Newcastle Inner City Bypass – Rankin Park to Jesmond

Surface and Ground Water Quality Construction Monitoring Program

October 2023 | Version: G

Contents

Revision history

Revision	Description	Date
Rev A	TfNSW review	23 September 2021
Rev B	TfNSW review	10 November 2021
Rev C	TfNSW review	05 April 2022
Rev D	TfNSW review	19 April 2022
Rev E	Updated to reflect agency review	17 May 2022
Rev F	Updated to reflect DPE comments	30 June 2022
Rev G	Minor changes: update groundwater monitoring locations ER Approval (MCoA A26(j))	23 November 2023

Approval and authorisation

Program reviewed by:	Program reviewed by:	Program endorsed by:
Lawson Gill		Simon Williams
Senior Environment and Sustainability Officer		Environmental Representative
17/05/2022 		

Author	Kat Hutton – Senior Hydrogeologist
Date	27 October, 2023
Version	Rev G

Glossary

TERM	DESCRIPTION
Project terms	
Construction	Includes all works required to construct the SSI, including commissioning trials of equipment and temporary use of any part of the SSI, but excluding the following low impact work which is completed prior to approval of the CEMP: (a) survey works including carrying out general alignment survey, installing survey controls (including installation of global positioning systems (GPS)), installing repeater stations, carrying out surveys of existing and future utilities and building and road dilapidation surveys (b) investigations including investigative drilling, contamination investigations and excavation (c) operation of ancillary facilities if the ER has determined the operational activities will have minimal impact on the environment and community (d) minor clearing and relocation of native vegetation, as identified in the documents listed in Condition A1 (e) installation of mitigation measures including erosion and sediment controls, exclusion fencing, hoardings and temporary or at property acoustic treatments (f) property acquisition adjustment works including installation of property fencing, and relocation and adjustments of utilities to property including water supply and electricity (g) relocation and connection of utilities where the relocation or connection has a minor impact to the environment and sensitive receivers as determined by the ER (h) archaeological testing under the Code of practice for archaeological investigation of Aboriginal objects in NSW (DECCW, 2010) or archaeological monitoring undertaken in association with (a)-(g) and (i) to ensure that there is no impact on Aboriginal artefacts or objects, and archaeological salvage works in accordance with A1, E17 and E18 (i) other activities determined by the ER to have minimal environmental impact which may include construction of minor access roads, temporary relocation of pedestrian and cycle paths and the provision of property access (j) maintenance of existing buildings and structures required to facilitate the carrying out of the SSI. However, where heritage items or threatened species or threatened ecological communities (within the meaning of the NSW Threatened Species Conservation Act 1995 or Commonwealth Environment Protection and Biodiversity Conservation Act 1999) are affected or potentially affected by any low impact work, that work is construction, unless otherwise determined by the Planning Secretary in

TERM	DESCRIPTION
	consultation with the relevant heritage authority, BCD or DPI Fisheries (in the case of impact upon fish, aquatic invertebrates or marine vegetation).
Environmental Representative (ER)	A suitably qualified and experienced person independent of Project design and construction personnel employed for the duration of Construction. The principal point of advice in relation to all questions and complaints concerning environmental performance.
The Project	Rankin Park to Jesmond Bypass
Project approval	The Infrastructure Approval for Newcastle Inner City Bypass, Rankin Park to Jesmond, issued by the New South Wales Government on 15 February 2019
Works	All physical activities to construct or facilitate the construction of the SSI, including environmental management measures and utility works. However, does not include work that informs or enables the detailed design of the SSI and generates noise that is no more than 5 dB(A) above the rating background level at any residence.

Acronyms

Acronym	Description
AHD	Australian Height Datum
AS	Australian Standard
ANZECC	Australia New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Governments
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BTEX	benzene, toluene, ethylbenzene and xylene
CAQMP	Construction Air Quality Monitoring Program
CAQMP	Construction Air Quality Management Plan
CBD	Central business district
CEMP	Construction Environmental Management Plan
CoA	Conditions of Approval
DO	dissolved oxygen
DPE	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
EC	electrical conductivity
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EPL	Environment Protection Licence
ER	Environmental Representative
GDE	Groundwater Dependent Ecosystem
GWL	Groundwater level
GWQ	Groundwater quality
ISO	International Organisation for Standardisation
JHH	John Hunter Hospital
JSA	Job safety analysis
LGA	local government area
mAHD	meters Australian Height Datum

Acronym	Description
mbgl	meters below ground level
mbTOC	metres below top of bore casing
mg/L	milligrams per Litre
µS/cm	microsiemens per centimetre
mTOC	metres at top of bore casing
NATA	National Association of Testing Authorities, Australia
NSW	New South Wales
NTU	nephelometric turbidity units
NWQMS	National Water Quality Management Strategy
PAH	polycyclic aromatic hydrocarbon
POEO Act	Protection of the Environment Operations Act 1997
REMM	Revised Environmental Management Measure
RP2J	Rankin Park to Jesmond Bypass
SGWQCMP	Surface and Ground Water Quality Construction Monitoring Program
SPIR	Submissions and Preferred Infrastructure Report submitted to the Planning Secretary of the DPE under the EP&A Act
SSI	State Significant Infrastructure
TfNSW	Transport for New South Wales
TPH	total petroleum hydrocarbon
TRH	total recoverable hydrocarbon
TSS	total suspended solids

1 Introduction

The Newcastle Inner City Bypass (the Project) is part of Transport for NSW's (Transport's) longterm strategy to provide an orbital road within Newcastle's road network to connect the Pacific Highway at Bennetts Green with the Pacific Highway at Sandgate. The Project would provide improved traffic flows across the western suburbs of Newcastle and connect key regional destinations such as Bennetts Green, Charlestown and Jesmond shopping centres, John Hunter Hospital precinct, The University of Newcastle and the Pacific Highway.

The Project would involve the construction of about 3.4 kilometres of new four lane divided road between Lookout Road at New Lambton Heights and Newcastle Road at Jesmond. The Project is located in the Newcastle local government area (LGA), about 11 kilometres west of the Newcastle central business district.

Approval for the project was granted on 15 February 2019 by the Minister for Planning (application number SSI 6888) and was subject to several conditions of approval. A modification report (Newcastle Inner City Bypass – Rankin Park to Jesmond Modification report: additional construction compounds, May 2021) to include additional construction compounds was prepared in May 2021 and was approved on 7 February 2022. The Project is no longer proposing to use the Peatties Road compound site. This program will be updated in the event that the Peatties Road compound site is used.

Figure 1presents the Project boundary, including the off-site compounds which are further detailed in Figure 2.

1.1 Project background

The Newcastle Inner City Bypass Environmental Impact Statement (EIS) (GHD, 2016) and the Submissions and Preferred Infrastructure Report (SPIR) (GHD, 2018) assessed the impacts of construction and operation of the Project on surface water and groundwater. For a detailed understanding and background of the main project, please refer to these documents. The information provided within this report relates only to the Project area.

The EIS identified the potential for minor impacts on groundwater during construction typically associated with drawdown and contamination. However, it concluded any potential impacts could be managed by the standard mitigation and management measures that are described in this Surface and Ground Water Quality Construction Monitoring Program (SGWQCMP).

This SGWQCMP has been prepared to address the requirements of the Minister's Infrastructure Approval (SSI 6888) and all applicable guidance and legislation.

1.2 Approval of SGWQCMP

The SGWQCMP was endorsed by the Environmental Representative (ER) and approved by the Department of Planning (DPE) in June 2022.

Since approval of the SGWQCMP, the groundwater monitoring locations that were known to be located within the project boundary and to be removed have since been decommissioned.

Eleven groundwater wells have been decommissioned since approval of this SGWQCMP in June 2022. The 11 groundwater monitoring wells were located within the project clearing boundary or have been lost and are unable to be monitored. Figure 3a and Figure 3b illustrates the groundwater monitoring wells that have been decommissioned and retained.

Additional bores were also installed to account for the bores that would be affected by construction activities. A hydrogeologist reviewed the SGWQCMP requirements and confirmed that the remaining groundwater monitoring wells are sufficient to monitor groundwater during construction in conjunction with four vibrating wire piezometers (VWP) in the southern interchange and two VWP in the vicinity of BH326. The locations of the VWP are shown in Figure 3a and Figure 3b.

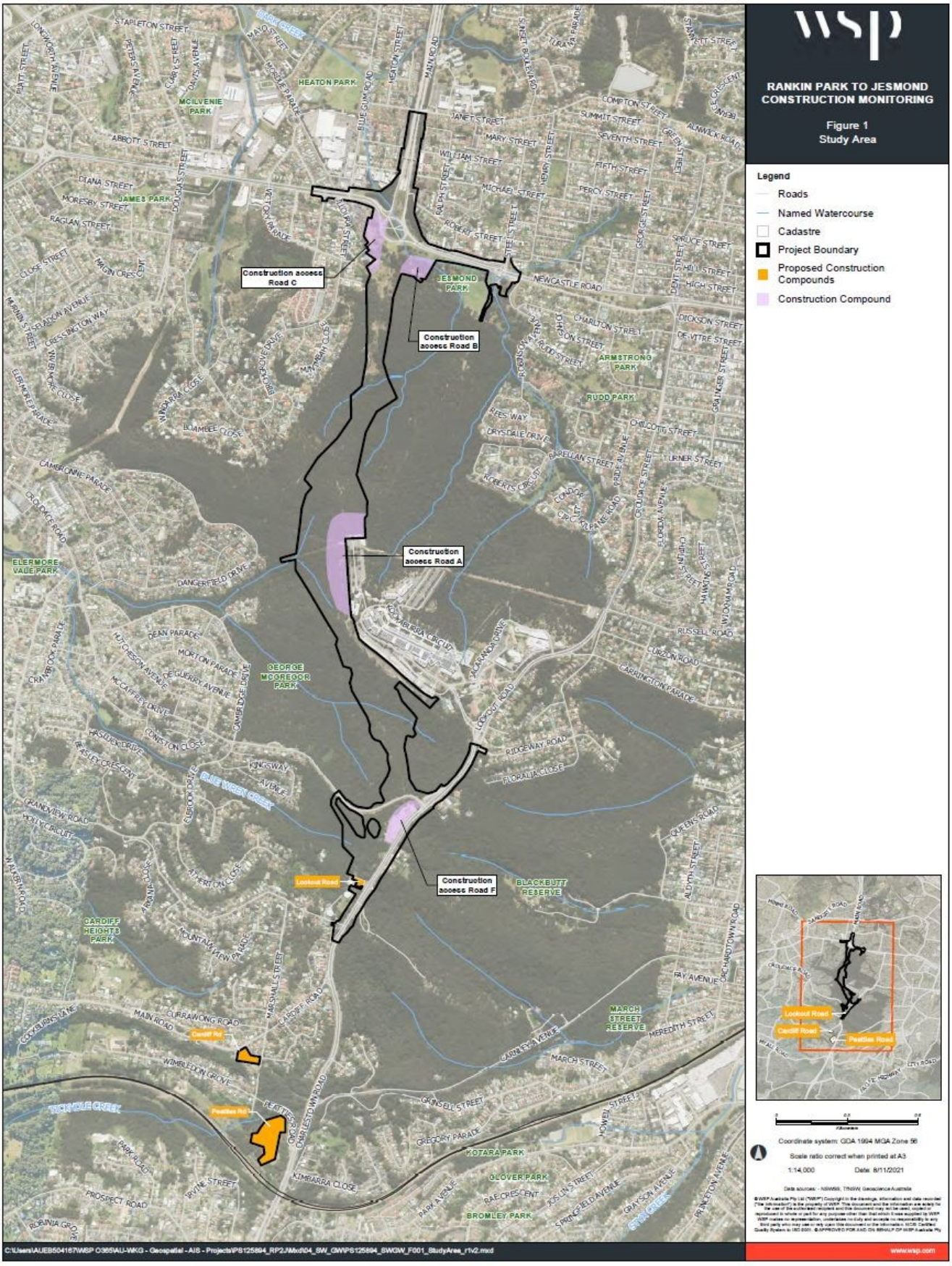

Figure 1 Project boundary

2 Purpose and Scope

2.1 Purpose

The purpose of the SGWQCMP is to meet the Conditions of Approval (CoA) and describe how the Project proposes to monitor the extent and nature of potential impacts to surface water quality, groundwater quality and groundwater elevation during construction of the Project. The SGWQCMP will be implemented to monitor the effectiveness of mitigation measures applied during the construction phase of the Project and provide performance criteria which will be used to identify potential impacts.

