CHAPTER 15

Groundwater

BORDER TO GOWRIE REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT

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15. Groundwater

15.1 Scope of chapter

This chapter describes the groundwater components of the Inland Rail—Border to Gowrie Project (the Project) with the purpose of objective of ensuring the Project is planned, constructed and operated in a manner that protects environmental values of groundwater. This chapter describes the existing environment, potential impacts associated with groundwater resources and those reliant on groundwater resources, and mitigation measures associated with the Project.

This chapter addresses the 'Groundwater' section of the Terms of Reference (ToR), inclusive of ToR items 11.36 to 11.63 and was updated in accordance with additional information requested by the Coordinator-General following the public notification of the draft Environmental Impact Statement (EIS) in 2021. Appendix A2: Terms of Reference Cross-reference Table provides a cross reference for each ToR against relevant sections in the revised draft Environmental Impact Statement (EIS).

The key objectives of this groundwater assessment are to:

- Identify and describe the existing groundwater resources, users, values, and conditions within the groundwater impact assessment area
- Identify and assess potential Project impacts on groundwater environmental values (EVs)
- Identify required mitigation measures
- Evaluate the significance of residual impacts on groundwater following mitigation
- Ensure potential cumulative impacts on groundwater resources are appropriately considered and managed.

This chapter should be read in conjunction with the following technical appendices to the revised draft EIS, where more detailed information is provided:

- Appendix U: Groundwater Technical Report

15.2 Regulatory environment

A summary of the groundwater-related policies and plans that are of relevance to the Project and this assessment are included in Table 15-1.

Legislation of relevance with respect to this groundwater assessment comprises the:

- *Water Act 2007* (Cth)
- *Water Act 2000* (Qld) (Water Act)
- *Environmental Protection Act 1994 (Qld)* (EP Act)
- *Acquisition of Land Act 1967* (Qld).

The relevance of these items of legislation and the Project's compliance with each is discussed in Chapter 3: Legislation and Project Approvals Process.

TABLE 15-1 SUMMARY OF REGULATORY CONTEXT

Regulatory context	Relevance to the Project
Commonwealth	
Basin Plan 2012	The *Basin Plan 2012* is a Commonwealth instrument, made under the *Water Act 2007* (Cth), that provides a framework to manage the water resources of the Murray–Darling Basin, and sets out limits for sustainable use of surface water and groundwater in each water resource plan area. The groundwater impact assessment area is located within the Condamine Balonne (groundwater unit GW21) and the Queensland Border Rivers Moonie (groundwater unit GW19) water resource plan area.

Regulatory context	Relevance to the Project
State	
Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity))	Under the EP Act, the EPP (Water and Wetland Biodiversity) achieves the objectives of the Act in relation to Queensland waters. This policy provides: - Identification of EVs and management goals for Queensland groundwaters - Identification of State water quality guidelines and water quality objectives (WQOs) to enhance or protect the EVs. Groundwater resources within the groundwater impact assessment area occur within the *Queensland Murray-Darling and Bulloo River Basins – Groundwater Environmental Values and Water Quality Objectives* (Department of Environment and Science (DES), 2020e) under Schedule 1 of the EPP (Water and Wetland Biodiversity). These basins are: - Queensland Border Rivers catchment from Chainage (Ch) 30.6 kilometres (km) (North Star to NSW/QLD Border (NS2B)) to Ch 116.5 km - Condamine River Basin from Ch 116.5 km to Ch 208.2 km.
Other	
Healthy Waters Management Plans (HWMPs)	HWMPs are a key mechanism to improve the quality of Queensland waters under the EPP (Water and Wetland Biodiversity). HWMPs provide an ecosystem-based approach to integrated water management. In addition to meeting requirements under the EPP (Water and Wetland Biodiversity), the HWMPs have also been prepared to meet requirements of a Water Quality Management Plan under the *Basin Plan 2012*. The HWMPs provide: - Identification and mapping of EVs, desired levels of aquatic ecosystem protection and management goals for Queensland waters - WQOs under the *National Water Quality Management Strategy* (Environment Protection and Heritage Council, 2009) to protect the EVs. The HWMPs/Water Quality Management Plans apply to the surface waters (including lakes and wetlands) and groundwaters across the following river basins (and HWMPs) of relevance to the Project: - Ch 30.6 km (NS2B) to Ch 116.5 km: within the boundaries of the Border Rivers catchment. The relevant EVs for the groundwater impact assessment area are described in the *Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins* (DES, 2019a) - Ch 116.5 km to Ch 208.2 km: within the boundaries of the Condamine–Balonne River catchment. The relevant EVs for the groundwater impact assessment area are described in the *Healthy Waters Management Plan: Condamine River Basin* (DES, 2019b).

Water plans	Water plans were developed under the Water Act to sustainably manage and allocate water resources in Queensland. The plans apply to water in watercourses and lakes, water in springs, overland flow water, and groundwater, and allow for identification of availability of water options for Project uses.
	Three water plans are relevant to the Project:
	- Water Plan (Border Rivers and Moonie) 2019
	- Water Plan (Condamine and Balonne) 2019
	- Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017 (Water Plan (GABORA) 2017).
	These plans specifically apply to the following groundwater units located within the groundwater impact assessment area:
	- Sediments above the Great Artesian Basin (GAB):
	  - Border Rivers Alluvium—Water Plan (Border Rivers and Moonie) 2019
	  - Central Condamine Alluvium—Water Plan (Condamine and Balonne) 2019
	  - Toowoomba City Basalts (Main Range Volcanics (MRV))—Water Plan (Condamine and Balonne) 2019.
	- Sediments of the GAB—Water Plan (GABORA) 2017:
	  - Kumbarilla Beds
	  - Walloon Coal Measures (WCM).

Regulatory context	Relevance to the Project
Water guidelines	Various water guidelines were applied in assessing EVs, WQOs and potential impacts. These include: ▸ *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Governments, 2018) ▸ *Australian Drinking Water Guidelines* (National Health and Medical Research Council (NHMRC) and National Resource Management Ministerial Council (NRMMC), 2011) ▸ Water—EIS information guideline, ESR/2020/5312 (DES, 2022g) ▸ *Queensland Water Quality Guidelines 2009* (Department of Environment, Heritage and Protection, 2009) ▸ *Monitoring and Sampling Manual* (DES, 2018b).

15.3 Methodology

15.3.1 Groundwater impact assessment area

The groundwater impact assessment area is generally defined as the area within a 1 km distance from the centreline of the Project alignment, in the first instance, as is industry-standard practice for a significance assessment. The depth of interest to identify potential impact on groundwater resources for the Project is 90 metres (m) below ground level (BGL). The depth of interest was adopted based on the depth of the deepest design excavation being 21 m BGL and the deepest aquifer with potential to be intersected by Project, the WCM. The maximum screened depth of a registered bore targeting the WCM within the groundwater impact assessment area is ~90 m BGL.

In some instances, where appropriate data to inform a particular value was unavailable within the 1 km distance, the impact assessment area was increased to account for a 5 km distance to appropriately characterise certain EVs. For example, an impact assessment area of 5 km distance from the rail centreline was adopted to inform potential groundwater dependent ecosystems (GDEs) that could be impacted by the Project as a conservative approach for ecosystems that can potentially source groundwater (and potential Project impacts) beyond the 1 km radius. Where an expansion of the groundwater impact assessment area was required to assess EVs (e.g. GDEs), this expansion is stated in the relevant EV discussions defined within Section 15.5.7.

The permanent Project footprint is wholly within the groundwater impact assessment area. The Project footprint consists of the permanent footprint, which encompasses all permanent infrastructure required for the Project, and the temporary footprint, which encompasses all land including any groundwater bores, that is temporarily required to enable construction of the Project.

The groundwater impact assessment area and Project location are presented on Figure 15-1.

15.3.2 Assessment methodology

A staged approach has been adopted for the groundwater impact assessment for the Project based on the DES 2022 guideline. Stages adopted for the groundwater study include:

- Stage 1—Desktop study
- Stage 2—Hydrogeological investigations
- Stage 3—Groundwater impact assessment
- Stage 4—Significance assessment.

The significance assessment herein should be updated should any fundamental design changes be needed. The mitigation measures defined in this chapter should be assessed against any change in the updated significance assessment outcomes, as warranted, to maintain and protect groundwater EVs.

15.3.2.1 Desktop study

Available geological and hydrogeological literature and site data were reviewed to establish a detailed description of the current hydrogeological regime and identification of groundwater EVs. Interrogation of publicly available databases, including the Department of Regional Development, Manufacturing and Water (DRDMW) groundwater database and water entitlements database. The databases provide bore construction and lithology information on registered groundwater bores and licenced groundwater extraction within the impact assessment area. Published studies and reports of relevance were also reviewed to further inform the understanding of regional geological and hydrogeological characteristics. Data sources accessed for this assessment are described below.

15.3.2.2 Data sources

The groundwater impact assessment has been developed using the information sources listed in Table 15-2.

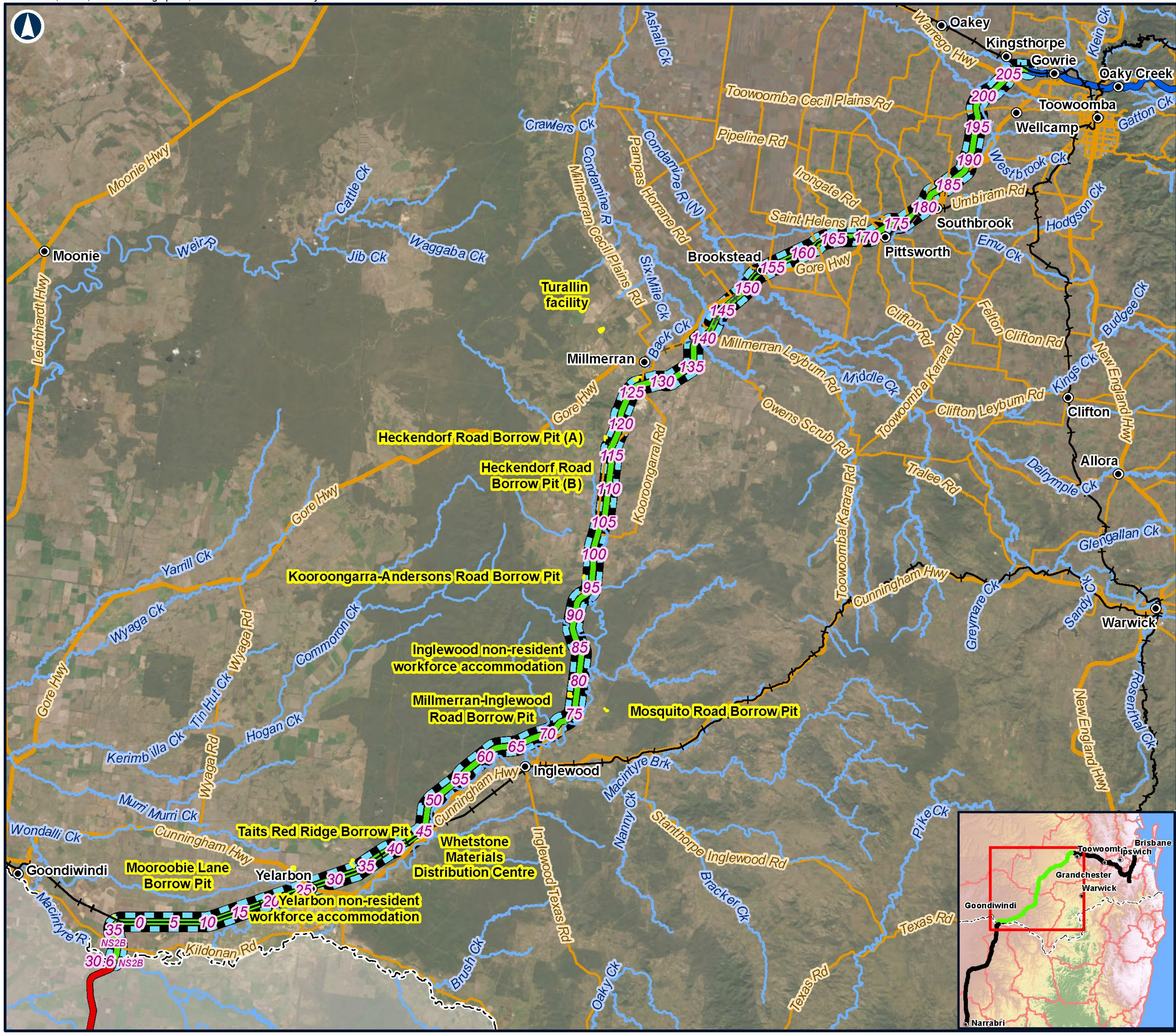
TABLE 15-2 DATA SOURCES REFERENCED FOR THE GROUNDWATER IMPACT ASSESSMENT

Data	Source

Hydrology/climate	▸ Historical Climate Database—Bureau of Meteorology (BoM) (bom.gov.au/climate/data)
	  ▸ Station 041047 – Inglewood Post Office
	  ▸ Station 041504 – Glen Royal
	  ▸ Station 041525 – Warwick
	▸ Queensland Globe datasets (qldglobe.information.qld.gov.au)
	▸ Chapter 13: Surface Water
	▸ Appendix T1: Hydrology and Flooding Technical Report – Volume 1.

Soil types	▸ *Inland Rail: Phase 2 –NSW/QLD Border to Gowrie; Geotechnical Interpretive Report* (Future Freight Joint Venture (FFJV), 2019) ▸ *Inland Rail: Phase 2 - North Star to NSW/QLD Border; Geotechnical Interpretive Report* (FFJV, 2020) ▸ Chapter 9: Land Resources ▸ Appendix J: Soil Assessment Report ▸ Queensland Globe datasets (qldglobe.information.qld.gov.au) ▸ Australian Soil Resource Information System (ASRIS) 'Atlas of Australian Soils' (**asris.csiro.au/mapping/viewer.htm**) (Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2014a).
Geology/ hydrostratigraphy	▸ *Inland Rail: Phase 2 – NSW/QLD Border to Gowrie; Geotechnical Interpretive Report* (FFJV, 2019) ▸ *Inland Rail: Geotechnical Factual Report – Border to Gowrie Section* (Golder, 2019a) ▸ *Inland Rail: Condamine River Valley Geotechnical Investigation – Factual Report, Inland Rail Project – Border to Gowrie Section* (Golder, 2019b) ▸ *Inland Rail: Border to Gowrie – 100% Feasibility Design Scope of Works – Hydrogeology* (Golder, 2019c) ▸ *Inland Rail – North Star to Border Section – Geotechnical Factual Report* (Golder, 2019d) ▸ *Inland Rail: Phase 2 – North Star to NSW/QLD Border; Geotechnical Interpretive Report* (FFJV, 2020) ▸ *Goondiwindi 1:250,000 Geological Sheet* (Mond, et al., 1972) ▸ DRDMW Groundwater Database ▸ Queensland Globe geological map datasets (qldglobe.information.qld.gov.au) ▸ *Groundwater connectivity between the Condamine Alluvium and the Walloon Coal Measures – A hydrogeological investigation report* (Department of Natural Resources and Mines (DNRM), 2016b). ▸ *Hydrogeological conceptualisation report for the Surat Cumulative Management Area* (DNRM, 2016c).
Groundwater levels and quality	▸ DRDMW Groundwater Database ▸ Queensland Globe datasets (qldglobe.information.qld.gov.au) ▸ *Inland Rail: Border to Gowrie; 100% Feasibility Design Scope of Works – Hydrogeology* (Golder, 2019c) ▸ *Inland Rail: Section 270 (North Star to Border), 100% Feasibility Design Scope of Works – Hydrogeology* (Golder, 2019e) ▸ *Inland Rail – Border to Gowrie – Project Groundwater Bore Visit and Data Collection Factual Memo* (FFJV, 2021) ▸ Inland Rail: Border to Gowrie – Ongoing baseline groundwater monitoring (in progress).
GDEs	▸ *Groundwater Dependent Ecosystems Atlas* (bom.gov.au/water/groundwater/gde/map.shtml) (BoM, 2022b) ▸ Queensland Globe datasets (qldglobe.information.qld.gov.au) ▸ Appendix L: Terrestrial and Aquatic Ecology Technical Report.
Groundwater use and management	▸ DRDMW Groundwater Database ▸ Water Plan (Border Rivers and Moonie) 2019 ▸ Water Plan (Condamine and Balonne) 2019 ▸ Water Plan (GABORA) 2017.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

BORDER TO GOWRIE

Figure 15-1: Location overview

LEGEND

- 5 Chainage (km)
- Localities
- North Star to NSW/QLD border
- Border to Gowrie
- Gowrie to Helidon
- Existing rail (operational)
- Existing rail (non-
- Major roads
- Minor roads
- NSW/QLD border
- Watercourses
- Borrow Pit (Temporary
- Groundwater impact assessment

Impact assessment

- Project footprint

0 20 40 km

Coordinate System: GDA 1994 MGA Zone 56

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Date: 08/01/2025 Paper: A4
Author: FFJV GIS Scale: 1:800,000
Data Sources: FFJV

Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Figure_15-1_Location_Overview_v3.mxd Date: 21/01/2025 17:07

15.3.2.3 Hydrogeological investigations

Data obtained during the Project geotechnical investigations and subsequent baseline groundwater investigations, undertaken between May 2018 and March 2022, were used to inform the assessment.

Direct impacts on groundwater resources by new freight rail infrastructure are typically associated with construction activities that intersect shallow groundwater resources, such as locations of deep cuts and bridge piling works. Project monitoring bores were primarily located near proposed bridge structures and deep cuts, defined as greater than (>) 10 m BGL, during the initial Reference Design stage. These locations have been reviewed and assessed against the revised reference design. Impacts on groundwater resources as a result of operation of the Project are not expected to occur.

The scope and findings of the groundwater investigations are discussed in Section 15.4.

15.3.2.4 Groundwater impact assessment

Potential impacts of Project construction and operation on the existing groundwater regime, at local and regional scales, were identified and assessed based on a review of planned Project activities with respect to the current geological and hydrogeological environment.

Two-dimensional (2-D) cross-sectional models were developed for deep cuts (> 10 m) in the revised reference design to assess potential impacts on groundwater resources from interception. The predictive modelling was used to inform the Project in terms of potential seepage rates into cut and the local drawdown of that groundwater unit. Modelling results were reviewed and interpreted to assess potential impacts on groundwater resources, users and determine the need for secondary approvals (i.e. water licence).

A discussion of the revised modelling results is provided in Section 15.6.2.

15.3.2.5 Significance assessment

The significance of potential impacts on groundwater resources and users has been assessed using a qualitative risk-based approach. The significance of an impact depends on the sensitivity of the groundwater EVs (i.e. the quality of the environment to be impacted) and the magnitude (i.e. intensity, duration and spatial extent) of the potential impact. Risks were assessed and ranked with and without mitigation, for construction works and operations stages of the Project.

Chapter 4: Assessment Methodology provides further details.

15.4 Hydrogeological investigations

Geotechnical and hydrogeological investigations have been undertaken within and adjacent to the Project footprint to inform the Project's revised reference design and the revised draft EIS.

Project-monitoring bores were primarily located near proposed design features with potential to impact on the shallow groundwater resources, primarily deep cuts (defined for the Project as >10 m BGL) and large embankments proposed to be constructed on compressive geology, and the proximity of any potential sensitive receptors.

The site-based groundwater investigative works have been ongoing from 2018 into 2023, and comprise:

- Two campaigns for the drilling and installation of monitoring bores to align with the evolution of the revised reference design
- Aquifer permeability tests
- Groundwater level monitoring
- Groundwater quality monitoring.

The Project groundwater investigation works completed to date and proposed future groundwater monitoring works are presented in Sections 15.4.1 to 15.4.4. The results of these investigations have been utilised to develop this revised draft EIS.

15.4.1 Groundwater monitoring bore installation 2018

The 2018 groundwater monitoring program was developed to inform potential impacts of the feasibility reference design on groundwater resources and development of the draft EIS. The site-specific investigations included:

- Installation of 34 Project groundwater-monitoring bores where the Project had greatest potential to interface with groundwater
- Hydraulic aquifer tests (falling head test or rising head test) in groundwater monitoring bores
- Groundwater level monitoring
- Groundwater quality sampling
- Laboratory analysis and data assessment.

15.4.1.1 Monitoring bore installation campaign 2018

Drilling and installation of groundwater monitoring bores in 2018 was conducted in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (Edition 3) (National Uniform Drillers Licensing Committee, (NUDLC), 2012). In each instance, the groundwater monitoring bore was designed by a qualified hydrogeologist, with installation conducted by the drilling contractor under the supervision of a qualified field engineer and licenced water bore driller.

Completed groundwater monitoring bores were developed by purging via either manual bailing or with a 12-volt Twister groundwater pump. Bore development was completed per the *Minimum Construction Requirements for Water Bores in Australia* (Edition 3) (NUDLC, 2012).

Field parameters for groundwater quality were monitored during bore development to quantify when drilling influences had been removed from the bore and quality was representative of aquifer stabilisation; or the bore was purged dry.

15.4.1.2 Permeability testing

In- situ hydraulic tests for aquifer permeability were conducted using the variable head 'slug test' method. Slug tests involve inducing a marked and measurable change in groundwater level within the bore by inserting (falling head) and then removing (rising head) a solid slug, or by sudden displacement of the water column in the casing using a gas slug, while measuring the water level response over time. In each instance, water level recovery was monitored until it returned to 90 per cent of the pre-test water level, as is industry standard practice. The recorded data allows for an estimation of hydraulic conductivity of the bore's screened material.

The hydraulic conductivity estimates thus derived are presented in Table 15-5 and discussed for each of the relevant aquifer units in Section 15.5.5.

15.4.1.3 Groundwater level monitoring

Dedicated automatic water level pressure transducers (data loggers) were installed in groundwater monitoring bores, with sufficient water, for continuous groundwater level monitoring. The loggers record a pressure measurement once an hour and are checked (calibrated) against manual static water level (SWL) measurements (gauging) collected as a part of site-specific groundwater monitoring events. Monitoring bores were manually gauged using an oil-water interface meter to determine the depth to groundwater (SWL), and tag lines were used to measure the total well depth at the time of logger installation. The groundwater level data obtained is presented in Table 15-5 and discussed for each of the relevant aquifer units in Section 15.5.5.

15.4.1.4 Groundwater quality monitoring

After the bores were installed and developed in 2018, a groundwater monitoring event was performed, and quality samples collected in accordance with the *Monitoring and Sampling Manual* (DES, 2018b), where there was sufficient water available to do so. The groundwater quality data obtained after drilling is presented in Table 15-4 and discussed for each of the relevant aquifer units in Section 15.5.5.

15.4.2 Baseline groundwater monitoring events 2018 to 2022

Since the Project-monitoring bores were installed in 2018, groundwater monitoring has been ongoing in accordance with the *Monitoring and Sampling Manual* (DES, 2018b) with the objective to ultimately develop a baseline dataset that can be utilised, in accordance with the *Using monitoring data to assess groundwater quality and potential environmental impacts guideline* (DES, 2021a), to identify potential impacts on groundwater EVs during the construction and operation of the Project.

Ten baseline site-specific monitoring events were undertaken between October 2018 and April 2022. The outcomes of which have been utilised to inform ambient groundwater conditions for each of the key aquifers that underlie the Project, and this revised draft EIS. Further, this data was assessed against the revised reference design to identify knowledge gaps in the monitoring network for future Project stages including informing the 2023 groundwater monitoring bore campaign in Section 15.4.3.

A summary of baseline groundwater monitoring events completed for each Project bore is provided in Table 15-3. The details of timing and climatic conditions of the bores considered in this revised draft EIS is provided in Table 15-4. Corresponding laboratory reports are provided in Appendix U: Groundwater Technical Report (Appendix B).

15.4.2.1 Groundwater level monitoring

The groundwater data loggers installed in bores after construction in 2018 were downloaded as a part of each site-specific monitoring event. The depth to water was measured manually in all groundwater monitoring bores visited; the manual measurements are used to calibrate the data loggers. A hydrograph was developed for all bores with a record of groundwater level measurements over time. The hydrographs are included and discussed in the relevant aquifers in Section 15.5.5.

15.4.2.2 Groundwater quality monitoring

Groundwater samples were procured from monitoring bores via the Hydrasleeve™ passive sampling technique. Field physicochemical parameters were measured and recorded including pH, dissolved oxygen, oxygen reduction potential, electrical conductivity (EC), and temperature. Groundwater quality samples were collected into laboratory supplied pre-preserved bottles and stored on ice in an insulated cooler box while onsite and in transit to a National Association of Testing Authorities (NATA) accredited laboratory for analyses.

15.4.2.3 Laboratory analyses of groundwater samples

All primary groundwater samples were submitted under chain of custody documentation to Australian Laboratory Services Brisbane, a NATA-accredited laboratory. Bore locations and sampling comments are detailed in Table 15-3. Inter-laboratory triplicate samples were sent to Eurofins Brisbane (a NATA accredited laboratory) under chain of custody documentation for analyses. Collected groundwater samples were analysed for, and corresponding results are discussed, in Section 15.5.5.5.

Samples submitted for analyses for quality control purposes include:

- Intra-laboratory duplicate sample (1 in 20 primary samples)
- Inter-laboratory triplicate sample (1 in 20 primary samples)
- Equipment rinsate (one per sampling round)
- Field blank (one per workorder).

All groundwater samples were laboratory analysed for the chemical analytes as follows:

- Major anions and cations: calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), fluoride (F^{-}), sulfate (SO_4^{2-}), carbonate and bicarbonate alkalinity and hardness
- pH
- EC
- Total dissolved solids (TDS)
- Total and dissolved metals: arsenic, boron, barium, beryllium, cadmium, chromium, cobalt, copper, manganese, iron, nickel, lead, selenium, vanadium, zinc, and mercury
- Nutrients: nitrate, nitrite, ammonia, reactive phosphorous (P), total nitrogen, total Kjeldahl nitrogen and total phosphorus
- Sodium adsorption ratio (SAR).

Select samples were laboratory analysed for additional chemical parameters, as a conservative measure upon review of the draft Chapter 8: Land Use and Tenure for registered contaminated land near shallow groundwater and/or surface water features, as follows:

- Total recoverable hydrocarbons
- Benzene, toluene, ethylbenzene, xylenes, and naphthalene
- Polycyclic aromatic hydrocarbons
- Polychlorinated biphenyls
- Organochlorine/Organophosphorus pesticides.

Groundwater quality results obtained as part of baseline monitoring are provided in Appendix U: Groundwater Technical Report.

TABLE 15-3 BASELINE MONITORING DATA SUMMARY

Bore	Aquifer	No. of sampling events	Comments
310-01-BH2213	Border Rivers Alluvium (BRA)	3	Historical site access restraints
310-01-BH2217	BRA	8	No access during November 2021 and March 2022 baseline event due to local flooding
310-01-BH2218	BRA	7	No access during November 2021 and March 2022 baseline event due to local flooding
310-01-BH2201	Kumbarilla Beds	6	Historical site access restraints
310-01-BH2302	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2203	WCM	10	These sample events were obtained despite no access during November 2021 baseline event due to local flooding,
310-01-BH2304	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2305	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2206	WCM	10	Notwithstanding there was no access during November 2021 baseline event due to local flooding 10 samples were obtained
310-01-BH2308	WCM	0	Historical site access restraints
310-01-BH2309	WCM	5	Historical site access restraints
310-01-BH2210	WCM	6	Historical site access restraints
310-01-BH2311	Eurombah Formation (WCM)	0	Bore dry since commencement of baseline monitoring
310-01-BH2214	WCM	7	Historical site access restraints
310-01-BH2215	WCM	7	Historical site access restraints
310-01-BH2216	WCM	10	These sample events were obtained despite no access during November 2021 baseline event due to local flooding
310-01-BH2617	BRA (Canning Creek)	3	Historical site access restraints
310-01-BH2341	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2323	Eurombah Formation (WCM)	0	Bore dry since commencement of baseline monitoring
310-01-BH2355	MRV	0	Bore dry since commencement of baseline monitoring
310-01-BH2326	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2229	WCM	0	Bore dry since commencement of baseline monitoring
310-01-BH2233	Condamine Alluvium (CA)	5	Historical site access restraints
310-01-BH2234	CA	5	Historical site access restraints
310-01-BH2235	CA	5	Historical site access restraints
310-01-BH2231	CA	1	Bore compromised – root intrusion
310-01-BH2337	MRV	0	Bore dry since commencement of baseline monitoring
310-01-BH2338	MRV	0	Bore dry since commencement of baseline monitoring
310-01-BH2343	MRV	10	These sample events were obtained despite no access during November 2021 baseline event due to local flooding
310-01-BH2344	Alluvium/MRV	7	No access during November 2021 and March 2022 baseline event due to local flooding. Initial access restraints
310-01-BH2345	MRV	10	These sample events were obtained despite no access during November 2021 baseline event due to local flooding
310-01-BH2347	MRV	10	These sample events were obtained despite no access during November 2021 baseline event due to local flooding
310-01-BH2248	MRV	9	No access during May and November 2021 baseline events due to local flooding
310-01-BH2352	MRV	0	Bore dry since commencement of baseline monitoring

TABLE 15-4 BASELINE MONITORING EVENT SUMMARY

Event dates	Project bores sampled	Climatic conditions#
October 2018	270-01-BH2217, 270-01-BH2218, BH2203, BH2206, BH2216, BH2214, BH2215, BH2201, BH2309, BH2210, BH2308, BH2229, BH2302, BH2304, BH2305, BH2311, BH2323, BH2326, BH2343, BH2345, BH2347, BH2248, BH2344, BH2355, BH2337, BH2338, BH2341, BH2352, BH2233, BH2234, BH2235, BH2231, BH2617	76.6 mm rainfall recorded during October 2018
31 March 2020 to 3 April 2020	BH2206, BH2214, BH2215, BH2216, BH2341, BH2323, BH2617, BH2355, BH2326, BH2229, BH2337, BH2338, BH2343, BH2344, BH2345, BH2347, BH2248, BH2352, BH2203, BH2304, BH2305, BH2646	1.0 mm rainfall recorded in 5 days preceding event
15 to 23 June 2020	BH2305, BH2304, BH2203, BH2206, BH2214, BH2215, BH2201, BH2303, BH2302, BH2311, BH2216, BH2617, BH2341, BH2323, BH2355, BH2326, BH2229, BH2337, BH2338, BH2343, BH2344, BH2345, BH2248, BH2347, BH2352	16.0 mm rainfall recorded in 5 days preceding event
22 to 25 February 2021	BH2302, BH2305, BH2304, BH2203, BH2206, BH2308, BH2311, BH2216, BH2326, BH2341, BH2323, BH2617, BH2229, BH2337, BH2338, BH2343, BH2345, BH2347, BH2352	0.0 mm rainfall recorded in 5 days preceding event
25 May 2021 to 3 June 2021	270-01-BH2218, 270-01-BH2217, BH2302, BH2302, BH2305, BH2304, BH2203, BH2206, BH2308, BH2311, BH2216, BH2617, BH2341, BH2323, BH2326, BH2337, BH2338, BH2343, BH2345, BH2352, BH2347, BH2229	0.0 mm rainfall recorded in 5 days preceding event
28 June 2021 to 1 July 2021	270-01-BH2217, 270-01-BH2218, BH2347, BH2229, BH2305, BH2304, BH2203, BH2206, BH2326, BH2355, BH2308, BH2311, BH2216, BH2341, BH2617, BH2337, BH2338, BH2323, BH2343, BH2345, BH2248, BH2352, BH2302, BH2344	24.6 mm rainfall recorded in 5 days preceding event
12 to 18 September 2021	270-01-BH2218, 270-01-BH2217, BH2235, BH2234, BH2233, BH2231, BH2352, BH2347, BH2248, BH2229, BH2326, BH2323, BH2341, BH2617, BH2216, BH2215, BH2214, BH2309, BH2210, BH2305, BH2304, BH2203, BH2206, BH2311, BH2308, BH2302, BH2355, BH2337, BH2338, BH2343, BH2344, BH2345	0.0 mm rainfall recorded in 5 days preceding event
7 to 11 March 2022	270-01-BH2217, BH2347, BH2345, BH2343, BH2337, BH2338, BH2341, BH2617, BH2216, BH2311, BH2302, BH2305, BH2304, BH2203, BH2206, BH2308, BH2323, BH2309, BH2210, BH2214, BH2215, BH2326, BH2229, BH2352	0.0 mm rainfall recorded in 5 days preceding event
19 to 24 April 2022	270-01-BH2213, 270-01-BH2217, 270-01-BH2218, BH2347, BH2352, BH2345, BH2229, BH2326, BH2323, BH2341, BH2617, BH2216, BH2311, BH2210, BH2309, BH2308, BH2305, BH2304, BH2203, BH2206, BH2302, BH2201, BH2235, BH2234, BH2233, BH2355, BH2215, BH2337, BH2343, BH2214, BH2338, BH2344, BH2248	0.0 mm rainfall recorded in 5 days preceding event
25 to 29 October 2023	270-01-BH2213, 270-01-BH2217, 270-01-BH2218, BH2201.	0.0 mm rainfall recorded in 5 days preceding event
29 to 30 November 2023	270-01-BH2213, 270-01-BH2217, 270-01-BH2218, BH2201	33.6 mm rainfall recorded in 5 days preceding event. Further, 29.0 mm rainfall recorded during event causing localised flooding
13 to 21 December 2023	270-01-BH2213, 270-01-BH2217, 270-01-BH2218, BH2201, BH2355*, BH2311*, BH2214*, BH2215*, BH2302*, BH2203*, BH2305*, BH2304*, BH2206*, BH2216*, BH2617*, BH2337*, BH2338*, BH2309*, BH2341*, BH2323*, BH2229*, BH2345*, BH3361*, BH2352*, BH2210*, BH2343*, BH2344*, BH2201*, BH2233*, BH2234*, BH2235*, BH2231*, BH2308*, BH2326*, BH2347*.	37.0 mm rainfall recorded in 5 days preceding event

Table note:

* Sampled up until 21 April 2022

\# Daily rainfall recorded at Woodspring Alert (BOM Station No 041391).

15.4.3 Groundwater monitoring bore installation 2023

The groundwater monitoring bore network installed in 2018 was constructed to inform the reference design as presented in the draft EIS. Since installation in 2018, localised design revisions resulted in the Project shifting from some of the original groundwater bores in the monitoring network. The data gaps between the existing groundwater monitoring network and the revised reference design (this revised draft EIS) were remedied by ARTC with the installation of additional groundwater monitoring bores to align closer with the revised reference design in 2023.

Twenty-two new groundwater monitoring bores were installed, and eight existing monitoring bores (BH2352, BH2355, BH2304, BH2305, BH2308, BH2311, BH2323, BH2617) were decommissioned in 2023 in accordance with *Minimum Construction Requirements for Water Bores in Australia* (Edition 4) (NUDLC, 2020). The outcome is that there are 48 Project bores that comprise the revised groundwater monitoring network and basis of the Project Groundwater Management and Monitoring Program (GMMP) (Table 15-21).

Locations of registered and site investigation bores are shown on Figure 15-2. The resultant updated groundwater monitoring network as of 2023, including borehole locations, installation detail, and hydraulic records (as available), are included by Project chainage in Table 15-3.

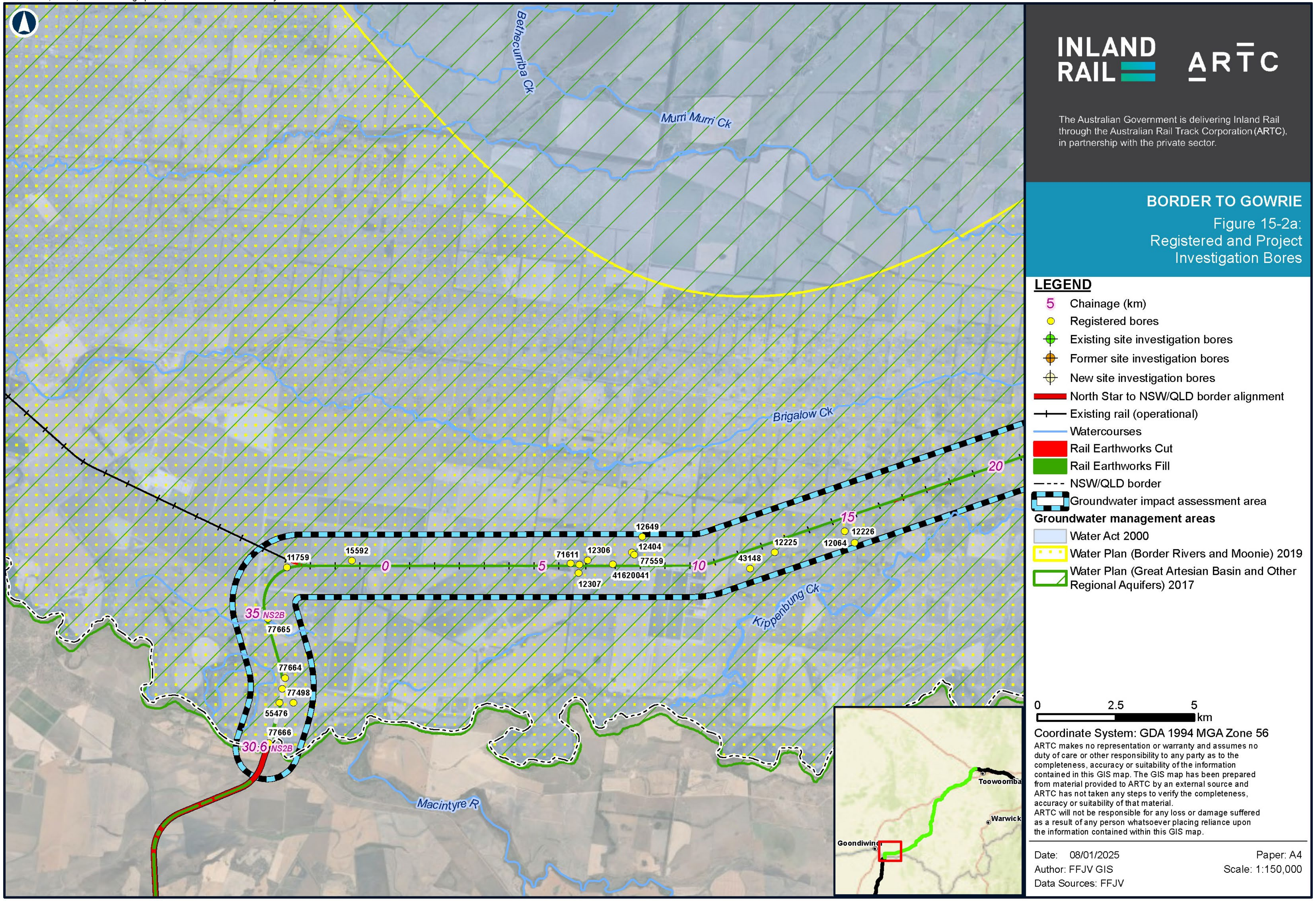
15.4.4 Baseline groundwater monitoring

Site-based groundwater monitoring events are on hold until the detailed design stage of the Project. Site-based monitoring will resume, in accordance with the *Monitoring and Sampling Manual 2009* (DES, 2018b) over sufficient time to achieve a baseline dataset. Site-specific WQOs can be developed and used to prepare the construction works stage GMMP for the Project (Section 15.7.3).

When the site-based groundwater monitoring events resume, pressure transducers (loggers) will be installed, and these groundwater level datasets will be collected and utilised to update the baseline hydrographs for each bore, and the ambient groundwater level (or range) identified.

