and include areas which are mapped as being dominated by Red Gum, River Red Gum, shallow freshwater wetland sedgeland with smaller areas of Ironbark and Box grassy woodland. The majority of these mapped GDEs are located close to Tulla Mullen Creek to the southeast of the Narrabri Mine and in areas close to the Namoi River to the north-east.

Monitoring is also proposed at a number of other GDE sites including Hardy's, Mayfield, and Eather Springs and Blairmore Feature 1 and 2. Quaternary Alluvium monitoring bores P71, P72, P74 and P75 (Figure 4-1) are located within, or in close proximity to, the GDEs associated with Sandy Creek and its tributaries. These monitoring bores can provide additional data on ground water level and quality for determining potential impacts if required.

The monitoring includes 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 on the GDEs as a result of mining operations.

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

The monitoring locations described above are shown on Figure 4-1.

4.2.4 Privately-owned bores

As discussed in section 3.4, NCOPL has committed to conduct a groundwater yield test (where allowed by the installed bore head works), conduct annual groundwater level and quality monitoring, monitor any drawdown as it develops, and implement 'make good' agreements at privately owned bores with more than 2m drawdown.

Yield tests will be conducted at commencement of the monitoring agreement/s to determine a baseline of pumping equilibrium. Monitoring will also include water quality analysis for EC and pH and an annual laboratory analysis for physical parameters, cations, anions, dissolved metals, and nutrients.

Groundwater level and quality monitoring will be conducted in accordance with the monitoring program summary provided in section 4.5.

4.3 Relationship between measured EC and TDS

In accordance with Condition B36(e)(iv), NCOPL will 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 (refer to the SWMP [Attachment 3 of the WMP]);
- 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 6.3).

4.4 Groundwater monitoring network review

Where existing monitoring bores are to be impacted by subsidence, suitable alternatives will be required to be installed in consultation with a suitably qualified hydrogeologist. Baseline data collection will be required prior to mining activities commencing.

Those monitoring bores predicted to be impacted by subsidence will be detailed in the relevant Extraction Plan.

If there are any other significant changes to the groundwater monitoring network, this will be conducted in consultation with a suitably qualified hydrogeologist.

4.5 Groundwater monitoring program summary

The Narrabri Mine groundwater monitoring program is summarised in Table 4-1 and the monitoring locations are shown on Figure 4-1. A detailed list of all monitoring locations and the type of monitoring conducted at each location is provided in Table D-1, Appendix D.

Table 4-1 Groundwater monitoring program

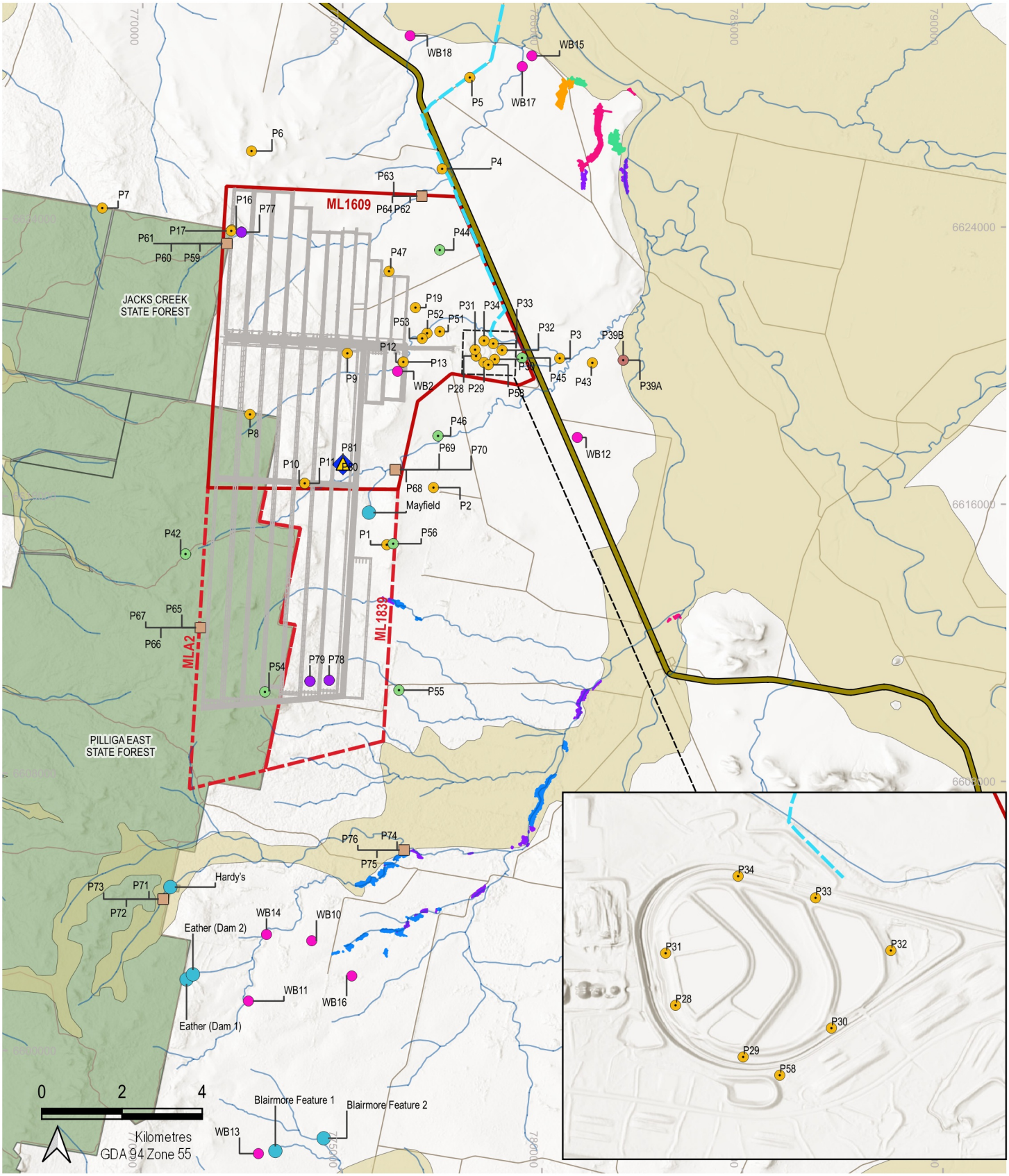
Monitoring focus	Monitoring type	Monitoring parameters	Frequency
Groundwater	VWPs **Sites:** P42, P44, P45, P46, P54, P55, P56, P61, P64, P67, P70, P73, P76, P77, P78, P79.	Pressure data.	Continuous with quarterly download of data
	Standpipes **Sites:** P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P16, P17, P19, P28, P29, P30, P31, P32, P33, P34, P39A, P39B, P43, P47, P51, P52, P53, P58, WB2, P59, P60, P62, P63, P65, P66, P68, P69, P71, P72, P74, P75.	• 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, chloride and fluoride); ▪ 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
	Additional 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

Monitoring focus	Monitoring type	Monitoring parameters	Frequency
	Additional monitoring of water quality entering the underground mine workings (i.e. within longwall panels).	• EC • TDS	Initial 6-month period and annually thereafter.
	Mine water pumping inflow and outflow.	Discharge rate	Monthly meter read
	Private bores with more than 2m predicted drawdown **Sites:** WB10, WB11, WB12, WB13, WB14, WB15, WB16, WB17, and WB18.	• 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, chloride and fluoride); ▪ 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).	Annually
Subsidence (subsurface cracking)	Subsidence calibration borehole P80 and geotechnical borehole P81 above LW 203^ – deep borehole piezometers, shallow standpipe piezometers and deep wireline extensometers.	• Water level • Displacement.	Continuous

Monitoring focus	Monitoring type	Monitoring parameters	Frequency
GDEs	Hardy's Mayfield, and Eather springs, Blairmore Feature 1 and 2, and mapped high priority GDEs.	• Site photographs (x4) and observations of: ▪ flow rates ▪ surface water levels and field water quality (EC and pH) in any standing pools. ▪ vegetation health.	Annually

Notes:

^ Location above LW 203 as recommended in the *Mine Subsidence Assessment for Longwalls LW203 to LW206 at the Narrabri Underground Mine* (Ditton Geotechnical Services 2022) and shown on Figure 4-1. The depths and formations associated with P81 will be determined during drilling.



WHITEHAVEN COAL

ONWARD CONSULTING

LEGEND

- ML1609
- MLA1
- MLA2
- Alluvium
- State forest
- Namoi River pipeline (buried)
- Surface disturbance area
- Highway
- Roads
- Watercourse

Groundwater monitoring sites

- Groundwater monitoring - standpipe nested
- Groundwater monitoring - standpipe single
- Groundwater monitoring - VWP nested
- New groundwater feature monitoring site
- New VWP location
- Privately owned bores >2m drawdown
- Quaternary Alluvium bores
- Subsidence calibration borehole
- Geotechnical Bore

High priority GDEs

- Box grassy woodland
- Narrow-leaved Ironbark
- Red Gum
- River Red Gum
- Shallow freshwater wetland sedgeland

NARRABRI MINE

FIGURE 4-1

Groundwater Monitoring Locations

4.6 Groundwater impact assessment criteria

4.6.1 Baseline data collection

Groundwater level and quality information has been routinely collected since 2007, some two years prior to commencement of mine operations in 2009. Whilst this is not the case for all monitoring locations, measurements and sampling is undertaken as soon as a location becomes operational. Historical water quality sampling and field data collection has been undertaken at 42 monitoring locations and the Mayfield Spring. These locations are screened within the various geological units identified in section 2.1. Depending on the monitoring location, NCOPL has collected groundwater data over a period ranging from three to 12 years.

This data collection enabled the establishment of baseline and background water level and water quality data. Through this process, it was established that unique water types exist with a rather large variation across each geological zone and across all monitoring bores. Because of the high variability in groundwater chemistry, it is therefore not feasible to single out individual bores for the establishment of background references.

Historical water level measurements have been collected at monitoring locations and used to inform calibration of, and updates to, the numerical groundwater modelling undertaken for the Narrabri Mine. To further demonstrate how baseline groundwater data was applied in the groundwater impact assessment (AGE 2020), the steady state and transient model simulated water levels in all available monitoring bores within the bedrock and alluvial aquifers. A total of 262 monitoring points were used to calibrate the model, comprising:

- 129 NSW State groundwater monitoring points, predominantly completed into the Namoi Alluvium;
- 115 monitoring points which form part of the Narrabri Mine monitoring network including a number of nested VWP facilities; and
- 18 monitoring points installed in the area to the west of the existing Narrabri Mine as part of the Narrabri Gas Project EIS.

4.6.2 Groundwater quality

Where suitable, the guideline water quality objectives for stock drinking water (beef cattle) and long-term irrigation have been adopted. These guideline values assume that groundwater is abstracted for the purpose associated with the identified environmental values and are based on guidance provided in OEH (2006) and ANZG (2018). However, because of the high variability in groundwater chemistry, groundwater quality may not meet the water quality objectives set in the ANZG (2018) at all locations and/or at all times.

As a result, water quality trigger values (Appendix E) have been developed for EC based on an assessment of historical data (AGE 2021) and utilising the methodology described in the Queensland Department of Science, Information Technology and Innovation guidelines "*Using monitoring data to assess groundwater quality and potential environmental impacts*" (DSITI 2017). In summary, the monitoring locations have been selected based on the suitability of the water quality (e.g irrigation or stock [beef cattle] drinking) and monitoring purpose.

The pH trigger values (Appendix E) have been derived from the ANZG (2018) recommended irrigation long term application pH range.

Since no significant drawdown and hence no significant water quality impacts are anticipated in the Namoi Alluvium and/or the Pilliga Sandstone, triggers have only been derived in a single monitoring bore in each of these aquifers.

Triggers for EC and pH

If pH is outside the range of 6.0 – 8.5 for three consecutive readings or the EC trigger value of 5,970 (µS/cm) is exceeded for three consecutive readings, the TARP (Level 2) will be initiated.

Two tiered triggers for EC

For those monitoring locations where water quality is unsuitable for use as irrigation / stock watering or where the intended purpose is seepage monitoring, two tiered EC triggers will be utilised. These triggers are not static values and are derived using the rolling median calculated from the eight most recent data points and plotted on a time series chart (control chart) that includes:

- individual data points;
- the 80th percentile calculated from the long-term dataset; and
- the 95th percentile calculated from the long-term dataset.

Two triggers are then identified as follows:

- Tier 1 – where the rolling median exceeds the 80th percentile of long-term data; and
- Tier 2 – where three consecutive exceedances of the 95th percentile of the long-term data occur. If this occurs, the TARP (Level 2) will be initiated.

The Tier 1 trigger provides a method for assessing a gradual change in groundwater quality over the medium term via use of the rolling median. Whilst the Tier 2 trigger is intended to detect an event related change over the short term.

Table 4-2 details the monitoring bores with an EC groundwater quality trigger.

Table 4-2 Monitoring bores with groundwater quality trigger criteria

Location ID	Easting (MGA 55)	Northing (MGA 55)	Bore Depth (m)	Screen Interval (m bgl)	Formation	Trigger criteria
P1	776116	6614694	50	44-50	Garrawilla Volcanics	ANZG (stock), bore specific
P2	777282	6616355	50	44-50	Napperby Formation	EC two tiered
P3	780433	6620115	45	34-40	Pamboola Formation	EC two tiered
P4	777490	6625553	30	24-30	Napperby Formation	EC two tiered
P6	772726	6626021	90	78-90	Pilliga Sandstone	ANZG (irrigation)
P7	768998	6624338	90	78-90	Pilliga Sandstone	ANZG (irrigation)
P8	772697	6618421	65	57-63	Purlawaugh Formation	ANZG (stock)
P9	775127	6620209	30	24-30	Purlawaugh Formation	EC two tiered
P10	774063	6616444	130	118-130	Napperby Formation (no sill)	EC two tiered
P11	774066	6616447	50	44-50	Purlawaugh Formation	EC two tiered
P12	776513	6619964	90	84-90	Napperby Formation (above sill)	ANZG (stock)
P13	776526	6619972	30	24-30	Garrawilla Volcanics/Napperby	ANZG (stock)
P16	772233	6623740	146	137-146	Garrawilla Volcanics	ANZG (stock), bore
P19	776827	6621543	187	184-187	Pamboola Formation	To be determined – never monitored
P29	778541	6619978	25	19-25	Napperby Formation (above sill)	EC two tiered
P31	778318	6620343	15	42248	Napperby Formation (above sill)	EC two tiered
P32	778993	6620335	15	41883	Napperby Formation (above sill)	EC two tiered
P39A	782024	6620076	80	72-78	Watermark Formation	ANZG (stock)
P39B	782018	6620077	32	15-30	Tullamullen Alluvium	ANZG (irrigation), bore specific
P43	781248	6619992	66	59-65	Watermark Formation	EC two tiered

Location ID	Easting (MGA 55)	Northing (MGA 55)	Bore Depth (m)	Screen Interval (m bgl)	Formation	Trigger criteria
P47	776166	6622586	31	8-30.5	Garrawilla Volcanics	ANZG (stock)
P51	777437	6620859	17	44174	Garrawilla Volcanics	EC two tiered
P52	777118	6620808	24	18-21	Napperby Formation	EC two tiered
P53	776995	6620655	24	18-21	Garrawilla Volcanics	EC two tiered
WB2	776382	6619701	26	22-26	Garrawilla Volcanics	ANZG (stock)

4.6.3 Groundwater levels

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). In cases where the maximum predicted drawdown exceeds the bottom of the bore "a conservative trigger level of one metre above the base of bore screen was adopted". The resulting annual trigger levels for each monitoring bore are presented in Table 4-3 (adopted trigger levels m AHD). Should observed water levels fall below the adopted trigger levels shown in Table 4-3, the TARP (section 5) will be initiated.

Interim yearly trigger values for the nine privately owned bores that have a predicted drawdown of more than 2m (adopted trigger levels m AHD) are presented in Table 4-4. The interim groundwater levels have been derived from the recalibrated numerical groundwater model (AGE 2020) based on the maximum predicted drawdown for each bore. The yearly trigger levels will be confirmed following collection of baseline groundwater level data over six to eight monitoring events. If a trigger level is exceeded for a given year, the TARP (section 5) will be initiated.

If the drawdown meets or exceeds the 2 m AIP criteria, the 'make good' agreements will apply (refer to section 3.4).

Early warning

Several of the new VWPs detailed in section 4.2.1 will be used as primary early warning detection for groundwater level drawdown at the boundary of the alluvium (i.e. predicted 2m drawdown contour) once trigger levels have been established.

NCOPL will also utilise existing monitoring bores P3, P4 and P5 as primary early warning detection bores (Figure 4-1). Monitoring bores P3, P4 and P5 are 45, 30 and 30 m deep, respectively and are constructed in the bedrock below the regolith (Napperby and Pamboola formations). These bores have groundwater level triggers as per Table 4-3. If drawdown exceeds the trigger level/s detailed in Table 4-3 or Table 4-4, the TARP (section 5) will be initiated.

The predicted groundwater levels at monitoring bores with no triggers will also be used as an internal early warning system for NCOPL.

Table 4-3 Groundwater level triggers for life of mine (m AHD)

Location ID	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
P1	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4	271.4
P2	242.7	240.4	238.4	236.8	235.5	234.3	233.2	232.2	231.3	230.4	229.6	229.0	228.5	228.0	227.6	227.2	226.8	226.4	226.2	226.2	226.2	226.1	226.0
P3*	223.7	223.4	223.1	222.8	222.5	222.2	221.9	221.5	221.2	220.9	220.7	220.4	220.1	219.8	219.5	219.2	219.0	218.7	218.5	218.2	218.0	217.8	217.6
P4*	228.3	228.0	227.8	227.6	227.4	227.2	227.0	226.9	226.7	226.5	226.4	226.2	226.0	225.9	225.7	225.6	225.4	225.2	225.1	224.9	224.8	224.7	224.6
P5*	205.4	205.2	205.0	204.7	204.5	204.2	203.9	203.6	203.3	202.9	202.5	202.2	201.8	201.4	201.1	200.7	200.3	199.9	199.5	199.2	198.8	198.4	198.1
P8	271.5	271.5	271.5	271.5	271.5	271.4	270.9	270.3	269.9	269.6	269.5	269.3	269.2	269.2	269.1	269.1	269.0	269.0	269.0	268.9	268.9	268.9	268.9
P9	267.7	267.7	262.4	262.8	263.3	263.6	263.8	264.0	264.1	264.2	264.2	264.2	264.3	264.3	264.3	264.3	264.3	264.3	264.3	264.3	264.3	264.3	264.2
P10	274.2	272.5	270.2	267.6	264.4	261.0	257.9	255.2	253.2	251.8	250.8	250.0	249.4	248.8	248.3	247.7	247.0	246.2	245.5	244.9	244.5	244.1	243.8
P11	279.7	279.7	279.6	277.8	273.1	272.9	272.9	272.9	273.2	273.3	273.4	273.5	273.8	273.9	273.9	274.0	274.0	274.0	274.0	274.0	274.0	274.0	274.0
P12	197.1	195.6	194.0	193.1	192.4	191.8	191.3	190.8	190.2	189.6	189.2	188.9	188.7	188.5	188.2	188.0	187.8	187.6	187.4	187.2	187.0	186.8	186.6
P13	267.0	266.9	266.8	266.7	266.6	266.5	266.4	266.3	266.2	263.4	262.6	262.4	262.3	262.2	262.2	262.2	262.2	262.2	262.2	262.2	262.2	262.2	262.2
P16	244.0	242.8	242.1	241.5	240.9	240.4	239.8	239.3	238.7	237.3	236.0	235.3	234.8	234.3	233.7	232.9	232.3	231.7	231.4	231.1	230.8	230.6	230.4
WB2	257.9	257.8	257.7	257.6	257.5	257.4	257.4	257.3	255.9	249.7	250.9	251.2	251.4	251.6	251.8	251.9	252.0	252.1	252.2	252.3	252.4	252.4	252.4
P39B*	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1	222.1

Note:
*Primary early warning monitoring bores

Table 4-4 Yearly interim and 2m AIP groundwater level triggers for private bores (m AHD)

Bore	2m drawdown trigger level	Predicted year 2m drawdown reached	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
WB10 (GW013858)	280.6	2092	282.8	282.8	282.8	282.8	282.8	282.8	282.8	282.8	282.7	282.7	282.7	282.7	282.7	282.7	282.6	282.6	282.6	282.5	282.4	282.4	282.2	282.1	282.0
WB11 (House Bore)	302.6	2300	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.6	304.5	304.5	304.5	304.5	304.5	304.5	304.5
WB12 (257_Bore)	222.4	2035	223.9	223.9	223.8	223.7	223.6	223.5	223.4	223.2	223.1	223.0	222.8	222.7	222.5	222.4	222.3	222.1	222.0	221.8	221.7	221.5	221.4	221.2	221.1
WB13 (GW008634)	305.2	2133	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2	307.2
WB14 (GW026121)	284.6	2509	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.7	286.6	286.6	286.6	286.6	286.6	286.6	286.6	286.6	286.6
WB15 (Windmill Bore)	211.7	2051	213.6	213.6	213.5	213.5	213.5	213.4	213.4	213.3	213.2	213.2	213.1	213.0	213.0	212.9	212.8	212.7	212.7	212.6	212.5	212.4	212.4	212.3	212.2
WB16 (South Caloola)	244.1	2044	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.2	246.1	246.0	245.7	245.5	245.3	245.1	244.9	244.7	244.5	244.3	244.1
WB17 (GW903687 - Solar Bore)	212.0	2044	213.8	213.7	213.6	213.6	213.5	213.4	213.3	213.3	213.2	213.1	213.0	212.9	212.9	212.8	212.7	212.6	212.5	212.4	212.3	212.3	212.2	212.1	212.0
WB18 (Mentone Bore)	212.3	2028	213.5	213.3	213.1	212.9	212.7	212.5	212.3	212.1	211.9	211.7	211.5	211.4	211.2	211.0	210.9	210.7	210.4	210.2	210.0	209.7	209.5	209.3	209.1

5. Trigger Action Response Plan

The TARP provided in Table 5-1 has been developed to focus upon appropriate triggers and associated response actions for mitigation of impacts to groundwater and other water users.