This SGWQCMP is informed by the baseline studies developed for the Project EIS (GHD, 2016), continued baseline monitoring reports (Aurecon, 2021) and surface water quality data collected by Transport. Details of the surface and groundwater monitoring network, frequency of monitoring, and test parameters are provided.

Table 1 outlines the CoA relevant to monitoring and how each condition has been addressed in this SGWQCMP.

2.2 Scope of the surface and groundwater monitoring program

The scope of this SGWQCMP is to describe how the Project proposes to monitor the extent and nature of potential impacts to surface water quality, groundwater quality and elevation during construction of the Project and 12 months following completion.

2.3 Related documents

This SGWQCMP forms part of the suite of Construction Monitoring Programs for the Project.

- Surface and Ground Water Quality
- Air Quality
- Noise and Vibration
- Flora and Fauna.

2.4 Consultation

In accordance with CoA C9 and C11, this surface and groundwater construction monitoring program has been prepared in consultation with:

- City of Newcastle
- Lake Macquarie City Council
- NSW Department of Primary Industries – Fisheries
- NSW Department of Planning and Environment – Water.

A copy of the draft program was provided to the above groups on 19 April 2022 for review and comment. Table 1 provides detail on issues raised and where in this SGWQCMP they have been addressed, where relevant.

Table 1 Consultation summary

Issue no.	Summary of issue	Where addressed in report
City of Newcastle		
1	*No issues raised during agency review*	*N/A*
Lake Macquarie City Council		
1	*No issues raised during agency review*	*N/A*
NSW Department of Planning and Environment - Water		
1	*No issues raised during agency review*	*N/A*
NSW Department of Primary Industries – Fisheries		
1	*No issues raised during agency review.*	*N/A*

3 Compliance

This SGWQCMP has been prepared to ensure all CoA, REMMs and legislative requirements relevant to surface water and groundwater monitoring are described, scheduled, and assigned responsibility as outlined in:

- Conditions of Approval SSI 6888
- Revised Environment Management Measures as per the SPIR
- All documents listed in CoA A1
- Transport QA specifications G36 and G38
- The Project's Environment Protection License (EPL)..

3.1 Relevant legislation and guidelines

Legislation and guidelines which relate to the surface water and groundwater monitoring program includes:

- Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales (DEC 2004)
- Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC and ARMCANZ 2000)
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)
- National Water Quality Management Strategy (NWQMS)
- NSW Groundwater Dependent Ecosystems Policy
- NSW Groundwater Quality Protection Policy
- NSW Protection of the Environment Operations Act 1997 (POEO Act)
- Water Management Act 2000.

3.2 Conditions of Approval

The Projects CoA are outlined in the NSW Government Department of Planning and Environment CoA for Newcastle Inner City Bypass Rankin Park to Jesmond (SSI 6888). Table 2 outlines the CoA relevant to monitoring and how each condition has been addressed in this SGWQCMP.

Table 2 Conditions of Approval

CoA Number	Condition description	Section addressed
C10	Each Construction Monitoring Program must provide:	
	a) details of baseline data available	Section 4.2 and 4.4
	b) details of baseline data to be obtained and when	Section 4.2 and 4.4
	c) the parameters of the Project to be monitored	Section 5.4.2
	d) the frequency of monitoring to be undertaken	Section 5.4.1
	e) the location of monitoring	Section 4.2.1 and 4.4.1
	f) the reporting of monitoring results	Section 6.3
	g) procedures to identify and implement additional or alternative mitigation measures where results of monitoring are unsatisfactory	Section 6.4
C11	The Construction Monitoring Programs must be developed in consultation with the relevant public authorities specified in Table 1 Where an authority's request(s) has not been included in the Monitoring Program, the Proponent must provide justification to the Planning Secretary as to why it was not included. Details of all information requested by an authority including copies of all correspondence from those authorities, must be provided with the relevant Construction Monitoring Program.	Section 2.4
C12	The Construction Monitoring Programs must be endorsed by the ER and then submitted to the Planning Secretary for approval at least one (1) month before the commencement of construction.	Section 2.4
C13	Construction must not commence until the Planning Secretary has approved, or as otherwise agreed by the Planning Secretary, all the required Construction Monitoring Programs, and all relevant baseline data for the specific construction activity has been collected.	Section 2.4
C14	The Construction Monitoring Programs, as approved by the Planning Secretary including any minor amendments approved by the ER must be implemented for the duration of construction and for any longer period set out in the monitoring program or specified by the Planning Secretary, whichever is the greater.	Section 5.1
C15	The results of the Construction Monitoring Programs must be submitted to the Planning Secretary, and relevant public authorities for information, in the form of a Construction Monitoring Report at the frequency identified in the relevant Construction Monitoring Program. Where a relevant CEMP Sub-plan exists, the relevant Construction Monitoring Program may be incorporated into that CEMP Sub-plan.	Section 6.3

3.3 Revised Environmental Management Measures

Revised Environmental Management Measures are outlined in Section 7 of the Newcastle Inner City Bypass – Rankin Park to Jesmond Submissions and Preferred Infrastructure Report. Table 3 outlines the REMMs relevant to monitoring and how they have been addressed in this SGWQCMP.

Table 3 Revised Environmental Management Measures

REMM ID	Description	Section addressed
SW15	Water quality monitoring will be carried out at key discharge points from the construction phase water management system. The monitoring requirements will be defined in the soil and water management plan and will include collection of samples for analysis from sedimentation basin discharge points and visual monitoring of other points of release of construction waters.	Section 5.6.2 & 5.5
GW02	A groundwater monitoring program will be prepared and implemented. The program will include:	
	Installation of monitoring bores (to replace those that would be removed during construction)	Section 4.2.1
	New monitoring bores will be installed both in and outside the predicted zones of perched groundwater drawdown to confirm the conceptual model. New bore(s) will be established in the proposed mine remediation area to confirm the depth to groundwater and groundwater quality	Section 4.2.2
	New monitoring bores will be installed near where mine remediation work is proposed to confirm the groundwater depth	Section 4.2.2
	Establishment of project specific water quality objectives	Section 6.2
	Bores will initially be monitored monthly for 12 months to collect baseline data. Monitoring will start as soon as possible and before the start of construction and will continue until completion, which may be after start of construction. The frequency of monitoring will then be reviewed to determine the appropriate regime	Section 4.2.2
	Bores will be monitored for standing water level and water quality (including pH, total dissolved solids, dissolved metals, nutrients and total recoverable hydrocarbons (silica gel clean-up)	Section 6.2
	A program of reporting of the monitoring results so that any unforeseen impacts are identified and responded to in a timely manner	Section 6.3
	The monitoring program will continue until 12 months after completion of construction with an annual review of groundwater data unless results permit an earlier end date.	Section 5.2

4 Baseline Groundwater and Surface Water Monitoring

4.1 Regional groundwater environment

Two main aquifers underlie the site; a discontinuous perched groundwater and a deeper regional sedimentary aquifer. Table 4 describes these aquifers.

Table 4 Summary of underlying groundwater aquifers

Aquifer	Description
Perched groundwater	Low yielding perched groundwater which is highly localised and limited in extent to areas of higher topography. It is not connected with any other aquifers in the surrounding area. Generally perched groundwater is separated from regional groundwater by an aquitard made of layers of lower permeability, discharging instead through seepage zones to nearby watercourses. The amount of seepage is proportional to the amount of rainfall infiltrating the perched aquifer, with a reduced seepage during dry periods.
Regional aquifer	A deeper regional groundwater aquifer within the Permian Newcastle Coal Measures underlies the Project area (NSW Department of Mineral Resources, Edition 1 1995). The aquifer is predominantly recharged in areas where the strata of the lower Newcastle Coal Measures outcrops to the north of the Project area, rather than from the overlaying perched groundwater source. Typically, the Coal Measures consist of Permian coals, tuffs, conglomerates, sandstones and shales.

4.2 Baseline Groundwater Monitoring

4.2.1 Monitoring Network

The groundwater monitoring network, shown in Figure 2 and Table 5, includes both shallow perched groundwater and a deeper regional aquifer.

Laterally the groundwater monitoring area consists of the area within the Project boundary and surrounding locations which are representative of potential indirect impacts from the Project, including the extent of potential drawdown of perched groundwater sources. Bores used during baseline monitoring will be maintained throughout construction to meet the objectives of this SGWQCMP.

During initial installation of the baseline monitoring bores, locations were selected to minimise the potential for impact during the construction phase of the project. Additional bores were also installed to account for any that may be impacted by construction activities. Any additional bores to be installed will be done in consultation with a suitably qualified Hydrogeologist.