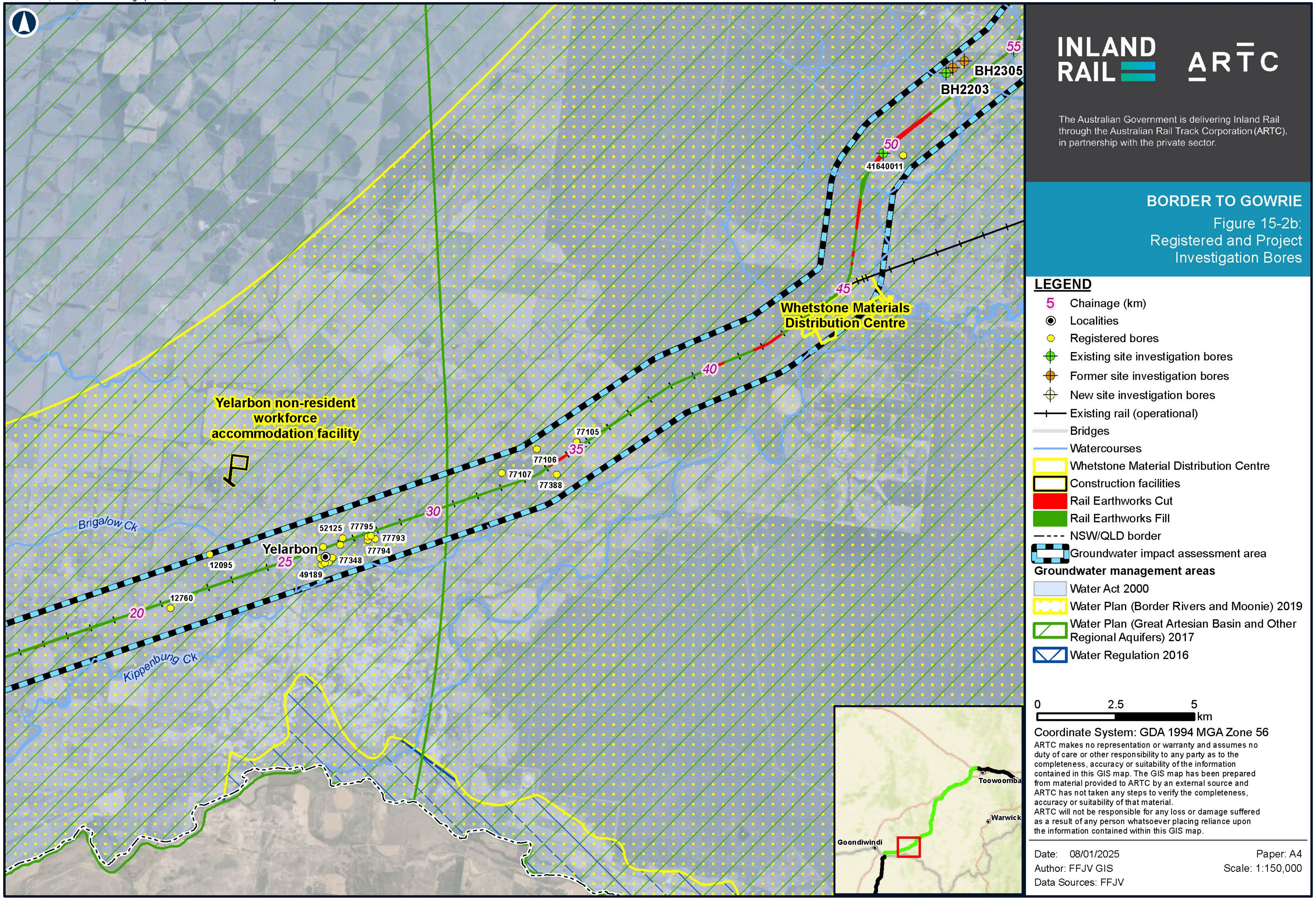
Groundwater quality samples will resume collection via site-based monitoring events during the detailed design stage of the Project, for a time period sufficient to inform a suitable baseline quality dataset that impacts can be identified, with consideration for seasonal variation, in accordance with the *Using monitoring data to assess groundwater quality and potential environmental impacts guideline* (DES, 2021a). The additional bores and data collected and to be collected ensure the requirements of the guideline are satisfied.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



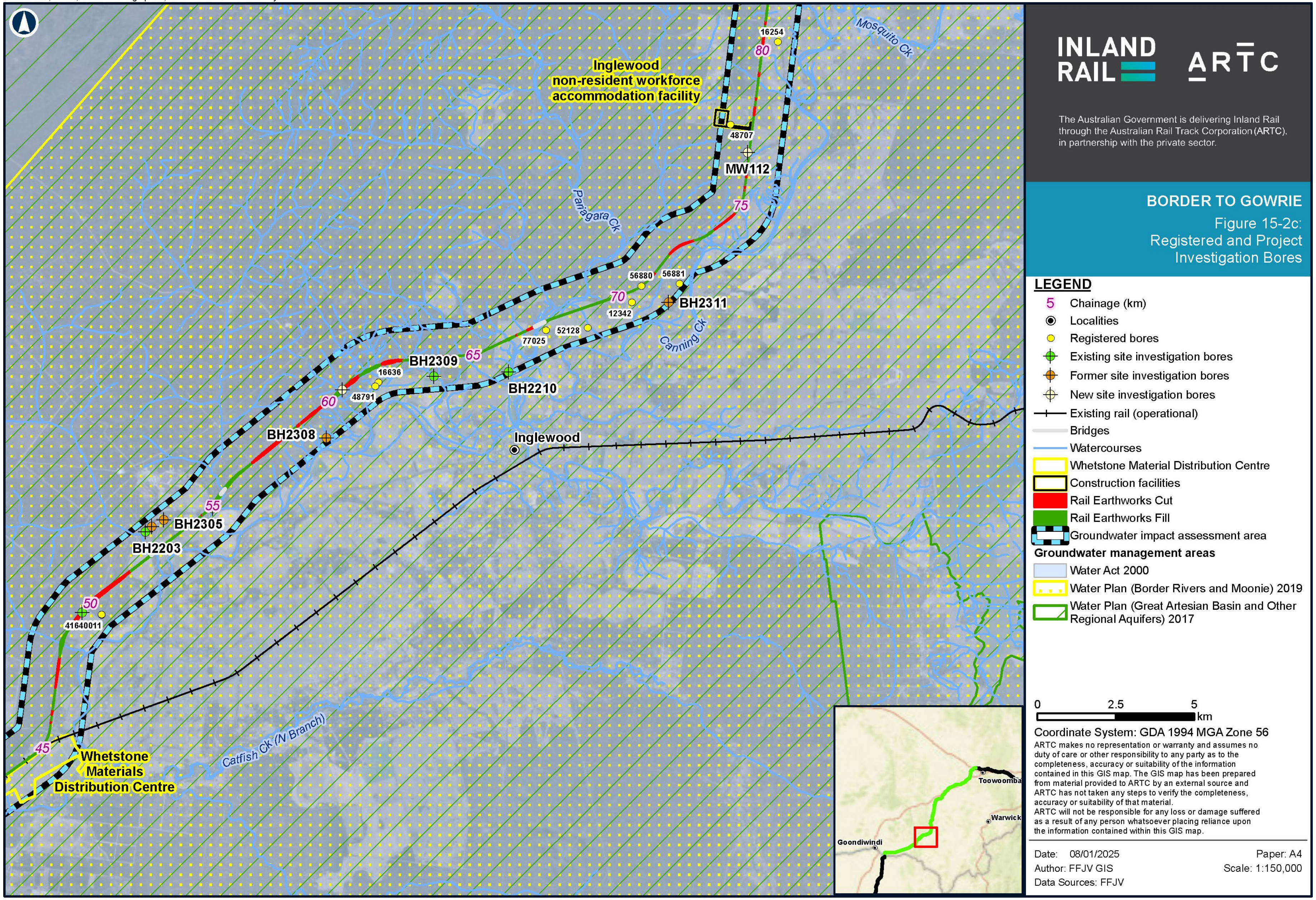
Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-2_Bores_v2.mxd Date: 8/01/2025 14:47

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



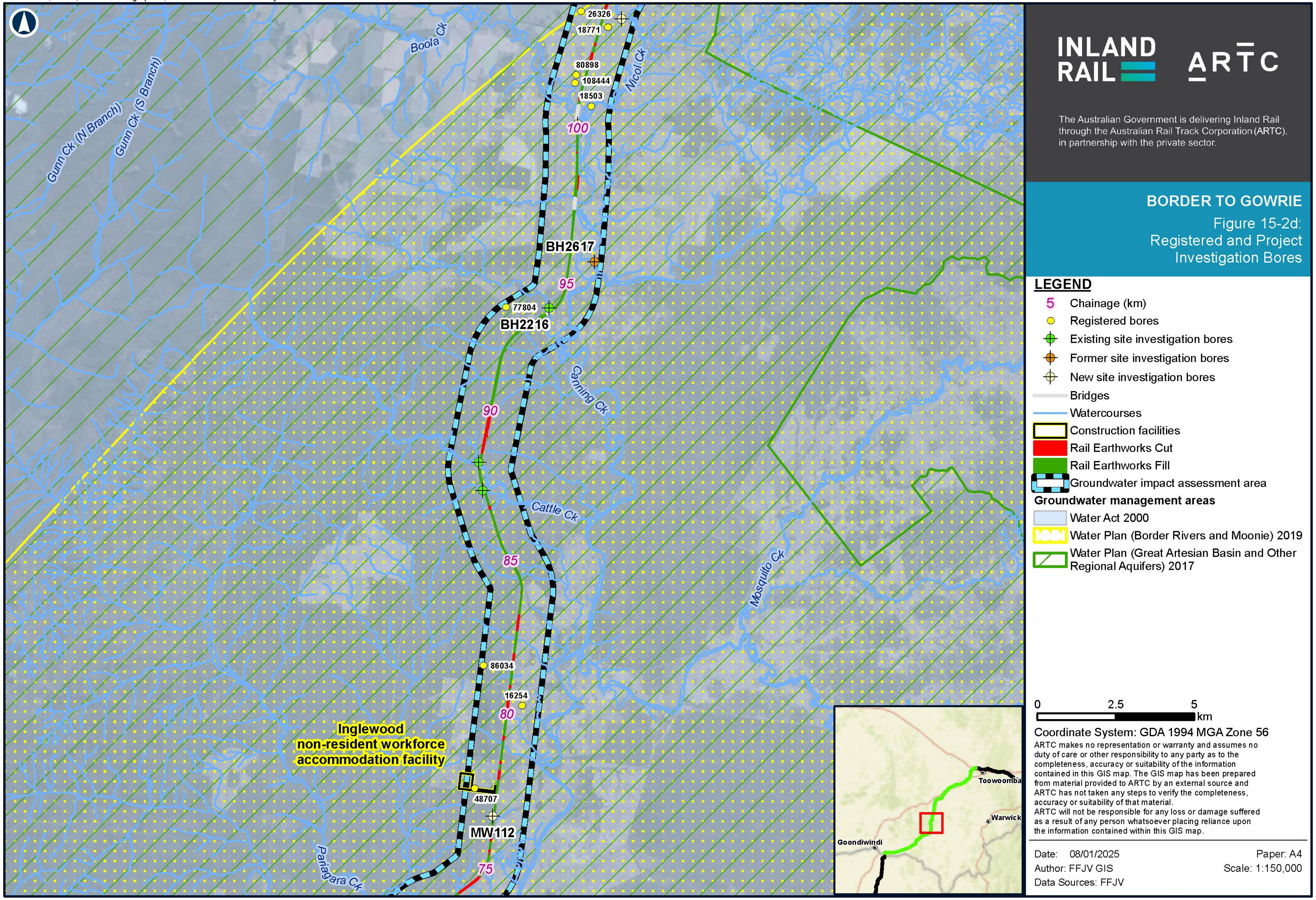
Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-2_Bores_v2.mxd Date: 8/01/2025 14:47

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



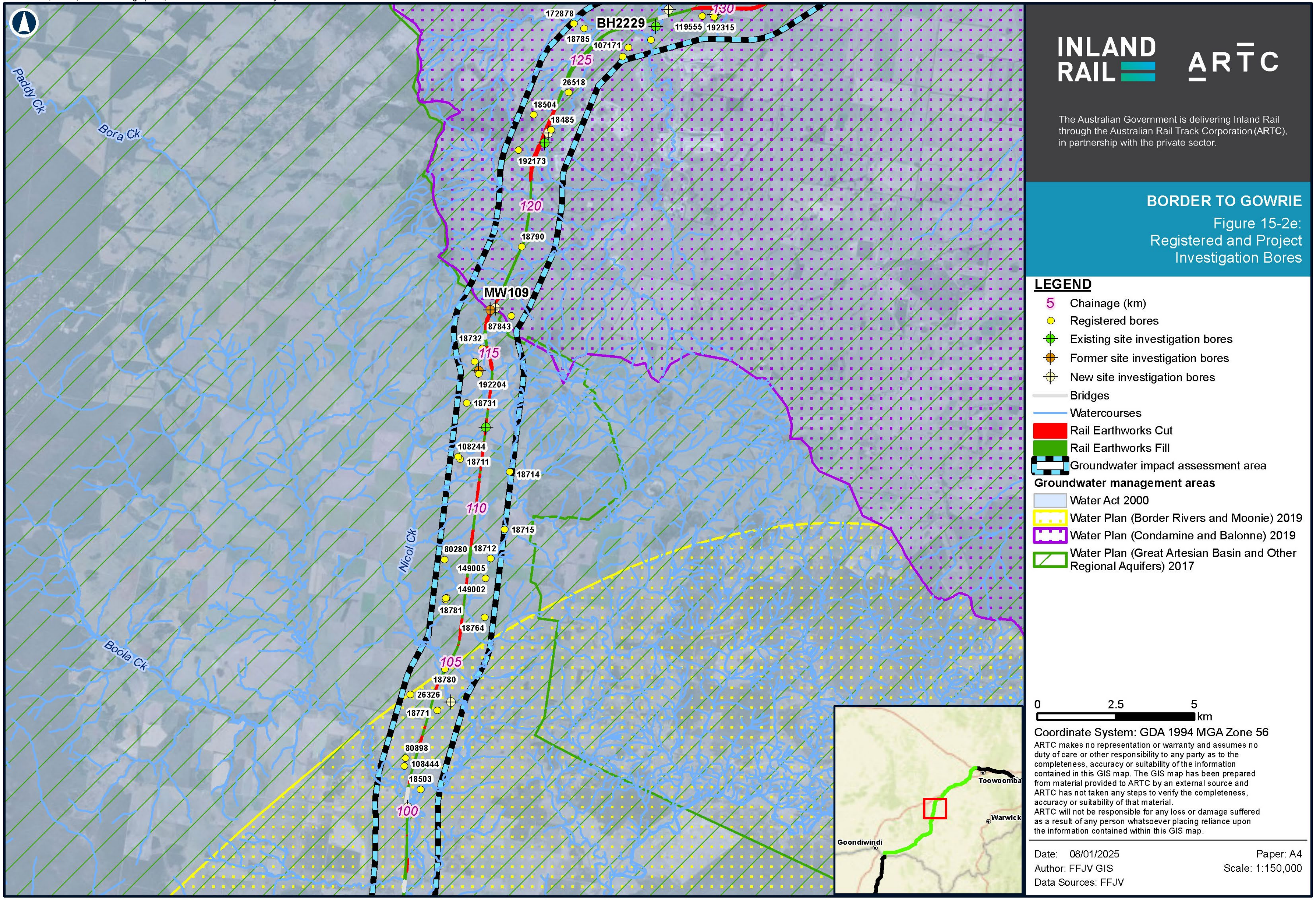
Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-2_Bores_v2.mxd Date: 8/01/2025 14:47

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-2_Bores_v2.mxd Date: 8/01/2025 14:47

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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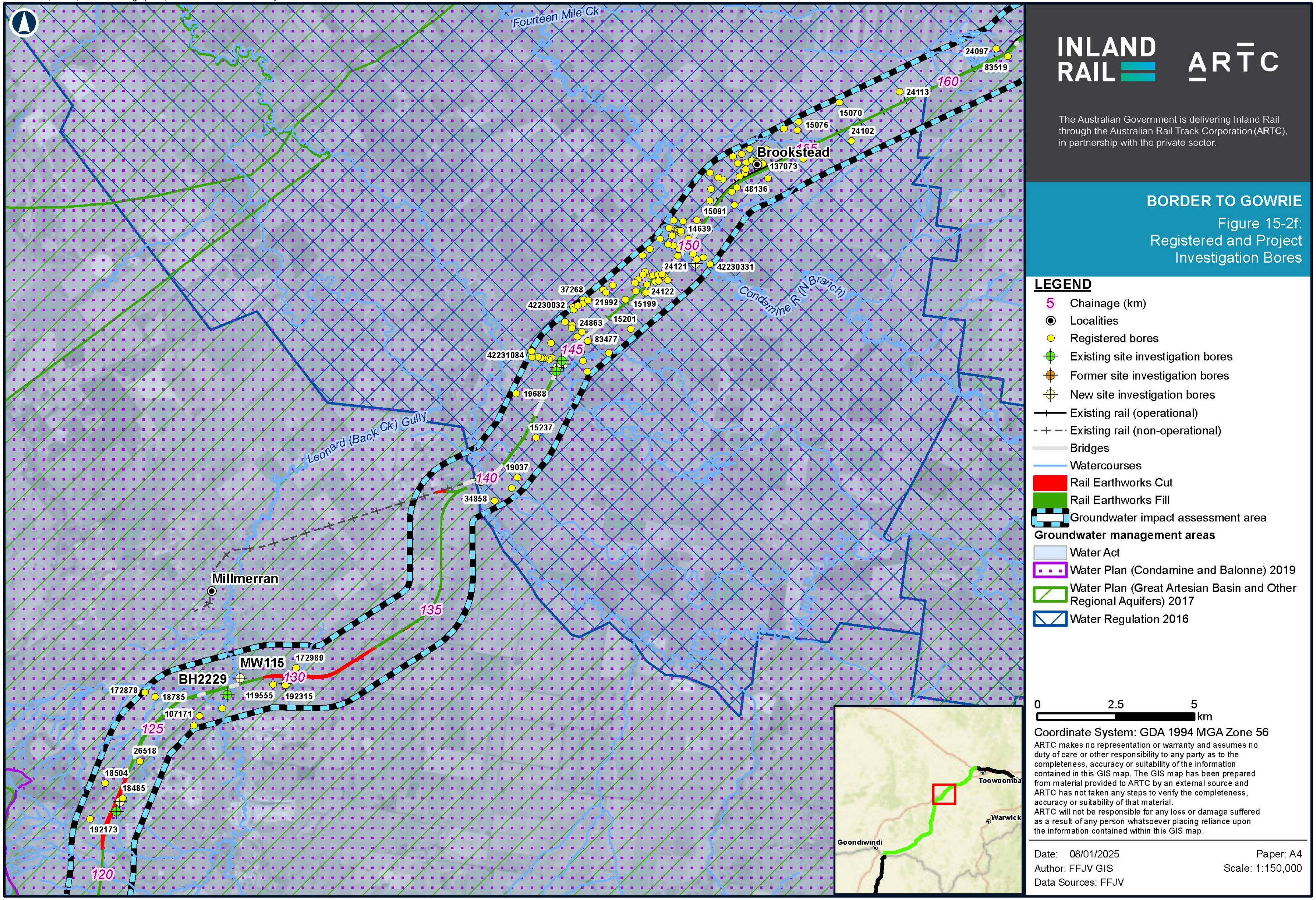
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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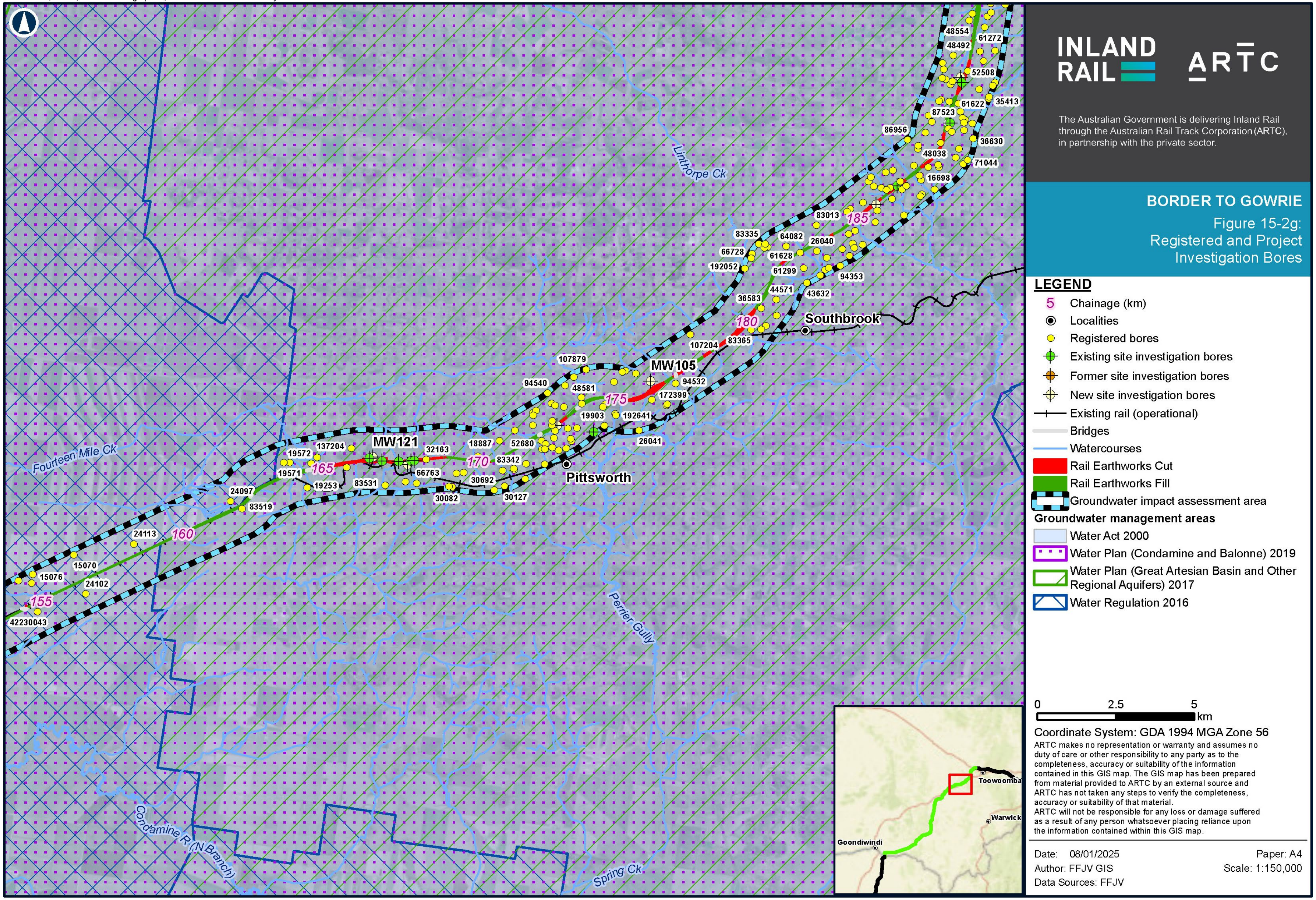
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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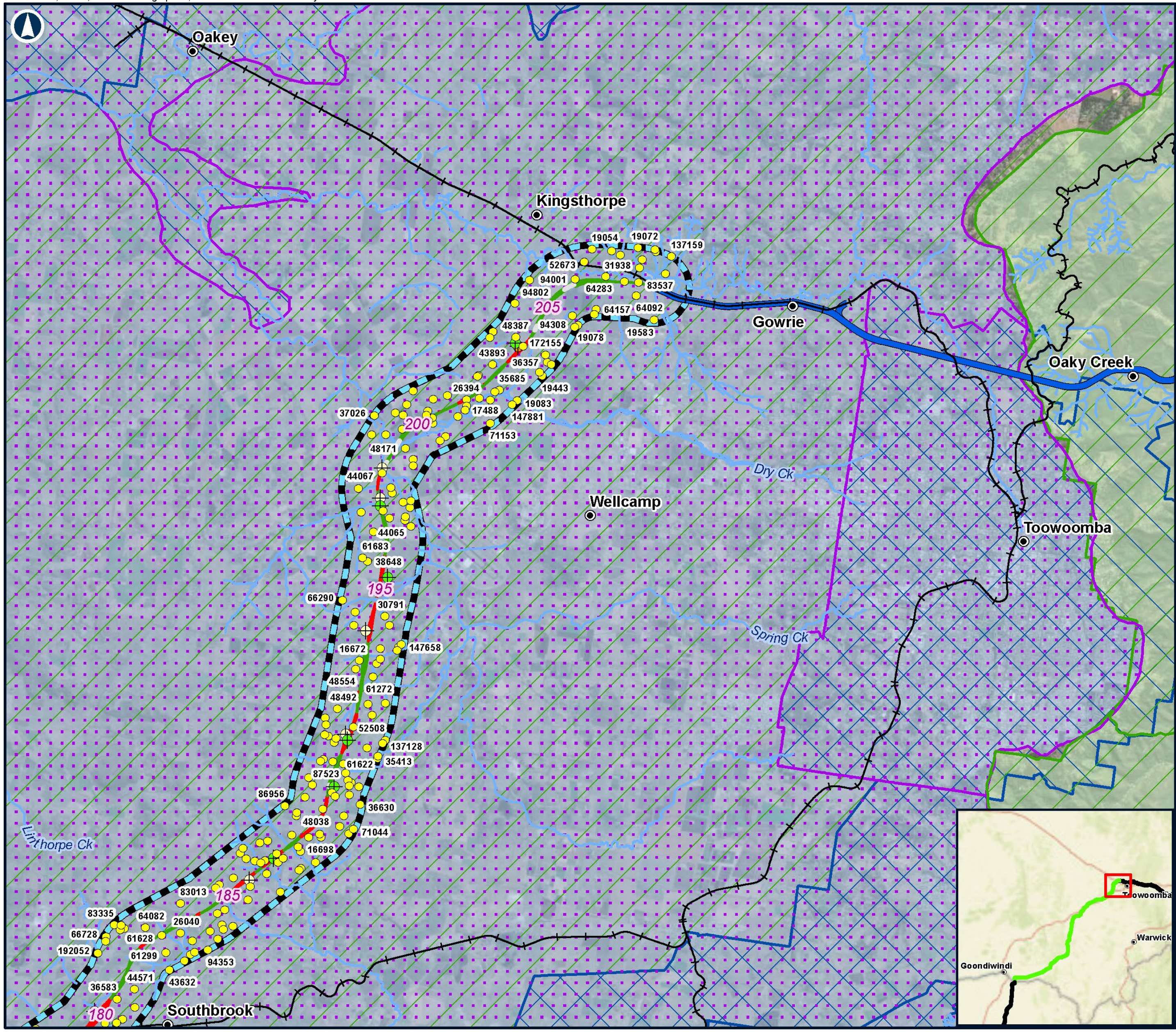
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



INLAND RAIL

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

BORDER TO GOWRIE

Figure 15-2h: Registered and Project Investigation Bores

LEGEND

- 5 Chainage (km)
- Localities
- Registered bores
- Existing site investigation bores
- Former site investigation bores
- New site investigation bores
- Gowrie to Helidon alignment
- Existing rail (operational)
- Bridges
- Watercourses
- Rail Earthworks Cut
- Rail Earthworks Fill
- Groundwater impact assessment area

Groundwater management areas

- Water Act 2000
- Water Plan (Moreton) 2007
- Water Plan (Condamine and Balonne) 2019
- Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017
- Water Regulation 2016

0 2.5 5 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 08/01/2025 Paper: A4
Author: FFJV GIS Scale: 1:150,000
Data Sources: FFJV

Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-2_Bores_v2.mxd Date: 8/01/2025 14:47

TABLE 15-5 PROJECT MONITORING BORE LOCATIONS AND RESULTS

Chainage (approximate in km)	Project bore ID	Screened interval (m BGL)	Screened lithology	Aquifer[1]	Surface elevation[2]	Median SWL (m AHD)	RL range from level logger during the field investigation works (m AHD)	Average hydraulic conductivity[3] K (m/day)	2023 network status
Ch 30.7 km (NS2B)	310-01-BH2213	13.5 to 19.5	Sandy gravel and sand	BRA	227.0	215.3	214.8 to 218.2	0.19	Existing bore part of revised GMMP
Ch 32.8 km (NS2B)	310-01-BH2217	9.2 to 15.2	Sand and gravelly sand	BRA	227.6	214.8	214.6 to 216.4	0.42	Existing bore part of revised GMMP
Ch 34.8 km (NS2B)	310-01-BH2218	8.8 to 14.8	Clayey gravel and gravelly sand	BRA	225.6	213.7	213.5 to 213.8	0.16	Existing bore part of revised GMMP
Ch 35.1 km	310-01-BH2201	20.2 to 29.2	Extremely weathered sandstone	Pilliga Sandstone/ Springbok Sandstone (Kumbarilla Beds)	256.5	248.5	248.4 to 249.0	0.3	Existing bore RN77771 part of revised GMMP
Ch 49.6 km	310-01-BH2302	9.0 to 15.0	Sandstone	WCM	300.9		Dry bore		Existing bore RN77767
Ch 52.8 km	310-01-BH2203	16.0 to 25.0	Sandstone	WCM	278.7	258.4	254.6 to 260.9	0.0003	Existing bore RN77769 part of revised GMMP
Ch 53.0 km	310-01-BH2304	2.6 to 8.6	Siltstone	WCM	289.8		Dry bore		Decommissioned
Ch 53.5 km	310-01-BH2305	9.0 to 15.0	Siltstone	WCM	287.2		Dry bore		Decommissioned
Ch 54.9 km	310-01-BH2206	16.5 to 25.5	Weathered mudstone/sandstone	WCM	272.4	263.3	263.1 to 263.6	0.05	Existing bore RN77763 part of revised GMMP
Ch 59.1 km	310-01-BH2308	9.0 to 15.0	Weathered clayey sandstone	WCM	301.6		Dry bore		Decommissioned
Ch 63.7 km	310-01-BH2309	9.0 to 15.0	Extremely weathered sandstone/mudstone	WCM	277.1	261.6	260.1 to 263.0	0.003	Existing bore RN77768 part of revised GMMP
Ch 65.8 km	310-01-BH2210	21.0 to 30.0	Siltstone	WCM	283.4	273.9	273.8 to 274.1	0.0001	Existing bore RN77765 part of revised GMMP
Ch 71.1 km	310-01-BH2311	9.0 to 15.0	Extremely weathered sandstone/mudstone	Eurombah Formation (WCM)	296.7		Dry bore		Decommissioned
Ch 87.4 km	310-01-BH2214	14.0 to 20.0	Extremely weathered sandstone	WCM	321.6	209.5	208.0 to 210.9	0.002	Existing bore RN77761 part of revised GMMP

Chainage (approximate in km)	Project bore ID	Screened interval (m BGL)	Screened lithology	Aquifer[1]	Surface elevation[2]	Median SWL (m AHD)	RL range from level logger during the field investigation works (m AHD)	Average hydraulic conductivity[3] K (m/day)	2023 network status
Ch 88.3 km	310-01-BH2215	21.0 to 30.0	Extremely weathered sandstone	WCM	225.1	213.0	211.5 to 214.4	3.3	Existing bore RN77669 part of revised GMMP
Ch 94.0 km	310-01-BH2216	12.5 to 18.5	Extremely weathered mudstone	WCM	320.8	312.1	305.2 to 317.0	0.0008	Existing bore RN77762 part of revised GMMP
Ch 115.5 km	310-01-BH2617	2.0 to 5.0	Sand	BRA (Canning Creek)	323.3		Dry bore		Decommissioned
Ch 112.6 km	310-01-BH2341	9.0 to 15.0	Mudstone/sandstone	WCM	446.3		Dry bore		Existing bore RN192202 excluded from revised GMMP
Ch 114.3 km	310-01-BH2323	9.0 to 15.0	Extremely weathered sandstone/mudstone	Eurombah Formation (WCM)	458.6		Dry bore		Decommissioned
Ch 116.4 km	310-01-BH2355	17.0 to 20.0	Basalt	MRV	477.5		Dry bore		Decommissioned
Ch 122.1 km	310-01-BH2326	9.0 to 15.0	Extremely weathered mudstone	WCM	477.0		Dry bore		Existing bore RN192245 excluded from revised GMMP
Ch 127.8 km	310-01-BH2229	24.0 to 30.0	Sandstone	WCM	406.6		Dry bore		Existing bore RN192211 excluded from revised GMMP
Ch 137.6 km	MW100	9.0 to 15.0	Siltstone and basalt	MRV	430.3	NS	NS	NS	New bore RN192747 part of revised GMMP
Ch 138.5 km	310-01-BH2231	11.4 to 17.4	Sandy gravel/Clayey sand/Gravely sand	CA	377.8		Dry bore		Existing bore excluded from revised GMMP
Ch 138.6 km	MW118	19.0 to 25.0	Siltstone	MRV	432.7	NS	NS	NS	New bore RN192748 part of GMMP
Ch 141.7 km	MW101	12.5 to 18.5	Basalt	MRV	500.5	NS	NS	NS	New bore RN192749 part of revised GMMP

Chainage (approximate in km)	Project bore ID	Screened interval (m BGL)	Screened lithology	Aquifer[1]	Surface elevation[2]	Median SWL (m AHD)	RL range from level logger during the field investigation works (m AHD)	Average hydraulic conductivity[3] K (m/day)	2023 network status
Ch 142.8 km	310-01-BH2233	9.5 to 12.5	Clayey sand/Clay/ Sand	CA	378.9	363.8	363.5 to 364.9	0.12	Existing bore RN192244 excluded from revised GMMP
Ch 143.2 km	310-01-BH2234	16.4 to 22.4	Clayey sand/Gravely sand	CA	379.2	362.2	358.9 to 363.1	0.29	Existing bore RN172705 excluded from revised GMMP
Ch 145.0 km	MW102	15.5 to 21.5	Basalt	MRV	535.5	NS	NS	NS	New bore RN192751 part of revised GMMP
Ch 148.7 km	310-01-BH2235	31.0 to 40.0	Sandy clay	CA	381.3	357.9	357.8 to 358.4	0.02	Existing bore RN172704 excluded from revised GMMP
Ch 150.0 km	MW103	4.0 to 10.0	Gravelly clay	MRV	532.4	NS	NS	NS	New bore RN192752 part of revised GMMP
Ch 156.0 km	MW104	18.0 to 24.0	Basalt	MRV	586.5	NS	NS	NS	New bore RN192743 part of revised GMMP
Ch 160.5 km	MW105	23.0 to 29.	Basalt	MRV	580.8	NS	NS	NS	New bore RN192745 part of revised GMMP
Ch 163.2 km	MW106	10.5 to 16.5	Clay	MRV	526.7	NS	NS	NS	New bore RN192750 part of revised GMMP
Ch 165.7 km	310-01-BH2337	9.0 to 15.0	Basalt	MRV	487.1		Dry bore		Existing bore excluded from revised GMMP
Ch 166.6 km	310-01-BH2338	9.0 to 15.0	Basalt/clay	MRV	504.8		Dry bore		Existing bore excluded from revised GMMP
Ch 168.1 km	MW123	17.5 to 23.5	Basalt	MRV	504.0	NS	NS	NS	New bore RN192742 part of revised GMMP

Chainage (approximate in km)	Project bore ID	Screened interval (m BGL)	Screened lithology	Aquifer[1]	Surface elevation[2]	Median SWL (m AHD)	RL range from level logger during the field investigation works (m AHD)	Average hydraulic conductivity[3] K (m/day)	2023 network status
Ch 169.6 km	MW121	17.5 to 23.5	Basalt and siltstone	MRV	500.0	NS	NS	NS	New bore RN192741 part of revised GMMP
Ch 185.4 km	310-01-BH2343	12.0 to 15.0	Basalt	MRV	532.8	520.7	518.7 to 521.5		Existing bore RN192209 excluded from revised GMMP
Ch 186.1 km	MW119	18.0 to 24.0	Sandy clay, gravelly clay, gravel	CA	382.2	NS	NS	NS	New bore RN192759 part of revised GMMP
Ch 188.0 km	310-01-BH2344	9.0 to 15.0	Sandy gravel/basalt	Alluvium/MRV	524.8	310.1	306.0 to 311.3	0.06	Existing bore RN192206 part of revised GMMP
Ch 189.4 km	310-01-BH2345	21.0 to 30.0	Basalt	MRV	536.1	515.7	512.4 to 515.9	0.007	Existing bore RN164151 excluded from revised GMMP
Ch 191.6 km	MW120	13.0 to 19.0	Clayey sand and sandy clay	CA	378.9	NS	NS	NS	New bore RN192760 part of revised GMMP
Ch 191.9	MW114	9.0 to 15.0	Clayey sand and sandy clay	CA	377.8	NS	NS	NS	New bore RN192755 part of revised GMMP
Ch 194.1 km	310-01-BH2347	17.0 to 20.0	Gravelly silt	MRV	463.0	453.6	453.3 to 454.4	0.3	Existing bore RN192205 part of revised GMMP
Ch 196.1 km	310-01-BH2248	19.0 to 25.0	Sandy clay and clayey sand	WCM	432.9	425.9	417.1 to 426.3	0.2	Existing bore excluded from revised GMMP
Ch 196.2 km	MW116	9.0 to 15.0	Clayey gravel and clayey sand	CA	378.2	NS	NS	NS	New bore RN192762 part of revised GMMP
Ch 202.3 km	310-01-BH2352	12.0 to 15.0	Basalt	MRV	487.3		Dry bore		Decommissioned
Ch 205.2 km	MW107	6.0 to 12.0	Sandy clay	WCM	415.0	NS	NS	NS	New bore RN192781 part of revised GMMP

Chainage (approximate in km)	Project bore ID	Screened interval (m BGL)	Screened lithology	Aquifer[1]	Surface elevation[2]	Median SWL (m AHD)	RL range from level logger during the field investigation works (m AHD)	Average hydraulic conductivity[3] K (m/day)	2023 network status
Ch 208.1 km	MW115	4.0 to 10.0	Sandy clay and clay	WCM	405.0	NS	NS	NS	New bore RN192756 part of revised GMMP
Ch 214.0 km	MW108	11.0 to 17.0	Siltstone and coal	WCM	479.0	NS	NS	NS	New bore RN192757 part of revised GMMP
Ch 220.0 km	MW109	7.5 to 13.5	Silty clay, siltstone, basalt	WCM or Eurombah Formation	470.0	NS	NS	NS	New bore RN172706 part of revised GMMP
Ch 231.7 km	MW110	9.0 to 15.0	Siltstone	WCM	349.0	NS	NS	NS	New bore RN188692 part of revised GMMP
Ch 235.7 km	MW111	7.0 to 13.0	Sandy clay and sand	WCM	332.1	NS	NS	NS	New bore RN192758 part of revised GMMP
Ch 261.0 km	MW112	3.0 to 9.0	Clayey sand, gravel, sand	CA	309.5	NS	NS	NS	New bore RN77815 part of revised GMMP
Ch 275.0 km	MW113	13.5 to 19.5	Shale and siltstone	WCM	295.7	NS	NS	NS	New bore RN77813 part of revised GMMP

Table notes:
RL = reference level
AHD = Australian Height Datum
NS = Not sampled yet available (results will be obtained to enable derivation of WQOs)
RN = Queensland registered bore number
1. Refer to Section 15.5.5 for introduction and description for each
2. Surface elevation derived from the digital elevation model spatial data or from bore completion logs
3. Mean hydraulic conductivity value derived from falling and rising head tests completed during reference design stage investigations (2018)

15.5 Existing environment

The subsections below provide discussion of the existing environment with respect to the groundwater regime within the groundwater impact assessment area that wholly contains the Project footprint; with the exception of select bores up to 5 km away from the alignment to inform potential impacts to GDEs. In each instance, further details are included in Appendix U: Groundwater Technical Report, or other chapters of the revised draft EIS, as referenced.

15.5.1 Land use

An overview of land uses relevant to groundwater resources is presented in Figure 15-3. Understanding the use of the land surface uses in the groundwater study area informs potential impacts on the local groundwater regime and, as such, was used to inform of the baseline monitoring analytes of potential concern. For example, in areas where land is used for agricultural/cropping purposes, the shallow groundwater has potential for elevated concentrations of ammonia from fertiliser than non-producing land uses. Whereas in the vicinity of a retail petrol station, there is potential for hydrocarbons to be present in the shallow groundwater. This information aids in identifying the potential quality of groundwater that could be encountered during construction and/or operation of the Project.

Land use within the groundwater impact assessment area is shown by the Queensland Land Use Mapping Program as being predominately grazing land. The next most common land uses are also of an agricultural nature, including cropping. Other land uses that exceed one per cent of the Project footprint include land classified as ‘other minimal use’ that consists of areas of land that are largely unused. For example, residual native cover or land reserved for stock routes, production forestry, and transport and communication (which includes transportation infrastructure and commercial services).

The land uses of the Project area, and within the groundwater impact assessment area, were considered and incorporated into the locations and depths for the 2023 bore installation campaign. Additional details of the land use within the groundwater impact assessment area are provided in Chapter 8: Land Use and Tenure and was used to inform the groundwater assessment and groundwater monitoring events.

15.5.2 Watercourses

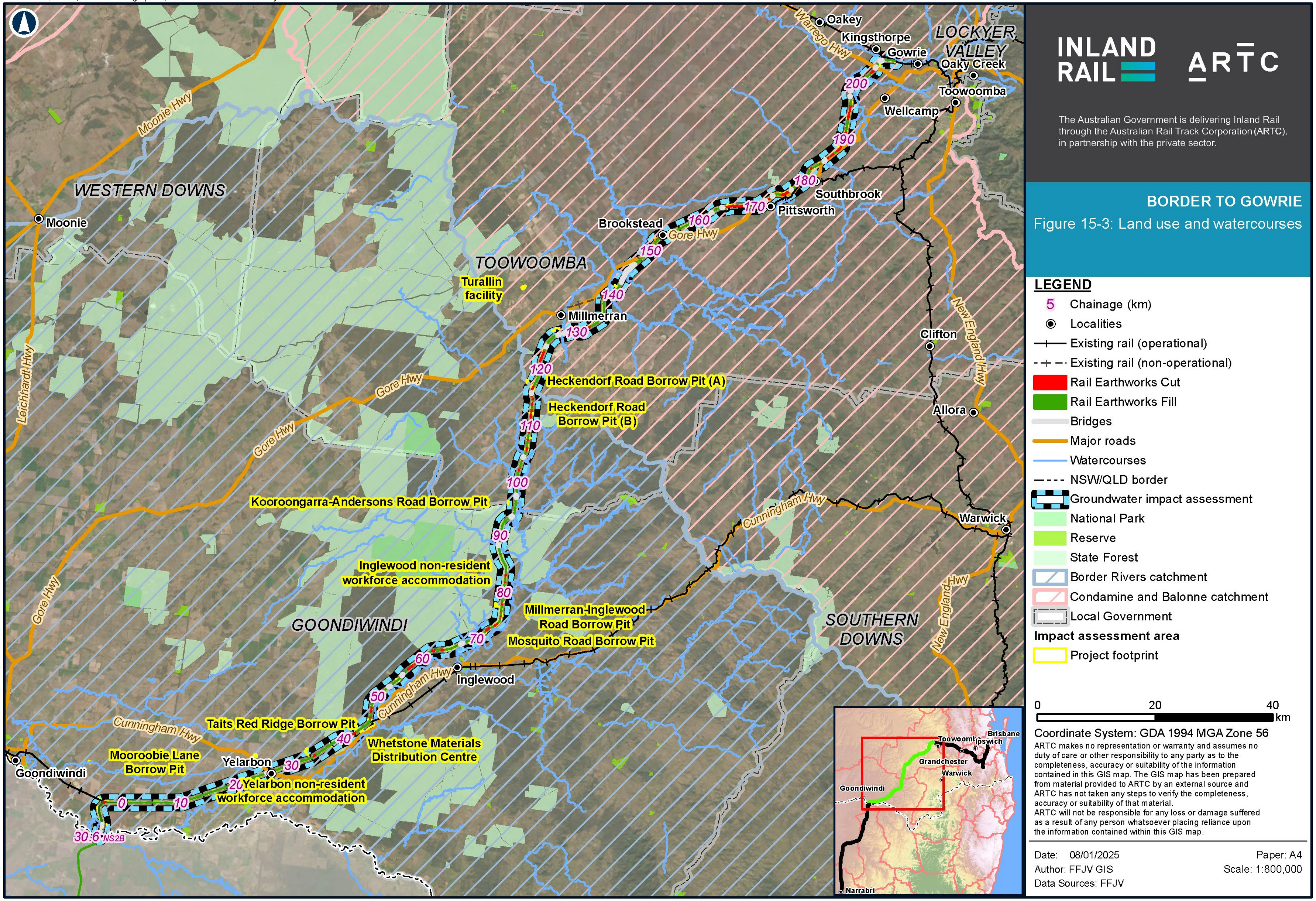
Under the Water Act, a watercourse is defined as a river, creek, or other stream which includes a stream in the form of an anabranch or a tributary where water flows either permanently or intermittently, regardless of the frequency of flow events. A watercourse, however, does not include any section of a feature that has a tidal influence or is downstream of a defined limit between potential estuarine and fresh water (Chapter 13: Surface Water).

The current defined watercourses within the groundwater impact assessment area are listed below. Where the watercourse is intersected by the Project alignment, the approximate chainage is given:

- Macintyre River—Ch 30.6 km (NS2B)
- Macintyre Brook
- Canning Creek
- Pariagara Creek—Ch 67.3 km
- Cattle Creek—Ch 88.2 km
- Bringalily Creek—at Ch 100.6 km
- Nicol Creek—Ch 104.4 km
- Back Creek unnamed tributary—Ch 126.9 km
- Back Creek—Ch 128.0 km
- Grasstree Creek—at Ch 139.9 km
- Condamine River (Main Branch)—Ch 144.2 km
- Condamine River (North Branch)—Ch 149.9 km
- Umbiram Creek unnamed tributary—Ch 184.89 km
- Half Mile Gully—Ch 190.0 km
- One Mile Gully—Ch 193.1 km
- Westbrook Creek—Ch 198.5 km
- Dry Creek—Ch 199.3 km
- Gowrie Creek.

