CHAPTER 14

Groundwater

ILLABO TO STOCKINBINGAL ENVIRONMENTAL IMPACT STATEMENT

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14. Groundwater

This chapter is a summary of the potential impacts of the Illabo to Stockinbingal project (the proposal) on groundwater. It describes the existing environment, assesses the impacts of construction and operation of the proposal, and provides recommended mitigation and management measures. The full assessment results are provided in Technical Paper 6: Groundwater Impact Assessment.

14.1 Overview

The development of the proposal took groundwater conditions into consideration to identify and avoid areas of high ecological importance, such as groundwater dependent ecosystems (GDEs), where possible.

Groundwater levels recorded in the groundwater study area ranged from 1.72 metres below ground level (mBGL) to 20.47 mBGL. The groundwater sources are less productive alluvial and fractured rock aquifers based on the *NSW Aquifer Interference Policy* (DPI, 2012b) (AIP). There were also 55 registered groundwater bores (beneficial use mainly listed as monitoring) and eight GDEs identified within the study area. The impact to private bores was raised as an issue during stakeholder and community consultation, and considered as part of the groundwater assessment.

During construction, the key potential impacts and proposed measures to address them are as follows:

- Construction dewatering could result in an unacceptable impact to sensitive receptors. No groundwater 'take' for use as construction water supply is proposed; however, groundwater dewatering may occur during construction if excavations (cuts) or piling for bridge foundations intersect with the groundwater table. Construction works are not anticipated to intersect and/or penetrate the groundwater table; however, due to the localised topographic influences on the shallow fractured rock hydrostratigraphic units (groundwater systems), a low risk is still present. If there is unforeseen water table penetration by earthworks, potential impacts would be assessed by a hydrogeologist and adaptive management measures implemented as required. The construction contractor would be required to apply for a water access licence (WAL) exemption prior to commencing any dewatering activity.
- Changes to soil moisture content may cause compression or settlement, including through groundwater take. The risk to settlement is low as cuts are not anticipated to intersect the regional groundwater table; however, appropriate drainage measures would be installed at the base of cuts and along high-walls to manage groundwater seepage in the unlikely event that it is encountered.
- Occurrence of contaminants infiltrating to groundwater. These impacts would be managed in accordance with a groundwater mitigation and management sub-plan, which would be implemented as part of the Construction Environmental Management Plan (CEMP). This sub-plan would include a groundwater monitoring program.

During operation, the key potential impacts and proposed measures to address them are as follows:

- Mobilisation of salts may cause an increase in groundwater salinity, which could affect sensitive receptors such as registered bores and GDEs. The risk of this impact remains low through avoidance by design as no additional drainage works or piling following construction is proposed and groundwater take is not proposed during operation.
- There could be impacts to groundwater recharge due to the presence of additional infrastructure and sealed surfaces and through seepage dewatering of cuts. To mitigate this impact, drainage measures would be maintained, where required, to manage ongoing groundwater seepage during operation. Any change would be negligible over the catchment area.

The assessment of the proposal's impacts on aquifers and GDEs in regard to the minimal impact considerations of the NSW AIP indicates the proposal complies with Level 1 criteria, which considers the potential impacts as acceptable.

14.2 Approach

A summary of the approach to the groundwater assessments is provided in this section, including the legislation, guidelines and policies driving the approach and the methodology used to undertake the assessments. A more detailed description of the approach and methodology is provided in Technical Paper 6.

14.2.1 Legislative and policy context to the assessments

The groundwater assessment was undertaken in accordance with the Secretary's Environmental Assessment Requirements (SEARs) and with reference to the requirements of relevant legislation, policies and assessment guidelines including:

- the requirements of the *Water Act 1912* (NSW) and the *Water Management Act 2000* (NSW) (WM Act), which govern the use of water from sources (including rivers, lakes, estuaries and groundwater) within NSW
- *Murray–Darling Basin Plan 2012* (Murray–Darling Basin Authority, 2012) under the *Water Act 2007* (Cth)
- relevant water sharing plans made under the WM Act, including:
  - NSW Murray–Darling Basin Fractured Rock groundwater sources (2020) (NSW MDB Fractured Rock groundwater sources)
  - Water Sharing Plan for the Lachlan Alluvial Groundwater Sources (MDBA, 2019)
- Water Sharing Plan for Murrumbidgee Unregulated and Alluvial Water Sources (NSW DPI, 2012)
- guidelines and policies relevant to the management of groundwater, including:
  - *NSW Aquifer Interference Policy* (NSW DPI, 2012c)
  - *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018 revision* (ANZG, 2018)
  - *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* (ANZECC/ARMCANZ, 2000);
  - the *NSW Groundwater Policy Framework*, including the *NSW Groundwater Quality Protection Policy* (NSW DLWC, 1998), the *NSW Groundwater Dependent Ecosystems Policy* (NSW DLWC, 2002), the *NSW Groundwater Quantity Management Policy* (NSW DLWC, undated).

Further discussion on the legislation and policies relevant to the assessment of groundwater are provided in Chapter 3 of Technical Paper 6.

14.2.2 Secretary's Environmental Assessment Requirements

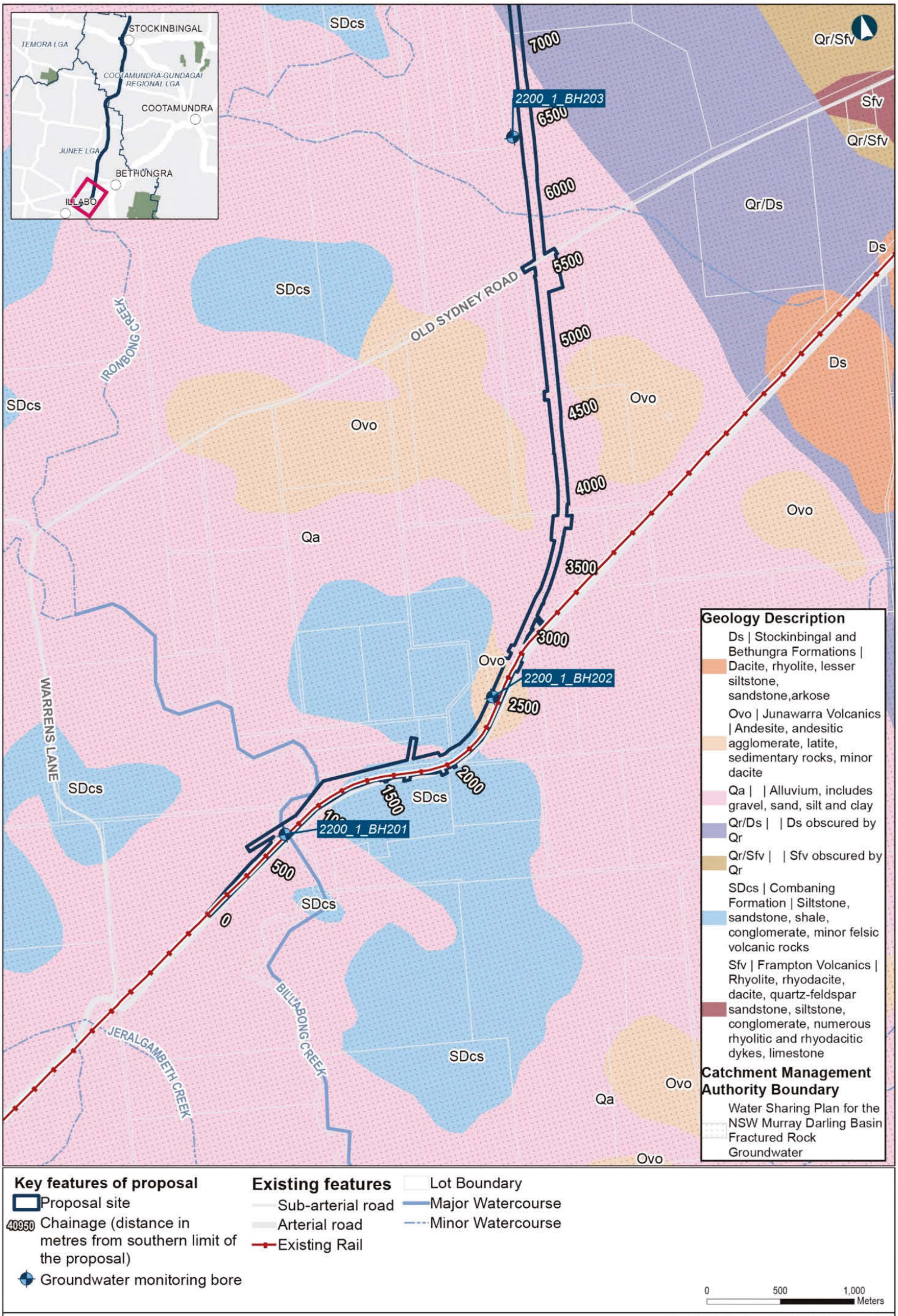
The SEARs relevant to groundwater, together with where they are addressed in the EIS, are provided in Appendix A.

14.2.3 Methodology

14.2.3.1 Study area

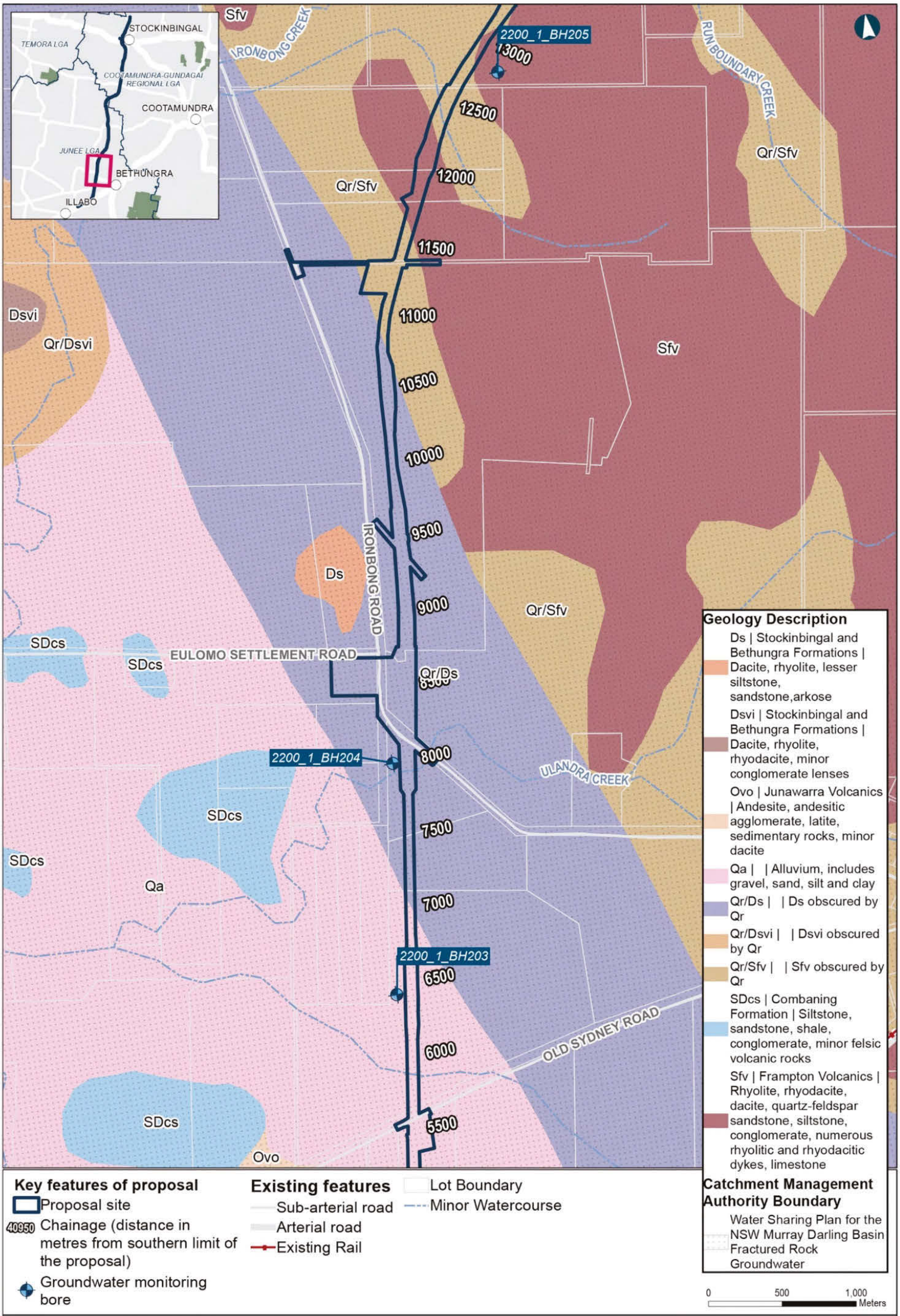
The study area for the purposes of this assessment is predominantly a 2 km buffer from the proposal site. This area has been selected as it incorporates important environmental receptors such as registered groundwater bores, and nearby aquatic and terrestrial groundwater dependent ecosystems (GDEs) and forms the basis of the groundwater impact assessment and development of the conceptual groundwater model.

The study area is shown on Figure 14-1.