Table 5 Construction groundwater monitoring bores during baseline monitoring

ID	Location	Screen Interval (mBGL)	Lithology	No. of groundwater samples	No. of Groundwater level monitoring
BHMW301	East of Cut 1	12.3 to 14.9	Coal and tuffaceous claystone	7	Datalogger since Sep- 2018
BHMW302	North of Fill 1	12 to 15	Tuffaceous siltstone / sandstone	8	Datalogger since Sep- 2018
BHMW303	East of Cut 2	5.7 to 7.2	Coal and siltstone	4	Datalogger since Sep- 2018

ID	Location	Screen Interval (mBGL)	Lithology	No. of groundwater samples	No. of Groundwater level monitoring
BHMW304	West of Cut 2	12 to 15	Sandstone and conglomerate	Nil	Datalogger since Sep- 2018
BHMW305	West of Fill 2	12 to 15	Tuffaceous siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW306	West of Cut 3	11.8 to 14.8	Sandstone and conglomerate	Nil	Datalogger since Sep- 2018 (buried since Nov 20)
BHMW307	West of Cut 4	29.3 to 35.3	Tuffaceous sandstone and tuff with coal	13	Datalogger since Sep- 2018
BHMW308	East of Cut 4	29.6 to 35.6	Siltstone / Sandstone and conglomerate	5	Datalogger since Sep- 2018
BHMW309	East of Fill 4	12.4 to 15.4	Siltstone and coal	18	Datalogger since Sep- 2018
BHMW310	West of Fill 5	11.95 to 14.95	Siltstone / sandstone	1	Datalogger since Sep- 2018
BHMW311	West of Cut 5	27.3 to 30.3	Siltstone / sandstone	2	Datalogger since Sep- 2018 (bore blocked since August 2019)
BHMW312	East of Cut 5/Fill 6	17 to 20	Siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW313	West of Fill 6	12.09 to 15.09	Siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW314	North West of Fill 6 – off Newcastle Rd	11.5 to 14.5	Siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW315	Steel St –off Newcastle Rd	12 to 15	Siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW316	East of Cut 5	36.68 to 39.68	Siltstone / sandstone	16	Datalogger since Sep- 2018
BHMW317	West of Fill 3	30.2 to 32.75	Coal and tuffaceous claystone	16	Datalogger since Sep- 2018
BHMW318	East of Fill 2	20.1 to 24.6	Coal	16	Datalogger since Sep- 2018
BH307	Fill 1	8.24 to 11.24	Coal and tuffaceous sandstone	5	Datalogger since Sep- 2018

ID	Location	Screen Interval (mBGL)	Lithology	No. of groundwater samples	No. of Groundwater level monitoring
BH310	Cut 1	14 to 17.6	Coal	16	Datalogger since Sep- 2018
BH315	Cut 1 / Cut 2	16.82 to 19.82	Tuffaceous siltstone	nil	Datalogger since Sep- 2018
BH321	Cut 3	21.8 to 28.8	Coal	13	Datalogger since Sep- 2018
BH326	Cut 4	7 to 13.5	Tuff coal and siltstone	Nil	Datalogger since Sep- 2018

4.2.2 Baseline groundwater monitoring

Since September 2018 groundwater elevation data has been collected from the 23 active monitoring bores shown in Figure 2. This baseline groundwater level dataset is augmented by data collected from eight additional monitoring bores in 1988 and 22 additional monitoring bores from 2015 to 2016. This historic groundwater level data was used during the Project concept design phase. Baseline analytical groundwater quality monitoring of the 23 active bores commenced in March 2019. Details of the groundwater monitoring network and the number of groundwater samples collected and analysed from each bore is presented in Appendix B.

Monitoring locations installed for baseline ground water monitoring were selected in consultation with a suitably qualified Hydrogeologist. The following was considered when selecting the monitoring bore locations:

- Monitoring inside and outside predicted zones of perched groundwater drawdown
- Monitoring inside proposed mine remediation area
- Monitoring near proposed mine remediation area.

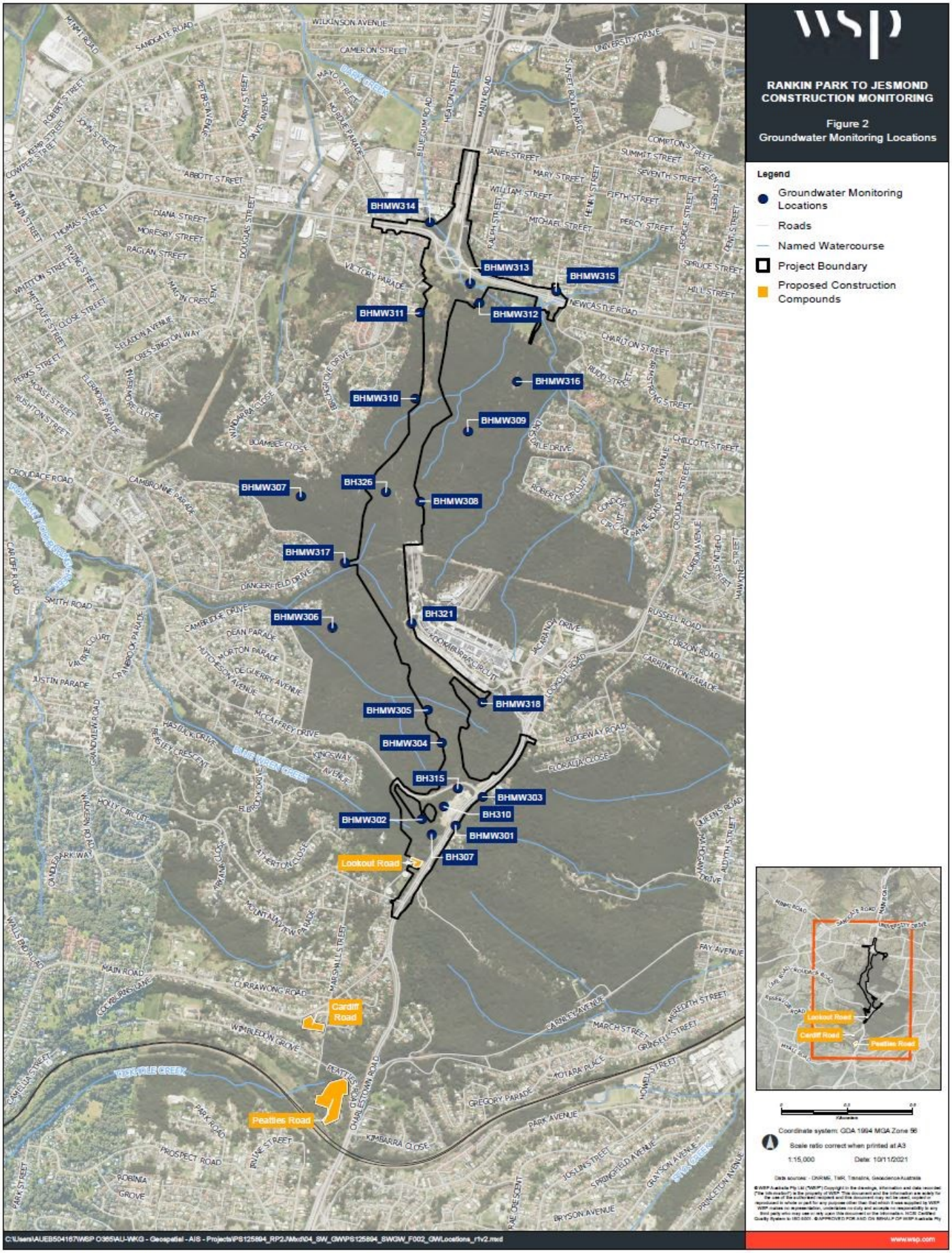

Figure 2 Groundwater monitoring locations (June 2022)

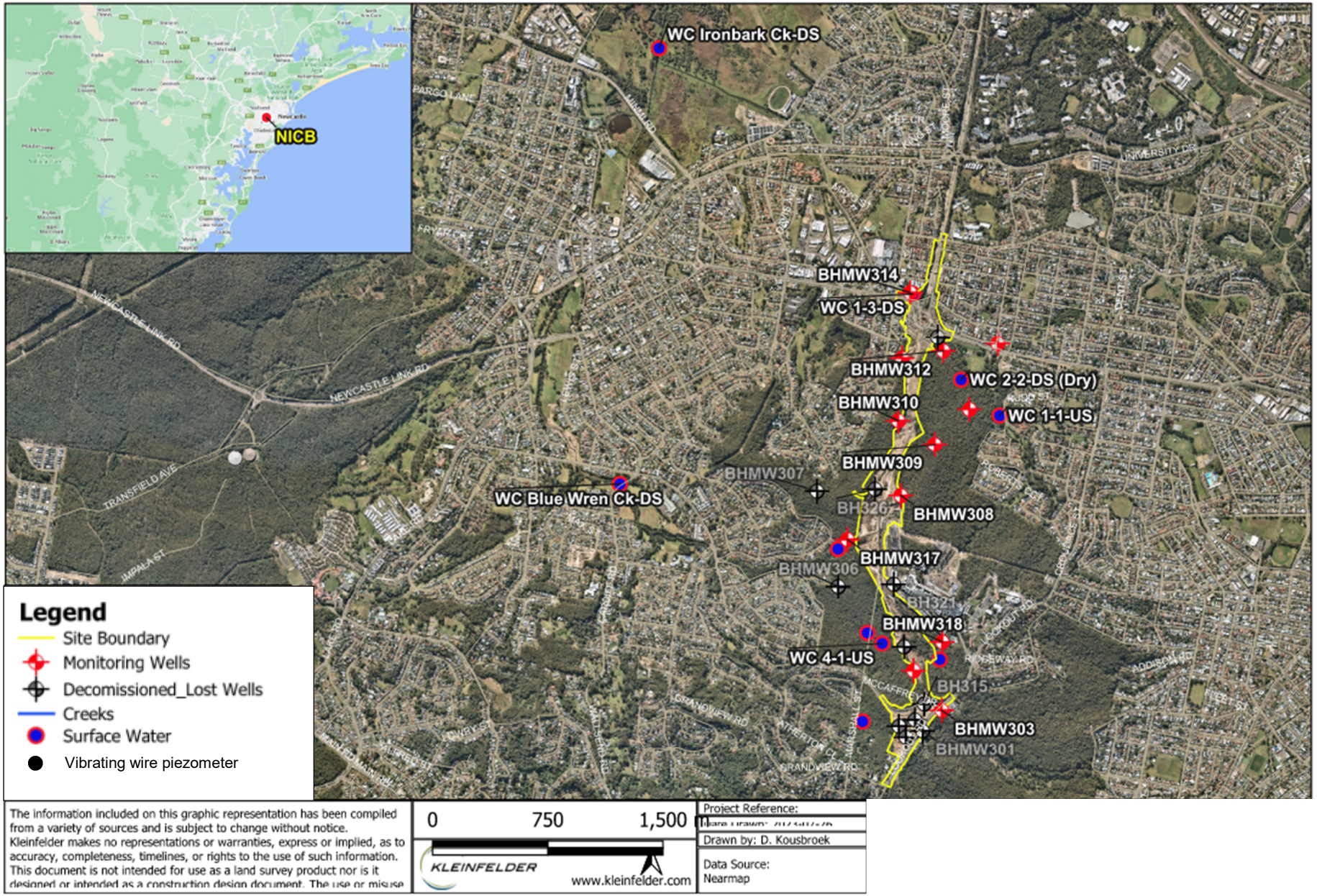

Figure 3a Updated groundwater monitoring locations (North) (July 2023)