Defined watercourses within the impact assessment area have been identified in reference to DRDMW’s Water identification map—watercourses—Queensland (2022). One unmapped water feature was noted within the current impact assessment area. The feature was an upstream reach of Pine Creek, a section of which occurred within the Turallin Facility footprint. Determination by DRDMW (in August 2023) confirmed this reach of Pine Creek as a drainage feature under the Water Act. A detailed discussion of watercourses and other drainage features that the Project intersects is provided in Chapter 13: Surface Water. An overview of watercourses relevant to groundwater resources is presented on Figure 15-3.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Map by: LUC/GN/RB/AWS Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Figure_15-3_LandUse_Watercourses_v2.mxd Date: 21/01/2025 17:25

15.5.3 Regional geology

The Project is underlain by the Jurassic- to Cretaceous-aged Surat and Clarence-Moreton basins, that overly the depositional Permo-Triassic-aged Bowen Basin at depth. The Surat and Clarence–Moreton basins are separated by the north–south trending Kumbarilla Ridge. This ridge forms a subsurface bedrock high, which the Project alignment encounters at Ch 116.5 km.

A summarised regional stratigraphic column relevant to the Project is included in Table 15-6. Where equivalent units exist for the Surat and Clarence-Moreton basins, these are shown side by side. Surface geology mapped across the groundwater impact assessment area is shown on Figure 15-4.

TABLE 15-6 SUMMARISED STRATIGRAPHIC COLUMN FOR THE PROJECT

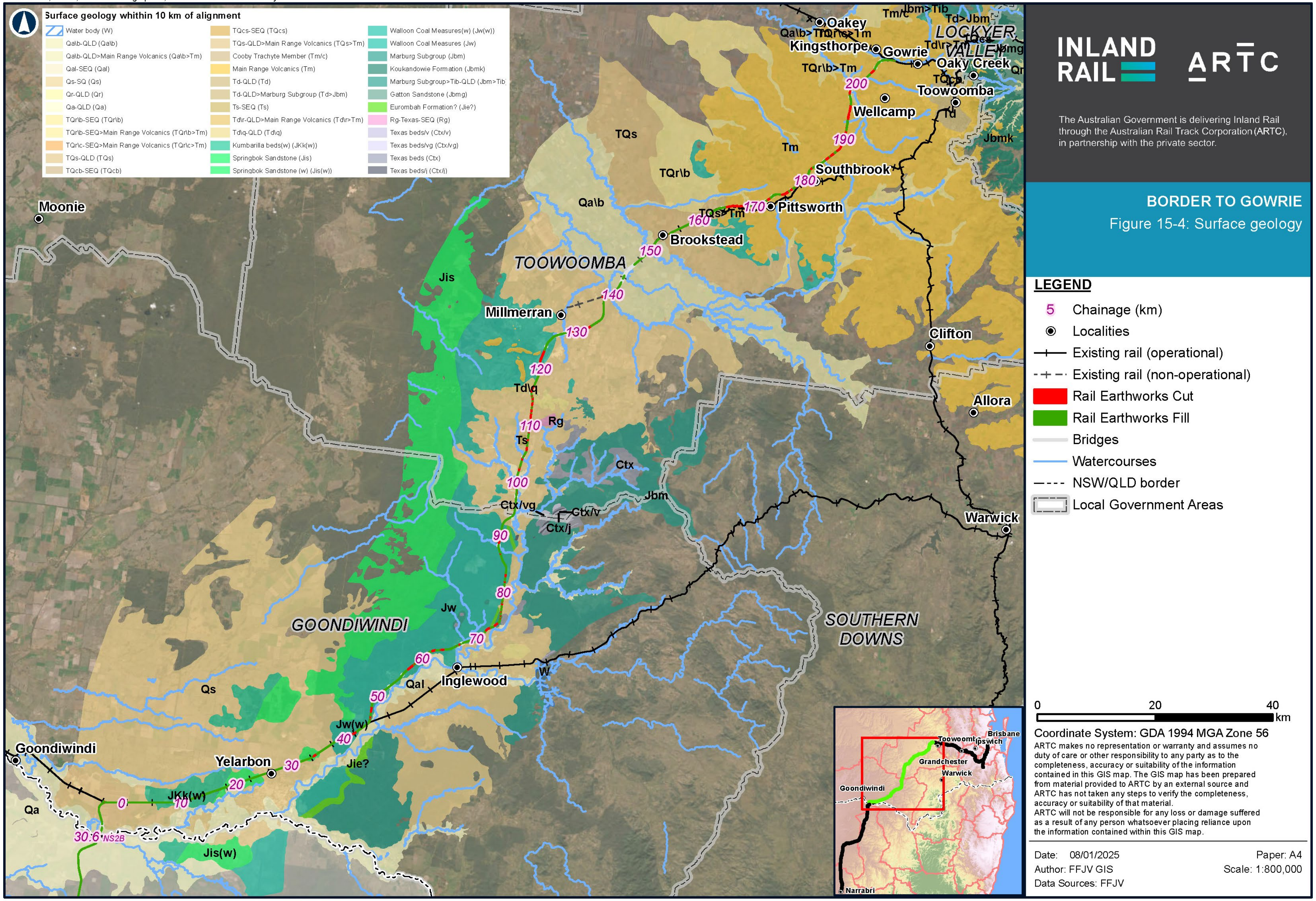
Age	Basin		Main lithology	Thickness	Extent and comments
	Surat	**Clarence-Moreton**			
Quaternary to Tertiary	Border Rivers Alluvium and Condamine Alluvium	Condamine Alluvium	Clays, silts, sands, and gravels	Border Rivers Alluvium: up to 100 m Condamine Alluvium: up to 150 m	Aquifer (water table) associated with modern river sediments, paleochannels and old alluvial fans. Clay in upper portion of both the Border Rivers and Condamine Alluvium is common. This is likely to reduce recharge via rainfall (Hillier, 2010).
Tertiary	Border Rivers Alluvium and Condamine Alluvium	Main Range Volcanics	Basalts, tuff, and agglomerate	Typically, 30 m to 150 m, highly variable (DNRM, 2016c)	Aquifer (fractured) Outcrop and sub-crop at higher elevations along the eastern portion of the rail alignment between Ch 163.0 km and Ch 208.2 km.
Cretaceous	Wallumbilla Formation*	-	Mudstone and siltstone	~ 100 m	Aquitard
	Bungil Formation	Kumbarilla Beds	Mudstone, siltstone, and carbonaceous sandstone	< 200 m	Partial aquifer
	Mooga Sandstone		Clayey sandstone, siltstone and mudstones	< 100 m	Aquifer
	Orallo Formation		Interbedded siltstone and mudstone	~ 150 to 250 m	Aquitard
	Gubberamunda Sandstone		Poorly sorted sandstone with minor conglomerates and siltstone	~100 m	Aquifer
Jurassic	Westbourne Formation		Fine-grained sandstone, interbedded with siltstone, claystone and (minor) coal	Up to 250 m	Aquiclude
	Springbok Sandstone		Porous, fine to coarse massive sandstone and conglomerate	~100 to 300 m	Aquifer
	Walloon Coal Measures	Walloon Coal Measures	Claystone, shales, sandstones and major coal seams	~ 200 to 400 m	Leaky aquitard
	Eurombah Formation		Conglomeritic sandstone, mudstone and siltstone	-	Leaky aquitard—not regionally extensive
	Hutton Sandstone	Marburg Subgroup	Porous quartz rich sandstone	120 to 180 m	Aquifer
	Evergreen Formation		Siltstone and mudstone	Average thickness is ~150 m	Aquitard

Age	Basin		Main lithology	Thickness	Extent and comments
	Surat	Clarence-Moreton			
Jurassic to Triassic	Precipice Sandstone	Ripley Road Sandstone	Medium to coarse sandstone	Up to 110 m	Aquifer
Triassic to Permian	-	Raceview Formation	Thinly interbedded, fine to medium grained sandstone, siltstone, claystone, and (minor) carbonaceous material	-	Aquitard
			Basement		

Source: Great Artesian Basin Consultative Council (1998) and DNRM (2016c)

Table note:
* Indicates stratigraphically significant unit; however, not mapped on geological mapping within groundwater impact assessment area.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Map by: LUC/GN/RB/AWS Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-4_Surface_Geology_v2.mxd Date: 8/01/2025 14:47

15.5.4 Groundwater users

15.5.4.1 Registered groundwater bores

A search of registered groundwater bores within the groundwater impact assessment area was completed in December 2023 using the DRDMW Groundwater Database and Queensland Globe. The search identified a total of 526 registered bores within the groundwater impact assessment area. Of the 526 registered bores, 197 have no aquifer, quality or bore construction attributes detailed. These 197 bores were excluded from the existing environment assessment (quality, aquifer designation, etc.) as part of the literature review and desktop assessment. These bores, along with the remaining registered bores within the groundwater impact assessment area, are shown on Figure 15-2.

15.5.4.2 Bore survey

ARTC has undertaken a bore survey of potential groundwater users (landowners) impacted by the Project footprint to confirm the location of registered bores and to establish the presence of unregistered bores. The bore survey captured landowners within the Project footprint and within 80 m of deep cuts (>10 m BGL).

The groundwater bore survey was undertaken between December 2021 to April 2022 by means of telephone, email and hard copy mail out. A total of 179 landowners were identified and invited to complete the survey. Of which, 74 surveys were completed.

The survey identified three unregistered groundwater bores within the Project footprint. The reported usage for all three bores was stock watering and domestic purposes. The locations of the unregistered bores were assessed against the predicted groundwater impacts to identify of any potential for these landowner bores to be impacted from the Project (Section 15.6.3).

Registered bores identified within the groundwater impact assessment area are discussed in Section 15.5.4.1. No unregistered bores were identified outside the Project footprint with potential to be impacted by groundwater impacts from the Project (i.e. deep cuts with potential for ongoing seepage).

15.5.4.3 Groundwater entitlements

A review of reported groundwater users from relevant aquifers of the groundwater impact assessment area was undertaken. This review is based on the Queensland water entitlements database (DRDMW, 2023c), that details the licence purpose and source aquifer for all water entitlements in Queensland. Entitlements associated with lot/plans that fall within the 1 km groundwater impact assessment area were considered and are summarised in Table 15-7 for the three water sharing plans of interest.

Analysis of water entitlements within the groundwater impact assessment area indicates that the authorised purpose ‘irrigation’ is the predominant groundwater entitlement licence purpose within the groundwater impact assessment area (entitlements associated with lot/plan that intersect the groundwater impact assessment area, noting that the actual use of the water may not be within the impact assessment area). This is followed by ‘any’, ‘stock’, ‘town water’ and ‘industrial’. In the BRA, the majority of the assigned entitlements are for supplementing surface water supplies during drought periods, which often results in only a small proportion of the groundwater allocation being used (DNRM, 2016c).

TABLE 15-7 SUMMARY OF GROUNDWATER ENTITLEMENTS WITHIN THE GROUNDWATER IMPACT ASSESSMENT AREA

Queensland Water Plan	Water source	Licenced purpose	Number of entitlements	Volume (ML/yr)
Water Plan (Border Rivers–Moonie) 2019	Border Rivers Alluvium[1] (Macintyre & Dumaresq Rivers)	Irrigation	52	3,181
		Any	6	907
		Irrigation and stock	4	451
		Industrial and commercial	6	17
		Aquaculture	1	2
Total assigned water volume within groundwater impact assessment area			**69**	**4,558**
Water Plan (Condamine and Balonne) 2019	Upper Condamine[2]	Any	303	42,712
		Productive base	4	40,128
		Irrigation and stock	167	9,762
		Town water and urban supply	6	3,411
		Commercial and industrial	5	40
		Stock intensive	7	78
		Aquaculture	1	38

Queensland Water Plan	Water source	Licenced purpose	Number of entitlements	Volume (ML/yr)
	Main Range Volcanics	Irrigation and stock	942	42,920
		Town water and urban supply	9	5,243
		Any	79	4,998
		Commercial and industrial	75	2,783
		Stock intensive	57	943
		Educational facility and irrigation	27	364
		Aquaculture	5	114
		Dairying and irrigation	7	228
		Agriculture and rural	9	198
		Amenities	9	160
Total assigned water volume within groundwater impact assessment area			**1,712**	**154,120**
Water Plan (GABORA) 2017	Balonne–Condamine and Border Rivers Basin Regions[3]	Stock intensive	119	5,124
		Irrigation	260	8,694
		Any	112	8,498
		Town water and urban supply	52	9,710
		Stock and domestic	2,041	Not defined
		Commercial and industrial	41	2,198
		Amenities	4	685
		Aquaculture	5	96
		Educational facility	13	48
		Agriculture	5	60.5
		Dairying	2	9
Total assigned water volume within groundwater impact assessment area			**2,654**	**35,667**

Table notes:
ML/yr = megalitre per year
1. Macintyre and Dumaresq River Alluvium
2. Upper Condamine Alluvium (and tributaries), Emu Creek Alluvium, Glengallan Creek Alluvium, Hodgson Creek Alluvium and Oakey Creek Alluvium
3. Bungil formation, Mooga formation, Kumbarilla beds, Springbok Sandstone, Gubberamunda Sandstone, Marburg Sandstone, and Walloon Coal Measures.

Review of each Water Plan and the Queensland Water Entitlement Viewer (available at: The Water Entitlement Viewer), accessed on 20 December 2023,was undertaken to determine total available water (unallocated) for each Water Plan for consideration:

- The Water Plan (Border Rivers and Moonie) 2019 area shows that 7,906 megalitre (ML) of unsupplemented groundwater is made available per annum and that no supplemented groundwater is shown to exist for the BRA. Unallocated groundwater is reported to be 11,887 ML per annum.
- The Water Plan (Condamine and Balonne) 2019 shows that:
  - 19,361 ML of unsupplemented groundwater is made available per annum
  - no unallocated groundwater is shown to be available.
- The Water Plan (GABORA) area shows:
  - 250 ML of unallocated groundwater (strategic reserve) exists for the Springbok Walloon groundwater unit that includes the WCM
  - no unallocated groundwater (general reserve) is shown to exist for the Toowoomba South Basalts (MRV).

15.5.5 Groundwater regime

There are four main hydrostratigraphic units present within the groundwater impact assessment area that are relevant to the Project:

- Cainozoic to recent alluvial/colluvial sediments (Quaternary/Tertiary) of shallow alluvial systems along river valleys (Border Rivers and Condamine River alluvial units)
- Tertiary MRV, fractured basalt aquifers in the eastern portion of the Project
- Jurassic- to Cretaceous-age Kumbarilla Beds
- Jurassic-age WCM.

The GAB underlies the impact assessment area, and some GAB units have potential to be sensitive to impacts from Project activities, including the WCM and the Kumbarilla Beds. While the Marburg Subgroup (equivalent of Hutton Sandstone in the Surat Basin) is a regionally significant aquifer, and a small area is mapped as an outcrop in the groundwater impact assessment area near Inglewood. Otherwise, the Hutton Sandstone is below the depth of interest for the Project (90 m; maximum design depth is 21 m BGL) and is not considered to be susceptible to impacts by the Project (Table 15-6); therefore, the Hutton Sandstone is not considered further in this assessment.

The subsections below summarise the physical and chemical aspects of the four hydrostratigraphic units that are considered susceptible to impacts in the context of their respective hydrogeological regime.

15.5.5.1 Alluvium/colluvium (Quaternary/Tertiary)

The groundwater impact assessment area is underlain by two alluvial units distinguished by their respective catchments, namely the:

- Border Rivers Alluvium (Queensland)—within the Border Rivers catchment between approximately Ch 30.60 km (NS2B) to Ch 116.4 km
- Central Condamine Alluvium (and Upper Condamine Alluvium Tributaries)—within the Condamine–Balonne catchment between approximately Ch 116.4 km to Ch 208.2 km.

In areas with colluvial sediments (in proximity to the Great Dividing Range) and alluvial deposits, these units are not distinguishable from each other, and hence discussed as one (alluvial/alluvium) unit. The characteristics of these two units are discussed below. Groundwater quality of the alluvial aquifers is summarised in Section 15.5.5.5 and groundwater users that are reliant on these units are discussed in Section 15.5.4. Further, Appendix J: Soil Assessment Report provides a more detailed breakdown of the surficial alluvial sediments.

Occurrence

In the Border Rivers catchment, groundwater is associated with alluvial sediments found along the Dumaresq and Macintyre rivers, Macintyre Brook, and Canning Creek. Much of the region is characterised by an upper and lower alluvial system containing groundwater. East of Macintyre Brook and Dumaresq River, alluvial sediments are largely confined to narrow valleys of Macintyre Brook and Canning Creek (Golder, 2019b). Collectively, these alluvial sediments are referred to the BRA.

The Quaternary CA is associated with the floodplain of the Condamine River and associated tributaries. It is incised primarily into the WCM of the Surat Basin that forms the primary bedrock to the alluvium (DNRM, 2016c). The MRV underlies the alluvium in the eastern portion of the impact assessment area.

The BRA and CA include colluvial sands and soils derived from slope wash deposition. Near the edge of valleys, the colluvium may be interfingered with alluvium and the two become difficult to distinguish. This colluvium is likely to comprise significant portions of the geological unit mapped as abandoned river terraces (Qs) on Figure 15-4. These units are distributed throughout the groundwater impact assessment area.

Recharge and discharge mechanisms

Recharge to alluvial aquifers is anticipated to occur from both rainfall and by seepage from ephemeral watercourses. Underlying units below permeable alluvium may also act as a source of recharge due to upward discharge of groundwater (Golder, 2019b) when hydraulic gradients allow (e.g. during the dry season when underlying aquifers may act as recharge).

Recharge to the CA is complex and there are differing views on the relative significance of different recharge pathways. The most common and prevalent view is that the alluvium is mainly recharged from river and stream flow leakage (39 millimetres per year (mm/year) to 115 mm/year) (DNRM, 2016b). Diffuse rainfall recharge is expected to be limited by the clay content of near-surface soils and fine-grained sheetwash deposits. On average, recharge to the CA is exceeded by outflows, the largest outflow being extraction from groundwater bores. As a result, groundwater levels in the CA have declined in many areas, by up to 25 m, over the past 60 years (DNRM, 2016c).

The dominant recharge mechanisms to the BRA include rainfall and flooding, side slope run off, and streamflow leakage (NSW Department of Planning, Industry and Environment, 2019b).

The primary discharge mechanisms from these units are extraction (bores), or as baseflow to the adjacent surface water features and local leakage into the underlying units. Evapotranspiration, from vegetation growing along the bed and banks of water features, and seepage to the underlying units from the alluvial/colluvial sediments, are also considered to be primary discharge mechanisms from these units.

Hydraulic parameters and yield

Interrogation of the DRDMW Groundwater Database reported 12 groundwater yield results from bores targeting alluvial aquifers within the groundwater impact assessment area, as shown on Figure 15-2. The yields reported for these bores ranged up to 7.1 litres per second (L/s), with an average yield of 1.6 L/s.

Hydraulic conductivity values were recorded at Project bores targeting the alluvial aquifers in 2018. Hydraulic conductivity ranged between 0.016 metres per day (m/day) and 0.35 m/day (Golder, 2019b).

Groundwater levels and flow

Border Rivers Alluvium

Records from the DRDMW Groundwater Database indicate that five registered bores within the groundwater impact assessment area are screened in the BRA aquifer but none with representative long-term groundwater level records (i.e. DNRM monitoring bores).

Four registered BRA bores with long-term groundwater level records were identified within 5 km of the Project alignment: 41640040, 41640003B, 41640039 and 41640038. These groundwater levels are displayed on Figure 15-5 in m AHD and Figure 15-6. The data shows a general decreasing trend between 1985 and 2020, with a subsequent increasing trend likely resultant from the 2021 to 2022 La Nina event.

Four Project investigation bores targeting the BRA were installed near Kurumbul 270-01-BH2213, 270-01-BH2217 and 270-01-BH2218. Project groundwater monitoring bore 310-01-BH2617, was installed in the Canning Creek Alluvium near Ch 115.5 km and exhibited a SWL of 4.8 m BGL following installation; however, that bore has since been dry for all subsequent groundwater monitoring events and subsequently decommissioned in 2023. Project groundwater monitoring bores 270-01-BH2213, 270-01-BH2217 and 270-01-BH2218 were installed in the Macintyre River alluvium in July 2018 and have exhibited average SWL (m BGL) of 9.14, 13.27 and 12.04, respectively. It is further noted, however, given the revised reference design, that bore BH2617 was no longer in a relevant location for the GMMP and was therefore decommissioned in the 2023 drilling campaign.

Groundwater flow within the BRA is inferred towards the southwest, as depicted in Figure 15-7. Groundwater elevation contours crossing the Dumaresq River and Macintyre River indicate that these rivers are losing systems, meaning they act to recharge groundwater within the alluvium.

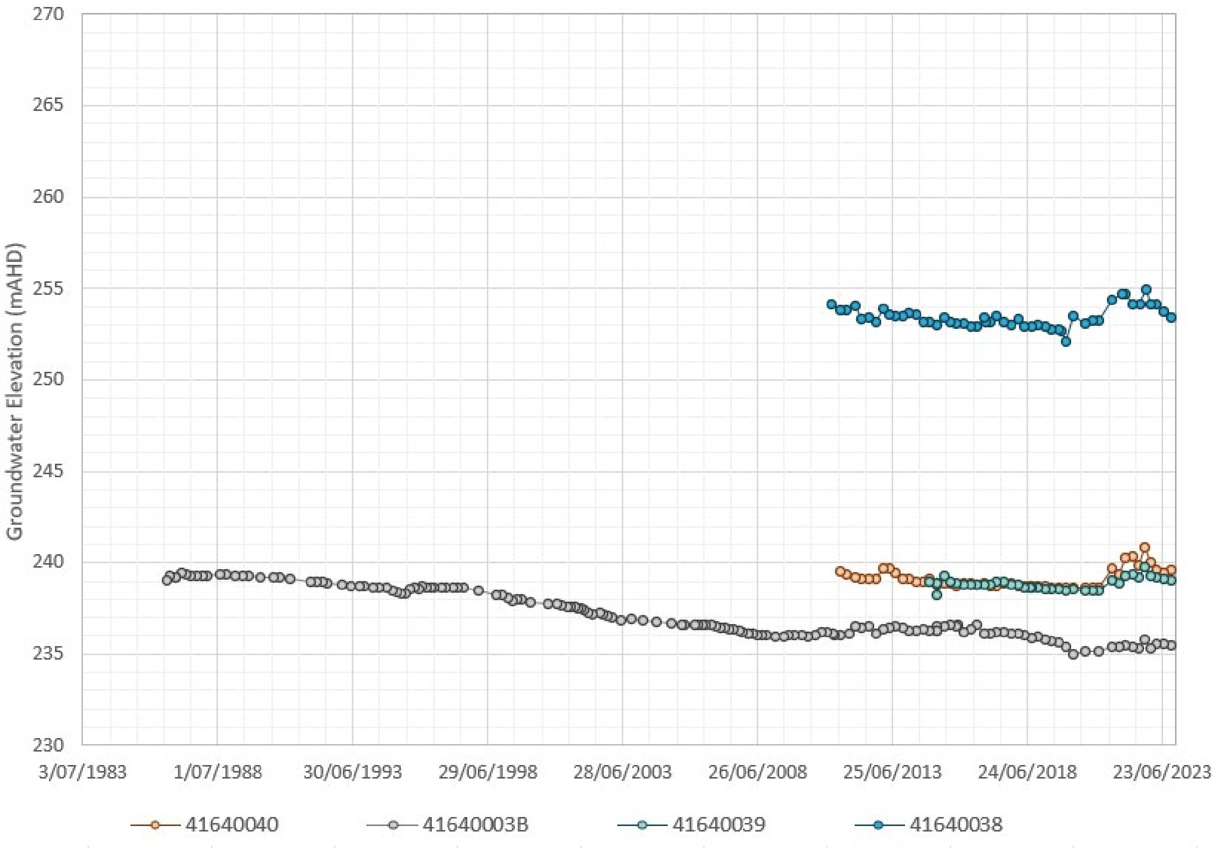


FIGURE 15-5 GROUNDWATER ELEVATION WITHIN THE BORDER RIVERS ALLUVIUM

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

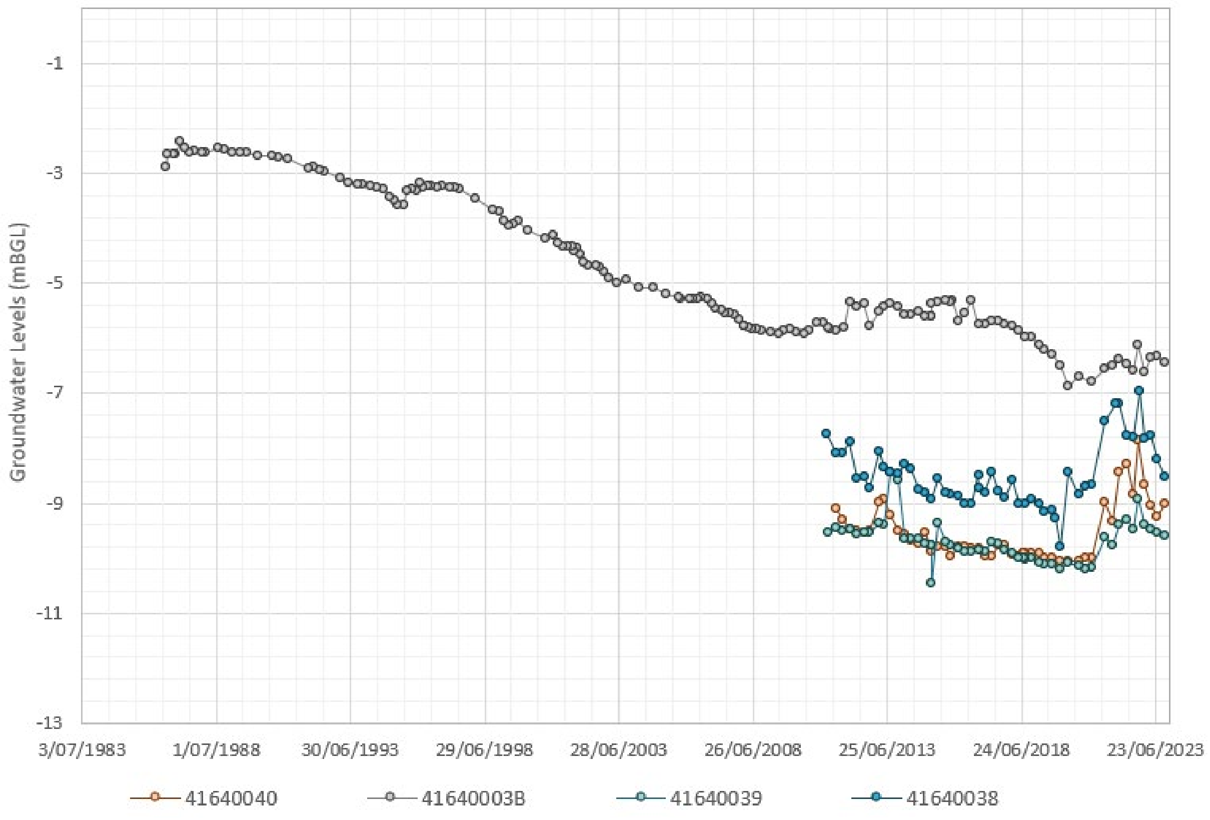


FIGURE 15-6 GROUNDWATER LEVELS WITHIN THE BORDER RIVERS ALLUVIUM

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

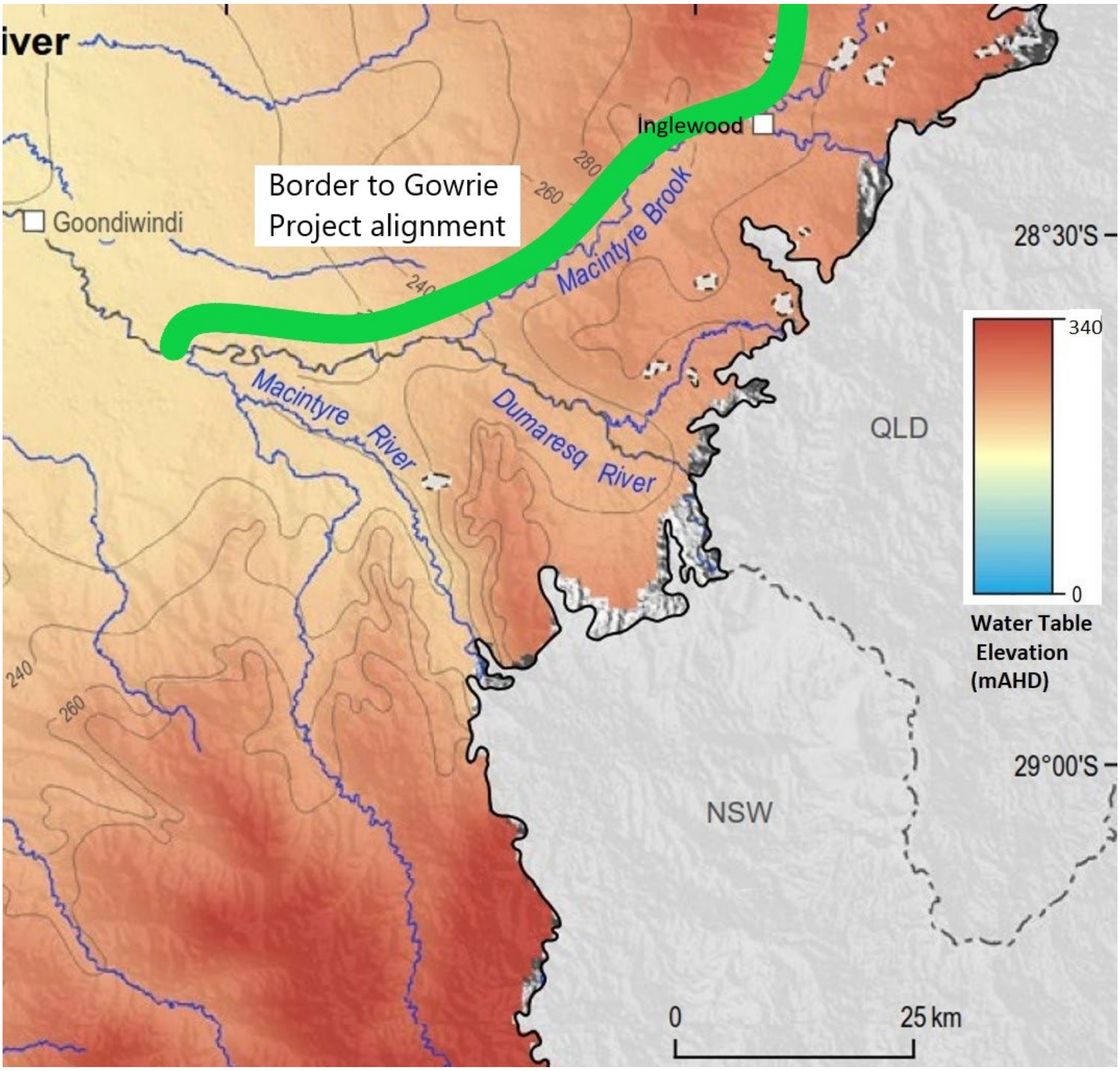


FIGURE 15-7 APPROXIMATE LOCATION OF THE PROJECT IN RELATION TO REGISTERED BORES AND THE INFERRED GROUNDWATER FLOW DIRECTION OF THE BORDER RIVERS ALLUVIUM

Source: Modified from Ransley et al. (2015)

Condamine alluvium

Records from the DRDMW Groundwater Database indicate that 85 registered bores within the groundwater impact assessment area are screened in the CA aquifer. Of the 85 registered CA bores, there are 54 with records for SWL. These levels range between 8.5 m BGL and 35.2 m BGL, with an average of approximately 18.3 m BGL.

Three CA bores have available long-term SWL records, including two nested bore sets; bores 4221378A, 42231416, 42213788, 422139B and 4221379A. Groundwater levels for the period August 1962 to January 2022 are shown on Figure 15-8 in m AHD and on Figure 15-9 in m BGL. Long-term trend analysis shows declining groundwater levels at RN4221378 and RN4221379 from commencement of monitoring to November 2009, with stabilisation following, then an increase in water level trends to current. An overall decline of ~2 m since the beginning of the monitoring period is noted at RN4221378 and RN4221379. Bore RN4221416 exhibits fluctuating level from commencement of monitoring to approximately 2009, with an increase in water levels to current.

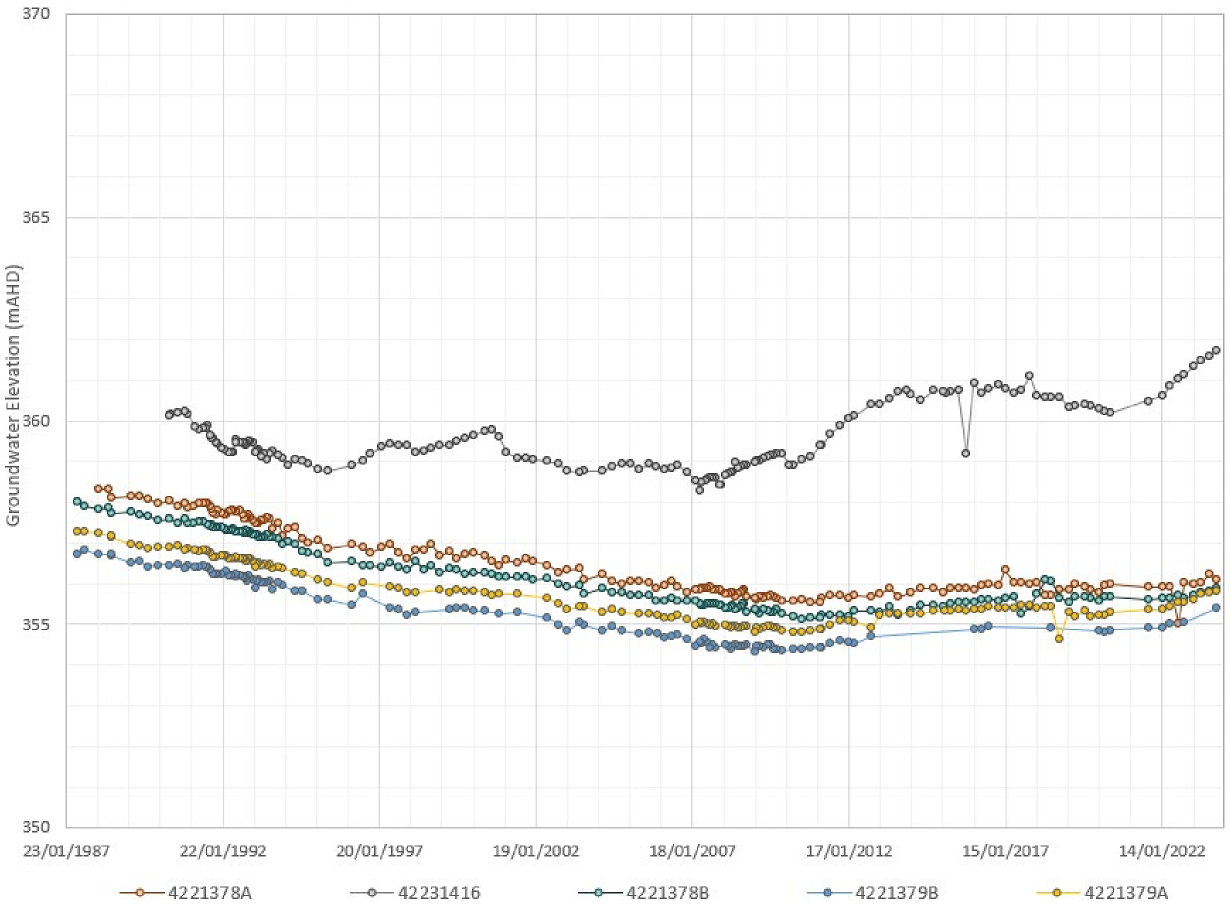


FIGURE 15-8 GROUNDWATER ELEVATION WITHIN THE CONDAMINE ALLUVIUM

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

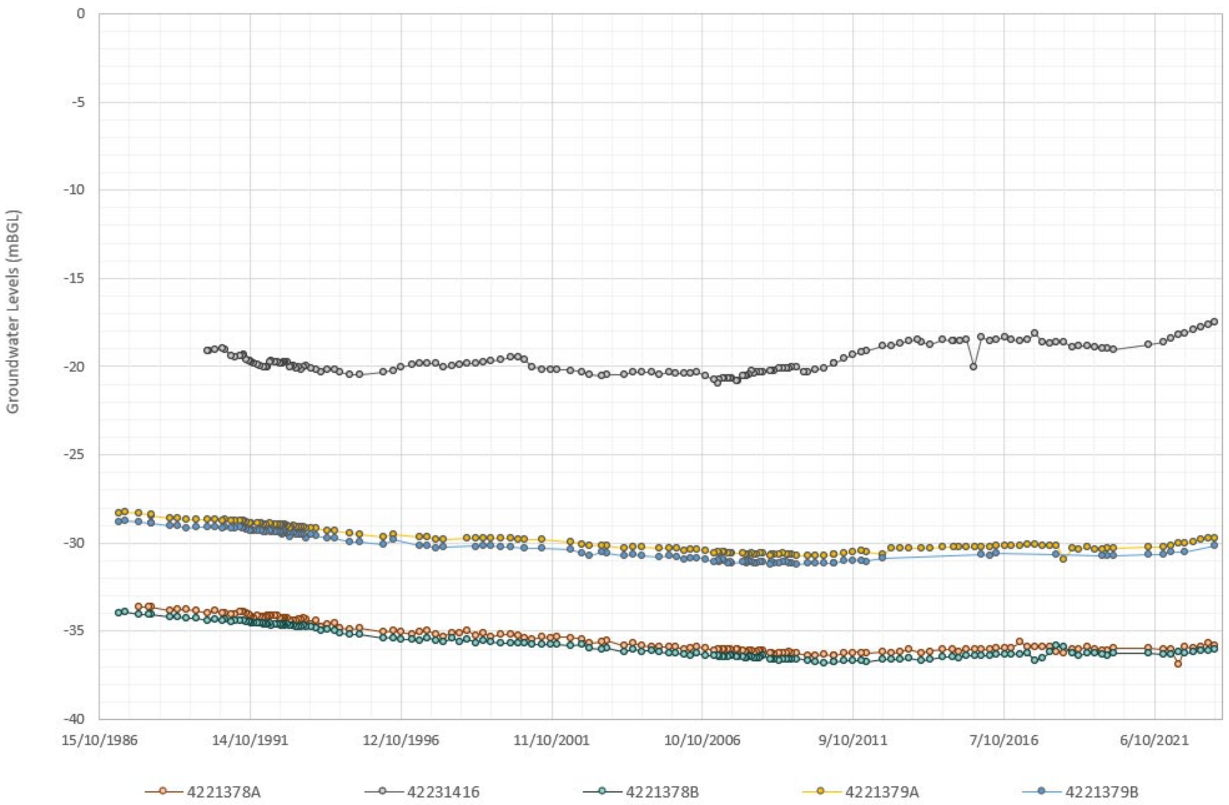


FIGURE 15-9 GROUNDWATER LEVELS WITHIN THE CONDAMINE ALLUVIUM

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

Four Project bores were installed into the CA in 2018. One bore, being 310-01-BH2231, was found to be damaged by roots in 2021 and has now been decommissioned as part of the 2023 drilling campaign. Recorded water levels in these bores have a median range of between 357.9 m AHD (310-01-BH2235) and 378.6 m AHD (310-01-BH2233) where the corresponding SWL are 23.3 m BGL and 15.1 m BGL, respectively. This range is consistent with historical water level ranges observed in registered bores within the same unit.

Groundwater flow of the CA with respect to the Project, is inferred to be north–northwest, with a local depression centred in Norwin (18 km east of Cecil Plains) inferred to be resultant from groundwater extraction (pumping) (DNRM, 2016b). This inferred direction of flow of the CA is shown in Figure 15-10.

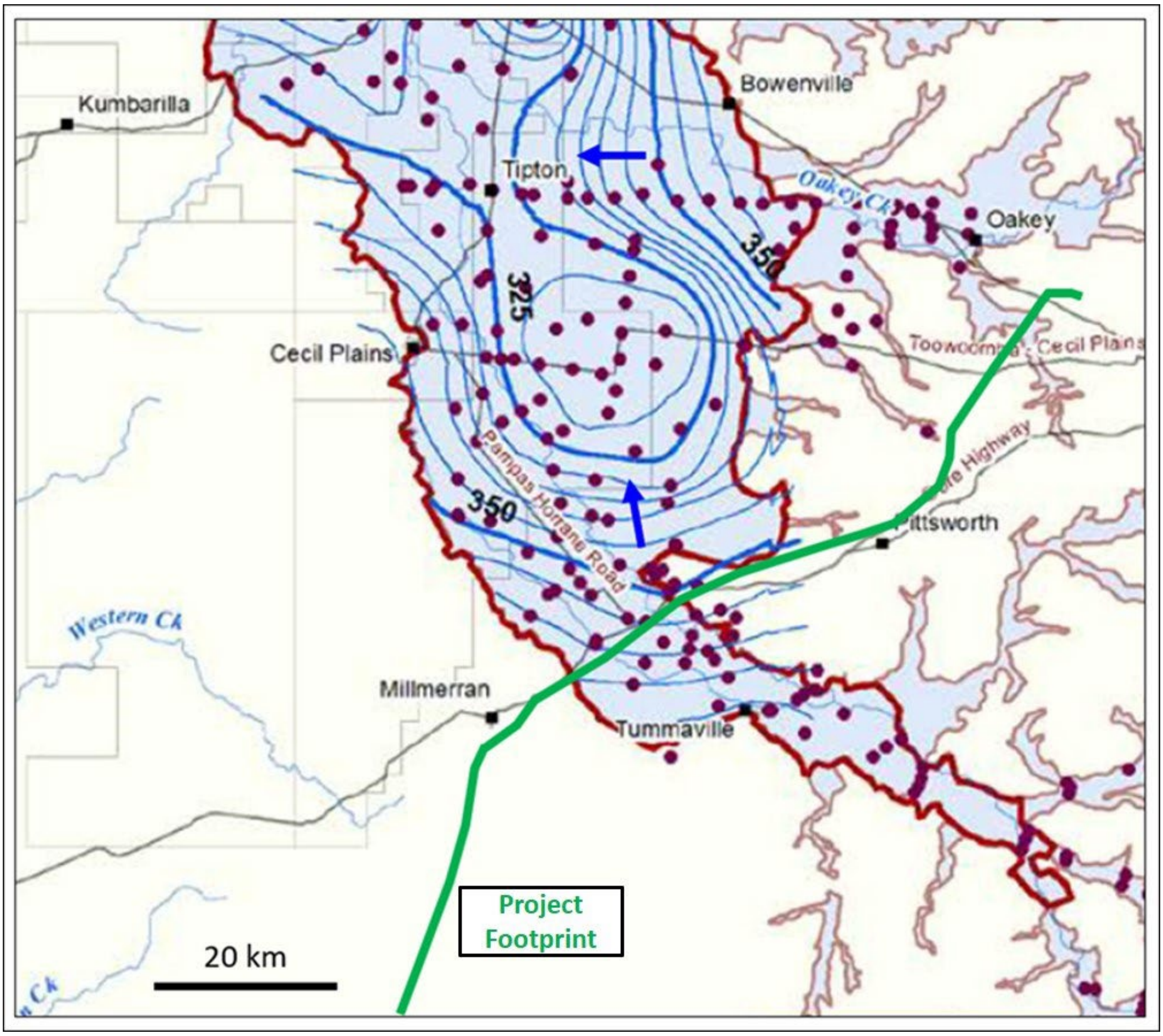


FIGURE 15-10 APPROXIMATE LOCATION OF THE PROJECT IN RELATION TO REGIONAL GROUNDWATER CONTOURS FOR THE CONDAMINE ALLUVIUM INDICATING PREDOMINANT FLOW DIRECTIONS

Source: Modified from DNRM, 2016b

15.5.5.2 Main Range Volcanics (Tertiary)

Occurrence

The MRV are located to the east and south-east of the CA and form the main geological unit that outcrops along the Project alignment between Ch 165.4 km, near Pittsworth, to Ch 208.2 km, near Kingsthorpe. The MRV is depicted as ‘Tm’ on Figure 15-4.

