APPENDIX

M

INLAND RAIL

Surface Water Quality Technical Report

PART 1 OF 2

Main Report

CALVERT TO KAGARU ENVIRONMENTAL IMPACT STATEMENT

IR_1381

ARTC

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

Inland Rail Calvert to Kagaru EIS

Appendix M – Surface Water Quality Technical Report

Australian Rail Track Corporation

Reference: 3400

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Abbreviations

Abbreviation	Explanation
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AMO	Aeronautical Meteorological Office
ANZECC/ARMCANZ 2000	Australian and New Zealand guidelines for fresh and marine water quality
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ARTC	Australian Rail Track Corporation Ltd
ASRIS	Australian Soil Resource Information System
ASS	acid sulfate soils
BoM	Bureau of Meteorology
C2K	Calvert to Kagaru
CBD	Central Business District
CEMP	Construction Environmental Management Plan
Ch	Chainage (kilometre along proposed Project)
CIA	cumulative impact assessment
Cth	Commonwealth
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DES	Department of Environment and Science
DLGRMA	Department of Local Government, Racing and Multicultural Affairs
DNRME	Department of Natural Resources, Mines and Energy
DotEE	Department of the Environment and Energy
DSDMIP	Department of State Development, Manufacturing, Infrastructure and Planning
EAM	Environmental Assessment and Management
EP Act	*Environmental Protection Act 1994* (Qld)
EPP (Water and Wetland Biodiversity)	Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EV	environmental values
Fisheries Act	*Fisheries Act 1994* (Qld)
GDE	Groundwater dependant ecosystem
GPS	Global Positioning System
H2C	Helidon to Calvert
HLW	Healthy Land and Waterways
IAA	important agricultural areas
IECA	International Erosion Control Association
Inland Rail	Melbourne to Brisbane Inland Rail
km	kilometres
km^2	square kilometres
m	metre
MNES	Matters of National Environmental Significance

Abbreviation	Explanation
MSES	Matters of State Environmental Significance
NATA	National Association of Testing Authorities
PAH	polycyclic (polynuclear) aromatic hydrocarbons
Planning Act	*Planning Act 2016* (Qld)
QLD	Queensland
QWQG	Queensland Water Quality Guidelines
Ramsar wetlands	Wetlands of International Importance
RCP	reinforced concrete pipe
RCBC	reinforced concrete box culvert
RE	regional ecosystems
SDA	State Development Area
SDPWO Act	*State Development and Public Works Organisation Act 1971* (Qld)
SEQ	South-east Queensland
SFRC	Southern Freight Rail Corridor
SPP	State Planning Policy 2017 (Qld)
TAL	Tonne axle load
ToR	Terms of Reference
the proponent	Australian Rail Track Corporation Ltd
the Project	C2K Project alignment
Water Act	*Water Act 2000* (Qld)
WMIP	Water Monitoring Information Portal
WQO	water quality objectives
WTP	Water Treatment Plant

Glossary

Term	Explanation
Acid sulfate soils (ASS)	Soils containing iron sulphides (Pyrite) which can produce sulphuric acids when disturbed (exposed to oxygen) through conversion of Pyrite.
Australian height datum (AHD)	The national vertical datum for Australia, acting as a vertical control for height above sea level.
Ballast	Rock placed under the rail ties (sleepers) to provide stable support for a rail line.
Catchment	Catchment at a particular point is the area of land that drains to that point.
Chainage	A measure of distance along the rail corridor. The values are progressive from the start of each package (from Melbourne to Brisbane) with the terminus of each being the alignment at the interface with the next package leading to Brisbane. For readability, chainage is noted in approximate kilometre throughout the document and noted in metres for figures.
Dispersive	A characteristic of soil indicating the potential for the breakdown of clay minerals into single clay particles in solution.
Disturbance footprint	The area relating to the permanent operational footprint and temporary construction footprint that would be affected from Project activities
Ephemeral	Temporary, short-lived. An ephemeral watercourse is one that flows following periods of heavy rainfall.
Greenfield	An undeveloped site.
Hydraulic	Water movements in regard to velocity and flow regime.
Hydrology	The study or rainfall and runoff process.
Limit of Reporting	The smallest concentration of analyte that can be reported by a laboratory.
Megalitres	A metric unit of capacity equal to 1 million litres
Perennial	Lasting or enduring. A perennial watercourse has continuous flow all year-round during years of normal rainfall.
Permanent operational footprint	The areas of the Project that will be permanently and directly impacted by the operation of the rail line and associated facilities.
Project	The construction and operation of the Calvert to Kagaru Project
Runoff	The amount of rainfall from a catchment that actually ends up as flowing water in the river or creek.
Salinity	Refers to the amount of salt present in the soil solution.
Stream order	A measure of the relative size of a watercourse.
Surface water quality receptor	A receptor is a feature, area or structure that may be affected by direct or indirect changes to the environment. Surface water quality receptors within this report are considered as waterways and waterbodies within the disturbance footprint, water quality study area and downstream receiving environments.
Temporary construction footprint	The areas of the Project that will be directly impacted by the construction of the rail line, lay down areas, borrow pits, and other areas that will only be used during construction and will be rehabilitated prior to operation and will only be used temporarily.
Track	The combination of rails, rail connectors, sleepers, ballast, points, crossings and any substitute devices.
Watercourse	A watercourse is a river, creek or other stream, including a stream in the form of an anabranch or a tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events, specifically excluding drainage features.
Waterway	A waterway broadly describes water flow paths that have not been defined as watercourses. These include the excluded drainage features and unmapped watercourses (under the Water Act).
Water quality receptor	A receptor is a feature, area or structure that may be affected by direct or indirect changes to the environment.

Term	Explanation
Water quality study area	The area that may be impacted by the project, based on a 1 km buffer extending horizontally from both sides of the proposed alignment, including an increased the extent where multiple design options exist.
Velocity	The speed at which the floodwaters are moving.

Executive summary

The Project

The Project consists of approximately 53 kilometres (km) of greenfield railway track between the towns of Calvert and Kagaru. It will also involve the construction of a 1,015 metre (m) tunnel through the Teviot Range to facilitate the required gradient across the undulating topography. The Project is located within the Logan River and Bremer River catchments and will intersect a number of defined watercourses and drainage features.

Purpose

This surface water quality technical report has been prepared to assess potential impacts of the Calvert to Kagaru Project on surface water quality. This assessment addresses the surface water quality matters required by the Terms of Reference (ToR) for an environmental impact statement: Inland Rail – Calvert to Kagaru project, dated December 2017.

This report outlines the legislative framework and methodology for undertaking the surface water quality assessment and potential impacts related to the Project. This report describes the existing water quality for the water quality study area (as a 1 km buffer around the Project alignment), thus providing a summary of the environmental values (EVs) and water quality objectives (WQOs) for the identified waterways.

Existing environment

A summary of the existing surface water environment is provided below:

- The water quality study area was based on a 1 km buffer extending either side of the proposed alignment, including an increased the extent where multiple design options exist
- The water quality study area is situated within a region of typical hot and dry conditions with seasonally distributed rainfall; rainfall is predominant during summer months
- Surface water values relevant to the water quality study area are located within the Logan River and Bremer River catchments
- The defined watercourses (excluding tributaries and drainage features), as defined and mapped under the *Water Act 2000*, which are intersected by the Project are:
  - Western Creek
  - Bremer River
  - Warrill Creek
  - Purga Creek
  - An un-named tributary of Purga Creek
  - Dugandan Creek
  - Teviot Brook
- Surface water use is primarily related to recreational, commercial and domestic uses. Principal water usage throughout the water quality study area is dominated by stock use, farming, and rural domestic uses.
- There are no wetlands of international importance (Ramsar wetlands) within 10 km of the water quality study area, however six high ecological significant (HES) wetlands occur within the water quality study area
- The water quality study area crosses areas of moderate to high salinity hazard.

The Healthy Land and Water report card (2018) indicates that the western catchments (including both Logan River and Bremer River catchments) have experienced a continual decline in freshwater stream health as a result of dry weather and poor vegetation cover.

Aquascores have been generated for the wetlands within the water quality study area. The water quality monitoring sites associated with medium Aquascores (indicating moderate sensitivity) for riverine wetlands were those on sections of the Western Creek, the Bremer River, Warrill Creek, Purga Creek and Teviot Brook. Those associated with low to very low Aquascores (indicating low sensitivity) were associated with a tributary of Western Creek and Purga Creek, Dugandan Creek and Woollaman Creek.

Upon comparison with historical water quality data for Warrill Creek, Purga Creek and Western Creek, water quality values observed during the three sampling rounds followed those of the gauging stations. Historic and field assessed water quality was identified as not currently meeting all WQOs for the protection of aquatic ecosystems, within each catchment.

Water quality objectives

Water quality objectives for the relevant sub-catchments have been determined by the Queensland Government. Within these WQOs, the most stringent protections are provided for aquatic ecosystems and these were selected as the basis for assessment. Note that although Australian drinking water guidelines denote threshold values for arsenic at levels lower than the objectives for each sub-catchment, these were not selected as they are equal to the limit of detection with laboratory analysis.

Surface water quality receptors

All waterways and waterbodies within the disturbance footprint, water quality study area and downstream receiving environments were nominated as moderate sensitivity water quality receptors for identification of potential impacts, associated mitigation measures and identification of residual impact after implementation of mitigation. Due to the potential presence of the Matters of National Environmental Significance (MNES) species Australian Lungfish (*Neoceratodus forsteri*), Mary River Cod (*Maccullochella mariensis*) and Matters of State Environmental Significance (MSES) wetlands within the water quality study area, the Project alignment associated and intersecting with Western Creek, Bremer River, Warrill Creek and Teviot Brook were considered as high sensitive water quality receptors.

Potential impacts

The construction and operation of the Project has the potential to impact on water quality receptors through:

- Increased debris
- Change to water quality and hydrology
- Increase in salinity
- Increases in erosion and sedimentation
- Increase in contaminants
- Exacerbation of listed impacts above, from inadequate rehabilitation processes.

Significant residual impact assessment

In order to determine the significance of potential impacts of the Project upon the identified surface water quality receptors, sensitivity categories were applied to each of the receptors. The sensitivity of the potential impact was grouped into three distinct categories: high, moderate and low. These groupings were based on factors including, but not limited to, legislative status, resilience and representation in the broader landscape. In addition to sensitivity, the magnitude of each potential impact was assigned based on the extent, duration and resultant change to the receptor. The magnitude of impact was grouped into four categories: high, moderate, low and negligible. Both the sensitivity of an impact and the magnitude of the potential impact were used to determine the significance of a potential impact.

The proposed mitigation measures (after design considerations) for the Project were identified in order to reduce the initial magnitude and ultimately the significance of the potential impacts upon the identified receptors. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate) which included a range of mitigation measures and management plans the residual impacts to the identified receptors were reduced. After the application of mitigation, it is anticipated that there will be a low residual significance of risk on water quality receptors.

- During the construction phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate most potential impacts, such that the residual significance would be low
- For the operational phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate most potential impacts, such that the residual significance would be low.

Cumulative impacts

A cumulative impact assessment (CIA) was undertaken where potential surface water impacts of the Project were assessed together with existing or planned surrounding activities. The CIA identified a medium risk of potential impact occurring during construction phase activities through riparian vegetation loss from vegetation clearing/removal. Further mitigation measures (during detailed design) may be necessary and specific management practices applied.

1 Introduction

1.1 Purpose

The purpose of this report is to assess the surface water quality components of the Calvert to Kagaru (C2K) Project (the Project) (refer Figure 1.1). Aquatic ecology, hydrology and flooding have been addressed in separate technical reports.

This technical report outlines the legislative framework and methodology for undertaking the surface water quality assessment related to the Project. This report describes the existing water quality for the water quality study area, providing a summary of the environmental values (EVs) and water quality objectives (WQOs) for the identified watercourses. The investigation was guided by the Queensland Monitoring and Sampling Manual 2018: Environmental Protection (Water) Policy (Department of Environment and Science (DES) 2018).

Potential impacts to surface water quality resulting from construction and operation of the Project are also identified, with a suite of mitigation measures proposed to minimise surface water impacts resulting from the Project. An assessment of the impacts of the Project following the application of mitigation measures is provided.

This report addresses the relevant surface water quality Terms of Reference (ToR) for an environmental impact statement: Inland Rail – Calvert to Kagaru project December 2017 as summarised in Table 1.1. Compliance of the EIS against the full ToR is documented in the EIS Appendix B: Terms of Reference Compliance Table.

Table 1.1 Surface water objectives

Water (general)		EIS Section
Existing environment		
11.36	Identify the water-related environmental values and describe the existing surface water and groundwater regime within the study area and the adjoining waterways in terms of water levels, discharges and freshwater flows.	Section 5 Chapter 13: Surface Water and Hydrology, Section 13.5
11.37	With reference to the EPP (Water and Wetland Biodiversity) 2009, section 9 of the EP Act, and SPP State Interest Guideline - Water Quality, identify the environmental values of surface water within the project area and immediately downstream that may be affected by the project, including any human uses of the water and any cultural values.	Section 5 Chapter 13: Surface Water and Hydrology, Section 13.5
11.38	At an appropriate scale, detail the chemical, physical and biological characteristics of surface waters and groundwater within the area that may be affected by the project. Include a description of the natural water quality variability within the study area associated with climatic and seasonal factors, and flows.	Section 6 Chapter 13: Surface Water and Hydrology, Sections 13.5.3, 13.5.4 and 13.5.5
11.39	Describe any existing and/or constructed waterbodies adjacent to the preferred alignment.	Section 5.5.4 Chapter 13: Surface Water and Hydrology, Section 13.5.2.2
Impact assessment		
11.41	The assessment of impacts on water will be in accordance with the DEHP Information guideline for an environmental impact statement – TOR Guideline – Water, where relevant, located on the DEHP website.	Section 7 and 9 Chapter 13: Surface Water and Hydrology, Sections 13.6 and 13.8
11.42	Identify the quantity, quality and location of all potential discharges of water and wastewater by the project, whether as point sources (such as controlled discharges) or diffuse sources (such as irrigation to land of treated sewage effluent).	Section 7 Chapter 13: Surface Water and Hydrology, Section 13.6.1

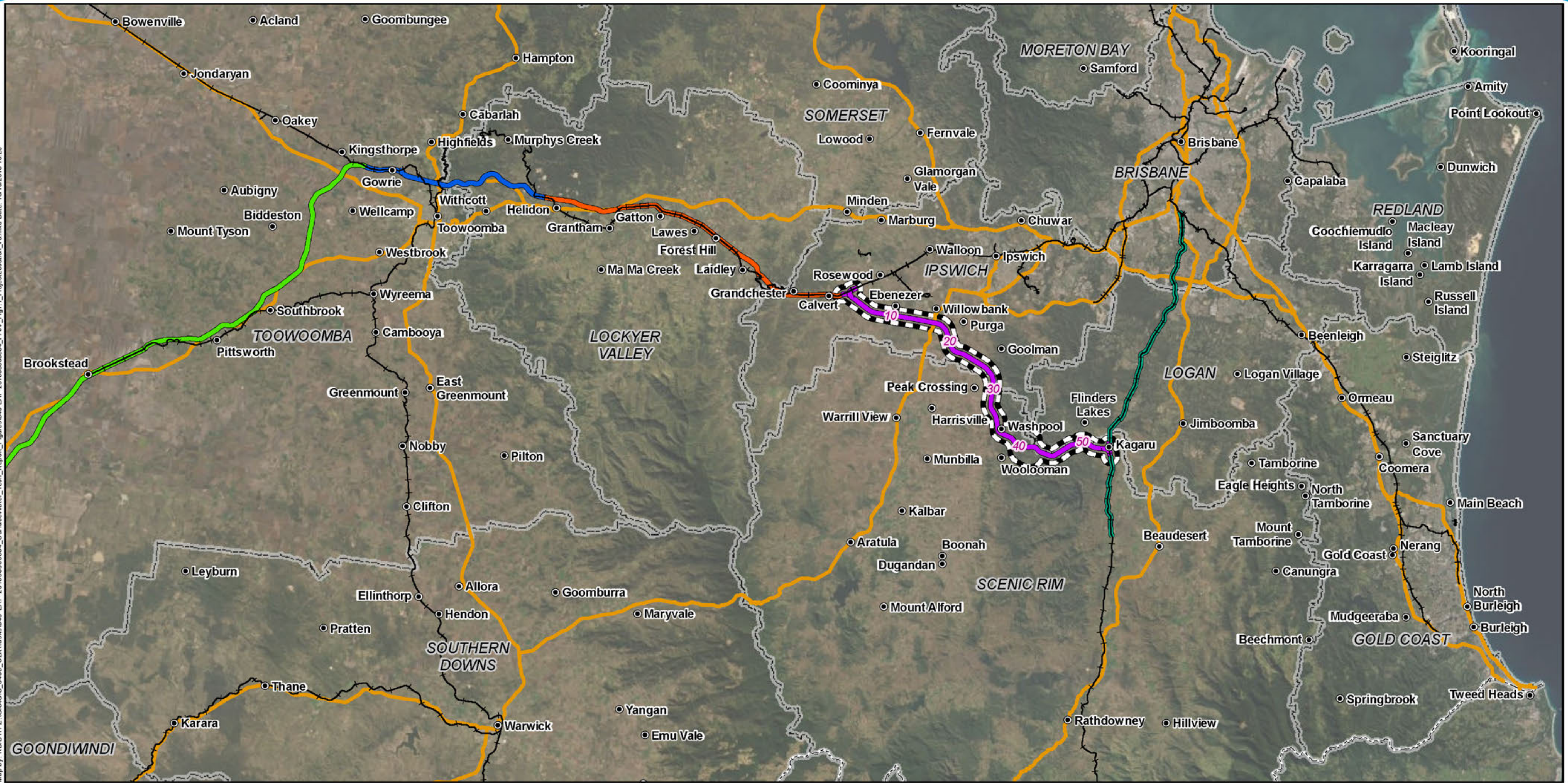
Water (general)		EIS Section
11.43	Assess the potential impacts of any discharges on the quality and quantity of receiving waters taking into consideration the assimilative capacity of the receiving environment and the practices and procedures that would be used to avoid or minimise impacts.	Section 7 Chapter 13: Surface Water and Hydrology, Section 13.6.1
11.45	Describe the potential impacts of in-stream works on hydrology and water quality.	Section 7.1 Chapter 13: Surface Water and Hydrology, Section 13.6
11.46	Undertake a salinity risk assessment in accordance with Part B of the Salinity Management Handbook, Investigating Salinity. In particular, consider how the project will change the hydrology of the project area and provide results of the risk assessment.	Section 5.9 and Figure 5.14 Chapter 13: Surface Water and Hydrology, Sections 13.5.2.5, 13.6.1, 13.7 and Figure 13.4 Chapter 9: Land Resources, Section 9.6.5 and Figures 9.8 – 9.13
Mitigation measures		
11.47	Describe how the water quality objectives identified above would be achieved, monitored and audited, and how environmental impacts would be avoided or minimised and corrective actions would be managed.	Sections 8.1, 8.2 and 8.3 Chapter 13: Surface Water and Hydrology, Section 13.7.1
11.48	Describe appropriate management and mitigation strategies and provide contingency plans for:	Sections 2.5, 8.2 and 8.3 Chapter 13: Surface Water and Hydrology, Section 13.7
	(a) Potential accidental discharges of contaminants and sediments during construction and operation	
	(b) Stormwater run-off from the project facilities and associated infrastructure during construction and operation, including the International Erosion Control Association, Best Practice Erosion and Sediment Control – November 2008 (Appendix 1), and the separation of clean stormwater run-off from disturbed and operational areas of the site	
	(c) Flooding of relevant river systems, the effects of tropical cyclones and other extreme events	Chapter 13: Surface Water and Hydrology, Section 13.8.2
	(d) Management of acid sulfate soils and acid producing rock and associated leachate from excavations and disturbed areas.	Sections 5.4.3, and 8.2 Chapter 13: Surface Water and Hydrology, Section 13.7.1.2
11.50	Propose suitable measures to avoid or mitigate the impacts of in-stream works on water quality and the stabilisation and rehabilitation of any such works.	Sections 8.1, 8.2 and 8.3 Chapter 13: Surface Water and Hydrology, Section 13.7.1
11.51	Where a salinity risk is identified, detail strategies to manage salinity ensuring the development must be managed so that it does not contribute to the degradation of soil, water and ecological resources or damage infrastructure via expression of salinity. See Part C of the Salinity management handbook second edition, Department of Environment and Resource Management 2011.	Sections 8.1, 8.2 and 8.3 Chapter 13: Surface Water and Hydrology, Section 13.7.1 Chapter 9: Land Resources, Section 9.7.2
Water (water resources)		**EIS Section**
Impact assessment		
11.52	Provide details of any proposed impoundment, extraction (i.e. volume and rate), discharge, use or loss of surface water or groundwater. Identify any approval or allocation that would be needed under the Water Act.	Section 2.7 Chapter 13: Surface Water and Hydrology, Section 13.7.1.3
11.53	Detail any significant diversion or interception of overland flow. Include maps of suitable scale showing the location of diversions and other water-related infrastructure.	Section 2.5 and Figure 2.1 Chapter 13: Surface Water and Hydrology, Section 13.5.2.2

Water (general)		EIS Section
11.54	Develop hydrological models as necessary to describe the inputs, movements, exchanges and outputs of all significant quantities and resources of surface water and groundwater that may be affected by the project. The models should address the range of climatic conditions that may be experienced at the site, and adequately assess the potential impacts of the project on water resources. This should enable a description of the project's impacts at the local scale and in a regional context including proposed:	Sections 7.1 and 7.2 Chapter 13: Surface Water and Hydrology, Section 13.6.1, 13.8.1 and 13.8.2 Appendix N: Hydrology and Flooding Technical Report, Sections 6 - 9
	(a) Changes in flow regimes from structures and water take	
	(b) Alterations to riparian vegetation and bank and channel morphology	
	(c) Direct and indirect impacts arising from the project.	
	(d) Impacts to aquatic ecosystems, including groundwater-dependent ecosystems and environmental flows.	
11.58	Identify relevant Water Plans and Resources Operations Plans under the Water Act. Describe how the project will impact or alter these plans. The assessment should consider, in consultation with the Department of Natural Resources and Mines, any need for:	Sections 5.10 and 7.2 Chapter 13: Surface Water and Hydrology, Sections 13.5.2.3 and 13.7.1.3 Chapter 3: Project Approvals, Section 3.4.20 and Table 3.4
	(a) A resource operations licence	
	(b) An operations manual	
	(c) A distribution operations licence	
	(d) A water licence	
	(e) A water management protocol.	
11.59	Identify other water users that may be affected by the proposal and assess the project's potential impacts on other water users.	Sections 5.10 and 7.2 Chapter 13: Surface Water and Hydrology, Sections 13.5.2.3 and 13.6.1
11.60	Identify and quantify likely activities involving the excavation or placement of fill that will be undertaken in any watercourse, lake or spring.	Sections 2.2, 2.4 and 7.1 Chapter 13: Surface Water and Hydrology, Section 13.6.1
Mitigation Measures		
11.62	Describe measures to minimise impacts on surface water and ground water resources.	Sections 8 Chapter 13: Surface Water and Hydrology, Section 13.7.1 Appendix N: Hydrology and Flooding Technical Report, Section 6 – 9
11.63	Provide a policy outline of compensation, mitigation and management measures where impacts are identified.	

1.2 Project overview and objectives

The Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the C2K section of the Inland Rail Program, which consists of approximately 53 kilometre (km) of single track, dual gauge greenfield railway to follow the existing Southern Freight Rail Corridor (SFRC), which was protected in November 2010 as future railway corridor under Section 242(1) of the *Transport Infrastructure Act 1994* (Qld) (TI Act). The railway line will include four crossing loops to accommodate double stack freight trains up to 1,800 metres (m). It will also involve the construction of an approximately 1,015 m long tunnel through the Teviot Range to facilitate the required gradient across the undulating topography. The corridor will be of sufficient width to accommodate future possible upgrades of the track, including a future possible requirement to accommodate trains up to 3,600 m in length. The approval for the construction of future 3,600 m crossing loops will be subject to separate approval applications in the future.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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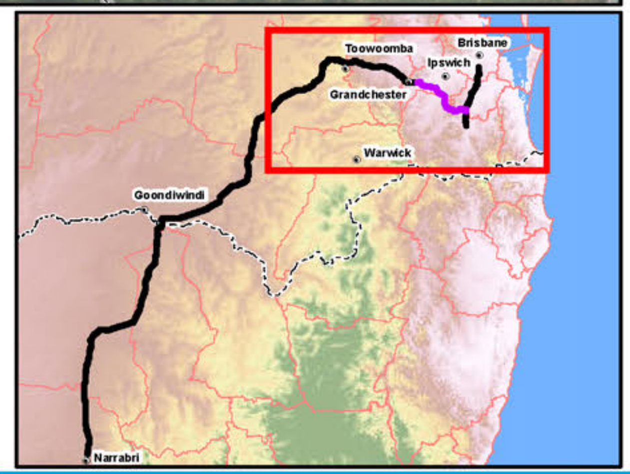


Legend

- 5 Chainage (km)
- Localities
- Existing rail
- B2G project alignment
- G2H project alignment
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Major roads
- EIS investigation corridor
- Local Government Areas
- QLD/NSW border

A3 scale: 1:600,000

0 4.5 9 13.5 18 22.5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 25/09/2019 Version: 0

Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 1.1: Regional context

Although ARTC are applying for approval to build infrastructure to accommodate trains up to 1,800 m in length, infrastructure will be designed such that the future extension of some crossing loops to accommodate 3,600 m trains is not precluded. ARTC intend to acquire the land for the future 3,600 m crossing loop extension with the initial land acquisition, however, the approval for the construction of future 3,600 m crossing loops will be subject to separate approval applications in the future.

The design response to key environmental features has been developed in line with engineering constraints for a feasible rail design. The rail design is based on minimising environmental and social impacts, minimising disturbance to existing infrastructure and meeting engineering design criteria.

The objectives of the Project are to:

- Provide new rail infrastructure that meets the Inland Rail specifications to enable trains using the corridor to travel between Calvert and Kagaru, connecting with other sections of Inland Rail at each end of the Project (i.e. the Helidon to Calvert and Kagaru to Acacia Ridge and Bromelton sections)
- Minimise the potential for adverse environmental and social impacts.

The objectives of overall Inland Rail Program are to:

- Provide a rail link between Melbourne and Brisbane that is interoperable with train operations to Perth, Adelaide, and other locations on the standard gauge rail network to serve future rail freight demand, and stimulate growth for inter-capital and regional/bulk rail freight
- Provide an increase in productivity that will benefit consumers through lower freight transport costs
- Provide a step-change improvement in rail service quality in the Melbourne to Brisbane corridor and deliver a freight rail service that is competitive with road
- Improve road safety, ease congestion, and reduce environmental impacts by moving freight from road to rail
- Bypass bottlenecks within the existing metropolitan rail networks, and free up train paths for other services along the coastal route
- Act as an enabler for regional economic development along the Inland Rail corridor.

1.3 Water quality study area

The water quality study area was based on a 1 km buffer extending horizontally from both sides of the proposed alignment, increasing the extent where multiple design options exist to account for an increased investigation area (refer Figure 1.2). The water quality study area was established to delineate the spatial extent of potential intersection of watercourses with temporary and permanent impact footprints of the Project.

1.4 Overview of surface water environment

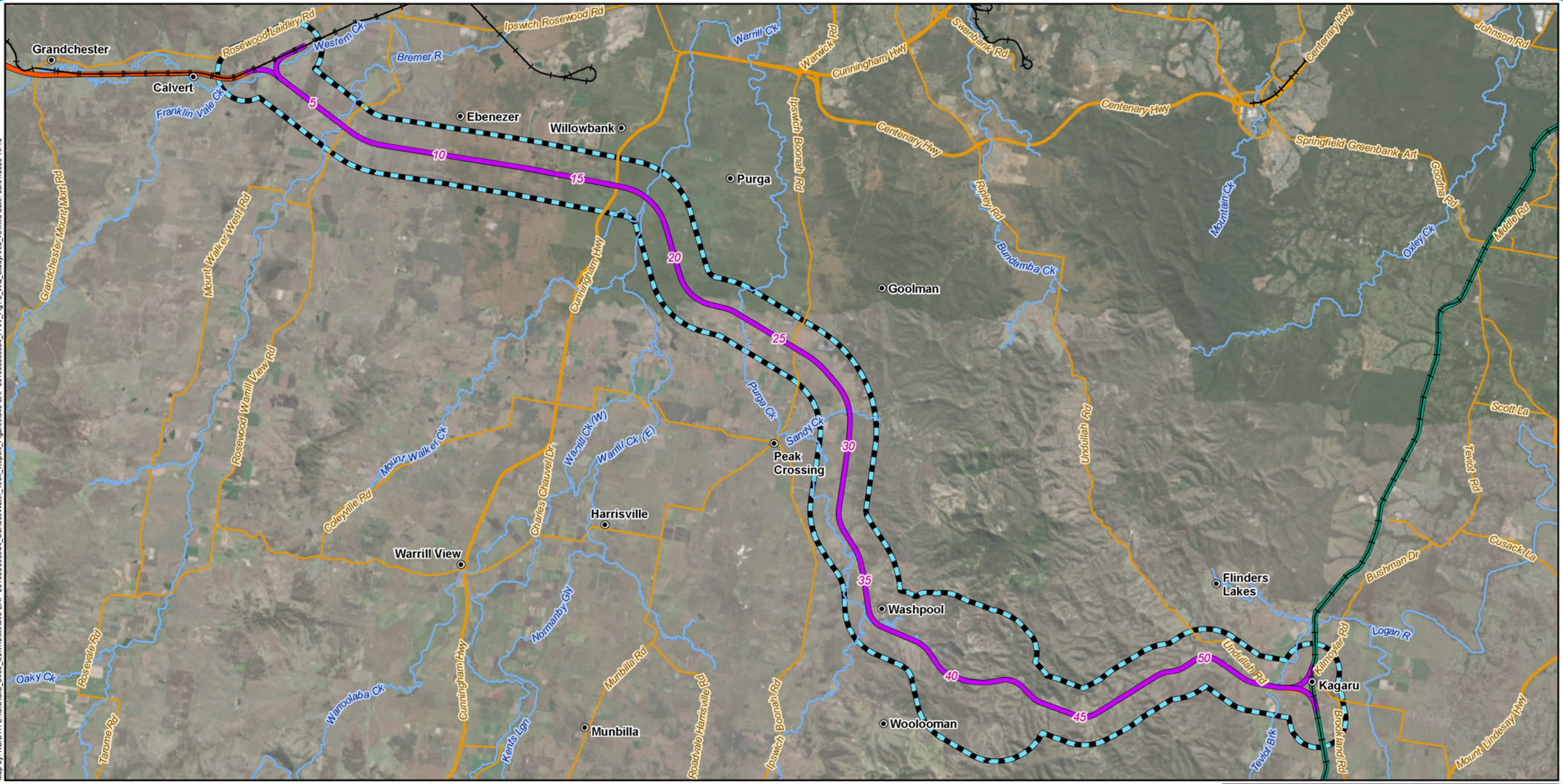
The Project alignment travels through two catchment areas; the Bremer River catchment (between Calvert and east of Woolooman as the alignment reaches the peak of the Scenic Rim mountain range), and the Logan River catchment (as the alignment descends the mountain range towards Kagaru).

Within the Bremer River catchment, the Project alignment includes the sub-catchments of the Mid Bremer River, Lower Bremer River, Lower Warrill Creek, Western Creek and Purga Creek.

Within the Logan River catchment, the Project alignment includes the sub-catchments of Lower Teviot Brook.

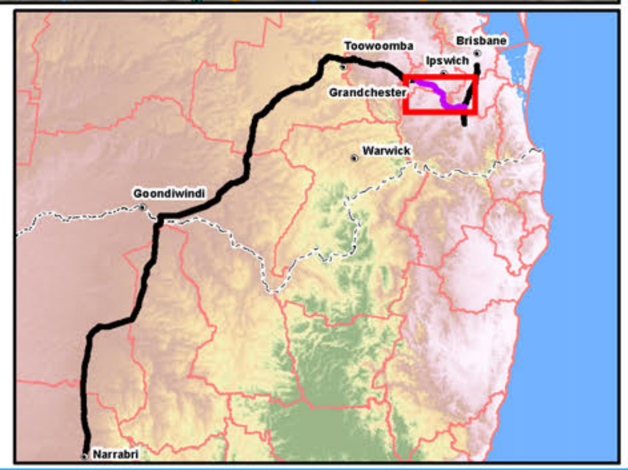
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: RB/DTH Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig1.2_WQ_StudyArea_v3.mxd Date: 30/01/2020 14:13



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area



A3 scale: 1:150,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru
Figure 1.2:
Water quality study area

2 Project description

The key components of the Project include:

- Approximately 53 km of single track dual gauge rail line with four crossing loops to ultimately accommodate trains up 3,600 m long, but initially constructed for 1,800 m long trains
- An approximately 1,015 m Teviot Range tunnel, and bridges to accommodate topography and Project crossings of waterways and other infrastructure
- Tie-in to the existing Queensland Rail (QR) West Moreton System at the Project boundary near Calvert
- Allowance for a future connection to the Ebenezer Industrial Area at Willowbank
- The construction of associated rail infrastructure including maintenance sidings and signalling infrastructure to support the Advanced Train Management System (ATMS)
- Rail crossings including level crossings, grade separations/road overbridges, occupational/private crossings, fauna crossing structures
- Tie-ins to the existing operational Sydney to Brisbane Interstate Line at Kagaru
- Significant embankments and cuttings will be required along the length of the alignment to suit the terrain
- Ancillary works including road and public utility crossings and realignments, signage and fencing and provision of services within the corridor (excluding those undertaken as enabling works)
- Construction worksites, laydown areas and access roads
- Defined watercourses under the *Water Act 2000* (Qld) (Water Act) intercepted by the proposed Project alignment, include:
  - Western Creek – at chainage (Ch) locations Ch 3.10 km and Ch 1.20 km
  - Bremer River – at chainage location Ch 6.30 km
  - Warrill Creek – at chainage location Ch 17.60 km
  - Purga Creek – at chainage location Ch 23.40 km
  - Sandy Creek – at chainage location Ch 28.70 km
  - Un-named tributary of Purga Creek – at chainage locations Ch 36.60 km, Ch 37.50 km and Ch 37.90 km
  - Teviot Brook – at chainage location Ch 52.80 km.

Construction of the Project is planned to start in 2021 and is expected to be completed in 2026.

The approval for the construction of future 3,600 m crossing loops will be subject to separate approval applications in the future.

2.1 Tunnel infrastructure and drainage

The Project proposes a tunnel through the Teviot Range to facilitate the required gradients for this area due to the undulating terrain. The tunnel will enter the western aspect of Teviot Range via a portal at Ch 39.83 km and exit the eastern aspect of the Teviot Range via a portal at Ch 40.85 km.

Stormwater will be diverted away from the tunnel and any water that falls within the tunnel portals will be captured by drainage and not directed through the tunnel. Any water collected inside the tunnel (groundwater, washdown, firefighting etc) will be collected via drainage pits and a carrier drain to provide drainage to a sump. Sumps are required to collect waters captured in the tunnel and act as a buffer tank prior to the water being treated through a water treatment plant (WTP). Any hydrocarbons making their way into the sumps are trapped in the minor flows sump and held for collection.

A long-term groundwater inflow of 0.10 to 0.14 litres per second has been estimated under drained conditions for the tunnel. Generally, there is greater groundwater inflow expected during tunnel construction when compared with long term inflows. However, elevated groundwater inflows are expected to be of short duration and decline after weeks or months to rates similar to long-term inflow rates.

2.2 Bridges

No reinstatement or reconstruction of existing bridges along the alignment is required as a result of the Project. Noting that no major works will be required for existing bridges, there may be the potential for upgrades or maintenance of existing bridges for construction purposes.

The Project requires 21 new bridge structures over waterways and/or floodplains (of a total 27 bridges) (refer Table 2.1). The new bridge structures are typically founded on driven precast or bored in situ piled foundations, supporting in situ reinforced concrete substructures. Bridge superstructures are typically formed from pre-stressed precast concrete girders with in situ decks incorporating walkways, guardrails and barriers as appropriate. The bridges are of various lengths and spans to suit the alignment and topography.

Table 2.1 Bridges associated with the Project alignment

Bridge name	Associated defined watercourse	Chainage (km)		Approx. length (m)	Bridge type	Crossing type
		from	to			
Western Creek 2 Rail Bridge	Western Creek	0.882	1.664	782	Rail	Waterway + Road
Western Creek 1 Rail Bridge		2.480	3.446	966	Rail	Waterway + Road
Bremer River Rail Bridge	Bremer River	5.870	6.554	684	Rail	Waterway + Road
Mount Forbes Road Bridge	NA	9.748	-	72	Road	Rail
UT Ebenezer Creek Rail Bridge	Warrill Creek	14.340	14.547	207	Rail	Waterway
Cunningham Highway Bridge	NA	16.448	-	53	Road	Rail
Warrill Creek Rail Bridge	Warrill Creek	17.300	18.013	713	Rail	Waterway
Purga Creek 1 Rail Bridge	Purga Creek	23.281	23.902	621	Rail	Waterway
Purga Creek 2 Rail Bridge		24.339	25.098	759	Rail	Waterway
Ipswich-Boonah Road Rail Bridge	NA	25.626	25.714	88	Rail	Road
Mount Flinders Road Rail Bridge	NA	27..904	27.973	69	Rail	Road
Sandy Creek Rail Bridge	Sandy Creek	28.676	28.791	115	Rail	Waterway
UT1 Purga Creek Rail Bridge	Purga Creek	35.637	35.752	115	Rail	Waterway
UT2 Purga Creek Rail Bridge		36.542	36.680	138	Rail	Waterway
Washpool Road Rail Bridge	NA	36.897	36.966	69	Rail	Road
UT3 Purga Creek Rail Bridge	Purga Creek	37.479	37.577	98	Rail	Waterway
UT4 Purga Creek Rail Bridge		37.644	37.943	299	Rail	Waterway
UT3 Dugandan Rail Bridge	Teviot Brook	41.786	41.970	184	Rail	Waterway
UT1 Dugandan Creek Rail Bridge		42.698	42.836	138	Rail	Waterway + Road
Dugandan Creek 1 Rail Bridge		42.994	43.155	161	Rail	Waterway
Dugandan Creek 2 Rail Bridge		43.288	43.518	230	Rail	Waterway
Wild Pig Creek Rail Bridge		46.142	46.257	115	Rail	Waterway
UT2 Dugandan Creek Rail Bridge		46.915	47.076	161	Rail	Waterway
UT1 Woollaman Creek Rail Bridge		50.506	50.713	207	Rail	Waterway

Bridge name	Associated defined watercourse	Chainage (km)		Approx. length (m)	Bridge type	Crossing type
		from	to			
UT2 Woollaman Creek Rail Bridge		51.246	51.476	230	Rail	Waterway
Teviot Brook Rail Bridge		52.468	53.190	722	Rail	Waterway + Road
Undullah Road Bridge	NA	773	-	70	Road	Rail

2.3 Cross-drainage infrastructure

There are 109 reinforced pipe culverts (RCP) culvert locations (with multiple cells in certain locations) and 17 reinforced concrete box culverts (RCBC) identified for the Project. Of these:

- 59 RCPs and 10 RCBCs will be constructed along the rail alignment
- 50 RCPs and 7 RCBCs will be constructed along roadways.