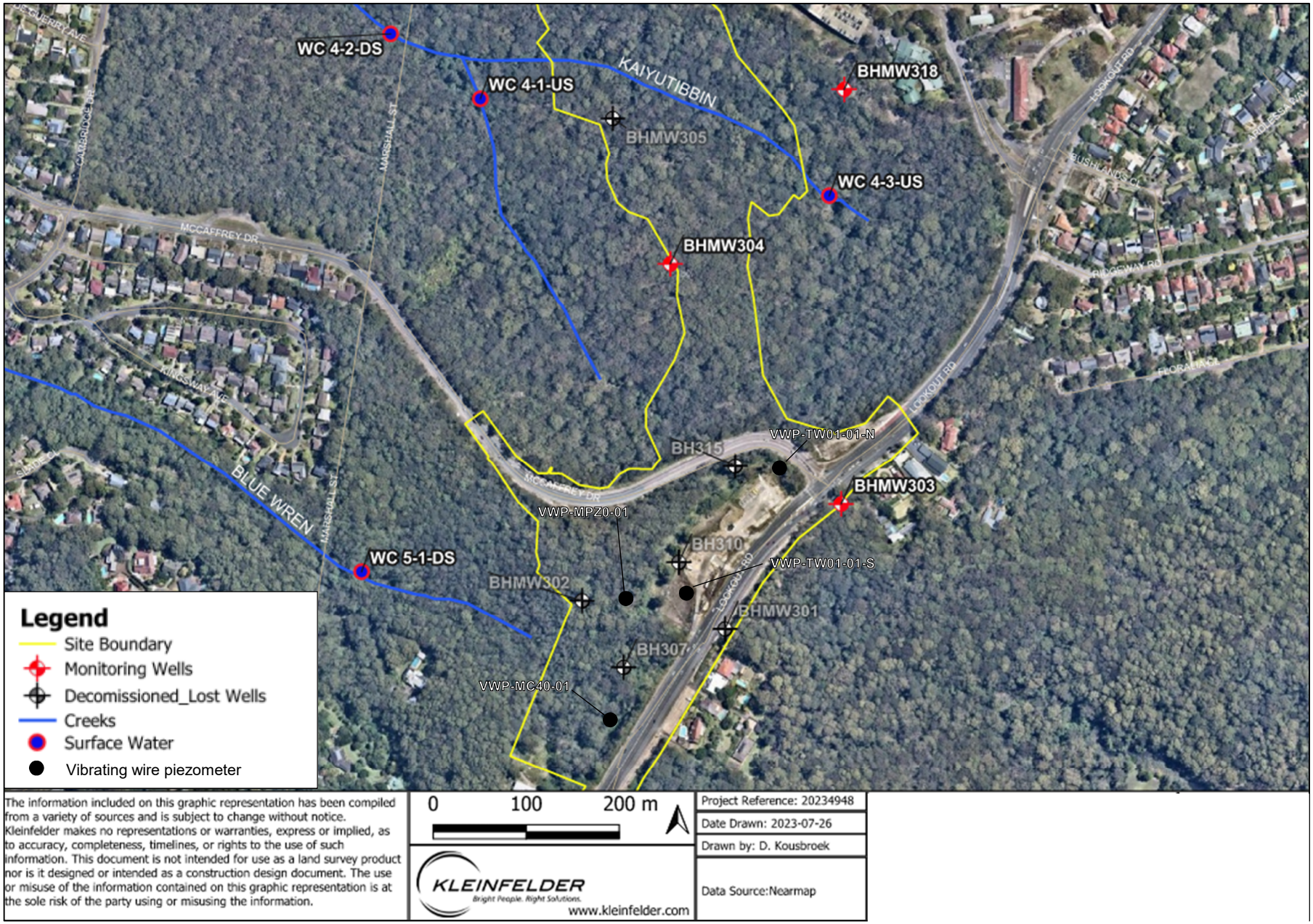

Figure 3b Updated groundwater monitoring locations (Southern) (July 2023)

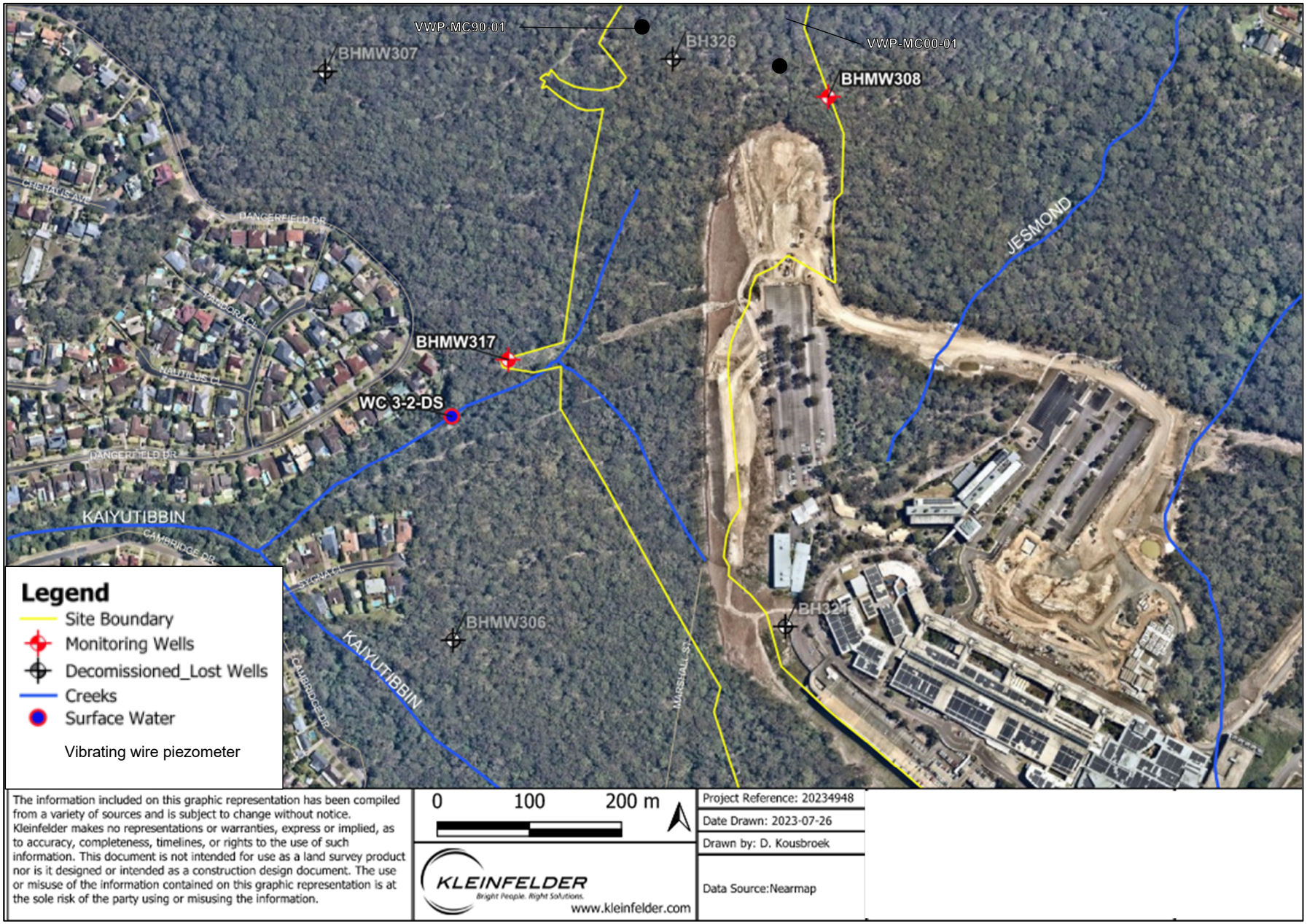

Figure 3c Updated groundwater monitoring locations (Mainline) (July 2023)

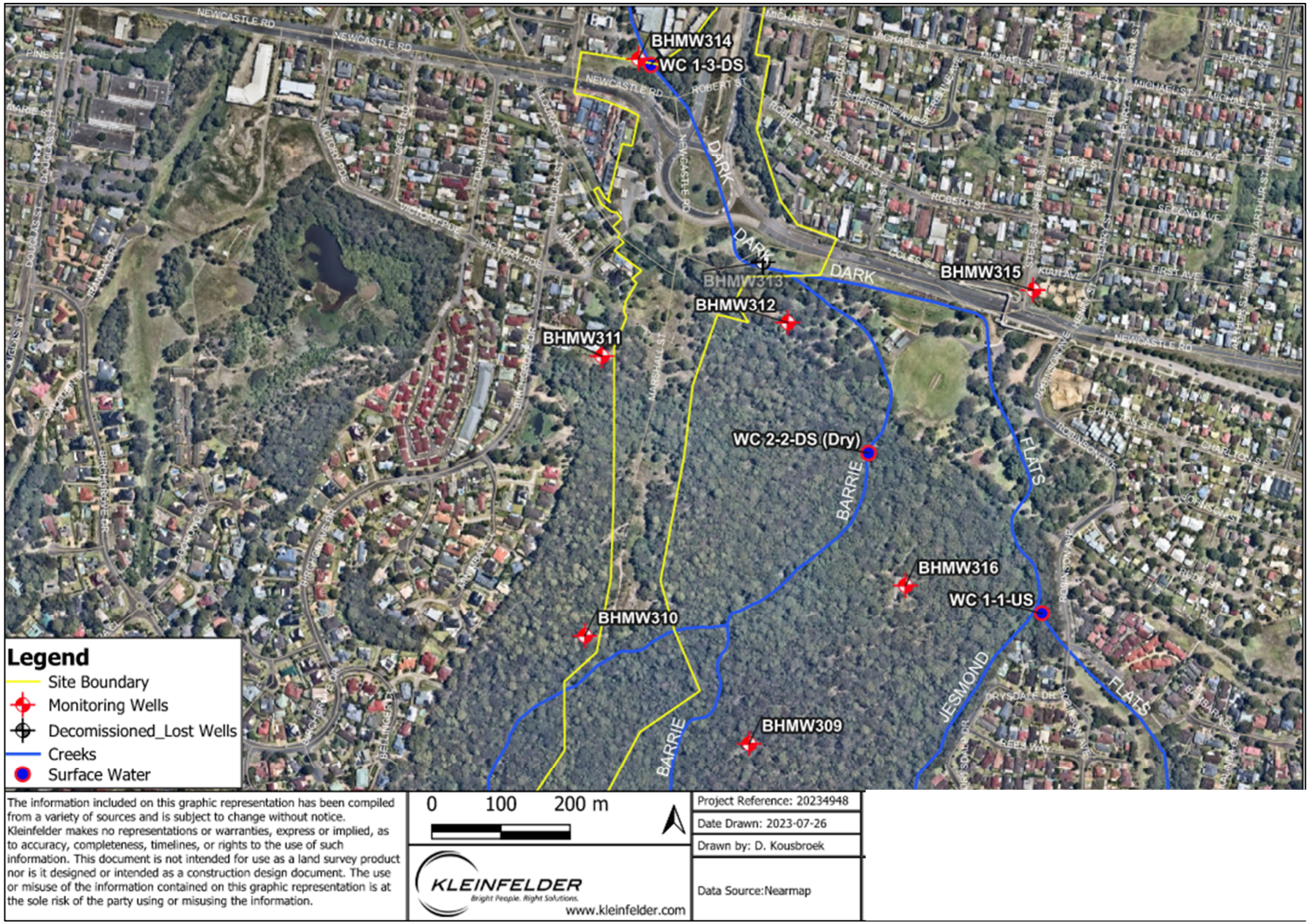

Figure 3d Updated groundwater monitoring locations (Mainline) (July 2023)

4.2.3 Groundwater level

In general groundwater elevation follows the variable topography. Monitoring results indicate highly variable hydrogeological responses to rainfall which vary from no change, immediate fluctuations, and a delayed response (Aurecon, 2021).