The MRV formation consists mainly of Oligocene–Miocene age alkaline olivine basalts, which erupted from fissures that have since become extensively eroded (DNRM, 2016b). Some portions of the formation are covered by alluvium from tributaries of the Condamine River system (i.e. Westbrook Creek near Ch 198.5 km). The thickness of the MRV is up to 150 m; however, thinner portions of the formation underlie some areas of the CA.

The MRV are comprised of primary permeability in the form of vesicular zones with secondary porosity in the form of cooling joints and fractures (DNRM, 2016c). The vesicular and weathered zones of these basalts can result in aquifer behaviour that ranges between unconfined, semi-confined or confined (DNRM, 2016c). As a result, groundwater occurrence and hydraulic properties of the MRV are inherently variable due to the nature, location, and frequency of the fractures and joints.

The MRV forms a significant productive aquifer used for irrigation, stock, and town water supplies. A total of 188 bores, from the DRDMW Groundwater Database, that fall within the groundwater impact assessment area reported with a screened section within the MRV (Figure 15-2). From these 188 bores, 174 are reported as wholly screened within the MRV; the data from these 174 bores was considered in the subsections below. Section 15.5.4 provides discussion on groundwater users that are reliant on the MRV and the availability of water from this aquifer.

Recharge and discharge mechanisms

Based on available data, recharge to the MRV occur via direct rainfall infiltration, local vertical leakage from the underlying/overlying units, and adjacent through flow from the CA where they are co-located, particularly after large rainfall events (DNRM, 2016c).

The primary discharge mechanisms are considered to include bore extraction and local vertical leakage to underlying/overlying and adjacent units as hydraulic gradients permit.

Hydraulic parameters and yield

The DRDMW Groundwater Database reported groundwater yield results from 57 MRV bores within the groundwater impact assessment area. The yields reported for the registered MRV bores ranged from 0.1 L/s to 16 L/s, with an average yield of 2.6 L/s.

Hydraulic testing (slug falling and rising head test) was conducted at one Project bore (310-01-BH2347) targeting the MRV during the reference design hydrogeological investigation. Hydraulic conductivity was reported from this slug test as 0.35 m/day based on the results from both the rising and falling head tests performed.

Literature values for transmissivity in the MRV typically range from 200 square metres per day (m^2/day) to 300 m^2/day (DNRM, 2016c). These transmissivity values correspond to horizontal hydraulic conductivity values of 2 m/day to 3 m/day for a typical MRV thickness of 100 m. The literature and Project hydrogeological investigation data indicate that the hydraulic conductivity of the MRV is highly variable, reflecting the fractured and anisotropic nature of the aquifer.

Groundwater levels and flow

Of the 174 registered MRV bores, there are 95 records for SWL. These levels range between 52 m above ground level and 64 metres m BGL, with an average of approximately 21.6 m BGL.

No registered bores screened within the MRV with available long-term water level data were identified within the groundwater impact assessment area. The search was expanded to a 5 km area of the alignment, which identified six MRV registered bores with SWL recorded through 2023, including three nested bore sets.

Representative groundwater levels from these MRV bores with long-term data are shown on Figure 15-11, in m AHD, and on Figure 15-12 in m BGL. The presented data covers the period from 1976 to 2023 and show a general declining trend up to 2007, followed by an increase up to 2011, a decrease to 2021 followed by an upward trend through 2022 and the subsequent decreasing trend post-2022 climatic events. These patterns reflect the MRV’s response to climatic (heavy rainfall and flooding) events.

Groundwater flow within the MRV is inferred to be towards the west and north-west as shown on Figure 15-13.

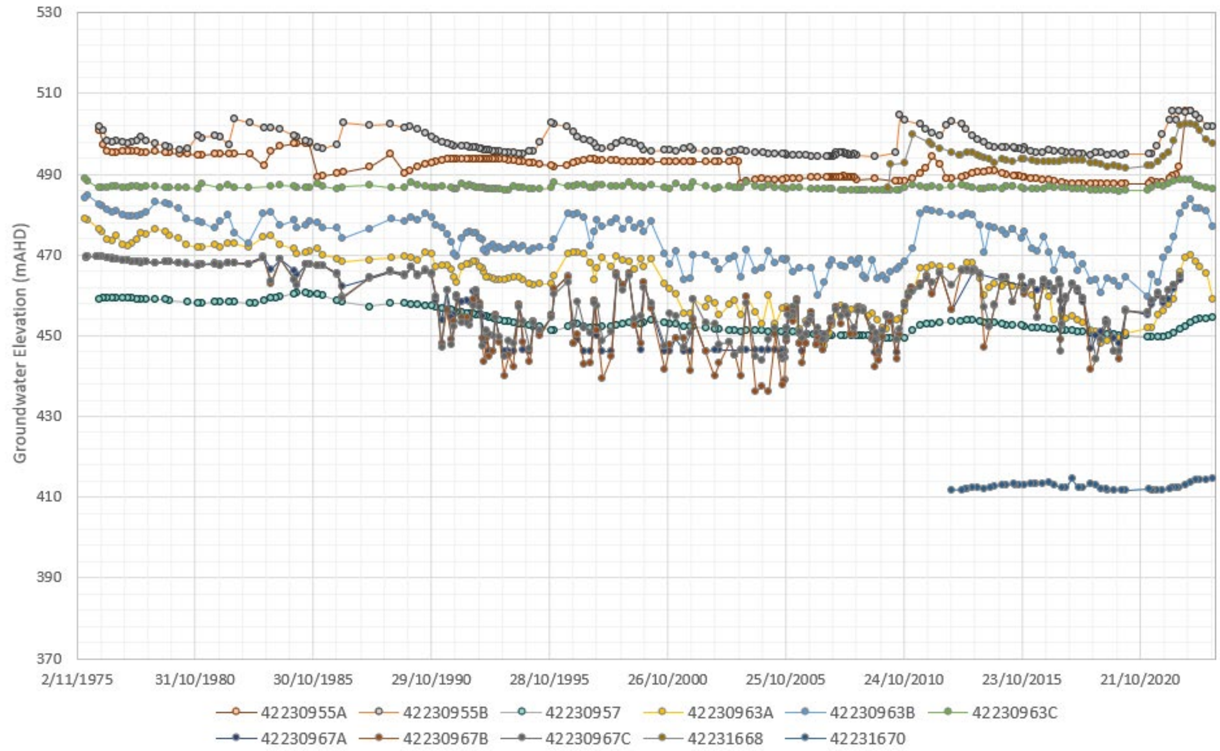


FIGURE 15-11 GROUNDWATER ELEVATION WITHIN THE MRV

Figure notes:
Water level data sourced from the DRDMW Groundwater Database December 2023.
Nested well RN42230962 is located 2.0 km east of Ch 190.0 km. Wells RN42231668 and RN4221669 are located 3.3 km east of Ch 202.0 km.

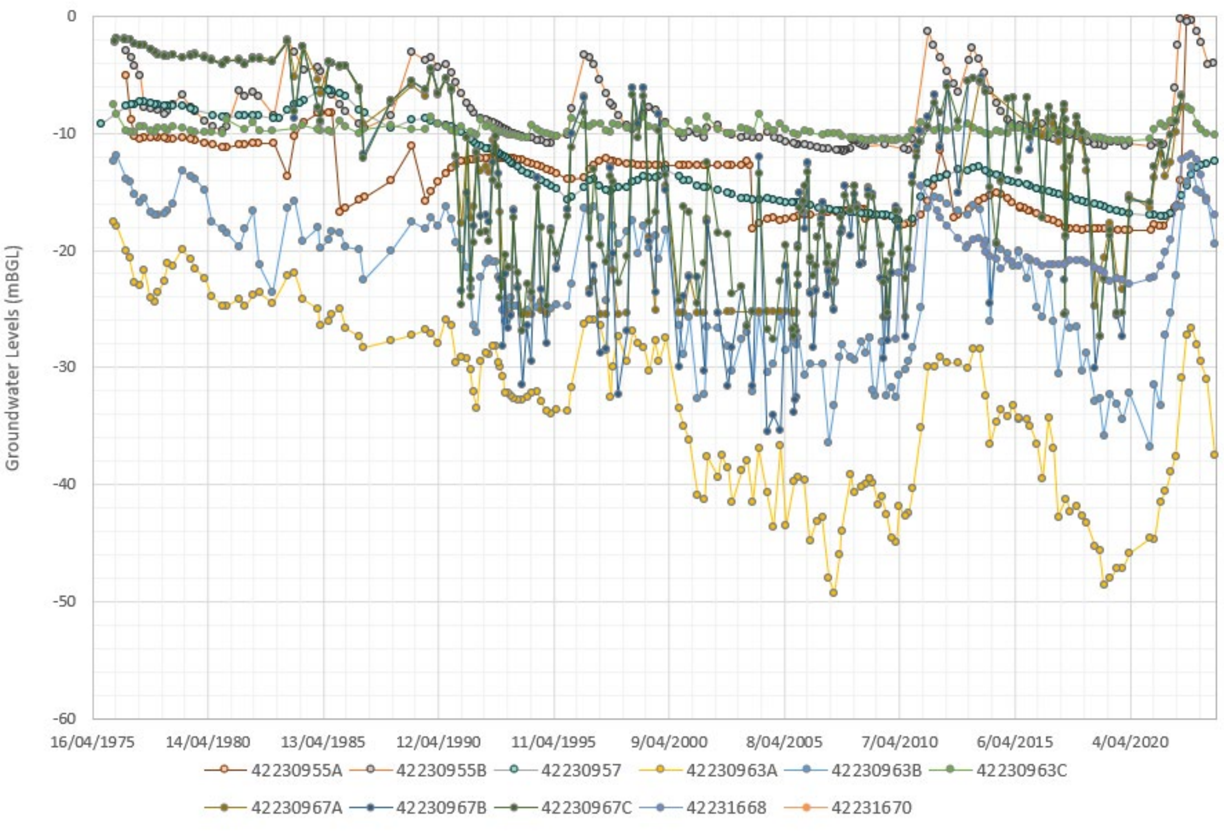


FIGURE 15-12 GROUNDWATER LEVELS WITHIN THE MRV

Figure notes:
Water level data sourced from the DRDMW Groundwater Database December 2023
Nested well RN42230962 is located 2.0 km east of Ch 190.0 km. Wells RN42231668 and RN4221669 are located 3.3 km east of Ch 202.0 km.

Five Project groundwater monitoring bores were installed targeting the MRV between Gowrie Mountain and Southbrook. Recorded levels at these bores range between approximately 426.7 and 520.8 m AHD, with a median of 513.0 m AHD, where the corresponding SWL are 22.5 m BGL and 15.1 m BGL, respectively. It's further noted, however, given the revised reference design that two bores (BH2352 and BH2355) were no longer in relevant locations and were therefore decommissioned in the 2023 drilling campaign.

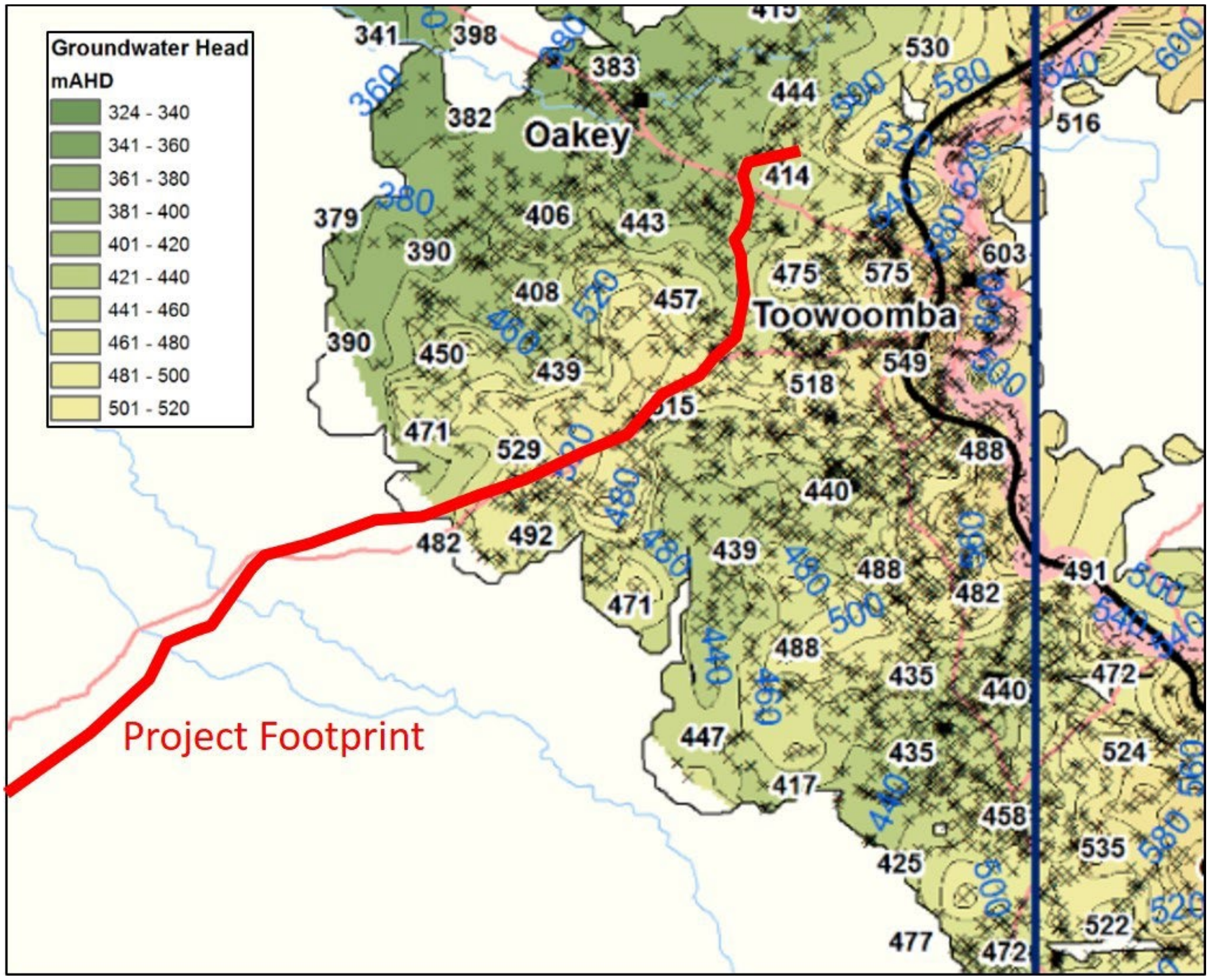


FIGURE 15-13 APPROXIMATE LOCATION OF THE PROJECT IN RELATION TO INFERRED GROUNDWATER FLOW DIRECTION OF THE MRV

Figure note: Red line is the approximate Project alignment.

15.5.5.3 Kumbarilla Beds

Occurrence

The lithology of the Kumbarilla Beds comprises sandstone, siltstone, mudstone, and some conglomerate. The formations within the Kumbarilla Beds lie unconformably (erosional contact) over the WCM and are often indistinguishable from each other in this area. The unconformity is likely the result of erosion, as scouring has been observed at the contact between the WCM and lower Springbok Sandstone unit of the Kumbarilla Beds (DNRM, 2016b).

The lower sandstones of the Kumbarilla Beds were deposited by streams flowing generally towards the centre of the basin, frequently in small channels eroded into the uppermost siltstones of the WCM, and occasionally into the coal seams (DNRM, 2016b).

The Project alignment traverses intermittent outcrop and sub-crops of the Kumbarilla Beds between approximately Ch 5.0 km and Ch 25.0 km, as shown in Figure 15-4.

Recharge and discharge mechanisms

The outcrops of the Kumbarilla Beds are likely recharged by direct infiltration of rainfall, and by seepage from ephemeral streams during periods of flow following rainfall.

Discharge mechanisms from the Kumbarilla Beds are likely to occur via seepage/through flow into the underlying and/or adjacent aquifers, evapotranspiration (primarily in sub-crop/outcrop areas), and groundwater extraction.

Hydraulic parameters and yield

Interrogation of the DRDMW Groundwater Database reported three groundwater yield results from Kumbarilla Beds bores within the groundwater impact assessment area. The yields reported for the registered Kumbarilla Beds bores ranged from 0.2 L/s to 5.5 L/s.

The DRDMW Groundwater Database has record of one pump test for a registered bore within the groundwater impact assessment area located in the Kumbarilla Beds. Transmissivity was estimated from this single pump test at 250 m^2/day (RN43148).

One variable head (slug) test near Ch 35.0 km (310-01-BH2201) was conducted within the Springbok Sandstone sub-unit of the Kumbarilla Beds during the Project hydrogeological investigations. Hydraulic conductivity was estimated from this slug test as 0.3 m/day based on the results of the test. This is consistent with the regional (literature) hydraulic conductivity data, which indicates the various units of the Kumbarilla Beds range from 3.7 x 10^{9} metres per second (m/s) (0.0003 m/day) to 8.2 x 10^{-6} m/s (0.7 /day) (Golder, 2019b).

Groundwater levels and flow

According to the DRDMW Groundwater Database, there are 12 registered bores within the specified groundwater impact assessment area that are screened in the Kumbarilla Beds. A total of 8 water levels have been recorded from these registered boreholes, between 1951 and 1993, and reveal a notable range of 2.4 m BGL to 133 m BGL.

No registered bores screened within the Kumbarilla Beds with available long-term water level data were identified within the groundwater impact assessment area. The search was expanded to a 5 km buffer of the alignment, which identified one registered bore (RN41640003) screened within the Kumbarilla Beds with SWL recorded through 2023. It is noted that review of casing and stratigraphy details for RN41640003 indicated potential for the bore to be screened across both the BRA and Kumbarilla Beds. Representative long-term groundwater levels at this bore are displayed on Figure 15-14 and Figure 15-15 for the period 1985 through 2023.

A long, gradual declining trend is apparent to 2009. After 2009, groundwater levels increased slightly then remain generally static until 2018 where they declined into 2020 followed by an upward trend into 2021. The data for bore RN41640003 demonstrates a relatively small degree of seasonal variance in water levels that reflect confinement of the aquifer.

Groundwater flow in the Kumbarilla Beds near the Project is inferred towards the west, which follows the general topographic trends in the region (University of Queensland, 2014).

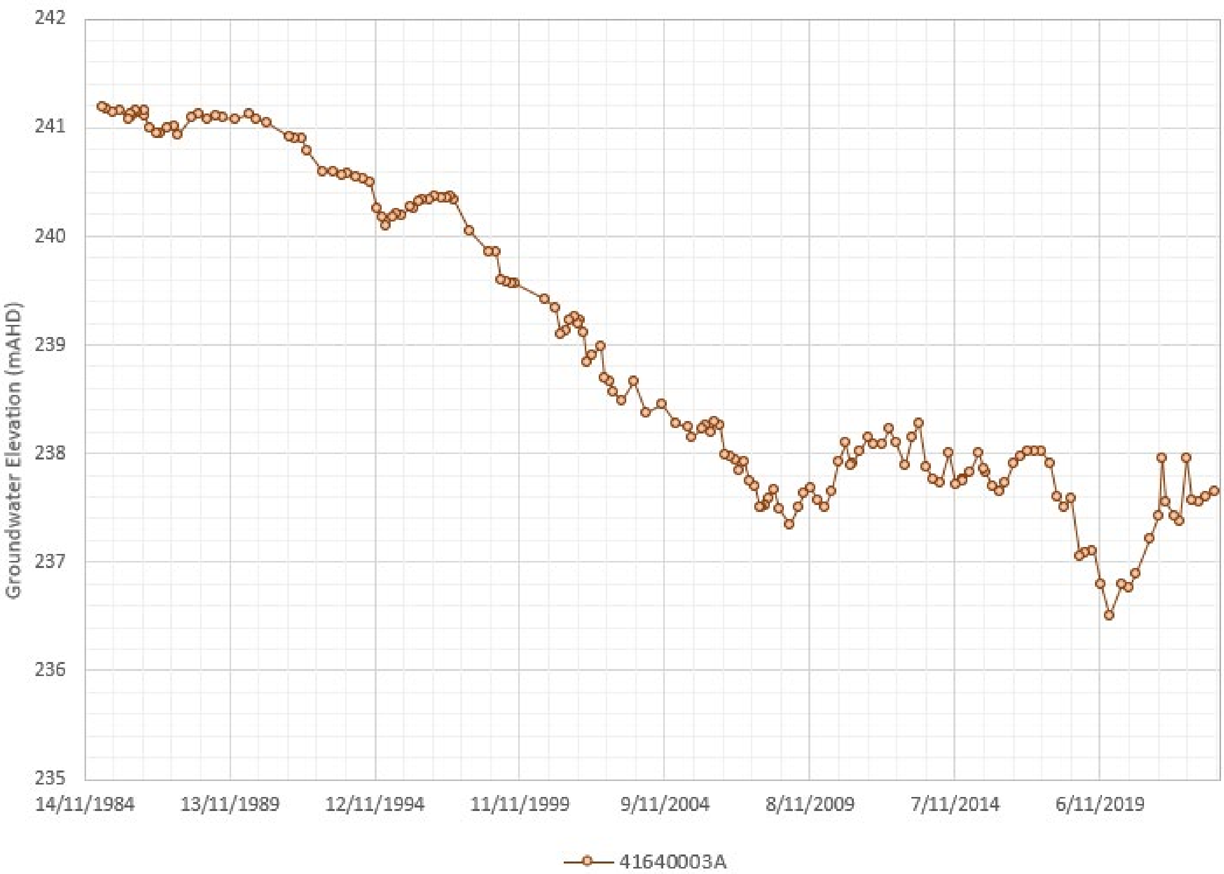


FIGURE 15-14 GROUNDWATER ELEVATION WITHIN THE KUMBARILLA BEDS

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

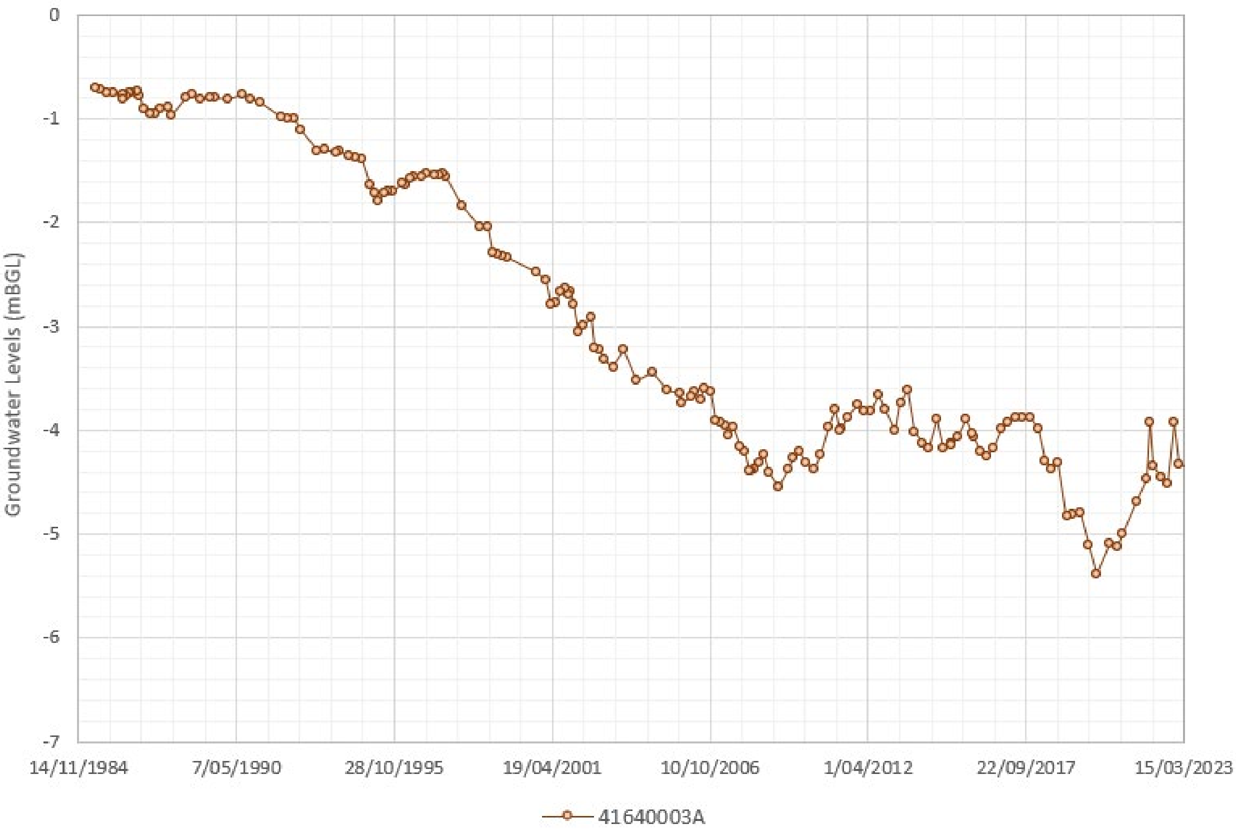


FIGURE 15-15 GROUNDWATER LEVELS WITHIN THE KUMBARILLA BEDS

Figure note: Water level data sourced from the DRDMW Groundwater Database December 2023.

15.5.5.4 Walloon Coal Measures (Jurassic)

Occurrence

The WCM are an important coal resource of the Surat Basin. The WCM comprise claystones, shales, sandstones, and coal seams of fluvial and lacustrine origin with an average total thickness of 300 m (Exon, 1976; DNRM, 2016c). The WCM are contiguous between the Surat and Clarence–Moreton basins, forming a continuous unit over the Kumbarilla Ridge, and represent a widespread episode of deposition of river, lake, swamp and marsh sediments. The formation has been either partly eroded, or exposed, over much of the eastern part of the Clarence–Moreton Basin (DNRM, 2016b).

The contact between the CA and the underlying WCM is characterised by a clay zone of undifferentiated origin, often dominated by multi-coloured clay (DNRM, 2016c). On a regional basis, the underlying WCM are considered to be an aquitard, although groundwater is extracted extensively for stock and domestic supplies where the WCM occur at shallow depth (DNRM, 2016b).

The WCM intermittently outcrop and sub-crop along the Project alignment between Ch 38.0 km and Ch 126.0 km, along the northern banks of Macintyre Brook and Canning Creek and towards Millmerran.

A review of data from the 23 registered bores within the groundwater impact assessment area in the WCM indicate bores are typically screened at depths shallower than 100 m BGL. Eleven bores established during the Project hydrogeological investigation between Ch 53.0 km and Ch 122.0 km intersected the WCM. In these locations, extremely weathered sandstone and mudstone was encountered from 2 m BGL to 20 m BGL (Golder, 2019a).

Recharge and discharge mechanisms

Recharge to the WCM is primarily through seepage from the overlying and underlying units and via direct rainfall infiltration in areas of sub-crop (DNRM, 2016c).

The primary discharge mechanisms from the WCM are considered to include bore extraction, where the WCM locally acts as an aquifer, and vertical seepage into the under and overlying units.

Hydraulic parameters and yield

The DRDMW Groundwater Database reported eight groundwater yield results from WCM bores within the groundwater impact assessment area. The yields reported for the registered WCM bores ranged from 0.2 L/s to 11.4 L/s, with an average yield of 2.7 L/s.

Nine bores were installed and screened in the WCM during the Project hydrogeological investigation. Aquifer tests, in the form of variable head tests, were completed at each bore. Hydraulic conductivity values from these tests ranged from 0.0001 m/day to 0.05 m/day. Typical literature values for the hydraulic conductivity in the WCM range from 0.00016 m/day to 0.045 m/day (DNRM, 2016c), consistent with the results obtained from testing during the Project hydrogeological investigation.

Groundwater levels and flow

Of the 23 bores reported as constructed in the WCM, 13 report SWLs that range from 1.5 to 102 m BGL, with an average of about 26.3.m BGL.

Only one registered bore screened within the WCM with long-term water level data was identified within the groundwater impact assessment area (RN42231135). The search was expanded to a 5 km buffer of the alignment, which identified two WCM registered bores with long-term SWL records for a total of three long-term data sets. Representative groundwater levels from these WCM bores are displayed on Figure 15-16, in m AHD, and Figure 15-17, in m BGL, over the period 1977 through 2023.

Time-series data shows significant variation and strong downward trend in level at RN42231135; RN42231358 also exhibits a slight decreasing trend. Conversely, bore RN42231340 shows a slight increasing trend. These water levels reflect the complex and variable hydrogeological setting of the WCM, coupled with climatic events (prolonged drought conditions, large rainfall/flood events), bore extraction, and regional depressurisation of this unit to enable resource extraction in the form of coal seam gas.

Groundwater flow in the WCM near the Condamine to Gowrie area (i.e. Ch 115.0 km to Ch 208.2 km) is generally towards the north-west; however, between Millmerran and Yelarbon, the flow direction is inferred towards the west to south-west (DNRM, 2016b). Available groundwater level data suggests that there is potential for groundwater flow from the basalts to the WCM (University of Queensland, 2014). This flow is likely exacerbated by depressurisation of the coal seams, that can induce flow from the adjacent units.

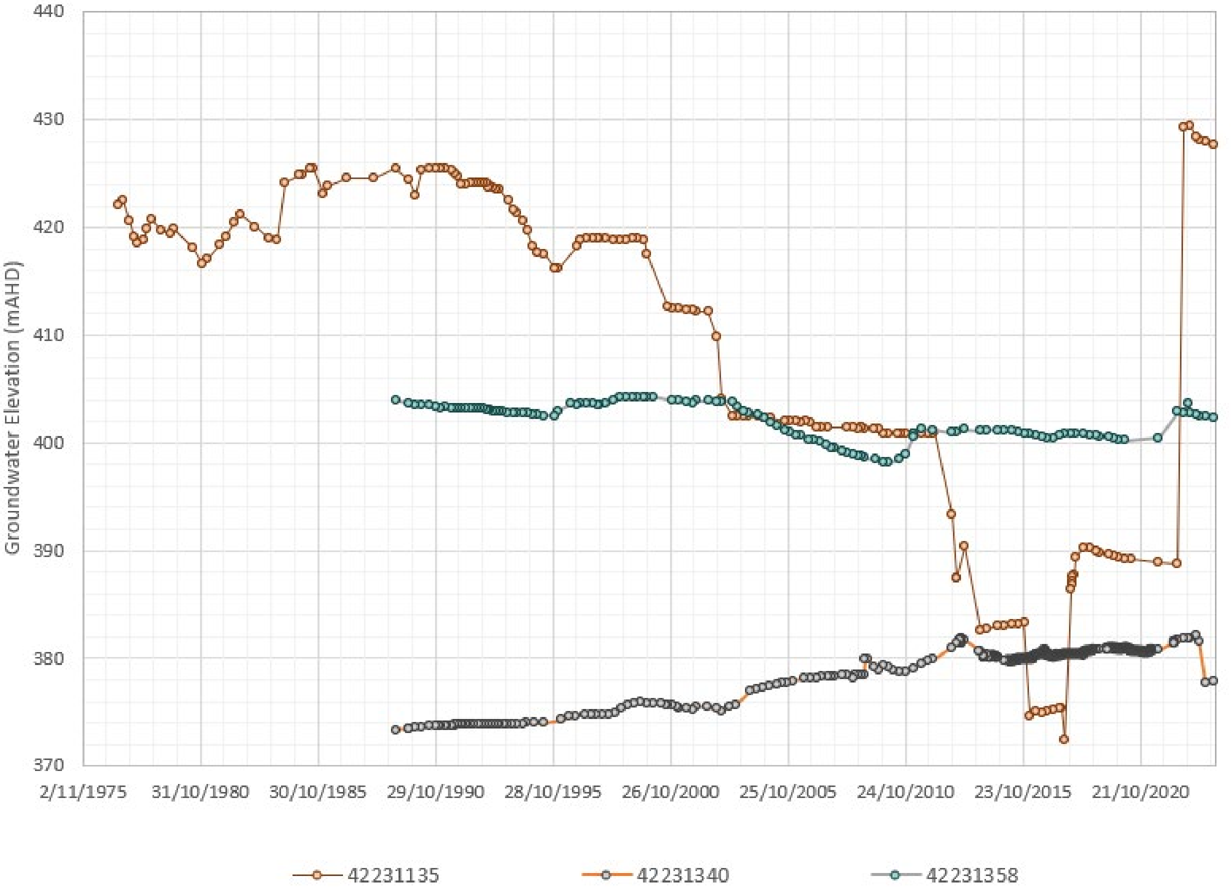


FIGURE 15-16 REPRESENTATIVE GROUNDWATER ELEVATION WITHIN THE WCM

Figure note: Water level data sourced from the DNRM Groundwater Database December 2023.

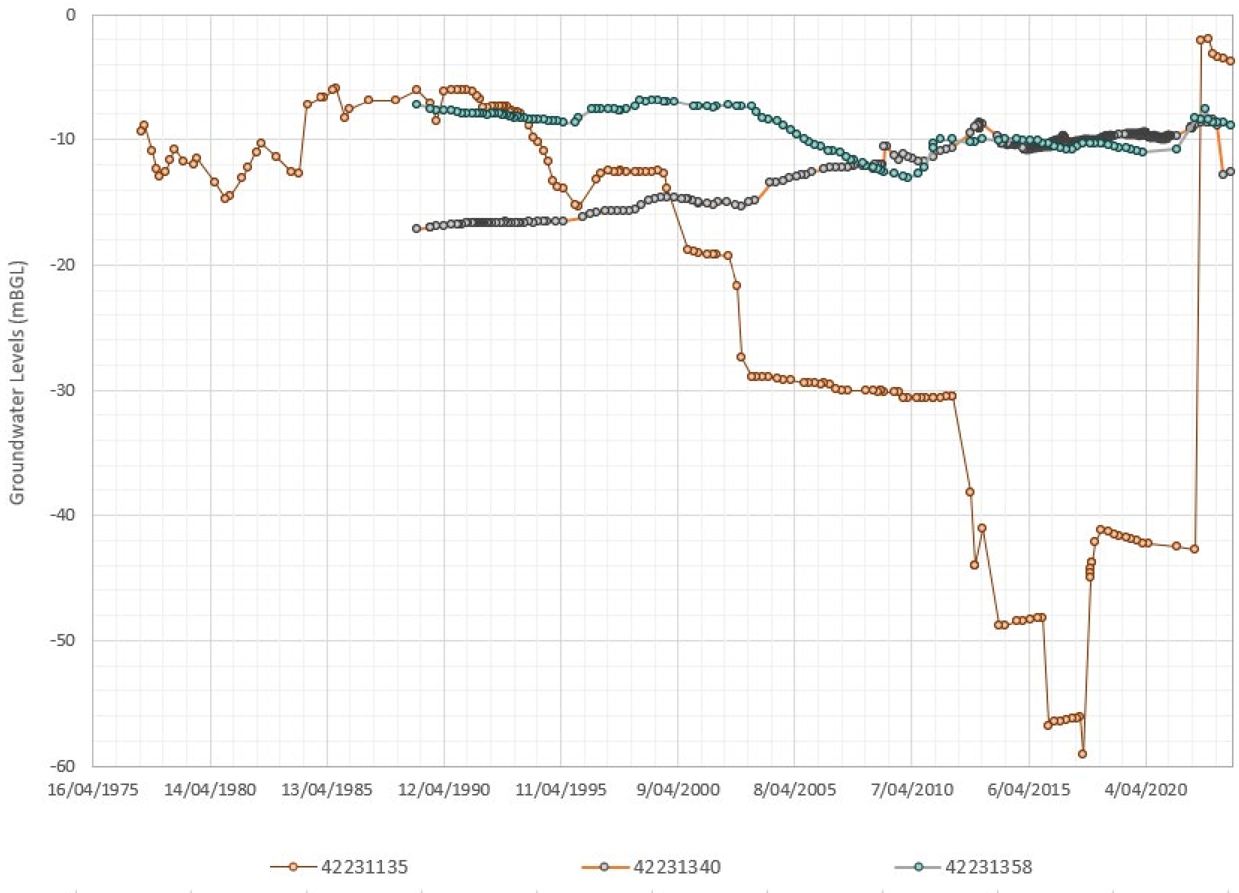


FIGURE 15-17 REPRESENTATIVE GROUNDWATER LEVELS WITHIN THE WCM

Figure note: Water level data sourced from the DNRM Groundwater Database December 2023.

Seven Project groundwater bores were installed in 2018 targeting the WCM between Bringalily and Inglewood. Recorded levels at these bores range between approximately 209.1 and 312.6 m AHD, with a median of 513.0 m AHD, where the corresponding SWL are 18.2 m BGL and 17.2 m BGL, respectively.

15.5.5.5 Groundwater chemistry

The DRDMW Groundwater Database was examined for groundwater quality data within the groundwater impact assessment area and yielded a total of 47 bores with recorded aquifer quality details. The water quality data was sorted according to aquifer type: only bores screened within alluvium, MRV or WCM were considered further. This registered bore data, together with available bore chemistry data collected for Project baseline monitoring have been considered as part of the aquifer groundwater chemistry assessment. Piper diagrams plot relative abundances of major cations and anions on adjacent tri-linear fields, with these points then being extrapolated to a central diamond field. Here, the chemical character of water, in relation to its environment, can be observed and changes in the chemistry interpreted. The cation and anion plotting points are derived by computing the percentage equivalents per million for the main diagnostic cations of Ca^{2+}, Mg^{2+} and Na^{+}/K^{+}, and anions Cl^{-}, $SO4^{2-}$, and CO_3^{2-}/HCO_3^{-}.

Waters from different environments typically plot in diagnostic areas or ‘hydrochemical facies’. The upper half of the diamond normally contains water of static environments, while the middle area normally indicates an area of dissolution and mixing. The lower triangle of this diamond shape indicates an area of dynamic and coordinated environments. Sodium chloride type (old water) normally plot in the right corner of the diamond shape while recently recharged water plots on the left corner of the diamond plot (magnesium bicarbonate type). The top corner normally indicates water with sulphate impact (gypsum).

Water chemistry, including Piper diagrams and determination of corresponding hydrochemical characteristics, is presented in the following subsections for each of the relevant aquifer units.

Border Rivers Alluvium

Available water chemistry data obtained from registered and Project bores targeting the BRA have been plotted onto a Piper diagram to determine the hydrochemical character of the aquifer (Figure 15-18). The data indicates Project bores are typically mixed type, while the registered bore is sodium bicarbonate type. Both indicate a mixed environment, typical of an alluvial aquifer that acquires its character from the hosting alluvial sediments and are subject to variable and seasonal conditions.

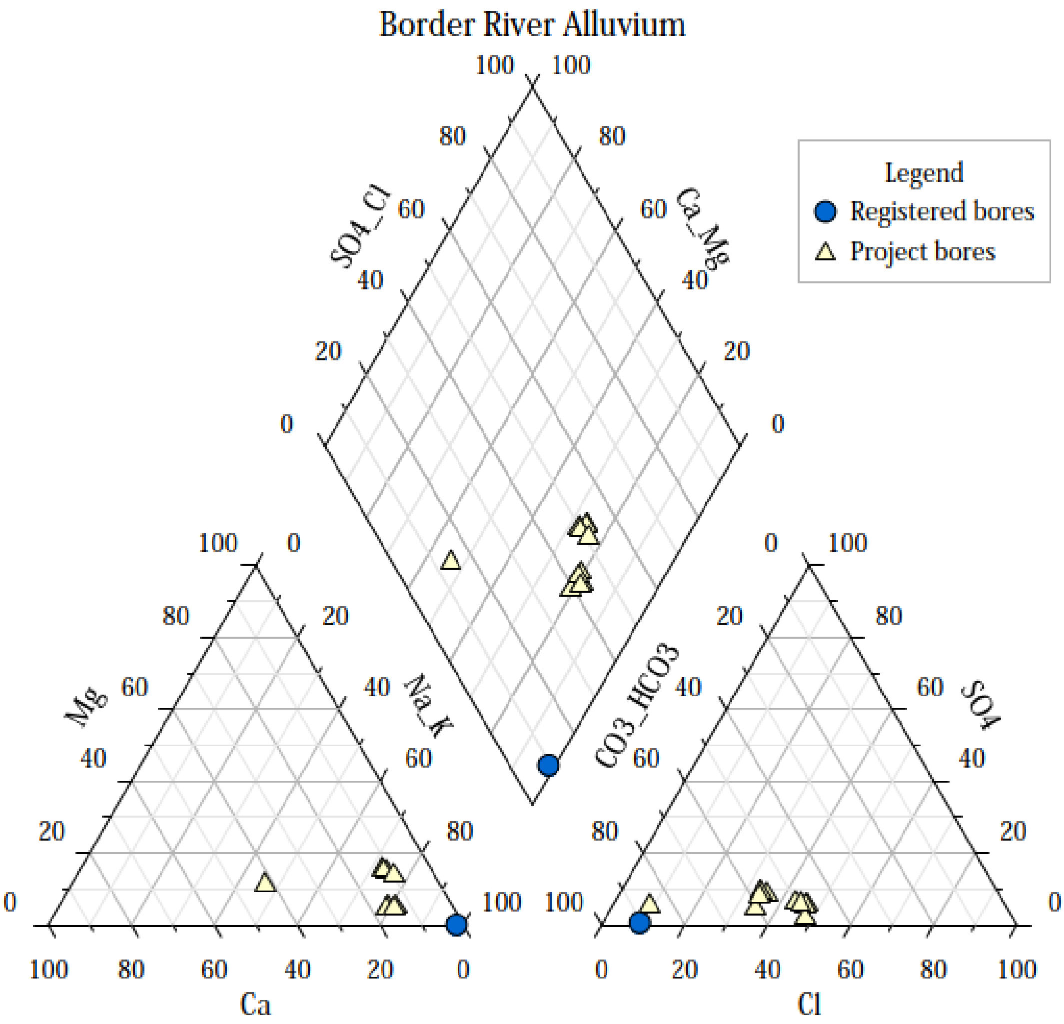


FIGURE 15-18 PIPER DIAGRAM OF RESULTS FOR GROUNDWATER COLLECTED FROM THE BORDER RIVERS ALLUVIUM

Salinity is variable in this aquifer, with EC ranging between 145 microsiemens per centimetre (µS/cm) and 1,527 µS/cm (TDS 93 parts per million (ppm) to 979 milligrams per litre (mg/L)), considered fresh (<1,000 mg/L). This suggests that certain parts of the aquifer can yield saline water and that such areas are probably further from recharge zones, which typically reflects longer residence time in the aquifer.