The location of the new culverts has been selected to maintain the existing flow paths and minimise the potential impacts to flood depths upstream and downstream of the culverts. The cross-drainage structures have been designed to meet the design criteria of a 1% Annual Exceedance Probability (AEP) event.

Trapezoidal drains are the preferred shape and are adopted for the longitudinal drainage. The water quality study area is undulating for most areas along the proposed rail corridor. The proposed drains are rock lined in steep area and grass lined with velocity stops as necessary in the flat area.

The drainage features at cuttings have been designed in accordance with relevant industry standards. Existing drainage paths above cuttings have been diverted to the nearest cross drainage structure through a catch drain where possible to minimise flow into cutting and subsequent size of cutting drainage. Drainage channels are provided along the cutting benches, which connect to batter chutes, which flow to the base of the cutting. A larger cutting (cess) drain is provided in the base of each cut adjacent to the rail embankment.

2.4 In-stream works

In-stream works will be required to be undertaken in accordance with Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works (Department of Agriculture and Fisheries (DAF) 2018) allowing for fish passage in defined (i.e. mapped) lower risk (low impact) watercourses. Higher risk (moderate, high and major impact) watercourses will be designed in accordance with development permits obtained for assessable development, if unable to meet accepted development requirements.

Alongside the design, in-stream works are anticipated to act within management prescriptions for each of the risk of impact class of waterway, with in-stream works expected, at a minimum, to reduce any increase in barriers for water movement during construction.

In stream works are expected to occur for each of the cross-drainage structures directly associated with watercourses throughout the water quality study area. Works associated with in-stream works are likely to trigger approvals under the Water Act (Riverine Protection Permit). Noting this, the Australian Rail Track Corporation Ltd is listed as an entity under Schedule 2 of the Riverine protection permit exemption requirements.

2.5 Waterway diversions

Five trapezoidal diversion drains are provided at locations where the rail embankment falls on top of existing overland and unmapped waterway flow paths. Four of the diversion drains are associated with unmapped overland flow drainage pathways and one is associated with a mapped overland drainage features (under the Water Act). The waterway is identified as a low risk of impact under the Department of Agriculture and Fisheries Queensland Waterways for Waterway Barrier Works spatial mapping.

The mapped overland drainage feature diversion runs from Ch 39.24 km to Ch 39.54 km (refer Figure 2.1) will require approval under State code 10 in the State Development Assessment Provisions as a diversion for works that take or interfere with watercourse, lake or spring. Under the *Planning Act 2016* (Qld), the diversion may require approval as an assessable development under waterway barrier works (in accordance with DAF requirements and the *Planning Act 2016* (Qld)).

The other unmapped overland flow drainage diversions run from Ch 8.72 km to Ch 8.98 km, Ch 16.09 km to Ch 16.20 km, Ch 40.87 km to Ch 41.11 km and Ch 41.36 to Ch 41.46 km (refer Figure 2.1).

All of the unmapped overland flow drainage diversions are not identified at risk of impact under the Department of Agriculture and Fisheries Queensland Waterways for Waterway Barrier Works spatial mapping.

The diversions are currently mapped within the design and will require consultation with Department of Natural Resources, Mines and Energy (DNRME) to determine the classification of the unmapped waterways and the resulting approvals process required for the diversion. Where the watercourse is deemed to be a defined watercourse under the Water Act, a development permit for operational works under the Planning Act is required to authorise the diversion work, together with a Water Licence under the Water Act as evidence of entitlement to the resource may be required. Approval under the Planning Act and *Fisheries Act 1994* (Qld) (Fisheries Act) may also be required.

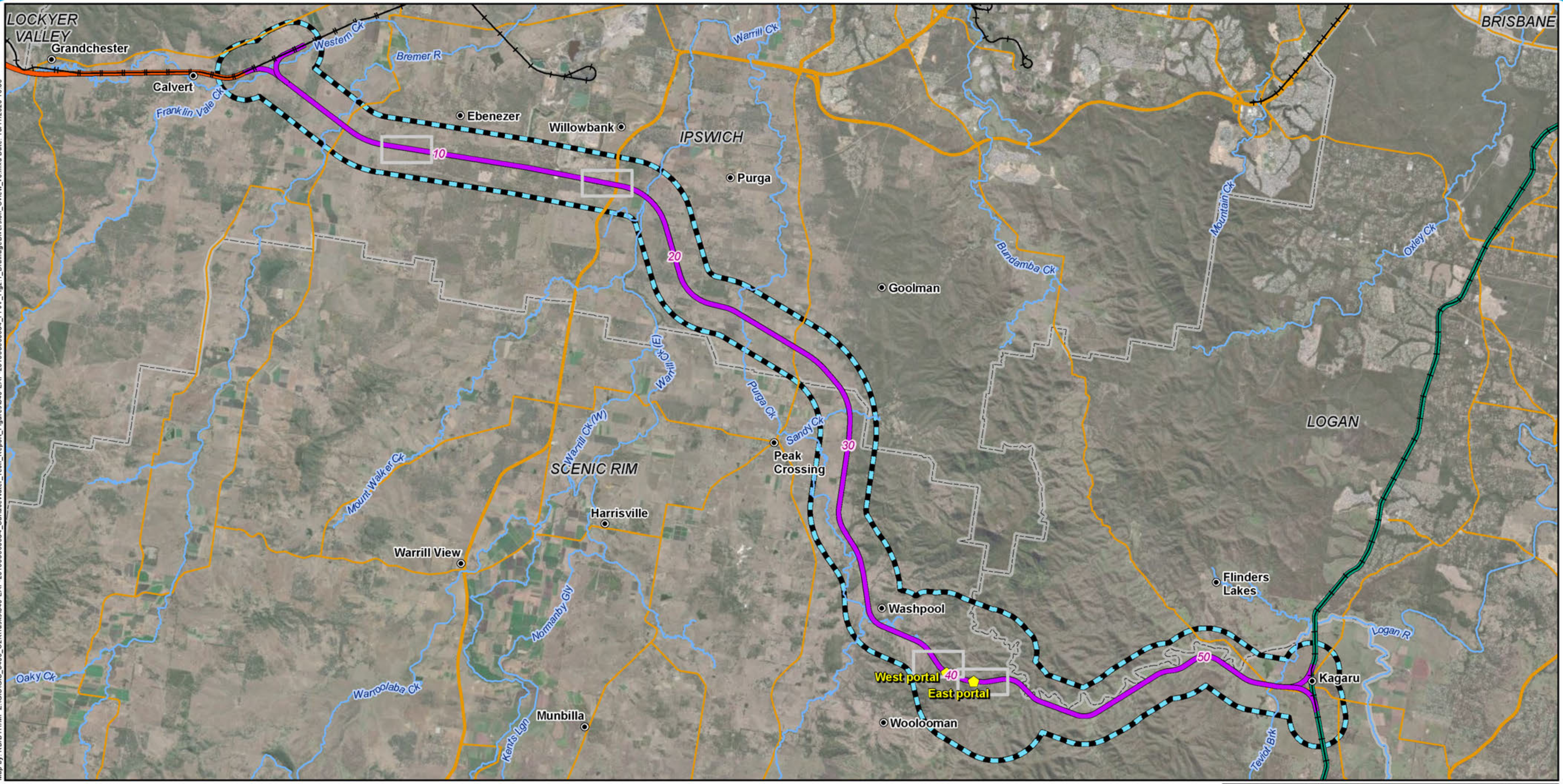
2.6 Erosion and sediment control basins

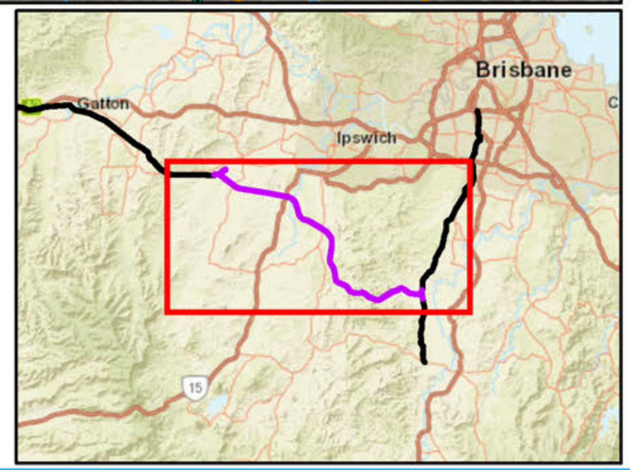
Temporary site drainage and water runoff management will be provided in line with the International Erosion Control Association Best Practice Erosion and Sediment Control Document and will:

- Minimise any runoff and sedimentation from Project activities to existing waterways
- Minimise disturbance to the water quality of existing waterways along the alignment.

Twenty-two sediment basins have been included in the design. All sediment basins are passive which allows surface runoff from a catchment to flow into the sediment basin without the need for pumping. The total volume of all sediment basins is considered to be approximately 11,922 cubic metres.

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





Legend

- 5 Chainage (km)
- Localities
- Tunnel portal
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Major roads
- Minor roads
- Watercourses
- Drainage diversion location
- Local Government Areas
- Water quality study area

A3 scale: 1:150,000

0 1 2 3 4 5km

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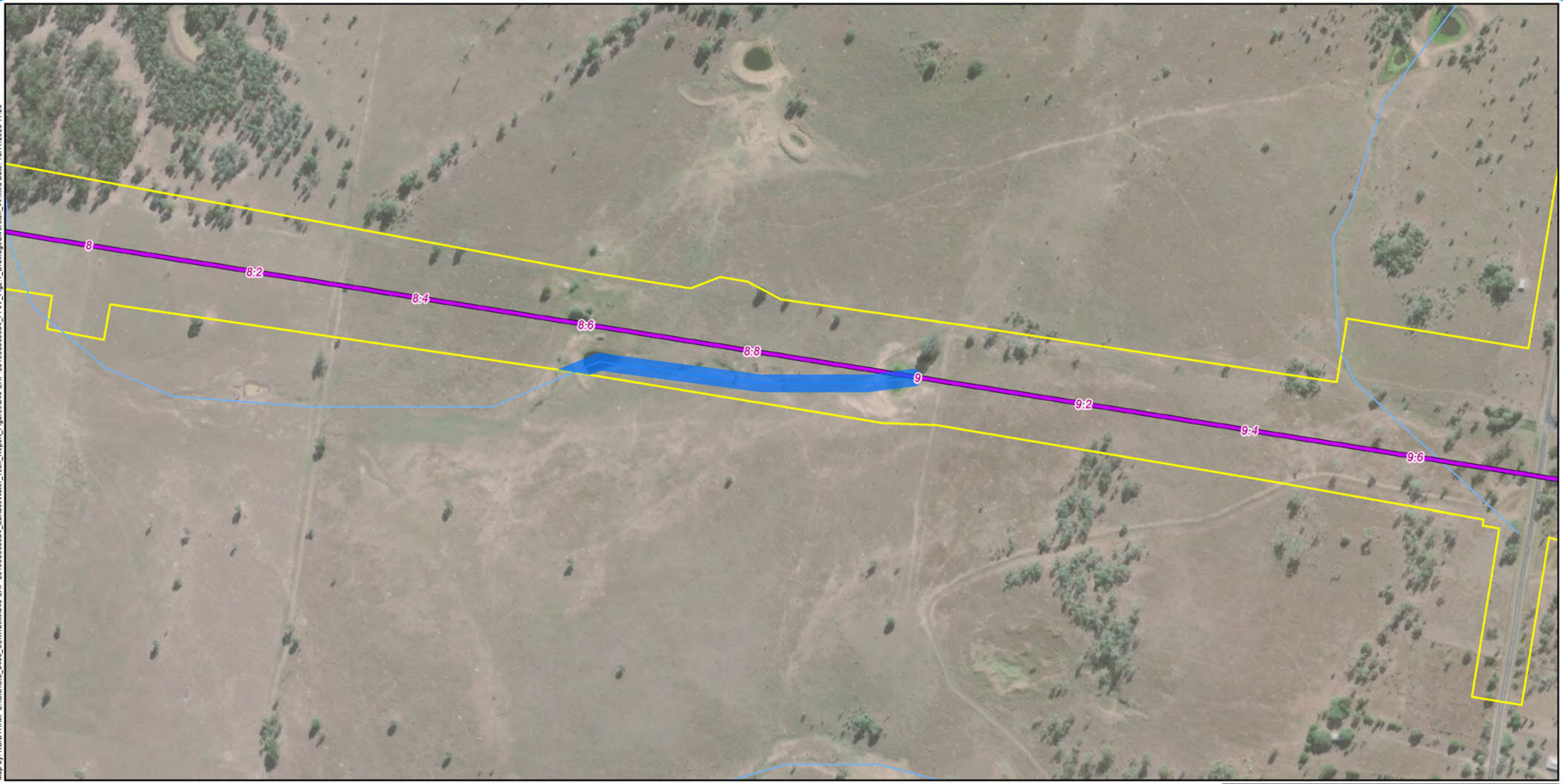
Calvert to Kagaru
Figure 2.1a:
Drainage feature diversion overview

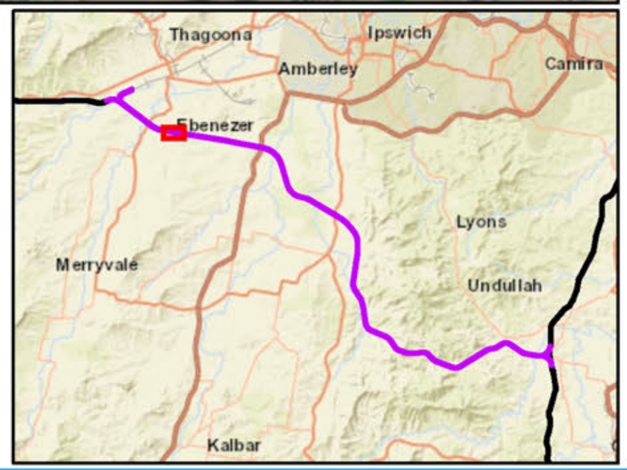
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the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

Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig2.1_DrainageDiversion_v4.mxd Date: 13/11/2020 11:26



Legend

- 5 Chainage (km)
- C2K project alignment
- Watercourses
- Tunnel
- Impacted section of water feature
- EIS disturbance footprint



A3 scale: 1:5,000

0 25 50 75 100 125 Metres

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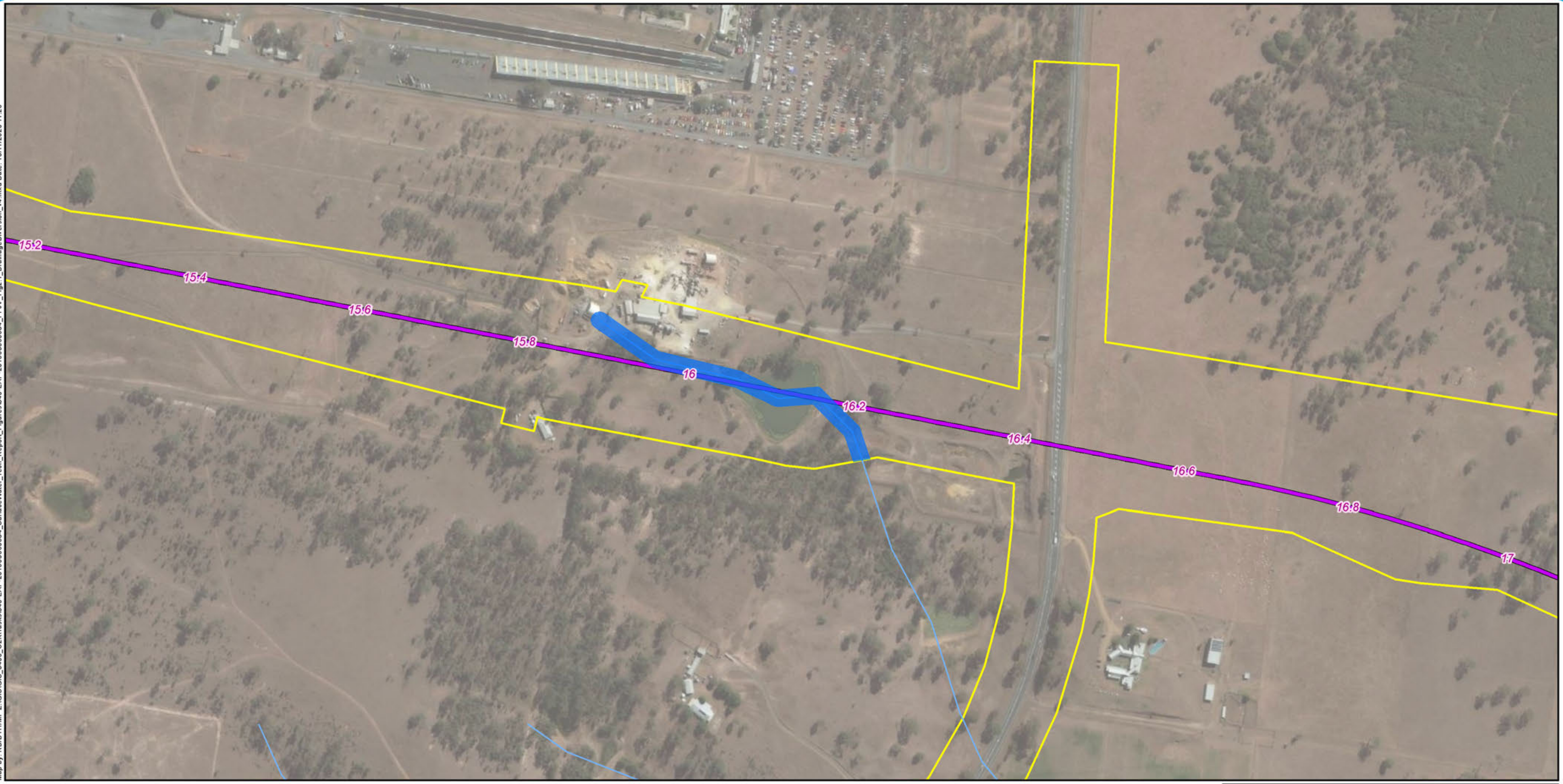
Coordinate System: GDA 1994 MGA Zone 56

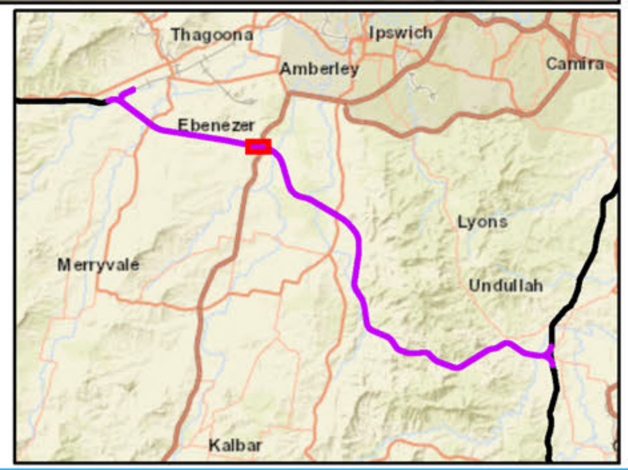
Calvert to Kagaru

Figure 2.1b:
Drainage feature diversion at chainage 8.72 - 8.98

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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

Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig2.1_DrainageDiversion_v4.mxd Date: 13/11/2020 11:26





Legend

- 5 Chainage (km)
- C2K project alignment
- Watercourses
- Tunnel
- Impacted section of water feature
- EIS disturbance footprint

A3 scale: 1:5,000

0 25 50 75 100 125 Metres

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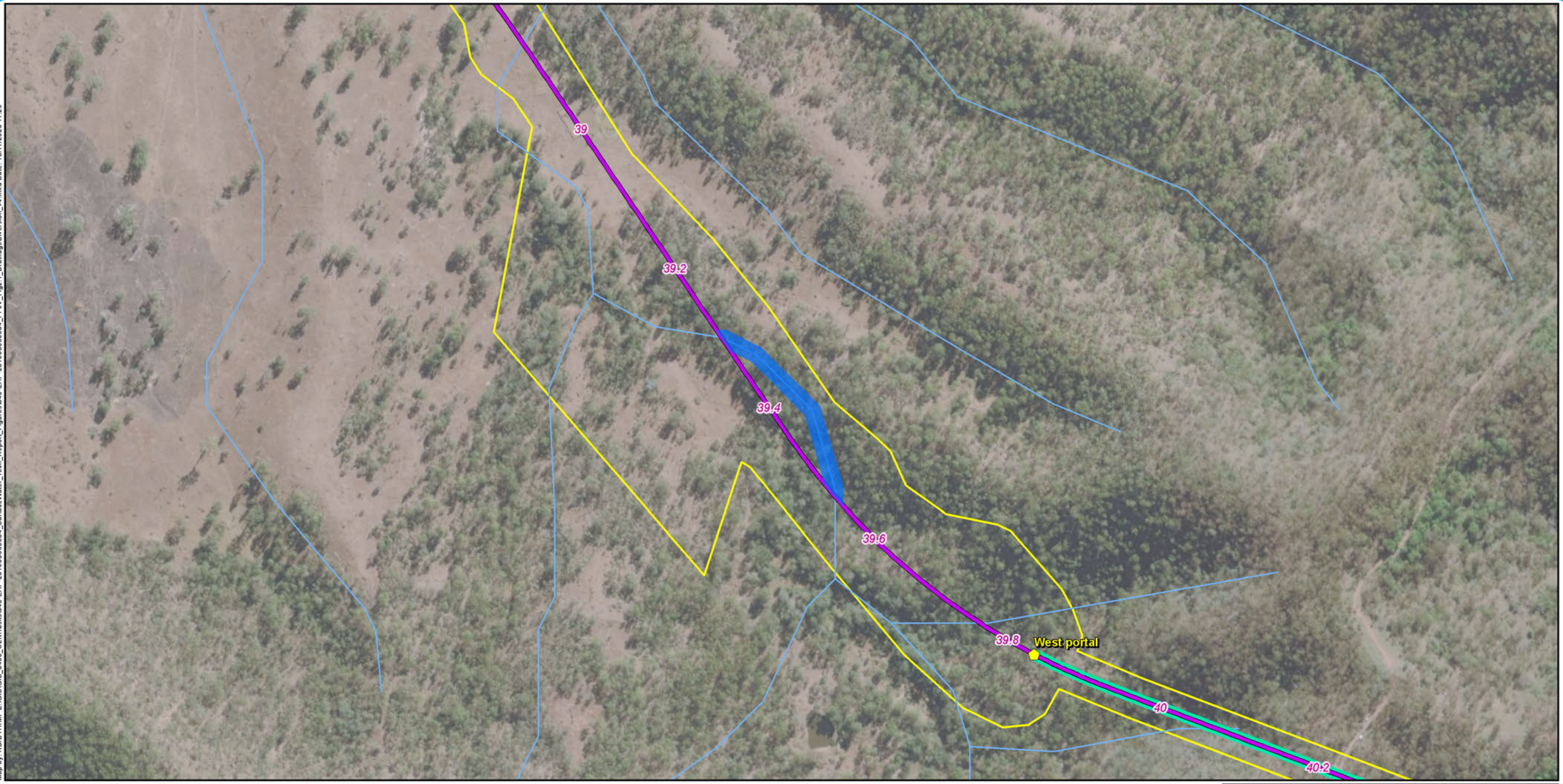
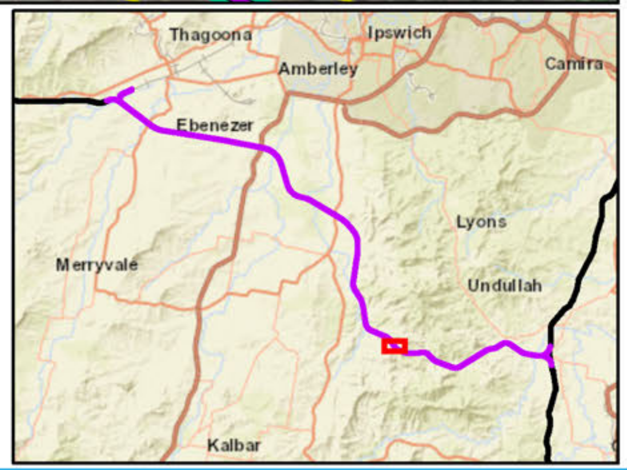
Calvert to Kagaru

Figure 2.1c:
Drainage feature diversion at chainage 16.09 - 16.20

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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

Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig2.1_DrainageDiversion_v4.mxd Date: 13/11/2020 11:26





Legend

- 5 Chainage (km)
- Tunnel portal
- C2K project alignment
- Watercourses
- Tunnel
- Impacted section of water feature
- EIS disturbance footprint

A3 scale: 1:5,000

0 25 50 75 100 125Metres

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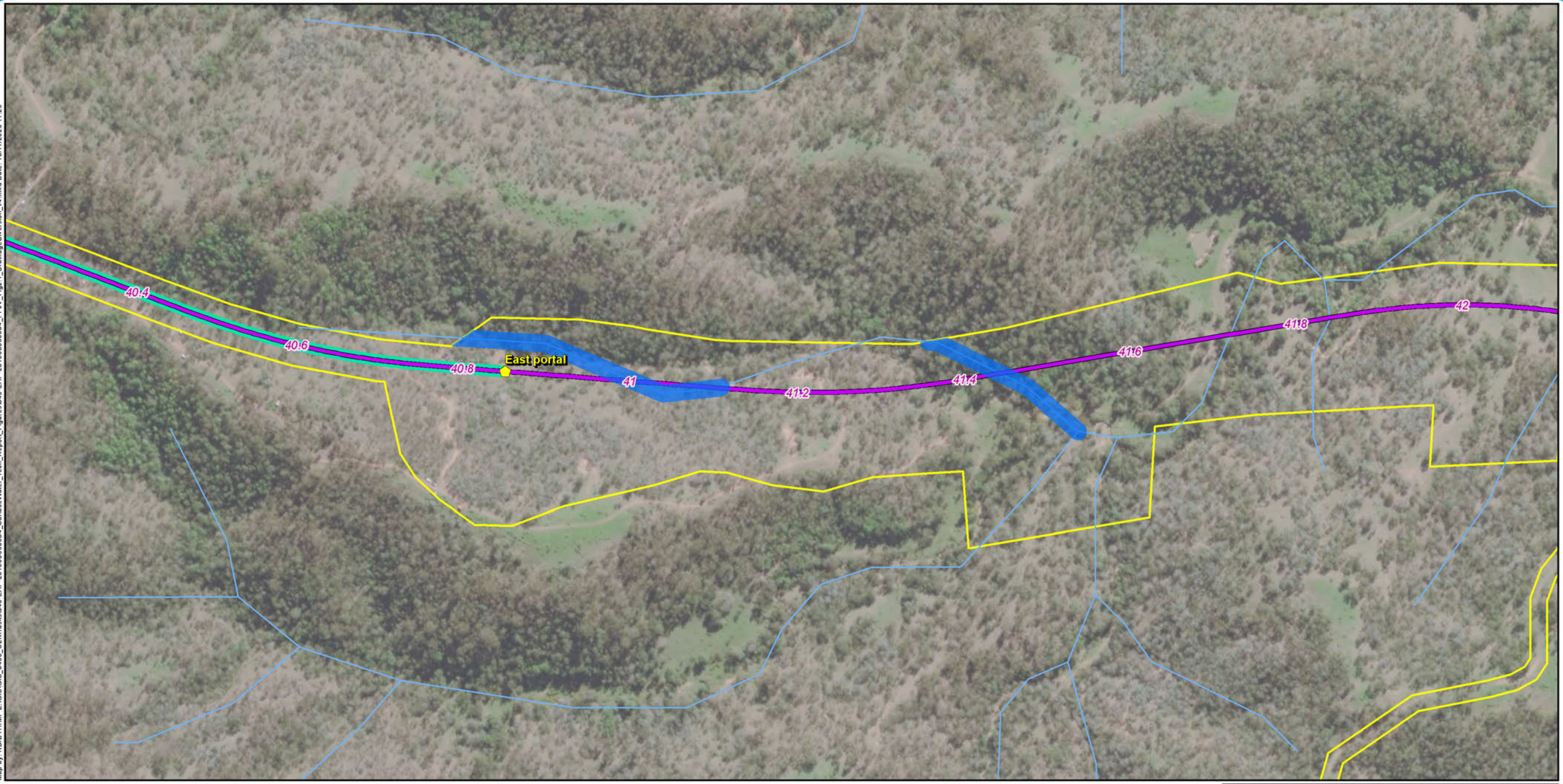
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 2.1d:
Drainage feature diversion at chainage 39.30 - 39.54

Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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

Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig2.1_DrainageDiversion_v4.mxd Date: 13/11/2020 11:26



Legend

- 5 Chainage (km)
- Tunnel portal
- C2K project alignment
- Watercourses
- Tunnel
- Impacted section of water feature
- EIS disturbance footprint

A3 scale: 1:5,000

0 25 50 75 100 125 Metres

Future Freight
Integrating Community, Environment and Engineering

Issue date: 12/11/2020 Version: 3

Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 2.1e:

Drainage feature diversion at chainage 40.87 - 41.11, 41.36 - 41.46

2.7 Project water requirements and usage

Water will be required for dust control, site compaction and reinstatement during construction. A number of potential water sources have been investigated, including extraction of groundwater or surface water, private bores, recycled water and watercourses. This will be further explored during detailed design in consultation with regulatory agencies, local councils and landowners. Where water is not available, it will be transported to the site via tanker truck and stored in temporary storage tanks. Potable water for human consumption will be supplied in potable water tanks or as bottled water, as necessary.

Activities during the construction phase with the highest water demand are:

- Soil conditioning
- General dust suppression
- Dust suppression and maintenance of laydown areas and haul roads
- Construction offices and amenities.

Overall, an allowance of 190 litres per cubic metre (L/m^3) of earthworks has been made in building up the estimated water demand requirements. Overall Project water requirements are noted in Table 2.2. The total earthworks water requirements along the Project (ML vs Chainage) is shown in Figure 2.2.

Project water requirements in regard to constructive workforce impact will be negligible due to there being no requirement for camp water. Onsite water consumption will be expected to be provided for portable lavatories.

Table 2.2 Construction water requirements

Construction activity/ process/phase	Uses/requirement	Approximate Quantity (megalitres (ML))	Quality	Flow rate	Supply
Earthworks	Material conditioning general dust suppression and general maintenance	480	Low	High	River, dam or bore
	General dust suppression	240	Low	High	River, dam or bore
	General maintenance	190	Low	High	River, dam or bore
Concrete (by concrete supplier)	Bridge and culvert locations	To be determined	High	Low	Town mains due to quality requirements
Trackworks	Ballast dust suppression during ballasting and regulating activities	28	Low	Low	River, dam or bore

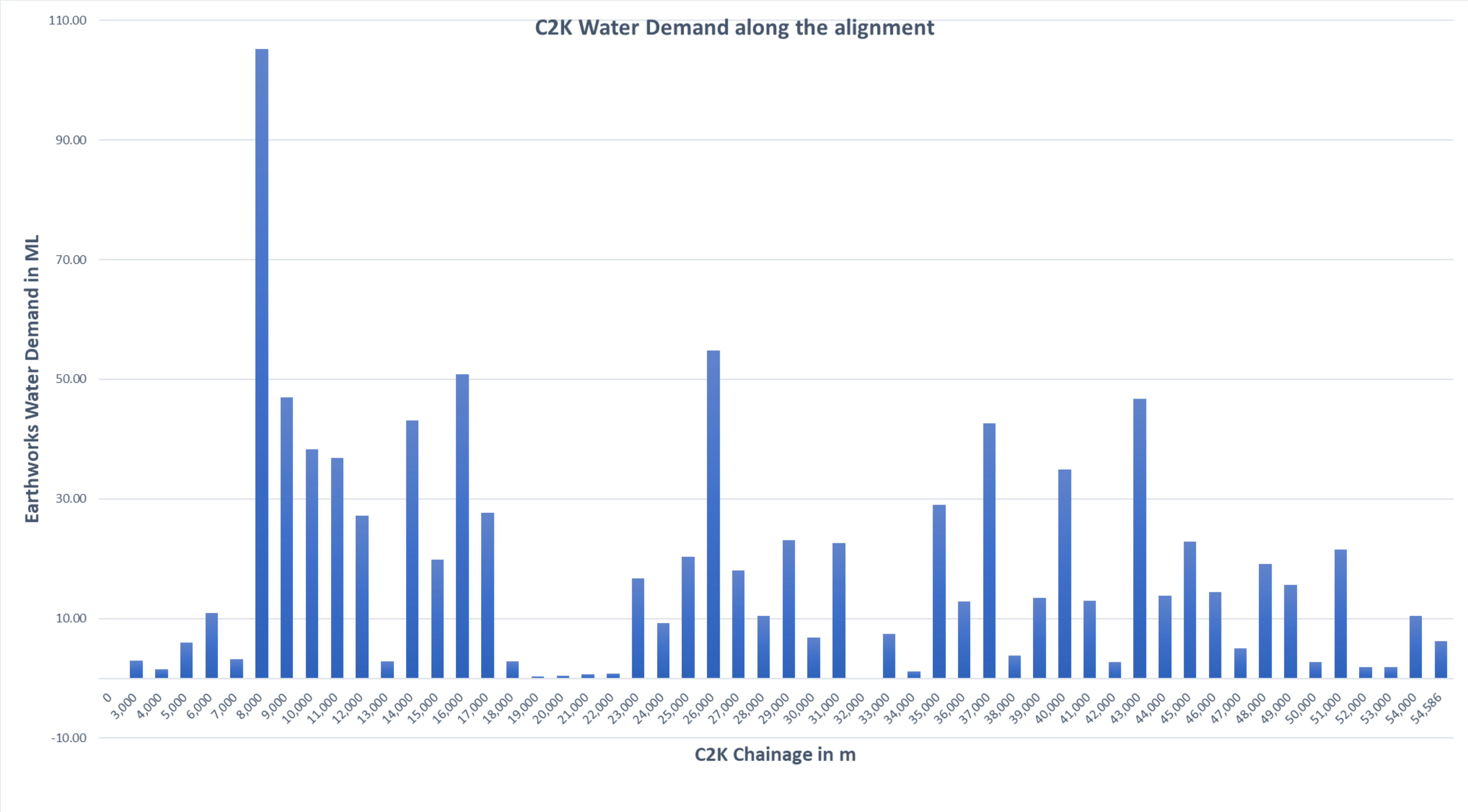


Figure 2.2 Water demand along Project alignment

Water sourcing and availability is critical to supporting the construction program for the Project. Sources of construction water will be finalised as the construction approach is refined during the detailed design phase of the Project (post-environmental impact statement (EIS)) and will be dependent on:

- Climatic conditions in the lead up to construction
- Confirmation of private water sources made available to the Project by landholders under private agreement
- Confirmation of access agreements with local governments for sourcing of mains water for concrete batching purposes.

The hierarchy of preference for accessing of construction water is generally anticipated to be as follows:

- Public surface water storages, i.e. dams and weirs
- Recycled water, where appropriate
- Permanently (perennial) flowing watercourses
- Privately held water storages, i.e., dams or ring tanks, under private agreement
- Existing registered and licensed bores
- Mains water.

An assessment of the suitability of each source will need to be made for each construction activity requiring water, based on the following considerations:

- Legal access
- Volumetric requirement for the activity
- Water quality requirement for the activity, e.g. non-resident workforce accommodation camps will need potable water
- Source location relative to the location of need.

The current water demand is expected to be met using existing water sources. Further options may need to be investigated depending on engagement with water resource owners and the following aspects:

- If water is available to be provided from existing dams and weirs operated by Seqwater
  - Water supply to meet the expected demand could be sourced from the Churchbank Weir (Warrill Creek) and Wyaralong Dam, however, consultation with Seqwater has indicated availability of water from Churchbank Weir would be subject to supply levels at the time construction water is required.

    It is noted that at the time of writing it was considered that supply to downstream users of Churchbank Weir will likely cease around December 2020, and therefore until significant rainfall occurs, it is unlikely there will be any water available at Churchbank Weir.
  - Further engagement with Seqwater will be required to confirm availability and supply arrangements during future stages of design and construction planning.
- Water will be supplied to various points along the alignment for activities including earthworks, trackwork and dust suppression
- If water is to be sourced from local town supplies, then an agreement will have to be made with the local councils on supply conditions, however it is also noted that local town supplies in the Warrill Valley are from a sole water source (Moogerah Dam) and without significant rainfall these supplies are likely be under restrictions
- If water is to be drawn from creeks and rivers crossing the alignment, then approvals will be required under the Water Act
- Further approvals will also be required to draw water from groundwater bores.

Extraction of water from a watercourse typically requires:

- A water entitlement, water allocation, water licence or water permit. Applications for resource entitlements are assessed against relevant criteria in the Water Act and relevant water resource plan and resource operations plan. It is noted that the Moreton and Logan Water Plans are fully allocated at this point in time and water would need to be supplied from an existing entitlement.
- A development permit for use of water that is assessable development under the *Planning Act 2016* (Qld).