The monitoring locations at higher elevations are likely to be intercepting perched groundwater and are likely to be subject to complete drying in some areas during low rainfall periods. Groundwater levels vary by up to 2.6 metres.

4.2.4 Groundwater quality

Baseline monthly groundwater quality monitoring commenced in March 2019. The objectives for the baseline groundwater quality monitoring program included:

- To provide ongoing groundwater monitoring and sampling services as required by the Environmental Impact Statement (EIS) and Submissions and Preferred Infrastructure Reports (SPIR) for the RP2J Project
- To meet CoA C9 and C10
- Characterise the existing hydro-geochemistry in the perched and regional aquifers
- Develop a groundwater quality baseline dataset to confirm the assumption in the EIS
- Characterise the potential aggressiveness of the native groundwater to the building material used to construct the Project infrastructure
- Obtain a preliminary understanding of potential groundwater treatment requirements prior to discharge during the construction and operation phases.

A summary of results for the groundwater quality samples collected within the Project boundary is shown in Table 4.

The baseline groundwater quality sampling program included the following analytes:

- Physio-chemical field parameters (temperature, dissolved oxygen, electrical conductivity (EC), pH, and redox potential)
- Major ions (calcium, magnesium, sodium, potassium, chloride, sulphate, carbonate and bicarbonate)
- Dissolved metals (aluminium, arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)
- Nutrients (ammonia, nitrite as N, nitrate as N, total Kjeldahl nitrogen (as N), total nitrogen (as N), total phosphate (as P), reactive phosphorus)
- Benzene, toluene, ethylbenzene, xylene, and naphthalene (BTEXN)
- Total recoverable hydrocarbons (TRHs)
- Polycyclic aromatic hydrocarbons (PAHs).

Table 6 Summary of baseline groundwater water quality

Parameter	Description
pH	pH in groundwater ranged between 3.95 to 7.73 pH units. This indicates that the majority of groundwater samples in the Project area are slightly acidic to acidic in nature and remained below the ANZECC/ARMCANZ (2000) lower limit criterion (6.5).

Parameter	Description
EC	EC of groundwater samples ranged between 706 µS/cm to 13282 µS/cm with an average 3828 µS/cm. Four monitoring locations (BHMW309, BHMW312, BHMW314 and BHMW316) record field values over 4,000 µS/cm and are above the ANZECC/ARMCANZ (2000) lowland river criterion. BHMW314 recorded the highest field EC of around 13,282 µS/cm followed by BHMW313 and BHMW312 at around 7,500 µS/cm and then BHMW3126. The average EC concentration indicates that the groundwater is slightly brackish in nature.
Major Ions	The dominant water type is Na-Cl with variants of Na-HCO_3 and Na-SO_4 and slight variation in chemistry most likely reflect seasonal variations and long-term weather trends. BH321 showed higher sulphate ratios (Na-SO_4 type water) and BH315 and BH317 showed higher bicarbonate ratio (Na-HCO_3) type of water.
Nutrients	Total nitrogen and reactive phosphorus are generally above the ANZECC/ARMCANZ (2000) lowland rivers criteria of 0.5 mg/L and 0.02 mg/L respectively for most monitoring locations for most monitoring rounds. Ammonia as N also showed elevated concentrations above the assessment criteria at several monitoring locations.
Metals	Elevated levels above the ANZG (2018) assessment criteria for aluminium, chromium, copper lead, nickel and zinc were detected at most monitoring locations.
Hydrocarbons	No PAHs were detected. TRH and BTEX were occasionally detected. No widespread hydrocarbon contamination was identified in the Project site. Occasional detections of TPH were noted in few monitoring wells. Testing of TPH after silica gel clean up in selected wells, to remove false positives (e.g., coal is an organic substance which may break down to substances that may be detectable in TRH analysis) resulted in most locations showing reduced or no detections.

4.2.5 Cuttings

Groundwater quality for the cuttings is fresh to brackish with near neutral to slightly acid pH. The groundwater chemistry is considered to be representative of background levels and reflects the chemistry of the aquifer system. As groundwater from the upper aquifer is likely to be naturally discharging to the surrounding environment and surface water, the proposed cuts are effectively short circuiting the existing flow paths and allowing discharge at different locations and at a higher flow rate. Groundwater quality is not considered to be significantly different to that of natural discharge points.

Direct rainfall (i.e., surface run-off) is likely to volumetrically far exceed groundwater discharge (GHD, 2016). As none of the cuts intersect the regional groundwater table all groundwater inflows are expected to be low to negligible and dependent on rainfall recharge.

4.2.6 Sediment basins

Sediment basins are proposed to capture and manage surface water prior to water quality testing and controlled discharge. Locations will be determined during detailed design and construction.

4.3 Surrounding surface water environment

Surface water within the Project area falls within the upper Ironbark Creek catchment. Ironbark Creek is the largest tidal creek draining into the Hunter River. It flows through Hexham Swamp, a large floodplain, entering the Hunter River through floodgates at Sandgate. Hexham Swamp is an estuarine wetland identified as a coastal wetland under the State Environment Planning Policy (SEPP) (Coastal Management) 2018 and is part of the Hunter Estuary Wetlands Ramsar site.

Flood gates at the confluence with the Hunter River have reduced tidal exchange and resulted in oxidation of acid sulfate soils, lowered pH levels in several tributaries and raised soluble iron levels in the local waterways (Newcastle City Council, 2004).

4.4 Baseline surface water monitoring

Baseline surface water monitoring has been conducted by Transport at 10 locations in and around the proposed Project boundary. Samples were collected between December 2019 and October 2020. The ephemeral nature of watercourses within the Project area have limited the sampling at some locations.

4.4.1 Monitoring locations

Monitoring locations include sampling points upstream and downstream of the Project boundary. Surface water monitoring locations are shown in Figure 4, summarised results are in Table 7.

4.4.2 Baseline surface water quality

Baseline surface water quality monitoring commenced in December 2019 and was conducted over 16 monitoring events until October 2020. The baseline surface water quality sampling program included the following analytes:

- Physio-chemical field parameters (temperature, dissolved oxygen, electrical conductivity (EC, pH, and dissolved oxygen (DO))
- Total suspended solids (TSS) and turbidity
- Dissolved metals (aluminium, arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)
- Nutrients (total nitrogen and total phosphate).

Results from the surface water baseline monitoring are summarised below in Table 7.

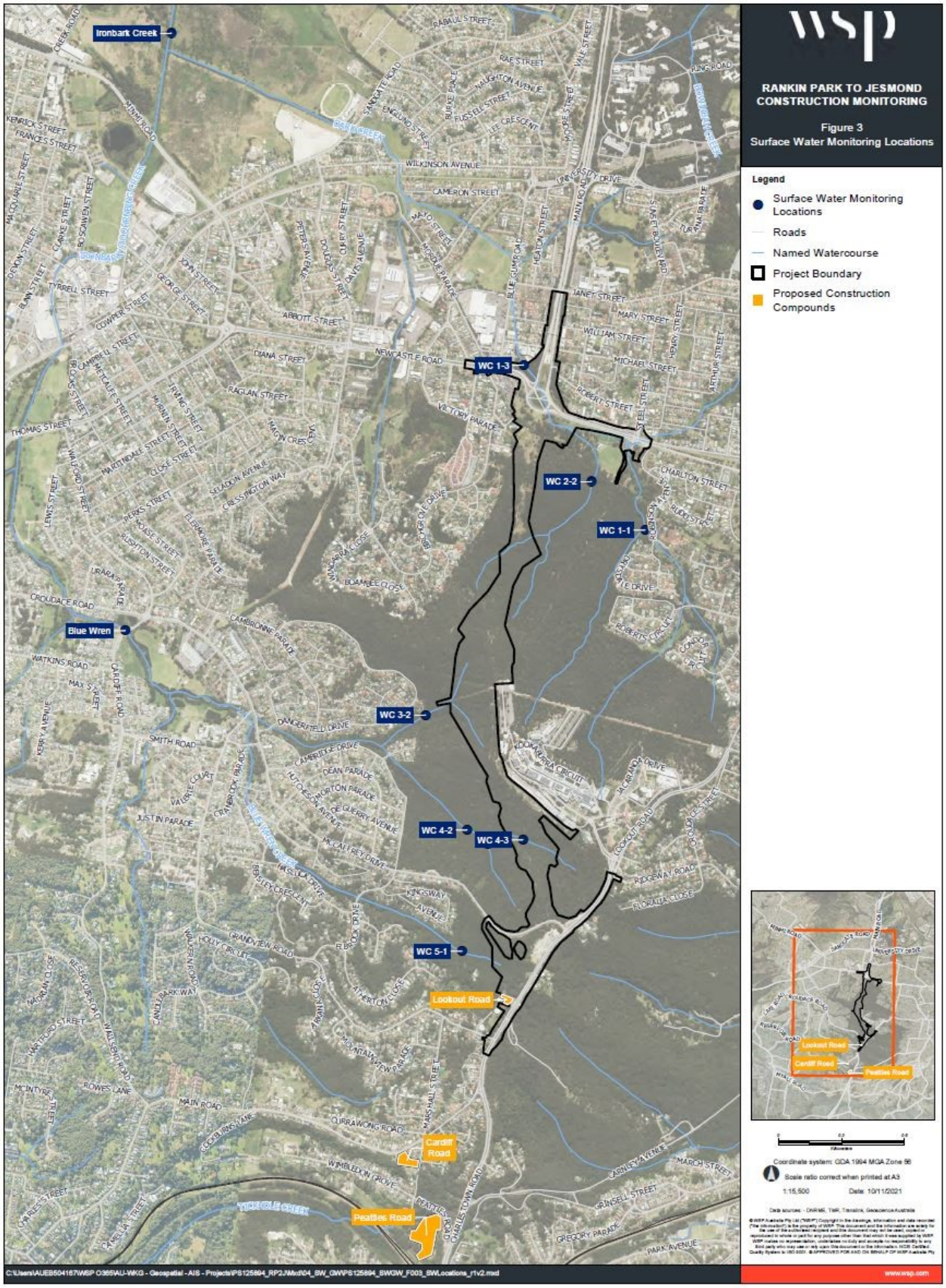

Figure 4 Surface water monitoring locations

Table 7 Summary of baseline surface water quality

Parameter	Description
pH	pH in surface water ranged from 5.9 to 8.8 pH units indicating the majority of surface water samples are slightly acidic to slightly basic in nature. Generally sampling points upstream and downstream (WC 1, WC 4) of the Project boundary were within the same pH range. pH measurements were generally within the ANZECC/ARMCANZ (2000) guidelines for a lowland river (slightly disturbed) (6.0 to 8.0 pH units) with the exception of location WC 1-3-DS, to the north-west of the Jesmond interchange, which exceeded the guideline for seven of the 16 sampling events. Results for WC 4-1-US and WC 4-1-DS both exceeded once, on the same sampling event. Results for Blue Wren Creek and Ironbark Creek consistently fell within the guidelines.
EC	EC of surface water samples ranged between 66 µS/cm to 1,290 µS/cm, within the ANZECC/ARMCANZ (2000) range (125 - 2200 µS/cm) for lowland rivers, with the exception of Ironbark Creek, which regularly reported brackish water at or above 8,000 µS/cm. Water upstream and downstream of the Project area recorded similar values. Ironbark Creek, which is tidal downstream of the Project area, recorded variable EC values between 8,000 µS/cm and 240 µS/cm. Eight of the 16 sampling events reported EC of 8000 µS/cm, reaching the maximum limits of the field equipment used.
NTU	Ironbark Creek and Blue Wren Creek both reported turbidity (avg. 27.6 NTU and 19.9 NTU) within the ANZECC/ARMCANZ (2000) guidelines (6 - 50 NTU). Sampling locations WC 3-2-DS and WC 5-1-DS were both over the maximum guideline values for each sampling event. WC 5-1-DS was noted as having shallow water at the time and is often found to be dry.
Nutrients	Total nitrogen and total phosphorus were generally above the ANZECC/ARMCANZ (2000) lowland rivers criteria of 0.5 mg/L and 0.05 mg/L respectively for most monitoring events.
Metals	Three surface water locations exceeded the ANZG 2018 95% level of species protection assessment criterion for copper, and two surface water locations exceeded the criterion for zinc. The concentrations were within the range reported in the perched and regional groundwater results which were considered likely to be naturally occurring background levels.