14.1 Groundwater investigations

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC



14.1 Groundwater investigations

Coordinate System: GDA 1994 MGA Zone 55
Date: 8/12/2021 Paper size: A4 Scale: 1:35,000

MAP 2 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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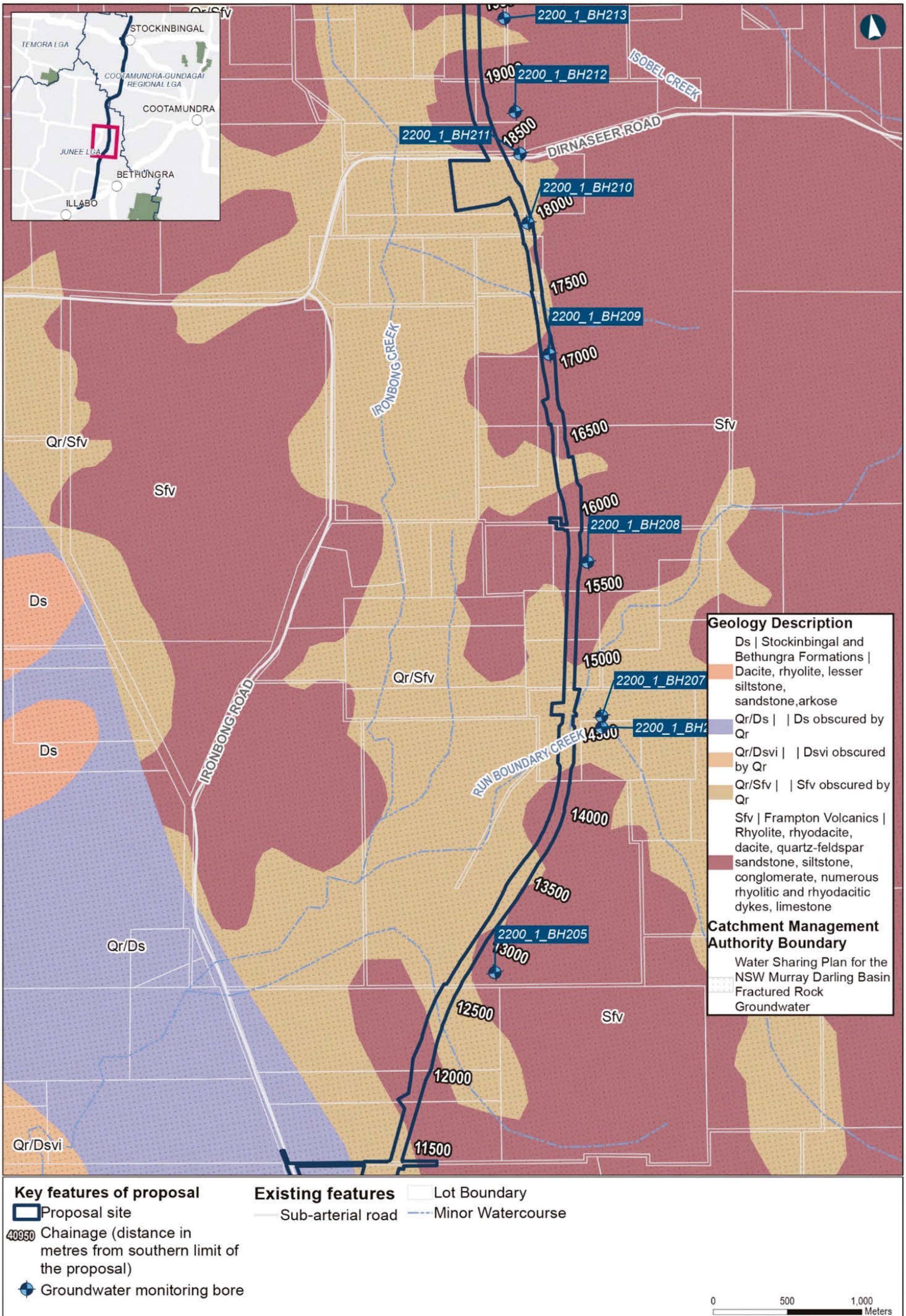

14.1 Groundwater investigations

Coordinate System: GDA 1994 MGA Zone 55
Date: 8/12/2021 Paper size: A4 Scale: 1:35,000
MAP 3 of 7

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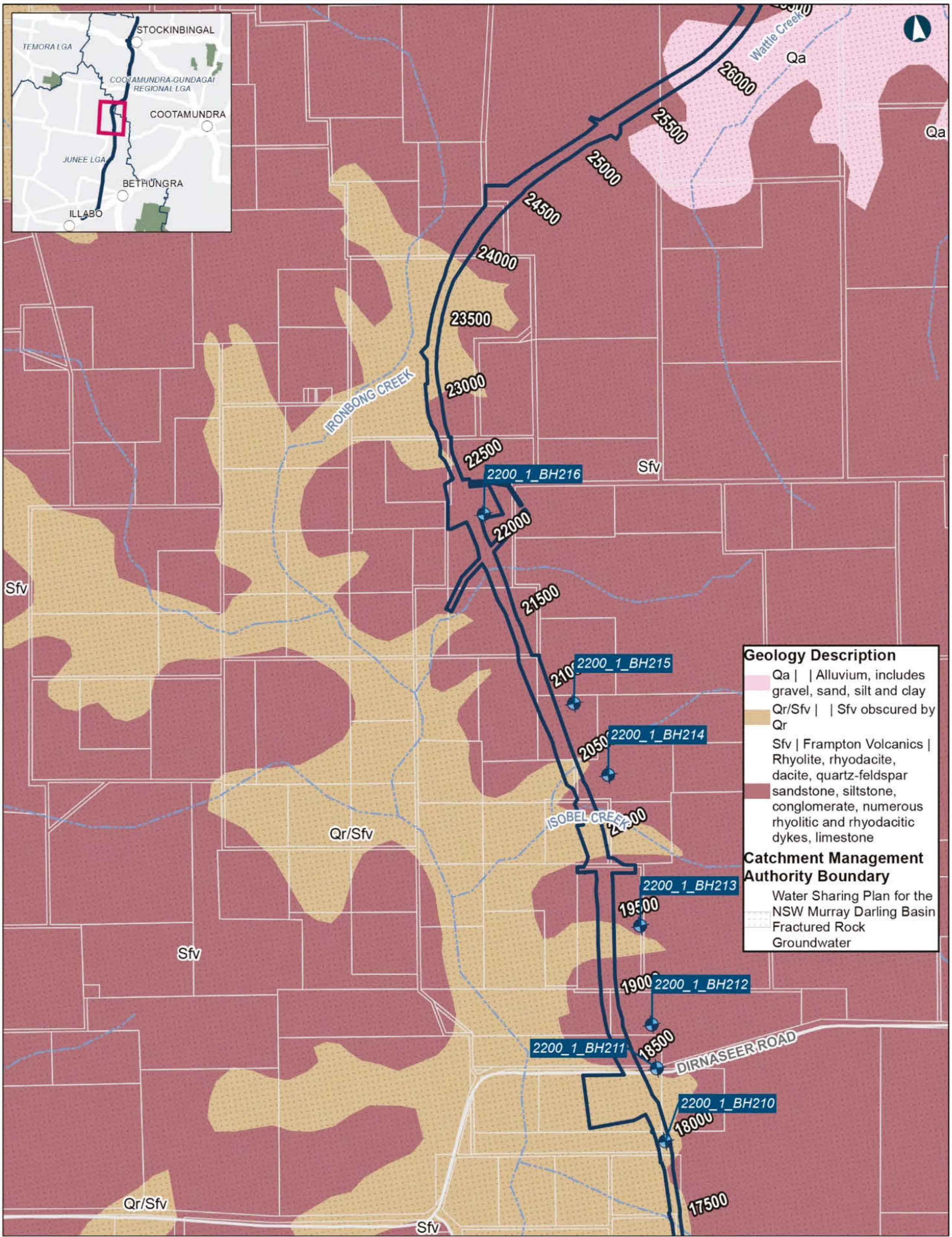
Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC



Key features of proposal
- Proposal site
- 40950 Chainage (distance in metres from southern limit of the proposal)
- Groundwater monitoring bore

Existing features
- Sub-arterial road
- Lot Boundary
- Minor Watercourse

0 500 1,000 Meters

14.1 Groundwater investigations

Coordinate System: GDA 1994 MGA Zone 55
Date: 8/12/2021 Paper size: A4 Scale: 1:35,000
MAP 4 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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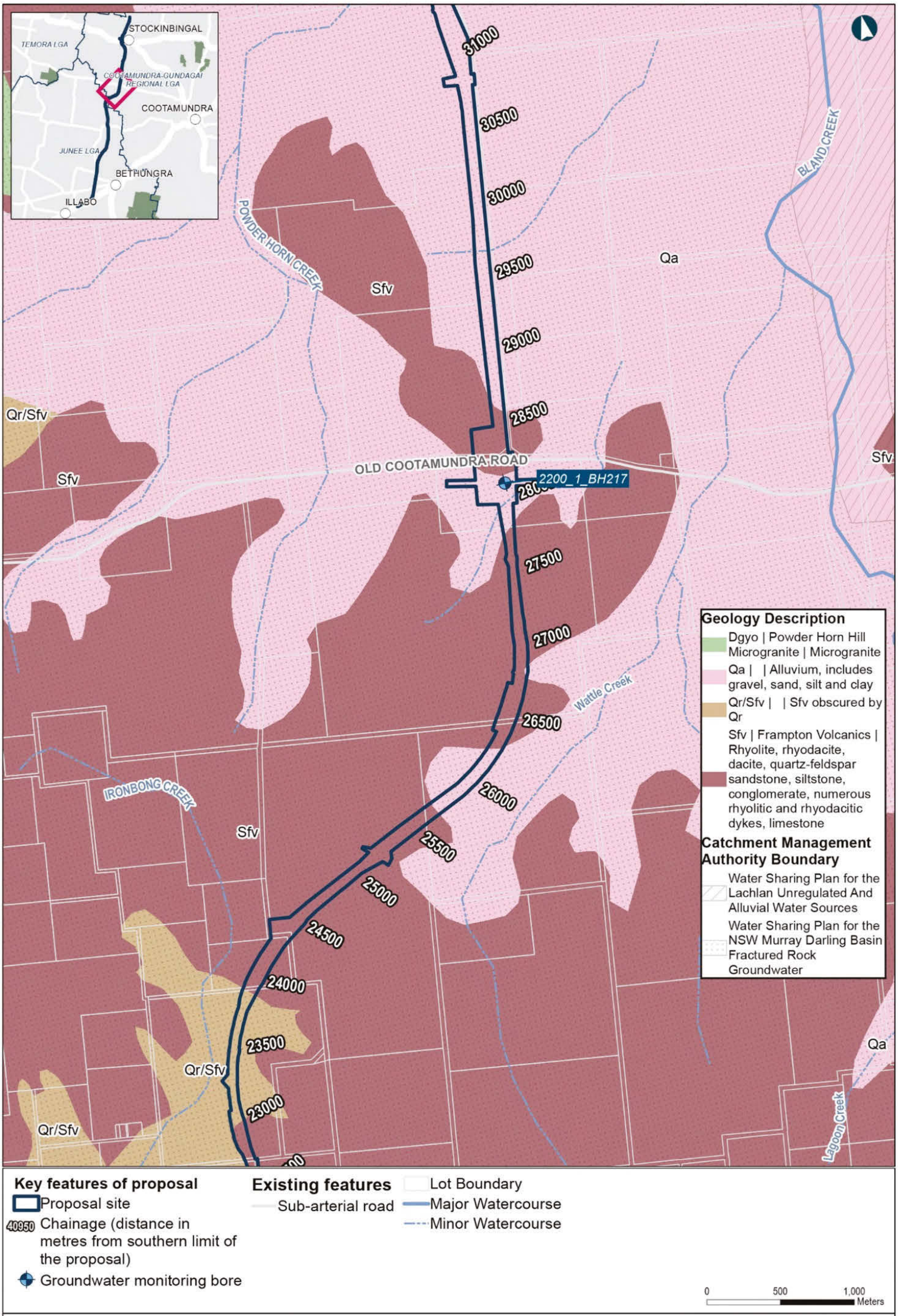
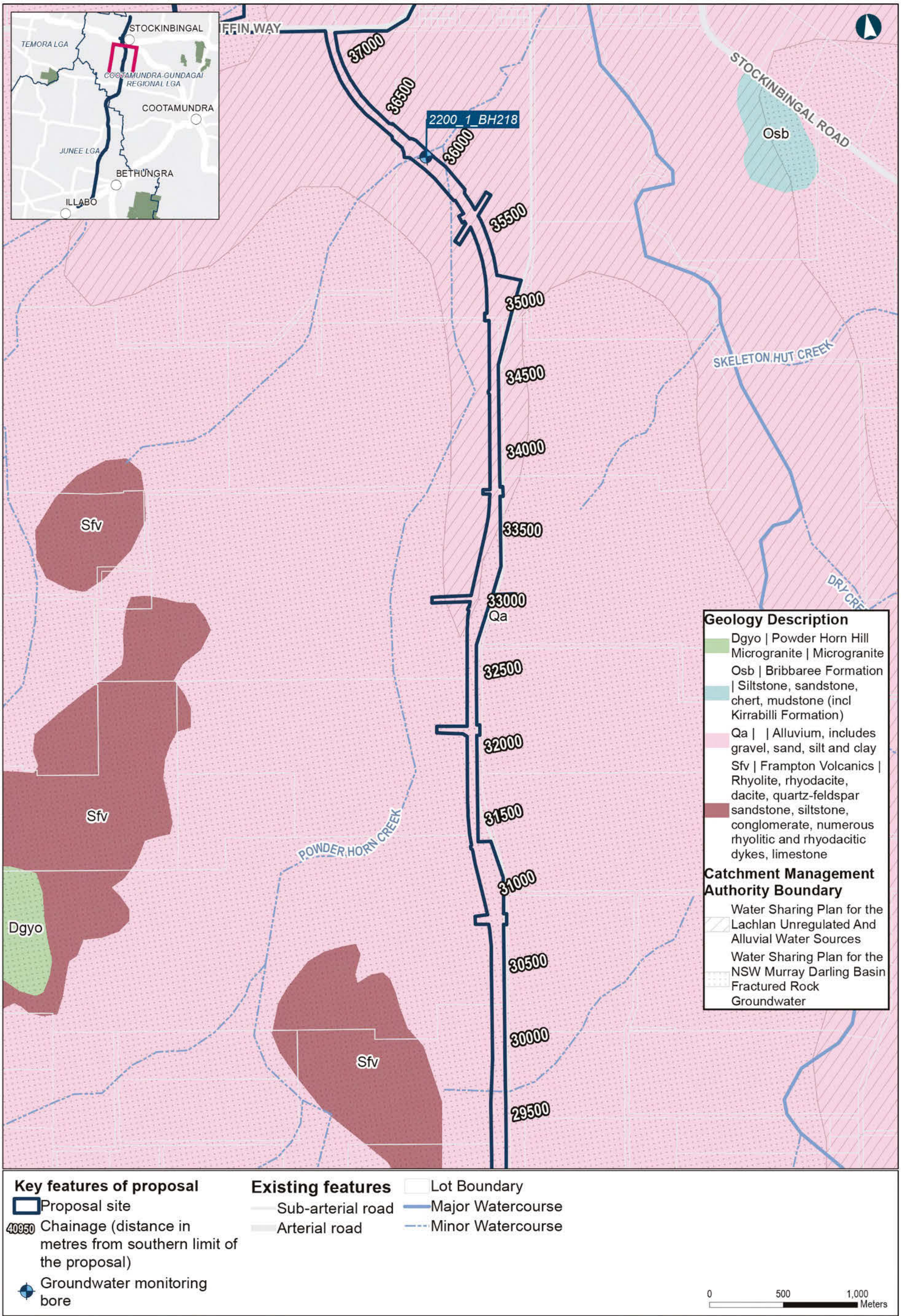