The responses proposed incorporate an assessment and development of management measures deemed appropriate for each individual event should it occur.

The triggers for instigation of response actions will occur when observed changes to monitored parameters exceed specified trigger levels. Such changes in observed parameters or conditions may include:

- sudden inrush of groundwater into the mine in exceedance of predicted inflows;
- trigger value exceedances in observed water quality or groundwater levels between sampling rounds; and
- significant variation from model predictions.

The trigger values for each monitoring methodology outlined in Table 5-1 are provided in the following sections of this Plan:

- Groundwater levels – section 4.6.3; and
- Groundwater quality – Appendix E.

Where groundwater level triggers are exceeded for three consecutive monitoring events (Level 2), this will result in an additional assessment by a hydrogeologist as defined in the TARP (Table 5-1). The primary aim of the assessment will be to assess if the trigger level exceedance is related to mining activities. The assessment will include collation or consideration of the following data sets:

- groundwater level records both for the mine monitoring network and other local monitoring bores (where relevant);
- surface water level or flow records for the mine monitoring network;
- updated local climate data;
- mine inflow volumes;
- mine subsidence monitoring data;
- available information on other local activities which might influence groundwater levels (other resource extraction activities, landholder bore operations etc); and
- validation of the numerical model 2m drawdown zone in the upper regolith/alluvium (for early warning monitoring bores only). If drawdowns outside the expected range occur, it should then be considered to install additional monitoring bores closer to the alluvium and the conditions re-assessed.

These data sets will then be reviewed to confirm whether or not the observed exceedance/s is likely to be related to operation of the Narrabri Mine and/or other external factors (climate, other local activities etc).

Where necessary, the existing Groundwater Flow Model (AGE 2020) can then be used to further quantify the contribution of difference sources of impact. Where trigger exceedances appear to be related to subsidence impacts, then the existing numerical model can be re-run with updated climate data and revised parameterisation of fracture zones above the mine to quantify the contribution of these two stresses to the observed drawdown.

Table 5-1 Trigger Action Response Plan

Method	Status	Trigger	Action	Response
Groundwater levels				
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:** P1, P2, P3*, P4*, P5*, P8, P9, P10, P11, P12, P13, P16, WB2, P39B*, WB10^, WB11^, WB12^, WB13^, WB14^, WB15^, WB16^, WB17^, and WB18^. **Parameters:** Water level. **Frequency:** Quarterly manual monitoring of groundwater levels and automatic groundwater level monitoring via VWPs (downloaded quarterly). Privately owned bores - Annually	**Normal**	Routine monitoring indicates water level below trigger levels.	None required	Continue routine groundwater monitoring and evaluation of results.
	Level 1	Routine monitoring indicates drawdown exceeds trigger level (i.e. single exceedance) (Table 4-3 and Table 4-4).	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. • For privately owned bores, notify landholder that exceedance has occurred.
	Level 2	Routine monitoring indicates drawdown exceeds trigger level over three consecutive monitoring events OR drawdown meets or exceeds the AIP 2 m drawdown criteria (Table 4-3 and Table 4-4).	• Conduct preliminary quality assurance of data to confirm an exceedance. • Environmental Superintendent to implement contingency and notification measures as per section 6 of the WMP.	• 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. • For privately owned bores, notify landholder that exceedance has occurred. If the AIP 2 m drawdown criteria is exceeded, the make good agreements will be implemented which may include compensatory water supply (CoC B28 to B32).

Method	Status	Trigger	Action	Response
Groundwater quality				
To assess performance of water management infrastructure. **Sites:** P1, P2, P3, P4, P6, P7, P8, P9, P10, P11, P12, P13, P16, P19, P29, P31, P32, P39A, P39B, P43, P47, P51, P52, P53, WB2, WB10^, WB11^, WB12^, WB13^, WB14^, WB15^, WB16^, WB17^, and WB18^. **Parameters:** EC and pH **Frequency:** Quarterly	**Normal**	Routine monitoring indicates water quality below the EC or pH trigger value.	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).	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.
	Level 2	Routine monitoring indicates water quality exceeds the EC or pH trigger value over three consecutive monitoring events.	• Conduct preliminary quality assurance of data to confirm an exceedance. • Environmental Superintendent to implement contingency and notification measures as per section 6 of the WMP.	• 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.

Notes:
***Primary early warning monitoring bores**
^Private landholder bore

6. Reporting, evaluation and review

Monitoring results will be reviewed against the impact assessment criteria detailed in section 4.6 and Appendix E. Where an exceedance of the relevant criteria or performance measures has occurred, NCOPL will implement the actions outlined in the TARP (Table 5-1) and the procedures outlined in section 6.2 of the WMP. In accordance with CoC B36(e)(iv), NCOPL will notify other water users of any elevated monitoring results.

Reporting of the water level results from the monitoring network will be included in the Annual Review. The reporting will include 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).

All internal and external reporting and the review of this document will be undertaken in accordance with section 7 of the WMP.

6.1 Data quality assurance plan

6.1.1 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 should 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 6-1. The flowchart outlines the pre-processing steps, including QA/QC undertaken for groundwater level data analysis.
- As indicated in Figure 6-1, manual standing water levels and electronic pressure logger/VWP data will be converted to a reduced water level with respect to Australian heigh datum (m AHD). Pressure logger data will be adjusted to remove the effects of barometric pressure changes where required.

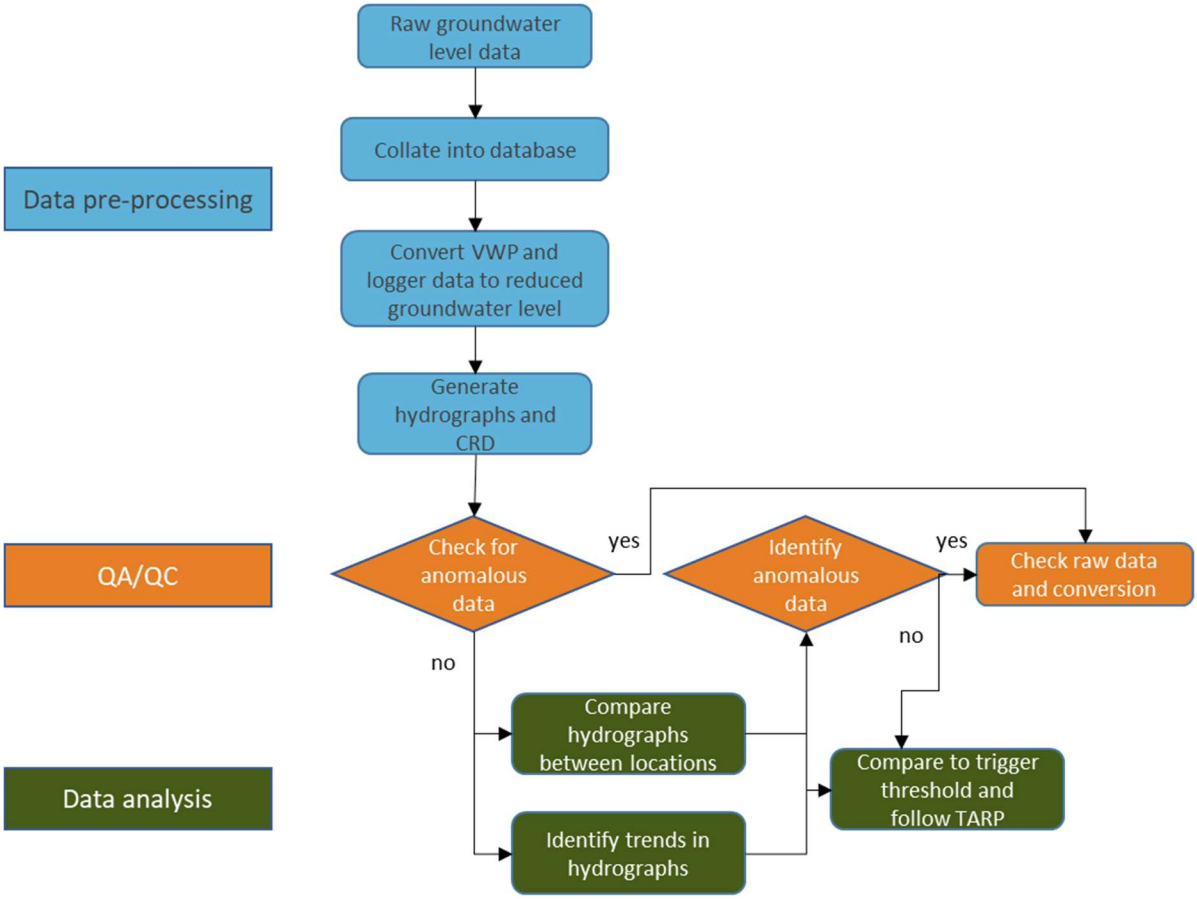


Figure 6-1 Groundwater level data pre-processing and analysis flowchart

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 6-2. Similar to the water level flowchart (Figure 6-1), this flowchart outlines the pre-processing, including QA/QC, as well as the steps that will be undertaken for groundwater quality data analysis.

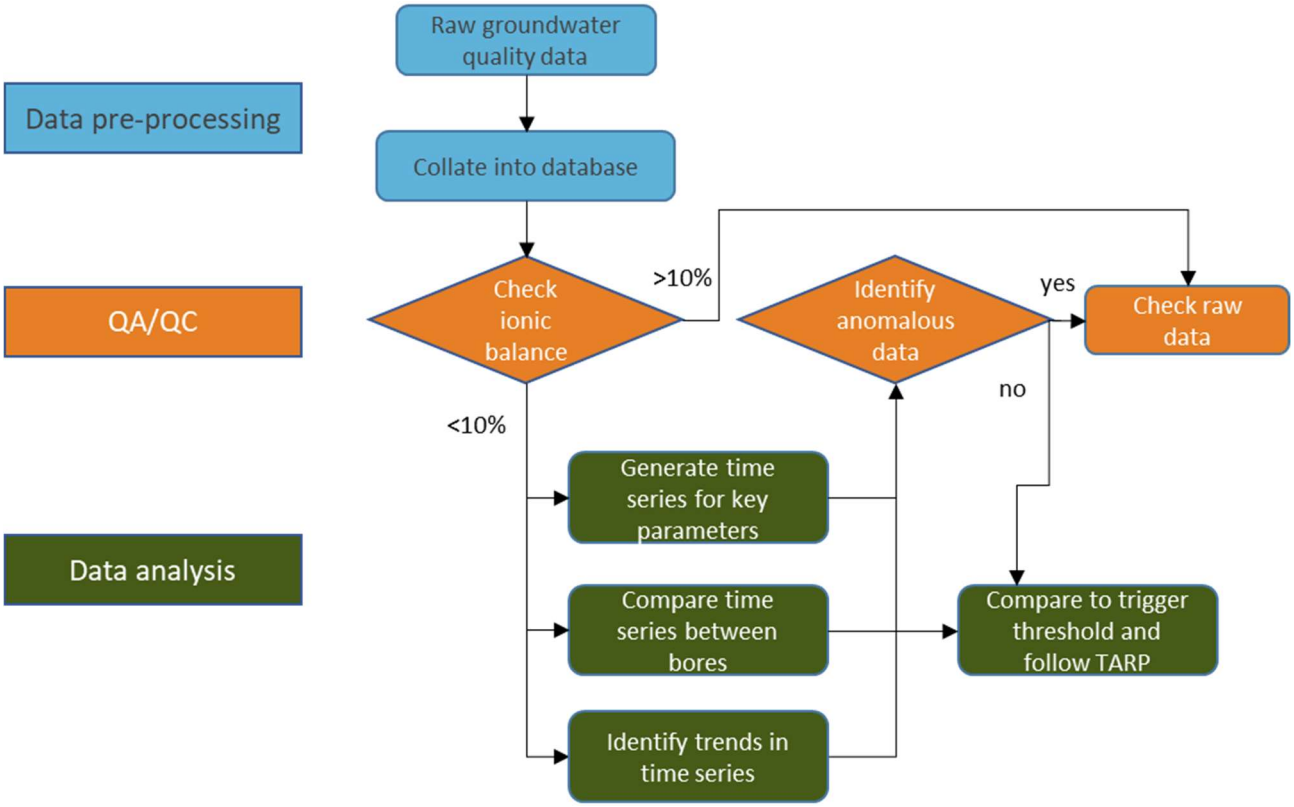


Figure 6-2 Groundwater quality data pre-processing and analysis procedures

6.1.2 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.

6.2 Groundwater model

The numerical model developed for the Stage 3 EIS (AGE 2020) 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 two years after the commencement of the Stage 3 development and every five years thereafter in consultation with DPE Water. If significant impacts on groundwater above the mine are identified, then NCOPL will reduce the period from five years to three years for at least the second update to capture new knowledge acquired.

The results of the groundwater monitoring program will assist to refine the numerical model, having regard to any impacts that may be occurring at the time due to the cumulative operation of Narrabri Mine and the Narrabri

Gas Project. Model calibration will predominantly use the available groundwater level data, estimated actual mine inflows and estimated baseflows in major local water courses.

In accordance with CoC B36(iv), during the first review, NCOPL will take into consideration all comments received regarding the groundwater model included in the Stage 3 EIS from DPE Water, the Independent Expert Scientific Committee (**IESC**) and the IAPUM.

Other circumstances which may trigger further development or refinement of the groundwater model include:

- a significant change to the mine plan and/or sequence;
- acquisition of new hydrogeological information, such as groundwater levels and aquifer properties (i.e. hydraulic conductivity) which are different to calibrated values used in the model; and
- groundwater drawdown and inflows which significantly exceed model predictions for that stage of mining.

Revised outputs from the numerical model will be reported periodically over the life of mine and incorporated into reviews of the Site Water Balance.

Should any review or post-audit indicate a significant variance from the model predictions with respect to either water quality or groundwater levels, then the implications of such variance will be assessed, and appropriate response actions implemented in consultation with DPE Water as appropriate. This may also include an independent peer review as requested by the Planning Secretary.

6.3 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 (e.g. the EC Tier 1 trigger 80th percentile rolling median as described in section 4.6.2), and compare observed groundwater quality and groundwater levels to the trigger values presented in Appendix E.

The review will also:

- 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 Appendix E;
- 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) as required by CoC B36(e)(iv);
- 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; 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.

7. References

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

Australasian Groundwater & Environmental Consultants (AGE) (May 2021). *Narrabri Underground Mine Stage 3 Extension Project Round 3 Bore Census.* Prepared for Narrabri Coal Operations Pty Ltd

Australasian Groundwater & Environmental Consultants (AGE) (31 May 2021). *Memorandum RE: Narrabri Underground Mine Stage 3 Extension Project – Impact Assessment Addendum*

Australasian Groundwater & Environmental Consultants (AGE) (June 2021). *Memorandum RE: Proposed groundwater quality trigger values and locations.* Prepared for Narrabri Coal Operations Pty Ltd

Queensland Department of Environment and Science (DES) (2021). *Using monitoring data to assess groundwater quality and potential environmental impacts.* Version 2. Queensland Government, Brisbane.

Independent Advisory Panel for Underground Mining (September 2021). *Advice Re: Narrabri Underground Mine Stage 3 Extension Project*

NSW Department of Primary Industries – Office of Water (2012). *Aquifer Interference Policy*.

NSW Office of Environment and Heritage (OEH) (2006). *NSW Water Quality and River Flow Objectives.* Retrieved from https://www.environment.nsw.gov.au/ieo/Namoi/index.htm

NSW Water Resources Commission, 1986-1988. *Australia 1:250 000 hydrogeological series / compiled by Hydrogeological Section, Water Resources Commission of New South Wales*

Queensland Department of Science, Information Technology and Innovation (March 2017). *Using monitoring data to assess groundwater quality and potential environmental impacts.* Version 1.

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*

8. Review history

Revision	Comments	Author	Authorised by	Date
0A	Approved by Department of Planning and Environment on 5 October 2023	Onward Consulting	Manager HSE	1 December 2022

Department of Planning and Environment

Our ref: SSD-10269-PA-24

Brent Baker
Manager HSE
Narrabri Coal Operations Pty Ltd
10 Kurrajong Creek Road
Baan Baa, NSW, 2390

05/10/2023

Subject: Narrabri Coal Stage 3 – Ground Water Management Plan

Dear Mr. Baker

I refer to your submission requesting review and approval of the Ground Water Management Plan for the Narrabri Coal Stage 3 project. I also acknowledge your response to the Department's review comments and request for additional information.

I note the Ground Water Management Plan has been prepared in consultation with DPE Water and EPA, and contains the information required by the conditions of approval.

The Department has carefully reviewed the document and is satisfied that it meets the requirements of the relevant conditions in Development Consent (SSD-10269).

Accordingly, as nominee of the Planning Secretary, I approve the Ground Water Management Plan (Rev 0A, dated 29 November 2022).

Please ensure you make the document publicly available on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Wayne Jones on (02) 6575 3406).

Yours sincerely

Stephen O'Donoghue
Director
Resource Assessments
As nominee of the Planning Secretary

Appendix A - Compliance conditions relevant to this Plan

Table A-1 SSD 10269 consent conditions directly relevant to this Plan

Condition	Requirement	Document reference
Obligation to minimise harm to the environment		
A1.	In addition to meeting the specific performance measures and criteria established under this consent, the Applicant must implement all reasonable and feasible measures to prevent, and if prevention is not reasonable and feasible, minimise, any material harm to the environment that may result from the construction and operation of the development, and any rehabilitation required under this consent.	Section 1.3 Section 3 Section 6.2 of the WMP
Evidence of Consultation		
A20.	Where conditions of this consent require consultation with an identified party, the Applicant must: (a) consult with the relevant party prior to submitting the subject document; and (b) provide details to the Department of the consultation undertaken including: (i) the outcome of that consultation, matters resolved and unresolved; and (ii) details of any matters not resolved between the party consulted and the Applicant and how the Applicant has addressed the matters not resolved.	Section 1.4 of WMP
Staging, combining and updating strategies, plans or programs		
A21.	With the approval of the Planning Secretary, the Applicant may:	
	a) prepare and submit any strategy, plan or program required by this consent on a staged basis (if a clear description is provided as to the specific stage and scope of the development to which the strategy, plan or program applies, the relationship of the stage to any future stages and the trigger for updating the strategy, plan or program);	No staging of GWMP proposed
	b) combine any strategy, plan or program required by this consent (if a clear relationship is demonstrated between the strategies, plans or programs that are proposed to be combined);	No combining of GWMP with another plan proposed
	c) update any strategy, plan or program required by this consent (to ensure the strategies, plans and programs required under this consent are updated on a regular basis and incorporate additional measures or amendments to improve the environmental performance of the development); and	Section 6
	d) combine any strategy, plan or program required by this consent with any similar strategy, plan or program required by an adjoining mining consent or approval, in common ownership or management.	No combining of GWMP with another plan proposed
Compliance		
A30.	The Applicant must ensure that all of its employees, contractors (and their sub-contractors) are made aware of, and are instructed to comply with, the conditions of this consent relevant to activities they carry out in respect of the development.	Section 2 of the WMP
Applicability of guidelines		
A31.	References in the conditions of this consent to any guideline, protocol, Australian Standard or policy are to such guidelines, protocols, Standards or policies in the form they are in as at the date of inclusion (or later update) in the condition.	Section 3.7 of the WMP
A32.	However, consistent with the conditions of this consent and without altering any limits or criteria in this consent, the Planning Secretary may, in respect of ongoing monitoring and management obligations, agree to or require compliance with an	

Condition	Requirement	Document reference
	updated or revised version of such a guideline, protocol, Standard or policy, or a replacement of them.	
Compensatory Water Supply		
B27.	Prior to the commencement of development under this consent, the Applicant must notify owners of licensed privately-owned groundwater bores that are predicted to have a drawdown of greater than 2 metres as a result of the development. This notification must set out the terms whereby the Applicant proposes to give effect to landowner entitlements and the Applicant's responsibilities under conditions B28 to B32 (i.e. a 'make good' agreement).	Section 3.4 Section 5
B28.	The Applicant must provide a compensatory water supply to any landowner of privately-owned land whose rightful water supply is adversely and directly impacted (other than an impact that is minor or negligible) as a result of the development, to the satisfaction of the Planning Secretary. The burden of proof that any loss of surface water or groundwater access is not due to mining impacts rests with the Applicant.	
B29.	The compensatory water supply measures must provide an alternative long-term supply of water that is equivalent, in quality and volume, to the loss attributable to the development. Equivalent water supply will be provided as soon as practicable after commencement of development under this consent, unless otherwise agreed with the landowner.	
B30.	If the Applicant is unable to provide an alternative long-term supply of water, then the Applicant must provide compensation, to the satisfaction of the Planning Secretary. **Notes:** ▪ *The Water Management Plan (see condition B34) is required to include trigger levels for investigating potentially adverse impacts on water supplies.*	
B31.	The Applicant must complete all measures that it is required to undertake under conditions B28 – B30 within two years of the date of commencement of development under this consent.	
B32.	If the Applicant and a landowner cannot agree on whether the loss of water is to be attributed to the development or the measures to be implemented under conditions B28 – B31, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Planning Secretary for resolution.	
Water Management Performance Measures		
B34.	The Applicant must comply with the performance measures in Table 4. ***Table 4: Water management performance measures***	Section 3 Section 5

Feature	Performance measure
Namoi Alluvium	No subsidence impact or environmental consequence greater than predicted in the EIS.
Water management – general	• Maintain separation between clean, dirty (i.e. sediment-laden) and mine water management systems; • Minimise the use of clean and potable water on the site; • Maximise water recycling, reuse and sharing opportunities; • Minimise the use of make-up water from external sources; • Design, install, operate and maintain water