5 Monitoring Methodology

5.1 Overview

The methodology for monitoring groundwater and surface water for the Project includes:

- Assessment of groundwater level (measurement and datalogger download)
- Assessment of discharge water quality to natural waterways from water control structures (sediment basins)
- Assessment of groundwater and surface water quality to assess any impact due to construction
- Implementation of quality control plan including appropriate chain-of-custody for laboratory analysis and provision of appropriate documentation.

Monitoring will be undertaken in accordance with Australian Standards and ANZECC/ ARMCANZ (2000). Monitoring is to be undertaken by suitably qualified personnel at all times. The monitoring program will commence prior to construction in accordance with the CoA. The monitoring program will continue until 12 months after completion of construction.

5.2 Groundwater monitoring

Groundwater monitoring will continue at the existing locations, as listed in Table 8 and identified in Figure 2. Since construction commenced, 11 groundwater monitoring bores have been decommissioned or lost and will no longer be monitored as part of the monitoring program. Decommissioned locations are shown in Figure 3 and identified in Table 8. It will include monthly groundwater level assessment and quarterly groundwater sampling of the parameters and analytes listed in Table 11.

Table 8 Groundwater monitoring requirements

ID	Location	Easting	Northing	Screen Interval (mBGL)	Lithology	Groundwater monitoring requirements	Active / decommissioned
BHMW301	East of Cut 1	377754.8	6355682.3	12.3 to 14.9	Coal and tuffaceous claystone	GWL, GWQ	Decommissioned
VWP-TW01-Nth	North of Cut 1	377816.00	6355843.00	n/a	Coal	GWL	Active
VWP-TW01-Sth	South of Cut 1	377742	6355727	n/a	Coal	GWL	Active
BHMW302	North of Fill 1	377600.8	6355711	12 to 15	Tuffaceous siltstone / sandstone	GWL, GWQ	Decommissioned
VWP-MC40-01	Fill 1	377631.239	6355558.699	n/a	Kahibah (lower) formation	GWL	Active
VWP-MC90-01	Fill 1	377421.201	6357320.987	n/a	Shepherds hill formation	GWL	Active
BHMW303	East of Cut 2	377877.9	6355817.6	5.7 to 7.2	Coal and siltstone	GWL, GWQ	Active

ID	Location	Easting	Northing	Screen Interval (mBGL)	Lithology	Groundwater monitoring requirements	Active / decommissioned
BHMW304	West of Cut 2	377691.1	6356073.1	12 to 15	Sandstone and conglomerate	GWL, GWQ	Active
BHMW305	West of Fill 2	377627.3	6356227.8	12 to 15	Tuffaceous siltstone / sandstone	GWL, GWQ	Decommissioned
BHMW306	West of Cut 3	377194	6356616.3	11.8 to 14.8	Sandstone and conglomerate	GWL, GWQ	Lost / decommissioned
BHMW307	West of Cut 4	377049.4	6357233.9	29.3 to 35.3	Tuffaceous sandstone and tuff with coal	GWL, GWQ	Decommissioned
VWP-MC90-01	West of cut 4	377421.201	6357320.987	n/a	Shepherds hill formation	GWL	Active
BHMW308	East of Cut 4	377594.1	6357210.1	29.6 to 35.6	Siltstone / Sandstone and conglomerate	GWL, GWQ	Active
VWP-MC00-01	East of cut 4	377565.530	6357201.389	n/a	Shepherds hill formation	GWL	Active
BHMW309	East of Fill 4	377810.19	6357545.2	12.4 to 15.4	Siltstone and coal	GWL, GWQ	Active
BHMW310	West of Fill 5	377570.7	6357697.1	11.95 to 14.95	Siltstone / sandstone	GWL, GWQ	Active
BHMW311	West of Cut 5	377590	6358101.1	27.3 to 30.3	Siltstone / sandstone	GWL, GWQ	Active
BHMW312	East of Cut 5/ Fill 6	377863.4	6358148.7	17 to 20	Siltstone / sandstone	GWL, GWQ	Active
BHMW313	West of Fill 6	377821.5	6358239.4	12.09 to 15.09	Siltstone / sandstone	GWL, GWQ	Decommissioned
BHMW314	North West of Fill 6 – off Newcastle Road	377638	6358529.6	11.5 to 14.5	Siltstone / sandstone	GWL, GWQ	Active
BHMW315	Steel St – off Newcastle Road	378213.1	6358204.3	12 to 15	Siltstone / sandstone	GWL, GWQ	Active

ID	Location	Easting	Northing	Screen Interval (mBGL)	Lithology	Groundwater monitoring requirements	Active / decommissioned
BHMW316	East of Cut 5	378033.8	6357776	36.68 to 39.68	Siltstone / sandstone	GWL, GWQ	Active
BHMW317	West of Fill 3	377250	6356921.1	30.2 to 32.75	Coal and tuffaceous claystone	GWL, GWQ	Active
BHMW318	East of Fill 2	377875.7	6356261.9	20.1 to 24.6	Coal	GWL, GWQ	Active
BH307	Fill 1	377646.3	6355640	8.24 to 11.24	Coal and tuffaceous sandstone	GWL, GWQ	Decommissioned
BH310	Cut 1	377701.1	6355771.9	14 to 17.6	Coal	GWL, GWQ	Decommissioned
BH315	Cut 1 / Cut 2	377763.5	6355856.9	16.82 to 19.82	Tuffaceous siltstone	GWL, GWQ	Decommissioned
BH321	Cut 3	377554.7	6356635.6	21.8 to 28.8	Coal	GWL, GWQ	Decommissioned
BH326	Cut 4	377437.2	6357254.2	7 to 13.5	Tuff coal and siltstone	GWL, GWQ	Decommissioned

GWL = Groundwater level; GWQ = Groundwater quality

5.2.1 Continuous groundwater level measurements

Groundwater level will be measured automatically by dataloggers installed (or maintained from the baseline monitoring phase) at selected monitoring locations. Continuous data (recorded every hour) will be validated by manual measurements taken when the dataloggers are downloaded quarterly. Dataloggers will be checked and maintained as necessary before being re-calibrated and then returned to the monitoring bore at a known depth below the top of casing.

Groundwater level/pressure measurements will be converted to mAHD using installation data and survey data. Spreadsheets will be maintained detailing the conversion and converted groundwater level measurement.

The locations of the dataloggers should include the following considerations:

- Proximity to surface water locations and groundwater dependent ecosystems (GDEs) to identify potential changes to the groundwater inflow
- Proximity to sediment basins
- Location and scheduling of construction
- Monitoring of the perched and deep groundwater

5.2.2 Manual groundwater level measurements

The static groundwater level will be measured and recorded quarterly at each bore. Measurements will be taken from the standpipe using an electronic groundwater level dip meter (dip meter) to verify the continuous data recorded by dataloggers. The level (to the nearest millimetre) will be referenced to a known (and consistent) surveyed point at the top of the bore casing (TOC). This measurement will be corrected to mAHD using survey data. Recorded groundwater level will be tabulated in both metres below top of bore casing (mbTOC) and mAHD.

5.3 Rainfall Monitoring

Rainfall will be monitored during the construction phase via a rain gauge within the Project boundary, which will be checked on each workday or automated using an electronic weather station. Rainfall will be measured and recorded in millimetres per 24-hour period at the same time each workday.

5.4 Surface water monitoring

Surface water sampling will be undertaken monthly and following significant rain events at the existing sites as listed in Table 9 and labelled in Figure 3. Additional monitoring sites, such as at the Peatties Road compound, may be added during the program if required.

Wet weather monitoring will be carried out following a continuous rainfall event of greater than 25 mm during a 24-hour period (as recorded at the Project's rain gauge or weather station), no more than once per month. Although sampling will not be undertaken during peak storm-flows for safety reasons, it will be completed while flows are constant and monitoring points can be accessed safely.

Surface water monitoring will include collection of physio-chemical field parameters and sampling for analysis of the suite detailed in Table 11. Surface water quality analysis results will be assessed and compared to baseline conditions, rainfall records, upstream monitoring results, and the performance criteria detailed in Table 12 and Section 6.2.

Table 9 Surface water monitoring locations

ID	Location	Upstream / Downstream	Easting	Northing
WC 1-1-US	Shallow isolated pond	Upstream	378231.6	6357738
WC 1-3-DS	Concrete drain	Downstream	377655.8	6358521
WC 2-2-DS	Flats Creek	Downstream	377977.7	6357967
WC 3-2-DS	Rock pond	Downstream	377189.5	6356859
WC 4-1-US	Shallow stream	Upstream	377484.7	6356247
WC 4-2-DS	Shallow stream	Downstream	377387.4	6356315
WC 4-3-US	Shallow stream	Upstream	377804.296	6356239
WC 5-1-DS	Dry waterway	Downstream	377363.4	6355739
WC Blue Wren Ck-DS	Blue Wren Creek	Downstream	375764.4	6357261
WC Ironbark Ck-DS	Deep open channel	Downstream	375983.5	6360096

5.5 Temporary sediment basins water quality discharge criteria

Water quality will be sampled prior to any controlled discharges to confirm that discharge water quality meets the EPL discharge criteria.

Visual inspections will also be conducted on a regular basis in accordance with the CEMP for points of construction water release, including sediment basins.

5.6 Water sampling plan

5.6.1 Water quality monitoring frequency

Monitoring of surface water and groundwater will be monitored according to the frequencies listed in Table 10.