14.1 Groundwater investigations

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC



14.1 Groundwater investigations

Coordinate System: GDA 1994 MGA Zone 55
Date: 8/12/2021 Paper size: A4 Scale: 1:35,000
MAP 6 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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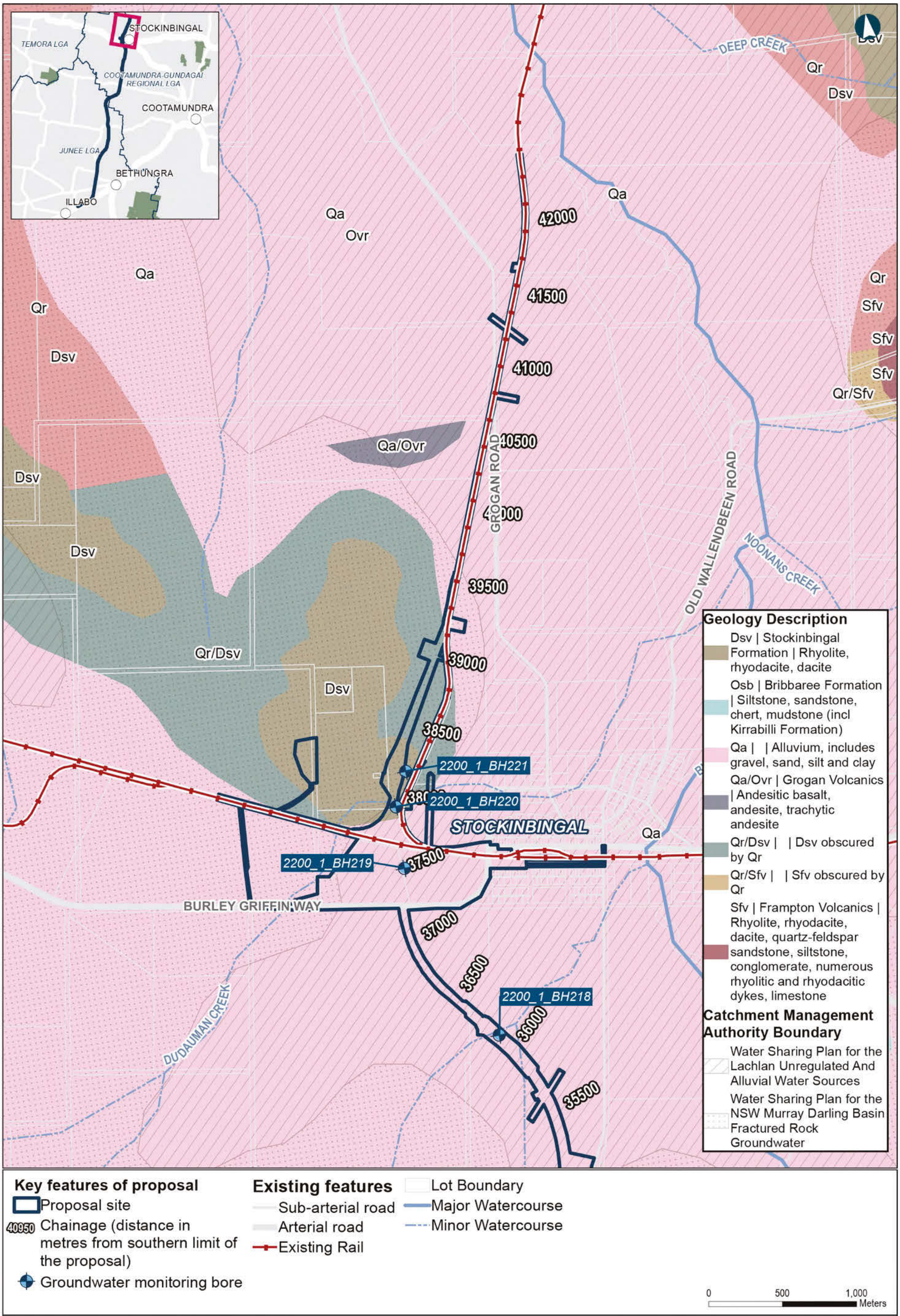


14.1 Groundwater investigations

Coordinate System: GDA 1994 MGA Zone 55
Date: 8/12/2021 Paper size: A4 Scale: 1:35,000
MAP 7 of 7

220_0115_EIS_14_1_GoundwaterInvestigations_r1v1.mxd

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

14.2.3.2 Key tasks

The key tasks of the groundwater assessment comprised:

- completion of a desktop study to describe the existing environment, characterise the hydrogeology and inform the scope of the site investigation. The desktop study included:
  - review of topographical data, including LiDAR survey
  - review of geological mapping including the Cootamundra (1:250000) geological sheet (Warren et al., 1996)
  - searches of groundwater dependent ecosystems using the Bureau of Meteorology (BOM) GDE Atlas (BOM, 2021)
  - searches for registered groundwater bores
  - rainfall and evapotranspiration recorded by BOM for the study area; and
  - publicly available reports and databases further detailing the existing groundwater, soil, geological, topographical and hydrogeological environments
- completion of a site investigation, including the installation of a network of 11 groundwater monitoring bores and completion of four groundwater monitoring events (GMEs)
- analysis of the results and development of a conceptual hydrogeological model, including a water balance
- assessing potential groundwater-related impacts from the proposal
- identifying mitigation and management measures.

A detailed methodology and results of site investigations is in section 3.4 of the Technical Paper 6.

14.2.3.3 Groundwater monitoring

A groundwater monitoring network was developed to inform the assessment and consists of 11 groundwater monitoring bores. Locations of the groundwater monitoring bores were selected to:

- characterise groundwater resources along the full length of the alignment, targeting areas where groundwater data is not available
- target locations where significant cuts are proposed, so the depth to the water table relative to the depth of the cut can be assessed
- provide for assessment and monitoring of potential impacts on sensitive receptors, including GDEs and landholder bores.

The details of the groundwater monitoring results are in section 14.3.1.3.

14.2.4 Risks identified

Construction and operation of the proposal, if undertaken without adequate management controls in place, has the potential to impact on the identified groundwater resources and environmental values through changes to groundwater availability and groundwater quality.

Table 14-1 is a summary of risks to the groundwater environment as a result of the construction and operational phase of the proposal. The key issue identified for the proposal is the risk associated with proposed cuts that intersect saturated Lachlan Alluvial or Fractured Bedrock.

TABLE 14-1: GROUNDWATER RISK SUMMARY

Risk aspect	Description
Dewatering	Construction dewatering resulting in an unacceptable impact to sensitive receptors.
Flow paths	Changes to groundwater flow paths or groundwater discharge impacting surface water and groundwater quality.
Settlement	Changes to soil moisture content causing compression or settlement.
Contamination	Degradation of water quality through the movement of potentially existing contamination plumes within the groundwater environment.
Contamination	Contamination of groundwater from construction activities during the construction phase and maintenance procedures during the operational phase.
Recharge	Changes to groundwater recharge through altering surface infiltration.

14.2.5 How potential risks have been avoided or minimised

The option development and assessment process for the proposal location/route options is summarised in Chapter 6: Alternatives and proposal options. The shortlist of route options was subject to a detailed assessment, and the proposed alignment was refined based on evaluation of key considerations, including environmental impacts. While selection of a different route alone would not result in changes of the proposal's impact to groundwater (due to its depth below the surface), potential environmental impacts include selecting the route to avoid impacts to sensitive areas including, surface water and GDEs.

Potential impacts on groundwater would continue to be avoided by:

- designing, constructing and operating the proposal to further minimise the potential for impacts to groundwater, including reducing cut sizes and depths where practicable
- managing the potential impacts on groundwater in accordance with relevant legislative and policy requirements, as outlined in section 14.2.1
- implementing the groundwater mitigation measures provided in section 14.6
- implementing other mitigation measures relevant to other issues also relevant to groundwater, which are identified in section 14.6.

Provided the above measures are implemented accordingly, the proposal poses a negligible to low risk of impacting the groundwater environment.

14.3 Existing environment

14.3.1 Hydrogeology and groundwater levels

14.3.1.1 Topography and catchments

The topography of the northern part of the study area (near Stockinbingal) comprises gently to moderately sloping terrain, with elevations between 300 m and 370 m Australian Height Datum (AHD). The southern portion of the study area near Illabo, is also generally characterised by gently to moderately undulating terrain. Elevation levels extend to about 390 m AHD. However, within a few kilometres east of the proposal, elevation can extend up to approximately 700 m AHD associated with the base of the Bethungra Range. The study area includes two major catchments, associated with the Lachlan and the Murrumbidgee rivers. The topography of the study area around Old Cootamundra Road marks the approximate divide between the two catchments. These surface water catchments were subdivided into the following three sub-catchments relevant to groundwater:

- Lachlan River catchment:
  - Lachlan lower slopes: a minor sub-catchment, located within the northern section of the proposal near Stockinbingal associated with alluvial soils
  - Lachlan upper slopes: the dominant sub-catchment from Old Cootamundra Road to Stockinbingal.
- Murrumbidgee major catchment:
  - Murray–Darling Basin Fractured Rock: the primary sub-catchment within the central to southern parts of the study area, between Illabo and south of Old Cootamundra Road, where it becomes part of the Lachlan upper slopes sub-catchment to the north. The sub-catchment generally passes through moderately to steep undulating land controlled by outcropping volcanics.

14.3.1.2 Hydrostratigraphic units within the study area

Hydrostratigraphic units (HSUs) are defined as geological materials of similar hydrogeological properties. HSUs are generally based on stratigraphic units, although units of similar storage and transfer properties are often classified together as a single HSU.

HSUs within the study area are generally delineated in accordance with the water sharing plans managed under WM Act and are described in section 14.2.1. The alluvial sediments associated with Billabong Creek (managed under the NSW Murray-Darling Basin Fractured Rock Groundwater Sources sharing plan), share similar hydrogeological properties to the Lachlan Alluvial groundwater sources i.e. contains a permanent unconfined to semi-confined groundwater resource. Therefore, the alluvial sediments associated with Billabong Creek have been grouped together with the Lachlan Alluvial groundwater sources sharing plan, for assessment purposes.

There are two relevant HSUs within the study area (refer to Table 14-2): the Lachlan Unregulated and Alluvial (Lachlan Alluvial) and the Murray-Darling Basin Fractured Rock (Fractured Rock). These units have been selected to match the dominant hydrogeology within the region.