Condition	Requirement		Document reference
		management systems in a proper and efficient manner; and • Minimise risks to the receiving environment and downstream water users.	
	Mine water discharges	Negligible environmental consequences beyond those predicted in the document/s listed in condition A2(c).	
Water Management Plan			
B36.	This plan must:		
	(c) be prepared by a suitably qualified and experienced person/s;		Section 1.4 of the WMP
	(d) be prepared in consultation with DPIE Water and the EPA;		
	(e) describe the measures to be implemented to ensure that the Applicant complies with the water management performance measures (see Table 4);		Section 3
	(f) build on existing monitoring programs and utilise existing data from nearby mines, where practicable;		Section 4
	(g) include a:		
	(iv) **Groundwater Management Plan** that includes:		
	• detailed baseline data of groundwater levels, yield and quality for groundwater resources potentially impacted by the development; including groundwater supply for other water users;		Section 2
	• measures to identify relationships between measured electrical conductivity and total dissolved solids in mine water and groundwater in the Hoskissons Seam and adjoining aquifers;		Section 6.3
	• a monitoring program for groundwater dependent ecosystems which may be impacted by the development, including (but not limited to) mapped 'high priority' features on the Namoi River floodplain, Tulla Mullen Creek and Little Sandy Creek and the Mayfield, Hardys and Eather Springs;		Section 4.2.3 Section 4.5
	• a detailed description of the groundwater management system;		Section 3
	• details of the proposed metering, monitoring and modelling measures;		Section 4 Section 6 Section 3.5 of the SWB (Attachment 1 of the WMP)
	• groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts (or trends) associated with the development (including for brine reinjection), on		
	- regional and local aquifers (alluvial and hardrock); and		Section 4.6 Section 5 Appendix E
	- groundwater supply for other water users such as licensed privately-owned groundwater bores;		Section 4.6.3 Section 5
	• implementation of the IAPUM's recommendations concerning installation of multilevel piezometer nests above longwalls 111,		Section 4.2.2

Condition	Requirement	Document reference
	203 and 204;	
	• a program to monitor and evaluate:	Section 4 Section 5 Section 6
	- compliance with the relevant performance measures listed in Table 4 and the performance criteria of this plan;	
	- water loss/seepage from water storages into the groundwater system;	
	- groundwater inflows, outflows and storage volumes, to inform the Site Water Balance;	
	- the hydrogeological setting of any nearby alluvial aquifers and the likelihood of any indirect impacts from the development;	
	- the effectiveness of the groundwater management system;	
	- the impact of any brine re-injection on salt concentrations in surrounding aquifers, for a period of 10 years following any such re-injections or such other period as required by the Planning Secretary;	
	• reporting procedures for the results of the monitoring program, including notifying other water user of any elevated results;	Section 6
	• a trigger action response plan to respond to any exceedances of the relevant performance measures and groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development;	Section 5
	• regular review of the groundwater model for the development, including:	Section 6.2
	- review within two years from the commencement of longwall mining under this consent and every five years thereafter throughout the life of the development (unless the Planning Secretary agrees otherwise) in consultation with DPIE Water;	
	- during the first review, consideration of all comments received regarding the groundwater model included in the EIS from DPE Water, the IESC and the IAPUM; and	
	- implementation of the IAPUM's recommendations which relate to review and development of the groundwater model (including that the five-year groundwater model review period be shortened to three years if greater than predicted impacts on groundwater are identified above the mine);	
	- independent peer review if requested by the Planning Secretary; and	
	- comparison of monitoring results with modelled predictions; and	
	• a plan to respond to any exceedances of the performance measures; and	Section 5 Section 6.3
Management Plan requirements		
E5.	Management plans required under this consent must be prepared in accordance with relevant guidelines, and include:	

Condition	Requirement	Document reference
	a) summary of relevant background or baseline data;	Section 2
	b) details of:	
	i) the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 1.4
	ii) any relevant limits or performance measures and criteria; and	Section 3 Section 4.6 Appendix E
	iii) the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 4.6 Section 5 Appendix E
	c) any relevant commitments or recommendations identified in the document/s listed in condition A2(c);	Appendix B
	d) a description of the management measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;	Section 3
	e) a program to monitor and report on the:	
	i) impacts and environmental performance of the development; and	Section 4
	ii) effectiveness of the management measures set out pursuant to paragraph (d);	
	f) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 5
	g) a program to investigate and implement ways to improve the environmental performance of the development over time;	Section 7.6 of the WMP
	h) a protocol for managing and reporting any:	
	i) incident, non-compliance or exceedance of any impact assessment criterion or performance criterion;	Section 6 of the WMP
	ii) complaint; or	Section 8 of the WMP
	iii) failure to comply with other statutory requirements;	Section 6.2 of the WMP
	i) public sources of information and data to assist stakeholders in understanding environmental impacts of the development; and	Section 3.7 of the WMP
	j) a protocol for periodic review of the plan.	Section 6
E6.	The Applicant must ensure that management plans prepared for the development are consistent with the conditions of this consent and any EPL issued for the site.	Appendix A Appendix B

Table A-2 EPL 12789 conditions relevant to this Plan

Condition	Requirement	Document reference
Discharges to Air and Water and Applications to Land		
P1	**Location of monitoring/discharge points and areas** P1.3 The following points referred to in the table are identified in this license for the purposes of the monitoring and/or the setting of limits for discharges of pollutants to water from the point.	Section 4 Appendix D

EPA ID No.	Type of monitoring point	Type of discharge point	Location description including NCOPL ID no.
28	Groundwater Monitoring Bore		P28
29	Groundwater Monitoring Bore		P29
30	Groundwater Monitoring Bore		P30
31	Groundwater Monitoring Bore		P31
32	Groundwater Monitoring Bore		P32
33	Groundwater Monitoring Bore		P33
34	Groundwater Monitoring Bore		P34
35	Groundwater Monitoring Bore		P58

Monitoring and Recording Conditions		
M2	**Requirement to monitor concentration of pollutants discharged** M2.1 For each monitoring/discharge point or utilisation area specified below (by a point number), the licensee must monitor (by sampling and obtaining results by analysis) the concentration of each pollutant specified in Column 1. The licensee must use the sampling method, units of measure, and sample at the frequency, specified opposite in the other columns: M2.3 Water and/or Land Monitoring Requirements	Section 4 Appendix D

Point 28. 29, 30, 31, 32, 33, 34, 35			
Pollutant	**Units of measure**	**Frequency**	**Sampling Method**
Bicarbonate	mg/L	Quarterly	Representative sample
Calcium	mg/L	Quarterly	Representative sample
Carbonate	mg/L	Quarterly	Representative sample
Chloride	mg/L	Quarterly	Representative sample
Electrical Conductivity	µS/cm	Quarterly	In situ
Magnesium	mg/L	Quarterly	Representative sample
pH	pH	Quarterly	In situ
Potassium	mg/L	Quarterly	Representative sample
Sodium	mg/L	Quarterly	Representative sample

Condition	Requirement	Document reference

Standing Water Level		Quarterly	In situ
Sulfate	mg/L	Quarterly	Representative sample

M2.6 Note: Groundwater monitoring has not been formally included in the licence. However, the licensee is required to undertake groundwater monitoring in accordance with the Department of Planning and Environment approved "Stage 2 Water Management Plan" required under Schedule 4, condition 18 of the Project Approval (08_0144) for the Stage 2 project. The results of this monitoring are required to be reported in the Annual Review.

Appendix B - Key EIS commitments

Table B-1 Key EIS groundwater management commitments

Source	Aspect	Details	Reference
Submissions Report Section 4.2.1	Validation of actual groundwater take and licensing and predictions	NCOPL supports the development of a comprehensive water balance to directly measure groundwater take as it occurs at the underground operations to validate groundwater take predictions and to inform model updates and licence requirements. Section 7 of the Surface Water Assessment (WRM, 2020) describes the water balance modelling undertaken for the Narrabri Mine operations. Water balance modelling has been continually refined and updated since mining operations commenced to incorporate changes in procedures and metered water data. The model is deemed by WRM to be suitably calibrated and sufficient to be used to define the volume of dewatered groundwater, separate from returned underground mine-filtered water. The process used to calculate these volumes (i.e. by analysing flow meter data for pumps into and out of the mine) is described in Section 5.5 of the Surface Water Assessment. NCOPL will continue collecting and metering all inflows and outflows and to use the water balance model to calculate the groundwater take.	Section 3.1 Section 3.2 Section 3.3 Section 3.4 Section 3.5 Section 4
EIS Section 6.4.4	Groundwater Monitoring	The recommendations of the Groundwater Assessment (Appendix B), in regard to the continuation of groundwater monitoring, will be adopted for Stage 3. In addition, consistent with the recommendations made by AGE, NCOPL will establish additional groundwater monitoring locations in the vicinity of Pine, Kurrajong and Tulla Mullen Creeks (or tributaries) (locations will be confirmed in consultation with relevant regulatory agencies and landowners).	Section 4.2.1
EIS Section 6.4.4	Groundwater Monitoring - Groundwater Levels	Groundwater monitoring will be undertaken in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version) and Extraction Plans for Narrabri Mine. The current monitoring regime involves monthly measurement of water levels in piezometers, and continuous automated monitoring of water levels from the network of VWPs.	Section 4
EIS Section 6.4.4 Amended BDAR Section 6.2.22	Groundwater Monitoring - Groundwater Levels	Ongoing monitoring will also be used to assess the extent and rate of drawdown and depressurisation against model predictions.	Section 4.6 Section 5 Section 6.3
EIS Section 6.4.4	Groundwater Monitoring - Groundwater Levels	Reporting of the water level results from the monitoring network will be included in the Annual Review. The reporting will include 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). The Annual Review will also identify if any improvements are required to the monitoring network, or if optimisation of the existing monitoring sites will be undertaken.	Section 6 Section 6.2
EIS Section 6.4.4	Groundwater Monitoring - Groundwater Quality	Reporting of the water quality results from the monitoring network would be included in the Annual Review. The Annual Review would consider if any additional monitoring sites are required, or if optimisation of the existing monitoring sites, frequency of sampling and analytical suite should be undertaken.	Section 6 Section 6.3
EIS Section 6.4.4	Groundwater Monitoring - Groundwater Quality	Groundwater quality sampling will continue to be conducted to monitor groundwater quality during operations and post-mining in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version) and Extraction Plans for Narrabri Mine. The current monitoring regime includes monthly sampling of piezometers (EC and pH), as well as annual sampling for a broader suite of parameters. Monthly sampling and analysis of water from the box cut sump will continue for Stage 3 (or as otherwise described in the Water Management Plan [NCOPL, 2017a] [or the latest approved version]).	Section 4
Submissions Report Section 4.2.1	Groundwater Monitoring - Groundwater Quality	Testing for antimony, molybdenum and selenium has not routinely been undertaken historically but will be added to the Stage 3 Water Management Plan following approval.	Section 4.5
EIS Section 6.4.4	Groundwater Monitoring - Groundwater Inflow	NCOPL will implement continuous monitoring of TDS, pH and temperature of groundwater inflows (e.g. via monitoring at the box cut sump). In addition, the current monthly analysis of water from the box cut sump will continue for Stage 3.	Section 4.5
EIS Appendix B Section 8.2	Additional monitoring recommendations	Water samples will also be routinely collected and sent for laboratory analysis. Such data can also provide an early warning of unexpected increases in inflow.	Section 4.5 Section 5
Submissions Report Section 4.2.1	Additional monitoring recommendations	Installation of six additional nested VWP installations are proposed to the west, south and east of Narrabri Mine. The additional VWPs will be installed as soon as practicable, following determination of Stage 3 as part of the updated Water Management Plan.	Section 4.2.2
Submissions Report Section 4.2.3	Additional monitoring recommendations	In addition to the further VWP installations outlined above, NCOPL will assess the feasibility of using helium gas, or other tracers/indicators to investigate seam to surface connectivity above selected longwall panels.	Section 4.2.1
EIS Appendix B Section 8.2 Submissions Report Section 4.2.3	Potential impacts to GDEs	Regular site visits to the Mayfield Spring, Hardys Spring and Eather Spring (Dams 1 and 2) sites are recommended to observe any changes to flow rates and surface conditions and to confirm whether these features are groundwater dependent. Depending on the results of the Spring visits, further ongoing groundwater and surface water monitoring at these sites, similar to that described above for local creeks, may also be required to confirm predicted impacts.	Section 4.2.3 Section 4.5

Source	Aspect	Details	Reference
EIS Section 6.4.4	Numerical Model Review	The numerical model developed and used for the Groundwater Assessment (Appendix B) will be used as a management tool for the periodic review and validation of predicted groundwater impacts through the life of Narrabri Mine. The validity of the groundwater model predictions will: • be assessed from time to time, and if the data indicates significant deviation from the model predictions, an updated groundwater simulation model will be developed. • the groundwater simulation model will also be recalibrated at the frequency described in the Water Management Plan (NCOPL, 2017a) (or the latest approved version). • the results of the groundwater monitoring program will assist to refine any future numerical models.	Section 6.2
EIS Section 6.4.4	Numerical Model Review	Revised outputs from the numerical model will be reported periodically over the life of Narrabri Mine and incorporated into reviews of the site water balance.	Section 6.2 Section 6.3
Submissions Report Section 4.2.1	Numerical Model Review	Consistent with Project Approval 08_0144, the current site Water Management Plan for the Narrabri Mine (NCOPL, 2017) includes a commitment to re-calibrate the Project groundwater model two years after commencement of longwall extraction and every five years thereafter. A similar commitment in the updated Water Management Plan for the Project is proposed, whereby the groundwater model would be updated two years after approval of the Project and every five years thereafter. The Water Management Plan would also identify a number of other circumstances, which may trigger further development and/or re-calibration of the model as follows: • a significant change to the mine plan; • acquisition of new hydrogeological information, such as groundwater levels and aquifer properties (i.e. hydraulic conductivity), which are different to calibrated values used in the model; and • groundwater drawdown and inflows which significantly exceed model predictions for that stage of mining.	Section 6.1
Submissions Report Section 4.2.1	Numerical Model Review – verification of groundwater level records at VWP installations	Further Quality Assurance checks carried out by NCOPL environmental staff during field data collection in the future will be described in the Stage 3 Water Management Plan.	Section 6.1
Submissions Report Section 4.2.1	Groundwater data quality assurance	The Water Management Plan will be updated to incorporate Stage 3. The Water Management Plan will include data quality assurance and control protocols and will consider comments provided.	Section 6.1
Submission Report Section 4.2.2	Numerical Model Review – Cumulative impacts with the Narrabri Gas Project	Majority of the predicted drawdown is due to Narrabri Mine. This will be confirmed by updates to the groundwater model, which will occur at regular intervals throughout Stage 3. Model updates will consider the latest groundwater monitoring data available at the time, therefore, model updates will have regard to any impacts that may be occurring at the time due to the operation of Narrabri Mine and Narrabri Gas Project.	Section 6.2
EIS Section 6.4.4 Submissions Report Section 4.1.1	Make Good Provisions	NCOPL has committed to 'make good' provisions for affected groundwater users. Appropriate make good provisions for a Project-related drawdown greater than 2 m at a groundwater bore may include: • deepening the affected groundwater bore (including lowering pump set and/or provision of new pump set and power supply if required); • construction of a new groundwater bore (including provision of a new pump set and power supply if required); and/or • provision of an alternative water supply of suitable quality and quantity. These contingency measures will be assessed on a case-by-case basis (i.e. including an assessment of the bore details and viability of any proposed measures), and implemented in consultation with the affected landholder and relevant regulators prior to drawdown exceeding the AIP minimal harm criterion.	Section 3.4
EIS Section 6.4.4 Submissions Report Section 4.1.1	Make Good Provisions	Ongoing groundwater monitoring, as well as any updates to the groundwater model, will also be used to confirm the predicted drawdown at these bores. Any groundwater monitoring at the bores will be described in the Water Management Plan (subject to agreement with the landholder).	Section 4.5 Section 6.2
EIS Section 6.4.5	Adaptive Management	Monitoring locations, methods, trigger levels and contingencies relating to groundwater will be detailed in an update of the Water Management Plan and Extraction Plans for Narrabri Mine. In the event that groundwater monitoring identifies an exceedance of an established trigger, NCOPL will implement a response plan in accordance with the Water Management Plan.	Section 4 Section 5 Appendix E
EIS Section 6.4.5	Adaptive Management	In the event that water levels deviate significantly from those predicted by the groundwater model, a suitably qualified hydrogeologist will undertake a review to determine the reason for this deviation. The review will consider the impact of mining and other factors that could result in declining water levels, including climatic conditions, rainfall recharge and pumping from privately-owned bores and/or nearby operations.	Section 5
Submissions Report Section 4.2.1	Depth of cracking prediction	As discussed in Sections 5.2.11 and D 2.5.6.1 (in Appendix D) of the Groundwater Assessment (AGE, 2020) site-specific data, in the form of groundwater data for the nested monitoring facility (P57) installed above Longwall 108A, has already been used to estimate potential heights of fracturing and calibrate the groundwater model. Modelled hydraulic parameters in the A and D-Zones are, therefore, already constrained by site-specific data. Furthermore, as summarised in Section D 5 in Appendix D of the Groundwater Assessment, a range of possible alternative parameters for functions affecting both hydraulic conductivity and storage above	Section 6.2

Source	Aspect	Details	Reference
		longwall panels have been assessed as part of the predictive uncertainty analysis. Further data collection above future longwall panels is also proposed. Additional data from these further sites will be considered as part of future re-calibration of subsidence predictions.	
EIS Appendix C Section 9.1	Water Management Plan	The Water Management Plan will be reviewed and revised to incorporate Stage 3. The Water Management Plan will describe the operational site water management system and will include provisions for review of the site water balance, erosion and sediment controls, water monitoring and management. The existing Water Management Plan will also be revised to incorporate any proposed beneficial re-use of excess filtered water or underground injection of excess mine water.	The WMP including Attachment 1 Attachment 2 Attachment 3 Attachment 4
EIS Section 6.5.4 EIS Appendix C Section 9.1	Water Management Plan – Site Water Balance	Review and progressive refinement of the site water balance will continue annually over the life of Narrabri Mine to record the status of inflows, storage and consumption (e.g. usage, return water from co-disposal areas, dust suppression and filtered water releases or beneficial re-use) and to optimise water management performance. The results of Site Water Balance reviews will be reported in the Annual Review.	Attachment 1 of the WMP
EIS Section 6.5.4	Water Management Plan - Erosion and Sediment Control Plan	The Erosion and Sediment Control Plan component of the Water Management Plan will be reviewed and updated for Stage 3 to identify measures to minimise soil erosion and transport of sediment off-site.	Attachment 2 of the WMP
EIS Appendix C Section 9.1	Water Management Plan	The Surface Water Monitoring Plan will be reviewed and updated for Stage 3. A recommended monitoring program is provided in Section 9.3.	Attachment 3 of the WMP
EIS Section 6.5.4	Water Management Plan - Surface Water Monitoring Program	The existing surface water monitoring network will continue to be implemented for Stage 3. The network will include the installation of two additional receiving water monitoring sites recommended by WRM (2020) within MLAs 1 and 2, locations will be confirmed in consultation with relevant government agencies and landowners.	Attachment 3 of the WMP
EIS Section 6.5.4	Water Management Plan - Surface Water Monitoring Program	The site water monitoring network of sediment dams and sediment basins will continue to be implemented for Stage 3, in accordance with the Water Management Plan (NCOPL, 2017a) (or the latest approved version). In addition, the Southern Mine Water Storage will be included in the monitoring network.	Attachment 3 of the WMP
EIS Section 6.5.4	Water Management Plan - Surface Water Monitoring Program	The suite of monitoring parameters will remain as per the approved Water Management Plan (NCOPL, 2017a) (or the latest approved version) with the addition of the following parameters to monitor the potential impacts of Stage 3 waste materials: • total alkalinity; • acidity; • sulphate; • As; • Co; • Mo; • Sb; and • Se. The frequency of monitoring will remain as per the approved Water Management Plan (NCOPL, 2017a) (or the latest approved version).	Attachment 3 of the WMP
Section 6.5.4	Water Management Plan - Surface and Groundwater Response Plan	The Surface and Groundwater Response Plan and TARPs (NCOPL, 2017a; 2017c) will be reviewed and updated for Stage 3. The Surface and Groundwater Response Plan will describe any additional measures and procedures that will be implemented over the life of Narrabri Mine to respond to any potential exceedances of surface water-related criteria and contingent mitigation compensation, and/or offset options if downstream private surface water users or riparian vegetation are adversely affected by Narrabri Mine.	Section 5