Condamine Alluvium

Water chemistry data from registered and Project bores targeting the CA have been plotted onto a Piper diagram to determine the hydrochemical character of the aquifer (Figure 15-19). The data points plot in a well-defined area of mixed type or sodium bicarbonate type waters, indicative of mixed environment that is typical of an alluvial aquifer.

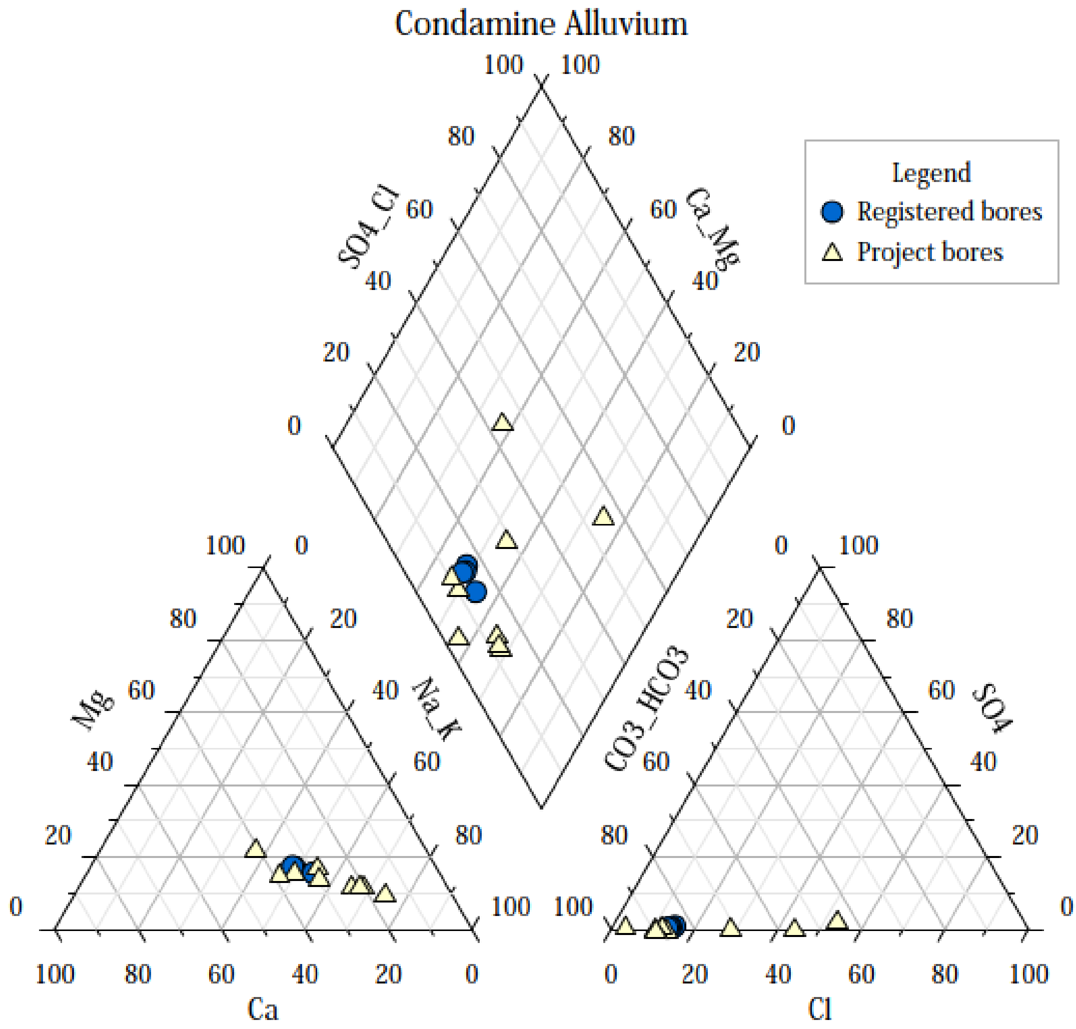


FIGURE 15-19 PIPER DIAGRAM OF RESULTS FOR GROUNDWATER COLLECTED FROM THE ALLUVIUM FROM CONDAMINE RIVER

Salinity is variable in this aquifer, with EC ranging between 192 µS/cm and 1,362 µS/cm (TDS 129 to 913 mg/L), considered to be fresh (<1,000 mg/L). This suggests that the aquifer is regularly recharged and that there is no extended residence time to facilitate water–sediment interaction (i.e. this is a typical dynamic primary aquifer system).

Main Range Volcanics

Water chemistry data from registered and Project bores targeting the MRV is plotted on Figure 15-20.The registered and Project bore data when plotted onto a Piper diagram show that water within this aquifer does not have a specific hydrochemical signature, with individual samples plotting across the diagram (rather than plotting in a cluster). The dominant cation in the majority of samples is shown to be sodium and potassium and the dominant anion is shown to be bicarbonate. The scattered nature of the samples indicates that there are multiple processes occurring in this aquifer. These processes are likely to involve recent recharge, mixing environments, and cation exchange of magnesium and calcium for sodium (Figure 15-20).

Water chemistry data from quality samples obtained from the MRV indicate EC values ranging from 183 µS/cm to 1,891 µS/cm (TDS 285 ppm to 2,950 ppm), which is considered fresh to brackish.

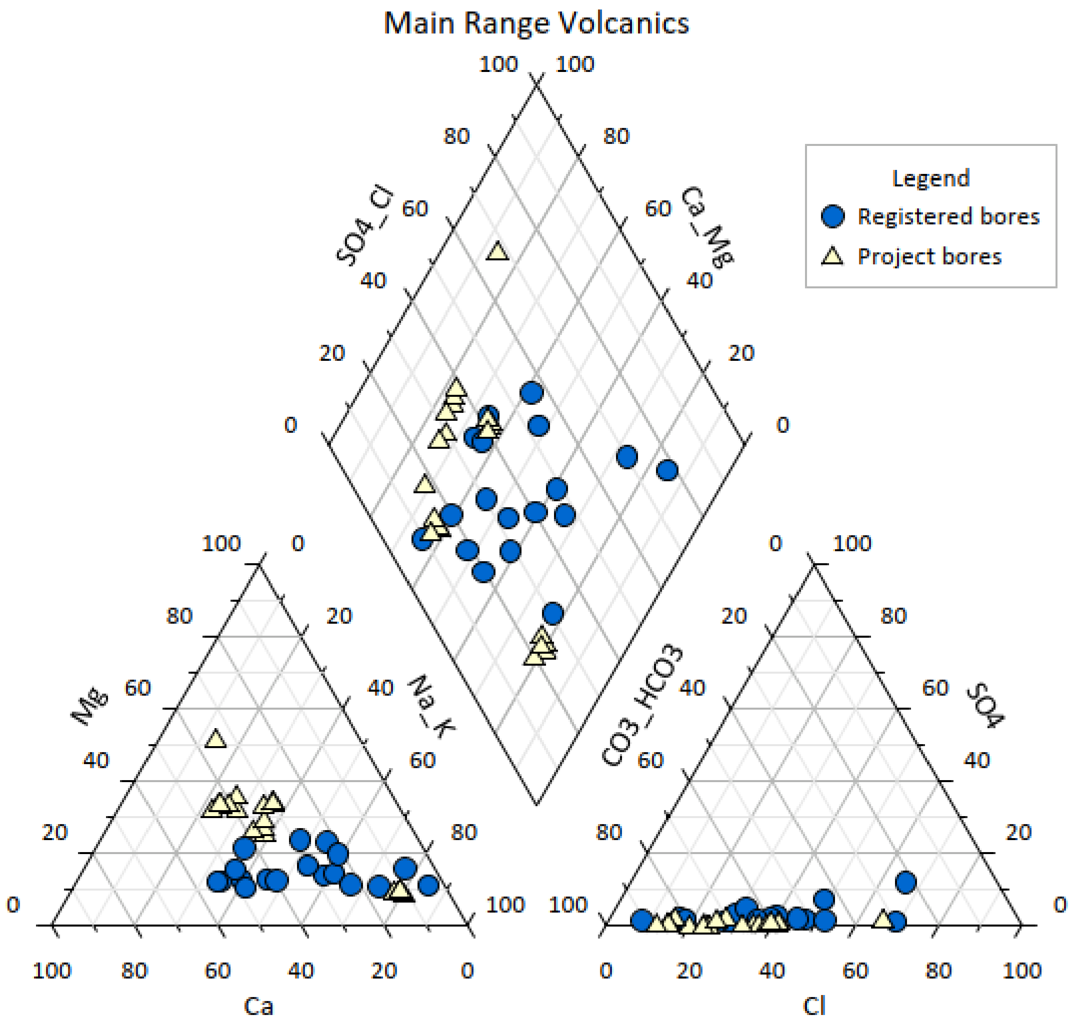


FIGURE 15-20 PIPER DIAGRAM OF RESULTS FOR GROUNDWATER SAMPLES COLLECTED FROM THE MRV AQUIFER (DRDMW GROUNDWATER DATABASE)

Walloon Coal Measures

The chemistry of the groundwater within the WCM is recognised to be highly variable due to the structure of the unit and the hydraulic connectivity (leakage) with the overlying units. Water chemistry data from registered and Project bores targeting the WCM are plotted on Figure 15-21. The data presents scattered distribution across the plot which is consistent with the known highly variable nature of the aquifer; however, the majority of data points plot as sodium chloride type, which is indicative of a longer residence time within the aquifer (old waters) and can be expected of groundwater within the WCM.

Water chemistry data from quality samples obtained from the WCM indicates EC values ranging from 178 µS/cm to 7,051 µS/cm (TDS 278 ppm to 11,000 mg/L), ranging from fresh to saline. The high variability in the dissolved salt load is also evident in the scattered distribution of data across the Piper plot.

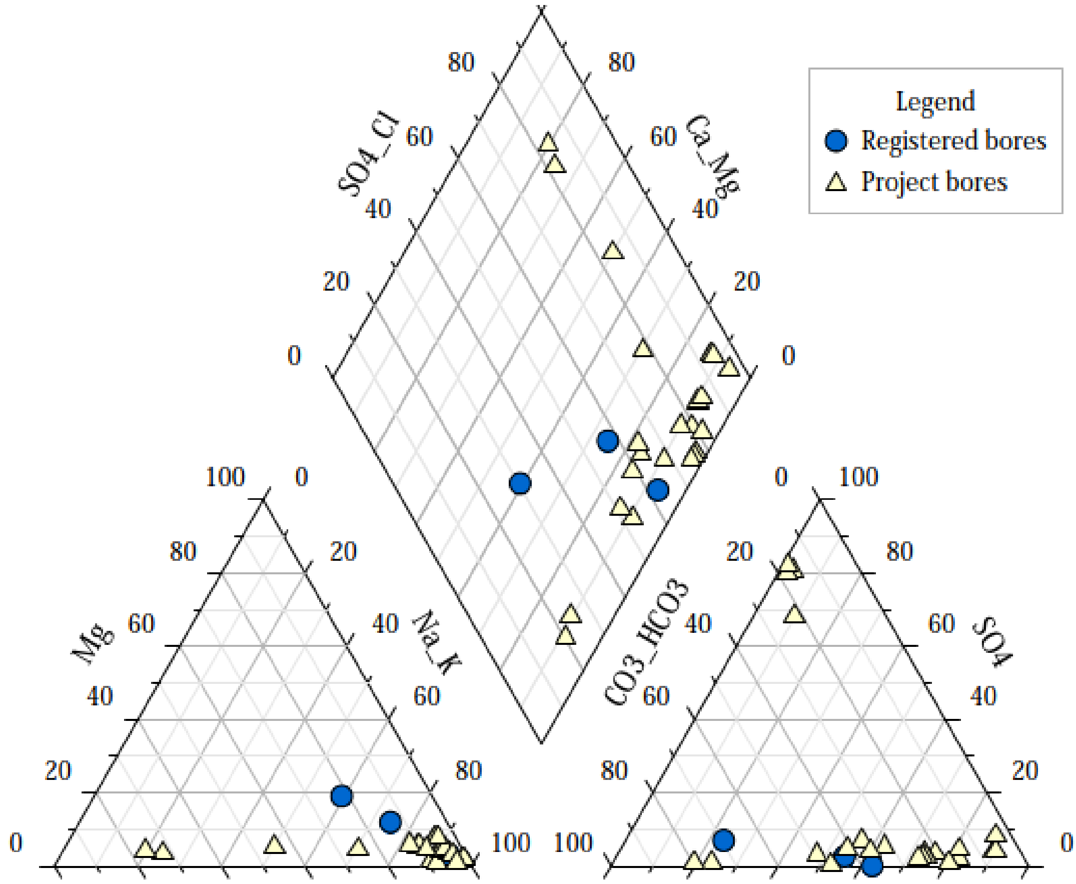


FIGURE 15-21 PIPER DIAGRAM OF RESULTS FOR GROUNDWATER SAMPLES COLLECTED FROM THE WCM AQUIFER

Regional salinity

Salinity is a major land degradation issue that can impact on land productivity, in-stream salt loads and concentrations. Two salinity risk assessments have previously been undertaken within the groundwater impact assessment area. The Murray Darling region salinity risk assessment intersects the groundwater impact assessment area between the Macintyre River and east of Millmerran State Forest (Biggs et al., 2010b). The Condamine Catchment salinity risk assessment intersects the groundwater impact assessment area from east of Millmerran State Forest to Gowrie (Searle et al., 2007).

The Murray Darling region salinity risk assessment identified 58 known salinity expression areas affected by secondary salinity, including the Yelarbon Desert in the Border Rivers catchment. The Yelarbon area is known for its extremely alkaline, sodic sodosol soils strongly attributed to upwelling of sodium bicarbonate rich groundwater (Biggs et al., 2010b). This upwelling is primarily attributed to an offset fault from the Peel Fault, which allows saline groundwater to infiltrate the soil zone (Knight et al., 1989). The Peel Fault is discussed in further detail in Appendix U: Groundwater Technical Report.

Within the Border Rivers catchment, the salinity risk assessment identified the use of saline groundwater for land irrigation, leaking dams, and dissolution of salts as the most common secondary salinity sources. Despite the need for greater research regarding secondary salinity formation and the impact of salinity on infrastructure assets, the risk assessment concluded salinity in the region will have a low risk to rail infrastructure (Biggs et al., 2010b).

The Condamine Catchment salinity risk assessment identified more than 170 salinity expression sites, with most influenced by climatic conditions. The assessment identified return to typical long-term weather patterns will likely increase the size and number of dryland salinity expressions in the region and increase salt load exported from the catchment. The groundwater impact assessment area intersected sub-catchments considered to contain a very-low-to-high overall salinity risk. The Millmerran area was considered to have a very low to low risk of secondary salinity, while the Pittsworth and Gowrie areas were considered to have moderate risk. An area of high salinity risk intersects the groundwater impact assessment area near Southbrook and presents a ‘current’ threat, through salinity, to infrastructure assets in the area (Searle et al., 2007).

Further details on the salinity risk within the Project footprint are provided in Chapter 9: Land Resources and Appendix J: Soil Assessment Report.

15.5.6 Groundwater dependent ecosystems

Groundwater plays an important role in sustaining aquatic and terrestrial ecosystems, such as springs, wetlands, rivers and vegetation. Understanding these GDEs is essential for groundwater management and planning.

The BoM has developed a Groundwater Dependent Ecosystems Atlas (GDE Atlas) as a national dataset of Australian GDEs and potential GDEs. The GDE Atlas contains information about three types of ecosystems:

- **Aquatic** ecosystems that rely on the surface expression of groundwater—this includes surface water ecosystems that may have a groundwater component, such as rivers, wetlands, and springs. Marine and estuarine ecosystems can also be groundwater dependent but these are not mapped in the Atlas
- **Terrestrial** ecosystems that rely on the subsurface presence of groundwater—this includes all vegetation ecosystems
- **Subterranean** ecosystems—this includes cave, karst, and aquifer ecosystems. No subterranean GDEs have been mapped within 5 km of the groundwater impact assessment area.

The sections below summarise mapped potential aquatic and terrestrial GDEs within the groundwater impact assessment area. The groundwater impact assessment area for GDEs was expanded to 5 km from the Project as a conservative approach.

Additional details on GDEs identified within the groundwater impact assessment area, in relation to ecological function and surface water quality are discussed in Chapter 11: Flora and Fauna and Chapter 13: Surface Water, respectively.

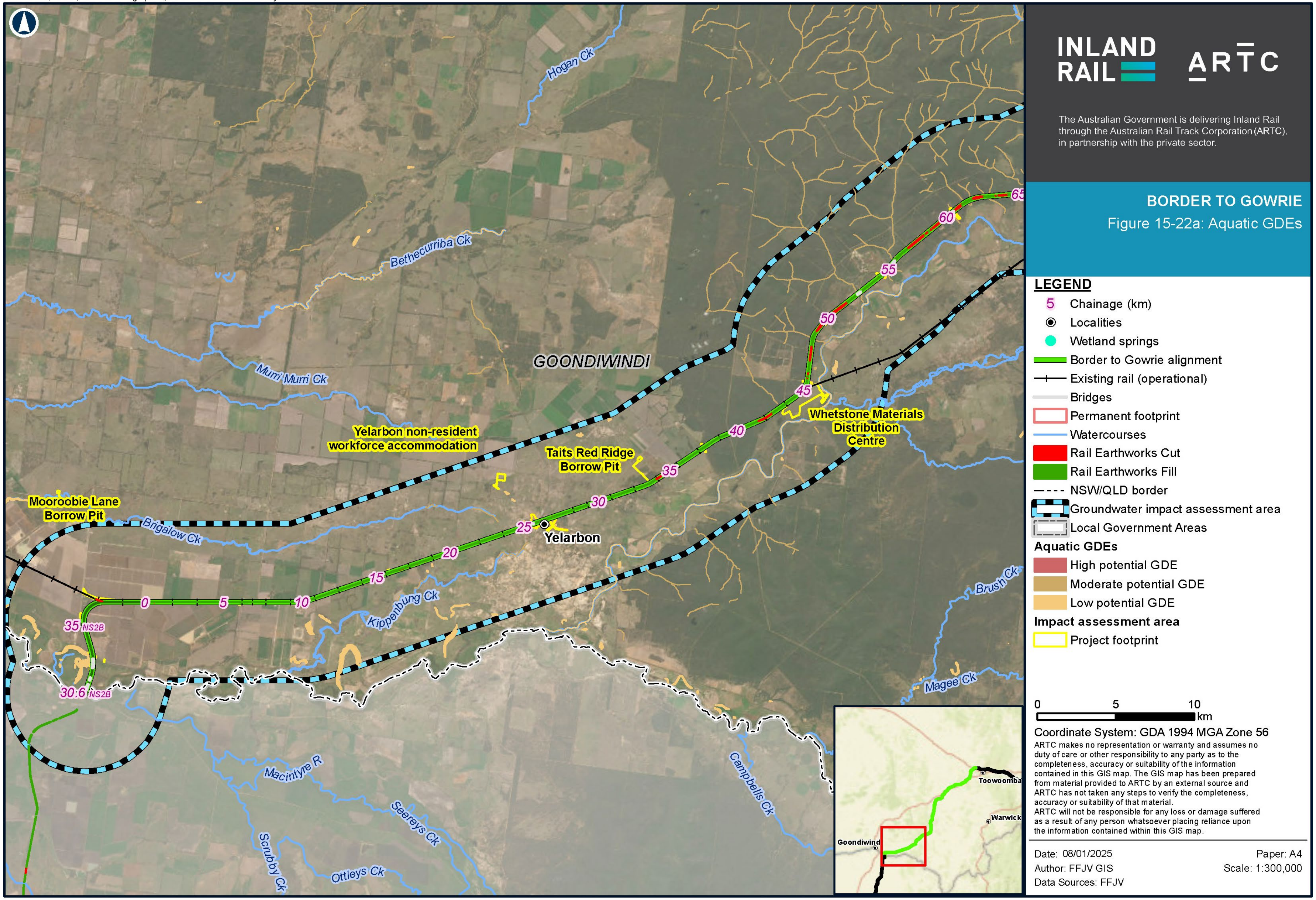
15.5.6.1 Aquatic groundwater dependent ecosystems

The GDE Atlas indicates that there are no high potential aquatic GDEs located within 5 km of the Project footprint. Areas where potential aquatic GDEs are identified within 5 km include:

- Between NS2B Ch 30.6 km and Ch 20.0 km the Project passes numerous low potential aquatic GDE associated the Macintyre River and associated tributaries
- Between Ch 40.0 km and Ch 95.0 km, the Project crosses numerous unnamed tributaries associated with Macintyre Brook and Canning Creek. These drainage features have been assigned a moderate aquatic GDE potential.
- Unnamed creeks and tributaries between Ch 115.0 km to Ch 125.0 km (southwest of Millmerran) are inferred to be associated with Bora Creek, located east of the groundwater impact assessment area, have been assigned a moderate potential for aquatic GDEs
- The Condamine River, which the Project alignment crosses near Ch 139.5 km, is considered to have a low potential for aquatic GDEs. The Condamine River North branch is not considered to support aquatic GDEs.
- Low-to-moderate potential for aquatic GDEs are mapped between Ch 165.0 km to Ch 185.0 km
- Low-to-moderate potential for aquatic GDEs are mapped between Ch 197.0 km and Ch 200.0 km, referred to be associated with Gowrie Creek.

The location of potential aquatic GDEs in relation to the Project footprint and groundwater assessment area are shown on Figure 15-22.

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Coordinate System: GDA 1994 MGA Zone 56

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Author: FFJV GIS
Scale: 1:300,000
Data Sources: FFJV

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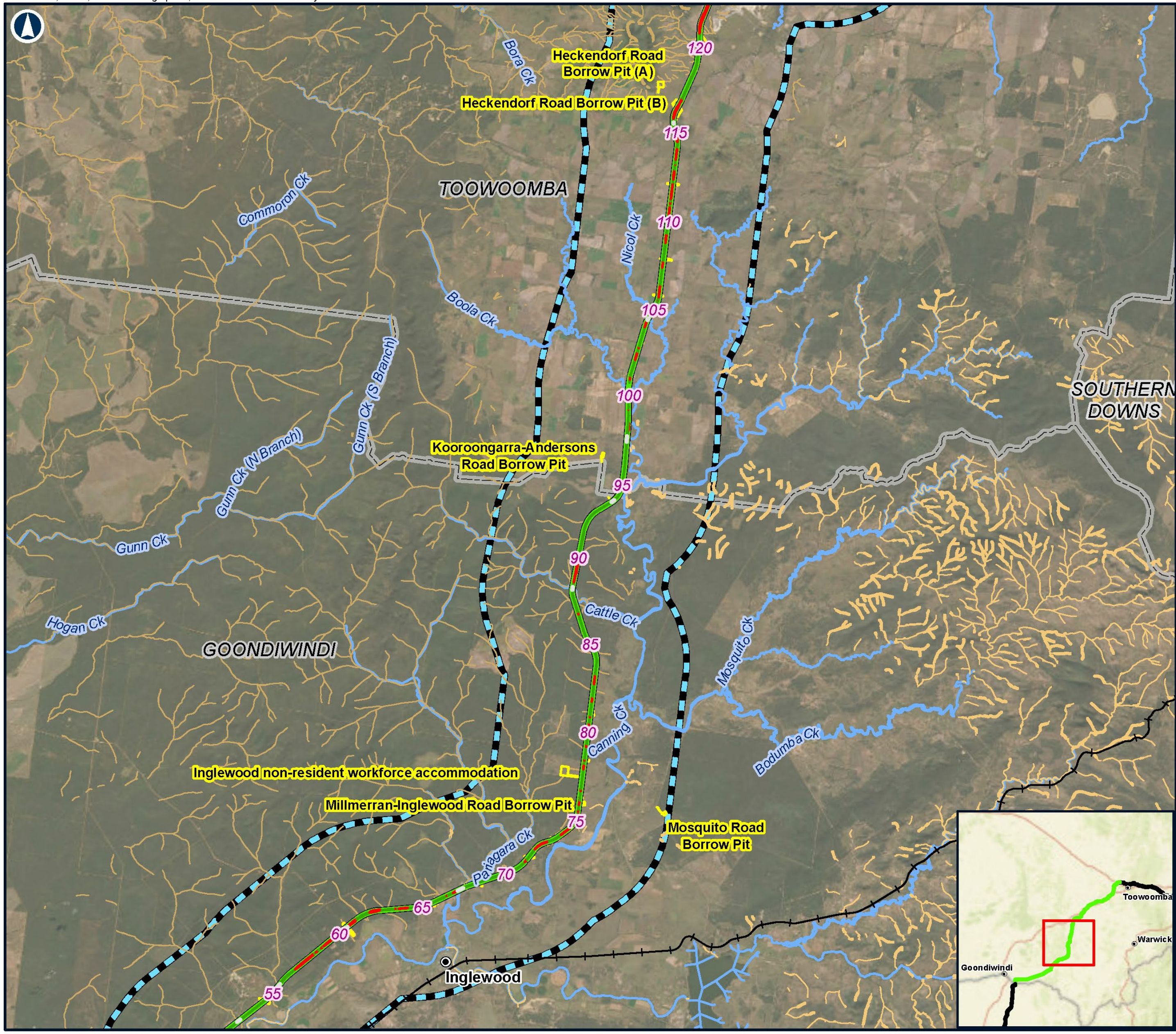

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BORDER TO GOWRIE

Figure 15-22b: Aquatic GDEs

LEGEND

- 5 Chainage (km)
- Localities
- Wetland springs
- Border to Gowrie alignment
- Existing rail (operational)
- Bridges
- Permanent footprint
- Watercourses
- Rail Earthworks Cut
- Rail Earthworks Fill
- Groundwater impact assessment area
- Local Government Areas

Aquatic GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Impact assessment area

- Project footprint

0 5 10 km

Coordinate System: GDA 1994 MGA Zone 56

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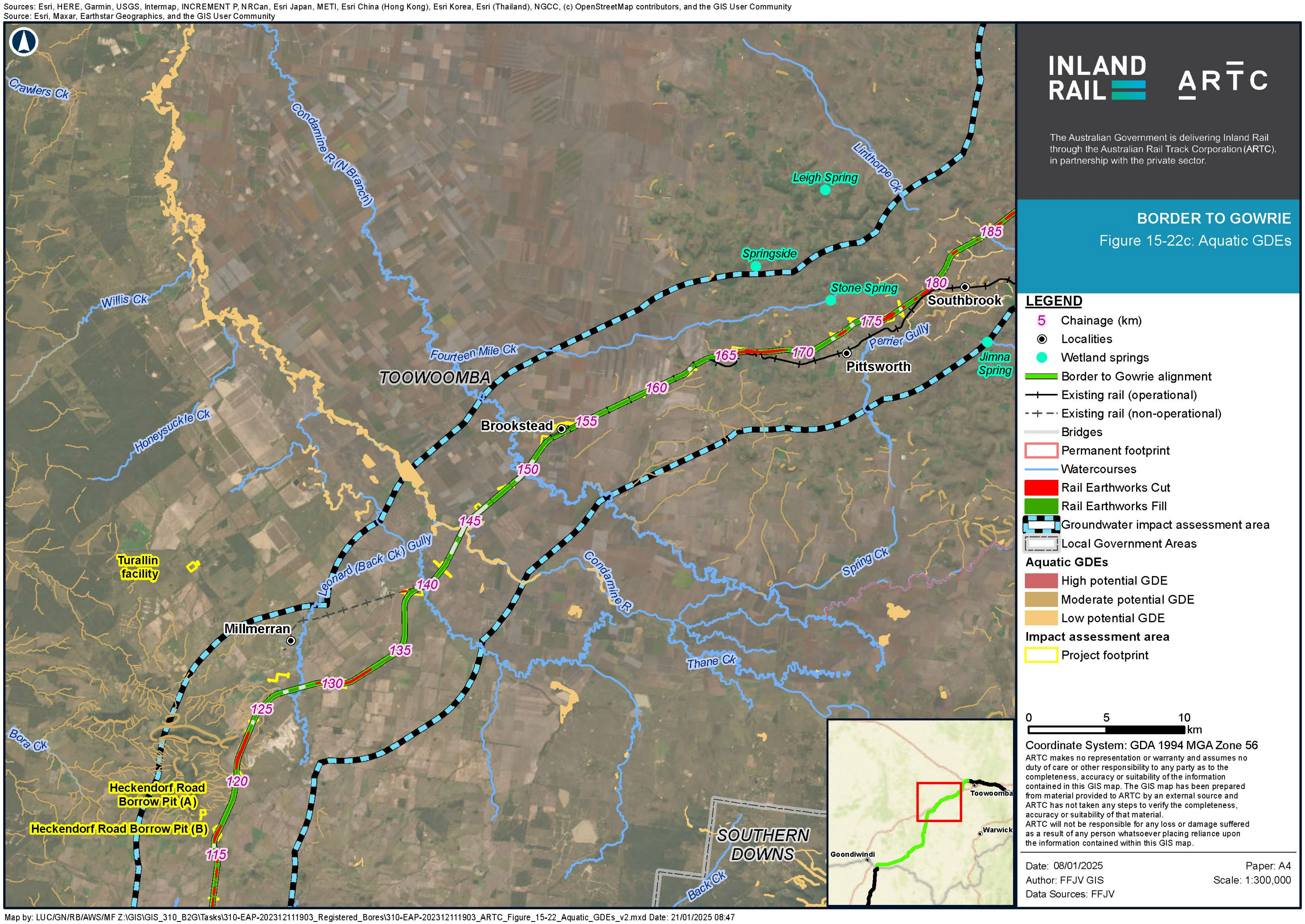
Author: FFJV GIS Scale: 1:300,000
Data Sources: FFJV

Map by: LUC/GN/RB/AWS/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Figure_15-22_Aquatic_GDEs_v2.mxd Date: 21/01/2025 08:47



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
INLAND RAIL
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The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.
BORDER TO GOWRIE
Figure 15-22c: Aquatic GDEs
LEGEND
Chainage (km)
Localities
Wetland springs
Border to Gowrie alignment
Existing rail (operational)
Existing rail (non-operational)
Bridges
Permanent footprint
Watercourses
Rail Earthworks Cut
Rail Earthworks Fill
Groundwater impact assessment area
Local Government Areas
Aquatic GDEs
High potential GDE
Moderate potential GDE
Low potential GDE
Impact assessment area
Project footprint
0 5 10 km
Coordinate System: GDA 1994 MGA Zone 56
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Author: FFJV GIS
Scale: 1:300,000
Data Sources: FFJV
Crawlers Ck
Condamine R (N Branch)
Linthorpe Ck
Leigh Spring
Springside
Stone Spring
Southbrook
Willis Ck
Fourteen Mile Ck
Perrier Gully
Pittsworth
Jimna Spring
TOOWOOMBA
Honeysuckle Ck
Brookstead
Turallin facility
Leonard (Back Ck) Gully
Condamine R
Spring Ck
Millmerran
Thane Ck
Bora Ck
Heckendorf Road Borrow Pit (A)
Heckendorf Road Borrow Pit (B)
SOUTHERN DOWNS
Back Ck
Toowoomba
Warwick
Goondiwindi
115
120
125
130
135
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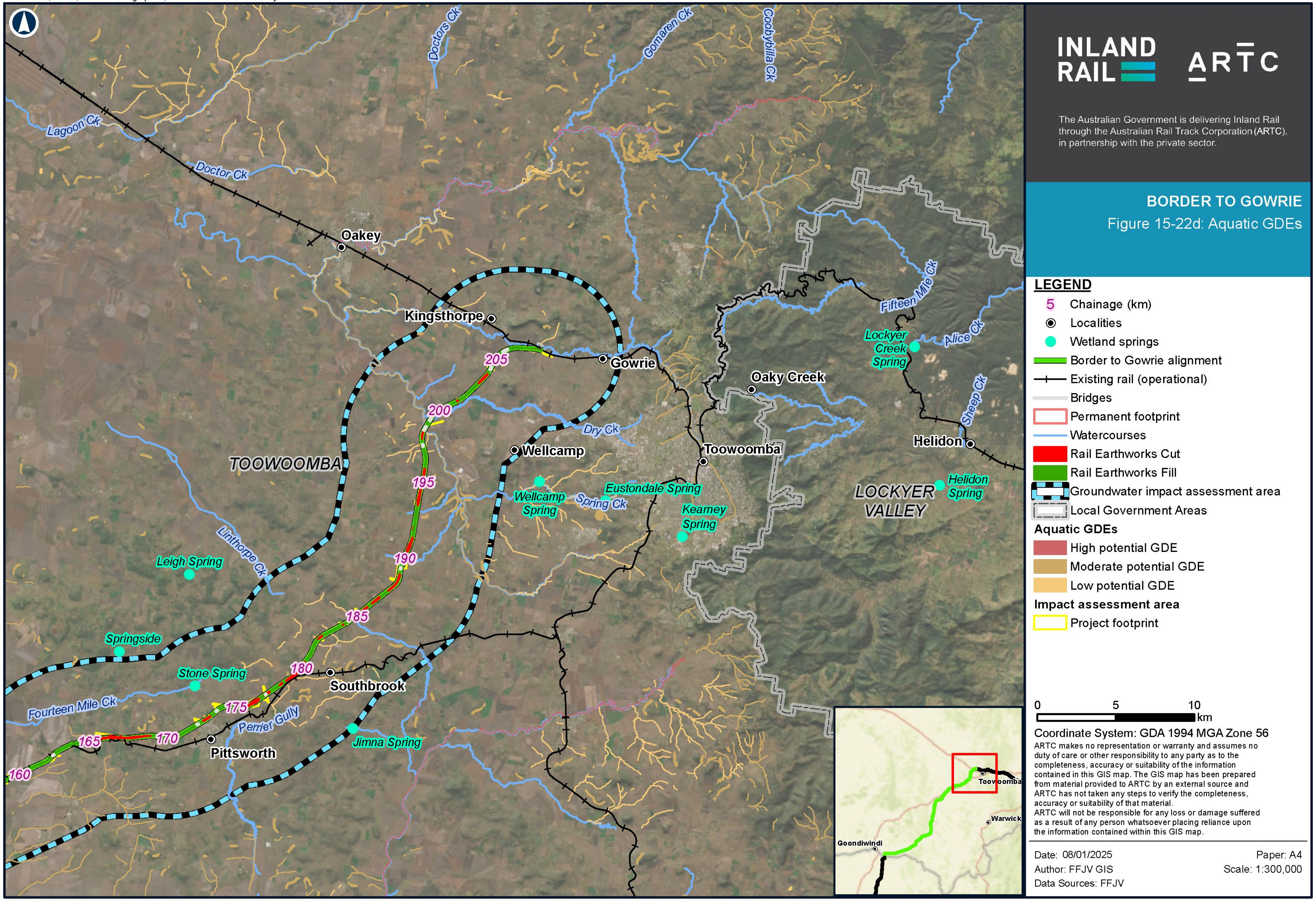
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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15.5.6.2 Terrestrial groundwater dependent ecosystems

Areas where terrestrial GDEs are identified by BoM's GDE Atlas within 5 km of the Project alignment include:

- One high potential terrestrial GDE is crossed by the Project alignment between Ch 24.4 km and Ch 26.8 km, near Yelarbon. This GDE is associated with the alkaline landscape of the Yelarbon Desert sandy plains (Department of Science, Information Technology and Innovation, 2017). This GDE is recognised under Water Plan (GABORA) 2017 as a GDE Area. The Yelarbon Desert GDE has not yet been attributed a source aquifer.
- Broad areas of moderate potential for terrestrial GDEs occur between Ch 33.0 km and Ch 95.0 km. These areas are characterised to have intermittent connection to brackish aquifers associated with sandy plains and shallow alluvium (Department of Science, Information Technology and Innovation, 2017).
- Irregular areas of moderate potential for terrestrial GDEs are crossed by and surround the Project footprint between Ch 165.0 km to Ch 196.0 km. These GDEs are associated with fractured-rock aquifers of the MRV, which may provide an intermittent connection to these ecosystems.

The location of terrestrial GDEs in relation to the Project footprint are shown in Figure 15-23.

15.5.6.3 Springs

A spring is a hydrogeological feature that occurs due to natural groundwater discharge and may be classed as having a permanent or non-permanent (ephemeral) saturation regime. GDEs may in turn be associated with the expression of groundwater in a spring. Springs can have substantial environmental, cultural and economic values.

A total of nine springs are identified within a 20 km distance from the Project alignment from the publicly available Queensland Herbarium active spring dataset. The groundwater impact assessment area for springs was expanded significantly, as a conservative measure, as it is recognised that hydraulic connectivity between a source aquifer and spring may be expansive. All of these springs are sourced from the MRV. Eight of these springs are classified as non-permanently saturated, as detailed in Table 15-8.

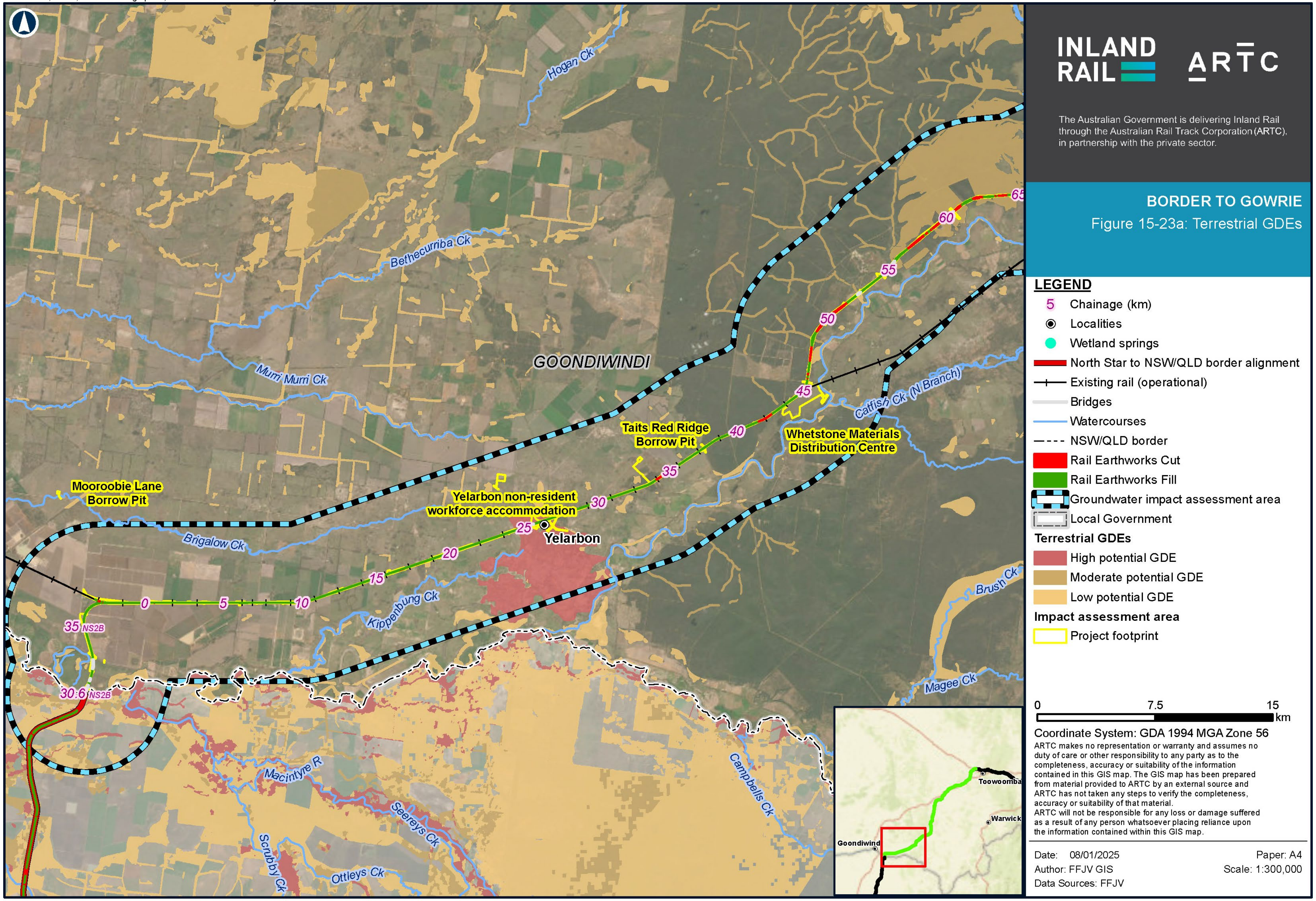
The closest registered spring to the Project alignment, Stone Spring, is 2.1 km northwest of Ch 173.7 km, near Pittsworth. There are no mapped GAB (WCM) springs identified within a 20 km distance from the Project alignment. Locations of the mapped springs in proximity to the Project are depicted on Figure 15-22.

TABLE 15-8 SUMMARY OF SPRINGS WITHIN 20 KM OF THE PROJECT ALIGNMENT

Spring name/Site #	Distance from Project alignment (km)	Direction from Project alignment	Spring type	Source aquifer
Stone Spring/1145	2.1	NW of Ch 173.7.0 km	Active—intermittently saturated	MRV
Springside/1146	5.5	N of Ch 166.9 km		MRV
Jimna Springs/1147	5.0	SE of Ch 179.5.0 km		MRV
Wellcamp Spring/1150	7.2	E of Ch 201.9 km		MRV
Leigh Spring/1144	8.7	NW of Ch 174.0 km		MRV
Eustondale Spring/1154	10.4	E of Ch 208.2 km		MRV
Lockyer Creek Spring/1382	23.7	E of Ch 208.2 km		MRV
Helidon Spring/1504	26.7	E of Ch 208.2 km		MRV
Kearneys Spring/1139	14.8	E of Ch 208.2 km	Active—permanently saturated	MRV

Table notes:
Data sourced from Queensland Springs database on 20 December 2023 (Queensland Government, 2019).