The Department of Natural Resources, Mines and Energy (DNRME) maintains Exemption requirements for construction authorities for the take of water without a water entitlement (WSS/2013/666). These exemption requirements may only be used by a constructing authority defined under schedule 2 of the *Acquisition of Land Act 1967* (Qld) (AL Act) and includes State government departments and local governments (noting that the maximum permissible volume under these exemptions is 50 ML). At present these guidelines do not directly apply to ARTC and a water entitlement would be required for the extraction of water from a watercourse. The water entitlement requirements for the Project will be confirmed during detailed design and by the construction contractor. The use of surface water and groundwater to supplement the construction demand for the Project may be considered if private owners of registered bores have capacity under their existing sustainable allocated entitlements that they wish to sell to ARTC or the construction contractor under private agreement.

2.8 Proposed timing

There are three proposed phases in the timing of the Project. These phases consist of the following:

- Pre-construction phase
- Construction phase
- Operational phase.

For the purposes of identification of potential impacts and throughout this report, pre-construction, commissioning and rehabilitation phases have been incorporated into the construction phase of the Project.

Further details related to each of these phases is provided in the sections below.

2.8.1 Pre-construction phase

Pre-construction activities are required to enable construction of permanent infrastructure components of the Project to commence. Pre-construction and land acquisition are expected to occur until late 2021. These activities are expected to include but are not limited to:

- Detailed design
- Land acquisition
- Obtaining environmental planning approvals
- Surveys and geotechnical investigations
- Establishment of access tracks
- Relocation or protection of QR assets
- Utility/service relocations
- Installation of fauna pest exclusion fencing
- Establishment of site compounds.

Pre-construction phase activities have been included with construction phase activities for assessment of potential impacts.

2.8.2 Construction phase

The construction phase will commence from 2021, with anticipated completion of construction in 2026.

The construction program defines a number of stages and activities. These comprise:

- Site preparation including site clearance, establishment of site compound and facilities, installation of temporary and permanent fencing, installation of drainage and water management controls and construction of site access (including temporary haul roads)
- Civil works including bulk earthworks including potential blasting or hydraulic rock-breaking, construction of cuts and embankments, construction of tunnel portals and the main line tunnel, installation of permanent drainage controls, bridge and watercourse crossing construction
- Track works including the installation of ballast, sleepers and rails
- Road realignments
- Rail systems infrastructure and wayside equipment including signals, turnouts and asset monitoring infrastructure
- Commissioning including integration testing and handover process to achieve operational readiness.

2.8.3 Operational phase

The Project will form part of the rail network managed and maintained by ARTC. Train services will be provided by a variety of operators. Trains will be a mix of grain, bulk freight (including coal and minerals) other general transport trains. Inland Rail as a whole will be operational once all 13 sections are complete, which is estimated to be in 2026.

The Project will involve operation of a single rail track with crossing loops, initially to accommodate double stacked freight trains 1,800 m long and 6.5 m high. Maximum train speeds will vary according to axle loads and track geometry and range from 80 to 115 kilometres per hour. It is estimated that the operation of Inland Rail will involve an annual average of about 33 train services per day in 2026. This is likely to increase to an average of 47 trains per day in 2040. Annual freight tonnages will increase in parallel, from approximately 39 million tonnes per year in 2026 to 59 million tonnes per year in 2040.

During the operational phase, electricity supply will be needed for points, signalling and other infrastructure. It is anticipated that the supply of these services will be delivered by relevant providers under the terms of their respective approvals and/or assessment exemptions.

Standard ARTC maintenance activities will be undertaken during operations. Typically, these activities include minor maintenance works, such as bridge and culvert inspections, sleeper replacement, rail welding, rail grinding, ballast dropping and track tamping, through to major periodic maintenance, such as ballast cleaning, formation works, turnout replacement, correction of track level, culvert cleanouts, general environmental maintenance and reconditioning of rail track.

3 Legislative, policy standards and guidelines

3.1 Commonwealth and State legislation

This section describes the legislative, policy and management framework relevant to surface water quality for the Project, including:

- Legislative framework which applies to the assessment of surface water quality applicable to the Project at the Commonwealth, State and local levels, and provides the statutory context for which the surface water quality assessment has been undertaken
- Statutory approvals that may be required as a result of potential impacts to surface water quality, based on consideration of the overall approvals pathway for the Project and the scope of applicable exemptions under Queensland legislation.

An overview of the Commonwealth and State legislation that is relevant to the surface water quality values of the Project, outlining the intent of the legislation and applicability to the Project, is presented in Table 3.1.

3.2 Water quality guidelines

Various water quality guidelines were used to assess the quality of surface waters within the water quality study area against defined reference conditions. Applicable guidelines are briefly described below and are used as an assessment tool for existing water quality conditions, and potential impacts from the Project.

3.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000/2018)

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2018) provide a method for assessing water quality through comparison with guidelines derived from local reference values.

The guideline values were developed based on the following criteria:

- Level of environmental disturbance of surface waters (i.e. highly or slightly/moderately disturbed waters)
- Freshwater or saline surface water
- Waterbody elevation (i.e. upland or lowland aquatic environments)
- Biogeographic region (i.e. southeast or tropical Australia).

The ANZECC/ARMCANZ 2000/2018 guideline values can be regarded as guideline trigger values that can be modified into regional, local or site-specific guidelines, with consideration to the variability of the subject environment, soil type, rainfall and contaminant exposure. Exceedances of the guideline trigger values would indicate a potential environmental issue and trigger an environmental management response.

Table 3.1 Legislation and policies relevant to the surface water quality values of the Project

Legislation/policy	Intent	Applicability
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	The EPBC Act provides that any action (i.e. a Project, development, undertaking or series or activities) that has, will have or is likely to have a significant impact on an MNES or other matters protected under the EPBC Act such as the environment of Commonwealth land, requires approval from the Commonwealth Environment Minister. Under Section 45 of the EPBC Act, the Australian Government and Queensland Government have implemented a bilateral agreement relating to environmental assessment. This agreement allows the Commonwealth Minister for the Department of Agriculture, Water and the Environment (DAWE) (formerly Department of the Environment and Energy) to rely on specified environmental impact assessment processes of Queensland in assessing actions under the EPBC Act.	The EPBC Act is applicable to projects that involve or have the potential to impact upon nationally and internationally important flora, fauna, ecological communities and heritage places – defined as MNES. The Project is a controlled action (EPBC 2017/7944) as a result of the Project's potential impacts on listed threatened species and communities. The Project will be assessed under the bilateral agreement between the Queensland and the Commonwealth governments. Aquatic fauna MNES are noted from the Project and are assessed within Chapter 11: Flora and Fauna of the EIS. Water quality impacts are associated with the predicted habitat for MNES fauna and is applicable to assessment of aquatic MNES fauna. Project activities do not involve coal seam gas and large coal mining development and are exempt from the trigger for MNES Water resources.
Planning Act 2016 (Qld) (Planning Act)	The Planning Act sets out a planning system for development assessment, plan making and dispute resolution. The system is performance based, which allows for innovation and flexibility in how development can be achieved, whilst ensuring responsiveness to community needs and expectations. Under the Planning Act, development is either accepted, assessable or prohibited. Assessment is carried out through the Development Assessment Rules.	The Project will trigger the requirement to obtain approval for aspects of development that are assessable under Schedule 10 of the Planning Regulation (and integrated through other legislation as part of the Development Assessment Rules process) following completion of the EIS process.
Environmental Protection Act 1994 (Qld) (EP Act)	The objective of the EP Act is to achieve ecologically sustainable development by protecting Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. Under the EP Act, environmental protection policies are developed to cover specific aspects of the environment.	The EVs of Queensland waterways, including those located within the water quality study area, are protected under the EP Act and the subordinate legislation. The Project triggers subordinate legislation under EP Act, in regard to quality of Queensland waters.
Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity))	The quality of Queensland waters is protected under the EPP (Water and Wetland Biodiversity). The EPP (Water and wetland biodiversity) seeks to achieve the objective of the EP Act in relation to Queensland waters. The EPP (Water and Wetland Biodiversity) seeks to achieve this purpose by identifying EVs and management goals for Queensland waters; stating water quality guidelines and objectives, to enhance or protect the EVs, provide a framework for decision making, and monitoring and report on the condition of Queensland waters.	The EPP (Water and Wetland Biodiversity) lists the EVs and WQOs and as they are part of the legislation they are considered by planners and managers when making decisions about waters and/or water quality. The Project will assess the water quality within the area against the EPP (Water and Wetland Biodiversity) EVs and WQOs.

Legislation/policy	Intent	Applicability
Water Supply (Safety and Reliability) Act 2008 (Qld)	The *Water Supply (Safety and Reliability) Act 2008* provides for the safety and reliability of water supply. The purpose is achieved by- ▪ A regulatory framework for providing water and sewerage services in the State, including functions and powers of service providers ▪ A regulatory framework for providing recycled water and drinking recycled water and drinking water quality, primarily for protecting public health ▪ The regulatory framework for providing recycled water and drinking water quality, primarily for protected public health ▪ The regulation of referable dams ▪ Flood mitigation responsibilities ▪ Protecting the interests of customers of service providers.	The Project will need to achieve the *Water Supply (Safety and Reliability) Act 2008* purpose. Key purpose of relevance to the Project will involve the protection of interests of 'service providers' in regard to water quality of surface waters from Project activities.
Water Act 2000 (Qld) (Water Act)	The Water Act provides for the sustainable management of non-tidal waters and other resources, together with the establishment and operation of water authorities, and for other purposes. Under the Water Act, a watercourse is defined as: ▪ A river, creek or other stream in the form of an anabranch or a tributary, in which water flows permanently or intermittently, regardless of the frequency of flow events- – In a natural channel, whether artificially modified or not; or – In an artificial channel that has changed the course of the stream. The Queensland Government maintains Watercourse Identification Mapping (WIM), which identifies defined watercourses under the Water Act, as well as drainage features (not related under the Water Act). Through the Planning Act, certain water related development is assessable under the Water Act and requires the assessment and approval for most works in a defined watercourse. Where applications are made for the purposes of 'taking or interfering with water' (and including surface water, artesian water, and in some instances overland flow where regulated through a Water Resource Plan (Moreton and Logan)), a Water Licence is required as evidence prior to lodging a Development Application. In addition to the approvals triggered under the Planning Act, the Water Act regulates the undertakings of works that involve the excavating or placing fill in a watercourse, lake or spring. Under the Water Act, a proponent must obtain a Riverine Protection Permit in order to lawfully undertake these works unless the works can be undertaken in accordance with a Riverine Protection Permit Exemption Requirements (DNRME 2018).	The Project involves works within defined watercourses and as such the provisions of the Water Act may apply. Further the Project involves the removal of vegetation, excavation or placing fill in a waterway, lake or spring. This will require a Riverine Protection Permit to authorise excavation and the Project will apply for licencing under the Riverine Protection Permit as necessary (if exemption is not granted as a Government-owned corporation). ARTC is listed as an entity under Schedule 2 of the Riverine protection permit exemption requirements (WSS/2013/726). Project activities that involve diversion or watercourses will require approval under works that take or interfere with watercourse, lake or spring (for interference with overland flow).

<table>
<tr><th>Legislation/policy</th><th>Intent</th><th>Applicability</th></tr>
<tr><td>Fisheries Act 1994 (Qld) (Fisheries Act)</td><td>The Fisheries Act provides for the management, use, development and protection of fish habitats and resources, together with the management of aquaculture activities. The Fisheries Act hold provisions for the following:
▪ Taking, causing damage to or disturbance to marine plants
▪ Works in a declared fish habitat area
▪ Constructing or raising waterway barrier works
▪ Tidal water, fresh and marine aquaculture operations.
In accordance with Planning Act, operational work for the purposes of the above activities is assessable development for which a Development Permit is required.
Under the provisions of the Fisheries Act and the Planning Act, a Development Permit for Operational Works involving Waterway Barrier Works is required for works which pose a barrier to fish passage (including permanent, partial and temporary barriers) within a waterway which is mapped by Department of Agricultural Fisheries (DAF) on the spatial data layer ‘Queensland waterways for waterway barrier works’ unless:
▪ The works have a low impact to fisheries productivity and comply with DAF’s requirements for ‘works which are not waterway barrier works’ which include (subject to specific design and construction requirements):
– New single or multi-span bridges
– Maintenance of existing bridge structures not subject to an existing permit
– Bank revetment
– Road resurfacing at waterway crossings
– Stormwater outlet construction.</td><td>The Project transverses mapped waterways for waterway barrier works and therefore may trigger the requirement to obtain a Development Permit for Operational Works involving constructing or raising temporary and permanent waterway barrier works.
The Project will require licencing for major risk impact waterways in order to maintain connectivity and water quality. As such, while waterway barrier works are not explicitly related to water quality (as a physical barrier), incorporating waterway barrier works licencing codes into the water quality assessments underpins the precautionary principle methodology used throughout the development of the Project.
Where structures do not meet the accepted development requirements, development permits for operational works for constructing or raising a waterway barrier works will need to be obtained. Acceptable development requirements are defined in the DAF guideline: Accepted development requirements for operational work that is constructing or raising waterway barrier works (2018), and at a minimum include standards such as:
▪ Development work minimises impacts to waterways and fish habitats.
▪ Where works are for the replacement of an existing waterway barrier work, the defunct waterway barrier work is to be completely removed as soon as possible and within four weeks of the completion of the replacement works.
▪ For any part of the waterway bed or banks adjacent to the works that has been altered by the waterway barrier works, the site is restored and/or rehabilitated.</td></tr>
<tr><td>Shaping South East Queensland (SEQ) Regional Plan 2017</td><td>Shaping SEQ Regional Plan is the Queensland Government’s plan to guide the future for the SEQ region.
Shaping SEQ Regional plan is based on the understanding that the region relies on its environmental assets to support our communities and lifestyles.
The Shaping SEQ Regional Plan provides strategies to protect and sustainably manage the region’s catchments to ensure the quality and quantity of water in our waterways, aquifers, wetlands, estuaries, Moreton Bay and oceans meets the needs of the environment, industry and community</td><td>The Project has been identified as a key priority in the region shaping infrastructure and is considered to be consistent with the Shaping SEQ Regional Plan.</td></tr>
</table>

Legislation/policy	Intent	Applicability
State Planning Policy 2017 (SPP) (including State Planning Policy (SPP) – State Interest Guideline (Water Quality) 2016	The State Planning Policy (SPP) is a key component of the Queensland land use planning system which expresses the state's interest (as defined under the Planning Act) in land use planning and development. The SPP defined the Queensland Government's State interests in land use planning and development which notably includes State transport infrastructure. The SPP includes a SPP code (Water Quality Appendix 2) that provides performance outcomes to ensure development is planned, designed, constructed and operated to manage stormwater and wastewater in ways that support the protection of EVs identified in the EPP (Water and Wetland Biodiversity).	Whilst no components of the Project are assessable under the provisions of a local government planning schemes, State approval requirements will trigger the chief executive of Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) as a referral agency for a number of applications. As such, relevant provisions of the SPP will require to be addressed as part of the supporting application materials to be submitted (around water quality performance outcomes with discharge from tunnel infrastructure) and will be considered in the assessment process.

3.2.2 Queensland Water Quality Guidelines

The Queensland Water Quality Guidelines (QWQG) (Department of Environment and Heritage Protection 2009) provide a framework for assessing water quality in Queensland via the setting of WQOs. The QWQG are intended to address the need identified in the ANZECC/ARMCANZ 2000/2018 Guidelines by:

- Providing guideline values (numbers) that are tailored to Queensland region and water types
- Providing a process/framework for deriving and applying more locally specific guidelines for waters in Queensland.

3.2.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The EPP (Water and Wetland Biodiversity) provides a framework for:

- Identifying EVs for Queensland waters, and deciding the WQOs to protect or enhance those EVs
- Including the identified EVs and WQOs under Schedule 1 of the EPP (Water and Wetland Biodiversity).

3.2.4 Water quality objectives and environmental values relevant to the Project

The Queensland Department of Environment and Science (DES) has published two reports relevant to the Project alignment listing relevant EVs and WQOs, including:

- Bremer River environmental values and water quality objective: Basin No 143 (part) including all tributaries of the Bremer River (Bremer River Environmental Values (EV) and WQOs) (Department of Environment and Resource Management (DERM) 2010a)
- Logan River environmental values and water quality objectives: Basin No 145 (part) including all tributaries of the Logan River (Logan River EVs and WQOs) (DERM 2010b).

These documents, relevant to the catchment areas of the Bremer River and the Logan River, form part of Schedule 1 of the EPP (Water and Wetland Biodiversity) subordinate to the EP Act (DERM 2010a; 2010b). The WQOs most relevant to the Project are those within the EPP (Water and Wetland Biodiversity) relating to moderately disturbed (as identified by the current condition within Schedule 1 of EPP (Water and Wetland Biodiversity)) surface water ecosystems. Default ANZECC/ARMCANZ (2000) guidelines for pesticides, heavy metals and other toxic contaminants are used where the regional EPP (Water and Wetland Biodiversity) guidelines are less applicable. Within the WQOs relevant to the Project, thresholds for the protection of aquatic ecosystems were selected for assessment of current environmental conditions.

The WQOs for the protection of aquatic ecosystems is associated with the most stringent trigger values. The achievement of this WQO would then confer protection of other environmental values. Given that no local or sub-regional WQOs for toxicants exist, the national WQOs for toxicants (metals and polycyclic (polynuclear) aromatic hydrocarbons (PAH)) at a 95 per cent protection level for species, apply to the water quality study area (ANZECC/ARMCANZ 2000/2018). These are derived from the default toxicant guideline values for water quality in aquatic ecosystems within the ANZECC/ARMCANZ 2000 guidelines. Due to a limited number of independent samples at each monitoring site, single point data were assessed against the WQO, in lieu of generation of median values for assessment.

Under the Bremer River EV and WQOs and Logan River EVs and WQOs document (DERM 2010a; 2010b) EVs are identified for protection for particular waters. The aquatic ecosystem EV is the default applying to all waters. Further WQOs applying to different EVs are identified for the aquatic ecosystem EVs and for EVs other than the aquatic ecosystem (e.g. human use).

The Project alignment traverses through five sub-catchments of the Bremer River and Logan River catchments which have varying applicable EVs as outlined in Table 3.2. The WQO and ANZECC/ARMCANZ 2000/2018 guidelines for are outlined in Table 3.3 and Table 3.4.

Table 3.2 Project alignment sub-catchment environmental values

Environmental values	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Bremer River catchment												
Mid Bremer (Site 2A)	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Lower Warrill Creek (Site 3A)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Western Creek (Site 1A Alt, 1A)	✓	✓	✓	✓				✓	✓			✓
Purga Creek (Site 13A, 6A, 12A)	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Logan River catchment												
Lower Teviot Brook (Site 11A, 10A, 9A, 8A, 7A, 7A Alt)	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓

Source: DERM (2010a; 2010b)

Table 3.3 Water quality objectives for moderately disturbed surface water ecosystems intersected by the Project

Sub-catchment	Management intent	Secchi depth (m)	Turbidity (NTU)	Chlorophyll *a* (µg/L)	Total N (µg/L)	Oxidised nitrogen (µg/L)	Ammonia (µg/L)	Dissolved oxygen (% saturated)	pH	Organic N (µg/L)	TSS (mg/L)	Total Phosphorus (µg/L)	Filterable Reactive Phosphorus (µg/L)	Electrical Conductivity (µS/cm)
Bremer River catchment														
Mid Bremer (Site 2A)	Moderately disturbed	n/a	< 17	< 5	< 500	< 60	< 20	85 – 110	6.5 – 8.0	< 420	< 6	< 30	< 15	< 770
Lower Warrill Creek (Site 3A)	Moderately disturbed	n/a	< 5	< 5	< 500	< 60	< 20	80 – 110	6.5 – 8.0	< 420	< 6	< 30	< 15	< 500
Western Creek (Site 1A Alt, 1A)	Moderately disturbed	n/a	< 17	< 5	< 500	< 60	< 20	85 – 110	6.5 – 8.0	< 420	< 6	< 30	< 15	< 770
Purga Creek (Site 13A, 6A, 12A)	Moderately disturbed	n/a	< 17	< 5	< 500	< 60	< 20	85 – 110	6.5 – 8.0	< 420	< 6	< 30	< 15	< 770
Logan River catchment														
Lower Teviot Brook (Site 11A, 10A, 9A, 8A, 7A, 7A Alt)	Moderately disturbed	> 0.5	< 25	< 5	< 450	< 15	< 30	80 – 105	7.0 – 8.4	< 400	< 25	< 30	< 10	n/a

Source: DERM (2010a; 2010b)

Table notes:

N = Nitrogen
P = Phosphorous
NTU = Nephelometric Turbidity Units
µg/L = micrograms per litre
mg/L = milligrams per litre
µs/cm = microsiemens per centimetre

Table 3.4 **Water quality objectives for 95% level of species protection heavy metals and other toxic contaminants for the Project**

Sub-catchment	Arsenic (III)(mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
Bremer River catchment									
Mid Bremer (Site 2A)	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Lower Warrill Creek (Site 3A)	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Western Creek (Site 1A, 1A (alt)	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Purga Creek (Site 13A, 6A, 12A)	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Logan River catchment									
Lower Teviot Brook (Site 11A, 10A, 9A, 8A, 7A, 7A Alt)	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016

Table notes:

mg/L = milligrams per litre
Metals guidelines are based on dissolved status and are used throughout in reference against field-filtered water quality samples.

Source: ANZECC/ARMCANZ (2000/2018)

4 Methodology

4.1 Surface water quality assessment

The assessment methodology has been designed to provide sufficient data to inform an existing environment condition for assessment against WQOs (with reference to Schedule 1 of EPP (Water and Wetland Biodiversity). This enabled the identification of potential Project impacts, expected mitigation measures, a residual impact assessment and a cumulative impact assessment. The desktop and field assessments (as a description of the existing environment) were used to determine the quality of receiving waters and were utilised in assessing the significance of specific potential impacts expected from the construction (including pre-construction), and operation phases of the Project.

Potential contaminant impact from the Project was identified using Model for Urban Stormwater Improvement Conceptualisation (MUSIC) modelling. The contaminant discharge load was calculated against the drainage basins parallel to the Project alignment, as discharge was likely to consist of overland flow from precipitation.

Other potential Project impacts to the receiving environment were assessed (using a conservative approach) under normal construction and operating activity levels, with the expectation of low-level contamination without appropriate mechanisms of mitigation in place.

4.1.1 Literature and database review

This section details the desktop analysis undertaken to identify existing information pertaining to the surface water quality values of the study area.

Details of the relevant database sources, search dates, search area parameters and type of information considered for the desktop study are summarised in Table 4.1 and are presented in Appendix C.

Table 4.1 Database review summary

Database/data source name	Database search date	Database search areas	Data type
Map of Referable Wetlands (DES)	15 January 2020	Water quality study area	Includes State-significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland Regional Ecosystems (RE)
Wetland*Info* (DES)	15 January 2020	Water quality study area (and wider Bremer River and Logan River catchments)	Includes nationally (Directory of Important Wetlands) and internationally important (Ramsar) wetlands
Queensland waterways for waterway barrier works (Department of Agricultural and Fisheries (DAF))	15 January 2020	Water quality study area	Waterways where proposed waterway barrier works require assessment and approval under the Fisheries Act
Watercourse Identification Mapping (DNMRE)	15 January 2020	Water quality study area	Known extent of watercourses and drainage features that are managed under the Water Act
Fish Habitat Areas (DAF)	15 January 2020	Water quality study area	Boundaries of gazetted, declared fish habitat areas.

Database/data source name	Database search date	Database search areas	Data type
Matters of State Environmental Significance (DES)	15 January 2020	Water quality study area	Location of Matters of State Environmental Significance including: ▪ Protected areas ▪ Marine parks ▪ Management A and Management B declared fish habitat areas ▪ Wetlands in a wetland protection area or wetlands of high ecological significance ▪ Wetlands and watercourses in high ecological value waters as defined in the EPP (Water and Wetland Biodiversity), schedule 2 ▪ Legally secured offset areas.
Water Monitoring Information Portal (DNRME)	15 January 2020	Water quality study area (and gauging stations on watercourses intersecting the Project alignment)	Includes information pertaining to stream height and stream flow values from the department's water monitoring stations throughout Queensland, historic streamflow data from decommissioned river and stream monitoring stations and the DNRME's water monitoring network site lists.
Climate data from the Bureau of Meteorology (BoM)	15 January 2020	Stations closest to water quality study area, to provide general climate	Includes climate data for the study area, including rainfall, evaporation and temperature data
Public notices of water licence applications (DNRME)	17 May 2019	Water quality study area	Lists public notices of water licence applications
Queensland land use mapping program (DES)	15 January 2020	Water quality study area	Land use mapping which identifies land use patterns and changes
Digital drainage and topographic data (DNRME)	15 January 2020	Water quality study area	Topographic data providing spatial and attribute information pertaining to drainage and topography
(Water Plans, Moreton and Logan) [Water Resource Plans] (DNRME)	15 January 2020	Water quality study area	Water Plans which provide information on how water is managed and accessed in the water plan area
Healthy Waterways report card	15 January 2020	Water quality study area (including Bremer River and Logan River catchments)	Includes healthy land and water report cards for Bremer and Logan catchment
Aquatic Conservation Assessment (AquaBAMM)	15 January 2020	Water quality study area (including Bremer River and Logan River catchments)	AquaBAMM assesses the conservation values of aquatic ecosystems within a specific area
Queensland Springs Database (Queensland Government 2018)	15 January 2020	Water quality study area (including Bremer River and Logan River catchments)	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression groundwater dependant ecosystems (GDEs)
Bureau of Meteorology: GDE Groundwater Dependent Ecosystem Atlas	15 January 2020	Water quality study area	Aquatic GDEs
Queensland GDE database (DES)	15 January 2020	Water quality study area	Aquatic GDEs

Details of the existing literature and previous study reports which have been reviewed for the desktop study are summarised in Table 4.2.

Table 4.2 Project related assessments and reports

Document title	Reference
SFRC Study (March 2010)	AECOM (2010)
Australian Rail Track Corporation/Transport - Land/southwest of Ipswich/Queensland/Inland Rail Calvert to Kagaru Project (EPBC Referral number 2017/7944)	ARTC (2017)
Initial Advice Statement: Inland Rail, Calvert to Kagaru	ARTC (2017)
Southern Freight Rail Corridor Study, Revised Assessment Report, Volume 1	AECOM (2010)

4.1.2 Field assessment

The surface water quality field assessment was designed to provide sufficient information to produce this report which will be used to inform the EIS for the Project, whilst also providing existing EVs and potential impacts for the Project's design. In addition to the field assessments, a desktop review of available and relevant water quality data to the Project was completed.

The data collection approach is consistent with the Monitoring and Sampling Manual 2018 (DES 2018). The surface water quality field assessment methodology is described in further detail below.

4.1.2.1 Assessment timing

Three discrete water assessments were originally chosen for analysis; one spring, one autumn and one summer assessment (refer Table 4.3). These were selected in order to efficiently incorporate varying environmental conditions (expected seasonal variation). Environmental conditions were identified as varied base flow and non-base flow surface water conditions (with the expectation this will be the typical environmental conditions encountered during construction and operational works related to the Project).

Dry conditions were noted throughout the monitoring period. Watercourse flow was limited, however flows were consistent with the highly seasonal, and sporadic flow regimes throughout the water quality study area. In consideration of the seasonal flow regimes of the watercourses, timing of the assessments was chosen in order to capture dry or wet condition water quality samples.

Due to dry (and no-flow) conditions within the water quality sample sites during the original summer assessment event, the timing of the assessment was extended into autumn in order to obtain the best representative sample of existing environmental conditions.

In situ water quality field data was collected during each monitoring round in addition to samples collected for laboratory analysis. All in situ water quality field data and laboratory samples were collected by a suitably qualified and experienced environmental scientist.

Table 4.3 Field assessment timing

Assessment	Date	Season
First	25 September 2017 to 29 September 2017	Spring
Second	27 February 2018 to 2 March 2018	Summer/Autumn
Third	11 March 2019 to 13 March 2019	Autumn

4.1.2.2 Assessment sites

Sampling was undertaken at 16 nominated surface water quality monitoring locations as presented in Table 4.4 and Figure 4.1. Waterbody names were determined by the Water Act watercourses and other related waterflow paths.

The locations of the surface water quality monitoring sites were initially identified during desktop assessment. Sites were located to target waterways which intersect the Project alignment, with additional sites located upstream and downstream of the alignment intersection. The location of the monitoring sites was refined in the field, following ground truthing of the waterway alignment and factors such as land access and water availability.

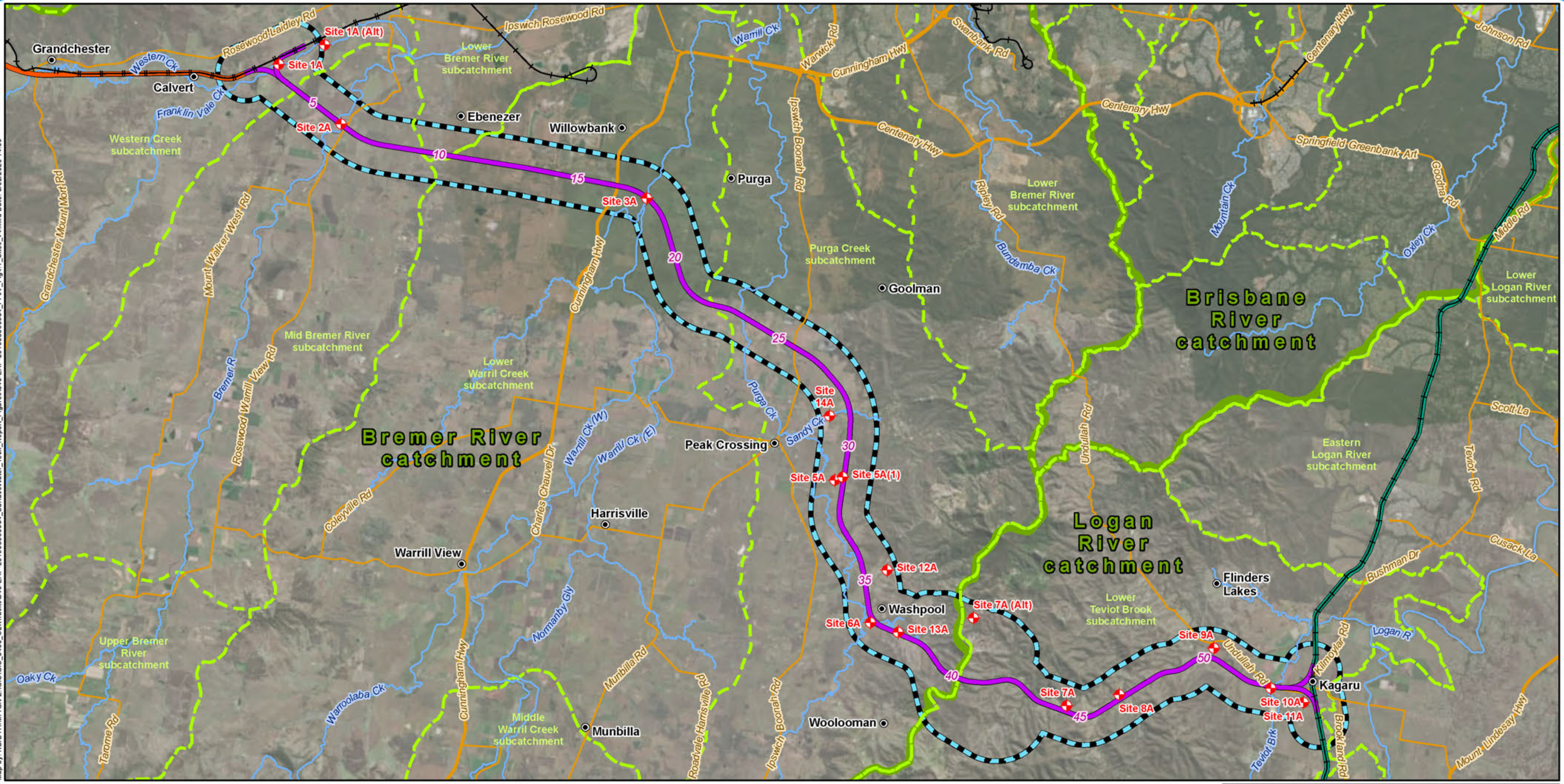
As such, due to conditions and access across all water quality assessments, some of the sites were not assessed across the entire sampling period due to a lack of adequate water and land access for assessment.

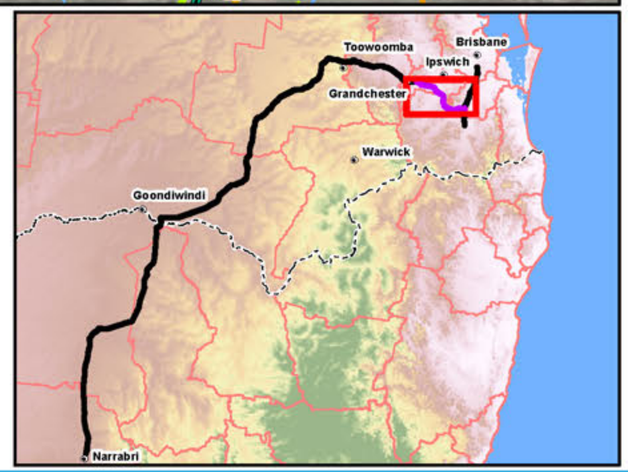
Table 4.4 Surface water quality survey sites

Site ID	Waterbody	Position	Site location (GDA 94)		Water present at time of assessment		
			Latitude	Longitude	September 2017	March 2018	March 2019
Bremer River catchment							
C2K 1A	Western Creek	Located 100 m upstream of the Project alignment	-27.6611899	152.5494666	No	No	No
C2K 1A (Alt)	Western Creek	Located 2 km upstream of the Project alignment	-27.6548532	152.5661112	Yes	Yes	No
C2K 2A	Bremer River	Located on the Project alignment	-27.6804387	152.5718674	No	Yes	No
C2K 3A	Warrill Creek	Located on the Project alignment	-27.7046838	152.6825343	Yes	No	No
C2K 5A	Impoundment	Located 200 m downstream of the Project alignment	-27.7958826	152.7505363	Yes	Yes	Yes
C2K 5A (1)	Un-named watercourse	Located 130 m downstream of the Project alignment	-27.7948481	152.7533258	No	Yes	No
C2K 6A	Un-named tributary Purga Creek	Located 180 m downstream of the Project alignment	-27.8417062	152.7632700	Yes	Yes	Yes
C2K 12A	Un-named watercourse	Located 900 m upstream of the Project alignment	-27.8248551	152.7693818	Yes	Yes	No
C2K 13A	Un-named tributary of Purga Creek	Located 40 m upstream of the Project alignment	-27.8447135	152.7733443	Yes	Yes	Yes
C2K 14A	Un-named tributary of Purga Creek	Located 750 m downstream of the Project alignment	-27.7750833	152.7485736	No	Yes	No

Site ID	Waterbody	Position	Site location (GDA 94)		Water present at time of assessment		
			Latitude	Longitude	September 2017	March 2018	March 2019
Logan River catchment							
C2K 7A	Dugandan Creek	Located 220 m upstream of the Project alignment	-27.8685914	152.8344211	Yes	Yes	No
C2K 7A (Alt)	Un-named watercourse	Located 2.5 km upstream of the Project alignment	-27.8402669	152.8007754	No	Yes	No
C2K 8A	Dugandan Creek	Located 180 m upstream of the Project alignment	-27.8650141	152.8536255	Yes	Yes	No
C2K 9A	Woollaman Creek	Located 360 m upstream of the Project alignment	-27.8501114	152.8879643	Yes	Yes	No
C2K 10A	Teviot Brook	Located 50 m downstream of the Project alignment	-27.8630385	152.9084987	Yes	Yes	Yes
C2K 11A	Impoundment	Located 300 m downstream of the Project alignment	-27.8675844	152.9204369	Yes	Yes	No

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





Legend

- Surface water quality field assessment sites
- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Sub-catchment boundaries
- Catchment boundaries
- Water quality study area

A3 scale: 1:150,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 29/01/2020 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 4.1:
Surface water quality field assessment sites

4.1.2.3 In situ analysis of surface water quality

A suite of water quality parameters was selected for the assessment of the existing environmental condition in relation to anticipated activities and associated impacts from the Project. Qualitative data was collected to provide contextual supplementary information in relation to the water quality values.

A fully serviced and calibrated YSI Professional Plus water quality meter and a TPS WP-88 Turbidity Meter were used to record the following in situ water quality parameters:

- pH
- Temperature
- Electrical conductivity (actual and specific)
- Salinity
- Dissolved oxygen (dissolved and saturated)
- Turbidity.

Additionally, the following qualitative data was recorded:

- Time
- Water flow (none/low/moderate/high/flood/dry)
- Optical clarity (clear/slight/turbid/opaque/other)
- Odour (normal/sewage/hydrocarbon/chemical)
- Surface condition (none/dust/oily/leafy/algae)
- Algae cover (none/some/lots)
- Other visual observations/comments (colour, presence of litter)
- A photo and Global Positioning System (GPS) point were collected from each sampling site.

Water quality meters were professionally calibrated within the month preceding field assessment events. Calibration certificates for the YSI Professional Plus water quality meter and TPS WP-88 Turbidity Meter used during the sampling works are provided in Appendix A.

4.1.2.4 Laboratory analysis of surface water quality

Before the commencement of field sampling, a National Association of Testing Authorities (NATA) accredited laboratory (Eurofins) was chosen and requirements for analysing water samples collected were discussed and agreed.

Surface water samples were collected at each monitoring location listed in Table 4.4 and submitted to Eurofins for analysis of the following water quality parameters (Limit of Reporting (LOR) indicates the lowest detection limit):

- pH
- Suspended solids
- Turbidity
- Total phosphorus
- Reactive filterable phosphorus
- Speciated nitrogen ammonia, nitrate, nitrite, organic nitrogen, total kjeldahl nitrogen, total nitrogen
- Dissolved metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc
- Salinity
- Electrical conductivity

- Chlorophyll *a*
- Polycyclic aromatic hydrocarbons (PAH).