Appendix C - Baseline groundwater level and quality data

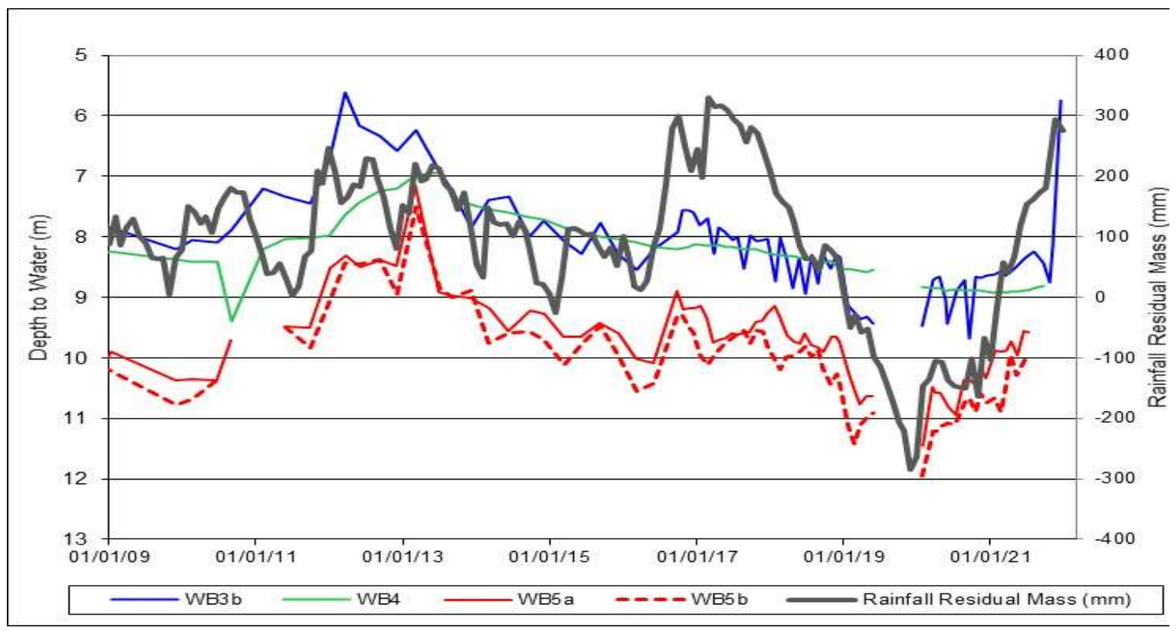


Figure C-1: Hydrograph for Selected Alluvial Monitoring Bores

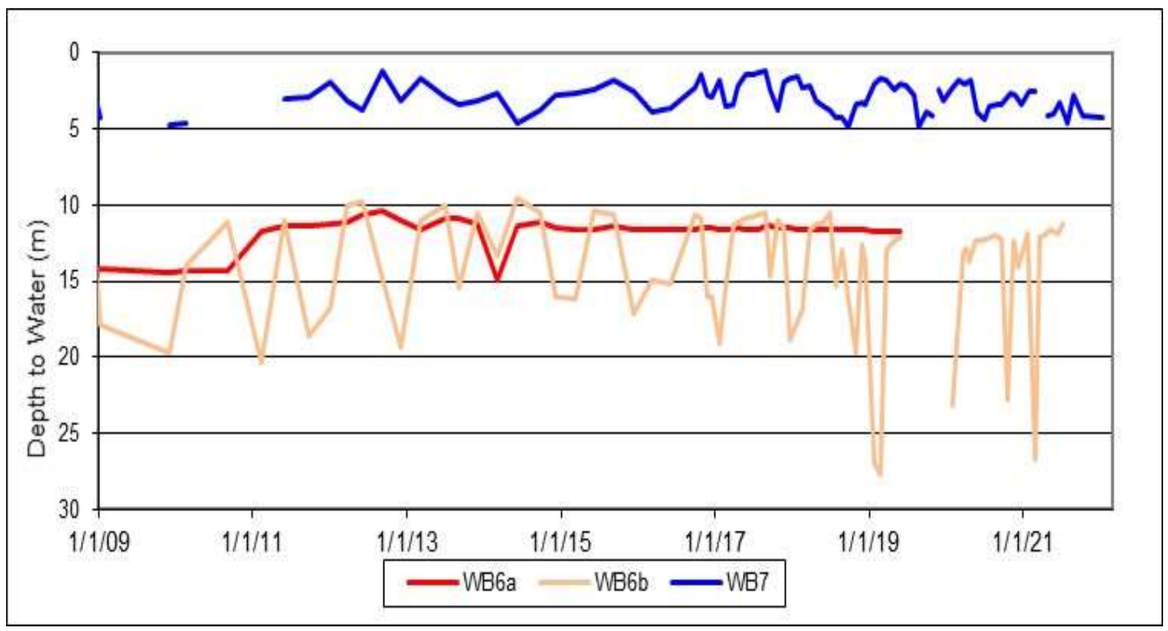


Figure C-2: Hydrograph for Selected Alluvial Monitoring Bores

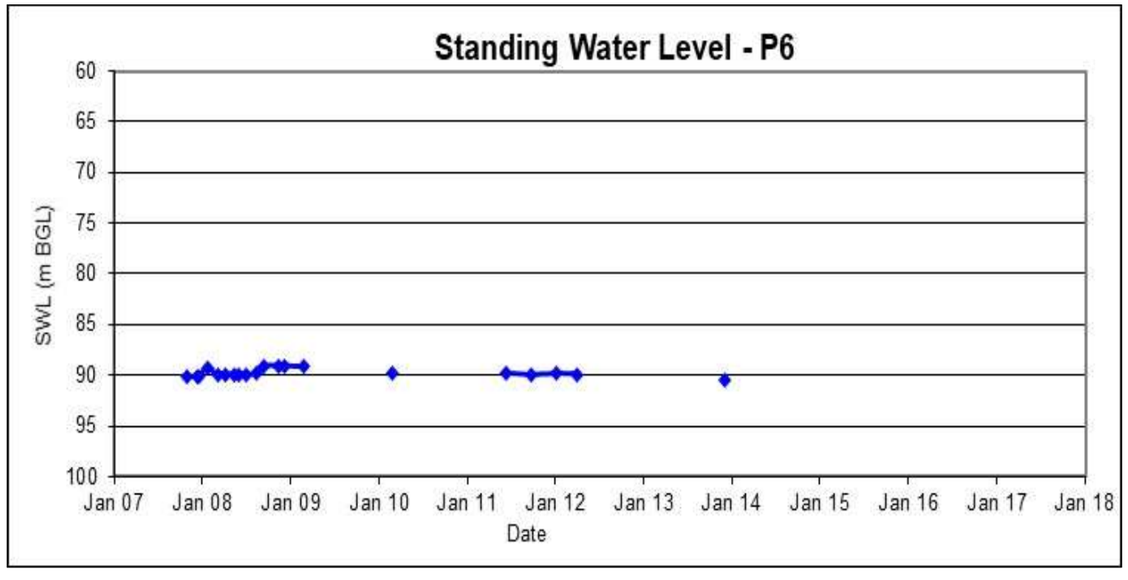


Figure C-3: Hydrograph for P6

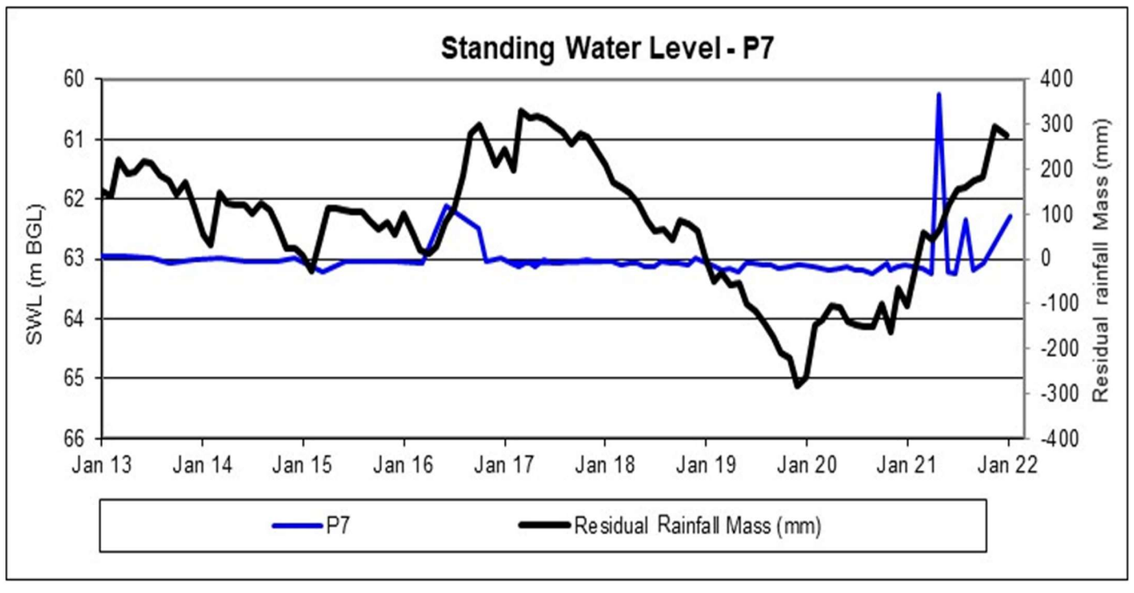


Figure C-4: Hydrograph for P7

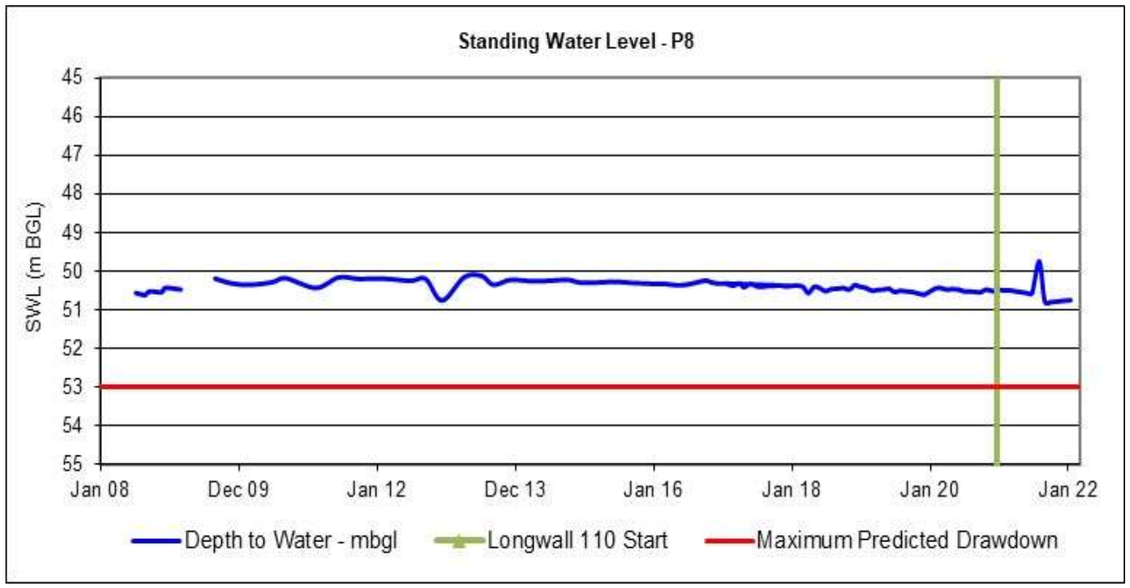


Figure C-5: Hydrograph for P8

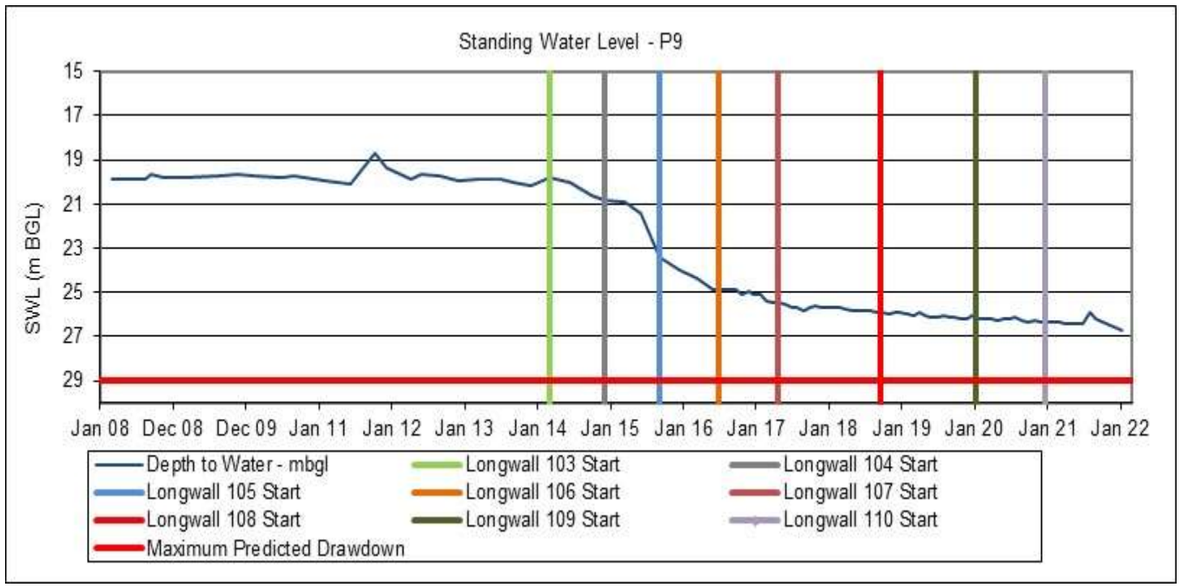


Figure C-6: Hydrograph for P9

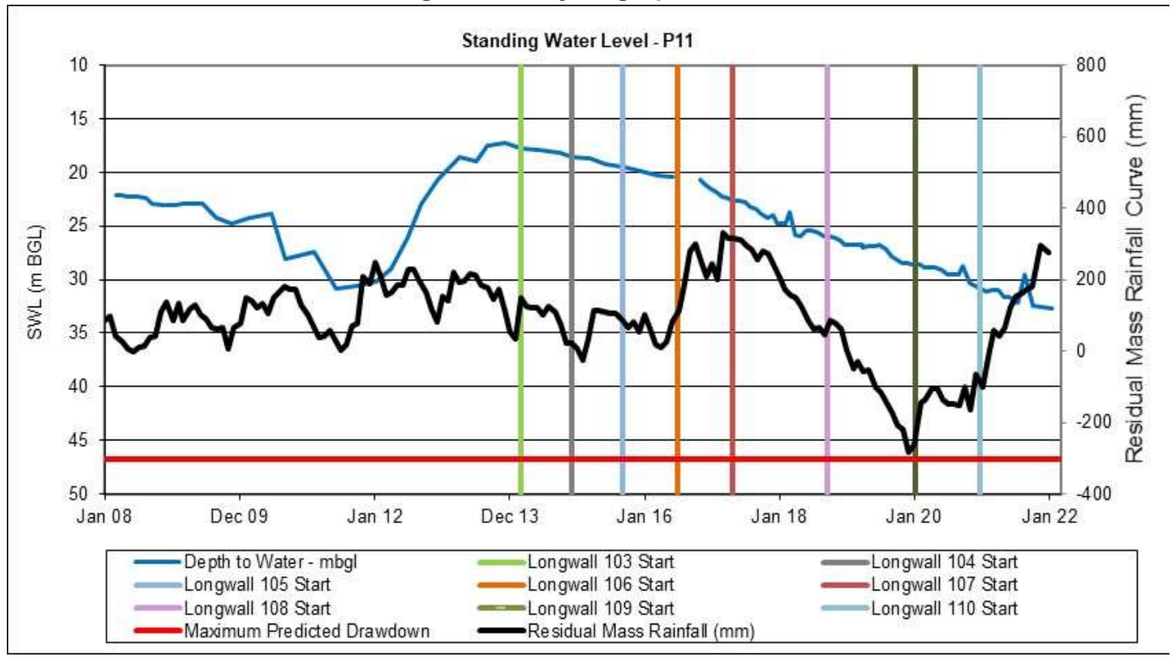


Figure C-7: Hydrograph for P11

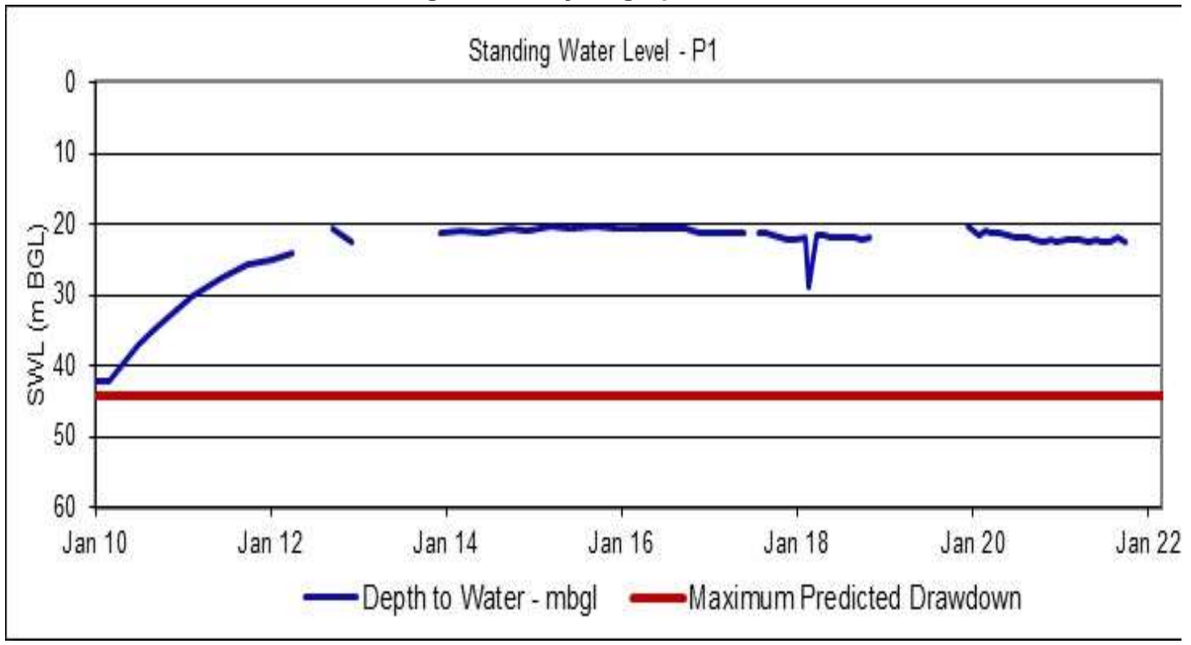


Figure C-8: Hydrograph for P1

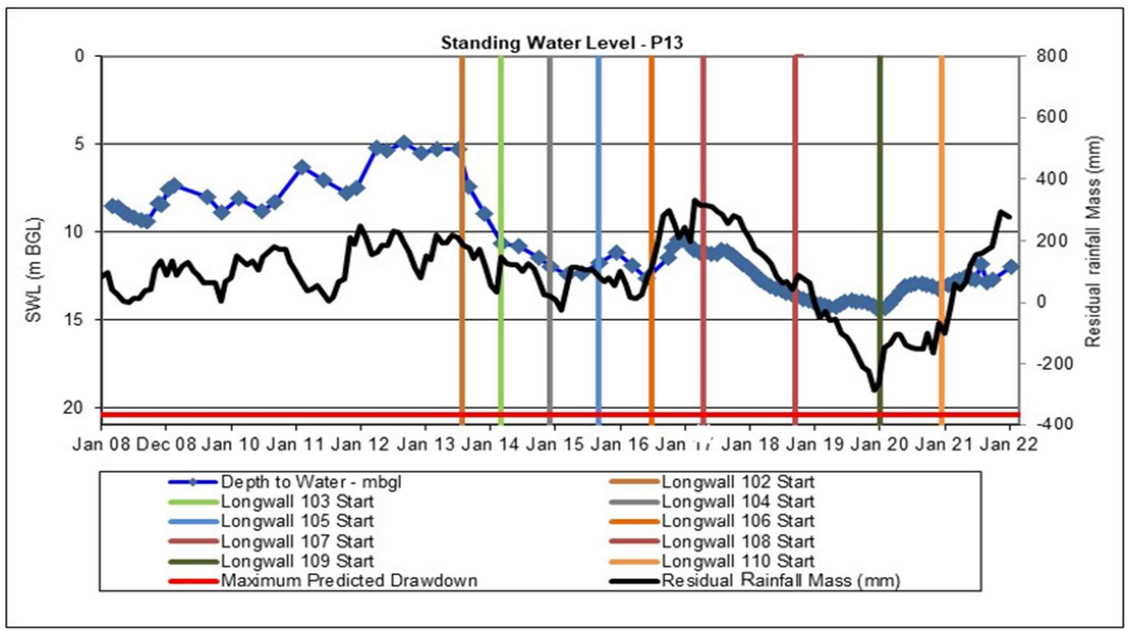


Figure C-9: Hydrograph for P13

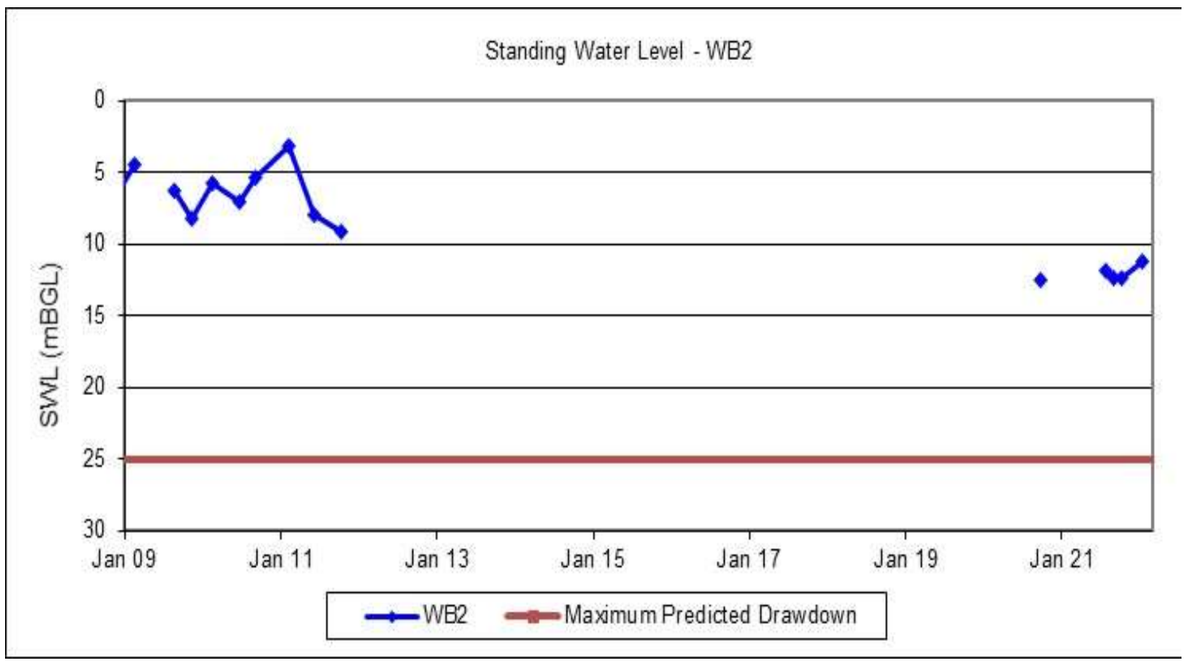


Figure C-10: Hydrograph for WB2

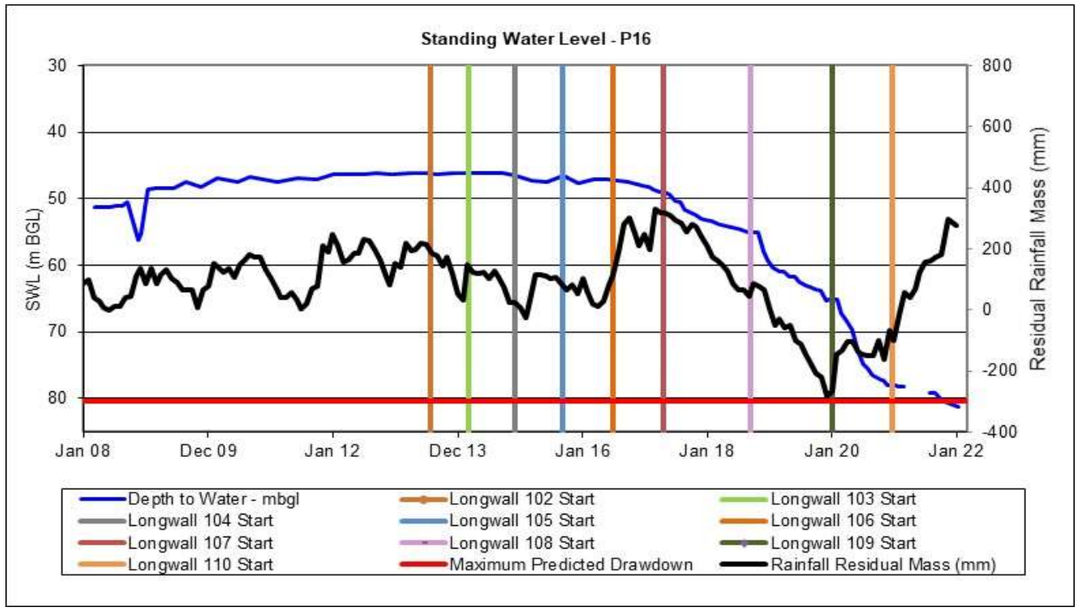


Figure C-11: Hydrograph for P16

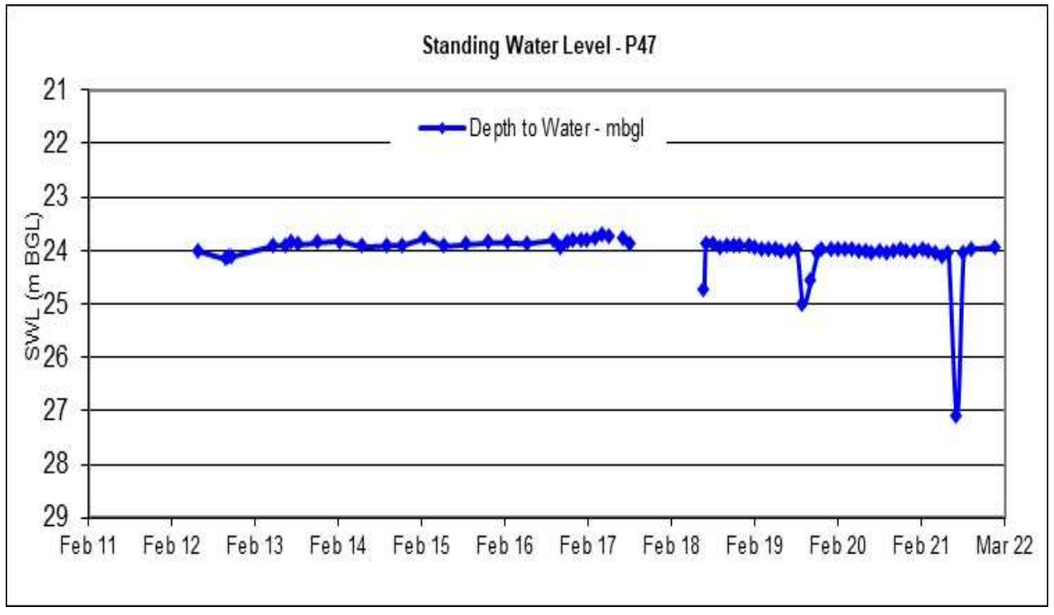


Figure C-12: Hydrograph for P47

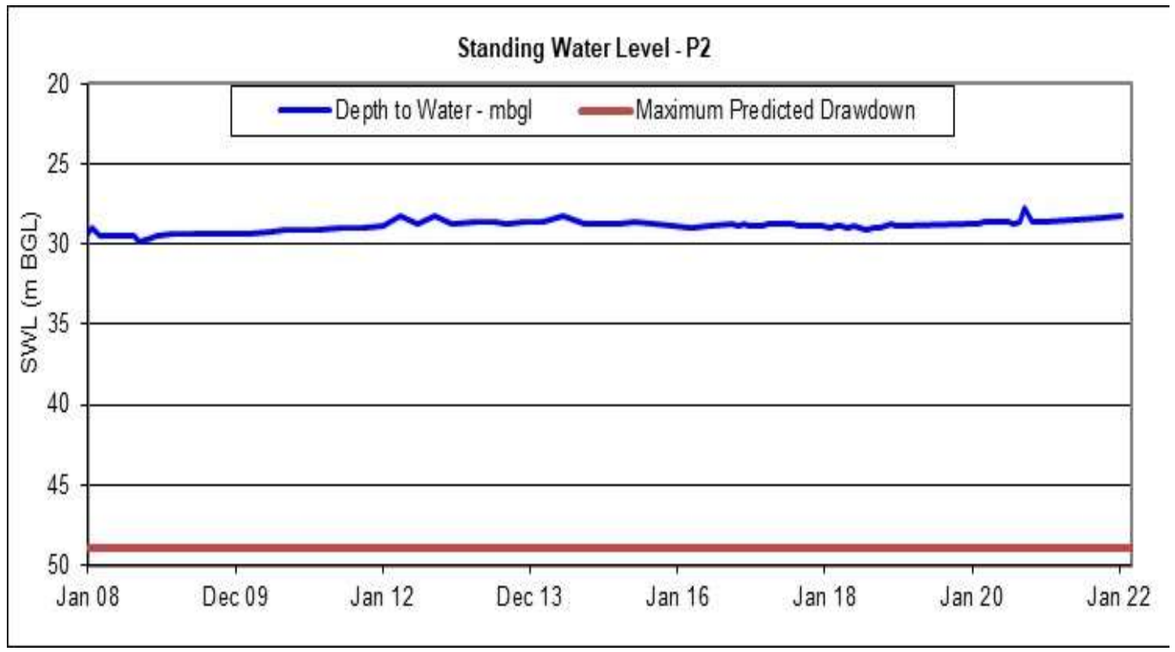


Figure C-13: Hydrograph for P2

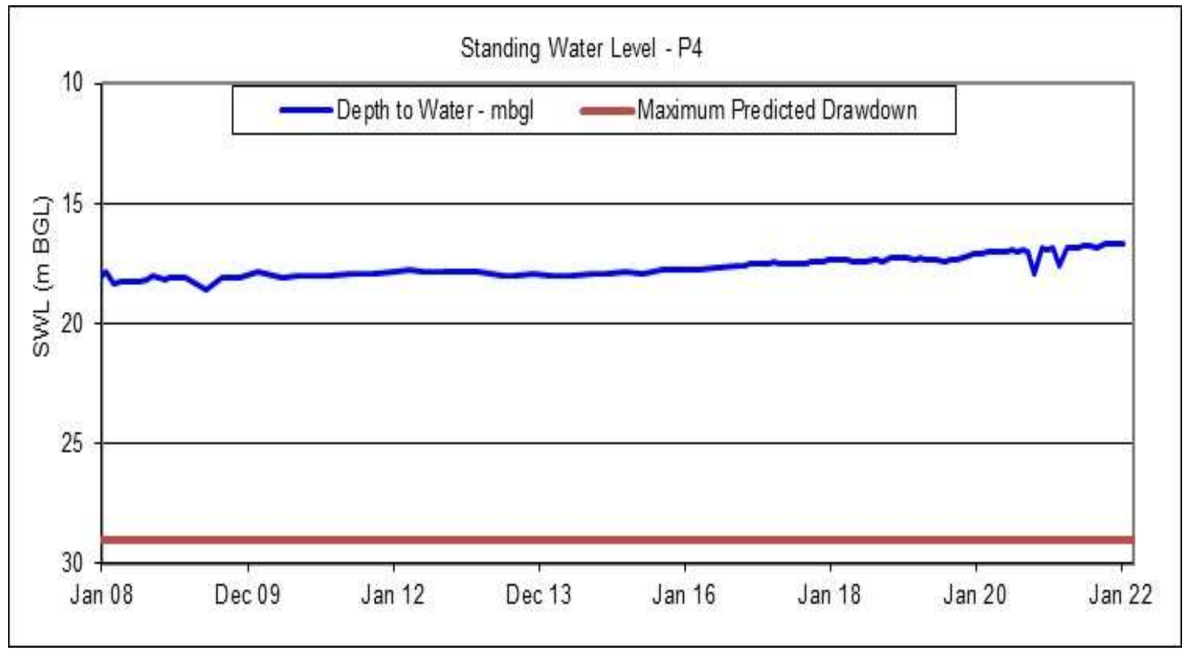


Figure C-14: Hydrograph for P4

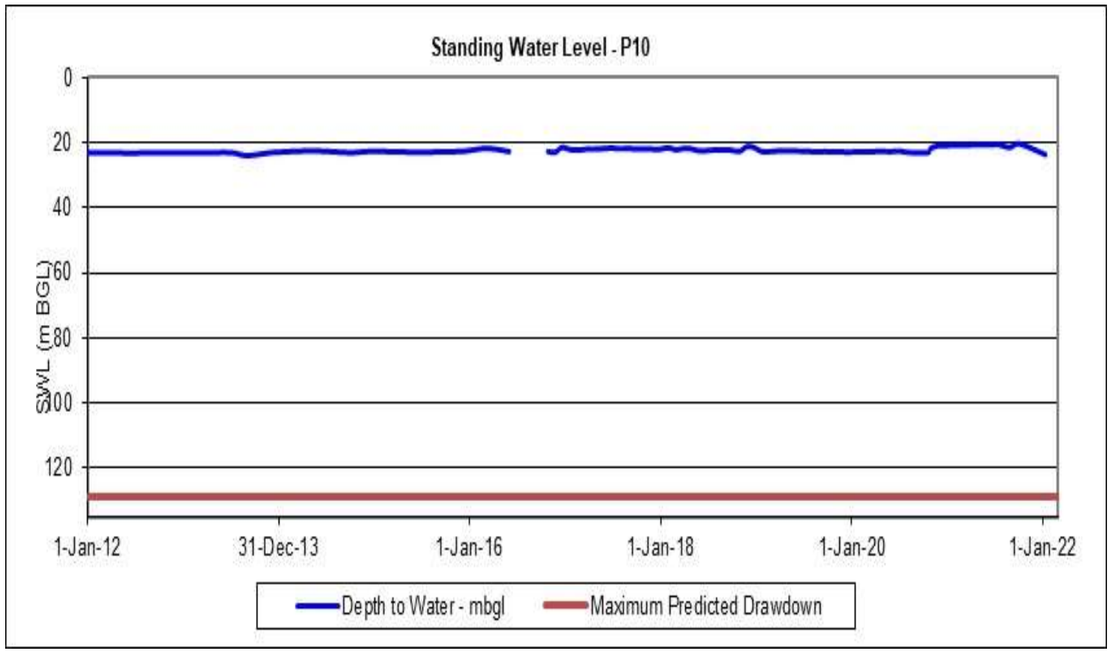


Figure C-15: Hydrograph for P10

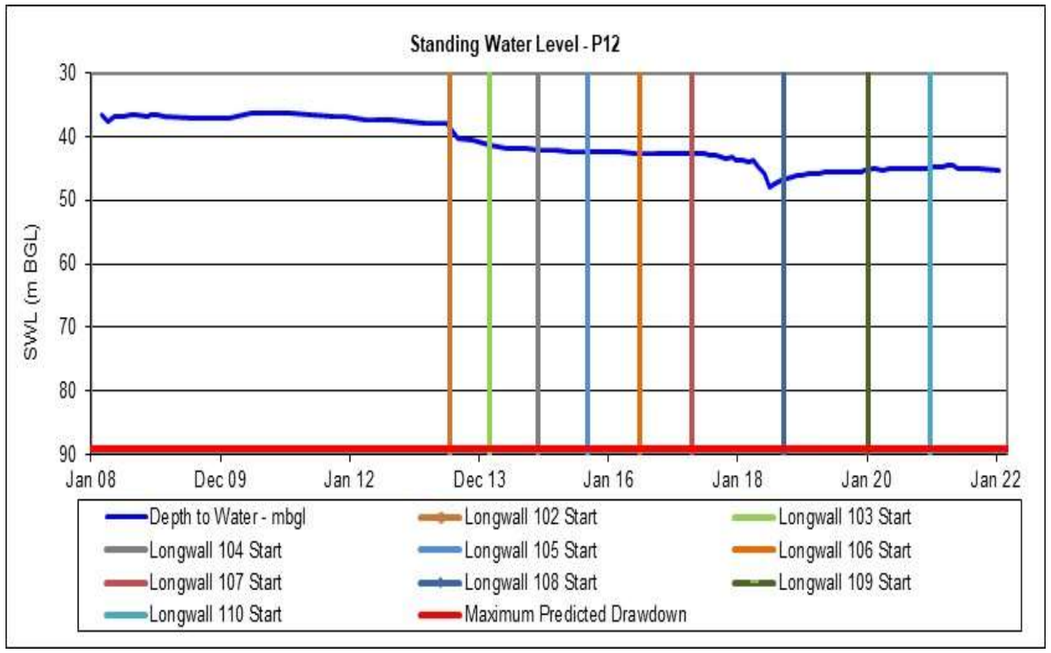


Figure C-16: Hydrograph for P12

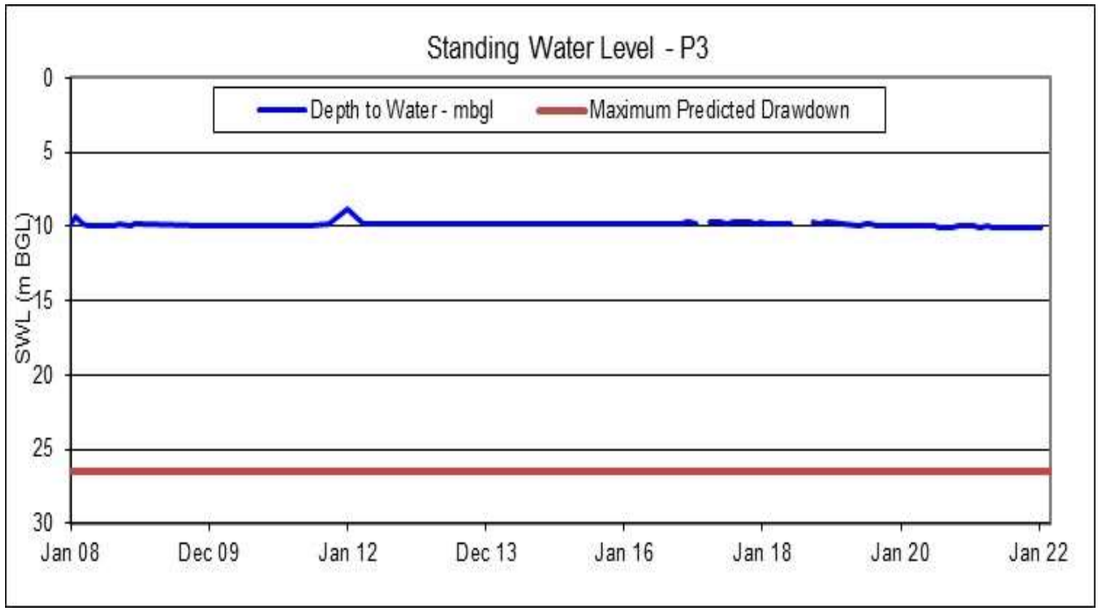


Figure C-17: Hydrograph for P3

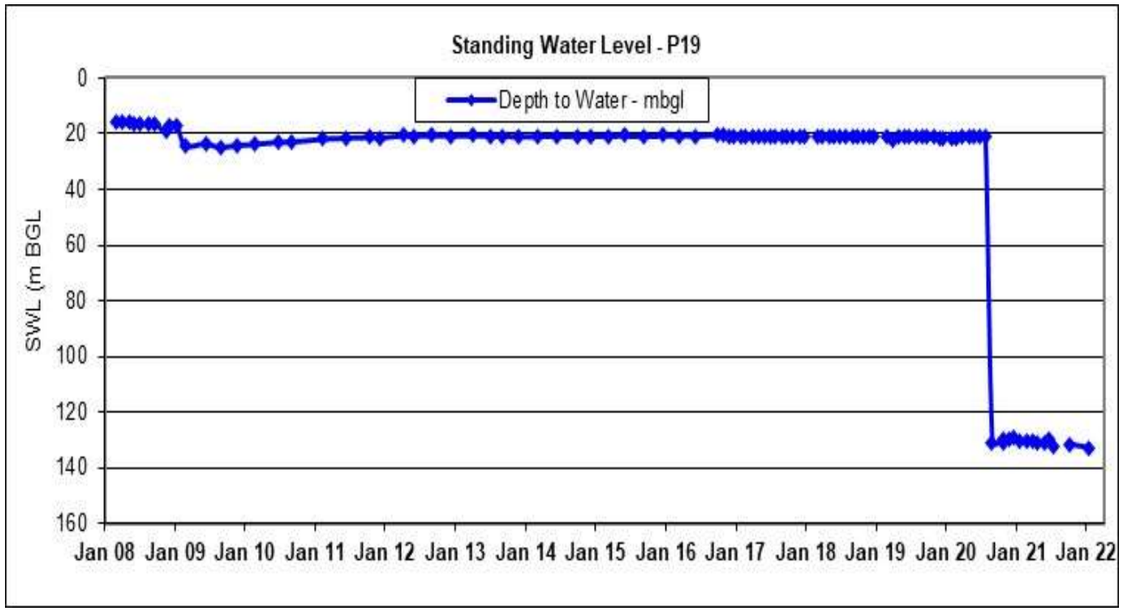


Figure C-18: Hydrograph for P19

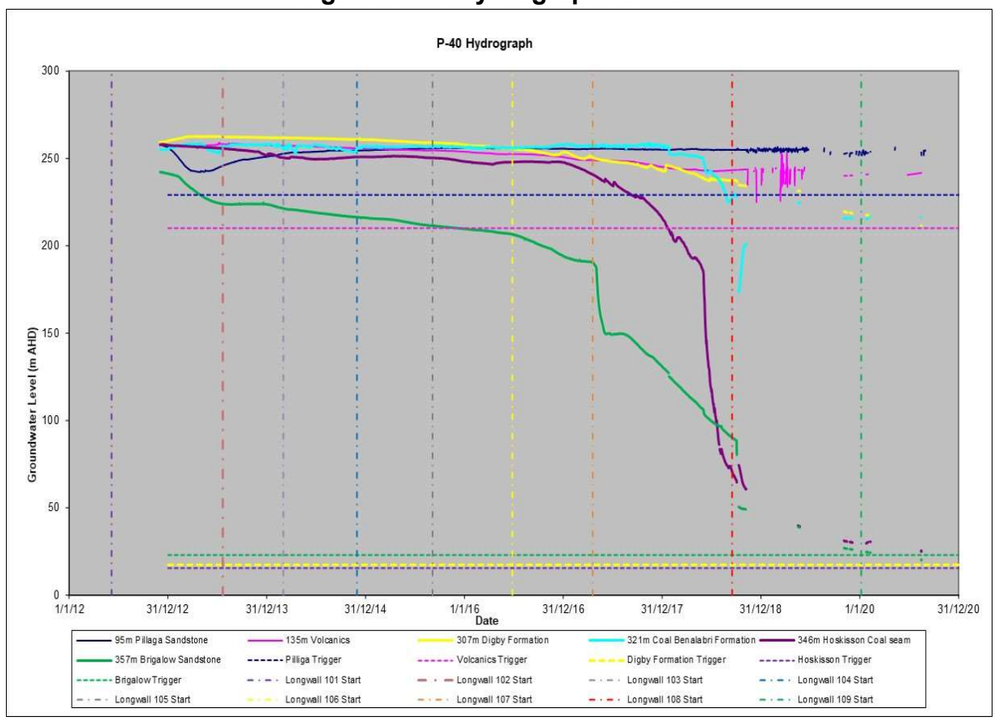


Figure C-19: Hydrograph for P40

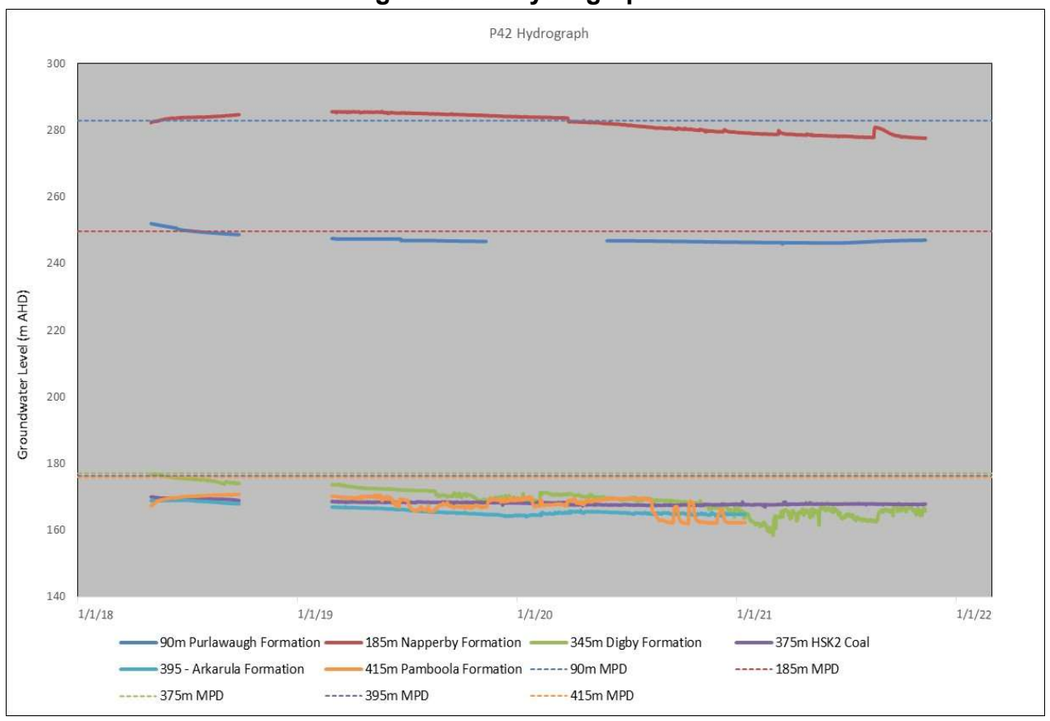


Figure C-20: Hydrograph for P42

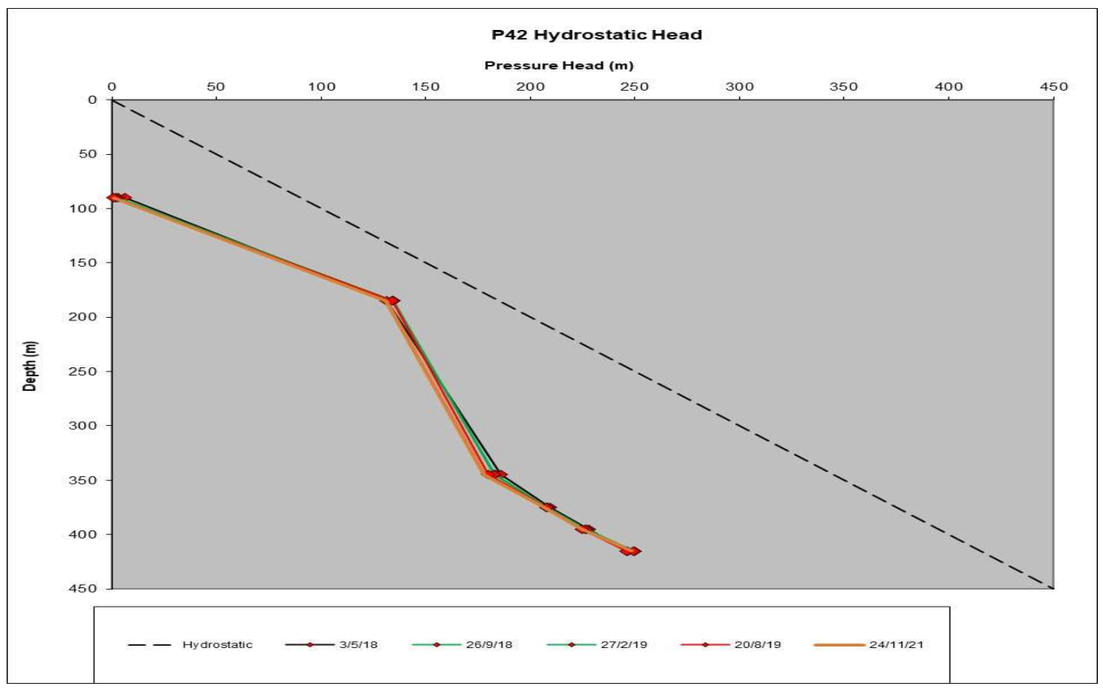


Figure C-21: Hydrostatic Profile for P42

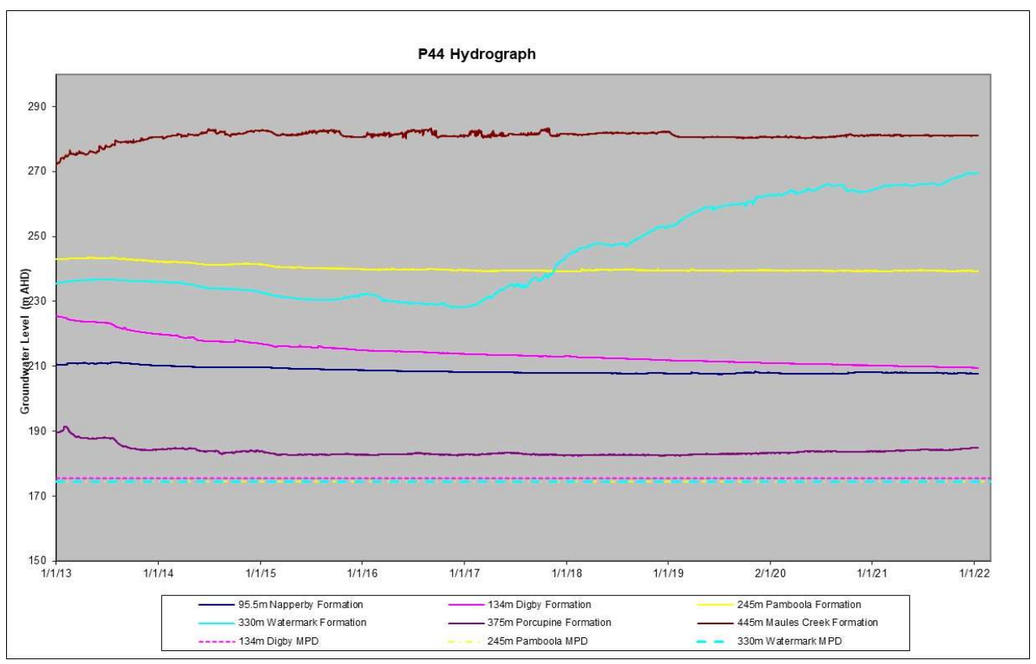


Figure C-22: Hydrograph for P44

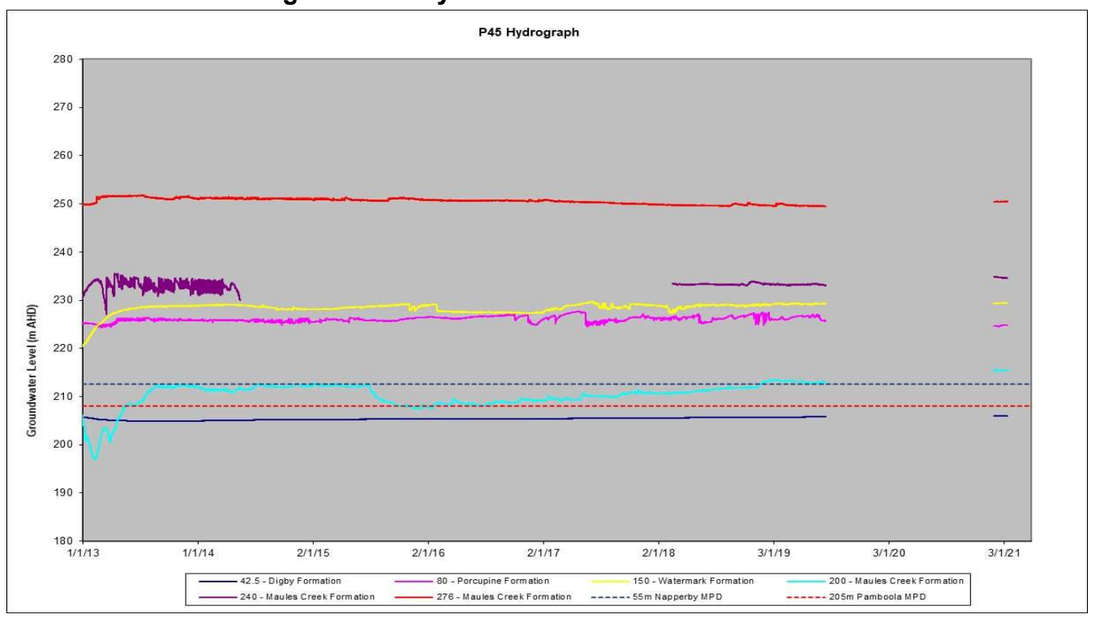


Figure C-23: Hydrograph for P45

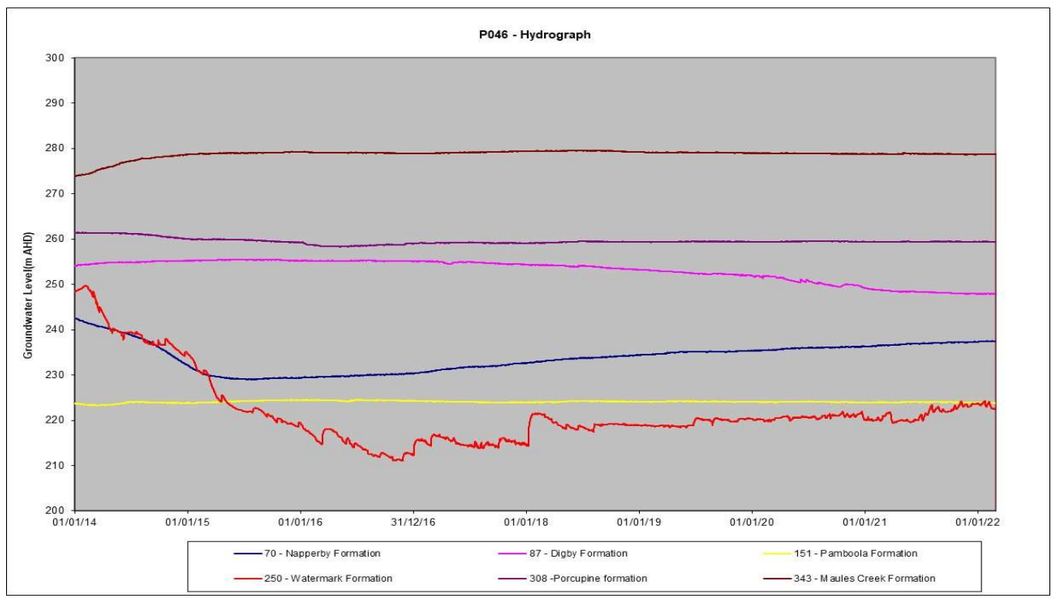


Figure C-24: Hydrograph for P46

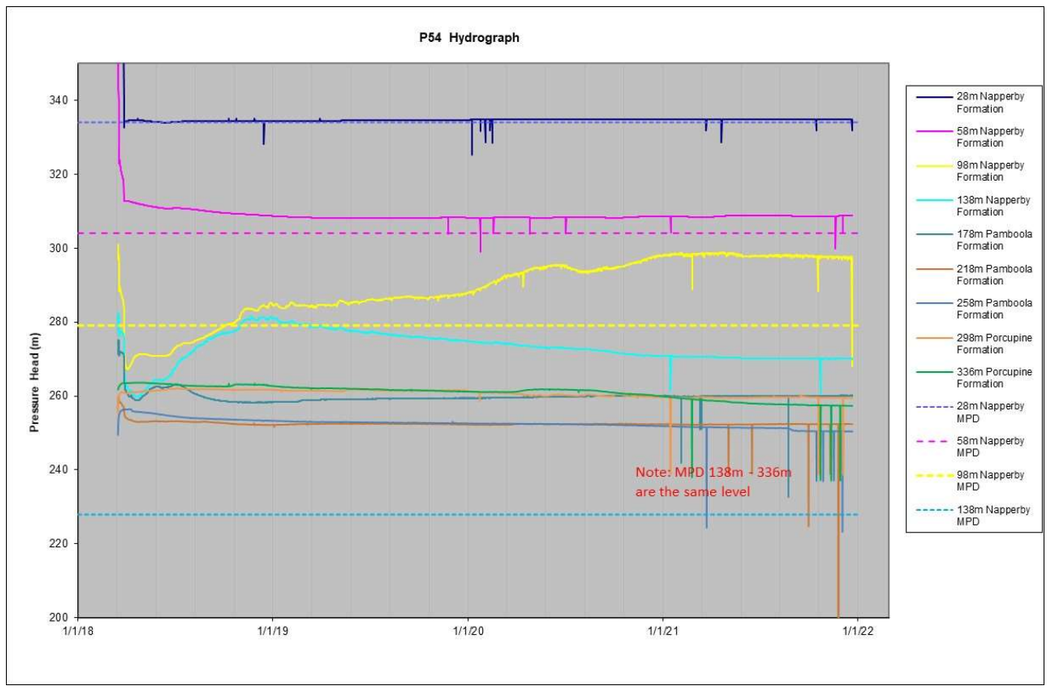


Figure C-25: Hydrograph for P54