Unidentified faults and regions of structural deformation will occur throughout the regional geological terrain and are inherently difficult to predict, especially in areas of quaternary cover. They are likely to follow pre-existing weakness in the geology and structural interpretation can only identify areas of potential higher risk.

TABLE 14-2: HYDROSTRATIGRAPHIC UNITS WITHIN THE STUDY AREA

Hydrostratigraphic unit	Groundwater resource unit (geology unit)	Estimated depth below surface (m)	Characteristics
Lachlan Alluvial [1]	Quaternary alluvial and colluvium—sand, gravels, clay, silt	0–20	Unconfined water bearing zones. Overlying basement fractured rocks mostly situated within drainage lines and low-lying plains. Limited connectivity to underlying fractured rock HSU.
Fractured Rock (shallow)	Quaternary and Tertiary colluvial, residual and/or alluvial—sand, gravels, clay, silt Ordovician—Devonian volcanics (Combaning Formation, Frampton Volcanics, Junawarra Volcanics)	0–15 (unconsolidated sediments of the shallow fractured rock)	Perched water within unconsolidated sediments that overlie the fractured rock basement. This water is anticipated to contribute negligible amounts to regional groundwater, as availability will be controlled by dominant climate factors such as evapotranspiration. Higher groundwater yield rates would be related to thickness and width of water bearing structural deformation zones that are present.
Fractured rock (deep)	Ordovician—Devonian volcanics (Combaning Formation, Frampton Volcanics, Junawarra Volcanics)	100+ (basement fractured rock of the deep fractured rock aquifer)	Semi-confined to confined system within a fractured rock basement. Low primary porosity, highly localised groundwater flow controls due to the varying degree of structural deformation. Higher groundwater yield rates would be related to thickness and width of water bearing structural deformation zones that are present.

1. Includes alluvium sediments associated with Billabong Creek that is governed within the NSW Murray-Darling Basin Fractured Rock groundwater sources (2020). Inclusion is due to the permanent nature of the groundwater resource within the watercourse's sediments.

14.3.1.3 Groundwater monitoring results for the study area

Four GMEs were completed in January and May 2019 and February and April 2021 to capture seasonal variation. Groundwater levels were recorded in the study area using both manual measurements and through the installation of level loggers in the groundwater monitoring bores (refer to Figure 14-1). Groundwater levels were measured in metres below ground level (mBGL), which identifies the depth at which standing water level (SWL) is encountered beneath the natural ground surface.

Two groundwater monitoring bores were installed within the Lachlan Alluvial. Groundwater levels recorded in the Lachlan Alluvial ranged from 7.36 mBGL to 19.09 mBGL. Monitoring bore BH201, which is situated adjacent to a drainage channel, consistently recorded the shallowest groundwater levels, ranging from at 7.36 mBGL to 7.72 mBGL.

Groundwater levels, where observed within the fractured rock, ranged from 1.72 mBGL to 20.47 mBGL. Groundwater monitoring bore BH217 recorded the shallowest value of 1.72 mBGL. Groundwater monitoring bore BH217 is located adjacent to an ephemeral watercourse and recorded a groundwater level of 1.77 mBGL.

Detailed bore logs are presented in Appendix A of Technical Paper 6. A summary of the groundwater levels is presented in Table 14-3.

TABLE 14-3: GROUNDWATER MONITORING SUMMARY INCLUDING STANDARD WATER LEVELS (SWL)

Bore ID	Easting/northing	HSU	SWL (mBGL)					Natural ground surface (mAHD)
			GME 1 (January 2019)	GME 2 (May 2019)	GME 3 (February 2021)	GME 4 (April 2021)	Bore depth	
BH201	571382 / 6149302	Lachlan Alluvial[1]	7.72	7.75	7.62	7.36	20.14	257.3
BH202	572979 / 6149825	Fractured Rock	Dry	Dry	Dry	Dry	13.02	289.8
BH204	574319 / 6155023	Fractured Rock	13.37	13.43	12.93	12.91	20.80	284.5
BH211	576936 / 6164824	Fractured Rock	19.48[3]	Dry	Dry	Dry	20.20	345.0
BH212	576950 / 6165203	Fractured Rock	20.47[3]	Dry	N/A[1]	N/A[1]	25.22	379.5
BH213	576994 / 6165779	Fractured Rock	8.29	8.70	N/A[1]	N/A[1]	26.30	350.3
BH215	576830 / 6167308	Fractured Rock	14.52	16.24	N/A[1]	N/A[1]	18.70	376.1
BH217	576142 / 6173054	Fractured Rock	1.72	1.90	2.51	1.76	20.36	346.5
BH219	579574 / 6182102	Fractured Rock	19.09[3]	Dry	Dry	Dry	20.97	303.8
BH220	579548 / 6182537	Fractured Rock	Dry	Dry	Dry	Dry	20.95	303.5
BH054	576756 / 6164869	Fractured Rock	N/A[2]	N/A[2]	16.97	16.95	30.00	350.0

1. BH212, BH213 and BH215 were unable to be monitored during GME 3 due to land access restrictions.
2. BH054 installed on 3 February 2021.
3. SWL measurement likely artificial due to residual drilling fluids, levels are not considered to be representative of groundwater level.

14.3.1.4 Hydraulic conductivity

Hydraulic conductivity is one of the measures used in understanding the potential rates of drawdown that may occur within a local hydrogeological regime. Hydraulic conductivity is measured in metres per day and is a calculation of how easily groundwater flows through a porous medium (soil matrix or rock mass) under natural conditions. The higher the value of hydraulic conductivity, the greater the permeability of the geological strata, contributing to a higher potential for the movement of groundwater that can be expected.

Successful slug testing or short-term pumping recovery tests were completed on two groundwater monitoring bores (BH212 and BH215) during GME 1 and on BH054 during GME 3 to provide estimates of hydraulic conductivity values at proposed cut locations for seepage assessment. A summary of hydraulic conductivity (K) is presented in Table 14-4.

TABLE 14-4: SUMMARY OF HYDRAULIC CONDUCTIVITY

Bore ID	Number of tests	Typical test length	Minimum K (m/day)	Maximum K (m/day)	Mean K (m/day)
BH213	8	5 seconds	4.53	10.10	7.22
BH215	1	20.5 hrs	1.5×10^{-4}		
BH054	8	5 seconds	10.1×10^{-3}		

The lower range hydraulic conductivity values found at BH215 and BH054 were considered to represent typical values within majority of the study area that does not intersect major water bearing zones associated from faults or folding. The lower range values were also considered to be representative of the Lachlan Alluvial. The higher value obtained at BH213 is likely to relate to a water bearing zone within the Fractured Rock.

14.3.1.5 NSW Aquifer Interference Policy

For aquifer impact assessments, the *NSW Aquifer Interference Policy* (NSW DPI, 2012c) (AIP) divides groundwater sources into ‘highly productive’ and ‘less productive’ based on water quality and yield. Highly productive groundwater sources have total dissolved solids less than 1,500 mg/L and can sustain yields greater than 5 L/sec. Groundwater sources that do not meet that criteria are considered less productive. Categories of less productive groundwater sources are Alluvial, Porous Rock and Fractured Rock.

The groundwater sources within the study area are considered to be less productive Alluvial and Fractured Rock aquifers. In accordance with the NSW AIP, the following minimal impact criteria are considered relevant to the study area:

- Impacts to the water table are considered to be minimal where the water table change is less than or equal to 10% of the cumulative variation in the water table and 40 m from any high-priority GDE or high-priority culturally significant site. If the impact is greater, it must be demonstrated that the variation will not prevent the long-term viability of a GDE.
- Impacts to the water table are considered minimal if the cumulative decline in any water supply work is less than 2 m. If the impact is greater, make good provisions apply.
- Impacts to water pressure are considered minimal if the cumulative decline in any water supply work is less than 2 m. If the predicted impact is greater, then appropriate studies are required to demonstrate to the satisfaction of the NSW Minister for Lands and Water that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Impacts to water quality are considered minimal if the change in groundwater quality remains within the current beneficial use category of the groundwater source beyond 40 m from the activity. No increase of more an 1% per activity in long term average salinity in a highly connected surface water source at the nearest point to the activity (alluvial water sources only). If this cannot be achieved, studies are required to demonstrate that the change will not prevent the long-term viability of the dependent ecosystem or affected water supply works.

14.3.2 Groundwater quality

Groundwater quality data for the proposal has been obtained through the desktop assessment and GMEs. Each of the groundwater monitoring bores that were accessible and contained retrievable groundwater quantities were sampled. Groundwater quality data (pH, EC, major ions and metals) obtained during the GMEs are summarised against the guideline values in Table 14-5. Full laboratory results are in Appendix C of Technical Paper 6.

The *Murray--Darling Basin Plan 2012* (MDBA, 2012) alongside the water sharing plans for the Murray-Darling Basin Fractured Rock groundwater sources and Lachlan Unregulated and Alluvial water sources provide the guiding salinity objectives for groundwater. The guideline values for pH, dissolved oxygen and major metals is based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2018* (ANZG, 2018), which currently defer to the *ANZECC Water Quality Guidelines for Fresh and Marine Waters* (ANZECC,2000).

TABLE 14-5: SUMMARY OF GROUNDWATER QUALITY RESULTS FROM GROUNDWATER MONITORING EVENTS COMPARED TO THE ADOPTED GUIDELINE VALUES

Parameter	Guideline value	Fractured Rock (BH204, BH213, BH215, BH217 & BH054)	Lachlan Alluvial (BH201)
Salinity—field electrical conductivity (EC)	1,343 µs/cm–4,478 µs/cm	Field values are above adopted guideline values, with marginal to slightly saline water quality; EC values ranging from 1,369 µS/cm (BH204) to 7,354 µS/cm (BH213).	Field values are above adopted guideline values, with marginal water quality; EC values were recorded at 1,351 µS/cm and 1,764 µS/cm.
Field pH	6.5–8.0	Within adopted guideline values. pH ranged from 6.53 (BH213) to 7.47 (BH204).	Within adopted guideline values. pH ranged from 7.04 to 7.43.
Dissolved oxygen (DO)[1]	90–110% saturated	Below adopted guideline values, with DO ranging from 6.2% (BH213) to 98.4% (BH054)[1].	Below adopted guideline values, with DO ranging from 34.6% to 60.6%.

Parameter	Guideline value	Fractured Rock (BH204, BH213, BH215, BH217 & BH054)	Lachlan Alluvial (BH201)
Dissolved metals	Aluminium: 0.055 milligram per litre (mg/L) Arsenic: 0.024 mg/L Cadmium: 0.0002 mg/L Chromium: 0.001 mg/L Copper: 0.0014 mg/L Lead: 0.0034 mg/L Mercury: 0.0006 mg/L Nickel: 0.011 mg/L Zinc: 0.008 mg/L.	The following analytes exceeded adopted guideline values: aluminium in BH054 during GME 3 & GME 4 cadmium in BH213 (GME 2) & BH054 (GME 3) copper in BH204 (GME 1 & GME 4), BH213 (GME 2), BH215 (GME 2), BH217 (GME 1 & GME 4) and BH054 (GME 3 & GME 4) nickel in BH215 (GME 1) and BH054 (GME 4) zinc in BH204 (GME 1), BH215 (GME1 & 2), BH217 (GME 1) and BH054 (GME 3 & GME 4).	Adopted guideline values were surpassed for copper during GME 1 and GME 4. All other analytes were below adopted guideline values throughout the GMEs.

1. A DO content of 530.3% was recorded in BH215 during GME 1. High DO values are likely due to the aeration of the water during extraction for testing and are not considered representative of the HSUs baseline DO water quality.

14.3.3 Sensitive receptors

An overview of sensitive receptors is provided below and shown in Figure 14-2.

14.3.3.1 Groundwater users

There are 55 registered groundwater bores within the study area. All identified registered bores from the National Groundwater Information System (NGIS) database (BOM, 2021) have been interpreted to take groundwater from the Fractured Rock HSU, with the beneficial use of the majority listed as monitoring. The remaining bores are listed as use for exploration, irrigation, household water supply, unknown and livestock. Of the 55 registered groundwater bores located within the study area:

- 7 are functioning
- 24 are in an unknown condition
- 24 bores are either non-functional, proposed or removed.

Details of the registered bores are in section 4.9 of Technical Paper 6.