Table 10 Water quality monitoring frequency

Sampling Location	Frequency
Surface water sampling	Monthly and Wet weather[1]
Sediment basin sampling	Prior to discharge as per the Project EPL
Groundwater data loggers and elevation	Quarterly
Groundwater sampling	Quarterly
Groundwater sampling post significant spill event	Should a significant spill incident occur, additional groundwater wells would be considered to be installed at that juncture if significant risks to groundwater quality were identified (which would likely trigger additional surface water monitoring locations).

1 Following 25 mm of continuous rainfall within a 24-hour period

5.6.2 Water quality monitoring parameters

Sample events for groundwater and surface water will monitor for the following parameters and analytes:

- Physical parameters (temperature, dissolved oxygen, electrical conductivity (EC), pH, and dissolved oxygen (DO))
- TSS and turbidity (NTU)
- Total metals (aluminium, arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)
- Nutrients (total nitrogen and total phosphate)
- TRH and BTEX following a release of hydrocarbons or visual identification of sheen or visible impacts.

Table 11 Water quality monitoring parameters

Parameter	Testing method
Turbidity (NTU)	Field test – probe/meter
Electrical conductivity	Field test – probe/meter
Temperature	Field test – probe/meter
Electrical conductivity	Field test – probe/meter
Dissolved oxygen	Field test – probe/meter
pH	Field test – probe/meter
Oxygen reduction potential	Field test – probe/meter
Total suspended solids (TSS)	Sampled and laboratory test
Total nitrogen	Sampled and laboratory test
Total phosphorus	Sampled and laboratory test
Dissolved metals (aluminium, arsenic, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel and zinc)	Sampled and laboratory test
TRH (C6-C40) (silica gel clean-up)	Sampled and laboratory test
Benzene, toluene, ethylbenzene, xylene	Sampled and laboratory test

5.6.3 Sediment basin sample collection

Grab samples will be collected manually from sediment basins (discharge locations) prior to discharge and the water quality will be determined by field or laboratory testing to confirm suitability for discharge in accordance with the Project EPL. Physio-chemical field parameters will be measured immediately prior to sampling.

5.6.4 Groundwater monitoring bore sample collection

The groundwater sampling methodology includes but is not limited to:

- Measurement of standing groundwater level to the top of PVC casing using an electronic dip meter
- Purging of a groundwater monitoring bore using a low flow sampling pump. Sampling of the bore can commence once three consecutive field readings of pH and EC are within ±10% of each other
- Field measurement of field water quality parameters pH, EC, redox, turbidity and temperature, colour, and any visual / olfactory indications of contamination. Quality measurements are to be made

using an appropriate water quality meter calibrated in accordance with the manufacturer's instructions

- Downloading and reinstallation at the same depth of dataloggers
- Measurement of the total depth of the monitoring bores
- General borehole maintenance, including cleaning of dirt from O-ring seals in gatic covers
- Observations of significant damage or issues with monitoring installations.

5.6.5 Field measurements

Field physio-chemical parameters including temperature, EC, pH, DO, TDS, redox potential, and turbidity will be measured at each monitoring location (surface water, sediment basins and monitoring wells) using fully calibrated water quality meters. Other observations including odour and colour will also be recorded.

5.6.6 Decontamination

Equipment will need to be cleaned between each location. The following method will be followed:

- Rinse the equipment in tap water
- Clean with De-Con 90 (a phosphate free detergent), or equivalent
- Rinse again with tap water
- Rinse three times with de-ionised water
- Allow to dry
- De-ionised and tap water will be available for washing equipment in the field.

5.6.7 Quality Assurance and documentation

Quality assurance and control protocols during sampling and recording of physio-chemical (field) parameters will be undertaken in accordance with ANZECC/ARMCANZ (2000) and Australian Standard AS/NZS 5667.1-1998 to ensure the integrity of the dataset. As part of sampling, quality assurance and control samples during sampling will be undertaken to ensure the integrity of the dataset. These are to include:

- Rinsate blanks (one per sampling event only)
- Blind duplicates (at a rate of 1 in 20 samples)
- Split duplicates (at a rate of 1 in 20 samples)
- Trip blanks and spikes for TRH and BTEX samples (one per day).

Samples are to be transported to a NATA-accredited laboratory under documented chain-of- custody protocols.

Field results will be checked for accuracy before leaving the site and errors or discrepancies will be cross-checked, and further investigation initiated if required.

5.6.8 Recording and documentation of results

All monitoring and sampling will be documented and electronically tabulated. This data will be reviewed and assessed as detailed in for each monitoring location will be recorded on appropriate field sheets (hard copy or digital) using unique sampling identification nomenclature consisting of the sample date, location, and sampler details. The field sheet will detail:

- Prevailing weather conditions
- Name of sampler

- Time and date of sampling
- Sampling location
- Physical observations such as odour, sheen, turbidity and colour
- Depth to groundwater
- Description of well condition and any standing water present in well casing
- Description of surface water depth and movement
- Presence of algae or debris in water
- Reference upstream locations (if downstream from construction).

6 Compliance Management

6.1 Data analysis

Results from the monitoring program will be compared with the performance criteria following each sampling event. Manual monitoring data will be used to verify continuous groundwater levels relative to climatic events.

6.2 Performance criteria

ANZECC (2000), ARMCANZ (2000) and ANZG (2018) provide water quality triggers for a range of ecosystems, which are intended to be applied at the receiving waterway, not at the point of discharge from the Project boundary. Any analysis of the impacts of the development requires consideration of the existing water quality within the catchment.

Ironbark Creek catchment is considered to be slightly to moderately disturbed, passing through residential areas and downstream considered highly disturbed where it is predominantly concrete lined and/or maintained for flood management purposes. The downstream Hexham Swamp is identified as a SEPP Coastal Wetland and is part of the Ramsar listed Hunter Estuary Wetlands.

Monitoring to-date shows that surface water and groundwater quality parameters often exceed the default water quality trigger values for slightly to moderately disturbed ecosystems. This is not unexpected due to the proximity of highly urbanised area around the project. As such Site Specific Trigger Levels (SSTLs) will also be utilised in determining investigation thresholds for surface water.

6.2.1 Surface water performance criteria

To assist in meaningful comparison of construction water quality, a comparison of upstream versus downstream data will be used. This methodology is deemed appropriate due to the wide variation in baseline monitoring data and the regular exceedances of default trigger levels during baseline monitoring.

Monitoring data will be assessed in consideration of location (upstream/downstream) at each location and an investigation will be triggered under the following conditions:

- A parameter exceeds the 90% species protection limit as per Table 12; and
- A parameter downstream exceeds the corresponding parameter upstream for any single monitoring event by more than 20%.

6.2.2 Groundwater performance criteria

SSTLs based on upstream / downstream monitoring locations are not deemed appropriate due to the nature of the groundwater network around the Project, including the presence of both localised and perched groundwater. As such, 90% investigation levels outlined in ANZG (2018), ANZECC (2000) and the ANZECC (2000) lowland rivers values for physical and chemical stressors will be applied. Some exceedances may still occur for heavy metals, physio-chemical properties and nutrients that are most likely a reflection of the natural hydrogeological environment rather than a construction impact.
Where there are exceedances of the ANZG (2018) 90% species protection criteria, the monitoring results should be assessed as to whether the results represent natural concentration fluctuations with long term weather trends or indicate a potential impact resulting from construction activities.

Table 12 Default water quality performance criteria

Parameter	Groundwater Investigation Levels	Surface Water Investigation Levels
Turbidity (NTU)	6 - 50 NTU	6 - 50 NTU
Electrical conductivity	2200 µS/cm	2200 µS/cm
Dissolved oxygen	85 – 110	85 – 110
pH	6.0 – 8.0 pH	6.0 – 8.0 pH
Total nitrogen	0.5	0.5
Total phosphorus	0.05	0.05
Aluminium	0.08*	0.08*
Arsenic (Dissolved)	0.042*	0.042*
Boron	0.68*	0.68*
Cadmium	0.0004*	0.0004*
Chromium	0.006*	0.006*
Copper	0.0018*	0.0018*
Lead	0.0056*	0.0056*
Manganese	2.5*	2.5*
Mercury	0.0019*	0.0019*
Nickel	0.013*	0.013*
Zinc	0.015*	0.015*
Benzene	1.3*	1.3*
Toluene	0.23*	0.23*
Ethylbenzene	0.11*	0.11*
o-xylene	0.47*	0.47*

* ANZG (2018)

Units are mg/L unless otherwise specified

6.2.3 Management response

In the event that any of the above triggers are observed, a review will be initiated immediately to determine the significance of the exceedance(s) and possible causes. The review will assess the baseline data for the relevant waterway, recent rainfall records, other activities within the catchment and recent activities or recorded erosion/sediment control incidents occurring in the catchment.

If the exceedance is determined to be attributable to Project works, the event will be treated as an environmental incident and managed in accordance with the requirements of the CEMP. Corrective and preventative actions will be identified and implemented as part of that process.

6.3 Reporting

During construction, surface water and groundwater data will be collected, tabulated, and assessed against baseline conditions and performance criteria. Annual monitoring reports will be submitted to Transport, City of Newcastle, Lake Macquarie City Council, DPE Water and the Planning Secretary.

Data provision and reporting requirements associated with the SGWQCMP for the construction phase of the Project are presented in Table 13. Each report will include:

- Purpose of the report
- Methodology which includes monitoring locations, monitoring frequency and duration, sampling methods, and recording of rainfall data
- Summary and discussion of results including observations, field parameters, analytical results, rainfall records and limitations
- Necessary management responses or adjustments to the SGWQCMP.

Table 13 Reporting Requirements

Schedule During Construction	Requirements	Recipients (Relevant Authorities)
Monthly Surface Water Summary	Surface water quality monitoring and any sediment basin monitoring will be tabulated and provided in a monthly report. Progressive trends and rolling means, including baseline data, to be identified as they emerge, and exceedances will be highlighted. Justifications and commentary should be provided for any exceedances. Summary to be presented at regular meetings with the ER and regulators.	Transport
Water monitoring reports (annually)	Data summary reports presenting tabulated groundwater monitoring data collected during the reporting period. Surface water and groundwater data collected and tabulated. Progressive trends and rolling means, including baseline data, to be identified as they emerge. Groundwater level hydrographs (including rainfall) and water quality results will be presented, and criteria exceedances will be highlighted. The report will present groundwater and surface water assessments and determine the need for any necessary management responses or adjustments to the SGWQCMP.	Transport, City of Newcastle, Lake Macquarie City Council, DPE Water and the Planning Secretary
EPL Annual Return (every 12 months)	An annual return will be developed as per the requirements of the EPL.	EPA

6.4 Non-compliances

In the event that one or more of the above triggers are exceeded, a review will be conducted against the performance criteria values, and against the results from surrounding locations to determine the significance of the exceedance(s) and possible causes. If the exceedance is determined to be attributable to Project works, an investigation would be conducted to determine whether implementation of additional management measures is required.

Additional management measures will be selected by the Environment Manager in consultation with the ER and Transport. Mitigations measures will be included in the Construction Soil and Water Management Sub-plan and may include:

- Targeted inspections
- Increased monitoring
- Management measure and work methodology reviews
- Review of erosion and sediment controls.