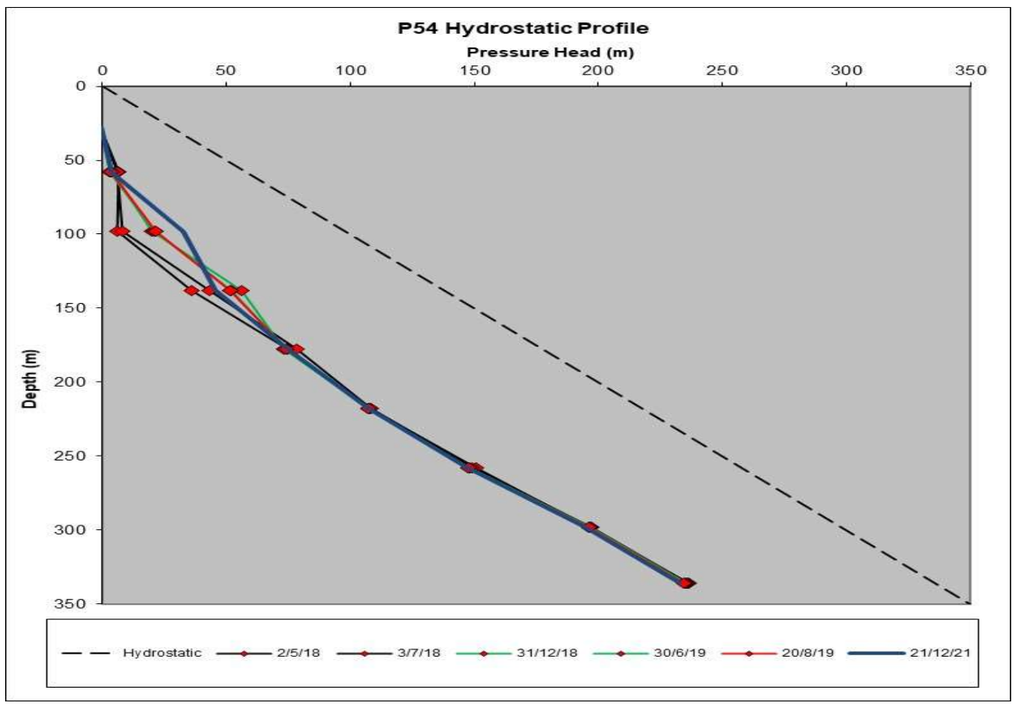


Figure C-26: Hydrostatic Profile for P54

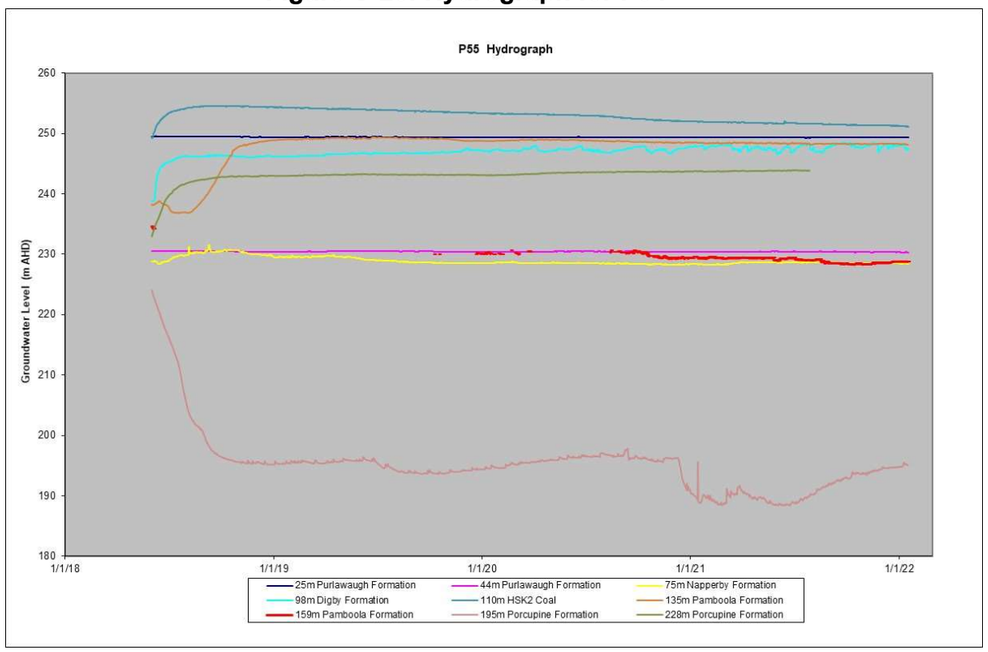


Figure C-27: Hydrograph for P55

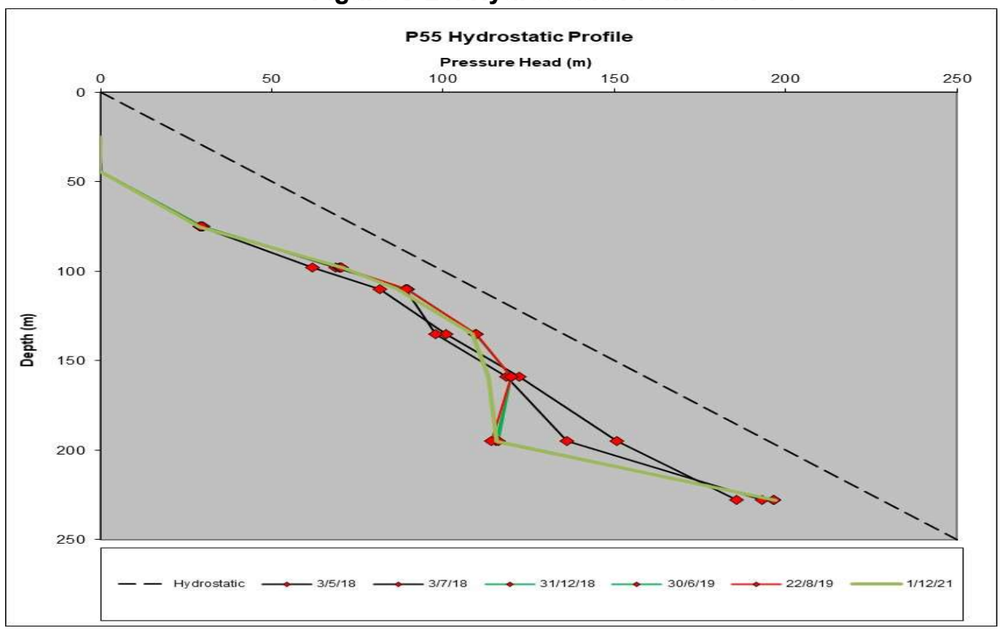


Figure C-28: Hydrostatic profile for P55

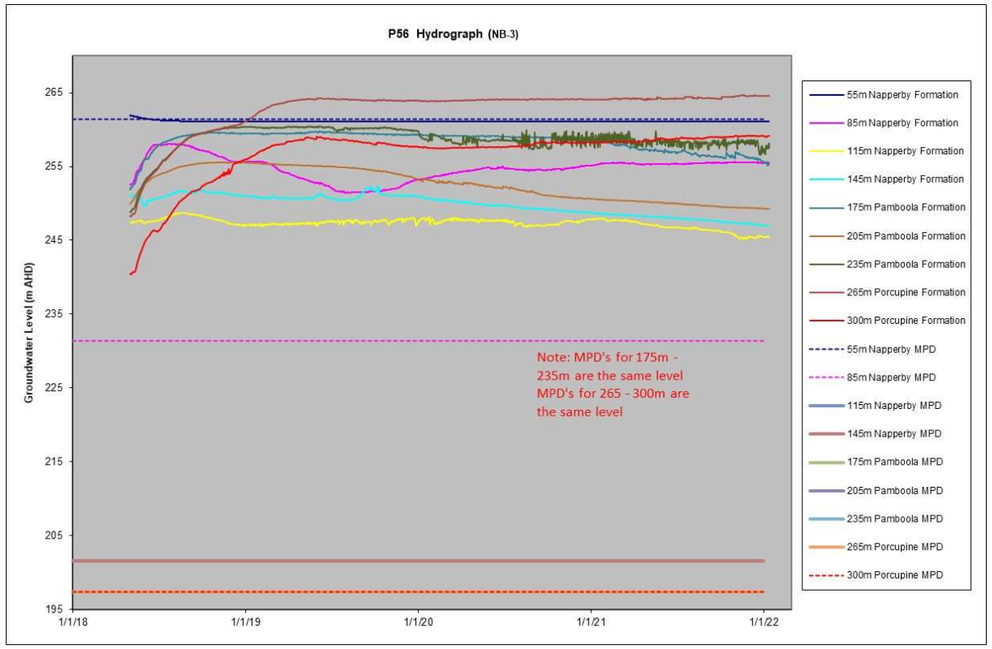


Figure C-29: Hydrograph for P56

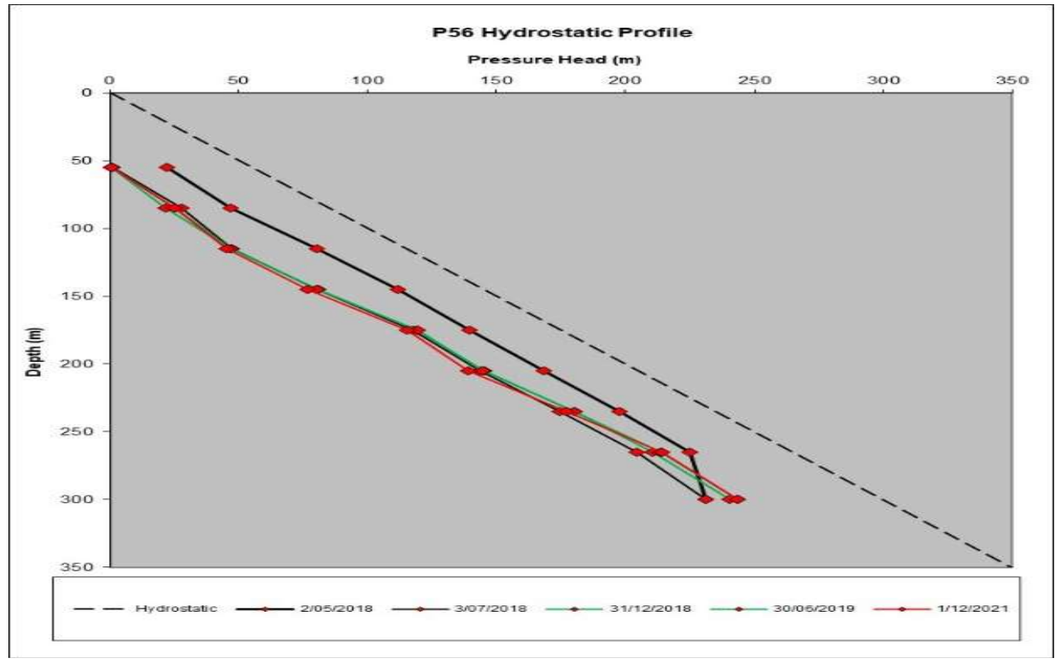


Figure C-30: Hydrostatic Profile for P56

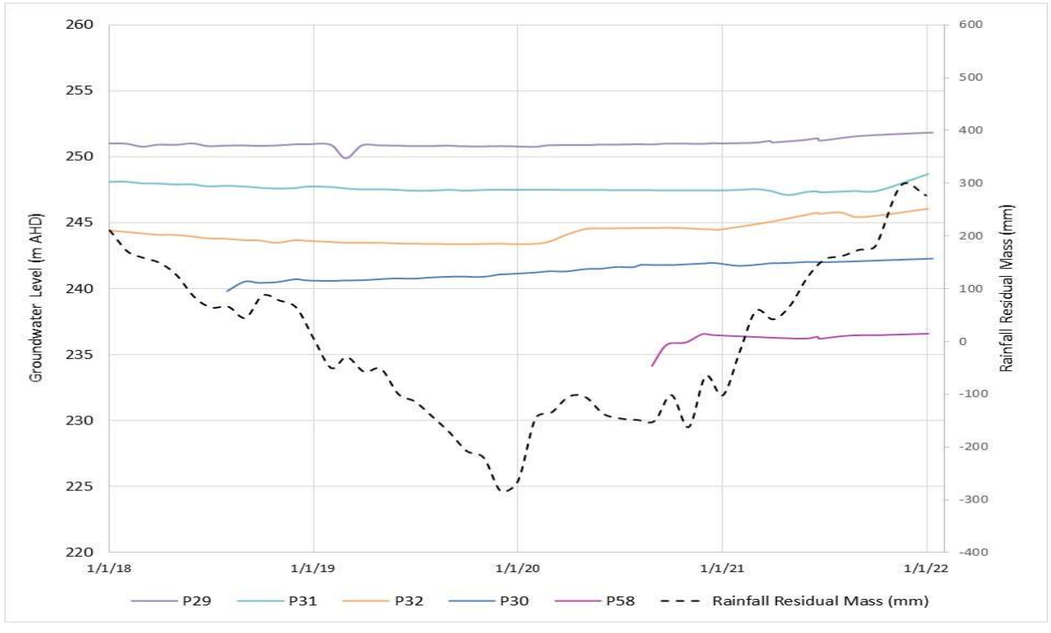


Figure C-31: Groundwater Levels Surrounding Rail Loop Dams

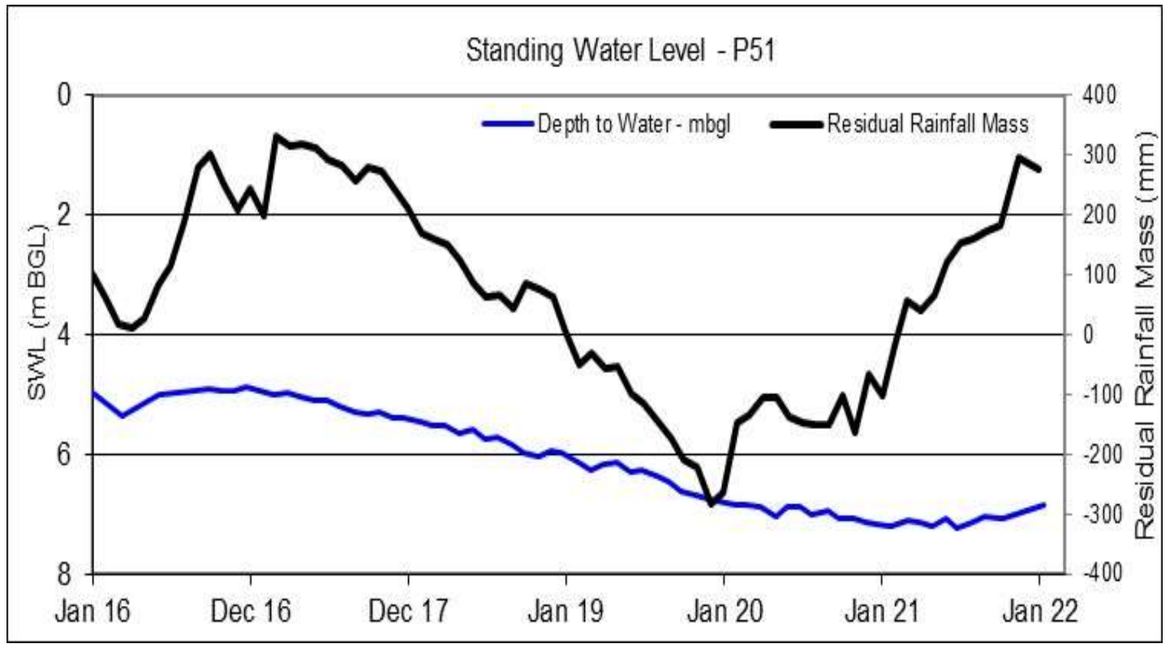


Figure C-32: Hydrograph for P51

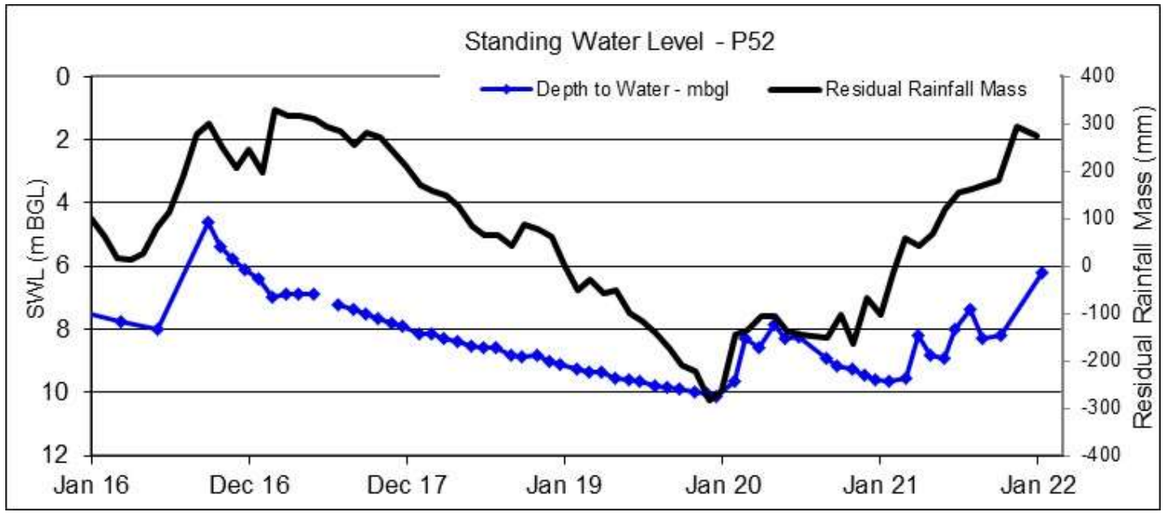


Figure C-33: Hydrograph for P52

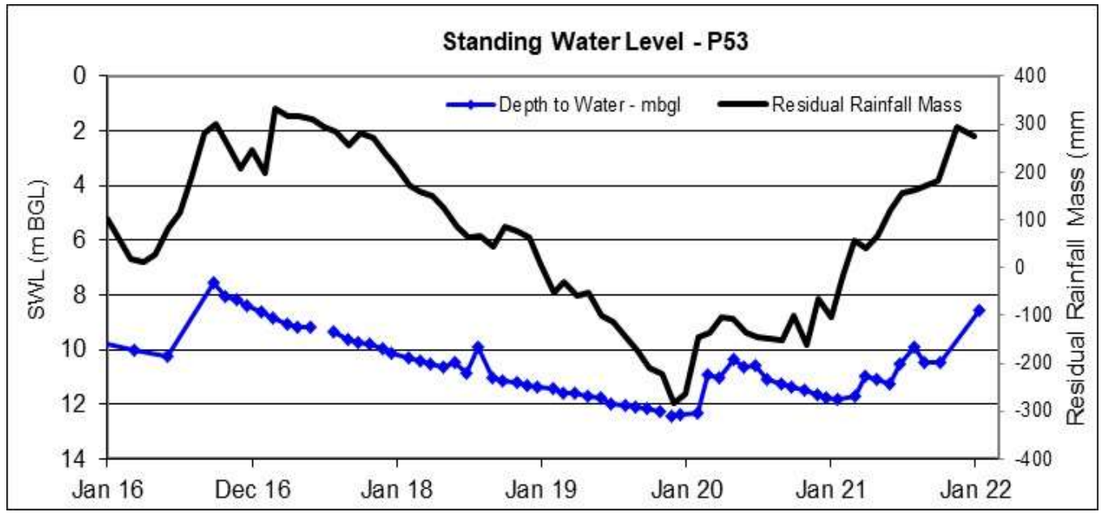


Figure C-34: Hydrograph for P53

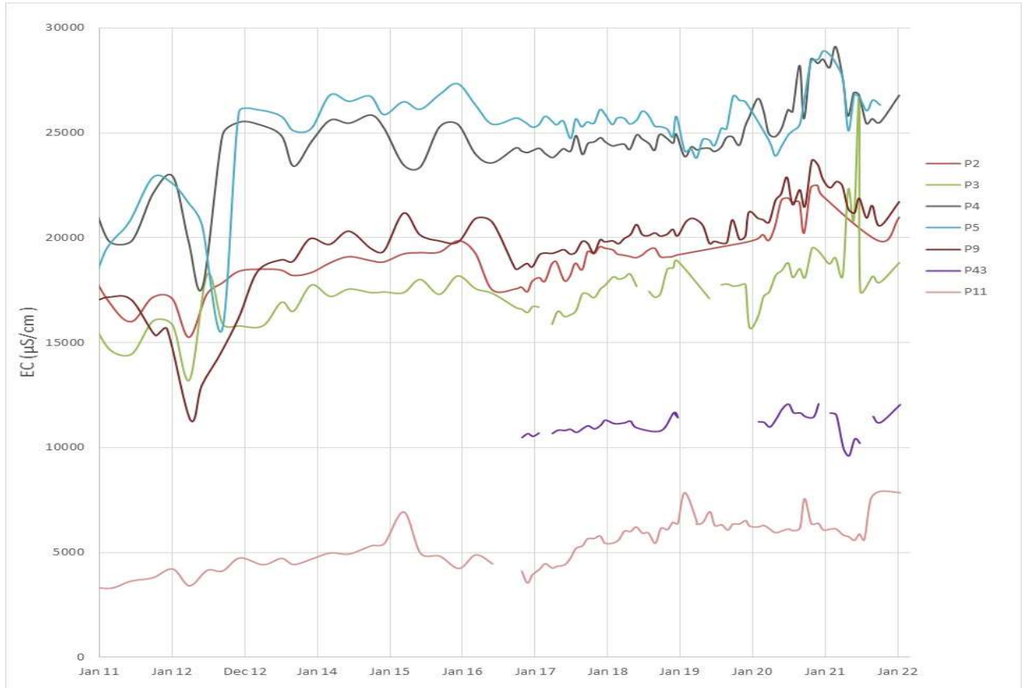


Figure C-35 Electrical Conductivity (EC) for Selected Shallow Piezometers

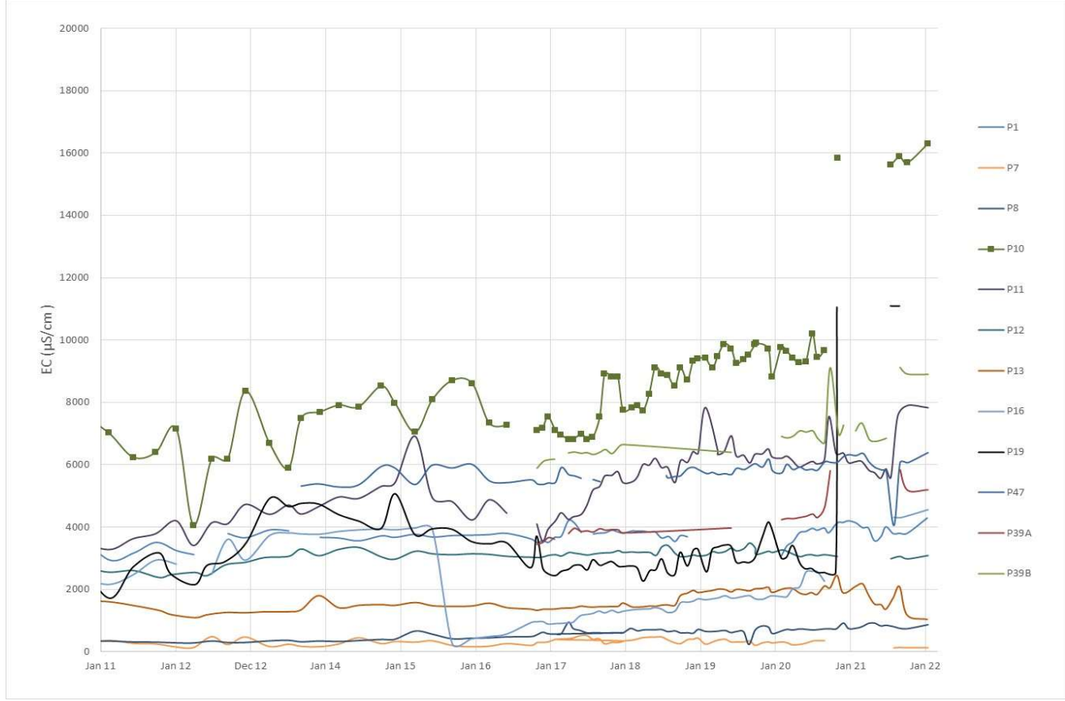


Figure C-36 Electrical Conductivity (EC) for Selected Deep Piezometers

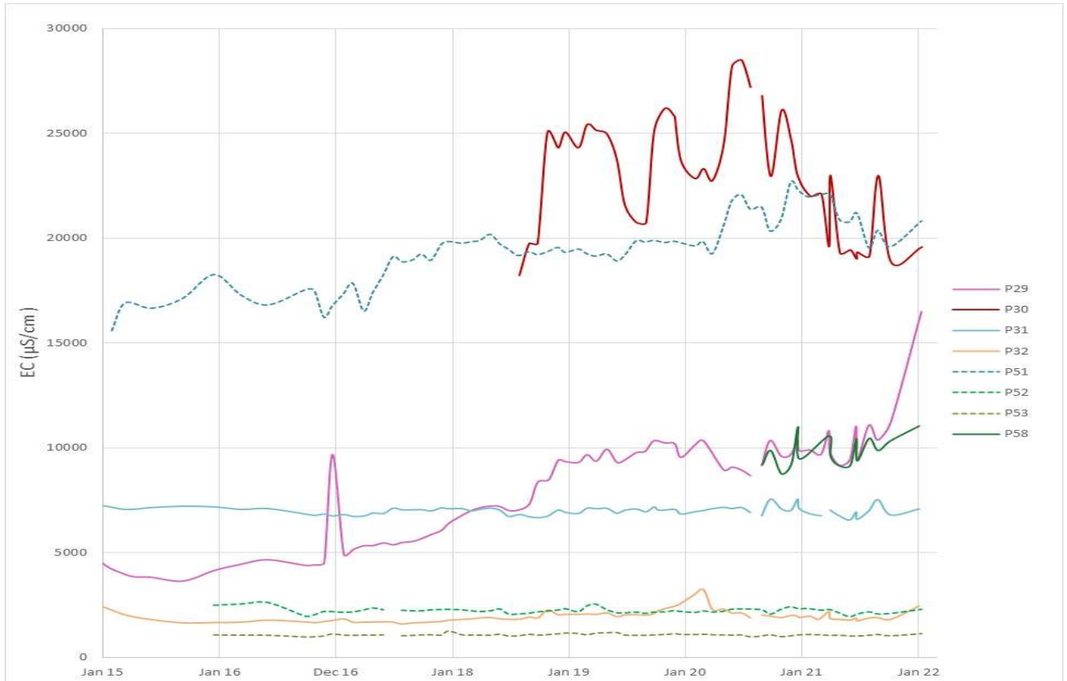


Figure C-37 Electrical Conductivity (EC) for Rail Loop and REA Network

Appendix D - Groundwater monitoring network

Table D-1 Groundwater monitoring network

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
P1	Standpipe	Narrabri Coal Operations	776116	6614694	50	44-50	Garrawilla Volcanics	level and quality	predicted drawdown	ANZG (stock)
P2	Standpipe	Narrabri Coal Operations	777282	6616355	50	44-50	Napperby Formation	level and quality	predicted drawdown	EC two tiered
P3	Standpipe	Private	780433	6620115	45	34-40	Pamboola Formation	level and quality	predicted drawdown	EC two tiered
P4	Standpipe	Private	777490	6625553	30	24-30	Napperby Formation	level and quality	predicted drawdown	EC two tiered
P5	Standpipe	Stock Route	778180	6628195	30	24-30	Pamboola Formation	Level	predicted drawdown	na
P6*	Standpipe	Private	772726	6626021	90	78-90	Pilliga Sandstone	level and quality	na	ANZG (irrigation)
P7	Standpipe	State Forest	768998	6624338	90	78-90	Pilliga Sandstone	level and quality	na	ANZG (irrigation)