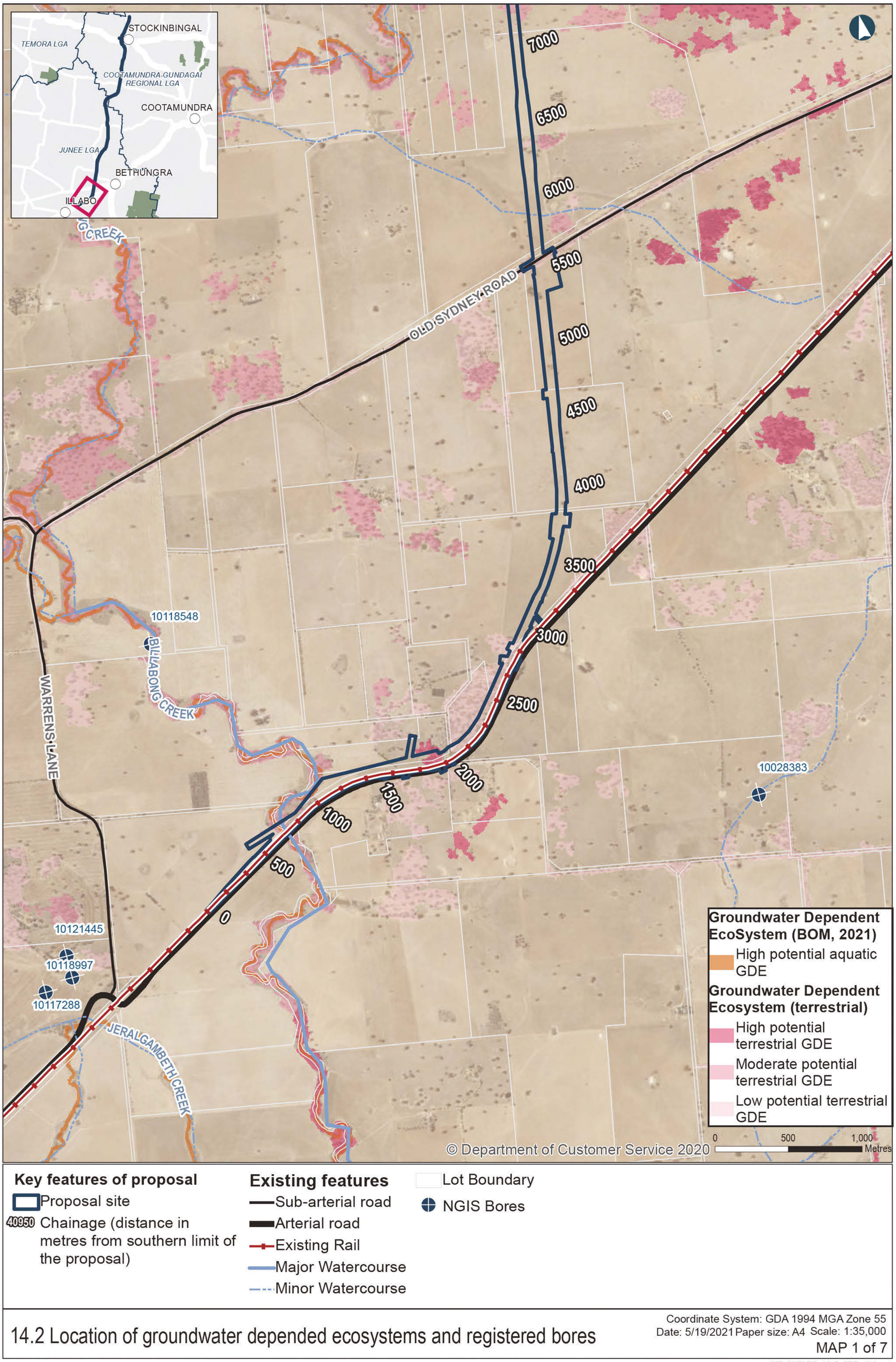
14.3.3.2 Groundwater dependent ecosystems

The GDE Atlas (BOM, 2021) categorises GDEs into three classes:

- ecosystems that rely on the surface expression of groundwater—this includes all the surface water ecosystems, which may have a groundwater component, such as rivers, wetlands and springs
- ecosystems that rely on the subsurface presence of groundwater—this includes all vegetation ecosystems
- subterranean ecosystems—this includes cave and aquifer ecosystems.

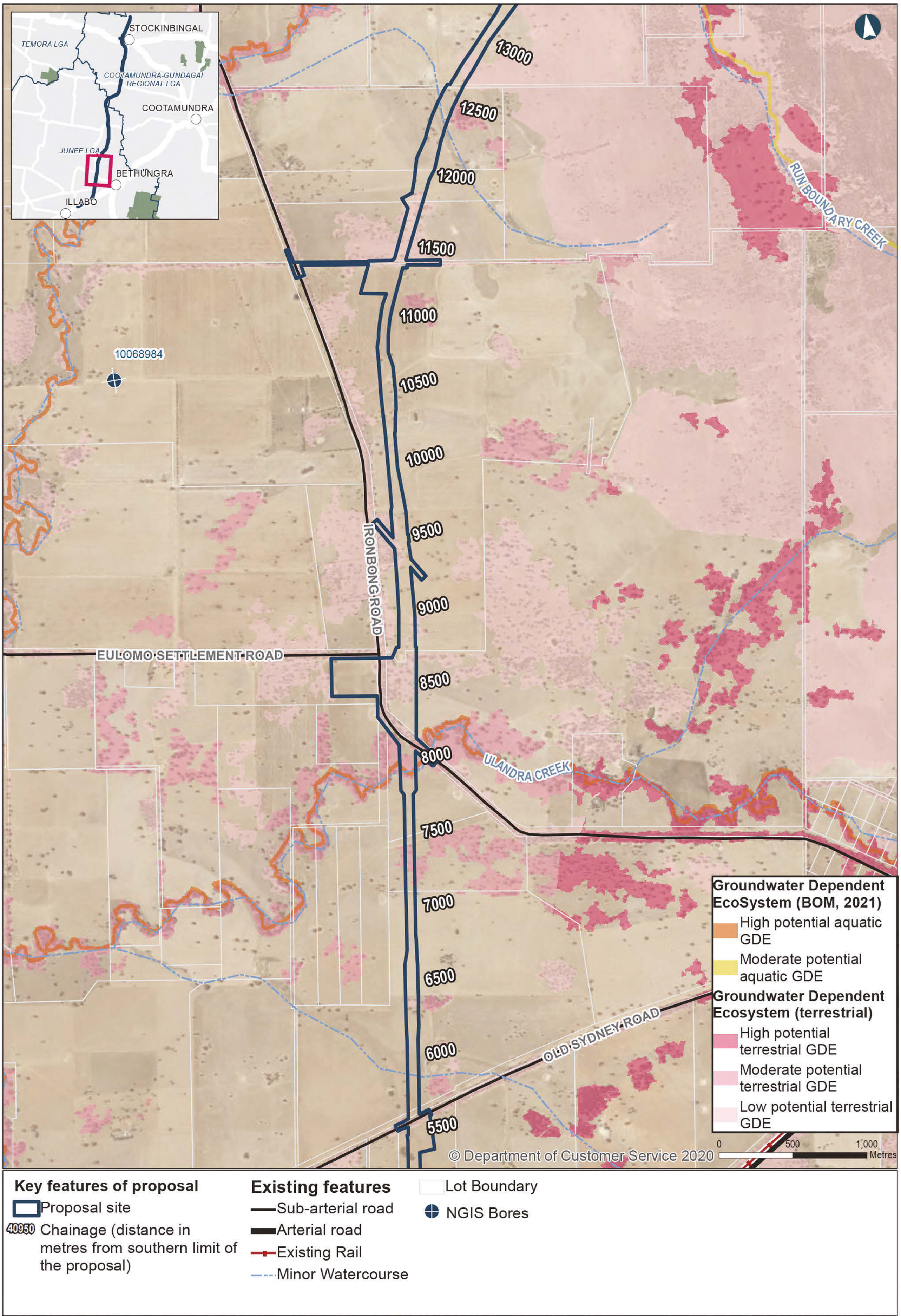
Eight ecosystems have been identified within the study area that rely on the subsurface presence of groundwater. The location of these GDEs relative to the proposal are presented in Figure 14-2. Within these ecosystems, the following high potential GDEs have been identified:

- four high potential aquatic (river) GDEs—Billabong Creek, Ulandra Creek, Ironbong Creek and Dudauman Creek
- four high potential terrestrial (vegetation) GDE species—Blakely's red gum, yellow box, western grey box and white cypress pine.



14.2 Location of groundwater depended ecosystems and registered bores

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC



14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 2 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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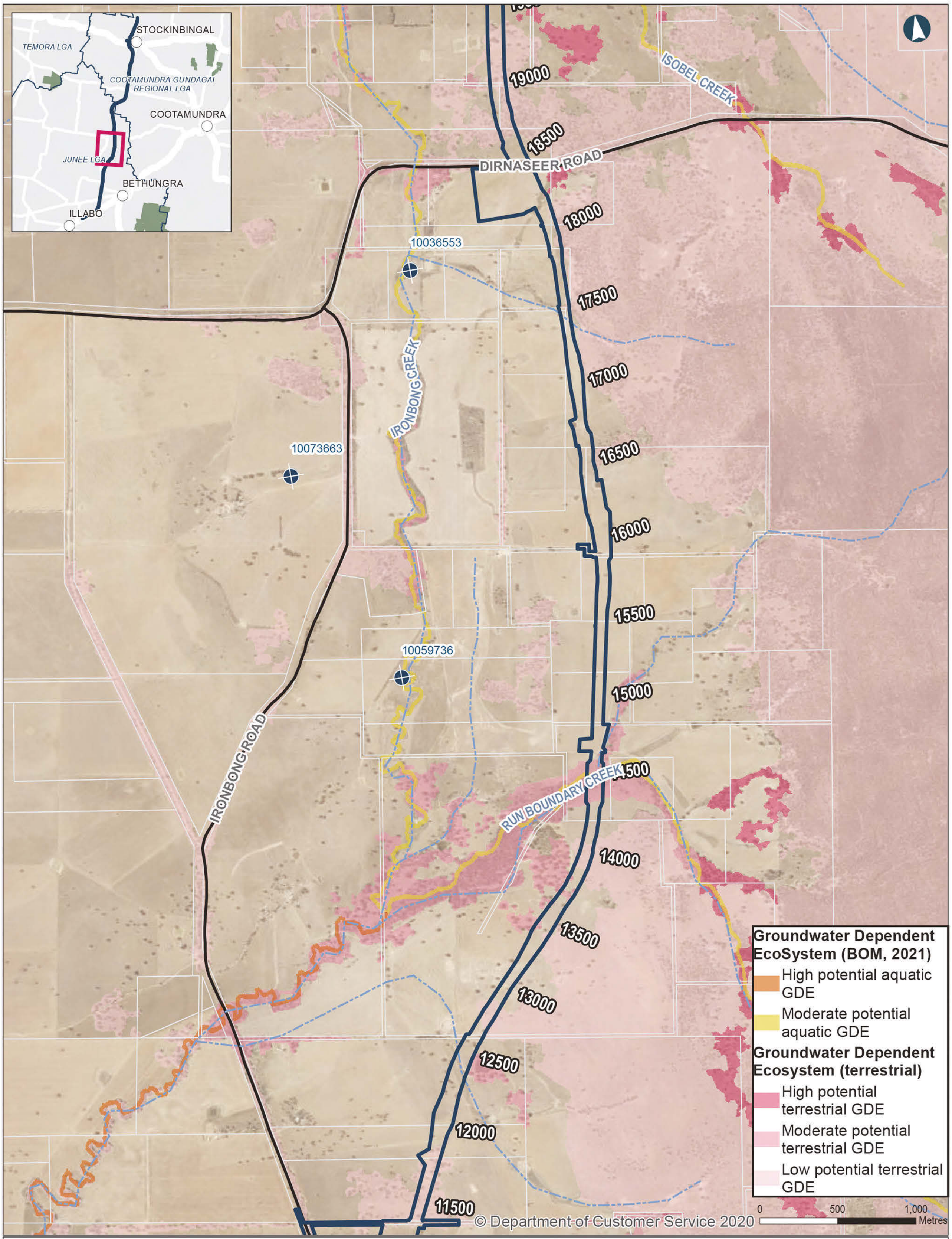

Key features of proposal

- Proposal site
- 40950 Chainage (distance in metres from southern limit of the proposal)