The above parameters were analysed to establish a preliminary contemporary assessment of the existing water quality within the water quality study area, against general WQOs to protect aquatic ecosystems, as indicated by EPP (Water and Wetland Biodiversity). No further sampling for specific hydrocarbon or biocide was completed due to qualitative assessment of other hydrocarbon through olfactory/visual assessments during field sampling and a specific mitigation requirement of aquatic-friendly pesticides nullifying the need for biocide assessment to determine assimilative capacity of the receiving environment.

4.1.3 Sampling and laboratory quality assurance/quality control

Surface water quality samples were collected in accordance with industry-accepted standards and quality assured procedures, including the Queensland Monitoring and Sampling Manual (DES 2018). Field quality control included rigorous sample collection, decontamination procedures (where appropriate), and sample documentation.

Where possible, surface water quality samples were collected from the centre of the waterway, where the velocity is the highest. The mouth of the sampling container was held above the base of the channel to avoid disturbing or collecting any settled solids or materials.

The surface water quality samples were collected directly into the appropriate sampling bottles provided by the laboratory to avoid potential contamination associated with the use of intermediate containers. Where a sampling pole was required to be used to enable safe sample collection, the sampling bottle was placed on the pole and the sample collected directly into the sampling bottle. Samples were field filtered as required. Syringes and filters were flushed with water from the sampling site prior to use.

As each sample was collected it was labelled with a unique sample identifier, the initials of the sampler, the date and the Project number. All sample jars were filled leaving no headspace and placed immediately into ice-filled cooler boxes. All samples were transported in ice-filled coolers to prevent degradation of organic compounds. Chain of Custody documentation was completed, with data including sample identification, date sampled, matrix type, preservation method, analyses required and name of sampler (refer Appendix B).

The collection of quality control samples is essential in order to provide confidence in the results of sampling program and is part of the overall quality assurance program. The Queensland Monitoring and Sampling Manual (DES 2018) provides guidance on the frequency of collection and purpose of quality control samples where duplicates are taken one per 10 samples for primary laboratory analysis. In line with the Queensland Monitoring and Sampling Manual (DES 2018), one duplicate sample was taken on each round of water sampling for Quality Assurance/Quality Control purposes. Surface water quality samples were submitted to a NATA accredited laboratory (Eurofins) for analysis. Samples were analysed within applicable holding times by the laboratory.

4.1.4 Assessment of results

Field and laboratory results were compared against relevant WQOs as presented in Section 3.2.4.

The field obtained data was assessed against the data obtained during the desktop assessments to supplement identified data gaps and provide a contemporary assessment of the physical and chemical status of aquatic systems to be intersected by the Project alignment, against current WQOs.

WQOs and assessment of surface water quality monitoring results against the relevant WQOs is discussed in further detail in Section 6.2.

4.2 Impact assessment methodology

The surface water quality assessment of the Project uses a significance-based impact assessment to identify and assess Project related impacts in relation to environmental receptors (identified in Section 5.11).

For the purpose of assessment, a significant impact depends upon the sensitivity of the surface water value, the quality of the environment which is impacted, and upon the intensity, duration, magnitude and potential spatial extent of the potential impacts. Determination of the sensitivity or vulnerability of the surface water value/receptor and the magnitude of the potential impacts facilitate the assessment of the significance of potential surface water impacts. The following sections discuss and define impact magnitudes, receptor sensitivity and impact significance.

4.2.1 Magnitude of impacts

The magnitude of a potential impact is essential to the determination of its level of significance on sensitive values/receptors. For the purposes of this assessment, impact magnitude is defined as being comprised of the nature and extent of the potential impacts, including direct and indirect impacts. The impact magnitude is divided into five categories (refer Table 4.5). Timeframe for duration of impact is divided into five categories (refer Table 4.6). The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the extent, duration and frequency of the impacts.

Table 4.5 Criteria for magnitude

Magnitude	Description
Major	An impact that is widespread, permanent and results in substantial irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of environmental management controls are required to address the impact.
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact.
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the Project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls.
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls.
Negligible	An extremely localised impact that is barely discernible and is effectively mitigated through standard environmental management controls.

Table 4.6 Timeframes for duration terms

Duration term	Timeframe – to be defined for each receptor type if required
Temporary	Days to months (e.g. 1 to 2 seasons; 3 to 6 months)
Short term	Up to 2 years (i.e. 6 to 24 months)
Medium term	From 2 to 11 years[1]
Long term/long lasting	From 11 to 21 years[2]
Permanent or irreversible	More than 21 years[3]

Table notes:

1. Derived from the term 'moderate' Environmental Assessment and Management (EAM) Risk Management Framework 2009 (GBRMPA 2009)
2. Derived from the term 'major' EAM Risk Management Framework 2009 (GBRMPA 2009)
3. Derived from the term 'catastrophic' EAM Risk Management Framework 2009 (GBRMPA 2009)

4.2.2 Sensitivity

To assess the significance of potential impacts on sensitive values/receptors, sensitivity categories are applied to each of the features. The sensitivity categories are split into five discrete groups as described in Table 4.7. These groupings are based on qualitative assessments utilising information related to the sensitivity of the receptor, in addition to the potential of a sensitive receptor's occurrence within the receiving environment.

Through the determination of sensitivity categories for each of the values/receptors, the features are then able to be assessed through a matrix against the magnitude of the potential Project impact type to indicate the level of significance for each of the impact types on the values/receptors.

Table 4.7 Sensitivity criteria for sensitive values/receptors within the water quality study area

Sensitivity	Description
Major	▪ The sensitive value is listed on a recognised or statutory state, national or international register as being of conservation significance and/or ▪ The sensitive value is entirely intact and wholly retains its intrinsic value and/or ▪ The sensitive value is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region, state, country or the world and/or ▪ It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. ▪ Project activities would have an adverse effect on the value.
High	▪ The sensitive value is listed on a recognised or statutory state, national or international register as being of conservation significance and/or ▪ The sensitive is intact and retains its intrinsic value and/or ▪ The sensitive value is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region and/or ▪ The sensitive value has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the sensitive value. ▪ Project activities would have an adverse effect on the sensitive value.
Moderate	▪ The sensitive value is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers and/or ▪ The sensitive value is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements and/or ▪ The sensitive value is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are exposed to threatening processes and/or ▪ Threatening processes have reduced the sensitive value's resilience to change. Consequently, changes resulting from Project activities may lead to degradation of the prescribed value and/or ▪ Replacement of unavoidable losses is possible due to its abundance and distribution.
Low	▪ The sensitive value is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations e.g. historical societies and/or ▪ The sensitive value is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value and/or ▪ It is not unique or rare and numerous representative examples exist throughout the system/area and/or ▪ It is abundant and widely distributed throughout the host systems/areas and/or ▪ There is no detectable response to change or change does not result in further degradation of the environmental value and/or ▪ The abundance and wide distribution of the sensitive value ensures replacement of unavoidable losses is achievable.
Negligible	▪ The sensitive value is not listed on any recognised or statutory register and is not recognised locally by relevant suitably qualified experts or organisations and/or ▪ The sensitive value is not unique or rare and numerous representative examples exist throughout the system/area and/or ▪ There is no detectable response to change or change does not result in further degradation of the sensitive value.

4.2.3 Significance of impact

The significance of a potential impact is a function of the significance of the sensitive value and its sensitivity of the receptor/value and the magnitude of the potential impact. Although the sensitivity of the value/receptor will not change (i.e. is generally determined qualitatively by the interaction of the receptor's condition, adaptive capacity and resilience), the magnitude of the potential impact is variable and may be categorised quantitatively to facilitate the prediction of the significance of the potential impact.

Once the sensitive value/receptor has been identified, and the sensitivity of the value/receptor and the magnitude of the potential impact have been determined, this will facilitate the assessment of the significance of the potential impact through use of a five by five matrix (refer Table 4.8).

Following the identification of the level of significance (refer Table 4.9), mitigation measures were then applied to the potential (unmitigated) impacts to identify the residual (mitigated) impacts.

Table 4.8 Significance assessment matrix

Magnitude of impact	Sensitivity				
	Major	High	Moderate	Low	Negligible
Major	Major	Major	High	Moderate	Low
High	Major	Major	High	Moderate	Low
Moderate	High	High	Moderate	Low	Low
Low	Moderate	Moderate	Low	Negligible	Negligible
Negligible	Moderate	Low	Low	Negligible	Negligible

Table note:

Significance categories as identified in Table 4.8 are defined in Table 4.9. Magnitude categories are defined in Table 4.5.

Table 4.9 Significance classifications

Significance rating	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to an environmental value that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
High	Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the environmental value. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
Moderate	Results in degradation of the environmental value due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable.
Low	Occurs where an environmental value is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
Negligible	Does not result in any noticeable change and hence the proposed activities will have negligible effect on environmental values. This typically occurs where the activities are located in already disturbed areas.

4.3 Cumulative impact assessment

4.3.1 General assessment methodology

The cumulative impacts of multiple projects occurring in the vicinity of the water quality study area may contribute to impacts to water quality if not managed appropriately.

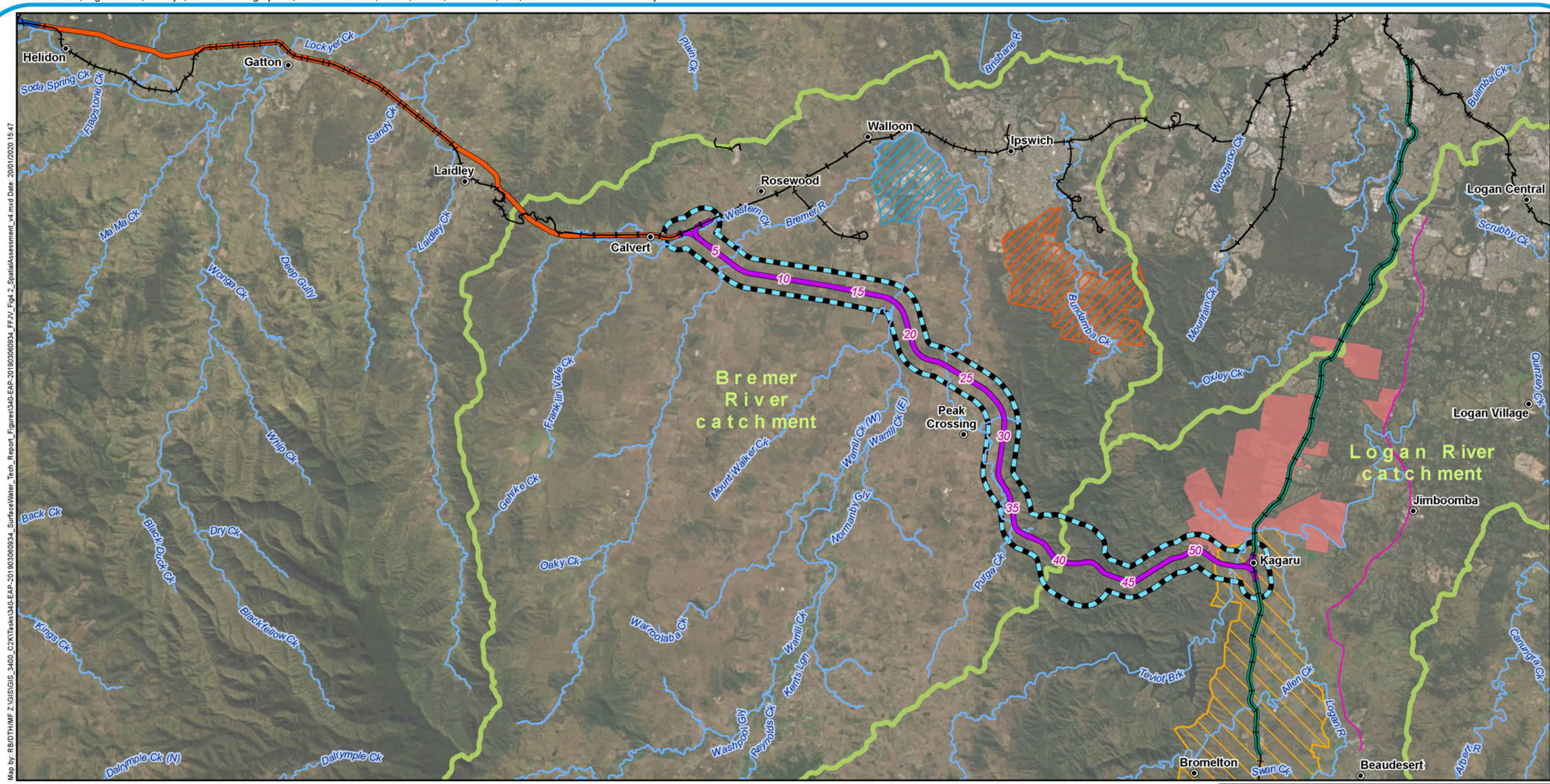
The CIA with regards to surface water quality impacts was conducted based on the following principles:

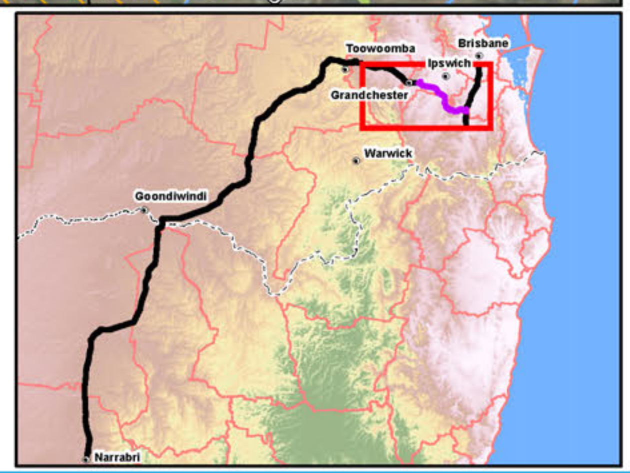
- The CIA considered ‘State significant’ or ‘strategic’ projects outside of the Project that are in the public domain as being planned, constructed or operated at the time the Project ToR were finalised (8 December 2017). The register of assessable Projects has been provided to the relevant regulator for endorsement
- The Inland Rail projects immediately adjacent to the Project have been included in the CIA (e.g. the Project CIA considered Helidon to Calvert (H2C) project and the Kagaru to Acacia Ridge and Bromelton (K2ARB) project)
- The area of influence for the purposes of the Project CIA for surface water quality were defined by the hydrological catchment area for the Project alignment
- Current operational projects and commercial or agricultural operations that are in the areas of influence around the water quality study area, and considered in the CIA, are accounted for, where appropriate, in this technical report
- The CIA is not retrospective. The CIA does not take into account impacts from past land use (e.g. vegetation clearing). The environment at the time of the Project ToR finalisation is the baseline for Project CIA.

The CIA process is summarised below:

- A list of applicable projects and operations for consideration in the CIA was prepared (refer Table 10.1). Figure 4.2 illustrates the areas of spatial influence of the Project being assessed in the CIA, demonstrating the overlap of potential cumulative impact with the projects and/or operations identified above
- The temporal impact zone of influence was identified via identification of temporal overlaps between the Project and the projects and/or operations identified above
- The CIA was conducted to determine the significance of cumulative impacts with respect to beneficial or detrimental effects
- Additional mitigation measures were proposed for cumulative impacts deemed to be of ‘medium’ or ‘high’ significance (refer Section 4.3.2) where it was considered within ARTC’s control to reduce the significance of impact.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





Legend

- Localities
- 5 Chainage (km)
- G2H project alignment
- C2K project alignment
- Existing rail
- Defined watercourses (Water Act 2000)
- Catchment boundaries
- Water quality study area

Projects

- Ripley Valley Priority Development Area
- RAAF Base Amberley
- State Development Area Boundary - Bromelton
- Priority Development Area Boundary - Greater Flagstone
- South West Pipeline
- H2C project alignment
- K2ARB project alignment

A3 scale: 1:275,000

0 2 4 6 8 10km

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 4.2: Areas of spatial assessment subject to the Project CIA for surface water quality and hydrology

4.3.2 Assessment matrix

Following the identification of each potential cumulative impact, a relevance factor score of Low, Medium and High was determined in consideration of the impacts, in accordance with the assessment matrix given in Table 4.10.

The significance of the impact was determined by using professional judgement to select the most appropriate relevance factor for each aspect in Table 4.10 and summing the relevance factors. The sum of the relevance factors determines the impact significance and consequence which are summarised in Table 4.11. For example, if an environmental value such as water quality was considered to have a probability of impact of 2, duration of impact of 3, magnitude /intensity of impact of 1 and a sensitivity of receiving environment of 1 the significance of impact would be '(2 + 3 + 1 + 1 = 7) = Medium'.

Table 4.10 Assessment matrix

Aspect	Relevance factor		
	Low	Medium	High
Probability of impact	1	2	3
Duration of impact	1	2	3
Magnitude/Intensity of impact	1	2	3
Sensitivity of receiving environment	1	2	3

Table 4.11 Impact significance

Impact significance	Sum of relevant factors	Consequence
Low	1 to 6	Negative impacts need to be managed by standard environmental management practices. Special approval conditions unlikely to be necessary. Monitoring to be part of general Project monitoring programme.
Medium	7 to 9	Mitigation measures likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring programme required, where appropriate.
High	10 to 12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring programme necessary, where appropriate.

4.4 Assumptions of assessment

This report has been prepared based on publicly available information and field water sampling results. The description of the existing surface water condition in this report is a desktop study from publicly available data complemented by contemporary field water quality samples (with seasonal variation) to enable an assessment of existing environmental conditions.

Drought declarations are considered as a rainfall deficiency over the last 12 months (as a once in 10-year event) and the water quality study area was covered by a drought declaration during the assessment period. Whilst a period of minimal hydrological flow within the watercourses across the Project was observed (coinciding with a drought-declaration), this period was considered to be indicative of the cyclic, episodic hydrological regime (although magnified) of the water quality study area.

As such, the field data gathered during this assessment was considered to be indicative of existing environmental conditions and relevant for assessment under the EIS ToR.

5 Description of environmental values/existing conditions

5.1 Local government areas

The Project alignment traverses the local government area of Ipswich City Council, between Calvert and Peak Crossing. From Peak Crossing to Kagaru the Scenic Rim Regional Council is the majority regional council with a small portion of the proposed alignment (in proximity to Kagaru) crossing into Logan City Council local government area.

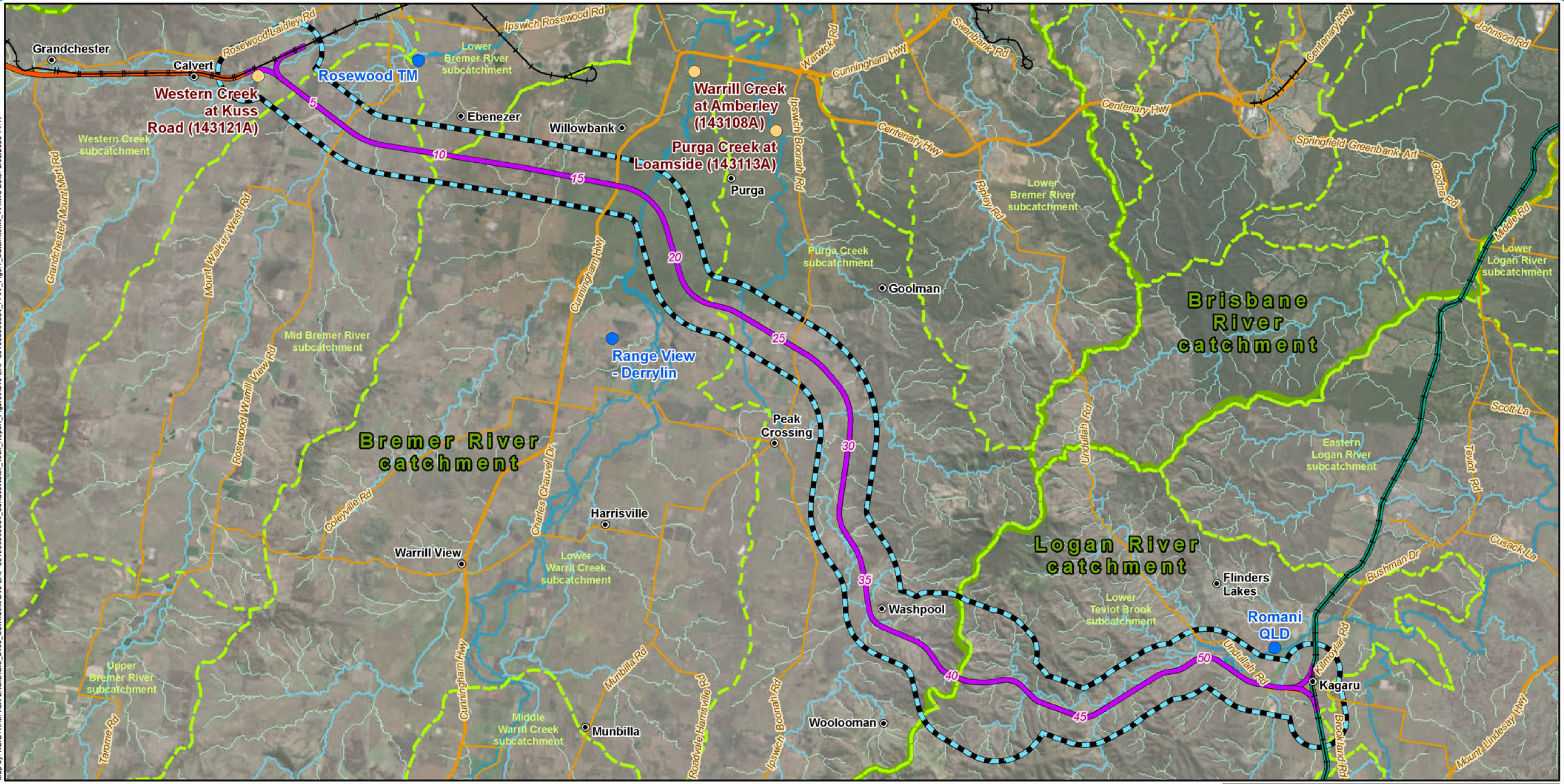
5.2 Catchment areas

The Project alignment travels through two catchments, the Bremer River and the Logan River. The Bremer River catchment covers the area between Calvert and east of Woolooman as the alignment reaches the peak of the Scenic Rim mountain range, and the Logan River catchment area, as the alignment descends the mountain range towards Kagaru (DES 2018) (refer Figure 5.1).

The Bremer River catchment is situated west of Brisbane within the local government boundaries of Ipswich City Council and the Scenic Rim Regional Council and expands to an area of approximately 2,030 square km (km^2) with the main Bremer River channel surrounded by smaller sub-catchments. The stream network length is approximately 4,425 km. The Project alignment predominantly traverses through the sub-catchments of Mid Bremer River, Lower Bremer River, Lower Warrill Creek, Western Creek and Purga Creek. Rainfall in the catchment is considered high along its steeper sections which are situated to the south and east whilst the remainder of the catchment experiences average rainfall of under 1,000 mm/yr (SEQ Catchments 2006). Dominant land uses within the Bremer catchment include grazing, native bushland, intensive agricultural and urban. The lower catchment is mostly urbanised, where the rest of the catchment is rural with the majority of the catchment cleared for cattle grazing. The upper catchment contains areas of natural bushland (DES 2016).

The Logan River catchment is situated to the south of Brisbane with its headwater in the McPherson and Main Ranges. The majority of the catchment features in the local government areas of the Scenic Rim Regional Council and Logan City Council but also includes small sections of other local government areas. The catchment area expands over 3,076 km^2 with approximately 5,500 km of stream network. The Project alignment intersects the sub-catchment of Lower Teviot Brook. Rainfall in the catchment is very high especially in the eastern headwaters which combined with good recharge of groundwater associated with basalt geology lead to permanent flow (SEQ Catchments 2017). The dominant land uses within the Logan catchment include grazing, native bush, rural residential and intensive agriculture. The upper catchment has been cleared for agriculture, grazing and dairying while the mid and lower catchment flows through rural, residential and urban areas (DES 2015).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



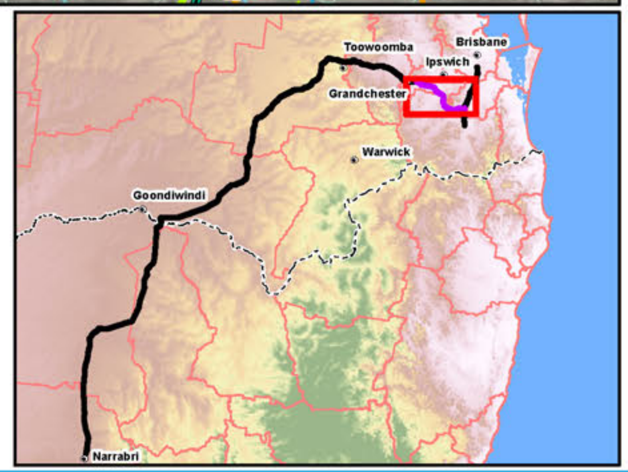
Map by: RB/DTH/MF/GN Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig5.1_Catchments_v4.mxd Date: 3/02/2020 14:17

Legend

- BOM weather station
- DNMRE gauging station
- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Major roads
- Minor roads
- Sub-catchment boundaries
- Catchment boundaries
- Water quality study area

Defined watercourses (Water Act 2000)

- Order 2 - 3
- Order 4 - 5
- Order 6 - 7



A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 5.1:
Catchment areas and surface water features

5.3 Physical environment

5.3.1 Context

A review of the BoM climate data was undertaken from the nearest monitoring stations at Amberley Aeronautical Meteorological Office (AMO) (040004) approximately 38 km north-west of Kagaru. The water quality study area has a typical hot and dry climate and experiences warm to hot summers and mild to cool winters.

Rainfall is seasonally distributed with a distinct wet season occurring during the summer months of December through February and an extended dry season during the months of April through September. Mean maximum monthly temperatures typically range from 30°C in summer to 20°C in winter (BoM 2020a).

Rainfall data collected from six weather stations across the water quality study area from 1917 to 2019, both currently active and inactive, revealed the area receives an average annual rainfall of 67.36 mm (BoM 2020d) (refer Table 5.1).

5.3.2 Rainfall

The summer season in the surrounding region of the water quality study area receives its heaviest rainfall with the highest recorded single rainfall event occurring in January 1974 with 309.9 mm. During winter months, the area predominantly receives low rainfall (BoM 2020d) (refer Table 5.1).

Table 5.1 Weather stations within proximity of water quality study area and rainfall data

Station #	Name*	Locality	Operation date	Annual rainfall average (mm)	Month of highest rainfall/ amount (average monthly mm)	Month of lowest rainfall/ amount (average monthly mm)
40736	Rosewood TM	Rosewood	2000-2006	505.4	Oct (75.6)	Jul (1.0)
40317	Range View	Mutdapilly	1961-2019	812.7	Dec (117.7)	Aug (28.2)
40155	Derrylin	Mutdapilly	1917-1957	698.4	Dec (104.3)	Aug (20.8)
40934	Romani Alert	Kagaru	2002-2019	885.3	Jan (139.9)	Jul (18.6)
40894	Romani TM	Kagaru	1994-2009	674.7	Nov (112.5)	Jul (19.0)
40411	Romani QLD	Kagaru	1967-2001	892.1	Jan (140.0)	Aug (27.7)

Table notes:

* TM denotes automated station

Source: BoM (2020)

5.3.3 Evaporation

The closest BoM weather station that has previously recorded evaporation (using modelling of pan evaporation data) is the Gatton DAF Research Station (040436), approximately 77.5 km north-west of Kagaru; however, 2014 was the last year evaporation data was recorded. From 1974 to 2014 evaporation data for the water quality study area generally consists of higher evaporation in the summer months where the mean average evaporation rate is 7.4 mm compared to the winter months where the mean evaporation rate is 3.5 mm (BoM 2020a).

5.3.4 Temperature

The climate of the surrounding region of the water quality study area remains relatively warm all year around with the only cooler temperatures occurring during winter nights and early mornings (BoM 2020b). Data collected from the Amberley AMO weather station between 1941 and 2018 revealed an average maximum temperature of 26.8˚C and an average minimum of 13.0˚C. The hottest day ever recorded for the surrounding region of the water quality study area occurred in January 1994 where it reached 44.3°C, whilst the coldest ever record reached by the area was -4.9˚C in August 1995 (BoM 2020b; BoM 2020c). Figure 5.2 provides the mean minimum and maximum temperature for the water quality study area.

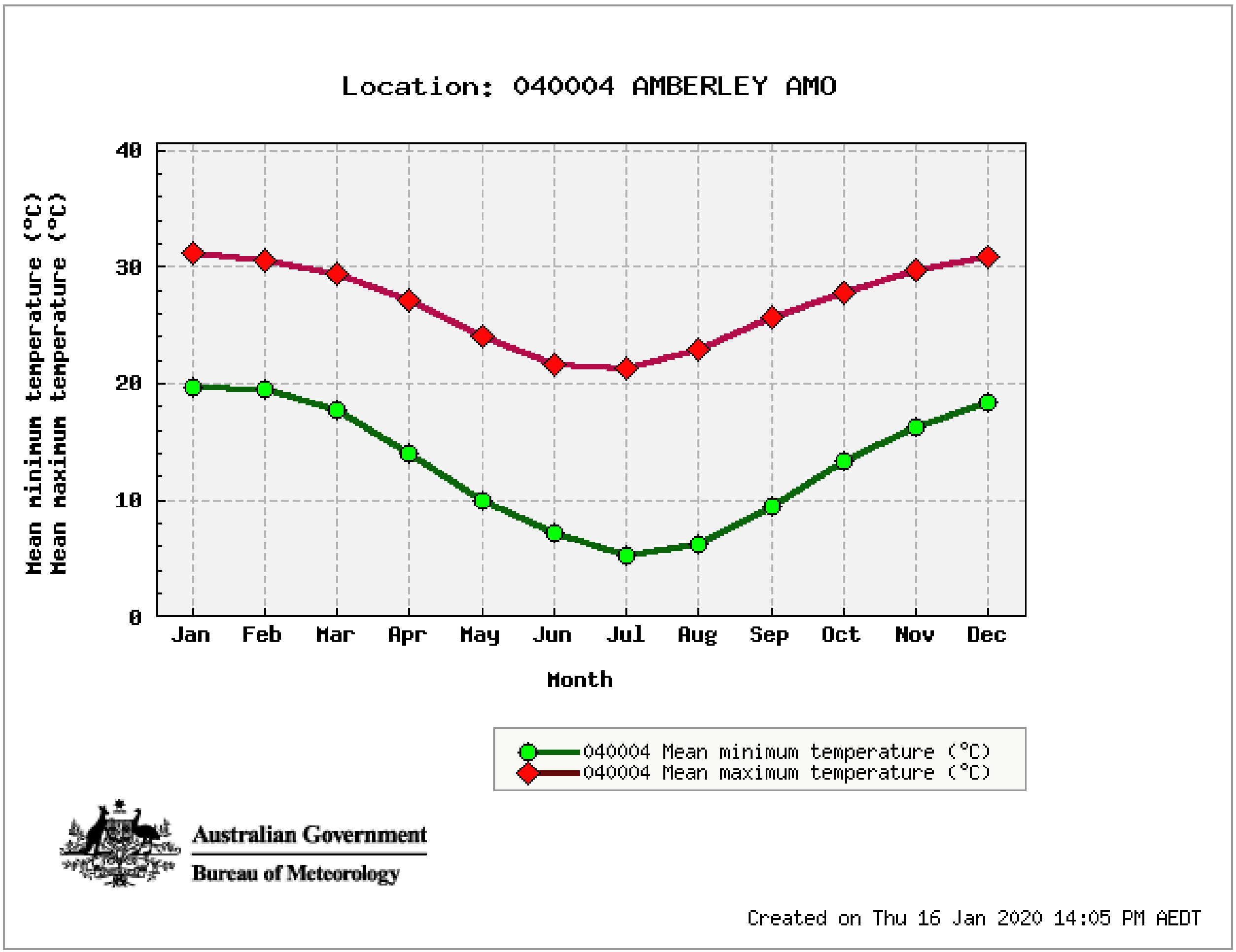


Figure 5.2 **Mean maximum and minimum temperature from Amberley AMO for water quality study area**

Source: BoM (2020 b, c)

5.3.5 Gauging station water monitoring (discharge and water quality)

The DNRME maintain a Water Monitoring Information Portal (WMIP) for stream gauge data with datasets typically including rainfall, stream flow and water quality data for numerous gauging stations across Queensland.

There are three stream flow monitoring stations located within the water quality study area that record real time data including flow creek data and other limited, basic parameters. The stations and their location respective to the Project alignment are provided in Table 5.2. Associated flow, rainfall and water quality parameters recorded at the gauge sites are provided in Table 5.3. Due to the data deficiency of the Western Creek at Kuss Road gauging station, the site was not used for any assessment other than hydrological flow.

Table 5.2 Department of Natural Resources, Mines and Energy gauge sites

DNRME gauge site	Location relation to Project alignment
Western Creek at Kuss Road (143121A)	Located 210 m south of the Project alignment at Western Creek
Warrill Creek at Amberley (143108A)	Located 5 km north of the Project alignment at Warrill Creek
Purga Creek at Loamside (143113A)	Located 6.5 km north of the Project alignment at Purga Creek

Source: DNRME (2018)

Table 5.3 Summary of median electrical conductivity, discharge and rainfall per month data for relevant Department of Natural Resources, Mines and Energy gauge sites (January 2015 to March 2019)

Station	Median rainfall (mm/month)	Median electrical conductivity (µs/cm) [WQO]	Median discharge (M/L day)
Warrill Creek at Amberley (143108A)	4.00	538 [500]	1.95
Purga Creek at Loamside (143113A)	N/A	2,168 [770]	0.41

Table note:

Number in bracket denotes WQO for the given watercourse
Coloured text denotes non-compliance with WQO
M/L day = Megalitres of water discharge per day

Source: DNRME WMIP (2019)

Table 5.4 provides tractable mean water quality data from the DNRME gauge sites of the Warrill Creek at Amberley (143108A) and Purga Creek at Loamside (143113A). Data for Western Creek is noted for illustrative purposes but not tractable to analysis and is not discussed further. Illustrative plots of indicative water quality parameters for condition; electrical conductivity, total suspended solids, total nitrogen and total phosphorus were compiled and identify seasonal trends (refer Appendix E). Of the three gauging stations, Warrill Creek at Amberley (143108A) and Purga Creek at Loamside (143113A) were assessed. The gauging station, Western Creek at Kuss Road (143121A), did not retain counts of data that allowed a seasonal assessment of the selected water quality parameters against discharge. The selected water quality parameters were selected due to the number of values for analysis. The values are considered to broadly identify existing physico-chemical water quality at the gauging stations.

The mean water quality data has been collected between 1962 to 2019 for Warrill Creek at Amberley and between 1974 to 2019 for Purga Creek at Loamside. The tables include the number of samples collected for each parameter for each site. Comparison of the historical water quality data indicates that typically limited achievement of relevant WQO for each of the discrete watercourses is observed (refer Table 5.3 and Table 5.4).

Table 5.4 Gauging station water quality data (mean) for Western Creek at Kuss Road (143121A) (2015-2019), Warrill Creek at Amberley (between 1962 to 2019) and Purga Creek at Loamside (between 1974 to 2019)

Water parameter	Western Creek at Kuss Road (143121A) (2015-2019)[1]			Warrill Creek at Amberley (143108A) (1962-2019)			Purga Creek at Loamside (143113A) (1974-2019)		
	Sample number	Recorded value	WQO	Sample number	Recorded value	WQO	Sample number	Recorded value	WQO
pH	(n=2)	7.35	[6.5 – 8.0]	n=147	7.74	[6.5 – 8.0]	(n=79)	7.71	[6.5 – 8.0]
Turbidity (NTU)	(n=2)	31.50	[<17]	n=107	18.43	[<5]	(n=62)	12.79	[<17]
Total suspended solids	(n=1)	12.00	[<6]	n=116	22.94	[<6]	(n=70)	17.80	[<6]
Ammonia (mg/L)	(n=2)	0.034	[<0.02]	n=48	0.029	[<0.02]	(n=26)	0.04	[<0.02]

Water parameter	Western Creek at Kuss Road (143121A) (2015-2019)[1]			Warrill Creek at Amberley (143108A) (1962-2019)			Purga Creek at Loamside (143113A) (1974-2019)		
	Sample number	Recorded value	WQO	Sample number	Recorded value	WQO	Sample number	Recorded value	WQO
Total nitrogen (mg/L)	(n=2)	1.04	[<0.5]	n=72	0.71	[<0.5]	(n=36)	1.31	[<0.5]
Total P (mg/L)	(n=2)	0.42	[<0.05]	n=86	0.17	[<0.05]	(n=44)	0.19	[<0.05]
Chlorophyll *a* (µg/L)	-	-	[<5]	13	2.30	[<5]	-	-	[<5]

Table notes:

Number in bracket denotes WQO for the given watercourse

Coloured text denotes non-compliance with WQO

1 Western Creek gauging station data is displayed but is intractable to analysis due to data deficiency

Source: DNRM (2019)

Figure 5.3, Figure 5.4 and Figure 5.5 present the stream discharge data for the Bremer River and Logan River catchment DNRME gauge sites. The recent stream discharges have generally remained low with only one high discharge event during March/April 2017 at Western Creek. The Warrill Creek at Amberley site had a higher stream discharge than the Western Creek at Kuss Road and Purga Creek at Loamside site. Within all of the gauging station sites a high variance in flow was observed. High flow periods were typically short and interspersed by periods of low to no discharge.