6.4.1 Corrective and preventative action

Procedures for corrective and preventative action will be prepared by the Contractor for various phases of construction (e.g., enabling works, excavations) to effectively manage potential or actual non-conformance(s). The procedures shall define:

- A process for timely identification and correction of potential or actual exceedances and management of their environmental impacts
- A process to investigate the causes (root cause analysis) of exceedances
- A process to develop and evaluate measures to avoid a recurrence of exceedances
- Requirements for recording corrective actions and assessing their effectiveness.

Corrective action shall be appropriate to the potential or actual exceedance and the associated impacts. The SGWQCMP shall be updated following amendments to any written procedures incorporating the corrective or preventative actions and a record of revisions maintained.

6.5 Inspections and auditing

Audits (both internal and external) may be undertaken to assess the effectiveness of environmental controls, compliance with this program and other relevant approvals, licences, and guidelines.

6.6 Communications

Records relating to the Project surface water and groundwater monitoring shall be maintained in the site Environmental Register or equivalent. These records shall include:

- Training/induction records
- Equipment inspections
- Surface water and groundwater monitoring reports
- Audit or reviews
- Communication regarding surface water and groundwater management
- Details of complaints.

6.7 Program review

Monitoring data will be reviewed throughout the construction period to provide validation of the groundwater impact predicted in the EIS and SPIR and potential requirements to increase or decrease the number of sampling locations and/or the analytical suites. The assessment/ performance criteria will be reviewed for appropriateness following 12 months of construction monitoring. Alterations to monitoring locations, analytical suites, or frequencies will be reported in the construction compliance monitoring reports.

Continuous improvement of this SGWQCMP will be achieved through ongoing evaluation of environmental management performance against environmental policies, objectives, and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance
- Determine the cause or causes of non-conformances and deficiencies
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies
- Verify the effectiveness of the corrective and preventative actions
- Document any changes in procedures resulting from process improvement
- Make comparisons performance criteria.

7 References

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Appendix A – Groundwater Monitoring Locations

ID	Location	Screen Interval (mBGL)	Lithology	Used in Baseline monitoring	No. of groundwater quality samples	No. of Groundwater level monitoring (year)	Monitored as part of the SGWQCMP?
RBH02	Cut 3	NR	NR	No	Nil	3 (1988)	No
RBH03	Fill 4	NR	NR	No	Nil	1 (1988)	No
RBH04	Fill 4 / Cut 4	NR	NR	No	Nil	4 (1988)	No
RBH05	Fill 4 / Cut 4	NR	NR	No	Nil	5 (1988)	No
RBH06	Cut 4	NR	NR	No	Nil	6 (1988)	No
RBH07	Cut 4	NR	NR	No	Nil	6 (1988)	No
RBH08	Cut 4	NR	NR	No	Nil	4 (1988)	No
RBH09	Cut 4	NR	NR	No	Nil	6 (1988)	No
RBH10	Cut 4	NR	NR	No	Nil	6 (1988)	No
RBH11	Cut 4	NR	NR	No	Nil	5 (1988)	No
RBH12	Fill 5	NR	NR	No	Nil	3 (1988)	No
RBH13	Fill 6	NR	NR	No	Nil	3 (1988)	No
RBH14	Cut 5	NR	NR	No	Nil	3 (1988)	No
BHAG01	Fill 1	5.3 to 8.5	Sandy gravel	No	Nil	3 (2015-2016)	No
BHAG03	Cut 1 (Bridge 1)	1.8 to 11.76	Residual Soil, Sandstone and Tuff with coal	No	Nil	3 (2015)	No
BHAG04	Cut 1	9 to 12	Montrose Seam	No	Nil	Nil	No
BHAG06	Fill 1 (Bridge 1)	19 to 25.19	Sandstone/ siltstone	No	Nil	4 (2015-2016)	No
BHAG11	Fill 3 (Bridge 3)	9 to 15	Tuff with coal and sandstone / siltstone	No	Nil	3 (2015)	No
BHAG15	Fill 4	3 to 9.78	Sandstone	No	Nil	Nil	No
BHAG18	Cut 4	22.1 to 28.1	Tuff	No	Nil	6 (2015-2016)	No
BHAG21	Fill 4 / Cut 4	6.3 to 12.19	Siltstone, sandstone with coal	No	Nil	5 (2015)	No
BHAG22	Cut 4	NR	NR	No	Nil	2 (2015)	No
BHAG23	Cut 4	9.3 to 15.3	Sandstone and siltstone	No	Nil	4 (2015-2016)	No
BHAG30	Fill 7 (Bridge 6)	0.9 to 5.1	Silty clay	No	Nil	4 (2015)	No
BHAG34	Bridge 6	6 to 9	Fill	No	Nil	3 (2015)	No
BHAG41	Fill 4	12 to 15	Interbedded siltstone and sandstone	No	Nil	5 (2015-2016)	No
BHAG42	Cut 4	15 to 21	Conglomerate	No	Nil	4 (2015-2016)	No
BHSM05G	Fill 5 (Bridge 5)	4 to 10	Siltstone	No	Nil	2 (2015)	No
BBHSM08	Cut 5	24 to 29.6	Siltstone with coal	No	Nil	3 (2015)	No
BHSM11G	Cut 5	1.3 to 14	Sandstone with coal	No	Nil	3 (2015)	No
BHMW301	East of Cut 1	12.3 to 14.9	Coal and tuffaceous claystone	Yes	7	Datalogger since Sep-2018	No
BHMW302	North of Fill 1	12 to 15	Tuffaceous siltstone / sandstone	Yes	8	Datalogger since Sep-2018	No, decommissioned

ID	Location	Screen Interval (mBGL)	Lithology	Used in Baseline monitoring	No. of groundwater quality samples	No. of Groundwater level monitoring (year)	Monitored as part of the SGWQCMP?
BHMW303	East of Cut 2	5.7 to 7.2	Coal and siltstone	Yes	4	Datalogger since Sep-2018	Yes
BHMW304	West of Cut 2	12 to 15	Sandstone and conglomerate	Yes	Nil	Datalogger since Sep-2018	Yes
BHMW305	West of Fill 2	12 to 15	Tuffaceous siltstone / sandstone	Yes	16	Datalogger since Sep-2018	No, decommissioned
BHMW306	West of Cut 3	11.8 to 14.8	Sandstone and conglomerate	Yes	Nil	Datalogger since Sep-2018 (buried since Nov 20)	No, decommissioned
BHMW307	West of Cut 4	29.3 to 35.3	Tuffaceous sandstone and tuff with coal	Yes	13	Datalogger since Sep-2018	No, decommissioned
BHMW308	East of Cut 4	29.6 to 35.6	Siltstone / Sandstone and conglomerate	Yes	5	Datalogger since Sep-2018	Active
BHMW309	East of Fill 4	12.4 to 15.4	Siltstone and coal	Yes	18	Datalogger since Sep-2018	Active
BHMW310	West of Fill 5	11.95 to 14.95	Siltstone / sandstone	Yes	1	Datalogger since Sep-2018	Active
BHMW311	West of Cut 5	27.3 to 30.3	Siltstone / sandstone	Yes	2	Datalogger since Sep-2018 (bore blocked since August 2019)	Active
BHMW312	East of Cut 5/Fill 6	17 to 20	Siltstone / sandstone	Yes	16	Datalogger since Sep-2018	Yes
BHMW313	West of Fill 6	12.09 to 15.09	Siltstone / sandstone	Yes	16	Datalogger since Sep-2018	No, decommissioned
BHMW314	North West of Fill 6 – off Newcastle Road	11.5 to 14.5	Siltstone / sandstone	Yes	16	Datalogger since Sep-2018	Yes
BHMW315	Steel St – off Newcastle Road	12 to 15	Siltstone / sandstone	Yes	16	Datalogger since Sep-2018	Yes
BHMW316	East of Cut 5	36.68 to 39.68	Siltstone / sandstone	Yes	16	Datalogger since Sep-2018	Yes
BHMW317	West of Fill 3	30.2 to 32.75	Coal and tuffaceous claystone	Yes	16	Datalogger since Sep-2018 (no logger data from Oct 18 to April 19)	Yes
BHMW318	East of Fill 2	20.1 to 24.6	Coal	Yes	16	Datalogger since Sep-2018	Yes
BH307	Fill 1	8.24 to 11.24	Coal and tuffaceous sandstone	Yes	5	Datalogger since Sep-2018	No, decommissioned
BH310	Cut 1	14 to 17.6	Coal	Yes	16	Datalogger since Sep-2018	No, decommissioned
BH315	Cut 1 / Cut 2	16.82 to 19.82	Tuffaceous siltstone	Yes	nil	Datalogger since Sep-2018	No, decommissioned
BH321	Cut 3	21.8 to 28.8	Coal	Yes	13	Datalogger since Sep-2018	No, decommissioned
BH326	Cut 4	7 to 13.5	Tuff coal and siltstone	Yes	Nil	Datalogger since Sep-2018	No, decommissioned
VWP-MC90-01	West of cut 4	82 (mAHD)	Coal	No	Nil - GWL	Datalogger since Mar-23	Active
VWP-MC00-01	East of cut 4	84 (mAHD)	Coal	No	Nil - GWL	Datalogger since Mar-23	Active
VWP-MC40-01	Fill 1	93 (mAHD)	Coal	No	Nil - GWL	Datalogger since Mar-23	Active
VWP-MC90-01	Fill 1	82 (mAHD)	Coal	No	Nil - GWL	Datalogger since Mar-23	Active
VWP-TW01-Nth	Cut 1		Coal	No	Nil - GWL	Datalogger since Mar-23	Active
VWP-TW01-Sth	Cut 1		Coal	No	Nil - GWL	Datalogger since Mar-23	Active

Appendix B – Surface water monitoring locations

ID	Location	Easting	Northing	No. of surface water samples analysed	Period of monitoring (dates)
WC 1-1-US	Shallow isolated pond	378231.6	6357738	16	Dec 2019 – Oct 2020
WC 1-3-DS	Concrete drain	377655.8	6358521	16	Dec 2019 – Oct 2020
WC 2-2-DS	Flats Creek	377977.7	6357967	0 (Dry)	Dec 2019 – Oct 2020
WC 3-2-DS	Rock Pond	377189.5	6356859	7	Dec 2019 – Oct 2020
WC 4-1-US	Shallow stream	377484.7	6356247	16	Dec 2019 – Oct 2020
WC 4-2-DS	Shallow stream	377387.4	6356315	16	Dec 2019 – Oct 2020
WC 4-3-US	Shallow stream	377652.3	6356267	16	Dec 2019 – Oct 2020
WC 5-1-DS	Dry waterway	377363.4	6355739	2 (Dry)	Dec 2019 – Oct 2020
WC Blue Wren Ck-DS	Blue Wren Creek	375764.4	6357261	16	Dec 2019 – Oct 2020
WC Ironbark Ck-DS	Deep open channel	375983.5	6360096	16	Dec 2019 – Oct 2020