P8	Standpipe	State Forest	772697	6618421	65	57-63	Purlawaugh Formation	level and quality	predicted drawdown	ANZG (stock)
P9	Standpipe	State Forest	775127	6620209	30	24-30	Purlawaugh Formation	level and quality	predicted drawdown	EC two tiered
P10	Standpipe	State Forest	774063	6616444	130	118-130	Napperby Formation (no sill)	level and quality	predicted drawdown	EC two tiered
P11	Standpipe	Narrabri Coal Operations	774066	6616447	50	44-50	Purlawaugh Formation	level and quality	predicted drawdown	EC two tiered
P12	Standpipe	Narrabri Coal Operations	776513	6619964	90	84-90	Napperby Formation(above sill)	level and quality	predicted drawdown	ANZG (stock)
P13	Standpipe	Narrabri Coal Operations	776526	6619972	30	24-30	Garrawilla Volcanics/Napperby	level and quality	predicted drawdown	ANZG (stock)
P16	Standpipe	State Forest	772233	6623740	146	137-146	Garrawilla Volcanics	level and quality	predicted drawdown	ANZG (stock)
P17*	Standpipe	State Forest	772222	6623712	56	47-56	Purlawaugh Formation	level and quality	na	na
P19	Standpipe	Narrabri Coal Operations	776827	6621543	187	184-187	Pamboola Formation	level and quality	na	To be determined – never monitored
P28*	Standpipe	Narrabri Coal Operations	778343	6620162	25	19-25	Napperby Formation (above sill)	seepage	na	na
P29	Standpipe	Narrabri Coal Operations	778541	6619978	25	19-25	Napperby Formation (above sill)	seepage	na	EC two tiered
P30	Standpipe	Narrabri Coal Operations	778808	6620071	15	9-15	Napperby Formation (above sill)	seepage	na	na
P31	Standpipe	Narrabri Coal Operations	778318	6620343	15	9-15	Napperby Formation (above sill)	seepage	na	EC two tiered
P32	Standpipe	Narrabri Coal Operations	778993	6620335	15	9-14	Napperby Formation (above sill)	seepage	na	EC two tiered
P33*	Standpipe	Narrabri Coal Operations	778772	6620523	15	9-14	Napperby Formation (above sill)	seepage	na	na

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
P34*	Standpipe	Narrabri Coal Operations	778542	6620604	15	9-14	Napperby Formation (above sill)	seepage	na	na