Existing features

- Sub-arterial road
- Minor Watercourse
- Lot Boundary
- NGIS Bores

14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 3 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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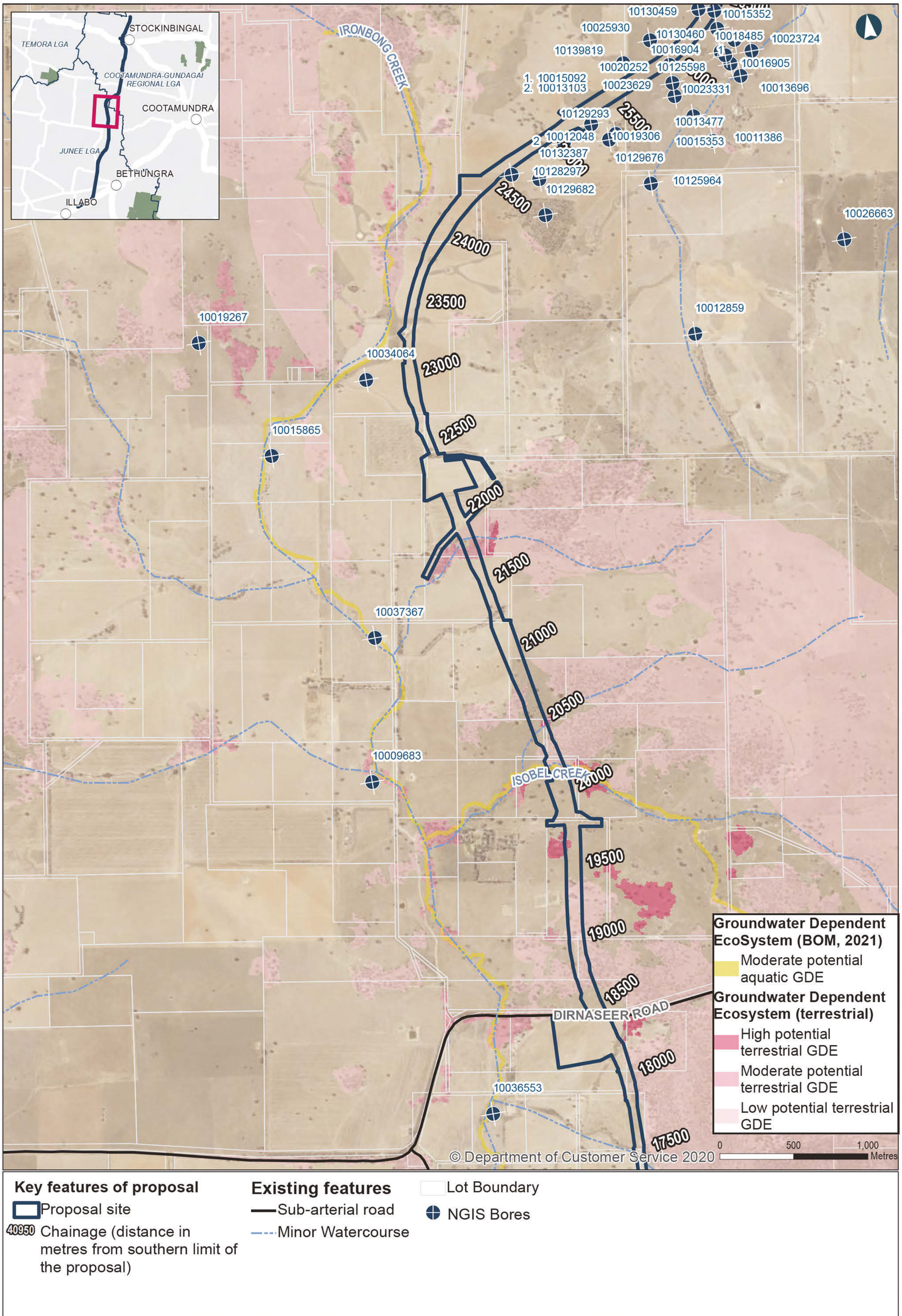

14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 4 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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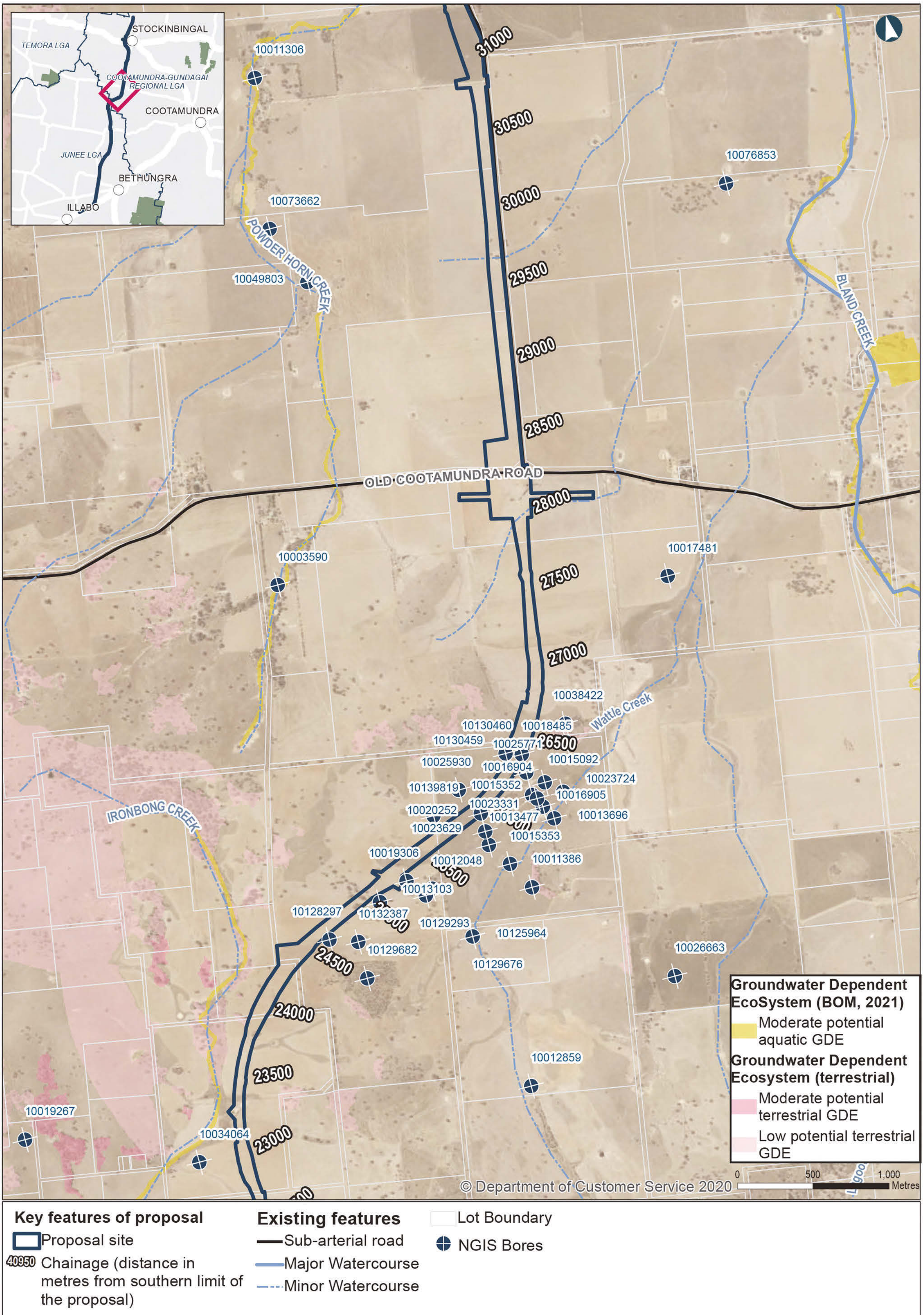

14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 5 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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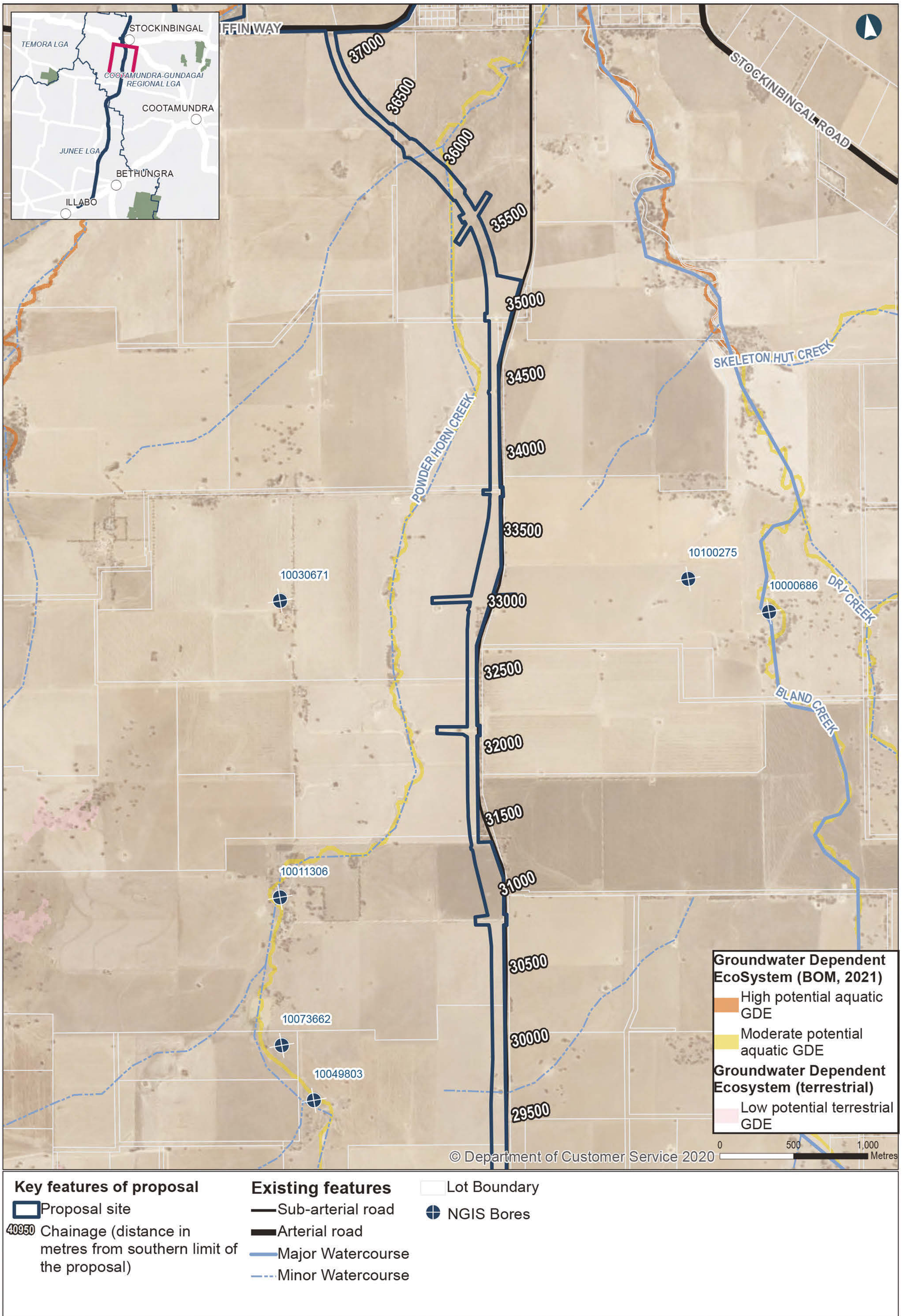

14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 6 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

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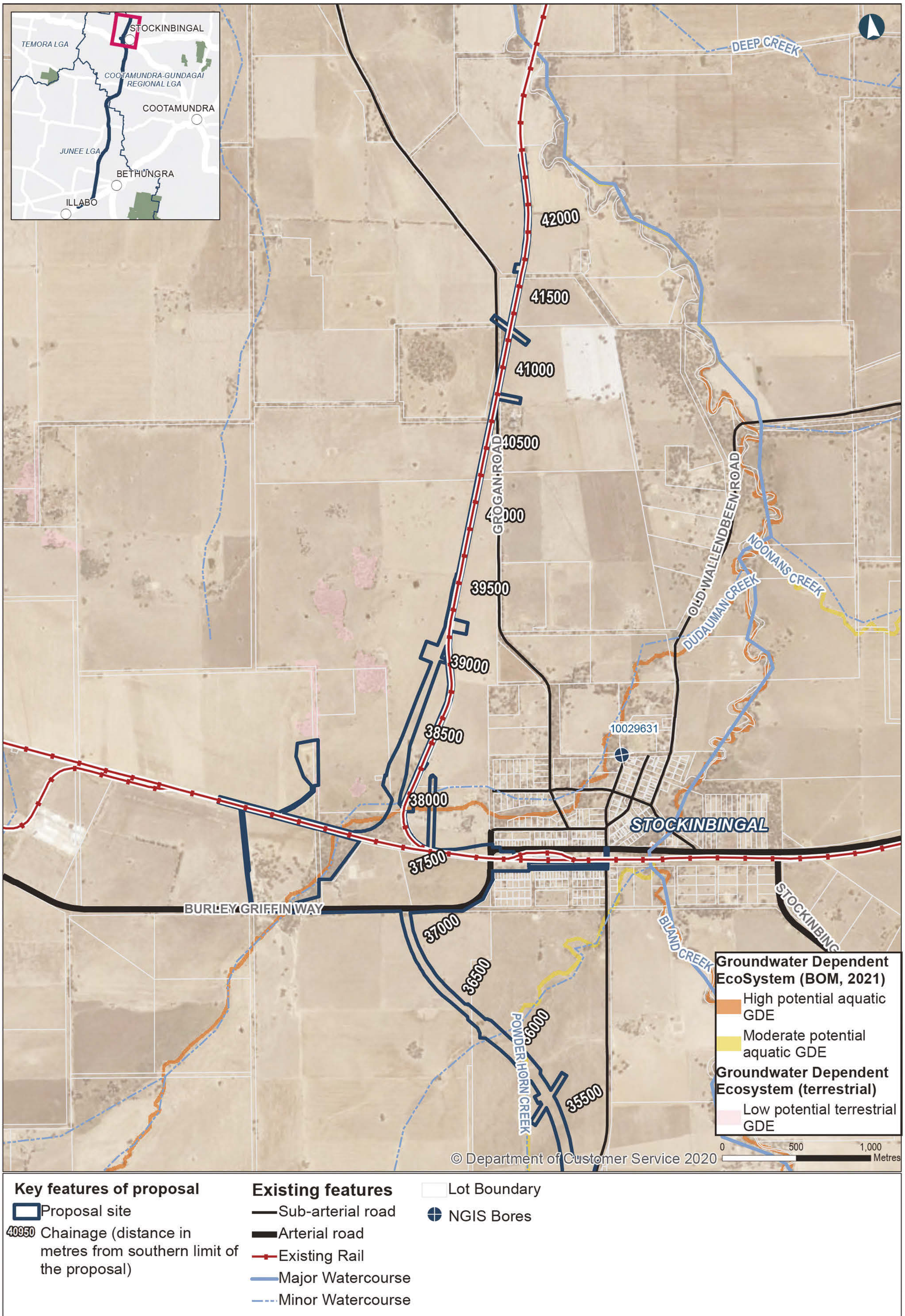

14.2 Location of groundwater depended ecosystems and registered bores

Coordinate System: GDA 1994 MGA Zone 55
Date: 5/19/2021 Paper size: A4 Scale: 1:35,000
MAP 7 of 7

Illabo to Stockinbingal Data Sources: LPI, IRDJV, ARTC

220_0110_EIS_14_2_GDE_r1v1.mxd

14.3.4 Conceptual hydrogeological model

A conceptual hydrogeological model was developed for the study area. Conceptual models are a useful tool that capture the existing hydrological and hydrogeological conditions and illustrate the interaction between the two. The output of the conceptual hydrological model is a water balance which can be used in the assessment of potential impacts.