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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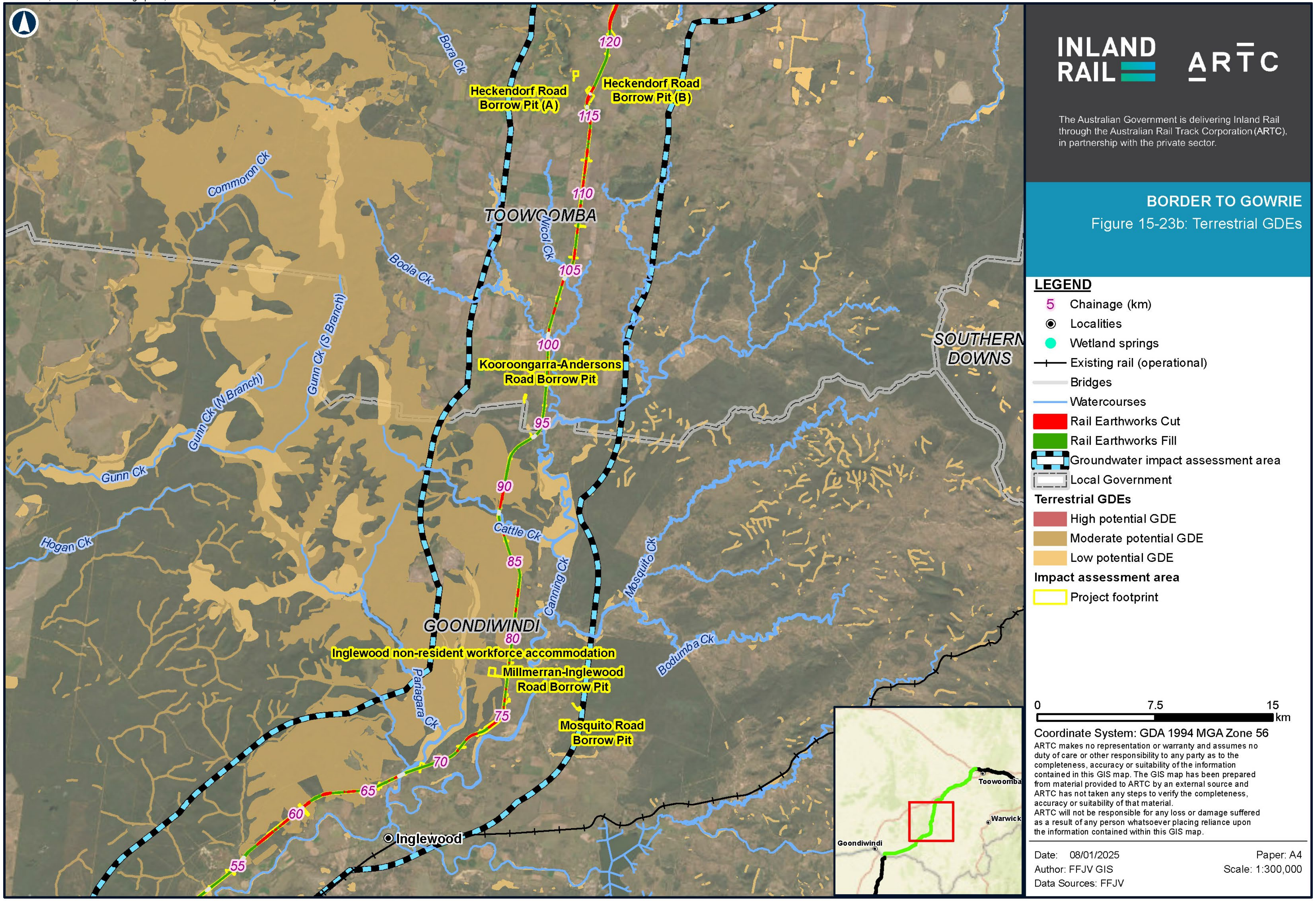
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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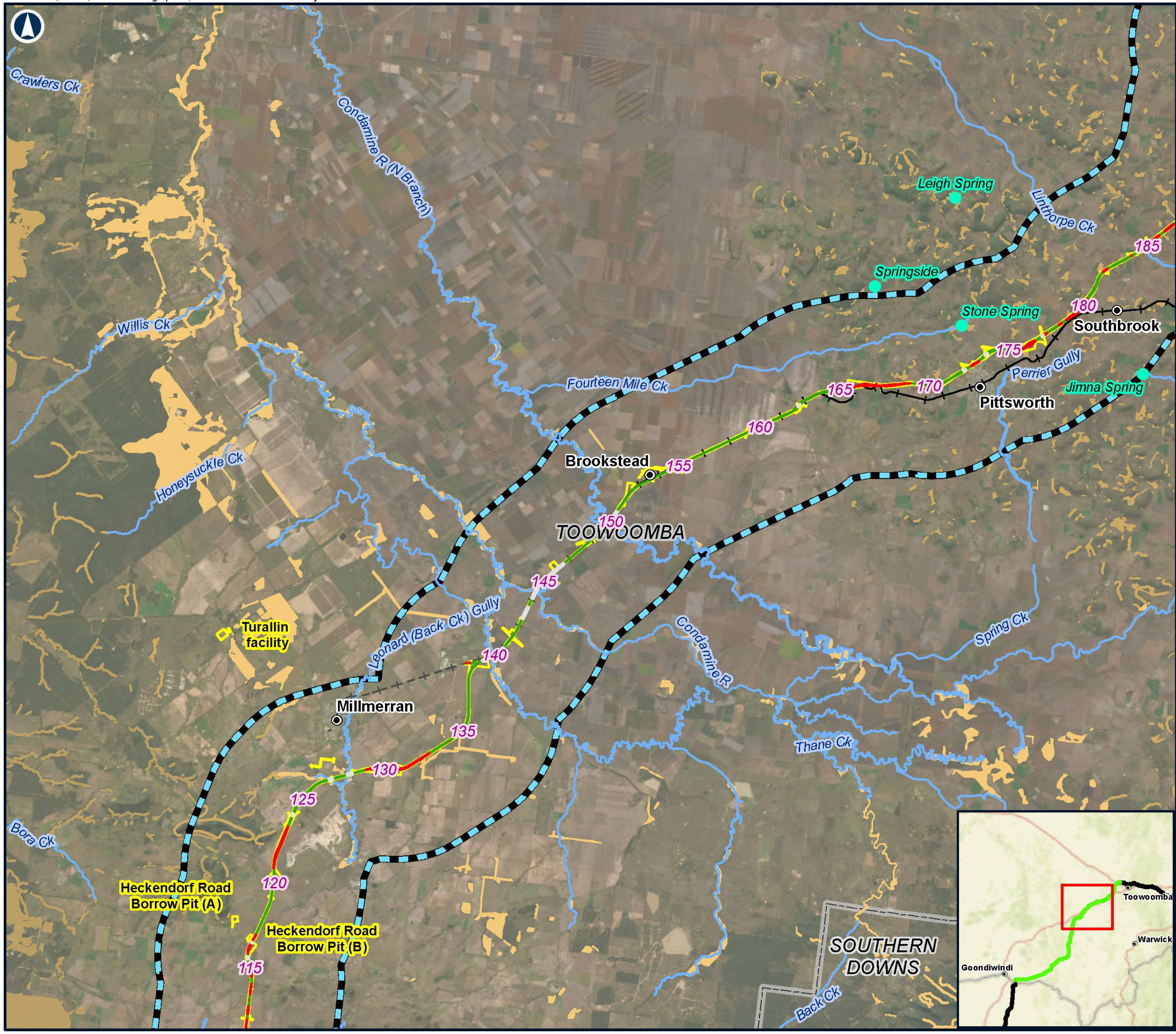
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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BORDER TO GOWRIE

Figure 15-23c: Terrestrial GDEs

LEGEND

- 5 Chainage (km)
- Localities
- Wetland springs
- Existing rail (operational)
- Existing rail (non-operational)
- Bridges
- Watercourses
- Rail Earthworks Cut
- Rail Earthworks Fill
- Groundwater impact assessment area
- Local Government

Terrestrial GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Impact assessment area

- Project footprint

0 7.5 15 km

Coordinate System: GDA 1994 MGA Zone 56

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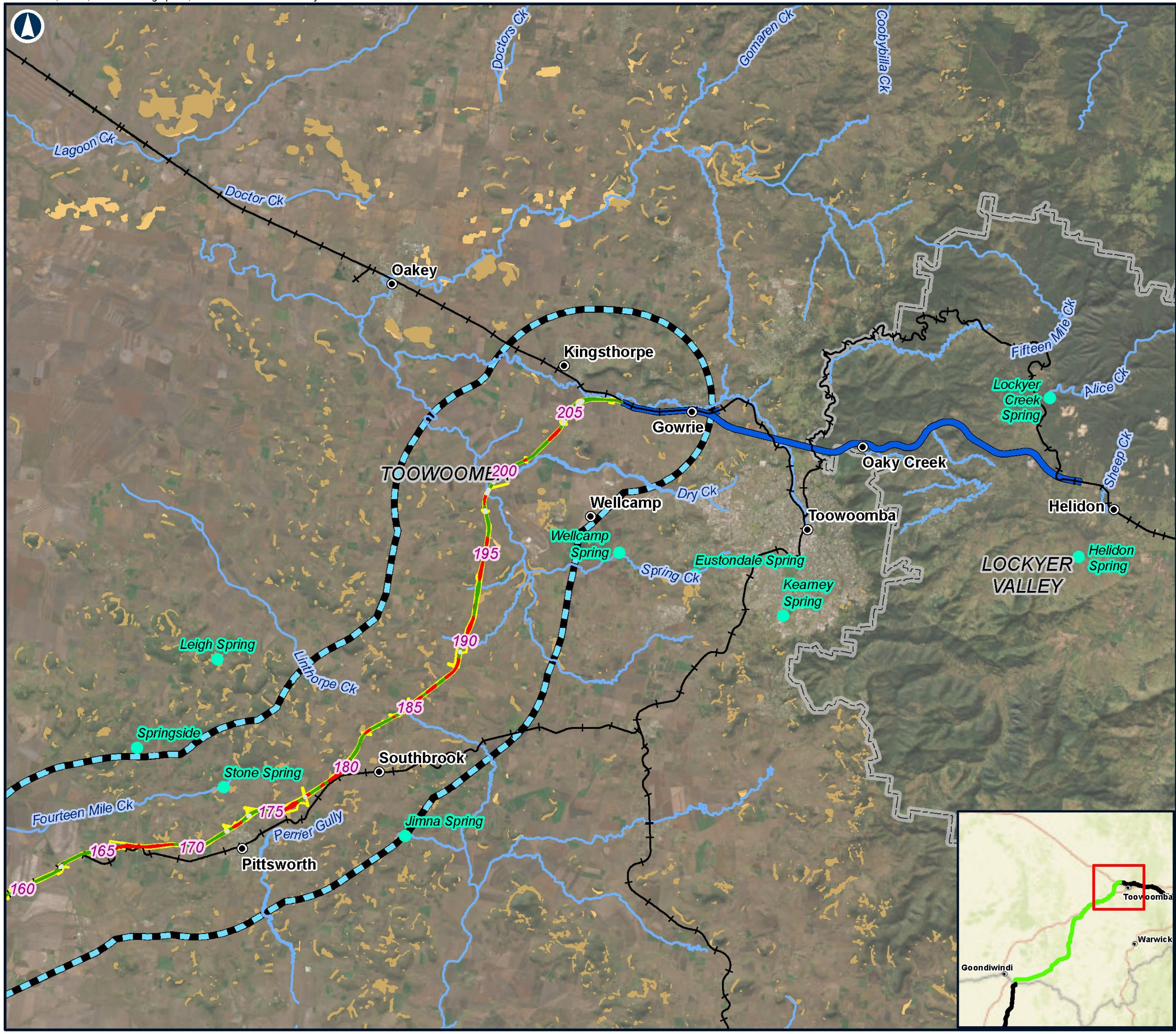
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



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BORDER TO GOWRIE

Figure 15-23d: Terrestrial GDEs

LEGEND

- 5 Chainage (km)
- Localities
- Wetland springs
- Gowrie to Helidon alignment
- Existing rail (operational)
- Bridges
- Watercourses
- Rail Earthworks Cut
- Rail Earthworks Fill
- Groundwater impact assessment area
- Local Government

Terrestrial GDEs

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Impact assessment area

- Project footprint

0 7.5 15 km

Coordinate System: GDA 1994 MGA Zone 56

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Author: FFJV GIS
Data Sources: FFJV
Paper: A4
Scale: 1:300,000

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15.5.7 Environmental values

The Queensland Government has developed HWMPs for each river catchment and they are the key planning tools for improving water quality in Queensland. For the purposes of this assessment, the EVs, as defined in the EPP (Water and Wetland Biodiversity), are attributes of the groundwater systems to be protected or enhanced that are relevant to the groundwater impact assessment area.

This section describes groundwater-related EVs within the groundwater impact assessment area as defined under the *Queensland Murray-Darling and Bulloo River Basins – Groundwater Environmental Values and Water Quality Objectives* (DES, 2020e):

- Ch 30.6 km (NS2B) to Ch 116.4.0 km: within the boundaries of the Border Rivers catchment. The relevant EVs for the groundwater impact assessment area are described in the *Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins* (DES, 2019a).
- Ch 116.4 km to Ch 208.2 km: within the boundaries of the Condamine–Balonne River catchment. The relevant EVs for the groundwater impact assessment area are described in the *Healthy Waters Management Plan: Condamine River Basin* (DES, 2019b).

The *Queensland Murray-Darling and Bulloo River Basins – Groundwater Environmental Values and Water Quality Objectives* (DES, 2020e) are based on the work of the HWMPs and succinctly comprises the EVs and WQOs for the entire Murray-Darling Basin in one document. Table 15-9 summarises the relevant EVs and associated WQOs for the Project and corresponding criteria to evaluate whether the WQO is being attained. Table 15-10 lists the default WQOs for aquatic ecosystem protection in full.

TABLE 15-9 SUMMARY OF ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

Environmental value	WQOs/Guidelines to assess WQO	Summary of EVs within impact assessment area
Groundwater—aquatic ecosystems	**Border Rivers catchment:** WQOs defined in Tables 35 and 37 in the HWMP for aquifers in the Border Rivers catchment (DES, 2019a). **Condamine–Balonne River catchment:** WQOs defined in Tables 31 and 32 in the HWMP for aquifers in Condamine–Balonne River catchment (DES, 2019b). *Queensland Murray-Darling and Bulloo River Basins Groundwater Environmental Values and Water Quality Objectives* (DES, 2020)	Regional aquatic GDE data from the GDE Atlas was evaluated in Section 15.5.6. This indicated there were no high-potential aquatic GDEs traversed by, or in proximity to, the Project footprint. Regional terrestrial GDE data from the GDE Atlas was evaluated in Section 15.5.6.2. This indicated there is one high-potential terrestrial GDE traversed by the Project alignment between Ch 25.0 km to Ch 28.0 km, near Yelarbon. The nearest spring is Stone Spring, located 2 km northwest of Ch 173.0 km. There are numerous areas with low-to-moderate potential to support aquatic and terrestrial GDEs; therefore, there is the potential for such GDEs to be impacted by possible dewatering or changes in groundwater quality and/or levels during the construction works stage of the Project. Mitigation measures to minimise such impacts are discussed further in Section 15.7.2.
Groundwater—irrigation	ANZG (2018) The threshold salinity tolerances for irrigation water of plants grown in loamy to clayey soils (considered the primary soil conditions traversed by the rail alignment) are 600 µS/cm to 7,200 µS/cm as stated in Section 4.2.4 of the ANZG (2018). Faecal coliforms Metals	Groundwater use for irrigation is a significant EV for the region, particularly from shallow aquifers such as the BRA, CA and MRV. The suitability of groundwater from registered bores within the groundwater impact assessment area and from bores installed during the Project hydrogeological investigation is discussed in Section 15.4. For example, the alluvium and MRV in the Border Rivers and Condamine catchments generally report median salinity values of less than 2,000 µS/cm in the area.
Groundwater—farm supply/use	ANZG (2018)	Water quality results (Section 15.5.5.5) indicate that groundwater abstracted from most aquifers traversed by the Project alignment could be used for farm purposes, although quality is noted to be highly variable.

Environmental value	WQOs/Guidelines to assess WQO	Summary of EVs within impact assessment area
Groundwater—stock water	ANZG (2018) (i.e. median faecal coliforms of < 100 organisms per 100 ml) The water quality tolerances of livestock vary between livestock types (e.g. beef cattle have no adverse effects up to TDS of 4,000 mg/L, whereas dairy cattle can only tolerate up to 2,500 mg/L TDS)	The review of entitlements, allocations and licenced uses confirmed that stock watering is a major use of groundwater in the area. This EV is the second most common use of groundwater, after irrigation, from the alluvium and MRV. Stock watering is the primary use for groundwater abstracted from the GAB aquifers (i.e. Kumbarilla Beds, WCM). Available salinity data for registered bores confirms that the alluvium, MRV and GAB aquifers are suitable for stock water (median EC values of < 1,500 µS/cm). More variable water quality is evident in the WCM and may preclude some landowner bores from use for stock watering for less tolerant livestock.
Aquaculture	ANZG (2018) *Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins* —Table 59 (DES, 2019a)	Aquaculture is recognised as an EV for some aquifers within the groundwater impact assessment area, no known commercial aquaculture operations are known to be in the groundwater impact assessment area.
Groundwater—drinking water	ANZG (2018) *Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins* —Table 61 (DES, 2019a) *Healthy Waters Management Plan: Queensland Condamine River Basin* – Table 56 (DES, 2019b)	The suitability of water for human consumption is defined in the *Australian Drinking Water Guidelines* (NHMRC & NRMMC, 2011). The TDS threshold for water palatability is < 900 mg/L under these guidelines. Most aquifers within the groundwater impact assessment area have median TDS values below this threshold and are potentially suitable for drinking water use. All relevant aquifers detailed in the Condamine and Border Rivers HWMPs are recognised to have a drinking water EV.
Industrial	Applicable WQOs to protect this EV are variable between different industries and are considered on a case-by-case basis	Industrial use is noted as a relevant EV for the BRA, CA, MRV and WCM units. Review of groundwater entitlements within the groundwater impact assessment area indicate (minor) usage of groundwater for commercial/industrial purposes (Section 15.5.1).
Cultural and spiritual	Protect or restore cultural, spiritual and ceremonial values consistent with approved policies and plans. Aboriginal waterways assessments may provide information to support the cultural, spiritual and ceremonial value.	Regionally, the Border Rivers and Condamine–Balonne River catchments have cultural and spiritual values recognised EVs for all relevant aquifers traversed by the Project, as detailed in the Border Rivers and Condamine–Balonne River catchment HWMPs (Appendix U: Groundwater Technical Report).
Visual recreation	Not applicable	The nearest spring is Stone Spring, sourced from the MRV, located 2 km northwest of Ch 173.0 km. At the deep cut locations where drawdown is anticipated to occur, the maximum extent of drawdown is predicted to range from 10 m to 43 m from the rail centreline, wholly within the Project footprint. Therefore, this item is not considered to be applicable to groundwater within the groundwater impact assessment area.
Secondary recreation	Not applicable	This EV is not considered relevant to in situ groundwater and is typically a consideration for surface water. There is a possibility of seasonal bore water use to fill swimming pools. There are no registered groundwater springs within 2 km of the Project alignment that could be considered for recreational use.

TABLE 15-10 DEFAULT GROUNDWATER WATER QUALITY OBJECTIVES APPLICABLE TO THE AQUIFERS WITHIN THE GROUNDWATER IMPACT ASSESSMENT AREA

Groundwater unit	Percentile	Sodium (Na)	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Chloride (Cl)	Sulphate (SO_4)	Nitrate (NO_3)	EC	pH	Alkalinity	Silicon dioxide (SiO_2)	Fluoride (F)	Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)	Sodium adsorption ratio	Total nitrogen	Total phosphorous
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pH units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Meq/L	mg/L	mg/L
Border Rivers	20th	150	13	10	110	117	15.1	0.3	531	6.5	104	31	0.16	0.000	0.01	0.005	0.013	4.95	0.085	0.000
	50th	329	34	23	253	381	64.5	1.9	1,800	7.3	214	60	0.30	0.010	0.04	0.020	0.015	17.00	0.543	0.049
	80th	4,589	710	569	489	8,723	1,100.0	12.5	23,910	8.0	414	81	0.90	0.056	9.74	0.160	0.070	35.70	2.717	1.235
Macintyre Brook	20th	44	3	1	145	46	1.1	0.0	410	7.5	132	10	0.20	0.005	0.01	ID	ID	1.80	ID	ID
	50th	124	19	11	295	115	7.9	0.8	1,178	7.9	243	40	0.41	0.005	0.01	ID	ID	8.92	ID	ID
	80th	412	32	28	610	270	30.2	6.4	1,700	8.6	559	44	0.89	0.121	0.83	ID	ID	31.59	ID	ID
GAB–South East Kumbarilla	20th	315	2	0	459	72	0.0	0.0	1,173	8.0	506	13	0.55	0.005	0.00	0.000	0.000	38.10	0.000	0.000
	50th	417	3	1	720	120	2.0	0.5	1,600	8.4	660	15	1.50	0.020	0.01	0.005	0.015	56.30	0.109	0.000
	80th	530	4	2	969	260	9.1	1.3	2,050	8.6	865	19	3.20	0.130	0.01	0.017	0.015	71.65	0.283	0.033
Central Condamine	20th	85	19	12	239	70	5.0	0.2	603	7.4	200	27	0.10	0.005	0.01	0.005	0.015	3.20	0.043	0.000
	50th	213	34	16	382	170	22.0	0.5	1,160	7.9	321	33	0.16	0.010	0.01	0.005	0.015	7.30	0.109	0.033
	80th	535	61	25	465	739	84.7	2.0	2,800	8.3	390	40	0.30	0.050	0.05	0.010	0.015	12.80	0.435	0.154
Condamine North Branch	20th	83	27	17	280	54	4.0	0.0	660	7.5	240	28	0.10	0.005	0.01	0.005	0.015	2.50	0.000	0.000
	50th	105	37	26	380	80	9.6	0.5	805	7.9	320	36	0.10	0.010	0.01	0.005	0.015	3.30	0.109	0.033
	80th	158	52	34	451	136	26.0	1.0	1,050	8.3	376	40	0.20	0.030	0.01	0.010	0.015	4.90	0.217	0.098
Toowoomba Region Basalts	20th	66	16	7	180	88	3.4	0.5	660	7.5	150	20	0.10	0.000	0.00	0.005	0.01	1.30	0.087	0.000
	50th	97	52	59	350	184	10.0	5.0	1,200	7.9	291	34	0.20	0.020	0.01	0.005	0.015	2.20	1.054	0.000
	80th	147	100	116	530	356	22.0	33.0	1,750	8.2	443	47	0.30	0.050	0.02	0.025	0.015	6.20	7.391	0.000
South East Walloons	20th	121	9	4	300	101	3.4	0.0	880	7.7	251	12	0.10	0.000	0.00	0.000	0.000	2.90	0.000	0.000
	50th	225	39	27	455	236	13.0	1.0	1,500	8.0	390	17	0.27	0.010	0.01	0.010	0.010	8.10	0.217	0.000
	80th	425	89	89	662	560	46.2	6.0	2,550	8.4	562	30	0.50	0.060	0.02	0.148	0.025	17.89	1.324	0.033

Source: Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins (DES, 2019a) and Healthy Waters Management Plan: Queensland Condamine River Basin (DES, 2019b)

Table notes:

In some instances, values have been rounded for consistent presentation of decimal places for each parameter

ID = insufficient data

15.6 Potential impacts

Potential impacts on groundwater resources, including groundwater quality and levels, were identified and assessed with the conceptual hydrogeological model and a series of numerical predictive models that were developed from site-specific and literature data presented in this revised draft EIS. The models, and identification of potential impacts relevant to the Project based on ambient conditions and land uses, have informed the development of mitigation and management measures that can be adapted any changes in conditions, as necessary.

15.6.1 Conceptual hydrogeological model

Key aspects of the hydrogeological regime within the groundwater impact assessment area are summarised below. A conceptual representation of the hydrogeological regimes within the groundwater impact assessment area are depicted on Figure 15-24 and Figure 15-25. Conceptualisation is divided broadly into two sections of the Project, based on depositional basin and the natural division feature of the Kumbarilla Ridge discussed in Section 15.5.3:

- Ch 30.60 km (NS2B) to Ch 116.4 km: characterised by the Surat Basin consolidated strata and overlying Cainozoic unconsolidated sediments of the BRA
- Ch 116.4 km to Ch 208.2 km: characterised by the Clarence–Moreton consolidated strata and overlying Cainozoic MRV and unconsolidated sediments of the Condamine Alluvium.

The groundwater conceptualisations are a representation of the groundwater systems that incorporate an interpretation of the geological and hydrogeological conditions. Further, the conceptualisations consolidate the current understanding of the key processes of each groundwater system, including the influence of stresses, to assist in the understanding of potential changes/impacts on the systems because of the Project.

Additional detailed discussion of the conceptual hydrogeological model is included in Appendix U: Groundwater Technical Report.

15.6.2 Predictive modelling

Golder Associates Pty Ltd (Golder) prepared a hydrogeological assessment report in 2019 to inform the draft EIS (Golder, 2019b). As part of the hydrogeological assessment, numerical predictive modelling of deep cuts (>10 m BGL) likely to intersect groundwater was performed. The objectives of the predictive modelling were to evaluate potential groundwater drawdown, estimate potential seepage rates, and inform of changes to groundwater flow regimes for deep cuts along the Project. These local-scale groundwater models were developed as 2-D cross-sectional models oriented perpendicular to the deep cut at the rail alignment (the deepest point of the cut in each stratigraphy intersected) to identify potential impacts. Five indicative cuts along the rail alignment were selected as they were considered to best represent the various construction methodologies, local geology, and worst-case potential impacts on groundwater resources. The modelling was undertaken using software SEEP/W™, modelling software for groundwater flow in porous media.

Following the updates to the revised reference design, further groundwater predictive modelling has been undertaken to inform this revised draft EIS. A review of the revised reference design alignment and design features was performed to identify representative locations for groundwater impact assessment modelling. The revised deep cuts with the greatest potential to intersect groundwater resources were selected to undergo additional 2-D cross-sectional models oriented both parallel and perpendicular to the cut at the rail alignment to evaluate the extent, both up and down gradient, of impacts from the Project. Potential impacts considered include potential drawdown and changes to flow regime; estimates of potential seepage were predicted consistent with the approach and methodology previously adopted by Golder for the draft EIS. The outcomes of the predictive modelling have informed of options for seepage control measures to suitably manage the predicted inflows.

Details of the construction methodology, conceptual models, assumptions, and predictive modelling aspects are summarised below. Additional information is provided in Appendix U: Groundwater Technical Report.

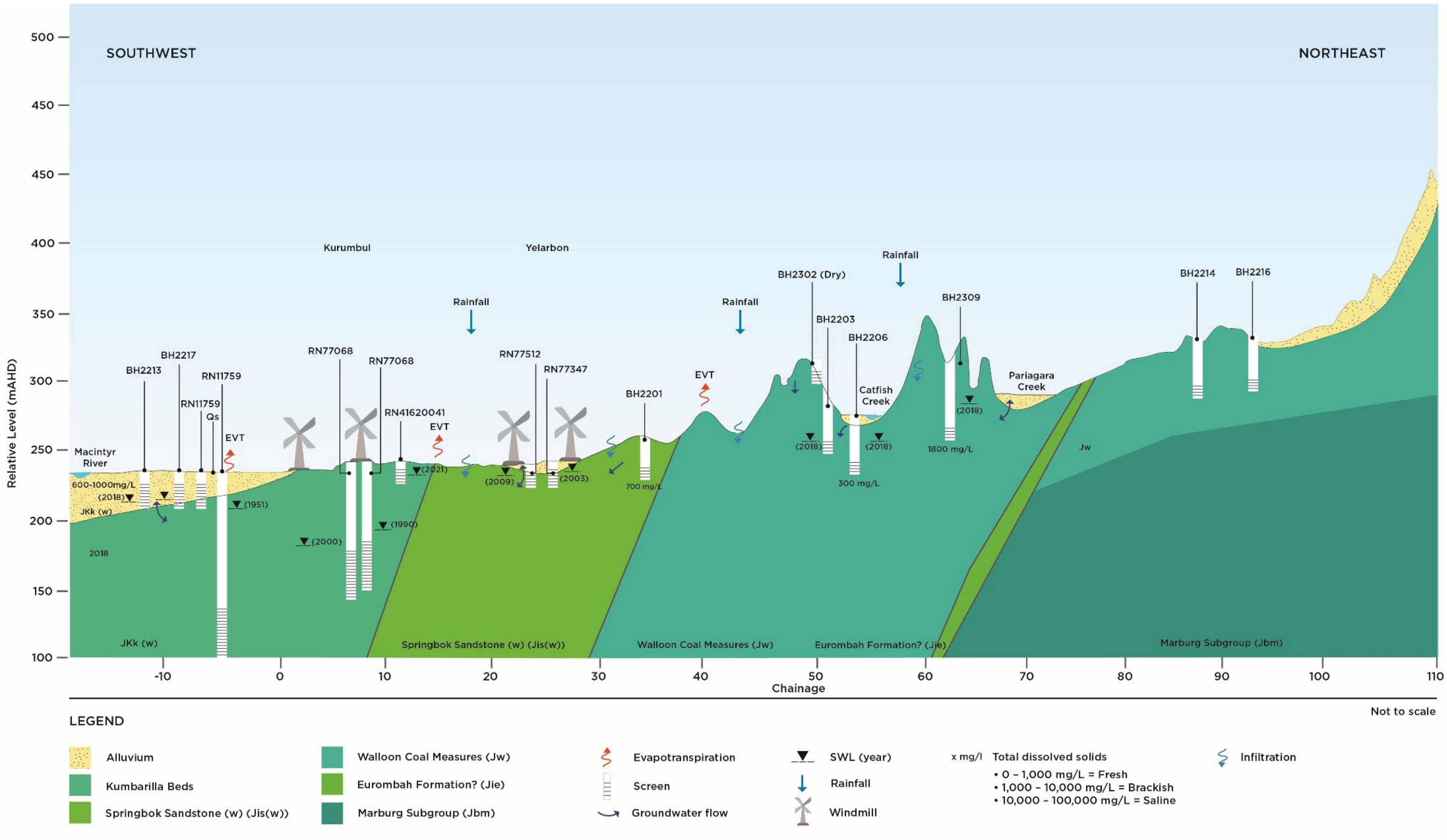


FIGURE 15-24 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL—SECTION A

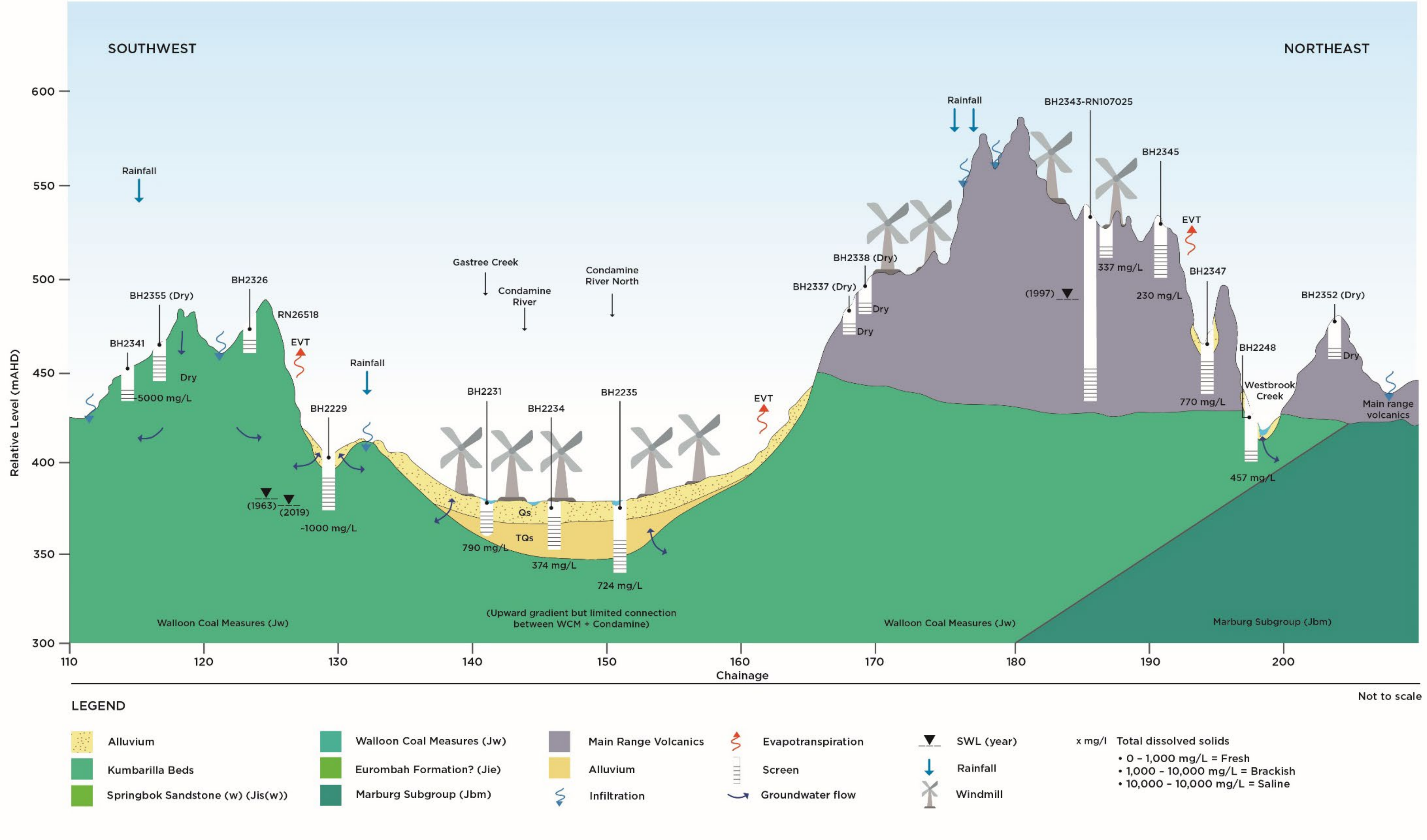


FIGURE 15-25 HYDROGEOLOGICAL CONCEPTUAL SITE MODEL—SECTION B

15.6.2.1 Approach

Numerical predictive models were developed to support the hydrogeological design and assessment of impacts for the Project. The objectives of the predictive modelling were to:

- Estimate potential groundwater seepage rates for cuts that intersect shallow groundwater (deeper > 10 m)
- Assess potential groundwater drawdown extent (zone of influence) due to groundwater seepage into the deeper cuts during construction
- Assess potential residual impact (drawdown) following application of seepage control measures
- Assess potential residual impacts due to groundwater seepage into the deep cuts following application of seepage control measures.

Seven deep cuts along the Project alignment were selected to undergo 2-D modelling as best representing conservative potential impacts on groundwater resources (deepest cuts into each stratigraphy) and in response to public submissions and following public notification of the draft EIS and consultation with technical authorities. The selected cuts and supporting rationale are listed in Table 15-11. These indicative cuts were modelled to evaluate potential groundwater drawdown and extent, changes to flow regime, and to estimate potential seepage rates for construction works and operations stages (residual impact) of the Project.

The vertical rail alignment and the earthworks design for the Project will continue to be developed and refined through the detailed design process. This may result in modifications to the location and dimensions (depth, width, and/or length) of cuts that are currently included in the revised reference design and subject to predictive modelling. Consequently, revision of the 2-D modelling of deep cuts will be required through the detailed design process to confirm potential drawdown, flow patterns, and seepage rates to ensure that appropriate controls are adopted as part of the design.

TABLE 15-11 CUTS SELECTED FOR PREDICTIVE MODELLING

Cut ID	Model section, chainage (km)	Reason for selection	Closest watercourse/water bore		Cut length (m)
			Bore	Watercourse	
310–C07	Ch 61.0	Second deepest cut within the WCM: • Maximum cut depth = 15.9 m BGL • Water strike during drilling at nearest project bore BH2308 (~1.75 km) = 14.68 m BGL	RN48791 730 m south east: • Tertiary sediments 7.32 to 12.5 m BGL • WCM 12.50 to 106.07 m BGL • Hutton Sandstone 106.07 to 120.0 m BGL. • Open hole from 103.7 to 120.7 m BGL • Bore record notes flowing artesian bore (Drilled 1975, test 2011).	Unnamed watercourse 50 m west	450
310–C08	Ch 62.4	• Deepest cut within the WCM. Maximum cut depth = 16.8 m BGL • Water strike during drilling at nearest project bore BH2308 (~2.95 km) = 14.68 m BGL	RN48791 950 m to southwest. As above.	Unnamed watercourse 330 m north	550
310–C23	Ch 114.65	Deepest cut within the Alluvium: • Maximum cut depth = 11.6 m BGL • Water strike during drilling at nearest project bore BH2323 (~0.43 km) = 14.26 m BGL	RN18711 located 700 m west of the alignment. No information was available for this bore. RN108244 located 770 m west: • Slotted casing from 134 to 143 m BGL and 183 to 192 m BGL • Inferred to be located in the WCM and the Marburg subgroup • No water levels are noted.	Unnamed watercourse 200 m south	250

Cut ID	Model section, chainage (km)	Reason for selection	Closest watercourse/water bore		Cut length (m)
			Bore	**Watercourse**	
310–C24	Ch 116.0	Second deepest cut within the Alluvium: ▸ Maximum cut depth = 10.9 m BGL ▸ Water strike during drilling at nearest project bore BH2355 (~ 0.40 km) = 9.79 m BGL	RN 18731 located ~980 m north of the alignment. No water levels or strata are identified, however the DNRM has assigned this bore to intersect the Upper Hutton Sandstone.	Unnamed watercourse located 130 m to the southeast	750
310–C31	Ch 176.35	Deep cut within the WCM. Assess potential impacts to nearby landholder bore: ▸ Maximum cut depth = 23.16 m BGL ▸ No near project bores in proximity.	RN19886 located 350 m south southwest: ▸ Open hole from 48.8 m to 73.2 m BGL ▸ One recorded water level of 39.6 m BGL (drilled 1964).	Perrier Creek located 1,300 m south of Ch 176.000 km	1,300
310–C34	Ch 179.9	Deepest cut within MRV. Assess potential impacts to nearby landholder bore: ▸ Maximum cut depth = 24.8 m BGL.	RN83365 located280 m southeast: ▸ Slotted casing from 64 to 71 m BGL ▸ One recorded water level 54.6 m BGL in 1986.	Unnamed watercourse located 150 m to the east	1,600
310–C39	Ch 193.75	Deep cut within the MRV. Shallow groundwater observed at nearby project bore BH2347 (~0.15 km) at 9.1 m BGL, indicating potential to intersect groundwater: ▸ Maximum cut depth = 16.0 m BGL	RN107856 located 570 m south southeast: ▸ Slotted Casing 14 to 41 m BGL ▸ One recorded water level 10.3 m BGL (2003).	One Mile Gully ~630 m southwest	2,350

Table note:
A 2-D model was selected as appropriate to consider potential groundwater impacts associated with deep linear cuts, as 2-D modelling allows for estimates of seepage and possible groundwater level drawdown perpendicular to the Project alignment (Barnett et al., 2012).

The seven models were set up to represent the anticipated hydrogeological conditions of each respective deep cut. A summary of the modelled cut locations and the corresponding design features is presented in Table 15-12. A 2-D model was selected as appropriate to consider impacts both parallel and perpendicular to the cut, and groundwater flow up and downgradient of the Project footprint.

TABLE 15-12 SUMMARY OF NUMERICAL MODELS/LOCATIONS WHERE CUTS MAY ENCOUNTER GROUNDWATER

Cut ID	Model section, chainage (km)	Model section cut elevation (m AHD)	Max cut depth (m BGL)	Aquifer intersected	Estimated median groundwater elevation at cut (m AHD)	Estimated depth of cut below the groundwater elevation (m)*
310–C07	Ch 61.0 km	309.1	15.9	WCM	312.9	3.8
310–C08	Ch 62.4 km	298.2	16.8	WCM	294.9	NA
310–C23	Ch 114.7 km	452.1	11.6	Alluvium	453.8	1.7
310–C24	Ch 116.0 km	463.8	10.6	Alluvium	459.5	NA
310–C31	Ch 176.4 km	560.1	12.8	MRV	559.8	NA
310–C34	Ch 179.9 km	571.1	22.6	MRV	564.9	NA
310–C39	Ch 193.8 km	480.4	16.1	MRV	480.2	NA

Table notes:
NA = Modelled cut does not intercept groundwater
* = Typical case

Each model was developed to consist of two geologic layers corresponding to the interpreted in situ profile, generally a top layer of alluvial or residual soils and second hard rock (WCM or MRV) layer. The SEEP/W finite element software package was used to construct the predictive models to estimate steady state and upper level (conservative) inflows to deep cuts and the resulting drawdown impacts from them. An example cross-sectional output from a 2-D SEEP/W model in presented in Figure 15-26.

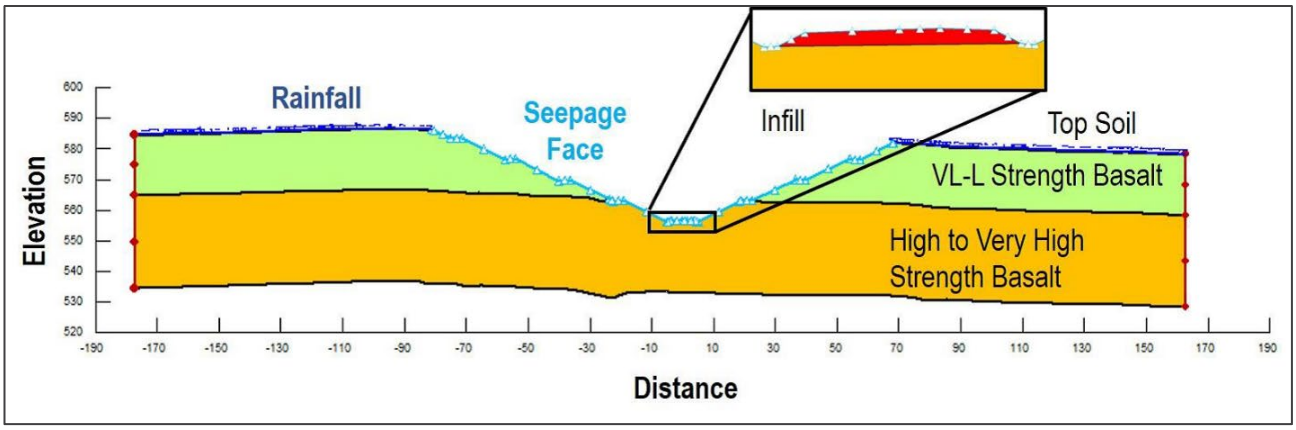


FIGURE 15-26 EXAMPLE OF CROSS-SECTIONAL OUTPUT FROM A 2-D SEEP/W MODEL

There are inherent uncertainties in the adoption of any numerical modelling, as the process involves development of a simplified representation of a real system. Sensitivity analysis was incorporated into the methodology to account for potential uncertainties in the modelling, such as heterogenous geological conditions, variable aquifer characteristics (as encountered in the alluvium and MRV), wet and average climatic conditions, and paucity of location-specific data.