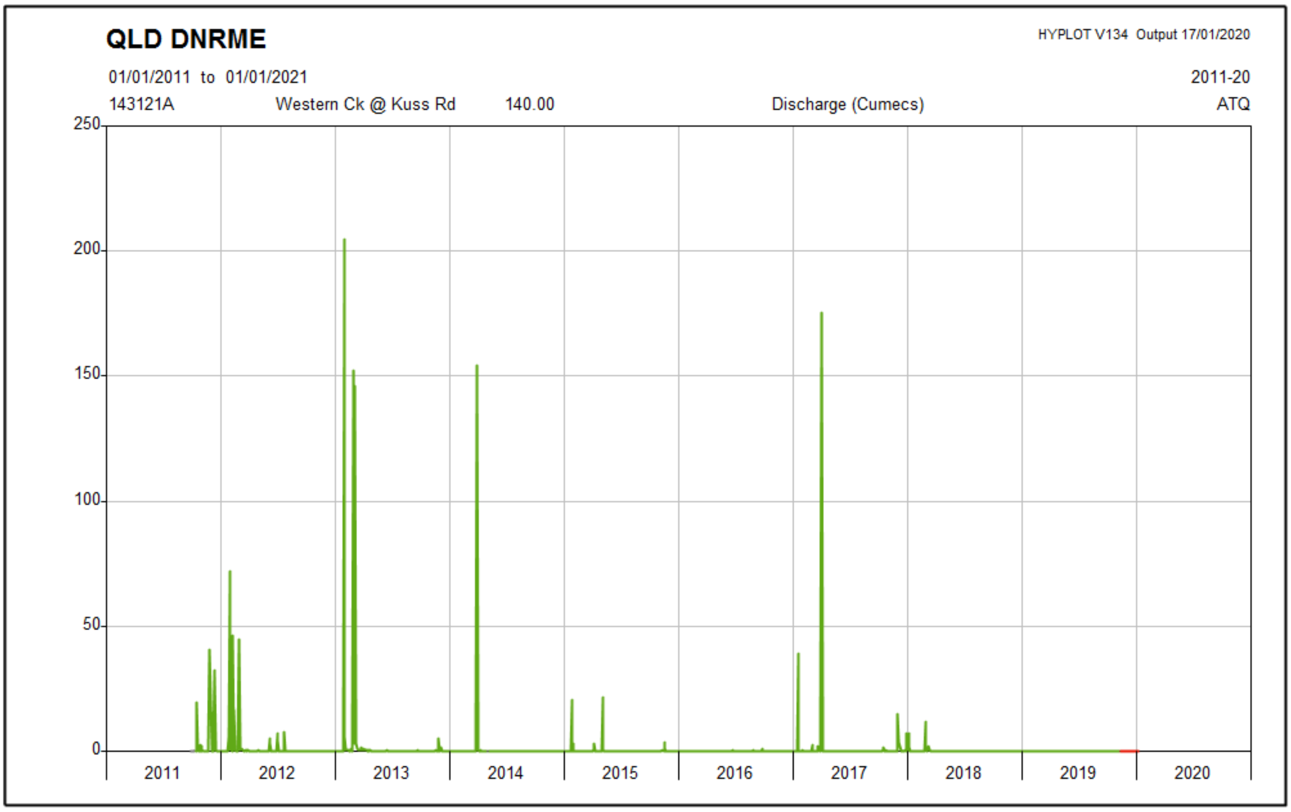


Figure 5.3 **Bremer River catchment watercourse discharge - Western Creek at Kuss Road stream discharge 2011 to 2020**

Figure note:

Red plot line denotes unvalidated data value for discharge

Source: DNRME (2020)

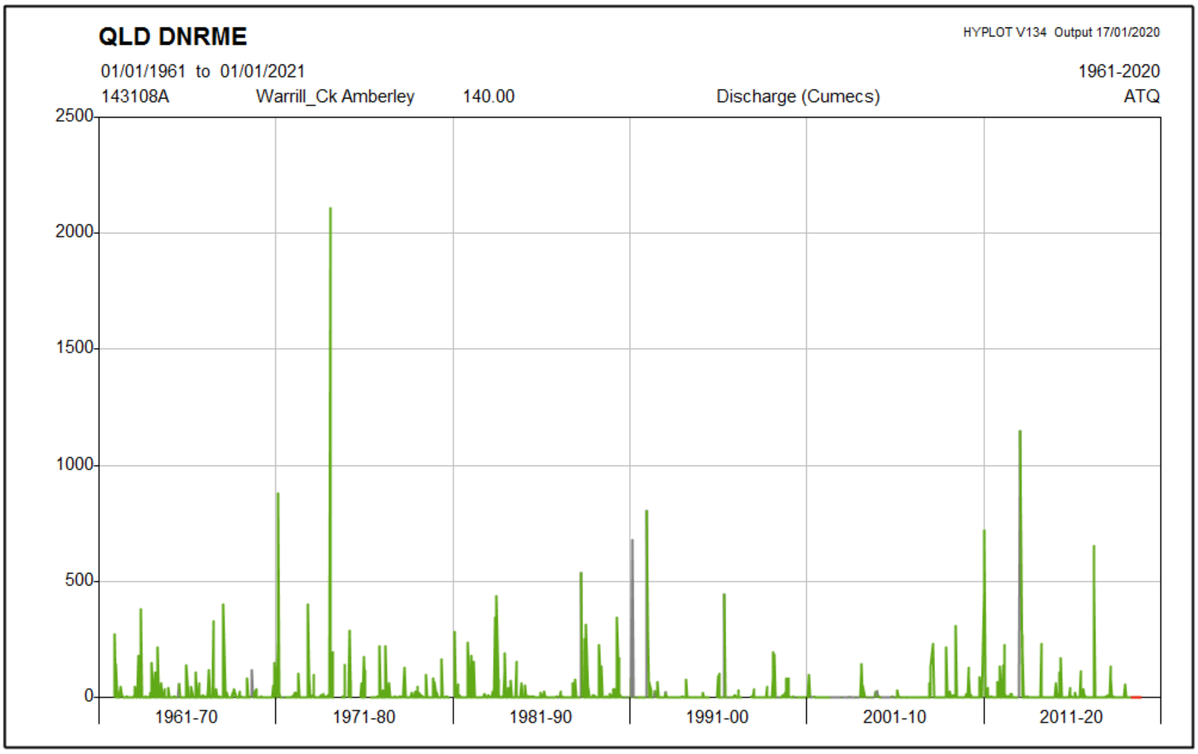


Figure 5.4 **Warrill Creek/Purga Creek catchment watercourse discharge - (a) Warrill Creek at Amberley stream discharge 1961 to 2020**

Figure note:

Red plot line denotes unvalidated data value for discharge

Source: DNRME (2020)

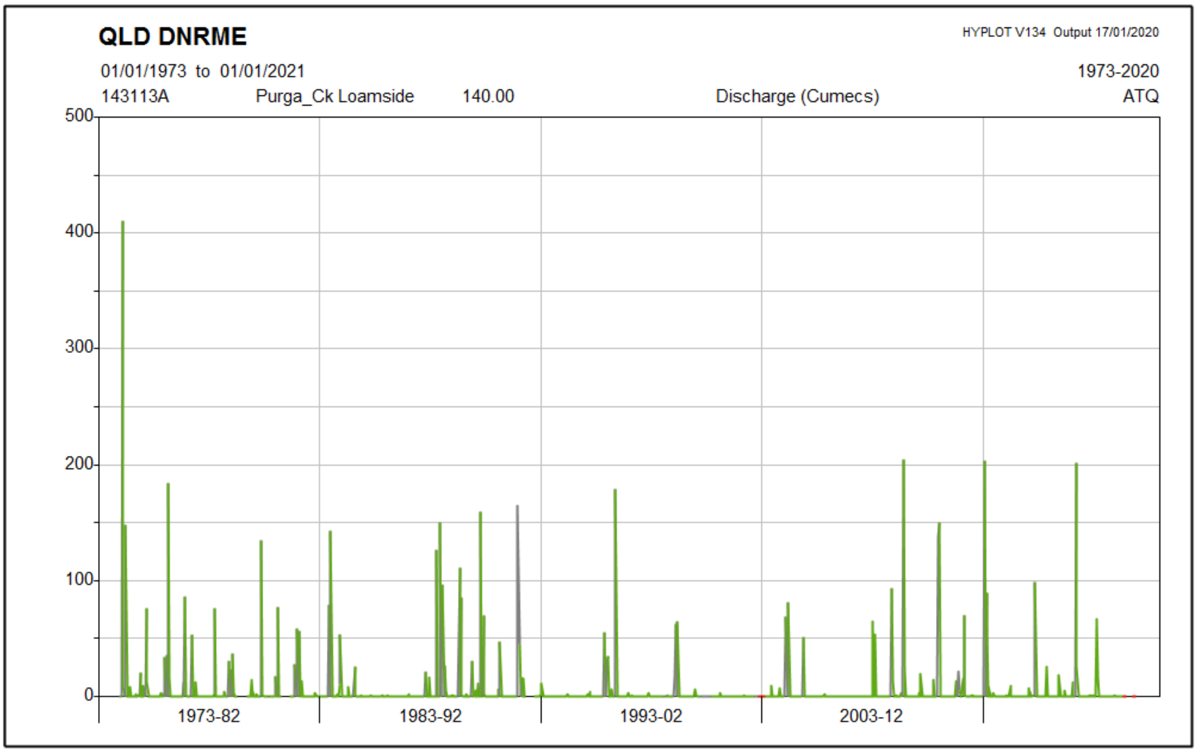


Figure 5.5 **Purga Creek at Loamside stream discharge 1973 to 2020**

Figure note:

Red plot line denotes unvalidated data value for discharge

Source: DNRME (2020)

The stream water level for all gauging stations tends to fluctuate with general flow recorded as relatively low with periods of high flow instances. However, in more recent years all sites have experienced prolonged periods of low to no stream discharge. Of the two DNRME gauging stations used for historic seasonal comparison, Purga Creek at Loamside recorded the lowest seasonal discharge during Spring (refer Figures E-1 to E8 of Appendix E). Discharge at both gauging stations was highest within the Summer/Autumn months (following general climatic condition) and was significantly reduced moving to Winter and Spring before gaining into Summer.

Electrical conductivity values typically adhered to stream discharge patterns across seasons with higher median electrical conductivity noted in Purga Creek during Winter and Spring (above 3,000 µs/cm) in comparison to Warrill Creek (~600 µs/cm). As discharge decreased towards the drier seasons with general climatic condition, water quality decreased with an increase in conductivity values. The increase in electrical conductivity with decreased discharge aligned with the field assessment across the water quality study area.

Seasonal total suspended solids for the Warrill Creek gauging station did not display a clear trend of decreasing load with continual discharge. Total suspended solids were highest following the periods of highest discharge (Autumn) and decreased to the lowest level as discharge decreased during winter. However, as discharge continued to decrease to the lowest levels in Spring, total suspended solid increased to levels nearing those from Summer and Autumn. At the Purga Creek gauging station, total suspended solid levels were highest during periods of low periods of discharge with a clear trend present between declining discharge and increased total suspended solids.

Total nitrogen and phosphorus concentration followed the similar trend for suspended total solids at the Warrill Creek gauging station. Both total nitrogen and total phosphorus were highest during Summer, linked to an increase in discharge (preceding the peak discharge). The lowest total nitrogen and phosphorus load was observed during the winter season, with continually decreasing discharge. As discharge reached the lowest level during Spring, total nitrogen and phosphorus loads increased. A similar trend of decreasing total nitrogen and total phosphorus with decreasing discharge was observed at the Purga Creek gauging station.

5.3.6 Fire hazard

A review of the fire hazard areas through the Department of State Development, Manufacturing, Infrastructure and Planning development assessment mapping system (DSDMIP 2016a) revealed scattered areas of ‘Medium Potential Bushfire Intensity’ existing throughout the water quality study area with an area of ‘Very High Potential Bushfire Intensity’ occurring between the Washpool and Undullah mountain range.

5.3.7 Flood hazard

A review of the flood hazard areas through the Department of State Development, Manufacturing, Infrastructure and Planning development assessment mapping system (DSDMIP 2016b) revealed the southern section of the Project alignment to potentially intersects a Flood hazard area – level 1 (indicative of floodplain extent resolution only) situated to the east of Peak Crossing.

5.3.8 Climate change assessment

Climate change resilience, with explicit regard to water quality, is derived from expected climate change 1% AEP pattern change. The climate change factor increases the resultant 1% AEP local drainage water levels by a maximum of 1.03 m along the alignment.

Within this, there is no expected change to flood immunity of the rail formation by expectant climate change within the local catchments with the minimum freeboard along the alignment being 0.39 m and the majority of culverts having a freeboard in excess of 1 m to rail formation. As such, water quality values would not be expected to be significantly impacted (in terms of differential from current values against current WQOs) from construction or operation of the Project.

For full details, refer to EIS Appendix N: Hydrology and Flooding Technical Report.

5.4 Geology, topography and soils

5.4.1 Geological and topographical setting

The Project alignment features regions of low to moderate high relief terrain becoming higher relative relief and elevation as the alignment passes south of Flinders Peak, within the Scenic Rim mountain range. The topography along the Project alignment is illustrated in Figure 5.6.

Topography in the land resources study area ranges between 30 metres Australian Height Datum (m AHD) at several drainage lines/surface water features, and 200+ m AHD in the Teviot Range with most slopes having a grade of less than 30 per cent. The proposed rail alignment does not have any significant peaks but rather undulates with many areas of steep slopes. An elevation profile of the proposed rail alignment revealed a maximum elevation of approximately 200 m AHD as it passes through the terrain between Mount Welcome and Ivorys Knob near Woolooman, whilst the lowest point of approximately 26 m AHD occurred as it passes over the Teviot Brook waterway approaching Kagaru.

The study area broadly consists of three distinct topographical areas: the western lowlands, the central ranges (Teviot Range), and the Beaudesert Basin.

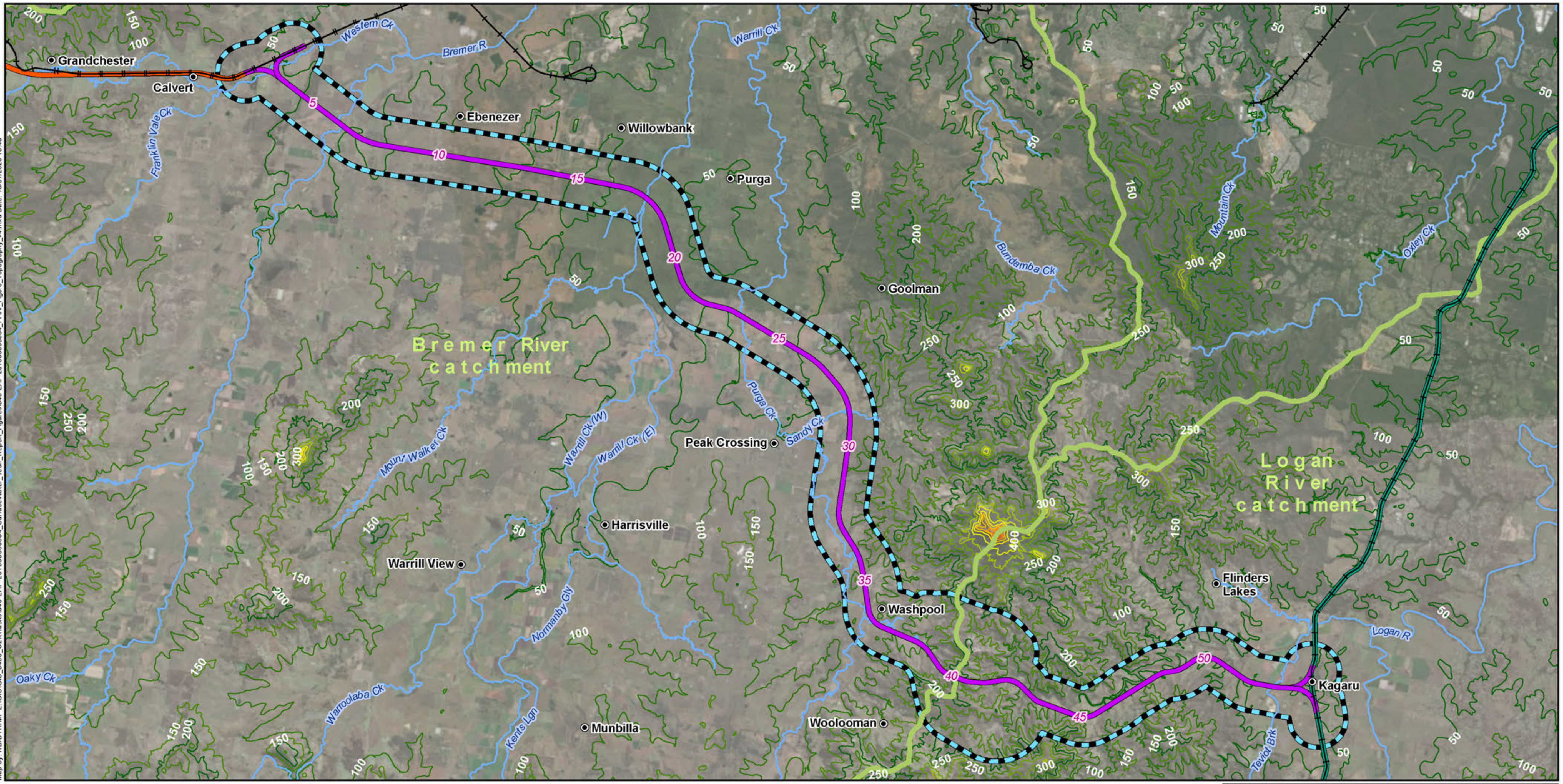
The 1:100,000 scale detailed surface and solid geology mapping (DNRME 2017) indicated the alignment is underlain by several geological layers, as illustrated in Figure 5.7 and described in Table 5.5.

Table 5.5 Geological units

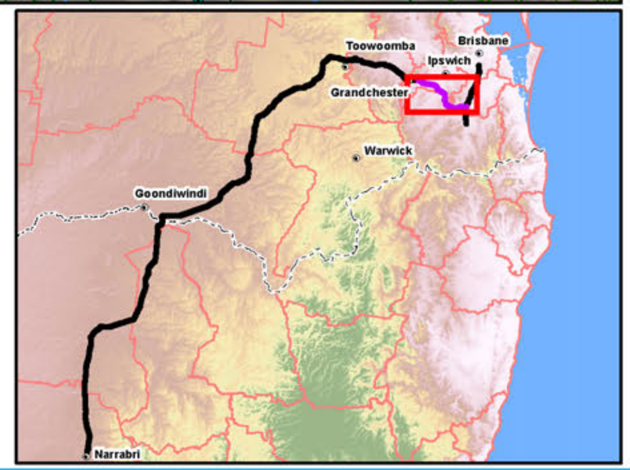
Geological unit	Location	Age	Description
Quaternary alluvium	▪ Teviot Brook ▪ Purge Creek ▪ Franklin Vale Creek ▪ Warrill Creek	Quaternary	Clay, silt, sand and gravel layer on a flood-plain dominated by alluvium
Heifer creek sandstone member	Near Kagaru	Middle Jurassic	Sublabile to quartzose sandstone, siltstone and shale dominated by arenite
Walloon coal measures	Near Kagaru Between Washpool and Calvert	Middle Jurassic	Shale, siltstone, sandstone and coal seam dominated by arenite-mudrock
Koukandowie formation	Near Kagaru and Washpool	Early to Middle Jurassic	Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker dominated by arenite-mudrock
Gatton sandstone	Between Kagaru and Washpool	Early Jurassic	Lithic labile and feldspathic labile sandstone dominated by arenite
TQw-QLD	Small pocket near Hillside and Ebenezer	Late Tertiary-Quaternary	Pediment slope wash, clay, scree, soil dominated by alluvium
Ts/1-SEQ	Small pocket near Willowbank	Tertiary	Claystone, siltstone and sandstone dominated by arenite-mudrock
Tv/1-SEQ	Small pocket near Willowbank	Tertiary	Basalt as part of the Amberley Basin
Tid-SEQ	Small pocket at the Boral Quarry (Purga)	Tertiary	Dolerite, basalt (dyke or plug) dominated by gabbroid rock
Tit-SEQ	Small pocket near Washpool	Oligocene to Miocene	Tachyte (anorthoclase and riebeckite) dominated by felsites (lavas, clastics and high level intrusive).

Source: DNRME 2017

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig5-6_Topography_v4.mxd Date: 15/01/2020 15:43



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Catchment boundaries
- Water quality study area

Elevation (mAHD)

- 50
- 100
- 150
- 200
- 250
- 300
- 350
- 400
- 450
- 500
- 550
- 600
- 650

A3 scale: 1:150,000

0 1 2 3 4 5km

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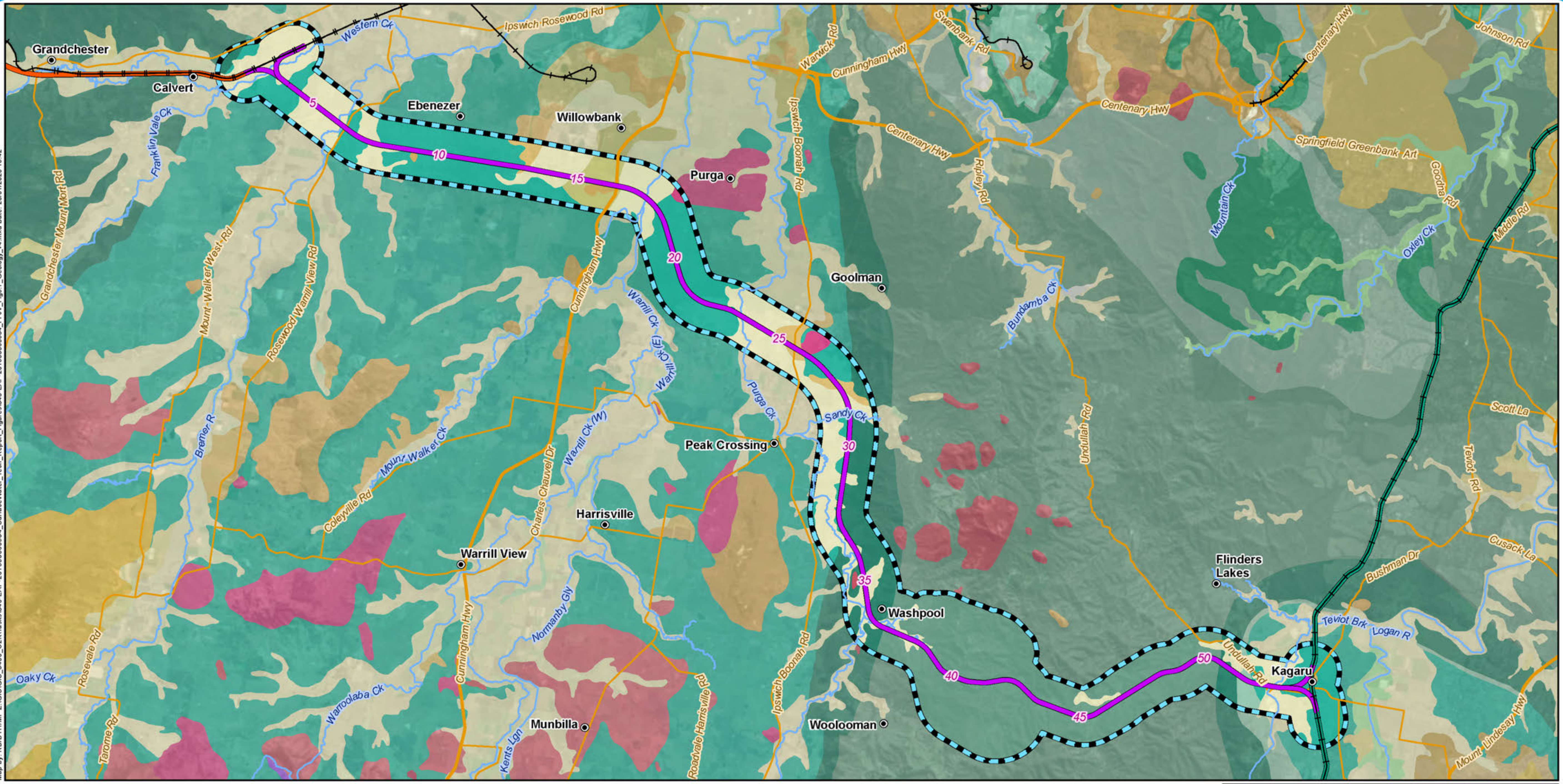
Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 5.6: Topography

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Major roads
- Minor roads
- Defined watercourses (Water Act 2000)
- Water quality study area

A3 scale: 1:150,000

0 1 2 3 4 5km

Detailed surface geology

Holocene
- Qha/2-QLD
- Qha/1-QLD,Qha/2-QLD
- Qha/1-QLD

Pleistocene
- Qpa-QLD (Qpa)
- Qpa/1-SEQ

Quaternary
- Qr-QLD (Qr)
- Qa-QLD (Qa)

Late Tertiary - Quaternary
- TQw-QLD: Slope wash, clay, screen

Oligocene - Miocene
- Tit-SEQ: Trachyte
- Tir-SEQ (Tir)

Oligocene
- Tis-SEQ: Syenite

Eocene - Miocene
- Main Range Volcanics (Tm)

Eocene
- Flinders Dolomite (Tfl)

Paleocene - Eocene
- Beaudesert beds/1 (Te/1)
- Beaudesert beds/2 (Te/2)
- Beaudesert beds/3 (Te/3)

Paleocene
- Redbank Plains Formation (Tbr)

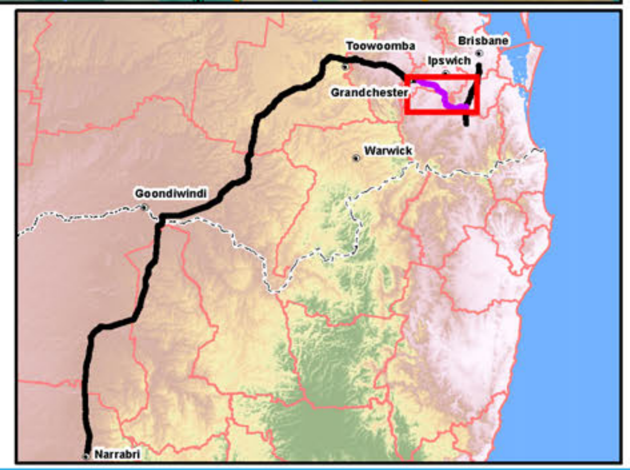
Tertiary
- Tid-SEQ: basalt and gabbro
- Td-QLD>Beaudesert beds/1 (Td>Te/1)
- Tv/1-SEQ: Basalt
- Tv/2-SEQ: Basalt, minor volcanic breccia
- Ts/1-SEQ: Claystone, siltstone, sandstone

Middle Jurassic
- Heifer Creek Sandstone Member (Jbmkh)
- Walloon Coal Measures (Jw)

Early - Middle Jurassic
- Koukandowie Formation (Jbmk)

Early Jurassic
- Marburg Subgroup/o (Jbm/o)
- Gatton Sandstone (Jbmg)

Late Triassic - Early Jurassic
- Ripley Road Sandstone (RJbwr)



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Calvert to Kagaru

Figure 5.7: Geology

Results from the topographical and surface geology study indicate the Project alignment is comprised of a central anticline, the South Moreton anticline, where the Triassic-Jurassic Bundamba and Marburg Group sandstone layers are exposed. The South Moreton anticline is flanked by complementary synclines featuring the Jurassic Walloon Coal Measure and Tertiary sedimentary and igneous rocks. As a result, rocks such as arenite which dominate the geological layers of the region, form rugged hills whilst the flanking synclines give rise to gently undulating lowlands.

Arenites are identified as texturally clean matrix free or matrix poor sandstone that allow cement precipitates to form in what were originally empty intergranular pores (UPRM Geology Department 2012). Another major unit dominating the geology of the Project alignment are alluvium deposits, associated with sediments deposited through the transportation of channelled stream water. The main form of alluvium deposit in the region was likely caused by prairie soils, black earths and grey clays which have developed on finer-grained sediment. Alluvium deposits in the region will potentially result in deposits of sand, silt or silty clay on low ridges along floodplains (Queensland Department of Science, Information Technology, Innovation and the Arts 2012). A study of the soil distribution and physical properties indicated that parent material strongly influences soil development in the area.

5.4.2 Soil condition

5.4.2.1 Soil description

The Australian Soil Resource Information System (CSIRO 2014) Level 5 (1:100,000 or better quality) Australian Soil Classification mapping indicated five distinct soil types including vertosols, sodosols, dermosols, chromosols and rudosols to occur in the land resources study area (refer Figure 5.8).

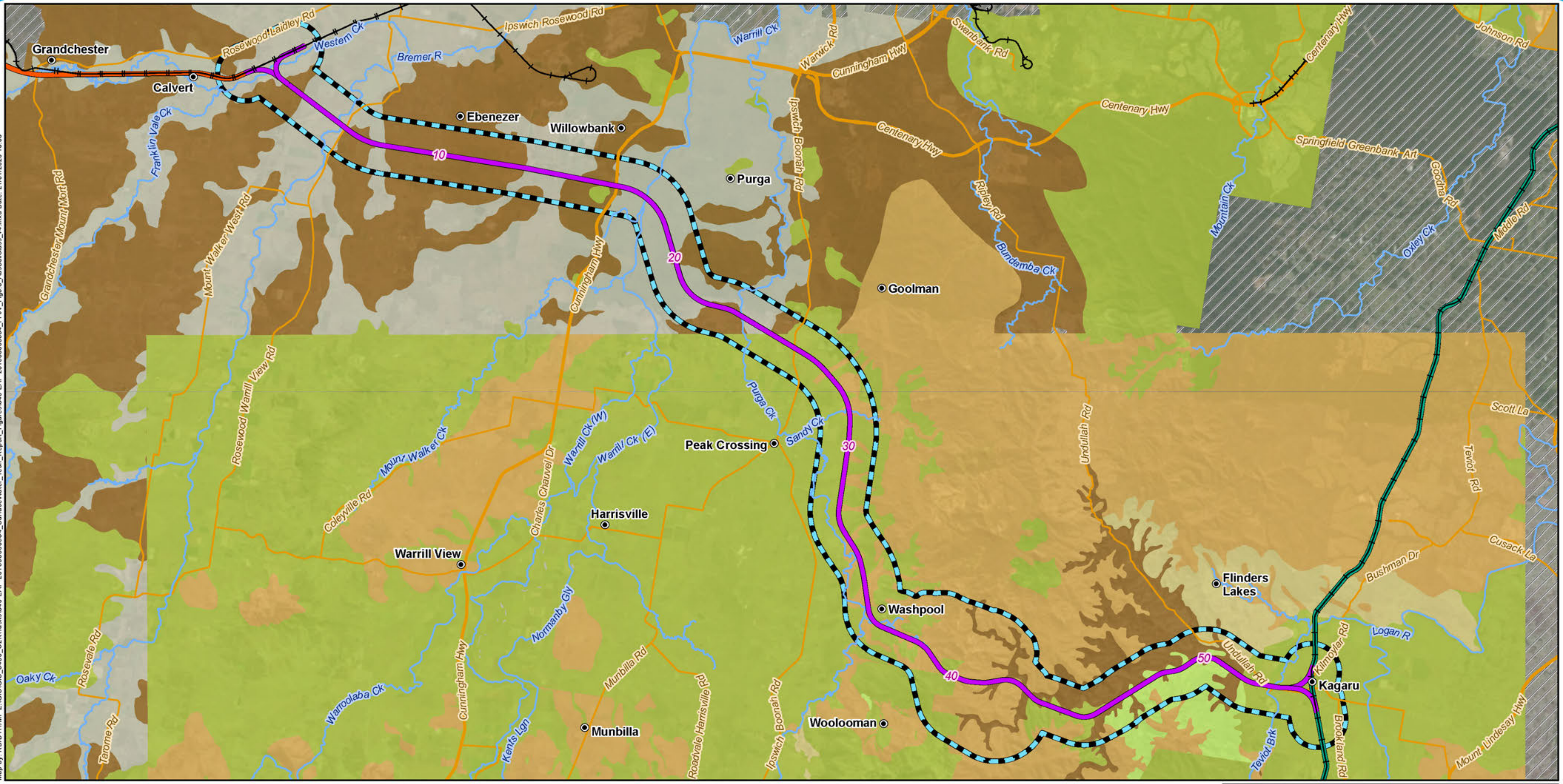
Both sodosols and vertosols featured strongly between Calvert (Ch 00.00 km) and the Purga Nature Reserve (Ch 24.90 km). The landform around Calvert is terraced valley plains defined by brown and red self-mulching cracking clays, which transitions to gently rolling areas of the subcoastal lowlands with hard pedal mottled-yellow duplex soils.

As the Project alignment traverses through the Peak Crossing area into the Scenic Rim mountain range, the soils are predominately dermosols and chromosols. Sodosols are also present along Woolooman Creek. The landform of the Scenic Rim mountain range is described as hilly country with hard pedal mottled-red duplex soils. These soils are chromosols, which are defined as strong textual contrast soils that are neither strongly acidic nor sodic in the upper B horizon.

The landform around Washpool is described as gently rolling areas of subcoastal lowland with black self-mulching cracking clays. These soils are dermosols, which are defined by the absence of a strong texture contrast, although they have a well-structured B2 horizon containing low levels of free iron.

As the Project descends towards Kagaru, a small area of rudosols is present. Rudosols are defined by their negligible pedologic organisation and can potentially be highly saline. They are usually young soils as formation has had little time to pedologically modify parent rocks or sediments (Isbell & National Committee on Soil and Terrain 2016). Rudosols have good infiltration capacity and low water holding capacity.

ACLEP
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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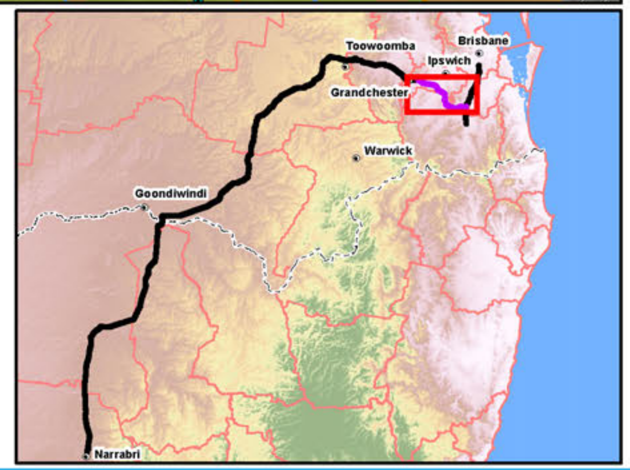
Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area

Australian soil classification

- Chromosol
- Dermosol
- Rudosol
- Sodosol
- Vertosol



A3 scale: 1:150,000

0 1 2 3 4 5km

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Calvert to Kagaru
Figure 5.8:
Australian soil classification

5.4.2.2 Soil acidity

An assessment of surface soil pH, using the ASRIS mapping (CSIRO 2014), found a pH range between 3.0 and 7.5 along the Project alignment. A large area of high acidic soils (pH 3.0 to 4.8) exists as the alignment passes the region south of Ebenezer, whilst smaller patches of acidic soils underlay the Project alignment near Willowbank and Queensland Raceway and south of Purga Nature Reserve on land used for irrigated cropping as well as modified grazing pastures (Queensland Globe 2018).

ASS is often associated with low lying areas below 5 m AHD, such as alluvial plains where groundwater generally is close to the surface and materials in reducing condition along coastal regions (RTA 2005). The ASS mapping along the Project alignment is illustrated in Figure 5.9.

The probability of encountering acid sulfate soils (ASS) is generally considered low for the Project alignment as mapped by the National Acid Sulfate Soils Atlas (CSIRO 2014), which revealed no known occurrence of high-risk ASS for the majority of the alignment. The exception is a dam to the east of the Cunningham Highway, which was mapped as high probability of containing ASS. Low probability of ASS occurring was evident in small patches both north of the Purga Nature Reserve and along the alignment traversing Willowbank and Queensland Raceway (refer Figure 5.9).

5.4.3 Acid rock drainage

Site inspections prior to the construction of cuts would provide an opportunity to visually examine surface outcrop for sulphide minerals or remnant products indicative of sulphide mineralisation. This would inform the management of potential Acid Rock Drainage (ARD) cuttings in the sedimentary units prior to construction works.

Periodic sampling of discharge waters from the deep cuts intersecting groundwater is recommended to assess the potential for ARD processes taking place. Screening of the seepage water onsite for pH (trending down) and EC (trending up) and comparison to the baseline groundwater monitoring program results/trends will allow for indication of ARD processes. Further laboratory analyses for the key analytes pH, TDS, EC, TSS, alkalinity, and dissolved metals will validate the presence or absence of ARD potential.

If ARD-contaminated discharge water is found to be generated from the deep cuts, this water may need to be impounded in ponds and neutralised via treatment with hydrated lime or dilution prior to release into the surrounding catchment or other discharge mechanism.