The following parameters were used in the development of the conceptual hydrological model:

- the catchment area
- groundwater recharge—occurring within the study area as infiltration from rainfall and irrigation, recharge from stream flows into the aquifer, and baseflow of groundwater into the catchment
- groundwater discharge—measured as extraction of groundwater and baseflow of groundwater from the catchment.

A summary of how these parameters were calculated is provided in Table 14-6.

TABLE 14-6: SUMMARY OF PARAMETERS USED IN DEVELOPMENT THE CONCEPTUAL HYDROGEOLOGICAL MODEL

Parameter	HSU	Input
Catchment area	Lachlan Alluvial and Fractured Rock	Approximate catchment area defined from topographic highs using LiDAR data in km^2.
Groundwater recharge (rainfall)	Lachlan Alluvial	2.5% infiltration factor from rainfall data obtained from Eurongilly (BOM Station 73124).
	Fractured Rock	1.0% infiltration factor from rainfall data obtained from Eurongilly (BOM Station 73124).
Groundwater recharge (stream flow)	Lachlan Alluvial	The streams within the catchment are ephemeral and dry (no flow) throughout most of the year. The Wattle Creek flood gauge (gauge 412134), calculated baseflow contribution from the December 2010 flood event has been extrapolated catchment wide and has a 2.5% annual exceedance probability of a similar event occurring.
	Fractured Rock	Negligible contribution assumed from streams due to low connectivity to the primary aquifer (fractured rock). Infiltration from stream to shallow, perched aquifer is subject to evapotranspiration, further reducing contribution to the deeper aquifer.
Groundwater recharge (irrigation)	Lachlan Alluvial and Fractured Rock	An irrigation recharge rate of 30 mm/ha per year. This value includes losses from evapotranspiration. Also, 25% of the catchment area was assumed to be subject to irrigation (dryland crops).
Groundwater baseflow	Lachlan Alluvial	The study area is located within the upper bounds of the regional catchment with negligible baseflow contribution.
	Fractured Rock	Negligible due to the localised controls on groundwater flow within the aquifer (BOM, 2012).
Groundwater discharge (extraction)	Lachlan Alluvial	Negligible volume assumed due to the identification of one registered bore user, listed for household and domestic.
	Fractured Rock	Sum of stock and domestic bore usage volumes, as these bores comprise the primary registered bore category within the study area.
Groundwater discharge (baseflow)	Lachlan Alluvial	Values taken from Stockinbingal, Zone 7 within the Upper Lachlan Groundwater Flow Model (Bilge, 2012).
	Fractured Rock	Negligible due to the localised controls on groundwater flow within the aquifer (BOM, 2012).

14.3.4.1 Water balance

The parameters detailed in Table 14-6 were calculated to determine the water balance for the study area. A summary of the water balance is provided in Table 14-7, with further detail in Chapter 5 of Technical Paper 6.

Both fractured rock and Lachlan Alluvial returned a positive water balance. In relation to the Lachlan Alluvial, the hydrographs in Appendix A of Technical Paper 6, as well as manual dip measurements of groundwater levels presented in Table 14-3, indicate oscillating groundwater levels, likely in response to climatic conditions. These levels would correlate, on average, to a zero change in storage of the groundwater baseflow as indicated in Table 14-7. The water balance and contributing factors would change over time and changes to assigned stream contribution, baseflow and evapotranspiration values would likely account for discrepancies between the observed trends in hydrographs and the calculated values.

In the fractured rock HSU, the identified water balance is dominated by the positive contribution from rainfall infiltration and the negative contribution from pumping of registered bores in the study area. Loss due to pumping would be localised around the registered bores identified in section 14.3.3. In addition, recharge from infiltration would be localised to outcropping rock, which is not present across the entire sub-catchment, resulting in likely exaggerated positive contribution from rainfall infiltration. A lower contribution from rainfall infiltration would have the potential to generate a negative water balance, which would align with the decreasing groundwater level trends observed in some of the fractured rock hydrographs in Appendix A of Technical Paper 6 and manual groundwater dip measurements presented in Table 14-3.

TABLE 14-7: WATER BALANCE FOR THE STUDY AREA

Parameter	Lachlan Alluvial (Lachlan upper and lower slopes)	Fractured Rock (Murrumbidgee)
Catchment area (km^2)	230	320
Groundwater recharge (rainfall) (m^3 per year)	2,928,000	1,629,000
Groundwater recharge (stream flow) (km^2)	501,000	Negligible
Groundwater recharge (irrigation) (m^3 per year)	170	240
Groundwater baseflow (m^3 per year)	0	Negligible
Groundwater discharge (extraction) (m^3 per year)	Negligible	1,444,000
Groundwater discharge (baseflow) (m^3 per year)	2,890,000	Negligible
Water balance (m^3 per year)	+539,170	+185,240

14.4 Impact assessment—construction

There would be significant earthworks associated with construction of the proposal. Principal earthworks would level the alignment to a design grade requiring 46 cuts as well as filling. Construction can impact both the availability and quality of the groundwater. As described in section 14.2.3.2, multiple risks to groundwater were identified during the environmental risk assessment (refer to Appendix G) which related to the following:

- construction dewatering resulting in an unacceptable impact to sensitive receptors
- changes to groundwater flow paths or groundwater discharge impacting surface water and groundwater quality
- changes to soil moisture content causing compression or settlement
- degradation of water quality through the movement of potentially existing contamination plumes within the groundwater environment
- contamination of groundwater from construction activities during the construction phase and maintenance procedures during the operational phase
- changes to groundwater recharge through altering surface infiltration.

14.4.1 Dewatering

No groundwater 'take' for use as construction water supply is proposed. However, groundwater dewatering may occur during construction if excavations (cuts) or piling for bridge foundations intersect with the groundwater table. The removal of the groundwater from its water source and the taking/using of water (even if the take and use is for disposal) may require approval under the WM Act). The construction contractor would be required to apply for a water access licence exemption prior to commencing dewatering activity. The requirements for a water access licence is discussed further in section 3.4.3.6.

All cuts have been assessed for their risk of intersecting groundwater based on the current level of available information, site investigations and conceptualisation. The identified risks are summarised below:

- The groundwater levels within the Lachlan Alluvial HSU was observed to be deeper than cut depths at 7 mBGL (in the alluvial sediments associated with Billabong Creek, chainage ID 750) and 19 mBGL (at Stockinbingal, chainage ID 37,524). Therefore, proposed cuts within the Lachlan Alluvial HSU are not anticipated to intersect the groundwater.
- Proposed cuts within the fractured rock HSU are not expected to intersect the shallow fractured rock aquifer. However, due to the localised topographic influences on the shallow fractured rock HSU, a low risk is still present.
- No proposed cuts are anticipated to intersect the deeper regional fractured rock HSU.
- Depending on final construction methodology for bridge piling, groundwater may be intersected. There is a low risk associated with unexpectedly intersecting the shallow Fractured Rock HSU. However, the groundwater seepage is anticipated to be limited in volume and contained by topographic influences. Due to the expected limited connectivity between the shallow and deeper regional Fractured Rock HSU, the impact on the regional groundwater environment would be limited and low.

The impact to registered users or GDEs due to construction of the proposal is considered to be negligible to low due to no groundwater take anticipated. Figure 14-3 indicates shallow groundwater in BH213, BH215 and BH217, relative to the underlying and inferred water level of the regional fractured rock (deep) aquifer.

BH213 and BH217 exhibit a piezometric effect, where the bores were dry until the depth at which the regional Fractured Rock (deep) aquifer was intersected. The groundwater levels in these bores slowly proceeded to rise to the shallow water level. This relatively shallow water is expected to have a low risk as the proposed cuts are not anticipated to intersect the regional Fractured Rock aquifer. It is noted that BH213 is approximately 220 m off the section alignment and is in the proximity of other dry bores.

The drawdown or decline in groundwater levels associated with the dewatering may pose a risk to groundwater resource availability and quality. The proposed alignment involves 46 cuts, that range from less than 0.1 mBGL to 13.7 mBGL, illustrated in Figure 14-3.

14.4.2 Salinity

Changes to groundwater (and surface water) flow patterns located in areas with saline land would have a higher likelihood and risk of mobilising salts and impacting groundwater quality downgradient. This could cause adverse effects to GDEs where present. Where practical, the proposal has minimised changes to flow paths through multiple realignments. The majority of proposed watercourse crossings are to be designed as pipe and box culverts and will have negligible to low impacts to changes of groundwater levels, flow paths and consequently salt mobilisation (salinity). Within these areas the risk of groundwater quality degradation due to salinity is considered low.

One surface flow diversion has been nominated for the proposal and is located at chainage 16,000 with flows diverted to a culvert at chainage 15,400. There is potentially saline affected soil is on the western side of the rail alignment. However, the surface flow diversion is designed to divert flows to the east. Therefore, there is a low risk that salts may be mobilised within these regions due to the construction of the proposal.

Risk to groundwater salinity changes associated with localised modification to groundwater levels from piling is considered low. Bridge pilings are not anticipated to significantly impact groundwater levels as the majority of piles have been designed with pile diameters less than 900 mm.

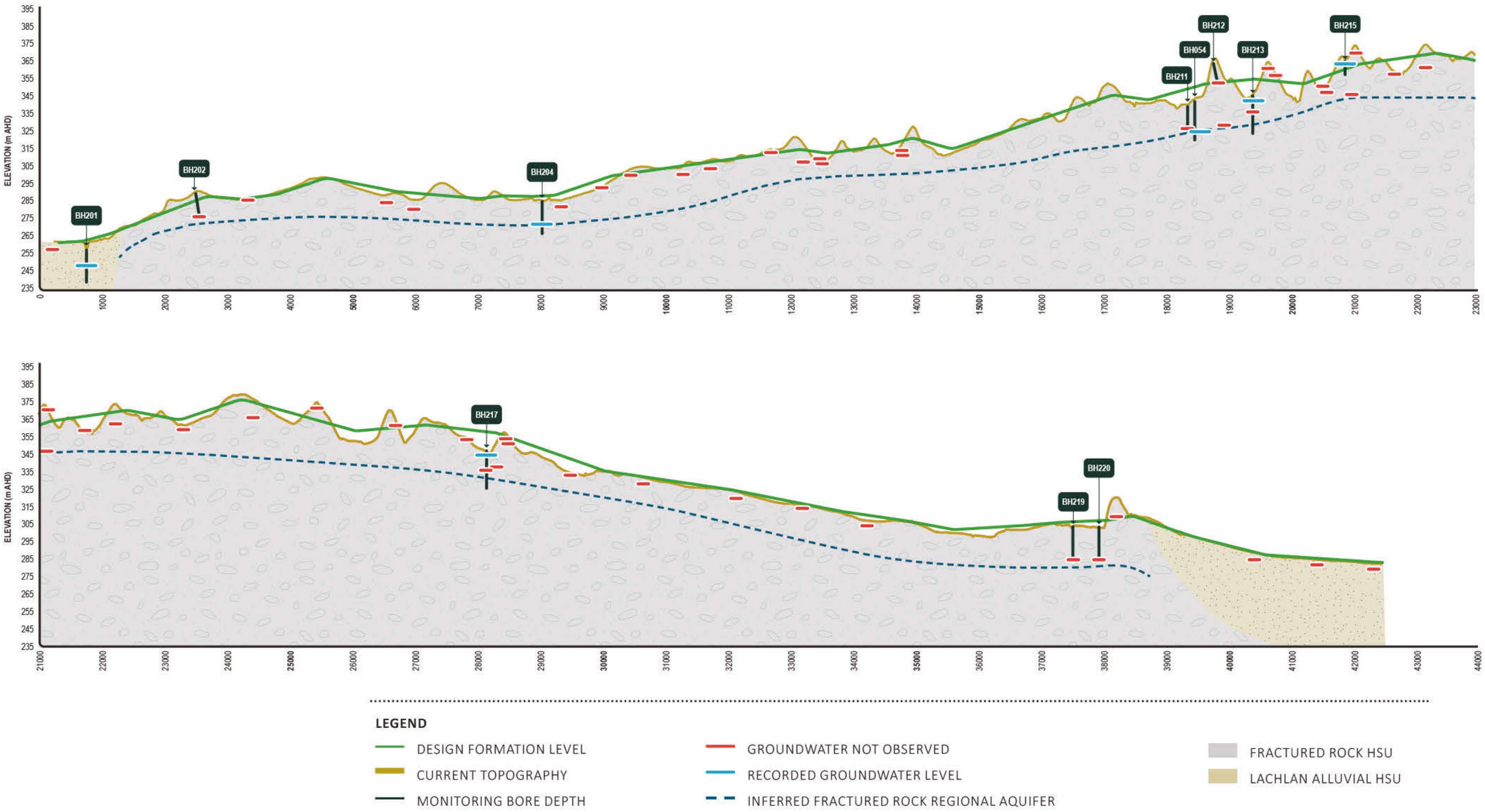

FIGURE 14-3: SIMPLIFIED CROSS-SECTION OF PROPOSED EARTHWORKS DEPICTING CUT LOCATION, DESIGN LEVEL, OBSERVED GROUNDWATER AND INFERRED GROUNDWATER TABLES

14.4.3 Settlement

Settlement occurring due to changes in soil moisture can be a result of groundwater take. As cuts are not anticipated to intersect the regional groundwater table, the risk to settlement is low. Where cuts unexpectedly intersect with groundwater, the soil moisture levels are not expected to change outside of the normal climatic variance, which will be seasonally controlled. If appropriate drainage measures are installed, natural moisture levels of residual clays are unlikely to be permanently altered by the proposal during the construction and operational phase, limiting the risk and impact caused from settlement.