P39A	Standpipe	Private	782024	6620076	80	72-78	Watermark Formation	level and quality	na	ANZG (stock)
P39B	Standpipe	Private	782018	6620077	32	15-30	Tullamullen Alluvium	level and quality	na	ANZG (irrigation), bore specific
P42_185	VWP	Narrabri Coal Operations	771092	6614376	427	185	Purlawaugh Formation	level	na	na
P42_345	VWP	Narrabri Coal Operations	771092	6614376	427	345	Digby Formation	level	na	na
P42_375	VWP	Narrabri Coal Operations	771092	6614376	427	375	Benelabri Formation	level	na	na
P42_395	VWP	Narrabri Coal Operations	771092	6614376	427	395	Hoskissons Coal Seam	level	na	na
P42_415	VWP	Narrabri Coal Operations	771092	6614376	427	415	Arkarula Formation	level	na	na
P42_90	VWP	Narrabri Coal Operations	771092	6614376	121	90	Pilliga Sandstone	level	na	na
P43	Standpipe	Private	781248	6619992	66	59-65	Watermark Formation	level and quality	na	EC two tiered
P44_134	VWP	Narrabri Coal Operations	777434	6623212	471	134	Digby Formation	level	na	na
P44_245	VWP	Narrabri Coal Operations	777434	6623212	471	245	Arkarula Formation	level	na	na
P44_330	VWP	Narrabri Coal Operations	777434	6623212	471	330	Arkarula Formation	level	na	na
P44_375	VWP	Narrabri Coal Operations	777434	6623212	471	375	Arkarula Formation	level	na	na
P44_445	VWP	Narrabri Coal Operations	777434	6623212	471	445	Arkarula Formation	level	na	na
P44_95	VWP	Narrabri Coal Operations	777434	6623212	98	95	Napperby Formation	level	na	na
P45_42	VWP	Narrabri Coal Operations	779491	6620117	291	42.5	Digby Formation	level	na	na
P45_80	VWP	Narrabri Coal Operations	779491	6620117	291	80	Arkarula Formation	level	na	na
P45_150	VWP	Narrabri Coal Operations	779491	6620117	291	150	Watermark Formation	level	na	na
P45_200	VWP	Narrabri Coal Operations	779491	6620117	291	200	Watermark Formation	level	na	na
P45_240	VWP	Narrabri Coal Operations	779491	6620117	291	240	Watermark Formation	level	na	na
P45_276	VWP	Narrabri Coal Operations	779491	6620117	291	276	Watermark Formation	level	na	na
P46_70	VWP	Narrabri Coal Operations	777395	6617847	396	70	Napperby Formation	level	na	na