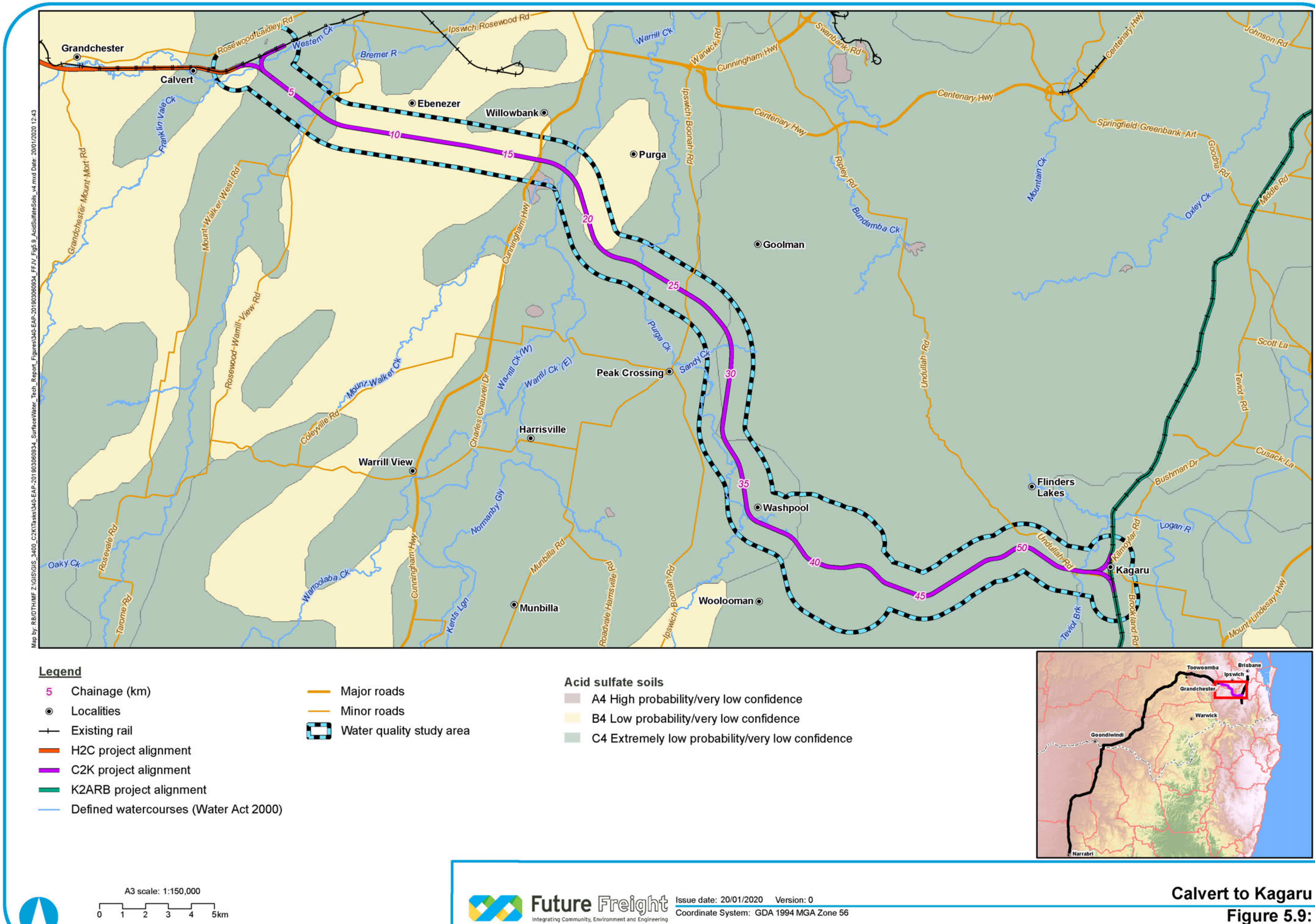
5.4.4 Land use

An assessment of the Queensland Land Use Mapping Program (2012) identified agriculture as the main land use with grazing native vegetation featuring extensively from Calvert to Kagaru. Smaller areas of irrigated cropping, irrigated modified pastures, grazing modified pastures, irrigated perennial horticulture and poultry farming also feature along the proposed site.

Agricultural land classified as Class A or Class B land is the most productive land in Queensland, with soil and land characteristics that allow successful crop and pasture production.

The Audit also identifies important agricultural areas (IAAs). IAAs are defined as land that has all the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and is strategically significant to the region or the State.

The study area intersects two areas of IAAs at Peak Crossing, along the western portion, and at Kagaru. Class A and Class B agricultural land also features in several small patches, scattered along the study area surrounding Calvert, south of Willowbank, west of the Boral Quarry at Goolman, along the western portion of the water quality study area at Peak Crossing, a small area at Undullah in the Teviot Range and at Kagaru.



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Calvert to Kagaru

Figure 5.9: Acid sulfate soils

Other non-agricultural land uses within the water quality study area include rural residential land uses, the disused Ebenezer Coal Mine, the Willowbank Raceway and Queensland Raceway when passing through the Willowbank locality and the Ivory's Rock Events and Conventions Centre at Peaks Crossing.

Strategic cropping land (SCL) has also been identified within the water quality study area in several smaller, scattered patches. SCL is defined in the *Regional Planning Interests Act 2014* (Qld) as land that is, or is likely to be, highly suitable for cropping due to a combination of the land's soil, climate and landscape features. The most extensive patch of SCL exists in the area surrounding Teviot Brook approaching Kagaru whilst smaller patches feature at Calvert, extending 5 km along the proposed site towards the Willowbank and Queensland Raceway, and south of the Purga Nature Reserve and Washpool (DNRME 2017).

5.5 Watercourses and waterbodies

5.5.1 Defined 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 flow frequency. A watercourse however does not include any section of a feature that has a tidal influence or is downstream of the defined limit (DNRM 2014).

A number of watercourses and waterbodies occur within the water quality study area (refer Sections 5.5.2 and 5.5.3). Figure 5.10 identifies the location of the defined watercourses (as defined under Water Act) that intersect the Project alignment.

Defined watercourses intersected by the proposed Project alignment include:

- Western Creek – at chainage locations Ch 3.10 km and Ch 1.20 km
- Bremer River – at chainage location Ch 6.30 km
- Warrill Creek – at chainage location Ch 17.60 km
- Purga Creek – at chainage locations Ch 23.40 km
- Sandy Creek – at chainage location Ch 28.70 km
- Un-named tributary of Purga Creek – at chainage locations Ch 36.60 km, Ch 37.50 km and Ch 37.90 km
- Teviot Brook – at chainage location Ch 52.80 km.

Unmapped waterways are intersected by the Project alignment are quantified using waterways barrier works mapping and stream order mapping (refer Sections 5.5.2 and 5.5.3). The unmapped waterways will be required to be verified during the detailed design phase to determine their status under the Water Act.

Further details of the intersection of these watercourses and artificial waterbodies and the Project alignment is provided in Section 5.5.4.

Table 5.6 provides a summary of the larger watercourses crossed by the proposed Project alignment. Further details of the watercourses and water quality monitoring sites are presented in Appendix C.

Table 5.6 General summary of assessed waterways within the water quality study area

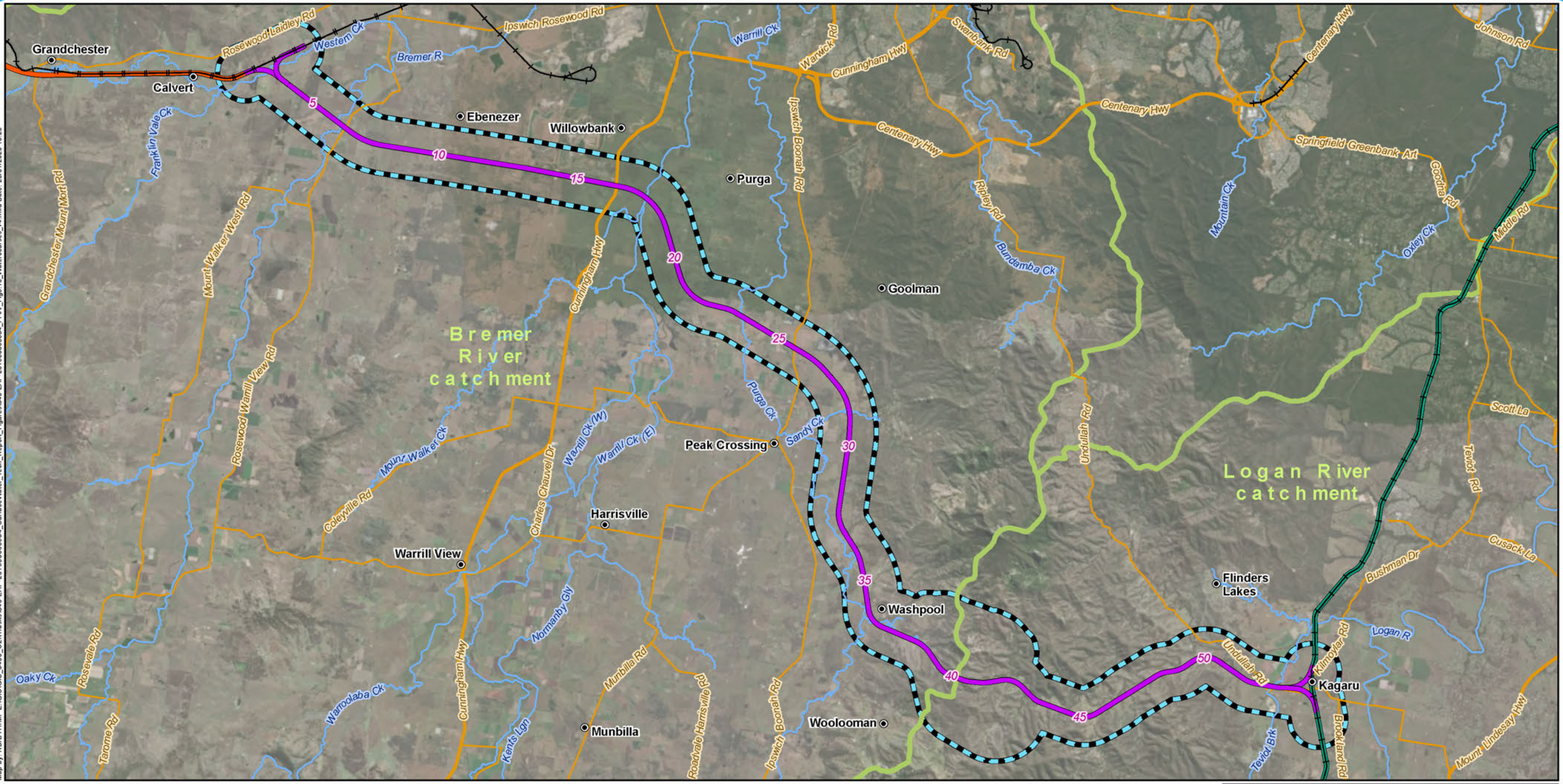
Waterway	Description
Western Creek	Western Creek is a creek that discharges into the Bremer River, downstream of Rosewood. The stream appears ephemeral, with a well-defined channel, noting some channel modifications are present. Typical land uses surrounding the Western Creek assessment (and proximal catchment) sites varied between a modified landscape consisting of rural residential, grazing and irrigated cropping areas. The water quality assessment sites were moderately disturbed with infrastructure and conversion of surrounding land use to grazing. Riparian vegetation was considered to have high disturbance and consisted of continuous vegetation on both sides of the assessment banks. Riparian vegetation was comprised of an even proportion of native and exotic species. The assessment reach did not support macrophyte vegetation. The creek bed was comprised mostly of fine sediment. The aquatic habitat score was quantified as fair.  **Western Creek downstream of the Project alignment**
Bremer River	The Bremer River is a river flowing into the Brisbane River, located in the Scenic Rim. The Bremer River is approximately 100 km long beginning east of the Great Dividing Range and connecting to the Brisbane River east of Ipswich. The intersection of the Project alignment and Bremer River is situated east of Calvert. The stream appears ephemeral, with a well-defined channel, and is likely to flow seasonally. Typical land use surrounding the Bremer River water quality assessment sites (and proximal catchment) varied between rural residential, grazing, farming and non-remnant vegetation. The riparian vegetation was considered to be of high disturbance and occurred as semi-continuous vegetation on both sides of the bank. The creek bed was comprised of moderately compacted soft sands, mud and clay. The aquatic habitat score was quantified as fair.

Waterway	Description
	 **Bremer River at the proposed site of Project alignment waterway crossing**
Warrill Creek	Warrill Creek is a major creek that discharges into the Bremer River. The stream appears to be semi-permanent, with a well-defined channel and is likely to flow seasonally (where unregulated). Typical land uses surrounding the Warrill Creek assessment (and proximal catchment) sites varied between a modified landscape consisting of rural residential, grazing and irrigated copping areas. Riparian vegetation was considered high disturbance with semi-continuous stands of mature vegetation on both sides of the bank. Riparian vegetation was comprised of an even proportion of native and exotic species. Macrophyte vegetation was evident during assessments. The creek bed was stable and comprised of low compacted soft sands, mud and clay. The aquatic habitat score was quantified as fair.  **Warrill Creek at proposed site of Project alignment waterway crossing**

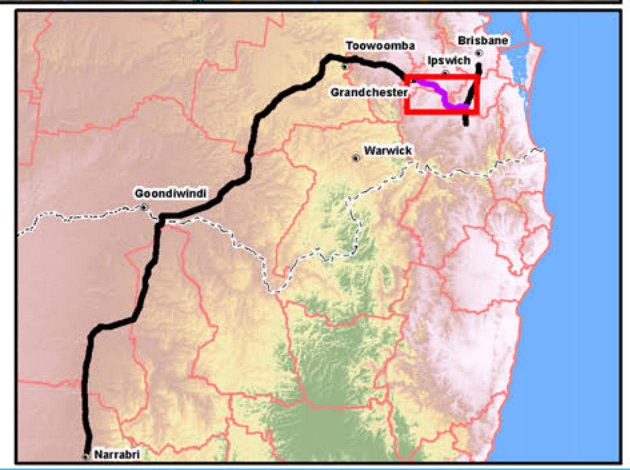
Waterway	Description
Purga Creek	Purga Creek is a tributary of Warrill Creek which discharges into Bremer River. Purga Creek begins north of Boonah and discharges into Warrill Creek south of Ipswich. The stream appears ephemeral, with a well-defined channel, noting some channel modifications are present. Typical land uses surrounding the Purga Creek assessment (and proximal catchment) sites varied between a modified landscape consisting of rural residential, grazing and irrigated copping areas. Riparian vegetation was very highly disturbed and occurred as isolated and scattered vegetation on the left and occasional clumps on the right with a great proportion as exotic species. Limited macrophyte vegetation was evident during assessments. The creek bed was stable and comprised of an array of sediment, cobble, pebble and gravel. The aquatic habitat score was quantified as fair.  **Upper tributary of Purga Creek upstream of the Project alignment**
Teviot Brook	Teviot Brook is a western tributary of the Logan River catchment, which flows into the Wyaralong Dam. The proposed intersection of the Project alignment and the Teviot Brook is situated near Flagstone. The stream appears ephemeral, with a well-defined channel, noting some channel modifications are present. Typical land use surrounding the Teviot Brook water quality assessment sites (and proximal catchment) varied between a modified landscape consisting of grazing, irrigated cropping and non-remnant vegetated areas. Riparian vegetation was considered to be highly disturbed and occurred as semi-continuous stands of mature vegetation, with a greater proportion as exotic species. Limited macrophyte vegetation was evident during assessments. The creek bed was stable and comprised of an array of sediment, cobble, pebble and gravel. The aquatic habitat score was quantified as fair.

Waterway	Description
	 **Teviot Brook at proposed site of Project alignment crossing**

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig5.10_Watercourses_v4.mxd Date: 20/01/2020 15:25



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Catchment boundaries
- Water quality study area

A3 scale: 1:150,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Calvert to Kagaru

Figure 5.10: Location of Water Act 2000 watercourses

5.5.2 Waterways for waterway barrier works mapping

Under the Fisheries Act, a waterway is defined as a river, creek, stream, watercourse or inlet of the sea. Waterways for waterway barrier works are regulated under the Fisheries Act and the Planning Act when barriers to fish movement including partial barriers are installed across waterways. Barrier works include construction, raising, replacement and some maintenance works on structures such as culverts crossings, bed level and low-level crossings, weirs and dams, both permanent and temporary.

A review of the DAF Queensland Waterways for Waterway Barrier Works mapping was undertaken, identifying a total of 34 individual waterways for waterway barrier works which cross the Project alignment. Of the 34 waterways, 7 waterways are intersected multiple times. The 34 waterways are classified (derived from DAF mapped waterways) as follows:

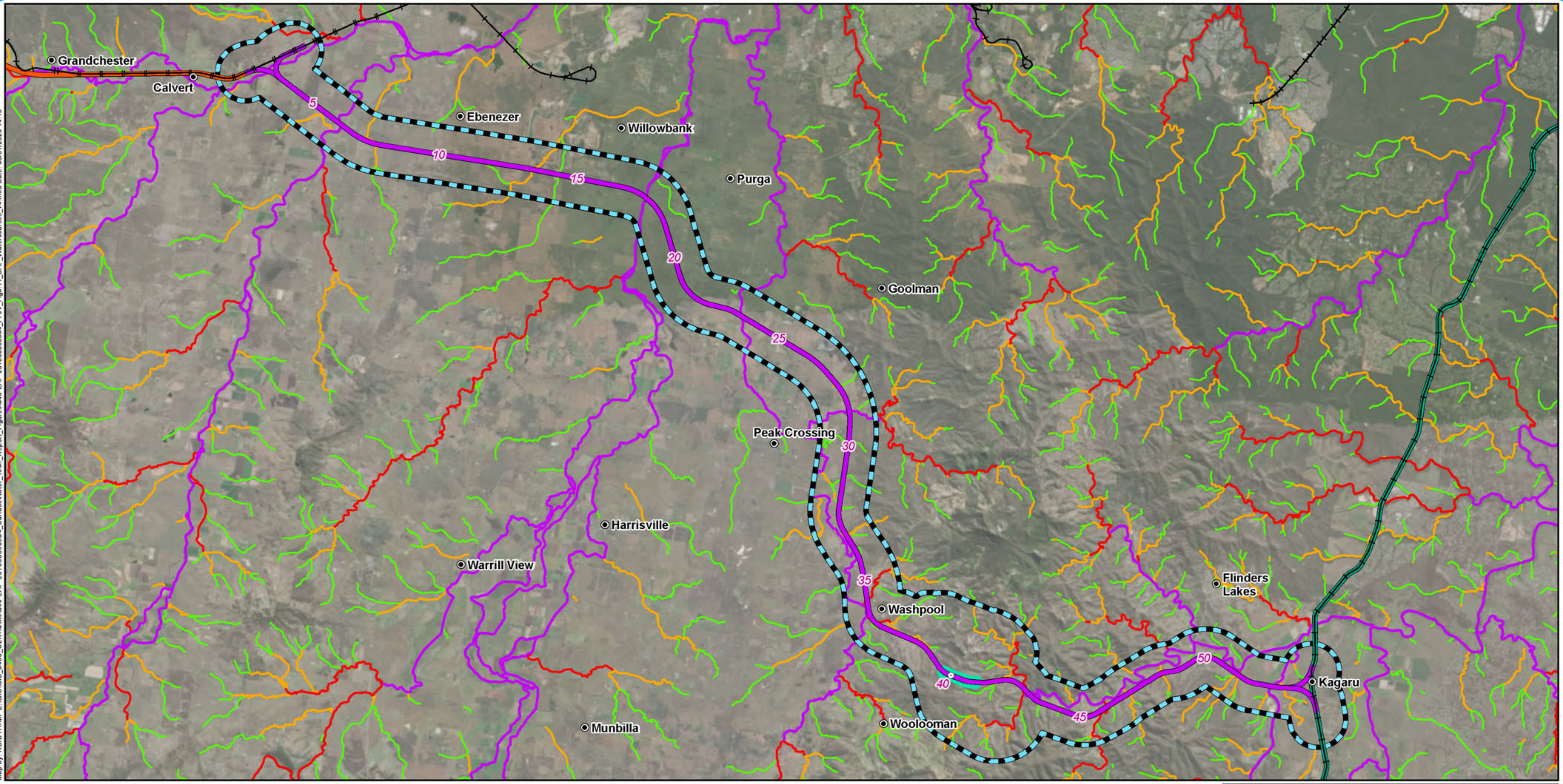
- Low risk of impact (category 1) – 11 waterways mapped as 'Low' intersect the alignment
- Moderate risk of impact (category 2) – 11 waterways mapped as 'Moderate' intersect the alignment
- High risk of impact (category 3) – 4 waterways mapped as 'High' intersect the alignment
- Major risk of impact (category 4) – 8 waterways mapped as 'Major' intersect the alignment.

Table 5.7 identifies the location of the DAF mapped waterways for waterway barrier works. The level of risk relating to each waterway will be considered by the detailed design team responsible for the design of infrastructure such as culverts, bridges and other potential barriers. At this stage of Project design, access roads are considered to be proximal to currently identified waterways intersecting the alignment and identified in Figure 5.11. Designs will need to be in accordance with the DAF factsheet 'What is not a waterway barrier work?', or accepted development requirements for operational work that is constructing or raising waterway barrier works, or under a relevant development approval.

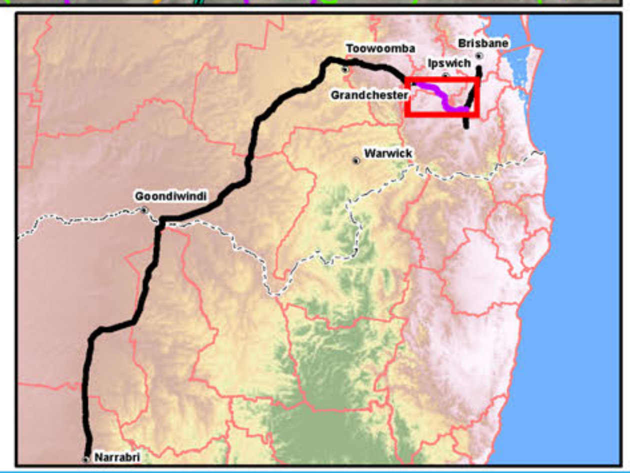
Table 5.7 Waterways for waterway barrier works that cross the Project alignment

Waterway impact risk (DAF)	Waterway (approximate chainage (km))
Major (Category 4)	Western Creek (Ch 1.30, Ch 3.10) Bremer River (Ch 6.20) Warrill Creek (Ch 17.60) Purga Creek (Ch 23.40) Un-named tributary of Purga Creek (Ch 28.70) Dugandan Creek (Ch 43.10) Teviot Brook (Ch 52.80)
High (Category 3)	Un-named tributary of Purga Creek (Ch 35.80, Ch 36.60) Un-named tributary of Teviot Brook (Ch 42.80) Un-named tributary of Teviot Brook (Ch 46.20)
Moderate (Category 2)	Un-named tributary of Bremer River (Ch 7.70) Ebenezer Creek (Ch 13.40) Un-named tributary of Purga Creek (Ch 33.30, Ch 37.60, Ch 37.90) Un-named tributary of Teviot Brook (Ch 41.70) Un-named tributary of Teviot Brook (Ch 47.00, Ch 48.30) Woollaman Creek (Ch 51.40, Ch 51.50) Un-named tributary of Teviot Brook (Ch 53.20)
Low (Category 1)	Un-named tributary of Ebenezer Creek (Ch 14.40) Un-named tributary of Purga Creek (Ch 27.80, Ch 29.90, Ch 31.20, Ch 32.00, Ch 33.90, Ch 38.90, Ch 39.30, Ch 39.60) Un-named tributary of Teviot Brook (Ch 43.50, Ch 44.20)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: RB/DTH/MF Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201903060934_SurfaceWater_Tech_Report_Figures\340-EAP-201903060934_FFJV_Fig5.11_DAF_Watercourses_v4.mxd Date: 30/01/2020 14:19



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Tunnel
- Water quality study area

Queensland waterways for waterway barrier works

Risk of Impact

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

A3 scale: 1:150,000

0 1 2 3 4 5km

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Calvert to Kagaru

Figure 5.11:

Mapped waterway barrier works within the proposed C2K alignment

5.5.3 Stream order mapping

Queensland uses the stream ordering system adopted from Strahler (1952) in which waterways are given an 'order' according to the number of additional upstream tributaries associated with each waterway. This system is used to provide an indication on waterway complexity and therefore the potential aquatic habitat present. In addition to providing for an indication of habitat complexity, stream order mapping identifies waterways that may be currently unmapped under the Water Act.

Headwaters or 'new' flow paths are given a stream order of one (or 'first order'), where two first order flow paths converge, the new stream is referred to as a second order stream. Where two second order streams join, a third order stream is formed. Third order streams and above are considered likely to reflect valuable fish habitat, capable of supporting viable population.

The stream orders for watercourses intersected by the Project alignment are outlined in Table 5.8. Stream order of one were not recorded as they are unlikely to contain valuable fish habitat and as such the number of streams recoded in Table 5.8 may not directly match up with the mapped waterways for waterway barrier works waterways in Table 5.7.

Table 5.8 Stream order intersected by the Project alignment

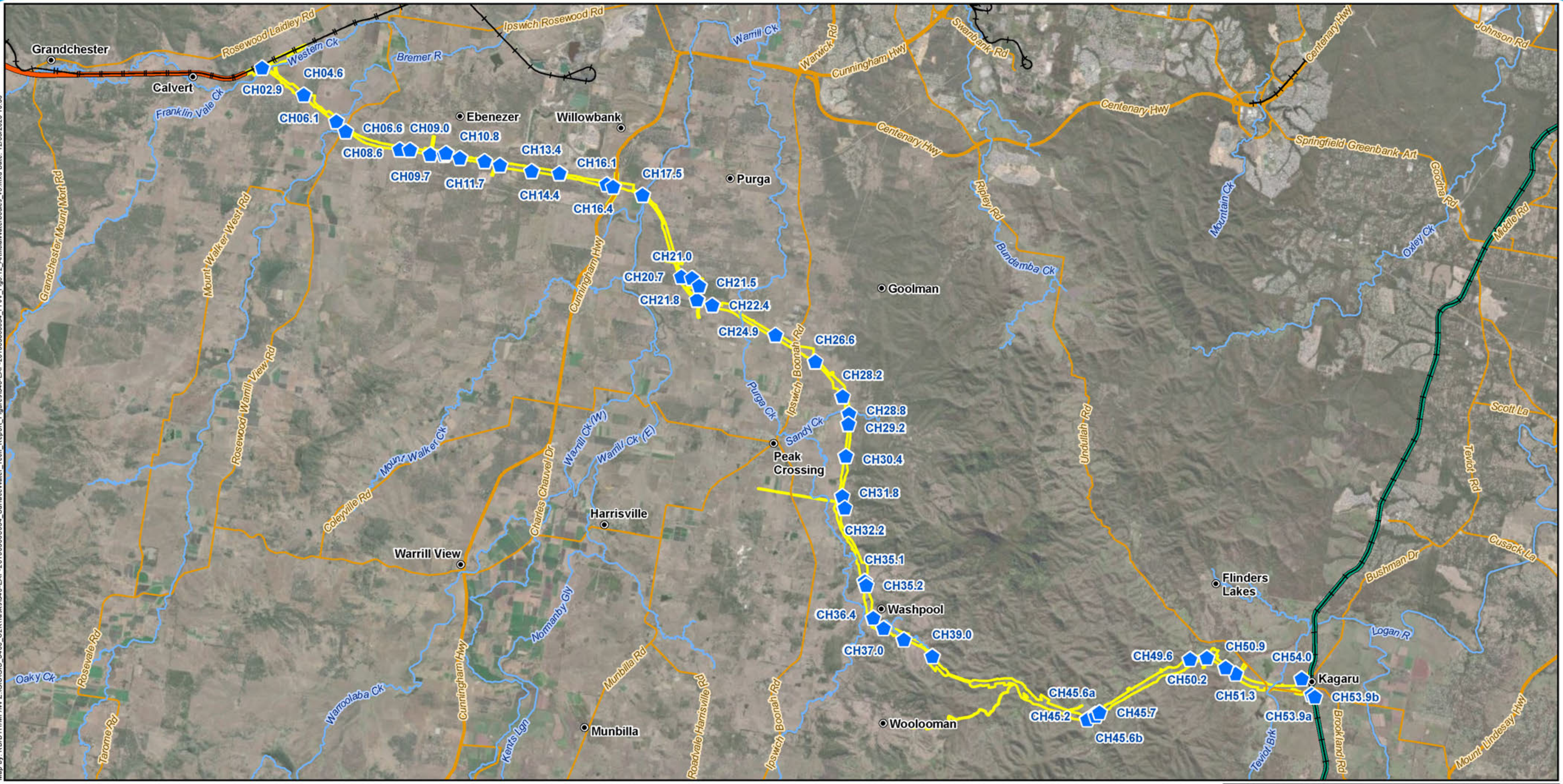
Stream order (DNRME)	Waterway (approximate chainage (km))
6	Warrill Creek (Ch 17.60) Purga Creek (Ch 23.40)
5	Western Creek (Ch 1.30, Ch 3.10) Bremer River (Ch 6.20) Un-named tributary of Teviot Brook (Ch 28.70, Ch 43.10) Teviot Brook (Ch 52.80)
4	Un-named tributary of Purga Creek (Ch 35.80, Ch 36.60) Un-named tributary of Teviot Brook (Ch 42.80, Ch 46.20, Ch 51.40)
3	Un-named Tributary of Bremer River (Ch 7.70) Ebenezer Creek (Ch 13.40) Un-named tributary of Purga Creek (Ch 33.30, Ch 37.60, Ch 37.90) Un-named tributary of Teviot Brook (Ch 41.70, Ch 47.00, Ch 48.30, Ch 53.20) Woollaman Creek (Ch 51.50)
2	Un-named tributary of Ebenezer Creek (Ch 14.40) Un-named tributary Purga Creek (Ch 27.80, Ch 29.90, Ch 31.20, Ch 32.00, Ch 33.90, Ch 38.90, Ch 39.30, Ch 39.60) Un-named tributary of Teviot Brook (Ch 43.40, Ch 44.20)
1	n/a

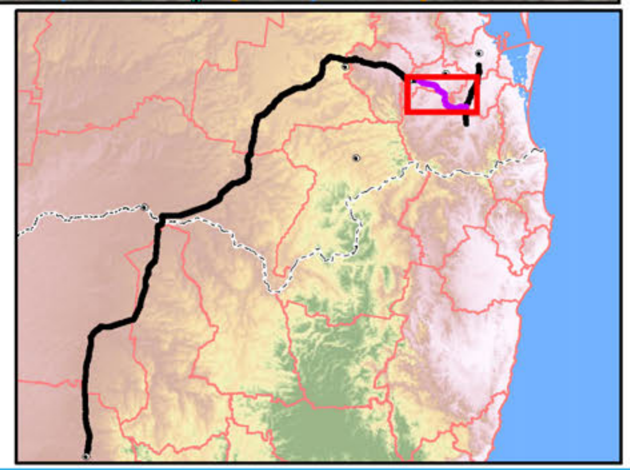
5.5.4 Artificial/constructed waterbodies

There are a number of artificial/constructed waterbodies that have been identified within the water quality study area and that are intersected by the Project alignment (refer Figure 5.12). These artificial/constructed waterbodies are predominantly rural farm dams used by stock. Artificial wetlands are considered to provide environmental value however are not considered as an MNES, MSES or matter of local environmental significance (MLES) value waterbodies. Artificial waterbodies dewatering strategies are considered with Section 8.2.

The artificial/constructed waterbodies that are intersected by the Project alignment are provided in Table 5.9 and illustrated in Appendix F.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





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Legend

- Artificial waterbodies
- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- EIS disturbance footprint

A3 scale: 1:150,000

0 1 2 3 4 5km

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Calvert to Kagaru
Figure 5.12:
Artificial/constructed waterbodies

Table 5.9 Artificial waterbody which intersect with the Project alignment

Artificial waterbody (approximate chainage (km))	Associated waterway
Ch 2.90, 4.60, 6.10, 6.60, 8.60, 9.00, 9.70, 10.20, 10.30, 10.80	Unmapped waterway of Bremer River
Ch 11.70, 12.20, 13.40, 14.40, 16.10, 16.40, 17.50	Unmapped waterway of Warrill Creek
Ch 20.70, 21.00, 21.50, 21.80, 22.40, 24.90	Unmapped waterway of Purga Creek
Ch 26.60	Unmapped waterway of tributary of Purga Creek
Ch 28.20, 28.80, 29.20, 30.40,	Unmapped waterway of tributary of Purga Creek
Ch 31.80, 32.20, 33.80, 34.00, 35.10, 35.20, 36.40, 37.00, 37.80, 39.00	Unmapped waterway of Purga Creek
Ch 45.20, 45.60, 45.70	Unmapped waterway of Teviot Brook
Ch 49.60, 50.20, 50.90	Unmapped waterway of Teviot Brook
Ch 51.30, 53.90[a], 53.90[b], 54.00	Unmapped waterway of Teviot Brook

Table note:

a, b Denotes discrete waterbodies located at the same relative chainage

5.6 Aquatic ecosystem values

A summary of the aquatic ecosystem values at each monitoring site is provided in EIS Appendix J: Terrestrial and Aquatic Ecology Technical Report, including a description of the physical environment, aquatic habitat, flora and fauna at the site and existing local impacts.

The water quality study area includes the following aquatic habitats (as defined by EPA (2005):

- Riverine wetlands– Wetlands contained within channel that are not dominated by trees, shrubs, persistent emergent and emergent mosses or lichens
- Palustrine – Wetlands dominated by trees, shrubs, persistent emergent and emergent mosses or lichens
- Lacustrine – Wetlands contained within a topographic depression or dammed river channel, lacking trees, shrubs, persistent emergent and emergent mosses or lichens and covering more than eight hectares.

Whilst some of these aquatic waterways contained no water at the time of assessment, they do provide habitat value for a number of aquatic species that are likely to occur in the landscape. Habitats with permanent water are likely to support the most diverse and abundant aquatic communities, however areas with seasonal water provide periodically available habitat and act as pathways for fauna.

Aquatic ecosystem values were identified to confirm the habitat values aligned with predictive habitat mapping of MNES species; Australian Lungfish (*Neoceratodus forsteri*), Mary River Cod (*Maccullochella mariensis*) and MSES wetlands within the water quality study area.

The intersection of the alignment with Western Creek, Bremer River, Warrill Creek and Teviot Brook were considered to have the highest aquatic ecosystem values These coincided with the presence of MNES and MSES ecological values and were considered in protection of water quality condition across the water quality study area.

5.7 AquaBAMM aquatic conservation assessment

The aquatic conservation assessment using AquaBAMM assesses the conservation and ecological value of wetland systems based on a series of national and international criteria, including naturalness (aquatic and catchment), diversity and richness, threatened species/ecosystems, priority species/ecosystems, special features, connectivity and representativeness (EHP 2015).

Table 5.10 provides the assessment for the catchments relevant to the water quality study area. The catchment aquatic conservation assessment indicates a skew towards higher value wetlands (against the criteria indicated above) throughout both catchments, indicating the presence of sensitive wetland receptors throughout both catchments. Noting this, water quality monitoring sites within the water quality study area were all classed as very low, low or medium (indicating limited sensitivity wetland receptors) (refer Table 5.11).

Table 5.10 Aquascore for Bremer River and Logan River catchments

Catchment	Aquascore (%)				
	Very low	Low	Medium	High	Very high
Riverine wetlands					
Bremer River catchment	3% of the catchment had an Aquascore of very low	3% of the catchment had had an Aquascore of low	64% of the catchment area had an Aquascore of medium	12% of the catchment had an Aquascore of high	18% of the catchment had an Aquascore of very high
Logan River catchment	0% of the catchment had an Aquascore of very low	6% of the catchment had had an Aquascore of low	43% of the catchment area had an Aquascore of medium	27% of the catchment had an Aquascore of high	24% of the catchment had an Aquascore of very high
Non-riverine wetlands					
Bremer River catchment	5% of the catchment had an Aquascore of very low	1% of the catchment had had an Aquascore of low	64% of the catchment area had an Aquascore of medium	0% of the catchment had an Aquascore of high	30% of the catchment had an Aquascore of very high
Logan River catchment	8% of the catchment had an Aquascore of very low	1% of the catchment had an Aquascore of low	32% of the catchment area had an Aquascore of medium	29% of the catchment had an Aquascore of high	29% of the catchment had an Aquascore of very high

Source: EHP (2015)

The results of the Aquascore riverine assessment against each water quality monitoring site are presented in Table 5.11. The majority of monitoring sites had Aquascores of medium, with an even spread of low and very low Aquascores for other monitoring sites.

Table 5.11 Specific Riverine AquaBAMM score for water quality monitoring sites

Aquascore	Monitoring site	Associated watercourse
Very Low	5A, 5A (alt), 12A	Purga Creek
Low	7A (alt), 7A, 8A, 9A	Dugandan Creek and Woollaman Creek
Medium	1A, 1A (alt), 2A, 3A, 14A, 6A, 13A, 10A, 11A	Western Creek, Bremer River, Warrill Creek, Purga Creek and Teviot Brook
High	-	-
Very High	-	-

5.8 Sensitive environmental areas

This section provides a summary of sensitive environmental areas known within the water quality study area.

5.8.1 Wetlands

There are no Wetlands of International Importance (Ramsar wetlands) within 10 km (as an expected spatial area of potential impact from Project activities) of the water quality study area. Several ecological significant wetlands (high ecological significance (HES)) as recognised under EPP (Water and wetland biodiversity) 2019 which are considered referable (MSES) under the Environmental Protection Regulation 2019 are present within the water quality study area with some in close proximity with the alignment. Of the 66 hectares of HES wetland that occur within the water quality study area, 0 hectares is within the current disturbance footprint and will not be directly impacted from activities associated with the Project.

Key HES wetland areas are located at the following watercourse and chainage (km):

- Two HES wetlands proximal to Western Creek (Ch 2.40)
- HES wetland at tributary of the Bremer River (Ch 5.20 to Ch 5.60)
- HES wetland at tributary of Warrill Creek (Ch 17.00 to Ch 17.60)
- HES wetland at Purga Creek (Ch 36.00)
- HES wetland at Teviot Brook (Ch 52.40 to Ch 52.80).

5.8.2 Fish habitat

Under the Fisheries Act, a declared fish habitat area is an area protected against physical disturbance from coastal development, while still allowing legal fishing. There are no declared fish habitat areas mapped within the water quality study area. The nearest gazetted fish habitat area is located approximately 70 km downstream of the water quality study area.

5.8.3 Groundwater dependant ecosystems and springs

A GDE is an ecosystem that require access to groundwater on a permanent or periodic basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

The GDE Atlas (BoM 2020e) identifies three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater – this includes surface water ecosystems which may have a groundwater component (i.e. rivers, wetlands, springs)
- Terrestrial ecosystems that rely on the subsurface presence of groundwater – this includes all vegetation ecosystems
- Subterranean ecosystems – this includes cave and aquifer ecosystems.

As the assessment using the BoM atlas is modelled at a large scale, the identification of potential GDEs in the Atlas therefore does not confirm that a particular ecosystem is groundwater dependant. Noting this, the Atlas has identified several potential aquatic and terrestrial groundwater dependant systems including wetland systems and watercourses.

A review of refined scale potential GDE mapping (DES 2018) was undertaken and the following GDEs aquifer categories have the potential to occur within the water quality study area:

- Unconsolidated sedimentary aquifers
- Consolidated sedimentary aquifers
- Metamorphic rock aquifers.