Permanent construction earthworks (embankments) that do not intersect groundwater can also impact groundwater availability by causing settlement or compaction of the underlying sediments. This can alter groundwater conductivity by reducing the permeability of the sediments. This may cause groundwater mounding (on the upslope hydraulic gradient) or groundwater drawdown or 'shadowing' (on the downslope hydraulic gradient side of the embankment). While these potential effects are caused by the construction of the proposal, the impacts tend to eventuate in the medium to long term, typically during the operational phase of the proposal.

14.4.4 Contamination

Construction of the proposal includes the storage of hazardous materials and chemicals. These substances, including waste-water discharge, can potentially interact with the groundwater through surface infiltration. The impact from hazardous chemicals (e.g. fuel) that may leach through surface infiltration during construction may be significant depending on the quantity and type of contaminate involved.

Contamination may also be encountered during construction. Areas of contamination have not been identified within the proposal site as discussed in Chapter 20: Soils and contamination. The migration of contamination to groundwater is considered low risk as potential sources of contamination are minor and surface related.

The presence of reactive natural soils that may undergo changes to its chemical composition because of construction activities (e.g. presence of acid sulfate soils or soil aggressivity) is considered to be low.

14.4.5 Groundwater recharge

Changes to surface infiltration (groundwater recharge), evaporation or evapotranspiration due to alteration of the existing sealed surfaces, vegetation coverage or topography can either increase or reduce groundwater availability temporarily or permanently. The proposal is not expected to result in significant change to these parameters during construction, and the overall change in surface infiltration is considered to be low. The proposal would also not result in significant changes to surface water flows, which would cause significant impacts to groundwater recharge.

Reduced groundwater flow arising from aquifer compression can occur due to site filling and soil stabilisation earthworks and change in the hydraulic conductivity of the natural soils. This process can alter groundwater flow, potentially leading to increased groundwater availability on the high, up gradient slope due to groundwater 'mounding'. While commencing during construction, these processes are typically considered medium- to long-term as groundwater systems take time to re-equilibrate to altered groundwater conditions. As such, changes to the groundwater environment often occur during the operational phase as discussed in section 14.5.4. The risk of impacts from construction filling activities is considered to be negligible due to compressibility characteristics of soils, degree of fill and identified non-cohesive bands (housing primary flow within alluvial).

14.5 Impact assessment—operation

Operation of the proposal has the potential to impact to impact groundwater quality. Impacts to groundwater availability are not anticipated during operation of the proposal as groundwater take (dewatering) is not proposed during operation. As described in section 14.2.3.2, multiple risks to groundwater were identified during the environmental risk assessment (refer to Appendix G) that related to operation as well, including:

- changes to groundwater flow paths, including groundwater flow barriers or groundwater discharge may mobile salts and impact surface water and groundwater quality
- changes to groundwater levels and quality resulting from salinity can impact sensitive receptors such as registered bores and GDEs
- changes to soil moisture content causing compression or settlement
- degradation of water quality through the introduction of new contaminants or the movement of potentially existing contamination plumes within the groundwater environment

- changes to groundwater recharge through altering surface infiltration, degree of evapotranspiration and groundwater seepage dewatering along the high wall of cuts leading to changes in groundwater availability for sensitive receptors, including GDEs.

14.5.1 Salinity

No additional drainage works or piling following construction are proposed and groundwater take is not proposed during operation. The risk and impact of mobilising salts that may cause an increase in groundwater salinity remains low.

14.5.2 Settlement

Whilst the risk and impact of settlement due to dewatering typically eventuates overtime and would become more prominent during the operation of the proposal, the risk and impact remains low.

14.5.3 Contamination

Changes to groundwater quality can still occur during operation through possible contamination due to spills and leaks from maintenance activities, however the impact would be negligible. Risk to groundwater from contamination is discussed further in Chapter 20: Soils and contamination.

14.5.4 Groundwater recharge and dewatering

The operation of the proposal has a low risk of impacting groundwater recharge and through seepage dewatering of cuts. Operation of the proposal may result in a minor reduction to surface infiltration and potential groundwater seepage dewatering from cuts. However, this change would be negligible over the catchment area.

14.5.5 Performance against NSW Aquifer Interference Policy

As stated in section 14.2.1, the AIP includes minimal impact considerations for assessing the impacts of all aquifer interference activities. NSW groundwater sources need to be categorised as being either highly productive or less productive, based on the general character of the water source meeting or not meeting the criteria of 1,500 mg/L total dissolved solids and a bore yield rate of greater than 5 L/s. This categorisation applies to a whole groundwater source as it is defined in a water sharing plan, not to the specific groundwater conditions at a specific location. The groundwater resources within the study area identified within this report are considered less productive due to their respective water quality and expected typical yield rates.

Further information on impact to the potential changes in groundwater levels and quality on GDEs, beneficial use category, water supply works (i.e. registered bores), highly connected surface water source and culturally significant sites is in Chapter 6 of Technical Paper 6.

Potential impacts to the groundwater environment as a result of the construction and operational phase of the proposal are presented in sections 14.4 and 14.5. The assessment concludes that there would be negligible to low due to no risk to groundwater environment.

The assessment of the proposals impacts on aquifers and GDEs in regard to the minimal impact considerations of the AIP indicates the proposal complies with Level 1 criteria, which considers the potential impacts as acceptable.

14.6 Mitigation and management

14.6.1 Approach to mitigation and management

To date, ARTC has, where possible, designed the proposal to avoid and minimise environmental impacts in the proposal planning stage, and a range of strategies have been included in the proposal to mitigate the impact on groundwater resources. This process would continue and consideration would be given to further refinements during detailed design, where possible, to minimise groundwater impacts.

The assessment identified that the proposal would be unlikely impact on groundwater resources due to the depth of excavations. There is a low risk associated with unexpectedly intersecting the shallow Fractured Rock HSU.

During operation, impacts to groundwater would be expected to be negligible with groundwater conditions expected to return to the existing conditions soon after construction is completed.

14.6.1.1 Approach to managing the key potential impacts identified

The potential for groundwater impacts would be managed in accordance with a groundwater management sub-plan, prepared as part of the Construction Environmental Management Plan (CEMP) and an operational environmental management framework (EMF) for the proposal. The groundwater management sub-plan will detail the processes and responsibilities to manage potential groundwater impacts and monitor the effectiveness of mitigation and management measures during construction and operation of the proposal.

As construction activities have the potential to increase the occurrence of contaminants infiltrating to groundwater a groundwater monitoring program would be implemented. This would monitor the impacts of the proposal on existing groundwater levels, confirm consistency with the predicted impacts identified and allow additional management measures to be implemented.

14.6.1.2 Approach to managing other potential impacts

Consideration of construction methodologies for piling implementation of environmental controls are key methods of addressing other potential impacts to groundwater. For impacts from circumstances such as spills and leaks, establishing drainage and removal of groundwater bores, relevant measures provided in section 14.6.4 would be implemented.

14.6.2 Expected effectiveness

Provided the mitigation measures are implemented accordingly, the proposal poses a negligible to low risk of impacting the groundwater environment. Implementing a groundwater monitoring program prior to, during and following construction, would confirm the effectiveness of mitigation measures. The results would provide information to drive further development of additional or improved measures to ensure that impacts are appropriately managed.

14.6.3 Interaction between mitigation measures

Mitigation measures proposed to minimise the potential impacts to groundwater and other water sources may overlap with mitigation measures recommended in other chapters of the EIS (Chapter 12: Hydrology and flooding, Chapter 13: Water quality and Chapter 20: Soils and contamination). The recommended mitigation measures from these chapters would be consolidated and described in the CEMP to integrate common impacts and mitigations measures identified and ensure consistency.

14.6.4 Recommended mitigation measures

The mitigation measures to manage impacts to groundwater from the proposal during detailed design/pre-construction, construction and operation phases are outlined in Table 14-8.

TABLE 14-8: MITIGATION MEASURES

Ref	Impact	Mitigation measures	Timing
GW-1	Management of groundwater bores	Any bores that are decommissioned will be undertaken in accordance with the *Minimum Construction Requirements for Water Bores in Australia—Edition 4* (National Uniform Drillers Licensing Committee (NUDLC), 2020).	Detailed design/ pre-construction
GW-2	Management of groundwater bores	Any existing groundwater bores that are destroyed during construction would be replaced subject to discussion with the registered owner.	Detailed design/ pre-construction
GW-3	Avoid or minimise groundwater seepage	Appropriate drainage measures would be installed at the base of cuts and along high-walls to manage groundwater seepage, in the unlikely event that they be encountered.	Detailed design/ pre-construction

Ref	Impact	Mitigation measures	Timing
GW-4	Groundwater management	A groundwater mitigation and management plan (GWMMP) would be prepared as part of the CEMP. The GWMMP would comply with the proposal conditions of approval and be implemented to monitor the effectiveness of mitigation and management measures applied during the construction phase of the proposal. The GWMMP would at a minimum: - provide details of the groundwater monitoring network, frequency of monitoring, and test parameters - be based on baseline studies developed for the proposal and establish baseline monitoring reports - contain procedures for the documentation and reporting of results - include requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction.	Construction
GW-5	Monitoring groundwater drawdown and quality	A groundwater monitoring program would be developed and implemented as part of the GWMMP to monitor potential groundwater impacts. The program would define the following: - monitoring parameters - monitoring locations - frequency and duration of monitoring. The monitoring program would include baseline monitoring to determine the water quality of groundwater from the proposed bore field bores.	Construction
GW-6	Unforeseen water table penetration by earthworks	If excavations intersect the water table, potential impacts would be assessed by a hydrogeologist and adaptive management measures implemented as required.	Construction
GW-7	Management of groundwater seepage	Drainage measures would be maintained where required to manage ongoing groundwater seepage during operation.	Operation

14.6.5 Managing residual impacts

Provided the mitigation measures are implemented accordingly, the proposal poses a negligible to low risk of impacting the groundwater environment as identified in the risk assessment in Table 14-9.

The key potential groundwater impacts originally identified by the environmental risk assessment (refer to Appendix G) are listed in Table 14-9. The (pre-mitigation) risks associated with these impacts, which were identified by the environmental risk assessment, are provided. Further information on the approach to the environmental risk assessment, including descriptions of criteria and risk ratings, is provided in Appendix G.

The potential issues and impacts identified by the environmental risk assessment were considered as part of the water quality impact assessment, summarised in Table 14-1. The mitigation and management measures (listed in Table 14-9) that would be applied to manage these impacts are also identified. The significance of potential residual impacts (after application of these mitigation measures) is rated using the same approach as the original environmental risk assessment.

Provided the mitigation measures are implemented, the proposal poses a negligible to low risk of impacting groundwater as identified by the risk assessment in Table 14-9.

TABLE 14-9: RESIDUAL IMPACT ASSESSMENT—GROUNDWATER

Phase	Potential impacts	Pre-mitigated risk			Mitigation measures (refer to Table 14-8)	Residual risk			How residual impacts would be managed
		Likelihood	Consequence	Risk rating		Likelihood	Consequence	Risk rating	
Construction	Extraction of groundwater may cause drawdown of the groundwater table, impacting sub-surface flows and water availability.	Possible	Major	High	GW-4 to GW-5, HF-4	Unlikely	Moderate	Low	n/a
	Potential for bulk excavations to intersect the water table and lead to groundwater level drawdown, impacting nearby groundwater bores, groundwater dependent ecosystems, and watercourse base flow.	Possible	Moderate	Medium	GW-1 to GW-7	Unlikely	Minor	Low	n/a
	Changes to soil moisture content causing compression or settlement.	Possible	Major	High	GW-1 to GW-6, WQ-3	Rare	Moderate	Low	n/a