The predictions generated by numerical models are not unique and multiple combinations of setups and parameters can achieve reasonable sensitivities when calibration data is limited. Sensitivity analysis was performed to compare model outputs with different sets of reasonable parameter estimates to allow for more accurate predictions. Sensitivity analysis also tested the robustness of the model to changes in parameters. As part of the sensitivity analysis the below parameters were adjusted to simulate an upper level or 'worst case' scenario:

- The estimate of expected hydraulic conductivity (K) of model layers was increased by one order of magnitude
- Annual rainfall recharge was doubled to account for potential extreme weather events (i.e. 1 per cent of mean annual rainfall was increased to 2 per cent)
- Groundwater level was increased by 3 m for alluvial aquifers and 5 m for the MRV. These groundwater level increases were adopted based on review of groundwater level responses exhibited at Project bores following a significant rainfall event.

The predictive models are considered to be Class 1 (Barnett et al., 2012), which is defined as having a high degree of uncertainty; however, the numerical simulations undertaken for this assessment are considered to be suitable for developing coarse relationships between groundwater extraction and associated impacts (Barnett et al., 2012), as the impacts on groundwater from the Project are expected to be limited due to the depth of groundwater typically reported below the maximum cut depth (Table 15-11 and Table 15-12).

15.6.2.2 Seepage estimates

Seepage rate estimates were obtained for the entire length of each cut, as specified in Table 15-11. To calculate, the geology and cut geometry for each section modelled have been extrapolated across the entirety of each cut, such that calculated seepage rates are considered to be conservative estimates.

The upper (wet) case is based on a 'wet' scenario representative of high rainfall recharge, increased hydraulic conductivity parameters, and subsequent elevated groundwater level. If these wet conditions are encountered, the elevated seepage rates would be periodic and temporary, directly following a large weather event (cyclone) or climatic event (wet season with heavy flooding). These predictions do not consider any treatment of cuts or management measures, as is generally industry standard, that will be applied for the Project.

The estimated seepage results are presented in Table 15-13.

TABLE 15-13 PREDICTIVE MODELLING RESULTS—SEEPAGE ESTIMATES

Cut ID	Model section, chainage (km)	Cut length (m)	Typical (base case)		Upper (wet case)	
			Model section (m^3/year)	Entire cut (m^3/year)	Model section (m^3/year)	Entire cut (m^3/year)
310–C07	Ch 61.0	450	0.14	62.8	1.37	618
310–C08	Ch 62.4	550	0.0003	0.2	0.0006	0.3
310–C23	Ch 114.65	250	0.17	42.6	1.39	347
310–C24	Ch 116.0	750	0.08	58.1	0.29	223.2
310–C31	Ch 176.35	1,300	0.000004	0.7	56.1	72,902
310–C34	Ch 179.9	1,600	0.0	0.0	0.0	0.0
310–C39	Ch 193.75	2,350	0.285	670.9	81.2	190,783

Predictive simulations indicate:

- Seepage is concentrated at the bottom of the cuts, on both sides of infill material
- Temporary increases in seepage may be observed in cuts with sandy soil or weathered sandstone following rainfall events
- Seepage of groundwater from bedrock is anticipated to be low except where it may be enhanced by weathering of fractures.

15.6.2.3 Drawdown estimates

The predicted groundwater drawdown resulting from the seepage rate estimates for the typical and upper scenario are presented in Table 15-14. It is noted that while both typical and upper estimates are presented, the upper scenario has been applied for groundwater impact assessment as a conservative measure.

Groundwater drawdown is predicted to only occur at three of the seven modelled locations, cuts 310-C07, 310-C23 and 310-C39. At these locations the maximum predicted lateral extent of drawdown ranges from 10 m to 43 m from the rail centreline, and all drawdown is wholly contained within the Project footprint.

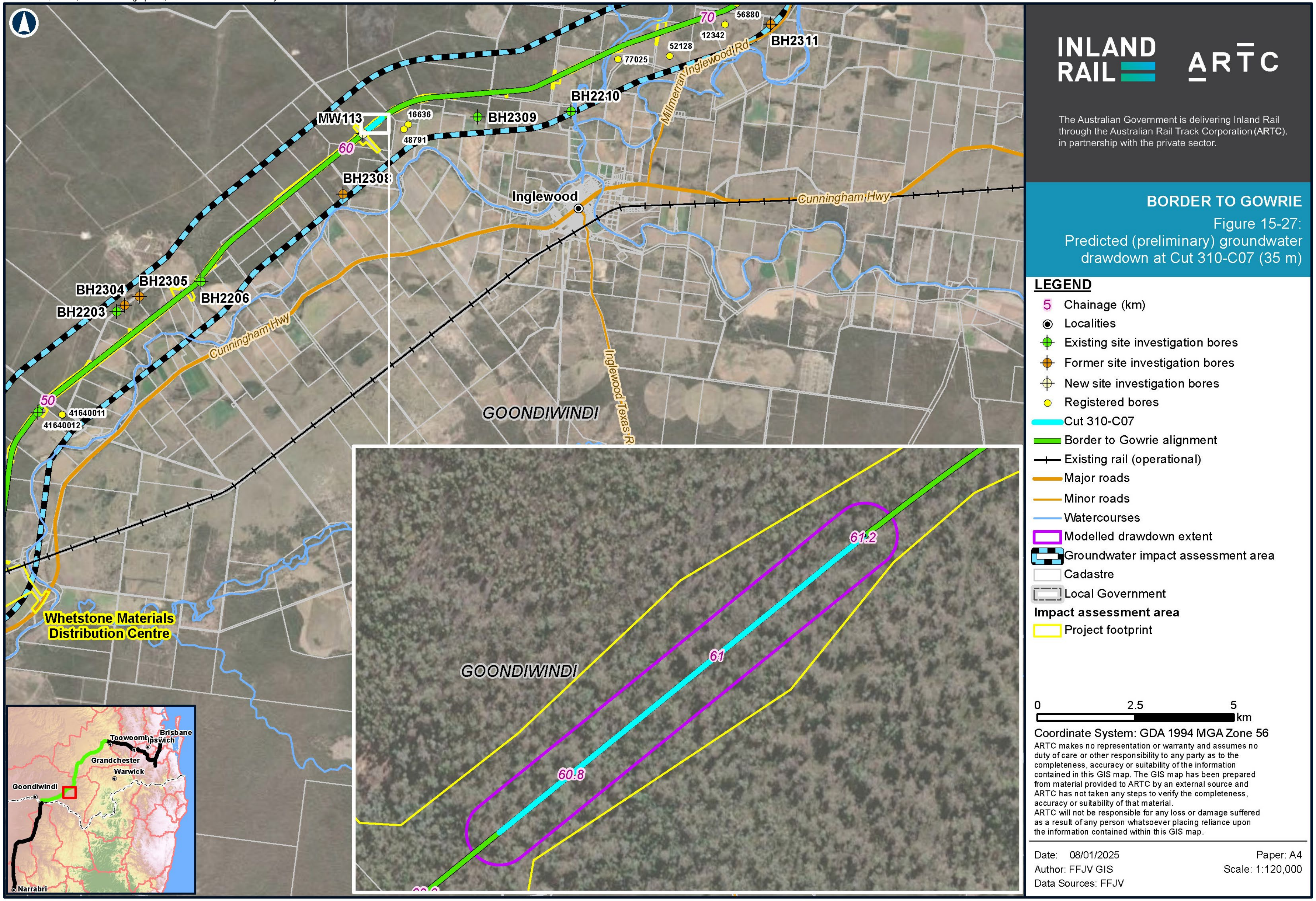
TABLE 15-14 PREDICTED DRAWDOWN VALUES AT MODELLED CUTS

Cut ID	Model section, chainage (km)	Estimated drawdown at rail centreline (m)		Lateral extent of drawdown from centreline (m)		Impact within footprint?
		Typical	Upper	Typical	Upper	
310–C07	Ch 61.0	4.0	8.8	NA	32 to 35	Yes
310–C08	Ch 62.4	<1.0	1.8	NA	NA	Yes
310–C23	Ch 114.7	1.7	6.7	NA	32 to 43	Yes
310–C24	Ch 116.0	<1.0	<1.0	NA	NA	Yes
310–C31	Ch 176.4	<1.0	2.65	NA	NA	Yes
310–C34	Ch 179.9	<1.0	<1.0	NA	NA	Yes
310–C39	Ch 193.8	<1.0	2.6	NA	10 to 15	Yes

Table note:
NA – No drawdown from centreline

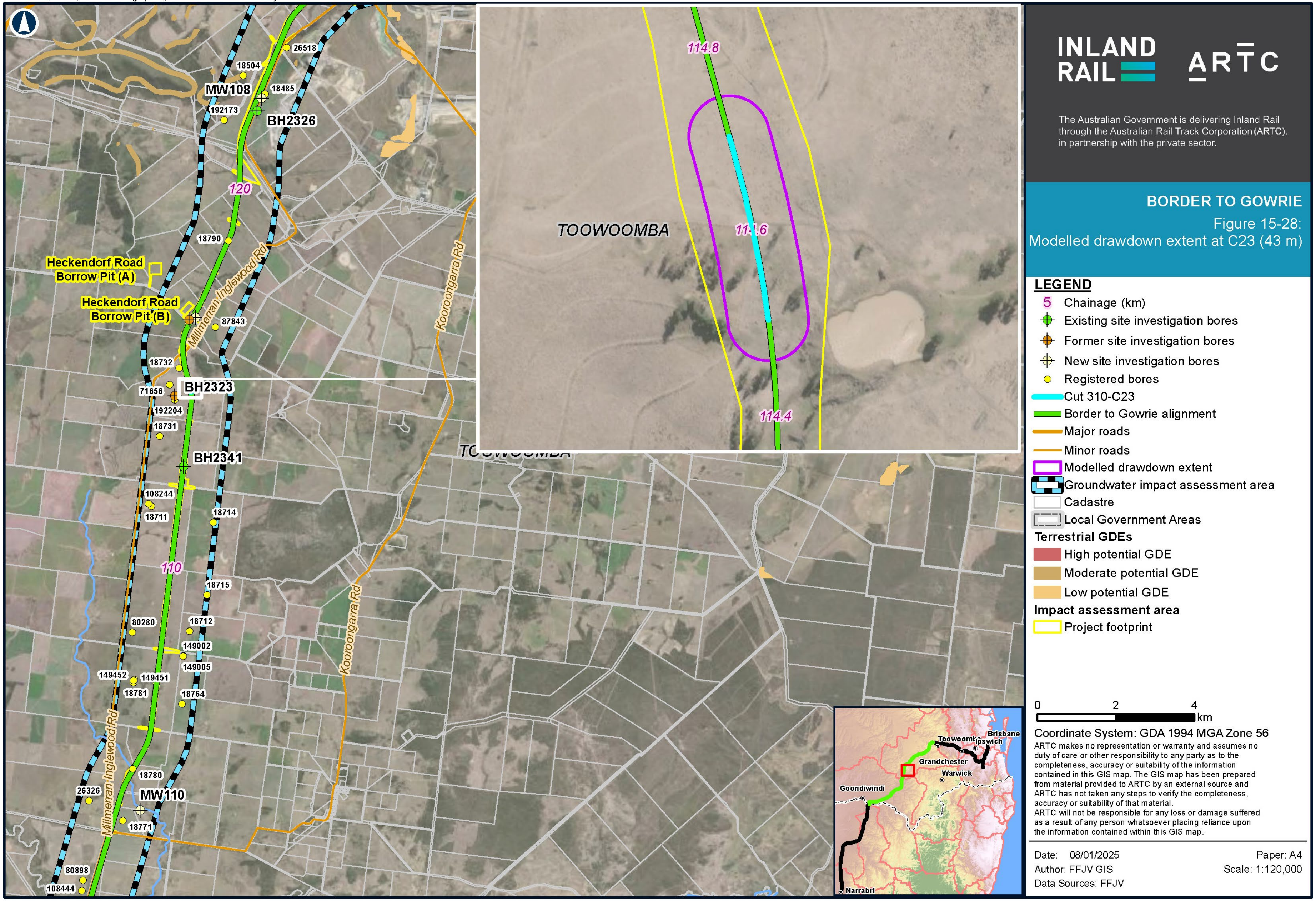
The predicted extent of drawdown at cuts 310-C07, 310-C023 and 310-C39 are shown on Figure 15-27, Figure 15-28 and Figure 15-29, respectively. No registered or unregistered bores have been identified within the anticipated upper predicted drawdown extent.

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



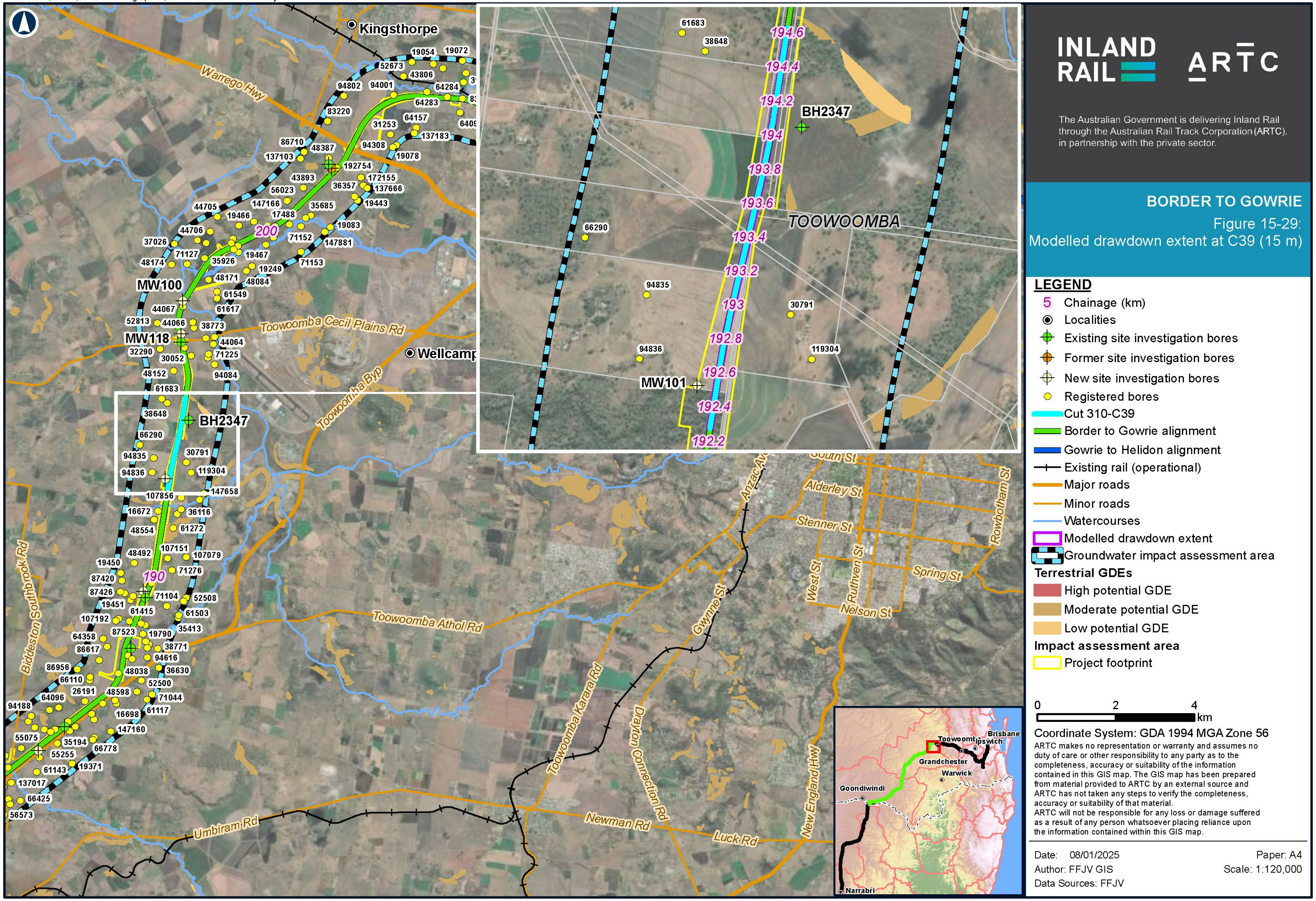
Map by: GN/RB Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-27_Drawdown_C07_v2.mxd Date: 15/01/2025 09:08

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Map by: GN/RB Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-28_Drawdown_C23_v2.mxd Date: 8/01/2025 14:47

Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community



Map by: GN/RB/MF Z:\GIS\GIS_310_B2G\Tasks\310-EAP-202312111903_Registered_Bores\310-EAP-202312111903_ARTC_Fig15-29_Drawdown_C39_v2.mxd Date: 8/01/2025 14:47

15.6.2.4 Residual impact

The nature of modifying the natural world inherently requires management measures, for a myriad of interactions. For example, after excavation of a cut, the exposed rock faces may have a geotechnical potential risk not previously identified. Depending on the geotechnical risk assessment, a treatment is identified and applied as a standard construction practice.

For the Project, some treatments that could be applied after identification of certain geotechnical risks include treated and finished slope protection, for cuts upon excavation, in accordance with Queensland Rail (QR) Civil *Engineering Standard QR-CTS-Part 35—Stone and Concrete Slope Protection* (2010) (i.e. shotcrete with weepholes and strip drains). To relieve potential groundwater pressure that may build up behind the finished cut facing, vertical drains and weep holes will be installed. Whilst the weep and drain holes are considered an engineering control, and not specifically a seepage mitigation measure, they are anticipated to manage seepage from the cut faces. Specifically, bench drains will be installed at 7 to 10 m vertical intervals. The bench design contains a cross fall to drain water away from the cut face and to drain longitudinally to prevent ponding of water (refer benching requirements within ARTC *Earthworks Construction Technical Specification ETC-08-04* (2019c).

Groundwater seepage and direct rainfall will be channelled from the cut face via drain and/or weepholes to the base of the cut where it will be transported via bench drain, and water is expected to be lost through evaporation, eventual transpiration, and/ or infiltration (groundwater/ recharge).

To estimate operational ('residual') seepage and post-construction groundwater levels (drawdown extent after construction), seepage modelling was again conducted. The modelling included the following parameters that were applied to each model section to simulate an operational or 'residual' scenario:

- Impermeable barrier placed along the seepage face to simulate shotcrete
- 'Seepage holes' to simulate drains or weep holes, which are near horizontal, incised (2 m) into the rock face starting at 0.6 m above the base of cut (as per the QR standard)
- Additional seepage holes were added, above the bottom seepage holes set at 0.6 m above the base of the cut, at even spacing up to the top of the predicted groundwater level. This allows for seepage through the face to prevent long-term groundwater mounding against the shotcrete.

As the unmitigated construction works stage modelling results indicate that drawdown is only expected to occur at three of the modelled cut locations, being 310-C07, 310-C23 and 310-C39, only these cuts were selected for modelling of the operational scenario. The above parameters were applied to these deep cutting cross sectional models to aid with assessing residual, post-construction (operations stage) seepage.

The estimated operational seepage, required to mitigate possible long-term groundwater mounding and associated pressure, for the typical case are presented in Table 15-15. It is noted that an upper (wet) case was not required as seepage will be maintained at the rate allowed by the weep or drain holes, to be finalised during detailed design.

TABLE 15-15 PREDICTIVE MODELLING RESULTS—OPERATIONAL SEEPAGE ESTIMATES

Cut ID	Model section, chainage (km)	Cut length (m)	Seepage estimates		Water Plan and management area
			Model section (m^3/year)	Entire cut (m^3/year)	
310–C07	Ch 61.0	450	0.16	70.9	Water Plan (Border Rivers and Moonie) 2019, underground management area
310–C23	Ch 114.7	250	0.20	50.0	Water Plan (GABORA) 2017), not applicable for alluvium
310–C39	Ch 193.8	2,350	0.20	469.6	Water Plan (Condamine and Balonne) 2019, underground water management area, sub area Toowoomba City Basalts

The predicted drawdown resulting from the operational seepage estimates for the typical (base-case) are presented in Table 15-16.

TABLE 15-16 PREDICTED OPERATIONAL DRAWDOWN VALUES AT MODELLED CUTS

Cut ID	Model section, chainage (km)	Estimated drawdown at rail centreline (m)	Extent of drawdown from centreline (m)	Aquifer being impacted	Extent of impact—within footprint
310–C07	Ch 61.0	3.80	11	WCM	Yes
310–C23	Ch 114.65	1.71	0	CA	Yes
310–C39	Ch 193.75	0.02	0	MRV	Yes

Modelling results indicate that operations stage drawdown is predicted (above negligible) to occur at one of the three modelled locations, cut 310-C07. At this location, the extent of drawdown is predicted to extend up to 11 m from the rail centreline and remain wholly within the Project footprint. The predictive models will be updated as more site-specific information is ascertained through the detailed design stage. It is expected the updated models will be utilised to inform of any required secondary approvals for residual groundwater management for seepage/inflows (i.e. water licence as prescribed by relevant Water Plan). Currently no unallocated underground water exists for the CA and MRV (Section 15.5.4).

15.6.3 Construction

Construction for the Project includes several activities that have the potential to impact on groundwater resources. These activities include site preparation, bulk earthworks (cut-and-fill sections), drainage construction, haul road and access track construction, bridge pilings, and the excavation of borrow pits for construction materials.

Table 15-17 presents the potential impacts on groundwater as a result of the construction works stage activities for the Project.

TABLE 15-17 POTENTIAL CONSTRUCTION IMPACTS ON GROUNDWATER

Impacting process	Potential impacts	Likelihood of impact
Groundwater resources		
Site clearing and grading	Removal of vegetation reduces evapotranspiration, compaction of ground and alteration of landform, can influence the groundwater recharge/discharge mechanisms (i.e. result in higher/lower groundwater levels). EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	The Project footprint has been delineated to include the minimum extent of land required to construct and operate the Project safely and efficiently. The Project alignment has also been selected to maximise the use of existing rail corridor, where possible. As a result, approximately one third of the total Project alignment is in existing rail corridor. The total area proposed to be cleared and graded for construction purposes is limited in comparison to the total recharge surface area of the alluvial aquifers that underlay the Project, as evident on Figure 15-10. Consequently, a negligible impact on the groundwater resources due to site clearing and grading activities is expected.
Loss or damage to existing groundwater bores, including restriction of access	Existing groundwater bores within the Project footprint are likely to be decommissioned to enable construction and operation of the Project. Groundwater bores that are not decommissioned may be damaged or become inaccessible due to temporary or permanent Project activities. EVs with potential to be impacted: irrigation, stock water, farm supply/use, and drinking water.	Thirty-eight registered bores that are not Project monitoring bores have been identified within the Project footprint. It is anticipated that each of these registered bores, in addition to any unregistered bores within the Project footprint, will be decommissioned to enable construction of the Project. Decommissioning of bores will be in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (Edition 4) (NUDLC, 2020). Landowners to be affected by the Project have been consulted (where the landowner was willing to participate) to confirm the location of registered bores and to establish the presence of any unregistered bores within the Project footprint (Section 15.5.4.1) to identify any potential impact on such bores from the Project. Where a groundwater bore is expected to be decommissioned or have access to it impaired because of the Project, ‘make good’ measures shall be developed on a case-by-case basis and agreed in consultation with the affected landowner during detailed design. Consultations with affected landowners has commenced and is ongoing. Where a bore is impacted by the temporary footprint and is assessed as impaired, 'make-good' measures will be developed on a case-by-case basis and agreed in consultation with the affected landowner. An overview of the make-good process, including timing to be implemented, is provided in Section 15.7.4.

Impacting process	Potential impacts	Likelihood of impact
Drawdown due to seepage	Localised drawdown of groundwater levels may occur as a result of seepage/inflows of groundwater through exposed cut faces that intersect the shallow groundwater table. This drawdown has the potential to reduce the availability of groundwater from bores in proximity to a cut. Drawdown also has potential to impact GDEs if located within the impact extent. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	As discussed in Section 15.6.5, predictive modelling results indicate that drawdown of the water table may be experienced at three deep cuts as a result of seepage during construction (Table 15-14). The predicted extent of drawdown is expected to be wholly contained within the Project footprint. No bores are anticipated to be impacted by drawdown (bores located in the footprint will be decommissioned and therefore not able to be impacted). Where the usage of an established bore is identified as being impaired by Project activities, 'make good' will be agreed in consultation with the affected landowner. Consultations have begun with all identified affected landowners. The 'make-good' process to be implemented is outlined in Section 15.7.4. Should excessive inflows be encountered that cannot be managed via construction environmental management techniques, a temporary water permit may be warranted. In this instance, during construction, the licenced volume is expected to be within the allowable extraction limits for the relevant Water Plan. Therefore, the Project is not expected to impact on, or alter, the identified relevant Water Plans or other plans under the Water Act outside of their designated use and objectives.
Ground settlement	Subsidence/settlement of compressible substrates due to dewatering or compaction can cause damage to adjacent structures, such as buried services, embankments, culverts and utilities. EVs with potential to be impacted: aquatic and terrestrial ecosystems.	Deep cuts, which intersect the shallow water table, have the potential to induce localised ground settlement in areas of unconsolidated compressible sediments and soil where drawdown impacts are anticipated (i.e. alluvium associated with rivers and creeks at Cut C23 and C24). Cuts in competent substrate, such as basalt and sandstone have low likelihood of settlement. Further discussion of substrate strength is included in Chapter 9: Land Resources and Appendix G1: Geotechnical Reports—Investigation Results.
Construction of new fill embankments	Establishment of new embankments may cause the obstruction of natural drainage pathways, resulting in more frequent inundation of areas upstream of the embankments. Increased inundation could enhance groundwater recharge, that can result in groundwater mounds forming beneath these areas. Groundwater mounding may also result from the compaction of underlying soils following the addition of embankment soils. The reduction in aquifer hydraulic conductivity (permeability) can restrict groundwater throughflow, leading to the mounding of groundwater on the upgradient side of the embankment/fill (compacted substrata). In addition, groundwater level drawdown may form in areas downgradient of the compacted substrata due to reduced throughflow. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm	The subgrade beneath the proposed embankments is primarily Cainozoic Alluvium and MRV, with some overlaying the WCM. The depth to groundwater is typically more than 10 m for the BRA and CA and WCM, such that the risk of mounding as a result of altered throughflow at this depth is considered to be low. Where embankments are located on the MRV, groundwater mounding is often only possible in areas where the fractured rocks are hydraulically connected to flooded alluvial units or outcrops in flooded areas.

Impacting process	Potential impacts	Likelihood of impact
	supply/use, drinking water, industrial and cultural and spiritual values.	
Bridges and pilings	The Project includes 37 new bridge sections with structural support from cast-in-place pilings. The expected subgrade for the bridge and piling works includes Cainozoic alluvium, WCM, and the MRV. The potential impacts on groundwater from the piling work during construction activities may include altered aquifer characteristics, groundwater flow, chemistry/quality, and/or reduction in groundwater resources. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	The pilings will span lengths ranging from 20 m to 30 m and be installed to depths ranging from 5 to 35 m BGL with pile diameters of 0.9 to 1.5 m. Only minor volumes of groundwater (within the wet sediment/soil/rock) are anticipated to be brought to surface, e.g. 5 to 10 L per 20 m deep auger hole. It is unlikely that active dewatering will be necessary in support of the proposed piling methodology, and that only minor volumes of groundwater (as a slurry with soil/rock) will need to be managed at each pile/drill site.
Construction water supply	Potential impacts to groundwater resources may occur where bore water is sourced to supply water for construction activities. EVs with potential to be impacted: Irrigation, stock water, farm supply/use, industrial drinking water.	A preliminary assessment of construction water options has been undertaken and investigations are ongoing by ARTC. The establishment of new groundwater bores for sourcing construction water is not considered a practical solution with: ‣ The existing pressure placed on groundwater as a resource in the region ‣ The licensing and approval requirements to establish new groundwater bores ‣ The flow rates required to meet construction water demands may not be appropriately met through reliance on groundwater ‣ Challenges regarding the management of groundwater quality ‣ Aquifers in the region are close to full allocation through existing water entitlements. However, the use of existing sustainable groundwater allocated entitlements to supplement the construction demand for the Project may be considered. Consideration may be given if owners of registered bores have capacity and the water is fit for the intended construction purpose under their water entitlement that they wish to lease to ARTC, under a water trading agreement. Therefore, the volumes extracted would be within the existing licensing limits, and the extent of drawdown experienced would be localised and consistent with that which is currently permissible for each licenced bore. Construction water sources will be finalised as the construction approach is refined during the detailed design stage of the Project (post-EIS) and will be documented as part of the Construction Water Plan. Potential sources include supplemented, unsupplemented and recycled sources. The current construction water sourcing strategy is summarised in Chapter 5: Project Description.

Impacting process	Potential impacts	Likelihood of impact
Dewatering	Temporary excavations during construction (i.e. trenching, boring for piles, etc.) may encounter groundwater at depths greater than 10 m. In these instances, it may be necessary to extract the water from the excavation to maintain structural integrity of the excavation and to enable safe establishment of the planned infrastructure. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, and cultural and spiritual values.	If dewatering is required in support of construction activities, the duration of the impacts is likely to be temporary as the construction works are limited in duration. Impact is not anticipated to extend long after construction works are completed, if at all, dependant on the localised recharge of the affected aquifer unit.
Alterations of existing groundwater flow	Deep cuts may potentially intersect shallow groundwater, resulting in drainage of groundwater and drawdown of the aquifer. Piles or other structures spaced closely together have potential to influence the natural groundwater flow regime. Reduced permeability of the substrate beneath embankments may modify the flow direction of shallow groundwater in portions of the alluvium and possibly the saturated portion of weathered bedrock. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	It is possible for the antecedent groundwater flow regime to be interrupted at deep cut locations; however, the length and depth of the cuts in comparison to the overall aquifer is negligible. Further, excavation cuttings C31, C34 and C39 are predicted to intersect the MRV aquifer, which, due to the fractured nature of this aquifer, is unlikely to be impacted outside of the localised area to the cuts. The foundation pilings associated with bridges for this Project will be spaced a sufficient distance apart (>20 m) to avoid impacts on existing groundwater flow patterns. Noting that the distance/spacing is bridge-specific and will be finalised during the detailed design stage. Only small volumes of groundwater are required to be dewatered during the cast-in-place piling installation and are therefore unlikely to impact on groundwater flow.
Groundwater quality		
Contamination/ accidental discharge	Contamination of groundwater associated with the Project may arise as a result of: - Accidental spills and leaks of hydrocarbons (i.e. oils, fuels and lubricants) and other chemicals related to the use and maintenance (workshops) of construction machinery - Accidental discharge from washdown areas - Upward seepage along piles/soil interfaces of saltier groundwater from the deeper confined aquifers into the fresher alluvium aquifers - Excavation and stockpiling of soil material with subsequent leaching of exposed contaminants to groundwater - Groundwater bores installed for environmental monitoring or water supplies have the potential to create a vertical pathway between aquifers if not installed correctly or if the bores deteriorate due to abandonment. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	Potential locations and sources of existing contamination are provided in Chapter 9: Land Resources and generally apply to the ground surface with the highest potential for disturbance by the Project. Infiltration of contaminants from ground surface into groundwater is likely to be limited due to the depth to groundwater of the hard rock aquifers and the presence of dominant fine-grained sediments (clays and silts) in the upper profile of the alluvial aquifers. The ephemeral nature of the majority of surface water bodies along the Project is also likely to reduce the chance of contaminants in surface water infiltrating into shallow aquifers during dry months. If used in sufficient volume, water applied during the construction works stage of the Project has the potential to infiltrate past the root zone (deep drainage) and contribute to rising water tables/levels and water quality alteration in shallow aquifers. Leakage and releases (accidental discharge) from water storage areas may also contribute to rising water levels but only significant volumes.

Impacting process	Potential impacts	Likelihood of impact
Acid rock drainage (ARD)	Intersection of sulphide-bearing rocks in cuts or use of sulphide-bearing materials in embankment fill could present an ARD risk following exposure of the rocks to oxygen and subsequent runoff (leachate), which could impact on EVs (i.e. aquatic GDEs and groundwater users). Rainfall infiltration into cuttings with sulphide-bearing minerals above the saturated zone may also pose an ARD (leachate) risk even if the entire cut is in the unsaturated zone (above groundwater). EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	Geology within the Project footprint indicates a potential for the Kumbarilla Beds and WCM to host disseminated sulphide minerals (i.e. pyrite), particularly within shale and mudstone units. However, given that cuts will primarily be into the weathered to extremely weathered upper portions of the Kumbarilla Beds and WCM and will be treated, the risk is greatly reduced as sulphide minerals are likely to have already been exposed and oxidised (Chapter 9: Land Resources).
Potential acid sulphate soils (PASS)	Acid sulfate soil mapping (ASS) provided on ASRIS ‘Atlas of Australian Soils’ (CSIRO, 2014a) indicates low probability of PASS within the groundwater impact assessment area. However, few isolated areas of high probability ASS associated with natural and man-made water storages are noted throughout the groundwater impact assessment area (Chapter 9: Land Resources). If exposed through excavation, PASS presents a risk to underlying groundwater though oxidation and generation of acidic conditions with subsequent leaching of acid precipitate into underlying groundwater. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values.	The risk associated with exposure of high probability ASS is low as significant excavation/cutting is unlikely in these areas (Chapter 9: Land Resources).

15.6.4 Operations

This section provides a discussion of the potential impacts on groundwater resources and related EVs as a result of operation of the Project.

TABLE 15-18 POTENTIAL IMPACTS OF OPERATION

Impacting process	Potential impacts	Discussion of potential impacts
Groundwater resources		
Loss or damage to existing groundwater bores, including impaired access	Long-term access restrictions to existing landowner bores due to the severance of properties. EVs with potential to be impacted: irrigation, stock water, farm supply/use, and drinking water.	ARTC have undertaken a bore survey of landowners impacted by the Project footprint to confirm the location of registered bores and to establish the presence of any unregistered bores. This data will assist when identifying bores subject to access restrictions resulting from the Project. Where a groundwater bore is expected to have access to it impaired by either severance or restrictions as a result of the Project, 'make good' measures shall be developed on a case-by-case basis and agreed in consultation with the affected landowner. All identified landowners with registered bores to be impacted have been consulted, where they chose to do so, and consultation and is ongoing. An overview of the make-good process to be implemented is provided in Section 15.7.4.
Embankments	Mounding of groundwater can result due to long-term surface loading of alluvial soils from embankments and other construction activities along the Project alignment where groundwater is shallow. Possible areas for compressible alluvial soils with potential for inhibited drainage and subsequent groundwater mounding include localised portions of Macintyre Brook, Canning Creek, and Condamine River floodplains associated with abandoned river channels and tributaries. EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, industrial and cultural and spiritual values (GDEs are outlined in Chapter 11: Flora and Fauna).	Impacts are expected to be localised due to the linear nature of the Project and the typical depth to groundwater, based on available information, being greater than 10 m BGL in the alluvium and WCM such that the risk of mounding as a result of altered throughflow at this depth is considered to be low.
Maintenance works (operation) water supply	Operational maintenance works are not expected to be reliant on groundwater for the sourcing of water. The Project's operational water requirements are anticipated to be minor relative to the construction works stage requirements. Water may be required to support localised maintenance activities, such as high-pressure cleaning of culverts. The volumes and quality required will be dependent on the specific activities and frequency of undertaking, and therefore cannot be quantified at this stage of the Project.	An assessment of the suitability of each source will be made for each maintenance activity requiring water, based on the following considerations: ▸ Legal access ▸ Volumetric requirement for the activity ▸ Water quality requirement for the activity ▸ Source location relative to the location of need. The source and required water quality will also consider the potential for maintenance water to be released during maintenance activities such as cleaning. Small volumes of suitable water are envisaged such that the possible release will have limited potential impact on receiving environments.

Impacting process	Potential impacts	Discussion of potential impacts
Drawdown due to seepage	Predictive numerical modelling indicates that residual seepage may occur at cut location C07, C23, and C39 following the application of seepage control measures.	As discussed in Section 15.6.2.3, predictive modelling results indicate that three deep cuts (i.e. C07, C23, and C39) are estimated to result in residual seepage following application of seepage control measures. No groundwater drawdown resulting from the residual seepage beyond the Project footprint was predicted. Seepage from the faces of cuts with potential to intersect groundwater will be minimised via the application of engineering controls during the construction works stage (i.e. shotcrete with weepholes and strip drains).
Alterations of existing groundwater flow pathways due to new infrastructure or modified landform	Long-term impacts on groundwater flow resulting from piling works are not anticipated given the spacing of the pilings for the rail alignment. Localised impacts may occur in the vicinity of the deep cuts which intercept groundwater.	Due to the limited cut extent when compared to the overall aquifer, it is expected the groundwater flow regime will re-equilibrate to the cuts constructed in/through unconsolidated sediments. Flow within the fractured MRV is expected to be limited to the cut and immediate vicinity.
Groundwater quality		
Groundwater quality	Contamination of groundwater can arise as a result of unintended spills and leaks of hydrocarbons (oils, fuels and lubricants) and other chemicals related to maintenance activities (accidental discharge, grinding and blasting) or rail incidents (e.g. loss of load). EVs with potential to be impacted: aquatic and terrestrial ecosystems, irrigation, stock water, farm supply/use, drinking water, cultural and spiritual values.	In the instance a spill, leak or any accidental discharge occurs during normal operation activities, the impact is likely to be superficial in nature and not expected to impact on shallow aquifers. Maintenance crews and emergency response teams will be equipped with spill kits and environmental response equipment to intercept spills and leaks and prevent such incidents from impacting groundwater.

15.6.5 Summary

The majority of potential impacts related to groundwater are temporary in nature and primarily associated with the construction works stage of the Project. Impacts that may occur through the operations stage are, in most instances, an extension of issues that will initially arise through the construction works stage of the Project.

Final construction design, engineering controls, and monitoring are considered adequate to mitigate potential impacts to groundwater. In the few locations where construction activities have the potential to intersect shallow groundwater, construction techniques have been identified for the Project such that impacts will be appropriately mitigated and managed through the adopted engineering controls. Where impacts to groundwater infrastructure cannot be avoided (e.g. decommissioning of bores or loss of access), 'make good' measures will be agreed in consultation with the affected landowner (Section 15.7.4).

15.7 Mitigation measures

This section provides discussion of mitigation measures and controls that have been incorporated into the revised reference design development process, as appropriate and where possible (Section 15.7.1), as well as those measures that are proposed to be adopted for future stages of Project delivery (Sections 15.7.2 and 15.7.3).

15.7.1 Mitigation through the reference design stage

Development of the reference design for the Project has progressed in parallel with the environmental impact assessment process. As a result, design solutions for avoiding, minimising and/or mitigating impacts have been incorporated into the revised reference design as appropriate and where possible.

Mitigation measures and controls that have been factored into the design, or otherwise implemented during the revised reference design stage for the Project, are summarised in Table 15-19. The significance assessment for groundwater is detailed in Table 15-23.

TABLE 15-19 INITIAL MITIGATION MEASURES OF RELEVANCE TO GROUNDWATER

Aspect	Initial mitigation measures
Groundwater resources	▸ The Project has used the existing South Western Line and Millmerran Branch Line rail corridors, where possible, to minimise the need to develop non-rail land and minimise the potential to impact on groundwater resources. ▸ Geotechnical and groundwater investigations have been undertaken to determine local conditions. Investigations were targeted to specific locations, such as locations of: ▸ bridge abutments ▸ significant cuts ▸ significant fill. ▸ Geotechnical and groundwater field data has been used to derive design criteria for structures and rail formation. This has enabled the Project to be designed to cater for field-verified geotechnical and groundwater conditions. ▸ Seepage control measures will be adopted in accordance with QR *Civil Engineering Standard QR-CTS-Part 35 – Stone and Concrete Slope Protection* (2010). Bench drains at every 7 to 10 m vertical interval for deep cuts has been included within the revised reference design. The bench design contains a cross fall to drain water away from the cut face and to drain longitudinally to prevent ponding of water (refer benching requirements within ETC-08-04 (ARTC, 2019c). The bench drain is also wide enough to enable safe access for specific maintenance vehicles/equipment to actively monitor, manage and maintain the earthworks cutting face, including seepage. Beyond this, other seepage control measures include: ▸ drainage blanket with weep holes and drain holes ▸ shotcrete/concrete/stone pitching/interlocking blockwork design for erosion stability and drainage ▸ installation of piezometers in major cuts to monitor groundwater levels pre/during/post construction ▸ in accordance with the QR Civil Engineering Standard (2010), exposed cut faces will be lightly compacted prior installation of strip drains and application of a 300 mm drainage blanket of granular material around weep or drain hole locations. ▸ Weepholes are installed in two rows along the cut face, one at 600 mm above the cut base and one at mid-height of the cut face. Drain hole specifications will be developed as part of the detailed design stage on a cut-by-cut basis. Cut faces will then be finished with stone pitching, interlocking blockwork, or concrete. Groundwater seepage and rainfall infiltration will be channelled from the cut face via the drain and weepholes to the base of the cut, to be transported by the bench drain and dissipate via longitudinal drain to transpiration or infiltration and recharge. ▸ Drain holes will be installed to relieve groundwater pressure in colluviums, residual soil, weathered rock or along joints in the rock mass, and are not specifically designed as seepage control measures. Deep cuts will drain in perpetuity; however, due to the depth of groundwater anticipated to be intercepted (>10 m), these measures will act to mitigate the minor seepage anticipated. The revised reference design has been developed to achieve as close to a net balance in earthworks as is practicable, thereby reducing the potential to impact water resources (e.g. dewatering of cuttings and embankment placement). For the most part, this has been achieved through: ▸ aligning the Project to avoid, where possible, steep terrain and topographical constraints to minimise earthworks, and provide for more efficient track geometry and grade ▸ considering the shape and size of batters to encourage cut-and-fill balancing ▸ optimising the number, width, and depth of cuts to avoid the generation of material that would be considered surplus to Project requirements.
Groundwater quality	▸ Groundwater sampling of the Project monitoring bores for the collection of baseline water quality and salinity parameters is ongoing. This data will be used to establish baseline conditions and WQOs for the Project.

15.7.2 Proposed mitigation measures

In order to manage and mitigate potential groundwater impacts associated with the Project (Section 15.6), several mitigation measures have been proposed for implementation in future stages of Project delivery, identified to address Project-specific issues and opportunities.

Table 15-20 identifies the relevant Project stage, the aspect to be managed and the proposed mitigation measure. The mitigation measures presented in Table 15-20 have then been factored into the assessment of residual impact significance, as documented in Table 15-23.

Chapter 24: Draft Outline Environmental Management Plan provides further context and the framework for implementation of these proposed mitigation and management measures.