Surface water expression areas (aquatic groundwater dependant ecosystems) are considered to be the aspect of relevance to the surface water quality environment and are described alongside terrestrial groundwater dependant environments below. As a conservative approach has been used to consider impact to GDEs, moderate and high confidence modelling of surface area have been identified within the existing environment.

5.8.3.1 Aquatic groundwater dependant ecosystems

Numerous watercourses traversing the water quality study area are designated as moderate potential GDEs from regional studies; including Western Creek, Bremer River, Warrill Creek, Purga Creek and Teviot Brook. The potential GDEs are described as wetlands 'supplied by alluvial aquifers with near-permanent flow'. The surface area groundwater areas are illustrated in Figure 5.13.

5.8.3.2 Terrestrial groundwater dependant ecosystems

Within the water quality study area, to the west and east of the Teviot Range, several moderate potential terrestrial GDEs (from regional studies) are either intersected or close to the proposed Project alignment. These are described as wetland or riparian vegetation 'supplied by alluvial aquifers with near-permanent flow'.

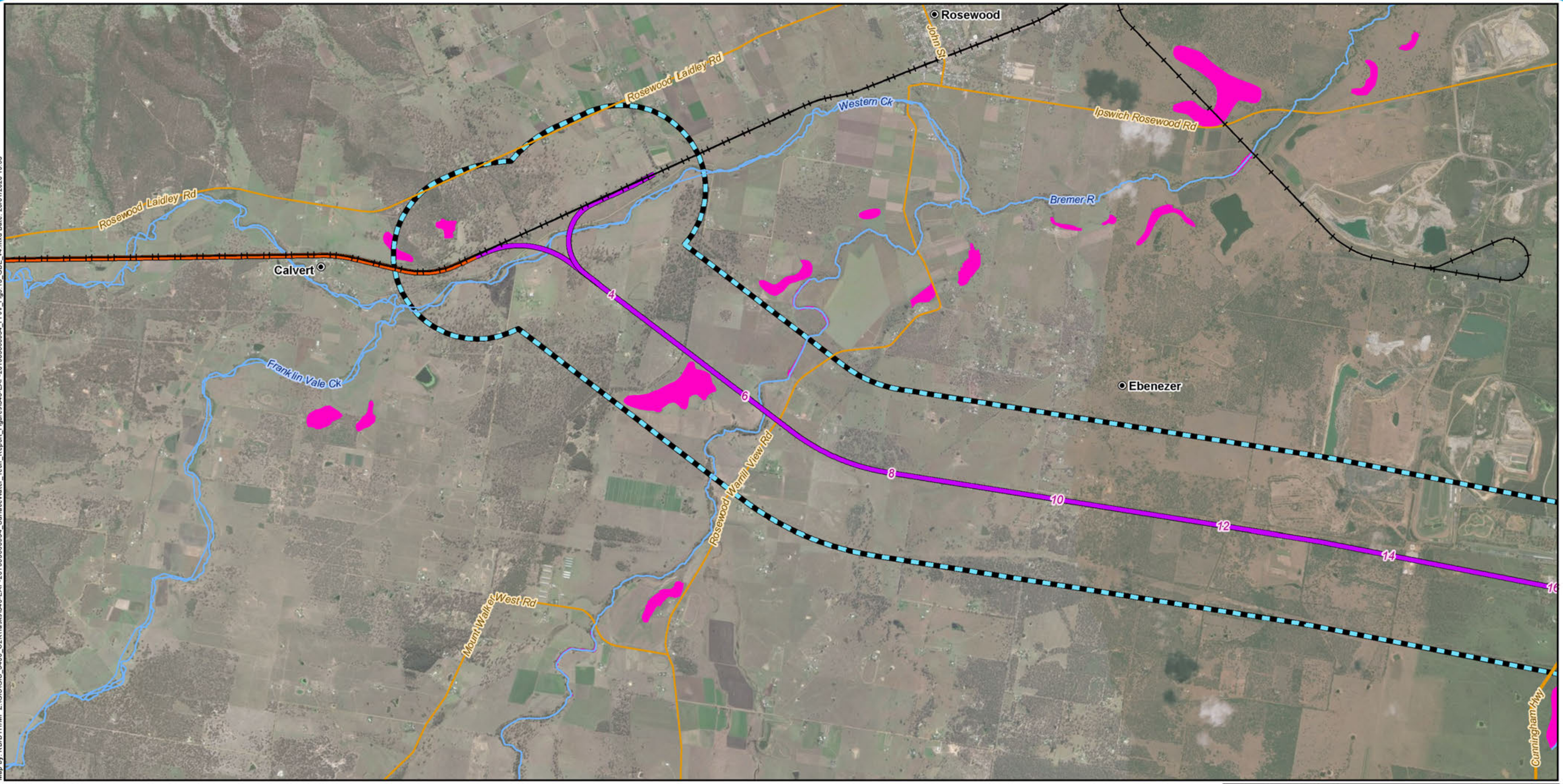
Low and moderate potential terrestrial GDEs (from regional studies) have been identified within the Teviot Range portion of the water quality study area. These are generally described as wetland vegetation supplied by low porosity sedimentary rock with intermittent flow. Wetland supplied by alluvial aquifers with near permanent flow (eastern flank) and riparian vegetation supplied by sedimentary rocks with saline flow (western flank) are also indicated.

5.8.3.3 Springs

No incidental observation of springs occurred during surface water quality field assessments associated with the EIS or identified from the GDE Atlas (BoM 2020e) within the water quality study area. Noting this, several first order stream intersect the Project alignment and may be associated with natural springs.

As no ground truthing of these particular environments were undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted as true presence, and thus form a potentially sensitive receptor. Therefore, GDEs and surface areas have been mapped as occurring within the water quality study area.

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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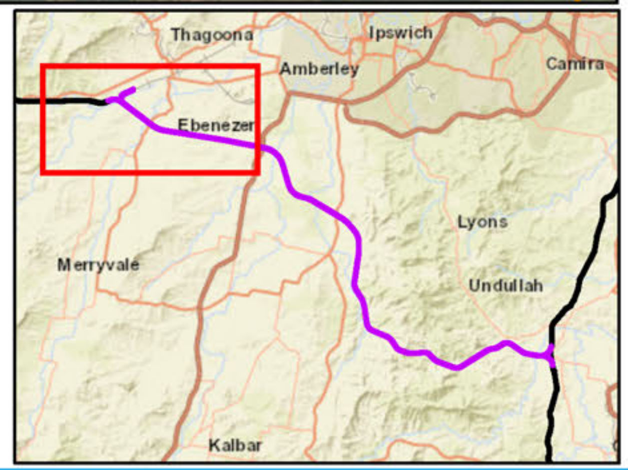

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads

Water quality study area

Surface areas - Groundwater Dependant Ecosystems

Surface Areas: known, high confidence and moderate confidence GDEs

A3 scale: 1:50,000

0 0.5 1 1.5 2 2.5km

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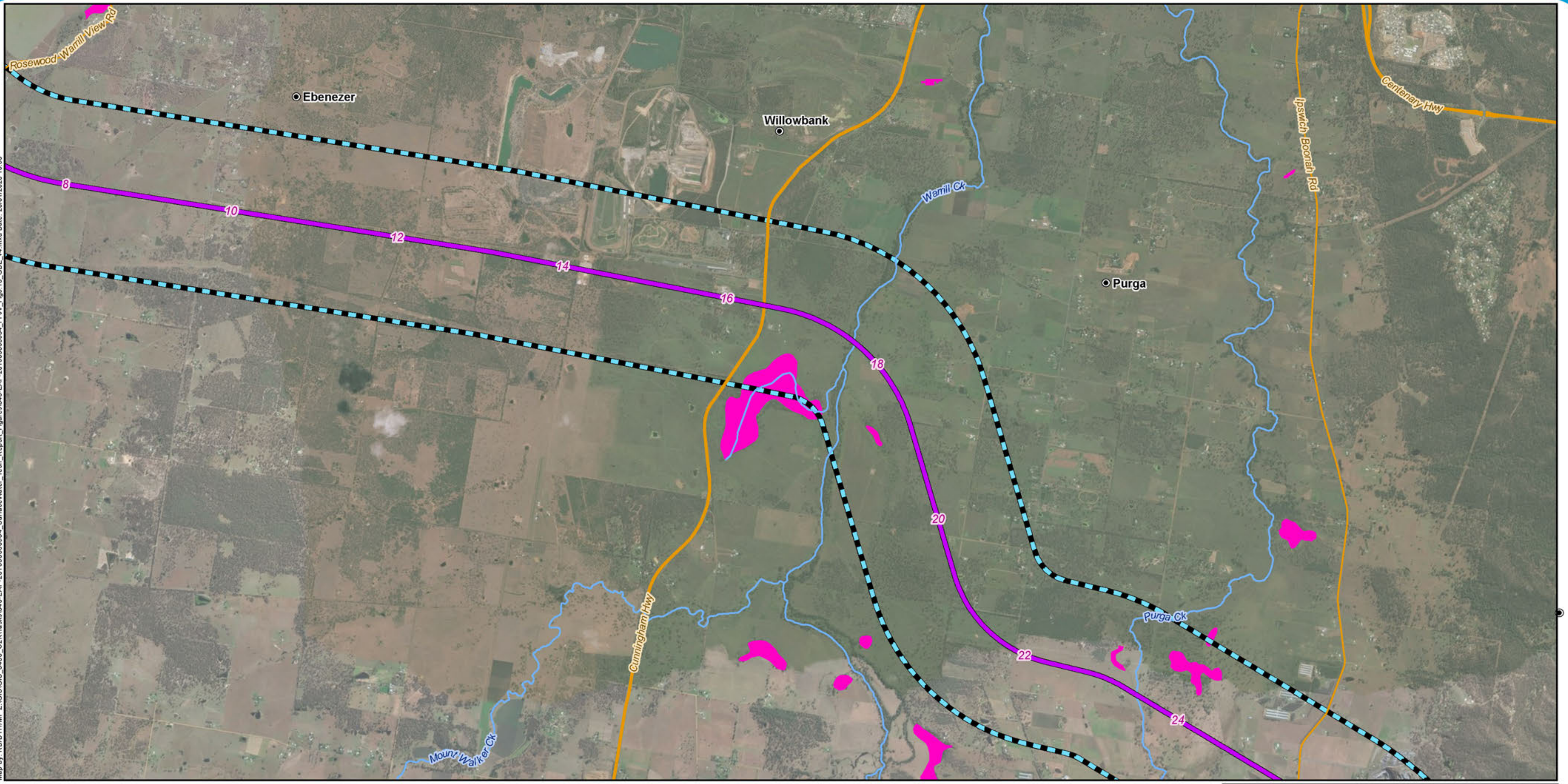
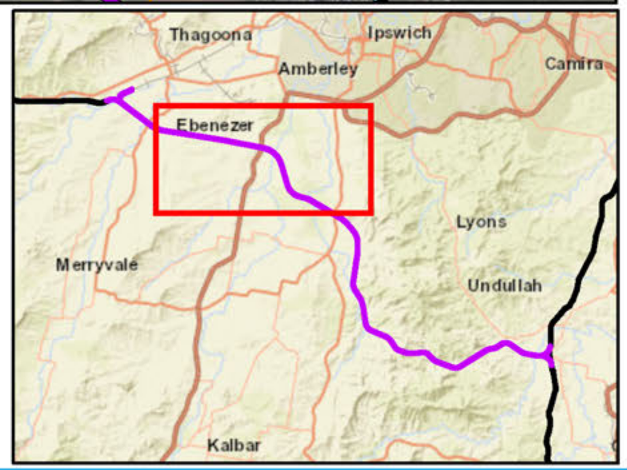
Calvert to Kagaru
Figure 5.13a:
GDEs within the Project water quality study area

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community





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Legend

- 5 Chainage (km)
- Localities
- C2K project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area

Surface areas - Groundwater Dependant Ecosystems

- Surface Areas: known, high confidence and moderate confidence GDEs

A3 scale: 1:50,000

0 0.5 1 1.5 2 2.5km

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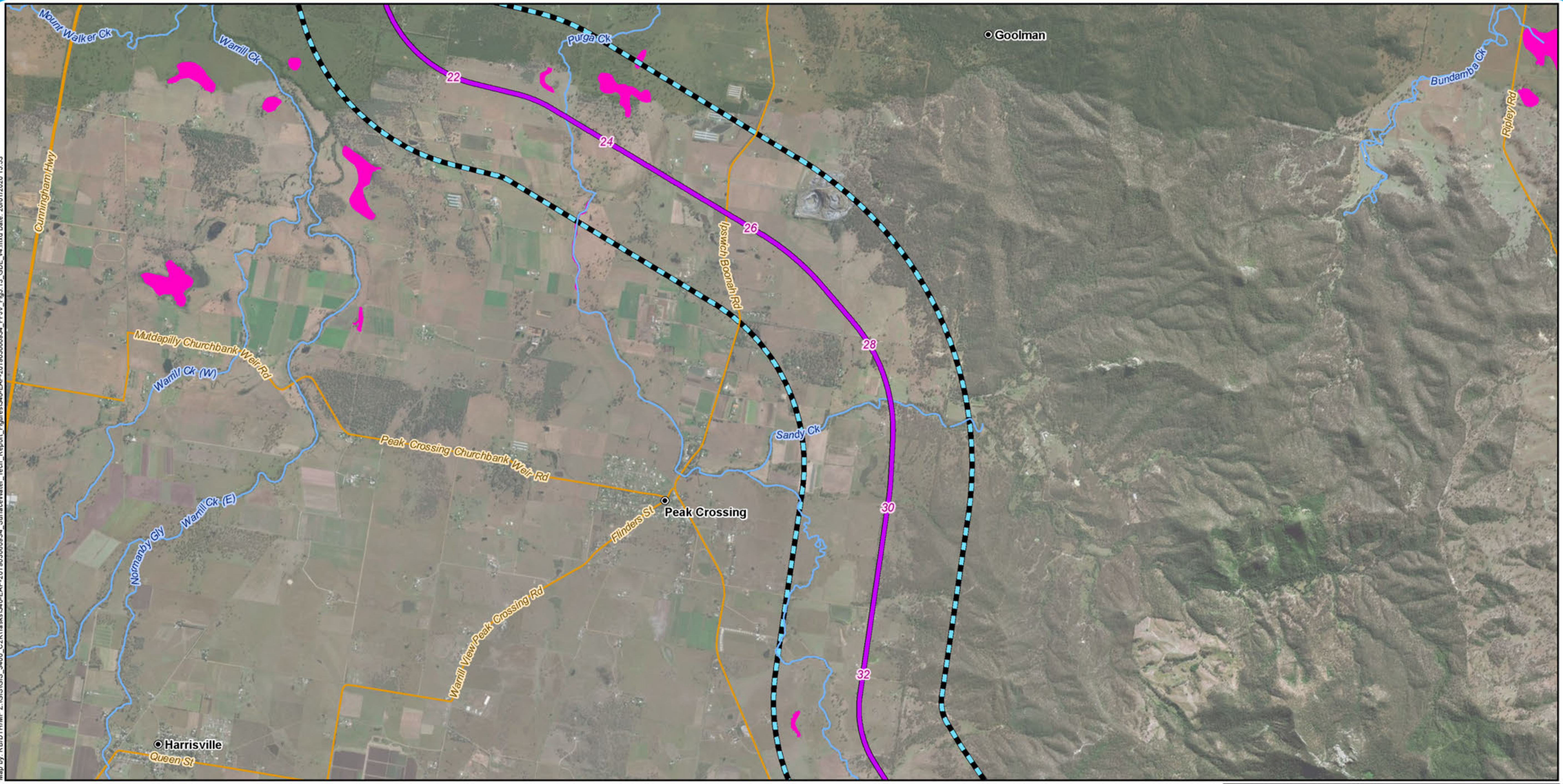
Calvert to Kagaru

Figure 5.13b:
GDEs within the Project water quality study area

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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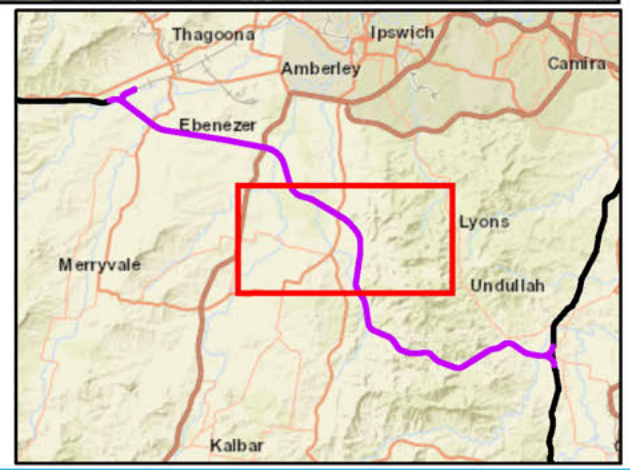
Legend

- 5 Chainage (km)
- Localities
- C2K project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area

Surface areas - Groundwater Dependant Ecosystems

- Surface Areas: known, high confidence and moderate confidence GDEs



A3 scale: 1:50,000

0 0.5 1 1.5 2 2.5km

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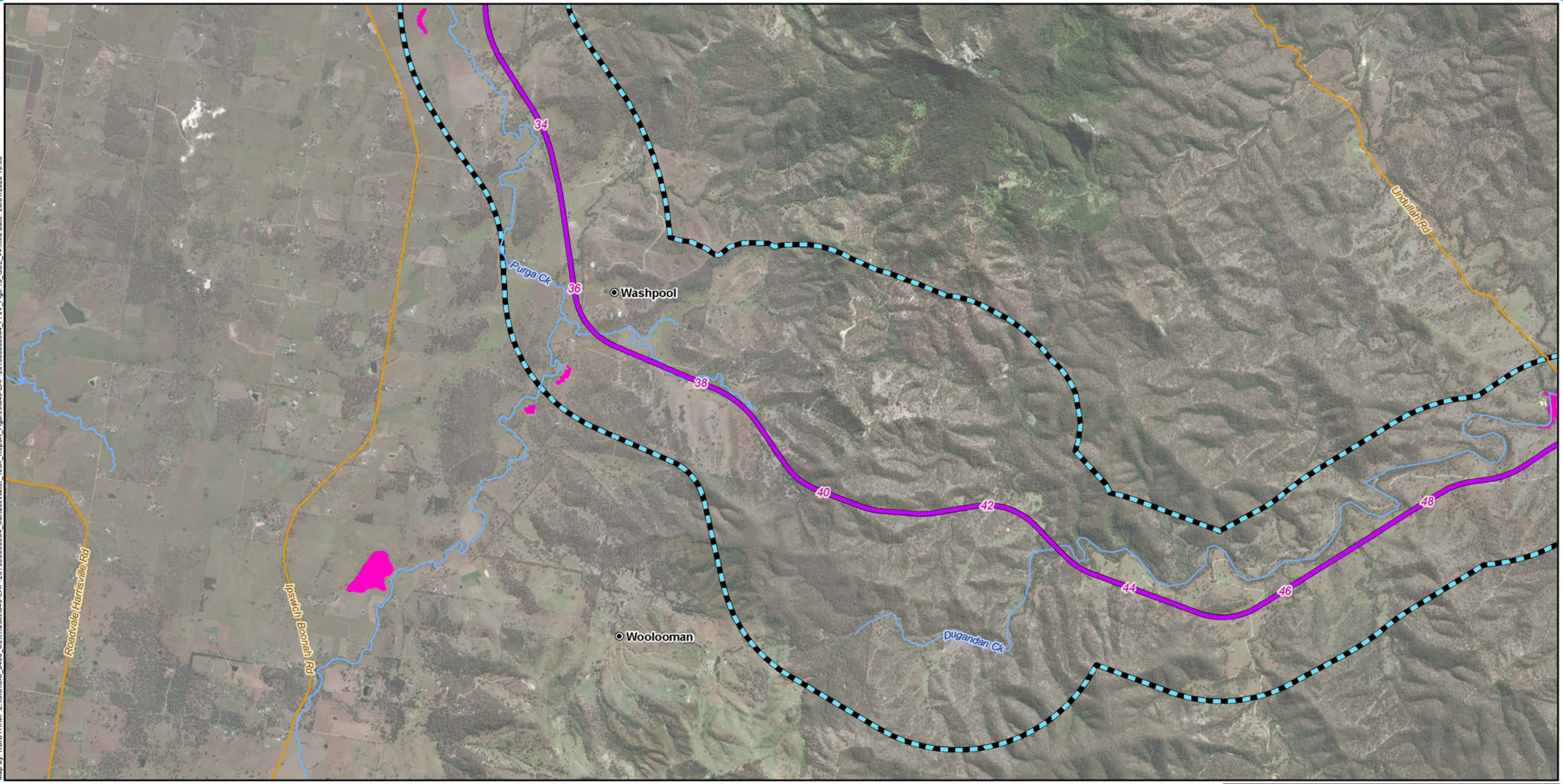
Calvert to Kagaru
Figure 5.13c:
GDEs within the Project water quality study area

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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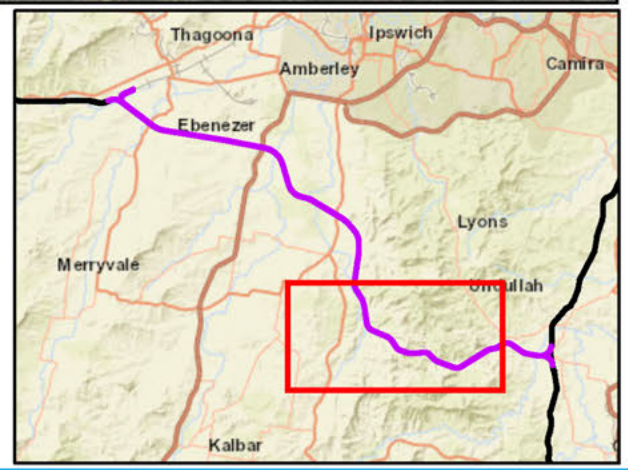

Legend

- 5 Chainage (km)
- Localities
- C2K project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area

Surface areas - Groundwater Dependant Ecosystems

- Surface Areas: known, high confidence and moderate confidence GDEs

A3 scale: 1:50,000

0 0.5 1 1.5 2 2.5km

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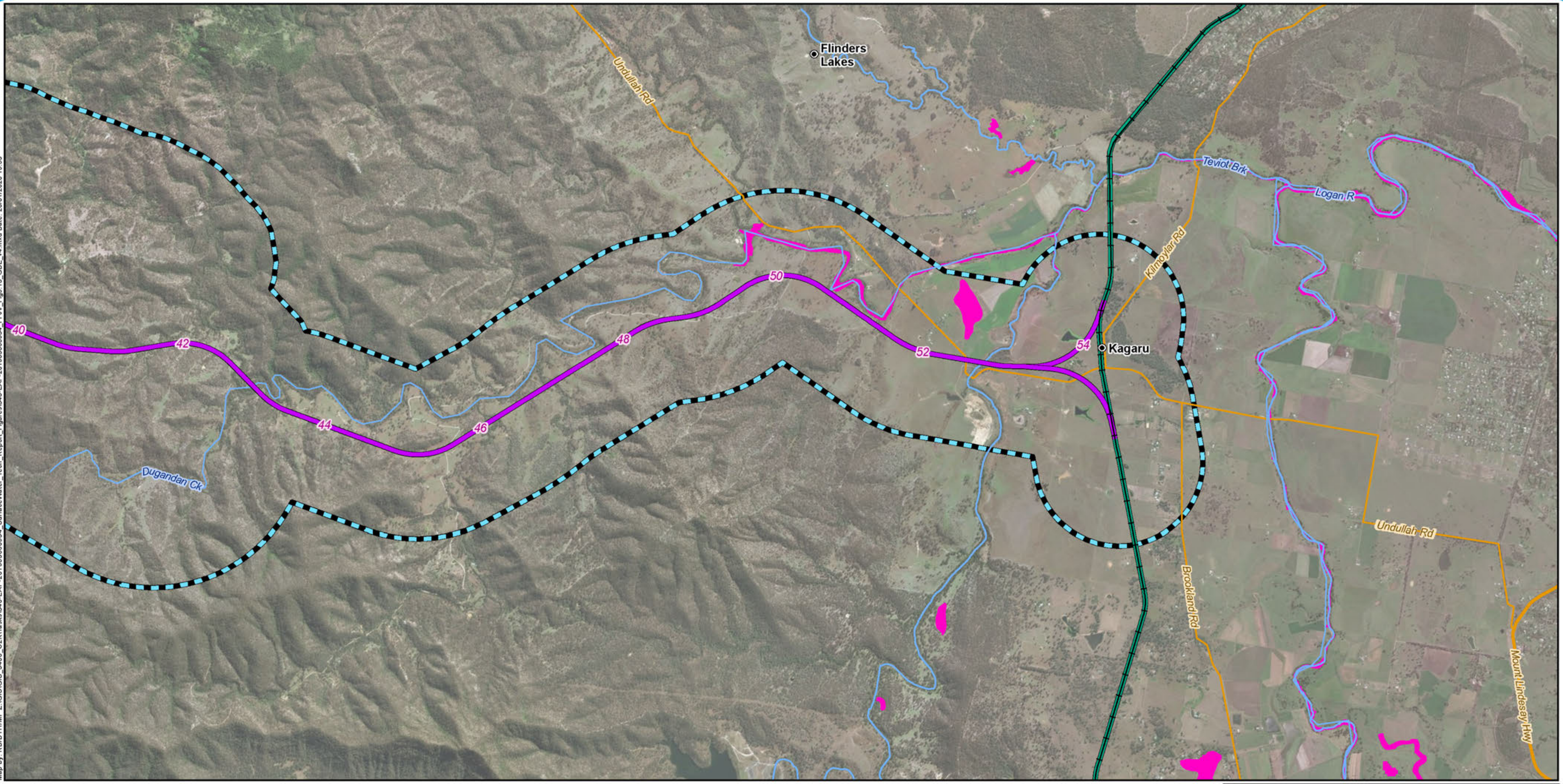
Calvert to Kagaru
Figure 5.13d:
GDEs within the Project water quality study area

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, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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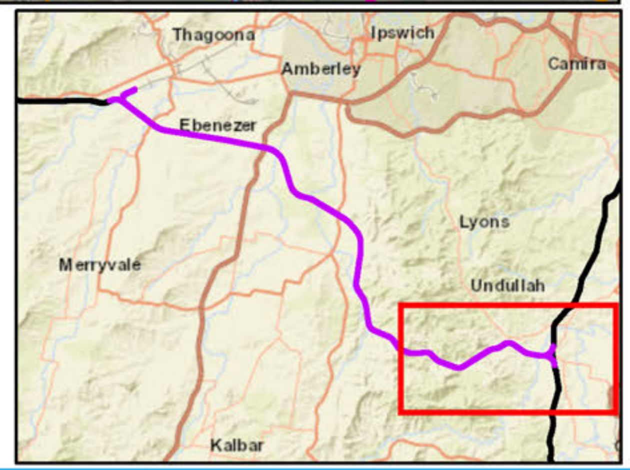

Legend

- 5 Chainage (km)
- Localities
- Existing rail
- C2K project alignment
- K2ARB project alignment
- Defined watercourses (Water Act 2000)
- Major roads
- Minor roads
- Water quality study area

Surface areas - Groundwater Dependant Ecosystems

- Surface Areas: known, high confidence and moderate confidence GDEs

A3 scale: 1:50,000

0 0.5 1 1.5 2 2.5km

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Calvert to Kagaru

Figure 5.13e:
GDEs within the Project water quality study area

5.9 Salinity hazard

The water quality study area was broken down by the Australian Hydrologic Geospatial Fabric Catchment Geographical Information Systems layer, into smaller sub-catchments to enable a more precise analysis of the Project. The sub-catchments were analysed for salinity hazard in accordance with Part B Investigating Salinity of the Salinity Management Handbook (DERM 2011). In particular, consideration was given to how Project construction activities may alter the hydrology of the water quality study area.

Once broken down into sub-catchments, the soils layer was intersected with the sub-catchments layer to identify which soils were dominant in each of the sub-catchments. Prior knowledge of soil type was applied to give a low, moderate, or high rating to each of the dominant soil types, to give an indication of inherent salt store.

The overall salinity hazard map was developed from the factors addressed above. Salinity hazard within the water quality study area was assessed using the CSIRO (2014) electrical conductivity mapping layer. The Project water quality study area generally contained low electrical soil conductivity between 0.05 dS/m and 0.1 dS/m, with two distinct patches of high electrical conductivity (0.5 dS/m to 1.0 dS/m) meandering through the water quality study area as the alignment crosses Western Creek, at Calvert, and the Bremer River, located west of Ebenezer.

Sections of the Project alignment directly intersect moderate to high salinity hazard rating areas (refer Figure 5.14). Details of potential impact from the Project in relation to the overall salinity hazard and actions for mitigation are detailed further in the EIS Chapter 9: Land Resources.

5.10 Surface water resources and use

The Water Act provides a framework under which catchment-based Water Plans and Water Management Protocols (previously Resource Operations Plans) are developed in Queensland. Water Plans establish a framework for sharing water between human consumptive needs and EVs. Water Management Protocols are developed in parallel with the Water Plans and provide a framework by which objectives of the Water Plans are implemented, including water allocations and administrative directions.

Water resource catchments (and water supply buffer area) associated with the water quality study area are limited to the Project water quality study area associated with the Logan River Catchment (Appendix G). Human requirements for drinking water quality supply are considered to be covered by the protection of aquatic ecosystem environmental values (due to stringency of water quality objectives)

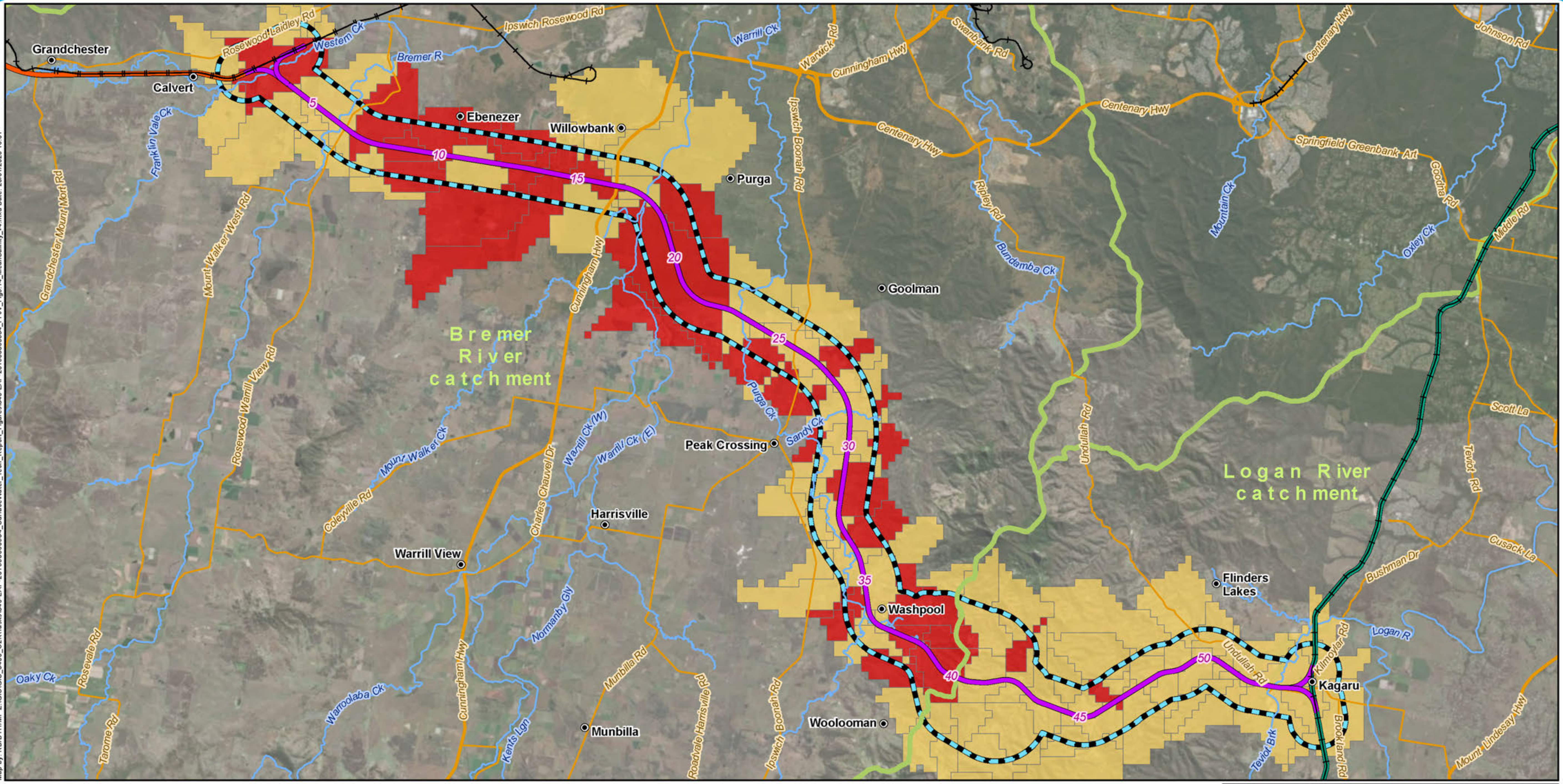
Surface water resources within the water quality study area are primarily managed by the Water Plan (Moreton) 2007 and Water Plan (Logan Basin) 2007. Both plans include performance indicators and objectives such as:

- Environmental flow objectives: assessing periods of low flow and medium to high flow, and
- Water allocation security objectives.

The Moreton Water Management Protocol implements parts of the Water Plan (Moreton) 2007. The Logan Basin Resource Operations Plan 2009 implements the Water Plan (Logan Basin) 2007. The Water Management Protocol defined the rules that govern the allocation and management of water in order to achieve the Water Plan outcomes.

Significant changes to the hydraulic regime of the watercourses are not expected to occur with design practices which account for typical hydrological flow to which the water plans pertain. Ecological and general outcomes for the Water Plan (Moreton) 2007 and Water Plan (Logan Basin) 2007 (i.e. achieving ecological outcomes consistent with supporting natural outcomes by minimising changes to natural flow regimes) will not be impacted with minimal variance to typical hydrological flow. As such, the Project is expected to comply with the Moreton and Logan Basin water plans.

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



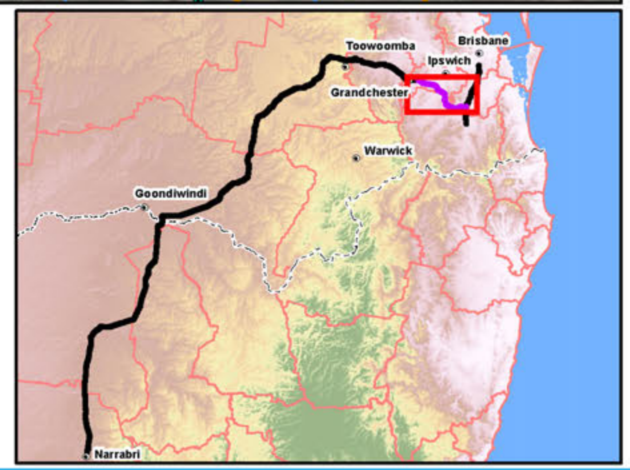
Legend

- 5 Chainage (km)
- Localities
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Major roads
- Minor roads
- Defined watercourses (Water Act 2000)
- Catchment boundaries
- Water quality study area

Mean salinity hazard rating

- Low: 0.00 - 1.00
- Moderate: 1.01 - 2.00
- High: 2.01 - 3.00

Note:
The mean salinity hazard rating is calculated as the average catchment rating from the following PEA assessments, where present:
- basalt/sandstone contact
- catena landscape
- artificial restrictions (road/rail)
- soil salt store
- dam seepage



A3 scale: 1:150,000

0 1 2 3 4 5km

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Calvert to Kagaru
Figure 5.14:
Salinity hazard rating for the Project impact assessment areas

The DTMR provides boat launching ramps, floating walkways, pontoons and jetties throughout Queensland. No public boating facilities are located within the water quality study area. There are known fishing spots in the Ipswich area, located east of the Project alignment and water quality study area in areas such as Kholo, Karalee and North Ipswich (City of Ipswich 2018).

Water usage within the water quality study area is dominated by stock uses, farming and rural domestic uses. Stock water is supplied from rivers in the wet season and for the rest of year by groundwater, natural waterholes or constructed artificial waterbodies. Within the water quality study area, water allocation licence data indicates 296 megalitres (ML) per year is allocated within the Warrill Valley water management area (refer Table 5.12). The search for water allocations are limited to the water quality study area as identified impacts to water quality would be expected to primarily impact these users.

Identification of potential impacts to surface water users is outlined in Section 7.2.

Table 5.12 Summary of 2018-2019 water licence data relevant to the water quality study area (under Water Regulation 2016)

Water source	No of water licences	Water made available (ML/yr)
Warrill Creek (Surface Water Source)	3	296
Warrill Creek East Branch (Surface Water Source)	1	123

Source: DNRME 2019

5.11 Water quality receptors

A receptor is a feature (including utilisation by human and ecological components), area or structure that may be affected by direct or indirect changes to the environment. The water quality receptors were assessed against relevant legislation and the overarching ecological values used to feed potential impacts which included:

- Queensland's natural environment (including utilisation by native flora and fauna)
- Finite natural resources, with specific regard to wetlands
- Watercourses conducive to the maintenance of existing landforms, ecological health and biodiversity.

Due to the interconnected nature of the watercourses intersecting the Project alignment and residing within the greater water quality study area, the water quality receptors for the existing environment (as a whole of package) were assigned a moderate sensitivity due to several factors:

- Protected by State legislation
- Important for biodiversity
- Existing sensitivity (under threatening process) and/or high exposure to impacts.

To maintain a conservative approach to assessment, all waterways and waterbodies within the disturbance footprint, water quality study area and downstream receiving environments were nominated as moderate sensitivity water quality receptors for identification of potential impacts, associated mitigation measures and identification of residual impact after implementation of mitigation.