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
P46_87	VWP	Narrabri Coal Operations	777395	6617847	396	87	Digby Formation	level	na	na
P46_151	VWP	Narrabri Coal Operations	777395	6617847	396	151	Pamboola Formation	level	na	na
P46_250	VWP	Narrabri Coal Operations	777395	6617847	396	250	Watermark Formation	level	na	na
P46_308	VWP	Narrabri Coal Operations	777395	6617847	396	308	Porcupine Formation	level	na	na
P46_34	VWP	Narrabri Coal Operations	777395	6617847	396	343	Leard Formation	level	na	na
P47	Standpipe	Narrabri Coal Operations	776166	6622586	31	8-30.5	Garrawilla Volcanics	level and quality	na	ANZG (stock)
P51	Standpipe	Narrabri Coal Operations	777437	6620859	17	9-12	Garrawilla Volcanics	seepage	na	EC two tiered
P52	Standpipe	Narrabri Coal Operations	777118	6620808	24	18-21	Napperby Formation	seepage	na	EC two tiered
P53	Standpipe	Narrabri Coal Operations	776995	6620655	24	18-21	Garrawilla Volcanics	seepage	na	EC two tiered
P54_30	VWP	State Forest	773079	6610419	348	30	Pilliga Sandstone	level	na	na
P54_60	VWP	State Forest	773079	6610419	348	60	Purlawaugh Formation	level	na	na
P54_100	VWP	State Forest	773079	6610419	348	100	Purlawaugh Formation	level	na	na
P54_140	VWP	State Forest	773079	6610419	348	140	Napperby Formation	level	na	na
P54_180	VWP	State Forest	773079	6610419	348	180	Napperby Formation	level	na	na
P54_220	VWP	State Forest	773079	6610419	348	220	Napperby Formation	level	na	na
P54_260	VWP	State Forest	773079	6610419	348	260	Napperby Formation	level	na	na
P54_300	VWP	State Forest	773079	6610419	348	300	Benelabri Formation	level	na	na
P54_338	VWP	State Forest	773079	6610419	348	338	Arkarula Formation	level	na	na
P55_68	VWP	Narrabri Coal Operations	776425	6610503	230	68	Napperby Formation	level	na	na
P55_91	VWP	Narrabri Coal Operations	776425	6610503	230	91	Napperby Formation	level	na	na
P55_103	VWP	Narrabri Coal Operations	776425	6610503	230	103	Digby Formation	level	na	na
P55_128	VWP	Narrabri Coal Operations	776425	6610503	230	128	Arkarula Formation	level	na	na
P55_152	VWP	Narrabri Coal Operations	776425	6610503	230	152	Pamboola Formation	level	na	na

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
P55_188	VWP	Narrabri Coal Operations	776425	6610503	230	188	Pamboola Formation	level	na	na
P55_221	VWP	Narrabri Coal Operations	776425	6610503	230	221	Pamboola Formation	level	na	na
P56_55	VWP	Narrabri Coal Operations	776277	6614725	368	55	Napperby Formation	level	na	na
P56_85	VWP	Narrabri Coal Operations	776277	6614725	368	85	Napperby Formation	level	na	na
P56_115	VWP	Narrabri Coal Operations	776277	6614725	368	115	Napperby Formation	level	na	na
P56_145	VWP	Narrabri Coal Operations	776277	6614725	368	145	Napperby Formation	level	na	na
P56_175	VWP	Narrabri Coal Operations	776277	6614725	368	175	Arkarula Formation	level	na	na
P56_205	VWP	Narrabri Coal Operations	776277	6614725	368	205	Pamboola Formation	level	na	na
P56_235	VWP	Narrabri Coal Operations	776277	6614725	368	235	Pamboola Formation	level	na	na
P56_265	VWP	Narrabri Coal Operations	776277	6614725	368	265	Watermark Formation	level	na	na
P56_300	VWP	Narrabri Coal Operations	776277	6614725	368	300	Porcupine Formation	level	na	na
P58	Standpipe	Narrabri Coal Operations	778649	6619912	40	32-38	Napperby Formation	seepage	na	EC two tiered
WB2	Standpipe	Narrabri Coal Operations	776382	6619701	26	22-26	Garrawilla Volcanics	level and quality	predicted drawdown	To be determined
WB10 (GW013858)	Standpipe (Stock and domestic)	Private	774254	6603250	33.5	24.3-30.3	Napperby Formation	level	predicted drawdown	To be determined
WB11 (House bore)	Standpipe (Stock and domestic)	Private	772678	6601496	58	unknown	Garrawilla Volcanics	level	predicted drawdown	To be determined
WB12 (257_bore)	Standpipe	Private	780874	6617836	100	60-75	Arkarula Formation and Pamboola Formation	level	predicted drawdown	To be determined
WB13 (GW008634)	Standpipe (Stock and domestic)	Private	772930	6597095	78.3	25.9-30.4 and 70.7-78.2	Garrawilla Volcanics/Napperby Formation	level	predicted drawdown	To be determined
WB14 (GW026121)	Standpipe	Private	773126	6603421	20.1	unknown	Garrawilla Volcanics	level	predicted drawdown	To be determined
WB15 (Windmill Bore)	Standpipe	Private	779733	6628836	20	Unknown	Napperby Formation	level	predicted drawdown	To be determined
WB16 (South Caloola)	Standpipe	Private	775254	6602244	41	Unknown	Napperby Formation	level	predicted drawdown	To be determined
WB17 (GW903687 - Solar Bore)	Standpipe (Stock and domestic)	Private	779491	6628525	23.88	Unknown	Napperby Formation	level	predicted drawdown	To be determined
WB18 (Mentone Bore)	Standpipe (Stock and domestic)	Private	776686	6629386	16.69	Unknown	Napperby Formation	level	predicted drawdown	To be determined
Mayfield	GDE	Narrabri Coal Operations	775670	6615617	na	na	Pilliga Sandstone	Flow rate and surface conditions	na	na

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
Eather (Dam 1)	GDE	-	771133	6602103	na	na	na	Flow rate and surface conditions	na	na
Eather (Dam 2)	GDE	-	771292	6602251	na	na	na	Flow rate and surface conditions	na	na
Hardy's	GDE	-	770726	6604763	na	na	na	Flow rate and surface conditions	na	na
Blairmore Feature 1	GDE	-	773353	6597177	na	na	na	Flow rate and surface conditions	na	na
Blairmore Feature 2	GDE	-	774557	6597554	na	na	na	Flow rate and surface conditions	na	na
Quaternary Alluvium bore P59	Standpipe	Narrabri Coal Operations	772114	6623344	To be confirmed	4-6	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P60	Standpipe	Narrabri Coal Operations	772114	6623344	40	28-34	Pilliga Sandstone	level and quality	To be determined	To be determined
Quaternary Alluvium bore P61-1	VWP	Narrabri Coal Operations	772114	6623344	28	na	Pilliga Sandstone	level	To be determined	na
Quaternary Alluvium bore P61-2	VWP	Narrabri Coal Operations	772114	6623344	93	na	Purlawaugh	level	To be determined	na
Quaternary Alluvium bore P61-3	VWP	Narrabri Coal Operations	772114	6623344	147	na	Garawilla	level	To be determined	na
Quaternary Alluvium bore P61-4	VWP	Narrabri Coal Operations	772114	6623344	212	na	Napperby	level	To be determined	na
Quaternary Alluvium bore P61-5	VWP	Narrabri Coal Operations	772114	6623344	71	na	Basalt Sill	level	To be determined	na
Quaternary Alluvium bore P61-6	VWP	Narrabri Coal Operations	772114	6623344	24	na	Digby Formation	level	To be determined	na
Quaternary Alluvium bore P62	Standpipe	Narrabri Coal Operations	776984	6624759	To be confirmed	4-6	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P63	Standpipe	Narrabri Coal Operations	776984	6624759	50	40-45	Napperby	level and quality	To be determined	To be determined
Quaternary Alluvium bore P64-1	VWP	Narrabri Coal Operations	776984	6624759	5	na	Alluvium/Colluvium	level	To be determined	na
Quaternary Alluvium bore P64-2	VWP	Narrabri Coal Operations	776984	6624759	43	na	Napperby	level	To be determined	na
Quaternary Alluvium bore P64-3	VWP	Narrabri Coal Operations	776984	6624759	90	na	Basalt Sill	level	To be determined	na
Quaternary Alluvium bore P64-4	VWP	Narrabri Coal Operations	776984	6624759	114	na	Napperby Base Sill	level	To be determined	na
Quaternary Alluvium bore P64-5	VWP	Narrabri Coal Operations	776984	6624759	134	na	Digby Formation	level	To be determined	na
Quaternary Alluvium bore P64-6	VWP	Narrabri Coal Operations	776984	6624759	143	na	Hoskissons ^	level	To be determined	na
Quaternary Alluvium bore P65	Standpipe	Narrabri Coal Operations	771467	6612256	To be confirmed	3-5	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P66	Standpipe	Narrabri Coal Operations	771467	6612256	40	30-35	Pilliga Sandstone	level and quality	To be determined	To be determined

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
Quaternary Alluvium bore P67-1	VWP	Narrabri Coal Operations	771467	6612256	30	na	Pilliga Sandstone	level	To be determined	na
Quaternary Alluvium bore P67-2	VWP	Narrabri Coal Operations	771467	6612256	106	na	Purlawaugh	level	To be determined	na
Quaternary Alluvium bore P67-3	VWP	Narrabri Coal Operations	771467	6612256	168	na	Garawilla	level	To be determined	na
Quaternary Alluvium bore P67-4	VWP	Narrabri Coal Operations	771467	6612256	243	na	Napperby	level	To be determined	na
Quaternary Alluvium bore P67-5	VWP	Narrabri Coal Operations	771467	6612256	301	na	Basalt Sill	level	To be determined	na
Quaternary Alluvium bore P67-6	VWP	Narrabri Coal Operations	771467	6612256	354	na	Digby Formation	level	To be determined	na
Quaternary Alluvium bore P68	Standpipe	Narrabri Coal Operations	776329	6616863	To be confirmed	4-6	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P69	Standpipe	Narrabri Coal Operations	776329	6616863	50	40-45	Napperby	level and quality	To be determined	To be determined
Quaternary Alluvium bore P70-1	VWP	Narrabri Coal Operations	776329	6616863	5	na	Alluvium/Colluvium	level	To be determined	na
Quaternary Alluvium bore P70-2	VWP	Narrabri Coal Operations	776329	6616863	41	na	Napperby	level	To be determined	na
Quaternary Alluvium bore P70-3	VWP	Narrabri Coal Operations	776329	6616863	83	na	Basalt Sill	level	To be determined	na
Quaternary Alluvium bore P70-4	VWP	Narrabri Coal Operations	776329	6616863	125	na	Digby Formation	level	To be determined	na
Quaternary Alluvium bore P70-5	VWP	Narrabri Coal Operations	776329	6616863	133	na	Hoskissons ^	level	To be determined	To be determined
Quaternary Alluvium bore P71	Standpipe	Narrabri Coal Operations	770548	6604413	To be confirmed	4-6	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P72	Standpipe	Narrabri Coal Operations	770548	6604413	50	40-45	Purlawaugh	level and quality	To be determined	To be determined
Quaternary Alluvium bore P73-1	VWP	Narrabri Coal Operations	770548	6604413	22	na	Pilliga Sandstone	level	To be determined	na
Quaternary Alluvium bore P73-2	VWP	Narrabri Coal Operations	770548	6604413	41	na	Purlawaugh	level	To be determined	na
Quaternary Alluvium bore P73-3	VWP	Narrabri Coal Operations	770548	6604413	91	To be confirmed	Garawilla	level	To be determined	na
Quaternary Alluvium bore P73-4	VWP	Narrabri Coal Operations	770548	6604413	180	To be confirmed	Napperby	level	To be determined	na
Quaternary Alluvium bore P73-5	VWP	Narrabri Coal Operations	770548	6604413	273	na	Digby Formation	level	To be determined	na
Quaternary Alluvium bore P73-6	VWP	Narrabri Coal Operations	770548	6604413	285	na	Hoskissons	level	To be determined	na
Quaternary Alluvium bore P74	Standpipe	Narrabri Coal Operations	776555	6605888	To be confirmed	4-6	Alluvium/Colluvium	level and quality	To be determined	To be determined
Quaternary Alluvium bore P75	Standpipe	Narrabri Coal Operations	776555	6605888	20	12-16	Napperby	level and quality	To be determined	To be determined

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
Quaternary Alluvium bore P76-1	VWP	Narrabri Coal Operations	776555	6605888	4	na	Alluvium/Colluvium		To be determined	na
Quaternary Alluvium bore P76-2	VWP	Narrabri Coal Operations	776555	6605888	8	na	Napperby		To be determined	na
Quaternary Alluvium bore P76-3	VWP	Narrabri Coal Operations	776555	6605888	21	na	Basalt Sill		To be determined	na
Quaternary Alluvium bore P76-4	VWP	Narrabri Coal Operations	776555	6605888	43	na	Napperby Base Sill	level	To be determined	na
Quaternary Alluvium bore P76-5	VWP	Narrabri Coal Operations	776555	6605888	66	na	Digby Formation		To be determined	na
Quaternary Alluvium bore P76-6	VWP	Narrabri Coal Operations	776555	6605888	79	na	Hoskissons ^		To be determined	na
P77-1	VWP	Narrabri Coal Operations	772478	6623677	24	To be confirmed	Pilliga Sandstone	level	na	na
P77-2	VWP	Narrabri Coal Operations	772478	6623677	82	To be confirmed	Purlawaugh Formation	level	na	na
P77-3	VWP	Narrabri Coal Operations	772478	6623677	134	To be confirmed	Garawilla Volcanics	level	na	na
P77-4	VWP	Narrabri Coal Operations	772478	6623677	198	To be confirmed	Napperby Formation	level	na	na
P77-5	VWP	Narrabri Coal Operations	772478	6623677	245	To be confirmed	Basalt Sill	level	na	na
P77-6	VWP	Narrabri Coal Operations	772478	6623677	261	To be confirmed	Napperby Base Sill	level	na	na
P77-7	VWP	Narrabri Coal Operations	772478	6623677	294	To be confirmed	Digby Formation	level	na	na
P78-1	VWP	Narrabri Coal Operations	774682	6610770	29	To be confirmed	Garawilla Volcanics	level	na	na
P78-2	VWP	Narrabri Coal Operations	774682	6610770	110	To be confirmed	Napperby Formation	level	na	na
P78-3	VWP	Narrabri Coal Operations	774682	6610770	166	To be confirmed	Basalt Sill	level	na	na
P78-4	VWP	Narrabri Coal Operations	774682	6610770	182	To be confirmed	Napperby Base Sill	level	na	na
P78-5	VWP	Narrabri Coal Operations	774682	6610770	203	To be confirmed	Digby Formation	level	na	na
P79-1	VWP	Narrabri Coal Operations	774203	6610738	17	To be confirmed	Purlawaugh Formation	level	na	na
P79-2	VWP	Narrabri Coal Operations	774203	6610738	56	To be confirmed	Garawilla Volcanics	level	na	na
P79-3	VWP	Narrabri Coal Operations	774203	6610738	136	To be confirmed	Napperby Formation	level	na	na
P79-4	VWP	Narrabri Coal Operations	774203	6610738	193	To be confirmed	Basalt Sill	level	na	na
P79-5	VWP	Narrabri Coal Operations	774203	6610738	209	To be confirmed	Napperby Base Sill	level	na	na

Location ID	Monitoring type	Owner	Coordinates (MGA55)		Bore depth (m)	Screen interval (mbgl)	Formation	Monitoring purpose	Trigger criteria	
			Easting	Northing					Level	Quality
P79-6	VWP	Narrabri Coal Operations	774203	6610738	228	To be confirmed	Digby Formation	level	na	na
P80-1	VWP	Narrabri Coal Operations	775019	6616999	31.82	To be confirmed	Garawilla Volacnics	level	na	na
P80-2	VWP	Narrabri Coal Operations	775019	6616999	80.07	To be confirmed	Napperby Formation	level	na	na
P80-3	VWP	Narrabri Coal Operations	775019	6616999	132.32	To be confirmed	Basalt Sill	level	na	na
P80-4	VWP	Narrabri Coal Operations	775019	6616999	161.57	To be confirmed	Napperby Base Sill	level	na	na
P80-5	VWP	Narrabri Coal Operations	775019	6616999	188.11	To be confirmed	Digby Formation	level	na	na
P81	Wireline extensometer	Narrabri Coal Operations	775019	6617032	270	To be confirmed	To be confirmed	displacement	na	na
P82										

Notes:

* Historically dry with insufficient water to sample

^the Hoskissons Coal Seam might not be present at the eastern sites (new sites 2, 4 and 6) or thinned out significantly.

Appendix E - Groundwater quality trigger values

Groundwater quality – seepage monitoring bores

Derived trigger values for six shallow monitoring bores located around the mine brine storage points are summarised in Table E-1 and Table E-2 for bores completed into the Napperby Formation and Garrawilla Volcanics, respectively. Water quality impacts are considered likely at these locations, hence trigger values for these monitoring points have predominantly been derived using a control charting approach (DES 2021).

Table E-1 Proposed trigger values for seepage monitoring bores situated in the Napperby Formation

Parameter	P29 [1]		P31 [1]		P32 [1]		P52 [1]	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	9,732	11,337	7,110	7,195	2,170	2,938	2,300	2,533
pH	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES 2021)
^ ANZG (2018) irrigation, long term application

Table E-2 Proposed trigger values for seepage monitoring bores situated in the Garrawilla Volcanics

Parameter	P51 [1]		P53 [1]	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	19,500	19,860	1,107	1,169
pH	**Min.**	**Max.**	**Min.**	**Max.**
	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES 2021))
^ ANZG (2018) irrigation, long term application

Groundwater Quality Trigger Values – strata likely to experience drawdown impacts

Water quality triggers have been derived for a number of locations in each unit as summarised below in Table E-3, Table E-4, Table E-5, Table E-6, and Table E-7.

Table E-3 Garrawilla Volcanics monitoring locations and proposed trigger values

Parameter	WB2, P13, P47 [1]	P1 [1]	P16 [1]
EC (µS/cm)	5,970	5,970	5,970
pH	**Min.**		**Max.**
	6.0^		8.5^

Notes:
[1] ANZG (2018) livestock drinking water (beef cattle)
^ ANZG (2018) irrigation, long term application

Table E-4 Napperby Formation monitoring locations and proposed trigger values

Parameter	P2[3]		P4[3]		P10[3]		P12	
	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)		
EC (µS/cm)	19,342[1]	19,731[1]	24,912[1]	25,610[1]	8,894[1]	9,426[1]	5,970[2]	
pH	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Napperby Formation monitoring locations P2, P4 and P10 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table E-5 Purlawaugh Formation monitoring locations and proposed trigger values

Parameter	P8		P9 [1 3]		P11 [1 3]	
			Tier 1 (80th)	Tier 2 (95th)	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	5,970[2]		20,330[1]	21,190[1]	6,052[1]	6,546[1]
pH	Min.	Max.	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Purlawaugh Formation monitoring locations P9 and P11 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table E-6 Watermark Formation monitoring locations and proposed trigger values

Parameter	Proposed trigger value (P39a)		P43 [1 3]	
			Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	5,970[2]		11,162[1]	11,412[1]
pH	Min.	Max.	Min.	Max.
	6.0^	8.5^	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DES 2021)
[2] ANZG (2018) livestock drinking water (beef cattle)
[3] Review of EC data for the Watermark Formation monitoring location P43 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Table E-7 Pamboola Formation monitoring locations and proposed trigger values

Parameter	P3 [1 2]	
	Tier 1 (80th)	Tier 2 (95th)
EC (µS/cm)	18,016[1]	18,564[1]
pH	Min.	Max.
	6.0^	8.5^

Notes:
[1] Tier 1 and Tier 2 control charting method (DSITI, 2017)
[2] Review of EC data for the Pamboola Formation monitoring location P3 suggests that salinity (EC) values for groundwater at these locations is unsuitable for use as livestock drinking water. These locations are recommended for exclusion from ongoing assessment against the livestock drinking water trigger values.
^ ANZG (2018) irrigation, long term application

Groundwater Quality Trigger Values – Strata unlikely to experience drawdown impacts

Consistent with the level of impact (i.e. no significant groundwater level or water quality impacts are predicted in the Pilliga Sandstone or the Namoi Alluvium), water quality triggers have been derived for at least one monitoring point in each aquifer. In each case, the closest monitoring point to the mine lease was selected. Adopted trigger values are summarised below in Table E-8 and Table E-9.

As shown for parameters where the historic baseline data suggest that the groundwater will not be suitable for long term irrigation (the dominant use of groundwater in these aquifers) then bore specific triggers, based on the 80th percentile of the observed data, have been developed. Trigger values for other parameters have been set based on ANZG guideline values (ANZG 2018).

Table E-8 Alluvium monitoring locations and proposed trigger values

Parameter	P39b	
EC (µS/cm)	6,546 [1]	
pH	Min.	Max.
	6.0^	8.5^

Notes:
[1] Bore specific 80th percentile
^ ANZG (2018) irrigation, long term application.

Table E-9 Pilliga Sandstone monitoring locations and proposed trigger values

Parameter	P6, P7	
EC (µS/cm)	2,327 [1]	
pH	Min.	Max.
	6.0^	8.5^

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

Groundwater Quality Trigger Values – Private Bores

As shown in Table E-10, groundwater trigger values have been derived for the nine privately owned bores with a predicted drawdown of more than2 m. No historic data is currently available for these bores and hence the initial EC trigger value is based on ANZG guideline values for beef cattle watering (ANZG 2018).

The nine new privately owned bores discussed in section 4.6 will require sufficient baseline data to be collected to determine if water quality trigger values will be required and included in the monitoring program.

Table E-10 Privately owned bores proposed trigger values

Parameter	Trigger values	
EC (µS/cm)	5,970[1]	
pH	**Min.**	**Max.**
	6.0^	8.5^

Notes:
[1] ANZG (2018) livestock drinking water (beef cattle)
^ ANZG (2018) irrigation, long term application