TABLE 15-20 PROPOSED MITIGATION MEASURES RELEVANT TO GROUNDWATER RESOURCES AND QUALITY

Delivery stage	Aspect	Mitigation and management measures
All	General	▸ A Groundwater Monitoring and Management Program (GMMP) will be developed for the Project to provide for an ongoing assessment of potential groundwater impacts throughout the various stages of the Project. The GMMP will comprise: ▸ Baseline GMMP ▸ Construction GMMP ▸ Operations GMMP ▸ The GMMP will be assessed and updated before the commencement of each relevant Project stage such that the GMMP for subsequent stages is informed by the outcomes of the previous stage. The GMMP will include, as a minimum: ▸ description of the principle aquifers of interest, local use of groundwater, and the predicted impacts on groundwater ▸ description of the groundwater monitoring program, including monitoring locations, monitoring frequency and the parameters to be recorded/analysed ▸ identification of the groundwater impact triggers and protocols for investigating and, if required, mitigating the impacts on groundwater ▸ Description of the process of continual review and improvement of the GMMP to ensure it continues to meet its objectives.
Detailed design	Interaction with groundwater by elements of the Project	▸ Undertake further geotechnical and hydrogeological investigations in parallel to the detailed design process to ensure site-specific geotechnical and groundwater conditions are reflected in the finalised design solution. Investigations will be targeted to specific locations, such as: ▸ bridge abutments ▸ significant cuts ▸ significant fill/embankments ▸ Revise the predictive groundwater modelling using additional information obtained during the detailed design stage to better understand seepage estimates and groundwater level variation resultant from cuts, both up and down gradient. Geological information and seepage analysis will be used to inform secondary approvals, drainage blanket specifications, or alternative design controls, for deep cuts into hard rock ▸ Conduct site inspections of proposed cut locations during detailed design, to visually examine surface outcrops for sulphide minerals or remnant products indicative of sulphide mineralisation. This would inform the need for management of potential ARD from cuttings in sedimentary units prior to construction works ▸ The management of ARD (leachate) potential, if identified through additional design stage site investigations, would be in accordance with *Preventing Acid and Metalliferous Drainage: Leading Practice Sustainable Development Program for the Mining Industry* (Commonwealth of Australia, 2016) and incorporated into design progression and the development of the Construction Environmental Management Plan (CEMP) ▸ Design culverts and embankments to minimise pre-loading and compaction of alluvial sediments. This will reduce the risk of altering shallow groundwater levels and recharge patterns. The current embankment designs allow for openings (i.e. culverts and bridge spans) near creeks and rivers to assist with flow ▸ Where design of embankment height allows, toe benching and drainage blankets will be provided for all transverse slopes greater than 7 degrees (1V:8H) ▸ Where design of embankment height allows, full embankment benching will be provided for all transverse slopes greater than 14° (1V:4H) ▸ Install cutting face treatments and seepage control measures in accordance with QR *Civil Engineering Standard QR-CTS-Part 35 – Stone and Concrete Slope Protection* (2010) as part of the detailed design stage.

Delivery stage	Aspect	Mitigation and management measures
	Impacts to landowner bores	▸ ARTC will continue consultation with landowners during detailed design, who will have their registered or unregistered bores potential impacted by the Project during the detailed design phase ▸ Where a groundwater bore is expected to be decommissioned or have access to it impaired as a result of the Project (the predicted impacts on groundwater resources is realised), 'make good' measures will be developed on a case-by-case bases and agreed in consultation with the affected landowner during the detailed design stage. An overview of the make-good process and make-good measures are provided in Section 15.7.4.

	Sourcing of construction water	▸ As part of ARTC's construction water planning process, construction water procurement studies have been undertaken and will be ongoing through the detailed design stage. Potential water supply options include supplemented, unsupplemented, and recycled sources.
		▸ The use of new groundwater bores or licences for construction water is not a considered water source for the Project. If groundwater is to be sourced for construction water, trading or purchasing of existing allocated entitlements will be pursued through a trade agreement. Construction water sources will be finalised as the construction approach is refined during the detailed design stage of the Project (post-EIS) and are to be documented as part of the Construction Water Plan.
		▸ Currently the water supply strategy does not include provision for new groundwater bores or licences in order to minimise impacts to aquifers and water users; however, during detailed design, the use of existing sustainable groundwater allocated entitlements to supplement the construction demand for the Project may be considered/investigated if owners of registered bores have capacity under their water entitlement that they wish to lease to ARTC under a water trading agreement. Therefore, the volumes extracted would be within the existing licensing limits and the extent of drawdown experienced would be localised and consistent with that which is currently permissible for each licenced bore
		▸ Construction water sources will be finalised as the construction approach is refined during the detailed design stage of the Project and will be documented as part of the Construction Water Plan. The sources will be dependent on:
		  ▸ climatic conditions as detailed design progresses and in the lead up to pre-construction and early works and construction works stages
		  ▸ confirmation of water sources made available under private agreement.
		▸ The current construction water sourcing strategy is summarised in Chapter 5: Project Description.

	Groundwater quality	▸ Baseline groundwater monitoring data (levels and quality) will recommence at Project monitoring bores during detailed design in accordance with the Baseline GMMP (Section 15.7.3), incorporating the monitoring bores installed during the 2023 campaign
		▸ Groundwater monitoring and sample collection is conducted in accordance with recognised groundwater sampling guidelines such as *Monitoring and Sampling Manual* (DES, 2018b) and *Groundwater Sampling and Analysis—A Field Guide* (Sundaram et.al., 2009)
		▸ Data collected during the detailed design stage will be used to establish a groundwater quality baseline for the Project prior to the commencement of construction. The groundwater quality baseline dataset provides a foundation against which construction works stage impacts can be monitored and compared. Baseline groundwater monitoring data will be used to establish:
		  ▸ location/bore-specific impact thresholds in accordance with *Using monitoring data to assess groundwater quality and potential environmental impacts* (DES, 2021a)
		  ▸ responses to impact threshold exceedances, including 'make good' agreements. These details will be incorporated into the Construction GMMP.
		▸ A Contaminated Land Management Plan will be developed during the detailed design stage and incorporated into the CEMP. This Plan will document management controls for works on land that is known or suspected of being contaminated and outline the process to identify, document and manage contaminated sites (Chapter 9: Land Resources)
		▸ Where potential for contamination risk exists, groundwater monitoring and investigations will be undertaken upgradient and downgradient prior to commencement of construction, to confirm the presence/absence of groundwater contamination and inform the requirement for management controls.

Delivery stage	Aspect	Mitigation and management measures
Pre-construction and early works and construction works	Impacts to bores	▸ There are 38 registered bores within the Project footprint, that are not Project monitoring bores, for the revised reference design. These bores, plus unregistered bores identified within the Project footprint (three unregistered bores currently identified), are likely to be decommissioned for the progression of the Project. Where a groundwater bore is expected to be decommissioned or have access to it impaired as a result of the Project, 'make good' measures will be developed on a case-by-case bases and agreed in consultation with the affected landowner. Bores will be decommissioned in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (Edition 4) (NUDLC, 2020) ▸ Prior to construction works commencing, groundwater modelling and monitoring will be conducted upgradient and downgradient of any deep cuts, as well as cuts that intercept groundwater, to determine potential for impact the groundwater in the vicinity of the cuts, including bores.
	Water resources	▸ The Construction GMMP will be implemented ▸ Opportunities to re-use/recycle water during construction will be identified and implemented where feasible (i.e. reuse of treated effluent from non-resident workforce accommodation facilities—further detail discussed in Chapter 5: Project Description).
	Sourcing of construction water	▸ Although unlikely, should the Project access groundwater, it would be secured through private agreement, the licenced capacity of existing bores will not be exceeded. Flow and volume monitoring during extraction will be required for each bore, with extraction logs maintained.
	Groundwater levels	▸ Groundwater level monitoring will be undertaken in accordance with the construction GMMP to identify potential impacts to groundwater levels resulting from the Project ▸ The construction GMMP will incorporate groundwater monitoring at 'reference bores' upgradient and downgradient of any deep cuts, as well as cuts that intercept groundwater, and will be undertaken prior to, during and post construction, to determine if impacts have occurred as a result of the construction of the cuts.

	Groundwater quality	▸ Where suspected contaminated soils or materials are identified, if encountered, these will be managed in accordance with the unexpected finds protocol/procedure documented in the Contaminated Land Management Plan of the CEMP.
		▸ Vehicle and plant maintenance will be undertaken in designated laydown areas, on hardstand surfaces. This will minimise the risk of contaminants from incidental spills or leaks (accidental discharge) from entering aquifers via infiltration or surface runoff
		▸ Refuelling will only occur at designated locations within the Project footprint and be sited at suitable separation distances from sensitive receptors, including surface water features and drainage lines. These refuelling locations will be equipped with onsite chemical and hydrocarbon absorbent socks/booms and spill kits
		▸ Bulk storage areas for dangerous goods and hazardous materials will be located away from areas of social and environmental receptors such that offsite impacts or risks from any foreseeable hazard scenario will not exceed the dangerous dose for the defined land use zone (i.e. either sensitive, commercial/ community, or industrial, in accordance with the intent of the State Planning Policy)
		▸ A Hazardous Materials Management Plan will be implemented for construction activities as a component of the CEMP. The Plan will be required to:
		  ▸ identify the materials required to be stored and used in support of construction, including volumes of each
		  ▸ identify the laydown areas that will be used for storage of hazardous materials and designated locations for storage of hazardous materials within the bounds of those laydown areas
		  ▸ specify how dangerous goods and hazardous materials will be handled, stored and transported for the Project
		  ▸ describe the response procedures in the event of an incident involving hazardous materials or dangerous goods
		  ▸ establish the waste storage and disposal procedures for hazardous materials and dangerous goods
		▸ Chemicals stored and handled as part of construction activities will be managed in accordance with:
		  ▸ The *Work Health and Safety Act 2011* (Qld) and Regulation
		  ▸ *AS 2187.1:1998 Explosives—Storage, transport and use: Part 1: Storage* (Standards Australia, 1998a)

Delivery stage	Aspect	Mitigation and management measures
		‣ *AS 1940:2017 The storage and handling of flammable and combustible liquids* (Standards Australia, 2017a) ‣ *AS 3780:2008 The storage and handling of corrosive substances* (Standards Australia, 2008a) ‣ The requirements of chemical safety data sheets. ‣ Spill kits will be available at all work fronts and laydown areas in the event of a spill or leak. All vehicles and machinery will have dedicated spill kits. These refuelling locations will be equipped with onsite chemical and hydrocarbon absorbent socks/booms and spill kits. ‣ Mobile plant, drill rigs, and equipment will be maintained in accordance with manufacturer requirements and inspected frequently to minimise breakdowns and decrease the risk of contamination ‣ All excavated material that is suspected to contain sulphides will be stockpiled, lined and covered, and managed to minimise rainfall infiltration and leaching. Where possible, treatment and onsite reuse is preferred to offsite disposal. A case-by-case assessment of the suitability of material for treatment and reuse will be required, in accordance with the earthworks material management options (Appendix AB: Earthworks Strategy and Draft Soil Management Plan) and spoil management (Chapter 22: Waste and Resource Management).
	Encountering ARD	‣ All excavated material that is suspected to contain sulphides will be stockpiled, lined and covered, and managed to minimise rainfall infiltration and leaching. Where possible, treatment and onsite reuse is preferred to offsite disposal. A case-by-case assessment of the suitability of material for treatment and reuse will be required, in accordance with the Project's earthworks material management options (Appendix AB: Earthworks Strategy and Draft Soil Management Plan) and spoil management (Chapter 22: Waste and Resource Management) ‣ If ARD (leachate) is identified during construction, seepage water from relevant deep cuts will be sampled at weekly intervals. This monitoring will involve the onsite screening of the seepage water for pH (trending down) and EC (trending up) and comparison to the baseline groundwater results. Further laboratory analyses for the key analytes (i.e. pH, TDS, EC, TSS, alkalinity, and dissolved metals) will be required if pH and EC trends indicate the potential for oxidation occurring and will be used to validate the presence or absence of ARD potential to mitigate potential leachate to the environment ‣ If ARD contaminated discharge water/leachate is found to be generated from the deep cuts, this water may need to be impounded in ponds and stabilised via treatment with hydrated lime or dilution prior to disposal.
Operations	Impacts to registered bores	‣ An operational GMMP will be developed prior to operations commencing to specify the groundwater monitoring requirements, if any, over the initial operation years of the Project (Section 15.7.3).
	Groundwater quality	‣ Before a train travels on the Inland Rail network, operators must make sure that the classes of dangerous goods, and the identification numbers of vehicles carrying dangerous goods, are recorded in the train consist documentation. Dangerous goods must be loaded, labelled, and marshalled in accordance with the *Australian Code for the Transport of Dangerous Goods by Road & Rail* (National Transport Commission, 2024.) ‣ Appropriate controls are to be in place to prevent environmental incidents, including leaks/spills from refuelling activities and locomotive operations, and to protect the environment in the event of an incident. All fuel and chemical spills will be dealt with in a manner consistent with relevant health and safety guidelines ‣ Procedures for the management of hazardous chemical spills and leaks will be developed and incorporated into the Operations EMP. These procedures will be in accordance with ARTC's *Work Instruction: Chemicals* (WHS-WI-214) (2016) and *Procedure: Emergency Management* (RLS-PR-044) (2024).

15.7.3 Groundwater Management and Monitoring Program

The GMMP provides for an ongoing assessment of the potential groundwater impacts (discussed in Section 15.6) throughout the various stages of the Project. The GMMP incorporates principles of performance assessment and adaptive management—a structured, iterative process for decision making. The GMMP will be assessed and updated before the commencement of each Project stage (pre-construction and early works, detailed design, construction works, and operations) such that the GMMP for subsequent stages is informed by the outcomes of the previous stage.

The environmental monitor will have oversight of the implementation of the GMMP, responsible for the review and verification of the monitoring results, throughout construction and operation of the Project and in accordance with the framework presented in Chapter 24: Draft Outline Environmental Management Plan. The evolution of the GMMP over sequential Project stages is discussed below and shown on Figure 15-30.

The GMMP will include:

- Description of the principal aquifers of interest, local use of groundwater, and the predicted impacts on groundwater
- Description of the groundwater monitoring program including monitoring locations, monitoring frequency and the parameters to be recorded/analysed
- Identification of the groundwater impact triggers and protocols for investigating and, if required, mitigating the impacts on groundwater
- Description of the process of continual review and improvement of the GMMP to ensure it continues to meet its objectives.

15.7.3.1 Baseline Groundwater Management and Monitoring Program

The Baseline GMMP's primary objective is to develop a baseline dataset that all subsequent monitoring will be assessed against to identify potential impacts from the Project in accordance with regulatory requirements. This dataset will also inform the development of Project-specific WQOs. Data collected during the baseline groundwater monitoring program has, to date, and will continue to, account for natural (seasonal) and/or anthropogenic fluctuations of groundwater levels or quality prior to construction. This is most important for the shallow alluvial aquifers, WCM outcrop and MRV outcrop areas the Project traverses as groundwater in these sediments are the most likely to fluctuate over time and has the greatest potential to be impacted as a result of the Project.

The baseline dataset resultant from this GMMP will provide site-specific information to support the assessment of potential Project impacts including intra- and inter-project cumulative impacts early identification of groundwater quality and monitoring local conditions over time promotes adaptive management for changing conditions to mitigate additional impact from the Project. Cumulative Impacts are further detailed in Chapter 23: Cumulative Impacts.

The groundwater monitoring network is presented in Table 15-21, and reflects the revised reference design while addressing data gaps identified during monitoring (Section 15.4). The network will be assessed as part of the detailed design stage of the Project and data gaps addressed prior to construction, if required.

The framework for groundwater level and quality monitoring, data management and reporting as part of the baseline monitoring program is presented below. Baseline groundwater monitoring to date has been conducted since 2018 and is discussed in detail in Section 15.4.2. Groundwater monitoring and sample collection has been conducted in accordance with groundwater sampling guidelines such as *Monitoring and Sampling Manual* (DES, 2018c) and *Groundwater Sampling and Analysis— A Field Guide* (Sundaram, et.al., 2009); future monitoring events should also adopt these guidelines until updated versions are available.

The baseline groundwater data will be compiled to provide a robust and repeatable data set that will promote early and confident warning of potential impacts from the Project. The baseline dataset will be adequate to develop site-specific WQOs, as warranted, and inform the construction works stage GMMP (Section 15.7.3.2).

Groundwater level monitoring

In bores with sufficient water column, groundwater levels have been, and will continue to be, monitored using automated pressure transducers (level loggers) to record measurements at hourly intervals. The logger data will be downloaded and manual, static groundwater level measurement collected from each bore as a component of the onsite groundwater monitoring event. The manual measurement acts as a quality control check for the pressure transducers.).

Groundwater quality monitoring

Groundwater quality samples are to be collected from all bores during every event. The analytes to be collected and assessed for each bore will be detailed in the GMMP and based on previous monitoring results, land use, Project design element, and Project stage. Field aquifer characteristics, including pH, EC, oxygen reduction potential, dissolved oxygen, turbidity, and temperature should be monitoring and measured prior to sample collection.

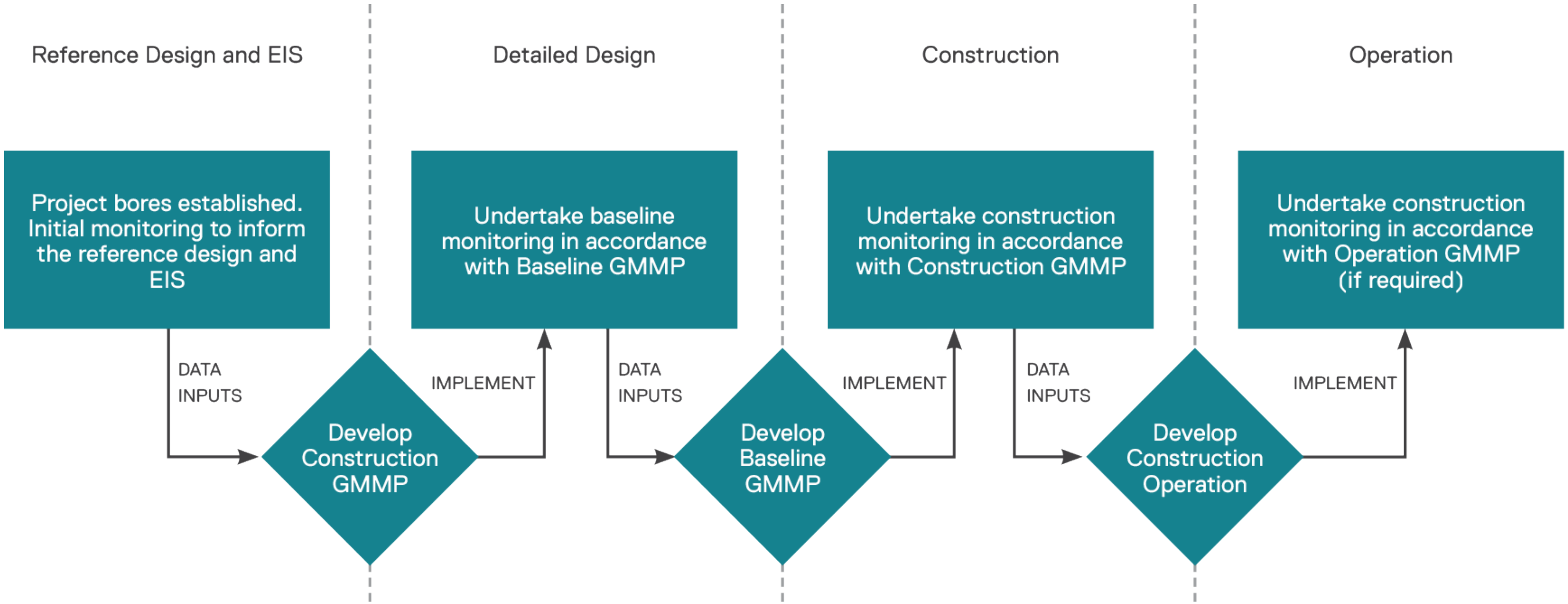


FIGURE 15-30 DEVELOPMENT AND IMPLEMENTATION OF THE GROUNDWATER MANAGEMENT AND MONITORING PROGRAM OVER SEQUENTIAL PROJECT STAGES

TABLE 15-21 BASELINE GROUNDWATER MANAGEMENT AND MONITORING NETWORK OF MONITORING BORES

Chainage (km)	Bore ID	Easting[1]	Northing[1]	Longitude[2]	Latitude[2]	Bridge or cutting	Aquifer	Rationale for inclusion in GMMP	2023 status
30.8 NS2B	270-01-BH2213	251109	6826531	-28.66448692	150.453287	Macintyre River	Alluvium	Baseline data for BRA aquifer and Macintyre River bridge structure	Existing bore
32.8 NS2B	270-01-BH2217	251620	6828602	-28.64590985	150.458962	NA	Alluvium	Baseline data for BRA aquifer	Existing bore
34.8 NS2B	270-01-BH2218	251072	6830485	-28.62882464	150.4537705	NA	Alluvium	Baseline data for BRA aquifer	Existing bore
52.8	310-01-BH2203	300144	6852564	-28.43815518	150.9592652	NA	WCM	Baseline data for WCM and VE reference design deep cut C04	Existing bore
55.0	310-01-BH2206	302299	6853323	-28.43163627	150.9813887	NA	WCM	Baseline data for WCM. Previously co-located with deep cut of the reference design	Existing bore
63.8	310-01-BH2309	309357	6857528	-28.39475019	151.0541129		WCM		Existing bore
65.8	310-01-BH2210	311744	6857672	-28.39379682	151.078489	NA	WCM	Baseline data for the WCM	Existing bore
78.4	RN41640009	320750	6866250	-28.31766957	151.1716999		Marburg	Baseline data for Marburg subgroup—bi-annual level data available from DRDMW	Existing bore
87.4	310-01-BH2214	319068	6875070	-28.2378626	151.1559228	NA	WCM	Baseline data for the WCM	Existing bore
88.3	310-01-BH2215	318929	6875972	-28.22970539	151.1546468	NA	WCM	Baseline data for the WCM	Existing bore
94.0	310-01-BH2216	321182	6880902	-28.18553261	151.1783533	NA	WCM	Baseline data for the WCM	Existing bore
139.9	310-01-BH2231	338076	6918598	-27.84756339	151.3555708	Condamine River and tributaries rail bridges	Alluvium	Baseline data for CA and Grasstree Creek bridge structure	Existing bore
144.0	RN42231089	338799	6922879	-27.8090197	151.3634905		Alluvium	Baseline data for CA—quarterly level data available from DRDMW	Existing bore
144.1	310-01-BH2233	340530	6922012	-27.81705053	151.3809418		Alluvium	Baseline data for CA and Condamine River bridge structure	Existing bore
144.5	310-01-BH2234	340696	6922345	-27.81406531	151.3826711		Alluvium		Existing bore
145.1	RN42230031	340326	6923742	-27.80141485	151.3791031		Alluvium	Baseline data for CA—quarterly level data available from DRDMW	Existing bore
146.2	RN42231416	341201	6924116	-27.79814381	151.3880324		Alluvium	Baseline data for CA—quarterly level data available from DRDMW	Existing bore
150.0	310-01-BH2235	344710	6926073	-27.78089455	151.4238959		Alluvium	Baseline data for CA and Condamine River North Branch bridge structure	Existing bore
186.7	310-01-BH2343	375835	6942386	-27.63690327	151.741418	C39	MRV	Baseline data for MRV	Existing bore
189.3	310-01-BH2344	377527	6944383	-27.61903361	151.7587688	C41	MRV	Baseline data for the MRV and revised reference design deep cut C41	Existing bore
190.7	310-01-BH2345	377893	6945680	-27.60736042	151.7626089	NA	MRV	Baseline data for the MRV	Existing bore

Chainage (km)	Bore ID	Easting[1]	Northing[1]	Longitude[2]	Latitude[2]	Bridge or cutting	Aquifer	Rationale for inclusion in GMMP	2023 status
195.3	310-01-BH2347	379008	6950198	-27.5666823	151.7743594	NA	MRV	Baseline data for the MRV	Existing bore
197.3	310-01-BH2248	378811	6952190	-27.5486853	151.7725642	NA	MRV	Baseline data for the MRV	Existing bore
197.0	RN42231135	379065	6951846	-27.55181287	151.7751018	NA	WCM	Baseline data for WCM—bi-annual level data available from DRDMW	Existing bore
198.4	MW100	378853	6953243	-27.53919755	151.7730889	-	MRV	Baseline data for the MRV	New bore (2023)
193.8	MW101	378406	6948707	-27.58009845	151.7681058	-	MRV	Baseline data for the MRV	New bore (2023)
190.8	MW102	377845	6945843	-27.60589757	151.762133	-	MRV	Baseline data for the MRV	New bore (2023)
185.7	MW103	375160	6941780	-27.64232318	151.7345082	-	MRV	Baseline data for the MRV	New bore (2023)
180	MW104	370856	6938120	-27.67495108	151.6904946	-	MRV	Baseline data for the MRV	New bore (2023)
176.4	MW105	367956	6936151	-27.69244077	151.6608788	-	MRV	Baseline data for the MRV	New bore (2023)
172.8	MW106	364981	6934723	-27.70503365	151.6305541	-	MRV	Baseline data for the MRV	New bore (2023)
129.7	MW107	331888	6912064	-27.90577212	151.2918195	-	WCM	Baseline data for the WCM	New bore (2023)
122.5	MW108	326591	6908284	-27.93920187	151.2374642	-	WCM	Baseline data for the WCM	New bore (2023)
116.5	MW109	324884	6902697	-27.98939005	151.2192935	-	EF or WCM	Baseline data for the Eurombah Formation and the WCM	New bore (2023)
103.7	MW110	323490	6890128	-28.10261319	151.2032397	-	WCM	Baseline data for the WCM	New bore (2023)
100.2	MW111	322102	6886748	-28.13292385	151.1886039	-	WCM	Baseline data for the WCM	New bore (2023)
76.5	MW112	319375	6864693	-28.33154128	151.1574328	-	Alluvium	Baseline data for CA	New bore (2023)
60.5	MW113	306436	6857106	-28.39814094	151.024236	-	WCM	Baseline data for the WCM	New bore (2023)
144.3	MW114	340545	6922128	-27.81601825	151.3811034	-	Alluvium	Baseline data for CA	New bore (2023)
128.3	MW115	330433	6912223	-27.90415337	151.2770635	-	WCM	Baseline data for the WCM	New bore (2023)
139.8	MW116	338125	6918508	-27.84839418	151.3560499	-	Alluvium	Baseline data for CA	New bore (2023)
197.6	MW118	378813	6952399	-27.54681176	151.7725992	-	MRV	Baseline data for the MRV	New bore (2023)
149.6	MW119	344962	6925457	-27.78649528	151.4263666	-	Alluvium	Baseline data for CA and Condamine River	New bore (2023)
144.5	MW120	340749	6922258	-27.8148694	151.3831913	-	Alluvium	Baseline data for CA and Condamine River	New bore (2023)
166.6	MW121	359097	6933721	-27.71347351	151.5707721	-	MRV	Baseline data for the MRV	New bore (2023)
167.7	MW123	360207	6933484	-27.71572819	151.5820007	-	MRV	Baseline data for the MRV	New bore (2023)

Table notes:

1 Coordinates for existing bores surveyed in GDA94, coordinates for new bores (2023) surveyed in GDA20

2 MGA94 Z56

XX = unknown construction detail

'-' – detail not currently available.

The following laboratory analytes were adopted for all bores (where sufficient water column is available) each monitoring event, and should be maintained for ongoing monitoring, for aquifer characterisation:

- pH, EC and total dissolved solids
- Major anions (HCO_3^-, Cl^- and SO_4^{2-})
- Major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+ and Si)
- Dissolved and total metals (Al, As, B, Cd, Cr, Cu, Mn, Pb, Ni, Se, Mo, Ag, Zn, Fe and Hg)
- Nutrients (ammonia, nitrite, nitrate, total N and total P).

The following additional laboratory analytes were adopted for select bores and monitoring events to inform of existing concentrations based on land use, if any, and will be considered in the GMMP:

- Total recoverable hydrocarbons
- Benzene, toluene, ethylbenzene, xylenes
- Polycyclic aromatic hydrocarbons including naphthalene
- Polychlorinated biphenyl.

Data management and reporting

The following data and reporting requirements were implemented:

- All groundwater data are validated with suitable quality assurance/quality control protocols
- Monitoring data is reported in the form of a factual memorandum on a per monitoring event basis, and will be reviewed and assessed at completion of baseline monitoring to identify trends and develop interim Project-specific WQO.

15.7.3.2 Construction Groundwater Management and Monitoring Program

The construction GMMP will be developed using a risk-based approach, with monitoring and sampling requirements dependent on the likelihood of construction activities encountering groundwater and the location of such activities, along with the outcomes of the baseline GMMP and final Project design. Monitoring will be managed by the environmental manager responsible for implementation of the CEMP and overall environmental monitoring for the Project post-EIS. Groundwater monitoring for construction will include targeted locations where construction activities have potential to impact on groundwater quality and/or levels, as identified in Section 15.6.

Monitoring will be performed at locations (distance and depth/aquifer) up- and down-gradient of the site where construction activities are occurring and at reference bores outside the anticipated extent of impact. Where construction activities are surficial in nature, monitoring of deep aquifers would not be warranted; however, surficial construction tasks may require specific monitoring for analytes being used in that task (task-specific monitoring).

15.7.3.3 Operation Groundwater Management and Monitoring Program

The operation GMMP will be developed from the groundwater data and observations collected during previous Project stages and will include a framework for monitoring in response to an environmental spill or incident. The environmental manager will be responsible for implementation of the CEMP and the GMMP that underpins it. Groundwater monitoring will continue into the operations stage of the Project to confirm the groundwater levels have recovered, where available, and/or to identify delayed impacts on groundwater, if any.

15.7.3.4 Summary

A summary of the monitoring approach proposed for each stage of the Project is presented in Table 15-22.

TABLE 15-22 SUMMARY OF PROPOSED GROUNDWATER MANAGEMENT AND MONITORING PROGRAM

	Baseline (pre-construction)	Construction	Operation
Groundwater level monitoring	▸ A baseline GMMP to be finalised for the resumption of monitoring ▸ Pressure transducers/level loggers record measurements at hourly intervals ▸ Pressure transducer data downloaded bi-monthly ▸ Manual measurements bi-monthly	▸ A construction GMMP will be developed prior to construction ▸ Groundwater level monitoring will be conducted at the locations and frequency nominated in the construction GMMP.	▸ An operational GMMP will be developed at the end of the construction period. ▸ Groundwater level monitoring will be conducted at the locations and frequency nominated in the operation GMMP.
Groundwater quality monitoring	▸ A baseline GMMP to be finalised for the resumption of monitoring ▸ Bi-monthly sample collection and analysis for the analytes as discussed in Section 15.7.3.1	Groundwater quality monitoring will be conducted at the locations and frequency nominated in the construction GMMP.	Groundwater quality monitoring will be conducted at the locations and frequency nominated in the operation GMMP.
Reporting	▸ Factual memorandum on a per monitoring event basis and baseline monitoring completion report.	To be confirmed	To be confirmed

15.7.4 Landowner bore make-good

The groundwater 'make good' or mitigation framework for the Project considers two pathways for bores to be made good: bores located on land accessed by the Project and bores located on land not accessed by the Project.

Where a groundwater bore is expected to be decommissioned or have access/usage impaired as result of the Project, 'make good' measures will be agreed in consultation with the affected landowner. As predictive modelling indicates all groundwater drawdown impacts from the Project would not extend outside the Project footprint (Section 15.6.5), a bore can be impacted by the Project through its location within the footprint or severance of access to the bore due to the footprint. That is, any groundwater drawdown resultant from the Project is unlikely to impact on bores and groundwater users outside the Project footprint. Therefore, the make good framework developed for the Project, Figure 15-31[1], considers two pathways for make good: bores located on land accessed by the Project and bores on land not accessed by the Project.

To inform the make good framework, ARTC sought advice from many stakeholders to promote a transparent, consistent, and collaborative approach. All landowners identified to have a registered bore within the Project footprint have been contacted and the consultation process started, where a landowner agreed. A bore survey was undertaken in between December 2021 and April 2022 to confirm the location of registered bores and to identify unregistered bores that may be impacted by the Project. Consultation with landowners will continue during the detailed design stage.

1 Bore impairment may include:
- Damage to the bores, bore pumps or other related infrastructure proximal to the construction area
- Impairment of bore access due to location within or proximal to the construction area
- Decline in bore water quality
- Decline in water quality.

15.7.4.1 Bore baseline report

A bore baseline report will be prepared for bores that are subject to consultation with ARTC. The information to be included in a 'bore baseline report' includes but is not limited to:

- Bore construction details
- Bore equipment and condition survey
- Bore yield
- Bore supply assessment—bore operating capacity and peak usage information
- Bore water level assessment—SWL
- Bore water quality assessment—analytes consistent with approved use of the bore
- Licence status and conditions and authorised water use (purpose and volume) under the relevant Water Plan, if appropriate.

Following the preparation of a bore baseline report, make-good measures will depend on where the bore is located, either within or outside of land accessed by the Project.

15.7.4.2 Bores located on land accessed by the Project

For bores to be decommissioned or otherwise impaired by the Project location/footprint, the following will likely be relevant:

- Where such bores are located on land that has been compulsorily acquired (either on a permanent or temporary basis) or temporarily occupied: compensation will be payable or able to be claimed in accordance with the *Acquisition of Land Act 1967* (Qld). Compensation will be assessed on a case-by-case basis and will depend on the impact of the Project on the bore and the water supply. If agreement on compensation cannot be reached, the constructing authority will arrange a conference to resolve differences. If agreement is still not reached referral can be made to the Land Court for independent determination.
- Where the land the bore is located on has been purchased in a voluntary transaction by the constructing authority, the purchase price will be agreed between ARTC and parties, and paid to parties under the contract
- For bores located on land occupied by the Project under licence or lease agreement, bore impairment measures will be determined by the terms of the licence/lease and such terms will make provision for 'make good' measures, which could likely include a monetary amount.

If a bore will not be decommissioned or impaired by the Project, groundwater monitoring will be undertaken and managed in accordance with the GMMP.

15.7.4.3 Bores not located on land accessed by the Project

Where a landowner bore is located outside the Project footprint (temporary and permanent footprints) and thus not anticipated to be impacted by the Project, a complaint would need to be made to Inland Rail regarding groundwater bore impairment. Any such bores will be subject to a bore assessment to confirm any impact. If a bore is assessed as impaired by the Project, an agreement and make-good measures with the landowner will be developed on a case-by-case basis. Otherwise, groundwater monitoring will be undertaken and managed in accordance with the GMMP.

Where there is a dispute, such disputes or related complaints will be managed in accordance with the proposed complaints management procedure as per the Draft OEMP.

If the landowner does not accept the bore assessment (either whether there is bore impairment in the first place, or the level of bore impairment), ARTC will:

- Provide ARTC's bore assessment to the landowner for review by the landowner's suitably qualified person
- Advise the landowner that they are entitled to obtain a bore assessment from a suitably qualified person
- Advise the landowner that ARTC will pay their reasonable costs for such bore assessment
- Advise landowners of their expectations as to the reasonable costs of obtaining a bore assessment.

For the purpose of this revised draft EIS the term 'bore baseline report' refers to the initial bore investigation works to be conducted to assess and report the baseline conditions (bore yield, capacity, use) of a landowner bore, while the 'bore assessment' refers to the detailed, downhole assessment to inform of any impaired capacity of a bore.

Bore make good process

Acronyms used

REIQ Real Estate Institute of Queensland

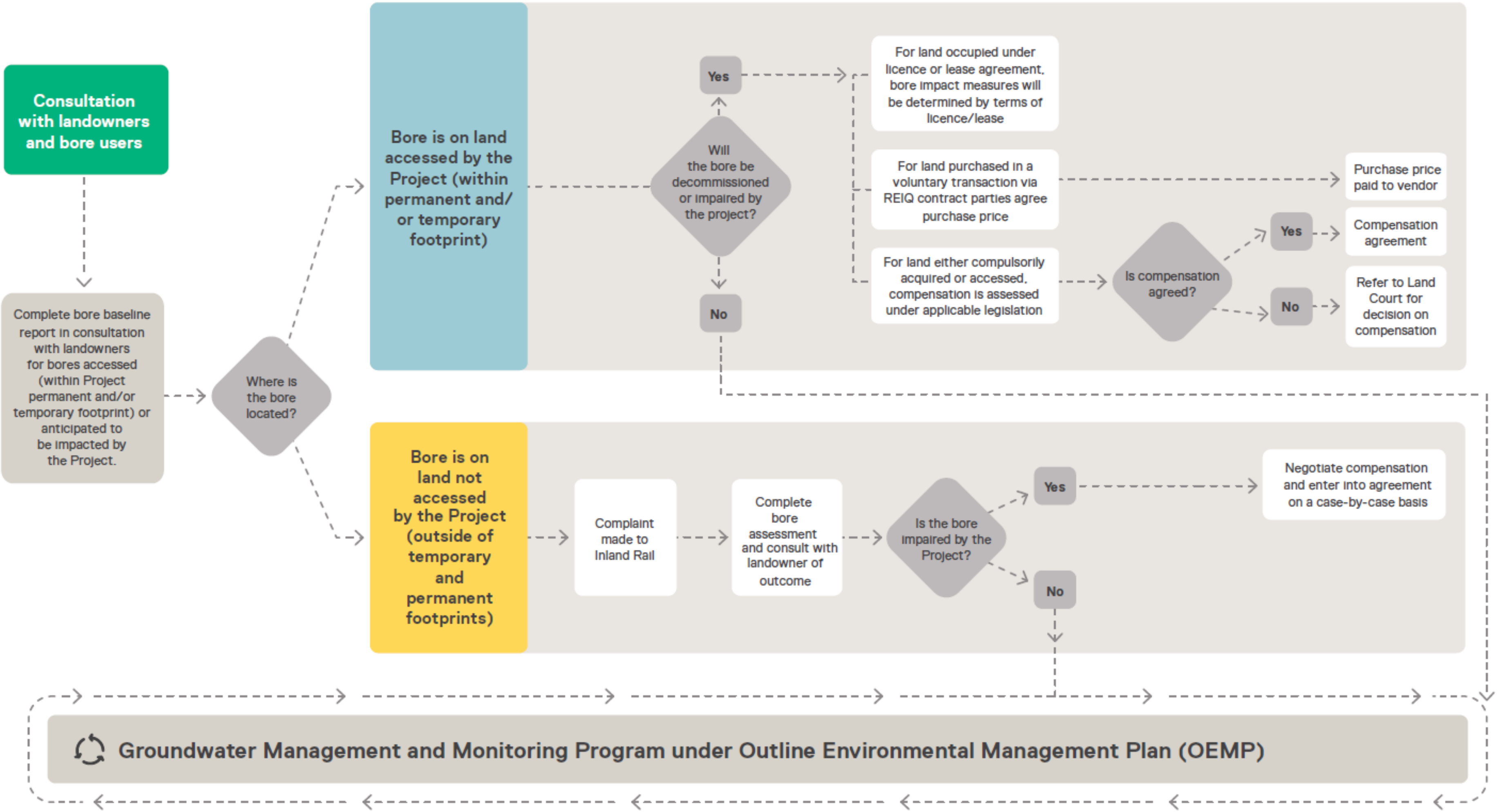


FIGURE 15-31 PROPOSED GROUNDWATER BORE ‘MAKE GOOD’ PROCESS

TABLE 15-23 SIGNIFICANCE ASSESSMENT FOR GROUNDWATER

Aspect	Stage	Initial significance[1]			Residual significance[2]	
		Sensitivity	Magnitude	Significance	Magnitude	Significance
Impacts to existing bores (registered and non-registered)	Pre-construction and early works and construction works	Moderate	Moderate	Moderate	Low	Low
	Operations		Moderate	Moderate	Low	Low
Subsidence/consolidation due to groundwater extraction or dewatering and/or loading	Pre-construction and early works and construction works	Moderate	Low	Low	Low	Low
	Operations		Low	Low	Low	Low
Altered groundwater levels (increase or decrease) affecting groundwater users and GDEs (including impacts due to embankments and seepage to cuts)	Pre-construction and early works and construction works	Moderate	Low	Low	Low	Low
	Operations		Low	Low	Low	Low
Altered groundwater flow regime	Pre-construction and early works and construction works	Moderate	Moderate	Moderate	Low	Low
	Operations		Low	Low	Low	Low
Contamination or altered water quality impacting vulnerable groundwater resources (spills or induced flow, borehole intersections. Upwards leakage along pile/soil interface)	Pre-construction and early works and construction works	Moderate	Moderate	Moderate	Low	Low
	Operations		Low	Low	Low	Low
ARD impacting on EVs (i.e. GDEs)	Pre-construction and early works and construction works	Moderate	Moderate	Moderate	Low	Low
	Operations		Low	Low	Low	Low
Vegetation removal and surface alteration affecting recharge/discharge, increasing associated salinity risks	Pre-construction and early works and construction works	Moderate	Moderate	Moderate	Low	Low
	Operations		Low	Low	Low	Low

Table notes:

1 Includes implementation of initial mitigation measures specified in Table 15-19

2 Assessment of residual significance once the mitigation measures specified in Table 15-20 have been applied.

15.8 Conclusions

This report has been prepared to evaluate potential impacts of the Project on groundwater resources, and addresses the ToR requirements and additional requirements and requests for information from the Coordinator-General with respect to groundwater. This chapter has identified existing conditions of the impact assessment area in accordance with industry standard methodology and relevant legislation. Through an assessment of existing conditions, Project activities with the potential to adversely impact on groundwater resources were identified.

Project activities, throughout the Project lifecycle, can impact on groundwater resources via:

- Loss or damage to existing landowner bores or groundwater use from the bore (quality/yield degradation)
- Loss of access to landowner bores due to Project location
- Seepage/inflows and groundwater level drawdown at deep cuts
- Alteration of aquifer parameters and/or flow patterns
- Subsidence/settlement of compressible substrates
- Contamination/reduction of groundwater quality
- ARD
- Groundwater level mounding
- Alteration to groundwater recharge/discharge mechanisms.

Potential impacts related to groundwater for the Project are considered minor and temporary in nature, associated with the construction works stage of the Project. All potential impacts on groundwater resources are localised and not expected to extend outside the Project footprint, and are manageable with the implementation of the mitigation measures specified in Section 15.7.2.

In the few deep-cut locations where construction activities have the potential to intersect groundwater, modelling has predicted impacts to be localised within the Project footprint. Best practice engineered controls will be utilised at deep-cut locations where groundwater is intercepted to minimise the extent and duration of disturbance to groundwater resources and ensuring structurally sound construction sites. As a conservative approach, the predictive modelling will be updated prior to construction commencement based on confirmed design at potential groundwater interception locations, both up- and down-gradient, to confirm the inflows and drawdown, and monitoring and management plans reviewed and updated accordingly as required.

Implementation of the GMMP, that embraces adaptive management principles will ensure that specific potential impacts identified for each stage of the Project can be managed and based on specific activities, locations, and WQOs to protect groundwater resources and users.