Water quality receptors identified as having high sensitivity were identified from the potential presence of the MNES species Australian Lungfish (*Neoceratodus forsteri*), Mary River Cod (*Maccullochella mariensis*) and MSES wetlands within the water quality study area.

Therefore, sensitivity of all receiving waterways were considered as either moderate or high sensitivity water quality receptors. High sensitivity water quality receptors include intersecting sections of the Project alignment associated with Western Creek, Bremer River, Warrill Creek and Teviot Brook.

6 Surface water quality assessment

6.1 Desktop review of surface water quality within the Bremer and Logan catchments

6.1.1 Healthy Land and Water

The healthy land and water monitoring program (Healthy Land and Water 2020) provides a regional assessment of the health for each of south-east Queensland (SEQs) major catchments, river estuaries and Moreton Bay zones. A generalised report card is produced annually for each catchment (from a variety of aquatic parameters) to indicate waterway health in SEQ, ranging from an ‘A’ for excellent to ‘F’ for failed ecosystem health.

Freshwater ecosystem health is considered across a variety of indicators including:

- Ecosystem processes
- Fish
- Invertebrates
- Physical – chemical, and
- Riparian extent.

The Project alignment is located within the Bremer catchment area and Logan catchment area.

6.1.1.1 Bremer catchment

The Healthy Land and Water report card (Healthy Land and Water 2020) identified the western catchments of SEQ (including Bremer catchment) range from poor to good, with the overall grades decreasing in condition. The western catchments have experienced a continual decline in freshwater stream health as a result of dry weather and poor vegetation cover. Therefore, the western catchments are highly susceptible to future erosion caused by storms and flooding. Table 6.1 provides historic results for the Bremer catchment for 2010 to 2018.

6.1.1.2 Logan catchment

The Healthy Land and Water report card (Healthy Land and Water 2020) identified the south east catchments (including Logan catchment) range from fair to good with the overall grades decreasing slightly in 2017 due to an increase in sediment loads. The region has sparse riverbank vegetation, making it highly sensitive to storm events. This was demonstrated by the floods caused by ex-tropical cyclone Debbie; however, the success of ongoing riverbank stabilisation projects has shown these problems can be fixed. Table 6.2 provides historic results for the Logan catchment for 2010 to 2018.

Table 6.1 **Bremer River catchment report card summary results from 2010 to 2018**

Category	Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Overall condition	The overall environmental condition of the Bremer is poor (E)	The overall environmental condition of the Bremer is poor (E)	The overall environmental condition of the Bremer is poor (D-)	The overall environmental condition of the Bremer is average (C-)	The overall environmental condition of the Bremer is poor (D)	The overall environmental condition of Bremer is poor (D-)	The overall environmental condition of the Bremer is poor (D+)	The overall environmental condition of the Bremer is poor (D-)	The overall condition of the Bremer is poor (D+).
Ecosystem processes	0.73 (average)	0.92 (excellent)	0.86 (excellent)	0.82 (good)	0.78 (good)	0.94 (excellent)	0.94 (excellent)	0.99 (excellent)	0.96 (excellent)
Fish	0.73 (average)	0.75 (good)	0.75 (good)	0.80 (good)	0.76 (good)	0.75 (good)	0.79 (good)	0.74 (good)	0.75 (good)
Invertebrates	0.83 (good)	0.88 (excellent)	0.93 (excellent)	0.90 (excellent)	0.84 (good)	0.86 (excellent)	0.89 (excellent)	0.88 (excellent)	0.84 (excellent)
Physical/ chemical	0.83 (good)	0.85 (excellent)	0.84 (good)	0.83 (good)	0.78 (good)	0.91 (excellent)	0.88 (excellent)	0.87 (excellent)	0.88 (excellent)
Riparian	Not assessed					0.56 (fair)	0.56 (fair)	0.56 (fair)	0.56 (fair)

Source: HLW (2018)

Table 6.2 **Logan River catchment report card results for 2010 to 2018**

Category	Year								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Overall condition	The overall environmental condition of Logan is poor (E)	The overall environmental condition of Logan is poor (E)	The overall environmental condition of Logan is poor (E)	The overall environmental condition of Logan is poor (D)	The overall environmental condition of Logan is poor (D)	The overall environmental condition of Logan is poor (D)	The overall environmental condition of Logan is fair (C-)	The overall environmental condition of Logan is fair (C-)	The overall environmental condition of Logan remains fair (C-)
Ecosystem processes	0.88 (excellent)	0.97 (excellent)	0.92 (excellent)	0.90 (excellent)	0.89 (excellent)	0.91 (excellent)	0.97 (excellent)	0.97 (excellent)	0.94 (excellent)
Fish	0.65 (average)	0.72 (good)	0.69 (fair)	0.70 (average)	0.72 (average)	0.69 (average)	0.71 (good)	0.71 (average)	0.72 (average)
Invertebrates	0.77 (good)	0.81 (good)	0.80 (good)	0.78 (good)	0.75 (good)	0.83 (good)	0.79 (good)	0.79 (good)	0.78 (good)
Physical/ chemical	0.86 (excellent)	0.93 (excellent)	0.84 (good)	0.84 (good)	0.84 (good)	0.95 (excellent)	0.93 (excellent)	0.93 (excellent)	0.94 (excellent)
Riparian	Not assessed					0.69 (average)	0.69 (average)	0.69 (average)	0.69 (average)

Source: HLW (2018)

6.2 Field assessment of surface water quality

6.2.1 General conditions

To capture representative stream flow behaviour from the water quality study area, stream flow data was retrieved from the gauging station from Warrill Creek at Amberley, downstream from the water quality study area, Pug Creek and the Western Creek at Kuss Road gauging station, upstream from the water quality study area.

The weather conditions leading up to the first assessment (undertaken between 25 September and 29 September 2017) were generally clear and dry. Table 6.3 identifies 0.8 mm of rain was recorded in the week leading up to the first assessment. Additionally, within August 2017, the water quality study area only received 2.8 mm of rain. Stream flow rates (in terms of passage over the gauging station control), indicate that low surface flow, and no surface flow was observed downstream of the gauging station preceding the first water quality assessment.

Streamflow within both catchments increased during the second assessment with a flash flow occurring in the Warrill Creek watercourse four days before the assessment (refer Table 6.4). Streamflow conditions returned to low flow conditions (as per the first assessment) during the third assessment (refer Table 6.5).

The weather conditions leading up to the second assessment (undertaken between 27 February and 2 March 2018) were generally hot with rainfall occurring most days. Table 6.4 identifies that 137 mm of rain was recorded in the week leading up to the second assessment. February 2018 received a total of 273.2 mm of rain. Stream flow increased due to the significant rainfall experienced on the 23 February and 24 February 2018.

The weather conditions leading up to the third assessment (undertaken between 11 March and 13 March 2019) were generally hot with very high temperatures (>38°C) with minimal rainfall occurring. Table 6.5 identifies that 4.6 mm of rain was recorded in the week leading up to the third assessment. February received a total of 20.8 mm of rain. With the limited rainfall experienced before the third assessment stream flow decreased from the second round of sampling.

Table 6.3 Recorded rainfall from Amberley AMO (station number 40004) and streamflow discharge at the Warrill Creek at Amberley (143108A) and Western Creek at Kuss Road gauging stations (143121A) leading up to and including the first assessment

Day/date	Rainfall amount (mm)	Warrill Creek stream flow (Avg M/L per day)	Western Creek stream flow (Avg M/L per day)
Monday 18/09/2017	0	1.97	0.00
Tuesday 19/09/2017	0	1.86	0.00
Wednesday 20/09/2017	N/A	5.54	0.00
Thursday 21/09/2017	0	7.44	0.00
Friday 22/09/2017	0	5.13	0.00
Saturday 23/09/2017	0.8	3.60	0.00
Sunday 24/09/2017	0	2.59	0.00
Monday 25/09/207	0	2.60	0.00
Tuesday 26/09/2017	0	3.71	0.00
Wednesday 27/09/2017	0	9.23	0.00
Thursday 28/09/2017	0	9.45	0.00
Friday 29/09/2017	0	7.55	0.00

Source: BoM 2020, DNRME 2020

Table 6.4 Recorded rainfall from Amberley AMO (station number 40004) and streamflow discharge at the Warrill Creek at Amberley (143108A) and Western Creek at Kuss Road (143121A) gauging stations leading up to and including the second assessment

Day/date	Rainfall amount (mm)	Warrill Creek stream flow (Avg M/L per day)	Western Creek stream flow (Avg M/L per day)
Monday 19/02/2018	0	34.48	0.00
Tuesday 20/02/2018	2.0	30.93	0.00
Wednesday 21/02/2018	2.0	28.08	0.00
Thursday 22/02/2018	0.6	26.07	0.00
Friday 23/02/2018	42.8	48.44	0.00
Saturday 24/02/2018	89.0	3,347.90	3.57
Sunday 25/02/2018	0.6	5,956.79	47.16
Monday 26/02/2018	29.4	1575.10	55.42
Tuesday 27/02/2018	4.0	7835.09	508.49
Wednesday 28/02/2018	0.2	3545.33	82.93
Thursday 01/03/2018	0.0	765.15	37.62
Friday 02/03/2018	0.0	430.29	23.42

Source: BoM 2020, DNRME 2020

Table 6.5 Recorded rainfall from Amberley AMO (station number 40004) and streamflow discharge at the Warrill Creek at Amberley (143108A) and Western Creek at Kuss Road gauging stations (143121A) leading up to and including the third assessment

Day/date	Rainfall amount (mm)	Warrill Creek stream flow (Avg M/L per day)	Western Creek stream flow (Avg M/L per day)
Monday 04/03/2019	1.4	11.93	0.00
Tuesday 05/03/2019	0	9.49	0.00
Wednesday 06/03/2019	0	6.93	0.00
Thursday 07/03/2019	0	5.69	0.00
Friday 08/03/2019	3.2	5.22	0.00
Saturday 09/03/2019	0	4.86	0.00
Sunday 10/03/2019	0	4.29	0.00
Monday 11/03/2019	0	3.23	0.00
Tuesday 12/03/2019	0.2	2.65	0.00
Wednesday 13/03/2019	0	1.00	0.00

Source: BoM 2020, DNRME 2020

6.2.2 Summary of field and laboratory assessed surface water quality data

Across all three assessments, pH values for watercourses within both the Logan River and the Bremer River catchments were typically neutral and mostly compliant with WQOs. Minor magnitude non-compliance instances of WQOs were noted, with one watercourse exceeding Bremer River WQOs and one watercourse exceeding Warrill Creek WQOs (refer Table 6.6).

Typically, turbidity values followed seasonal flow conditions across the assessments. Within the first assessment, turbidity values were below WQOs for watercourses within both the Logan River and Bremer River catchments and followed a pattern of variable turbidity linked to low to no flow conditions during the assessment (refer Table 6.6). Mobilisation of sediment with higher flow conditions were observed within the second assessment, with high level non-compliances of turbidity WQOs within both catchments. Within the second assessment, sites 5A, 9A and 14A were the only sites (across both catchments) that were compliant with surface water turbidity WQOs. Within the third assessment stream flow conditions were representative of the environmental conditions experienced across the catchments, with minimal to no flow experienced throughout all the water quality monitoring sites and variable turbidity values (dependant on localised standing pool conditions during assessment).

Electrical conductivity levels were typically below WQOs for the Logan River and Bremer River catchments. Noting that flow conditions varying between standing pools to high flow were present during the second assessment, the electrical conductivity levels observed were not considered atypical. A similar artefact of low flow conditions was noted during the third sampling event, as those watercourses that were sampled were limited to standing pools and were likely exhibiting concentrations impacted by evaporation.

In line with other physico-chemical parameters, dissolved oxygen concentrations within the watercourses demonstrated the disparity in flow conditions (refer Table 6.6). Expectantly, none of the sites sampled during the first round of monitoring were within WQOs. This pattern of non-compliance was present within the second round of sampling, as while improved, several sites across both the Logan River and Bremer River catchment still exhibited dissolved oxygen concentrations below WQOs. Within the third assessment, dissolved oxygen concentrations were highly variable with some sites compliant with WQO. It is worth noting that the sites with elevated dissolved oxygen concentrations also exhibited high chlorophyll *a* concentrations and suggest an enhancement of dissolved oxygen levels by algal photosynthesis within these sites (refer Table 6.6 and Table 6.7).

Chlorophyll *a* concentrations did not follow any discernible pattern across the sampling periods with non-compliances noted during assessments and across both the Logan River and Bremer River catchments (refer Table 6.7). Notably, most non-compliances were typically minor (relative to threshold concentrations for non-compliance), with a notable exception of one site (11A) within the Logan River catchment exhibiting very high chlorophyll *a* concentrations during the first assessment (that coincided with high levels of suspended solids and nutrient load), with a return to WQO levels in the second assessment. Within the third assessment, monitoring sites that were assessable typically did not meet WQOs for chlorophyll *a,* coinciding with non-compliances in other WQOs.

Patterns of degradation were noted within several of the watercourses across the sampling period, indicating the potential for existing anthropogenic influences (refer Table 6.7). Specifically, within sites 5A, 7A, 8A, 9A, 11A, 12A and 13A, nutrient (primarily Total P and Total N) concentrations exceeded WQOs across assessments; indicating limited improvement of water quality with an increase towards base-flow conditions. Of the non-compliances in nutrient concentrations, high levels of ammonia concentrations were noted in Sites 5A, 5A (1) and 12A (both within the Bremer River catchment). As the 5A sites are located proximal to each other on the same watercourse, similar heightened concentrations are not considered atypical. Comparatively, site 12A exhibited ammonia concentrations elevated well above WQOs during the first event. Lower ammonia concentrations (yet exceeding water quality objectives) were noted during the second monitoring event, indicating improvement with a return to base-flow conditions before the site was assessed as dry at the time of the third sample event.

6.2.3 Field assessment water quality results

The field-assessed water quality results for the assessments are provided in Table 6.6. Refer Table 4.3 for field assessment timings.

Table 6.6 In situ water quality results for water quality monitoring sites (2017 – 2019)

Site	Date	pH	Electrical conductivity (µs/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)
Logan River catchment								
Logan River WQO	**-**	**6.5 – 8.0**	**< 780**	**n/a**	**< 10**	**n/a**	**n/a**	**85 – 110**
7A Dugandan Creek	27/09/2017	7.42	-	20.8	13.9	-	-	-
	27/02/2018	7.54	224	24.3	130	0.11	8.15	99
	13/03/2019	Dry at time of sampling						
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling						
	28/02/2018	7.26	160.5	23.6	95.5	0.08	6.75	79
	13/03/2019	Dry at time of sampling						
8A Dugandan Creek	27/09/2017	7.04	-	20.5	11.4	-	-	-
	28/02/2018	7.47	232.5	23.4	108	0.11	7.33	86.8
	13/03/2019	Dry at time of sampling						
9A Woollaman Creek	25/09/2017	7.83	-	25.0	10.2	-	-	-
	27/02/2018	7.59	176.3	24.5	88	0.08	7.09	85.1
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)						
10A Teviot Brook	25/09/2017	6.93	-	18.5	10.2	-	-	-
	27/02/2018	6.85	78.3	26.1	90	0.03	0.9	16
	13/03/2019	7.52	2775	27.2	7.8	1.37	5.55	71.5
11A Dam	25/09/2017	7.4	-	22.4	7.2	-	-	-
	27/02/2018	6.85	78.3	26.1	90	0.03	0.9	16
	13/03/2019	No access to site at sampling						
12A Un-named watercourse	28/09/2017	7.51	-	19	11.5	-	-	-
	28/02/2018	7.54	202.6	24.7	101.1	0.1	7.5	92
	13/03/2019	Dry at time of sampling						

Site	Date	pH	Electrical conductivity (µs/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)
Bremer River catchment								
Western Creek/ Bremer River WQO	**-**	**6.5 – 8.0**	**< 770**	**n/a**	**< 17**	**n/a**	**n/a**	**85 – 110**
1A alt Western Creek	29/09/2017	7.49	-	18	5.9	-	-	-
	2/03/2018	7.82	338.4	25.5	76.2	0.16	3.63	44.1
	12/03/2019	Dry at time of sampling						
2A Bremer River	29/09/2017	Dry at time of sampling						
	28/02/2018	7.39	235	26.1	140	0.11	3.98	51
	12/03/2019	Dry at time of sampling						
5A Dam	26/09/2017	7.84	-	24.6	2.8	-	-	-
	28/02/2018	9.3	356.6	32.4	14.4	0.14	8.7	118.2
	13/03/2019	9.14	782	28.7	46.5	0.35	7.72	101.1
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling						
	28/02/2018	6.75	156	26.1	77.5	0.07	0.55	7.7
	13/03/2019	Dry at time of sampling						
6A Un-named tributary of Purga Creek	28/09/2017	7.66	-	19.2	5.3	-	-	-
	28/02/2018	7.52	321.9	27.2	105	0.15	6.2	77
	13/03/2019	7.49	3206	23.5	39.6	1.72	1.45	17.1
13A Un-named tributary of Purga Creek	26/09/2017	7.49	-	19.6	1.3	-	-	-
	28/02/2018	7.4	213.6	26.9	130	0.11	5.29	71
	13/03/2019	7.53	2110	24.5	35.7	1.09	4.56	53.9
14A Un-named tributary of Purga Creek	27/09/2017	Dry at time of sampling						
	28/02/2018	7.46	252.6	25.8	61.4	0.12	6.91	85
	13/03/2019	Dry at time of sampling						

Site	Date	pH	Electrical conductivity (µs/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen (%)
Warrill Creek WQO	**-**	**6.5 – 8.0**	**< 500**	**n/a**	**< 5**	**n/a**	**n/a**	**85 – 110**
3A Warrill Creek	28/09/2017	8.01	-	21.2	0.4	-	-	-
	28/02/2018	Dry at time of sampling						
	13/03/2019	No access to site at sampling						

Table note:

Colour text indicates value is above WQO or outside WQO range where applicable

Source WQO: DERM (2010a; 2010b)

In general, WQOs for metals were typically met across all assessable water quality monitoring sites for the survey period (refer Table 6.8). Exceedances within two specific dissolved metals (copper and zinc) were noted in the second round of sampling for both the Logan River and Bremer River catchment, while no non-compliances were noted in the first round of sampling. Laboratory analysis of PAH concentrations at all sites were below detection limits, indicating no continued point source contamination of sampled sites, though it is recognised that these compounds are volatile and may not be very persistent in the environment.

A general summary description of water quality encountered for the water quality study area is presented in Appendix C Table C-1. A general description of each site is provided in Appendix C Table C-2.

6.2.4 Laboratory assessed water quality results

The summary of the laboratory results for the assessments for the water quality study area are provided in Table 6.7 and Table 6.8.

Table 6.7 Key laboratory results for water quality monitoring sites (refer Table 4.3 for field assessment timings)

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll a (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
Logan River catchment														
Logan River WQO	**-**	**6.5 – 8.0**	**< 780**	**< 5**	**< 0.05**	**0.02**	**< 6**	**< 10**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**< 0.5**
7A Dugandan Creek	27/09/2017	8	1500	<5	<0.05	<0.05	9.9	7.3	0.03	<0.02	<0.02	0.7	0.7	0.7
	27/02/2018	7.7	180	<5	0.09	<0.05	14	120	0.03	0.07	<0.02	0.9	0.9	0.97
	13/03/2019	Dry at time of sampling												
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling												
	28/02/2018	7.4	140	<5	0.07	<0.05	10	90	<0.01	<0.02	0.03	0.5	0.5	0.5
	13/03/2019	Dry at time of sampling												
8A Dugandan Creek	27/09/2017	7.9	1200	<10	<0.05	<0.05	12	6.6	0.06	<0.02	<0.02	0.5	0.6	0.6
	28/02/2018	7.4	180	<5	0.07	<0.05	7.7	99	0.02	0.06	<0.02	0.7	0.7	0.77
	13/03/2019	Dry at time of sampling												
9A Woollaman Creek	25/09/2017	8.2	940	<5	<0.05	<0.05	15	5.2	0.04	<0.02	<0.02	<0.02	0.7	0.7
	27/02/2018	7.4	160	<5	0.08	<0.05	45	140	0.03	0.04	<0.02	0.8	0.8	0.86
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)												
10A Teviot Brook	25/09/2017	7.8	990	<5	<0.05	<0.05	6.8	5	0.02	0.09	<0.02	0.4	0.4	0.4
	27/02/2018	8	470	6	0.06	<0.05	14	9	0.02	<0.02	<0.02	0.5	0.5	0.5
	13/03/2019	8.2	2700	<5	0.01	0.01	13	7.4	<0.01	<0.02	<0.02	0.29	0.3	0.29
11A Dam	25/09/2017	6.9	100	580	<0.05	<0.05	110	35	<0.01	<0.02	<0.02	2.3	2.3	2.3
	27/02/2018	6.8	49	<5	0.18	<0.05	33	32	0.05	<0.02	<0.02	0.6	0.6	0.6
	13/03/2019	Dry at time of sampling												

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll *a* (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
12A Un-named watercourse	28/09/2017	8.1	5400	12	0.25	<0.05	11	2.4	0.89	<0.02	<0.02	1.6	2.5	2.5
	28/02/2018	7.3	180	<5	0.08	<0.05	6.4	97	0.07	0.19	<0.02	0.6	0.7	0.89
	13/03/2019	Dry at time of sampling												
Bremer River catchment														
Western Creek/ Bremer River WQO	**-**	**6.5 – 8.0**	**< 770**	**< 5**	**< 0.05**	**<0.02**	**< 6**	**< 17**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**< 0.5**
1A alt Western Creek	29/09/2017	8.1	910	33	0.17	0.11	14	5.9	0.04	0.03	<0.02	1.0	1	1
	2/03/2018	7.7	290	<5	0.48	0.92	22	58	0.02	0.2	0.05	1.0	1	1.3
	12/03/2019	Dry at time of sampling												
2A Bremer River	29/09/2017	Dry at time of sampling												
	28/02/2018	7.4	200	<5	0.54	0.36	49	95	0.07	0.05	<0.02	0.7	0.8	0.85
	12/03/2019	Dry at time of sampling												
5A Dam	26/09/2017	8.1	280	<5	0.19	0.12	8	8.4	0.08	<0.02	<0.02	1.4	1.5	1.5
	28/02/2018	8.5	270	11	0.07	<0.05	25	7.9	0.28	<0.02	<0.02	1.2	1.5	1.5
	13/03/2019	9.1	380	32	0.01	0.01	36	21	<0.01	<0.02	<0.02	1.6	1.6	1.6
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling												
	28/02/2018	6.8	130	<5	0.12	0.07	17	56	0.19	<0.02	<0.02	1.1	1.1	1.1
	13/03/2019	Dry at time of sampling												
6A Un-named tributary of Purga Creek	28/09/2017	8.1	2800	<10	<0.05	<0.05	4.9	3.2	0.02	<0.02	<0.02	0.6	0.6	0.6
	28/02/2018	7.6	250	<5	0.08	<0.05	26	98	0.02	<0.02	<0.02	0.7	0.7	0.7
	13/03/2019	8.3	3400	<5	0.02	0.01	42	34	0.67	0.06	<0.02	1.2	1.9	1.9

Site	Date	pH	Conductivity (at 25°C) (µs/cm)	Chlorophyll *a* (µg/L)[1]	Total P (mg/L)[2]	Filterable reactive nitrogen (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
13A Un-named tributary of Purga Creek	26/09/2017	8.2	2100	<5	<0.05	<0.05	3.8	0.3	0.03	<0.02	<0.02	0.3	0.3	1
	28/02/2018	7.6	200	<5	0.07	<0.05	95	120	<0.01	<0.02	<0.02	0.6	0.6	0.6
	13/03/2019	8.4	2000	20	0.01	0.01	24	9.7	<0.01	<0.02	<0.02	0.59	0.6	0.59
14A Un-named tributary of Pura Creek	27/09/2017	Dry at time of sampling												
	28/02/2018	7.6	220	<5	0.09	<0.05	9.3	62	0.02	<0.02	<0.02	0.7	0.7	0.7
	13/03/2019	Dry at time of sampling												
Lower Warrill Creek WQO	**-**	**6.5 – 8.0**	**< 500**	**< 5**	**< 0.05**		**< 6**	**< 5**	**< 0.02**	**-**	**-**	**< 0.06**	**-**	**< 0.5**
3A Warrill Creek	28/9/2017	8.3	980	<10	0.07	0.05	3.5	1.1	<0.01	<0.02	<0.02	0.4	0.4	0.4
	28/02/2018	Dry at time of sampling												
	13/03/2019	No access to site at sampling												

Source WQO: DERM (2010a; 2010b)

Table notes:

Coloured text where value is above WQO or outside WQO range where applicable

1 Chlorophyll *a* concentrations during the 2017 assessment were recorded as <10 or <5 at concentrations below <10 µg/L

2 LOR changes for total P occurred between field assessments 2 (September 2018) and 3 (March 2019)

Table 6.8 Dissolved metal and indicative PAH laboratory results for C2K water quality monitoring sites

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
LOR	**-**	**0.001**	**0.0002**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.005**	**0.001**
Logan River catchment										
Logan River WQO	**-**	**0.024**	**0.0002**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
7A Dugandan Creek	27/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	0.001	0.001	<0.0001	0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
7A alt Un-named watercourse	27/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
8A Dugandan Creek	27/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.01	<0.001
	13/03/2019	Dry at time of sampling								
9A Woollaman Creek	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	0.009	<0.001
	13/03/2019	Dry at time of sampling (*visual assessment due to no access at time of sampling)								
10A Teviot Brook	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
11A Dam	25/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	27/02/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								
12A Un-named watercourse	28/09/2017	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.001	<0.005	<0.001
	13/03/2019	Dry at time of sampling								

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
LOR	**-**	**0.001**	**0.0002**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.005**	**0.001**
Bremer River catchment										
Western Creek/ Bremer River WQO	**-**	**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
1A alt Western Creek	29/09/2017	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	02/03/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.004	0.008	<0.001
	12/03/2019	Dry at time of sampling								
2A Bremer River	29/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.004	<0.001	<0.0001	0.004	<0.005	<0.001
	12/03/2019	Dry at time of sampling								
5A Dam	26/09/2017	0.003	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	13/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
5A (1) Un-named watercourse	29/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.002	0.009	<0.001
	13/03/2019	Dry at time of sampling								
6A Un-named tributary of Purga Creek	28/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.001	0.006	<0.001
	13/03/2019	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
13A Un-named tributary of Purga Creek	26/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	28/02/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.001	0.011	<0.001
	13/03/2019	0.006	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
14A Un-named tributary of Pura Creek	27/09/2017	Dry at time of sampling								
	28/02/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	<0.005	<0.001
	13/03/2019	Dry at time of sampling								

Site	Date	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Naphthalene (mg/L)
LOR	**-**	**0.001**	**0.0002**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.005**	**0.001**
Lower Warrill Creek WQO	**-**	**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
3A Warrill Creek	28/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	02/09/2018	Dry at time of sampling								
	13/03/2019	No access to site at sampling								

Table note:

Coloured text where value is above WQO or outside WQO range where applicable

Source: WQO: DERM (2010a; 2010b)

6.3 Summary of existing surface water quality condition

Upon comparison with historical water quality data for Warrill Creek, Purga Creek and Western Creek (refer Section 5.3.5) (as a general proxy for the water quality study area), water quality values observed during the three sampling rounds typically followed those of the gauging stations. Water quality was typically outside of WQOs with TSS exceeding WQOs historically and within the current assessment. Total nitrogen and phosphorus as a typical anthropogenic contaminant also followed historical data with WQO non-compliance noted throughout the entire assessment period.

Whilst WQOs generally do not meet historical mean values, results from the three sampling rounds conducted for this study suggest that compliance with WQOs is affected by highly seasonal water flow conditions observed throughout the water quality study area. Within the gauging stations, a majority of the quantified water quality parameters (i.e. TSS, ammonia, total nitrogen and total phosphorus) did not meet WQOs. The gauging stations indicate the discharge along Western Creek, Warrill Creek and Purga Creek were highly variable and indicate low flow conditions experienced across periods of the entire monitoring period are not atypical. Water quality (specifically physico-chemical parameters and laboratory analysed data) was observed to improve with an increase in hydrological flow and the assimilative capacity would be expected to be greatest during high flow conditions.

Moderate, low and very low Aquascore riverine wetlands are modelled along the Project alignment and correspond to the healthy water assessment of each catchment. The assessment indicates typical processes are ‘good’ with fair-average riparian condition throughout the catchment. While non-compliances of WQO were noted within particular parameters throughout the entire assessment period, water quality can be generalised to be meeting a large variety of WQO and ANZECC guidelines (including metals and PAH analysis). However, non-compliances of several nutrient contamination are notable and continuing (through assessment of historic and current field assessment).

The water quality monitoring sites associated with moderate Aqauscores for riverine wetlands were those on sections of the Western Creek, the Bremer River, Warrill Creek, Purga Creek and Teviot Brook. Those associated with low to very low Aquascores were associated with a tributary of Western Creek and Purga Creek, Dugandan Creek and Woollaman Creek.

In summary, habitat conditions during assessment was not considered atypical (in terms of periods of low surface hydrological flow), however clear impacts of diminished flow conditions were noted throughout the assessment. In regard to the field assessment, water quality parameters improved with a higher surface hydrological flow within the second field assessment and, where water persisted, decreased in the third assessment.

7 Potential impacts

Potential surface water quality impacts will be avoided/minimised through initial mitigation through design responses and proposed in situ mitigation measures as required (refer Section 8.1 and Section 8.2 respectively). Potential impacts were assessed with consideration of the existing surface water quality condition, sensitivity of water quality receptors (including acknowledgment of downstream impacts and the assimilative capacity of the surrounding catchment).

The assessment of surface water quality included consideration of the assimilative capacity of the receiving environment through historical and existing compliance with WQOs and input from the existing surface water environment assessment from a variety of watercourses within both the Bremer River and Logan River catchments. Currently, the existing environment does not meet all the WQO for these catchments. The assimilative capacity was assessed using qualitative risk of degradation of water quality from potential Project impacts.

It is noted that electrical conductivity at high flow significantly decreases and it is considered likely that assimilative capacity of the watercourses within the water quality study area will be higher during higher flow conditions (refer Appendix E). In contrast, the lowest assimilative capacity and highest realisation of impact would occur during periods of extended low flow (such as those currently experienced). Noting this, potential impacts from the Project would likely occur with periods of continued rainfall, resulting in higher hydrological flow and greater assimilative capacity in regard to potential impacts.

Within this impact assessment, the total quantity of waste water (across the entire alignment) was not calculated as the quantities are only considered for tunnel wastewater discharge during construction and operational works (refer Section 2.1). Further, wastewater is considered to be contained by the twenty-two sediment control basins utilised for construction (refer Section 2.6).

Point source discharge for the Project is anticipated only to occur along cut-and-fill lines. The principle discharges are considered to occur at cross-drainage infrastructure points as associated with potential upward seepage from aquifers. Given discharges will be reliant on the water quality and quantity of overland flows at these points any impacts are likely to be minor.

Waste water quality was incorporated as part of the significant impact assessment across several facets, including dewatering of artificial impoundments and tunnelling, and, overland flow of construction water.

Waste water quality involving total suspended solids, total phosphorus and total nitrogen via MUSIC modelling of alignment drainage, indicated that impacts to rural areas associated with potential stormwater discharges are expected to be negligible with buffering from swales producing discharge of a better quality (reduced concentrations) than typical for rural areas. Modelled discharge along the alignment is predicted to contain suspended solids and nutrients in concentrations higher than forested conditions, however, these pollutant loads would be expected to be discharged from a comparable area of nearby rural catchment. It is expected that these will be contained within the areas of targeted restoration and be limited in impact to receiving waterways.

Through information gathered during the assessment process, sensitive receptors within the receiving environment (refer Section 5.11) which have the potential to be subject to significant impacts, have been identified within the water quality study area. These sensitive receptors are considered for the identification of potential impacts, associated mitigation measures and identification of residual impact after implementation of mitigation.

7.1 Surface water quality impacts

7.1.1 Construction phase impacts

A number of construction phase (including pre-construction phase) activities which are likely to impact the surface water quality are discussed below:

- Increased debris is considered to have the potential to impact all watercourses and waterbodies along the Project alignment due to conveyance through overland flow pathways to both static waterbodies and flowing watercourses and unmapped waterways. Increased debris and rubbish is considered to have the potential to result in a degradation of surface water quality receptors via both direct and indirect impacts. The potential impact to surface water quality values includes; a reduction in water flow (via mechanical blockages), loss of ecosystem values (via smothering and aquatic ecological value impact) and direct leachate impacts (via the accumulation of rubbish and debris blown off or washed away from a construction area into nearby waterways).
- Changes to receiving surface water quality and hydrology (principally from increased water turbidity and sedimentation load) are considered to result in indirect and direct impacts on surface water quality receptors. Without adequate mitigation measures in place, the potential indirect impacts from potential changes to overland flow pathways and diversions are considered to have a high risk of impacting surface water quality receptors associated with both:
  - Flowing watercourses and unmapped waterways
  - Static waterbodies occurring downstream of the Project works.
- Indirect surface water quality changes may occur downstream as a result of increased turbidity and sedimentation associated with an increase in mobilisation of sediment-bound metals and other substances. The mobilised substances have an increased potential to directly impact surface water quality values and indirectly impact aquatic ecosystem values. In addition, increased water turbidity and sedimentation may also result in significant changes to localised hydrological regimes, especially in pinch points (such as existing culverts) which may result in smothering of aquatic flora receptors, leading to a direct impact on surface water quality receptors. Alteration of surface water quality and hydrology from increased turbidity and sedimentation load may occur from a variety of Project activities such as:
  - Construction works resulting in elevated sediment concentrations in surface water runoff as a result of inadequate erosion sediment controls
  - Construction works involving disturbance to the riparian corridor may result in erosion and scouring of streambanks
  - Physical disturbance of stream beds and banks leading to a reduction in stability during construction of creek crossings
  - Erosion of cleared riparian areas and inadequate rehabilitation processes
  - Altered hydrological regimes from drainage flow change (of unmapped waterway) due to diversion at western tunnel portal
  - Dewatering works resulting in an increase of sediment loads from dewatering activities near excavations and water quality issues from dewatering activities associated with tunnel infrastructure works. Dewatering associated with decommissioning artificial waterbodies that intersect the Project alignment may additionally cause an increase in erosion and sedimentation of watercourses and drainage features if dewatering activities are not adequately managed
  - Vegetation clearing, which could leave exposed soils prone to erosion
  - Bank-cutting to re-direct the drainage feature at the western tunnel portal
  - Potential erosion risk associated with soils exposed during topsoil stripping, earthworks, excavation and trenching activities required for infrastructure and material borrow pits development

- Changes to the physical attributes of waterways from removal of buffering vegetation.

- Altered hydrology and subsequent water chemistry changes are considered potential direct and indirect impacts from Project activities. Alteration to the hydrological regime of the Purga Creek catchment associated with tunnel dewatering is considered a potential direct impact on surface water quality receptors through potential changes in wetting and drying regimes. This is considered to indirectly impact surface water quality receptors downstream of the dewatering release through diversion changes to overland flow pathways and through potential changes to aquatic ecological values. Potential surface water quality changes from Project activities are considered a direct impact and have potential to impact all surface water quality receptors associated with the Project. Potential impact is expected to occur from all Project activities associated with potential changes to hydrology, especially those resulting in the liberation of contaminants (typically associated with problematic soils from any potential changes to hydrology). The direct impact on surface water quality receptors is considered to have a localised indirect impact on aquatic ecological receptors through degradation of water quality parameters. Project activities considered to cause a potential impact on hydrology and water chemistry are:
  - Clearing activities and construction of infrastructure, resulting in changes to habitat form (biotic and abiotic) through alteration of hydrological regime (flow and quality)
  - Accidental spills and leaks of chemicals or fuels from construction equipment or fuel storages, which could introduce chemicals into overland flows
  - Overland flow diversions (e.g. between Project Chainages Ch 39.28 km to Ch 39.54 km)
  - Introduction of exotic weed species
  - Increase of sediment loads from dewatering activities near excavations and surface water quality issues from dewatering activities associated with tunnel infrastructure works, including the removal of wastewater from the tunnel during construction and operation. Dewatering associated with decommissioning artificial waterbodies that intersect the Project alignment may additionally cause an increase in erosion and sedimentation of watercourses and drainage features if dewatering activities are not adequately managed.
  - Subsoil exposure within excavations and borrow pits which have the potential to result in the leachate of acid rock drainage from the soil into overland flow
  - The erosion of stockpiled materials, which could lead to increased nutrient concentrations in overland flow
  - Impact to proximal wetlands, with high sensitivity receptor areas associated with Teviot Brook and Bremer River
  - Dewatering of tunnel infrastructure may result in changes to water quality within Purga Creek tributaries due to disparity in groundwater discharge from tunnel construction, resulting in potentially high impact to aquatic ecology and surface water quality

- Increase in salinity at a localised and regional scope are considered potential indirect impacts from the Project activities. Salinity impacts on surface water quality receptors are considered to potentially occur from a variety of Project activities and have the capacity to result in regional impacts derived from point source impacts associated with the Project works. Salinity issues are considered to have a direct impact on surface water quality receptors within the Project alignment and are further considered to have an indirect impact on ecosystem services (and water quality receptors) downstream of the point source salinity impact. Project activities considered to cause a potential increase in localised and regional salinity are due to:
  - Project alignment directly intersecting moderate to high salinity hazard rating areas potentially resulting in discharge of saline runoff into proximal waterways, particularly within the high salinity hazard rating areas that have been modelled as occurring along the Project alignment
  - Disturbance of saline soils during construction, which may increase salinity pressures in overland flows through identified high risk salinity hazard areas

- Erosion and sedimentation increases are considered a direct impact from Project activities. These are considered to have a direct impact on surface water quality receptors at a localised scope. At a regional scope after transport downstream from the point source, the impact is considered to be indirect. Transport of sediment and eroded material can be washed off into cleared areas or stockpiled areas during rainfall events. This may increase sediment loads and turbidity within waterways and potentially increase nutrient loads. Direct impact from degradation of surface water quality will be realised from changes to light conditions and loss of ecosystem services due to changes to aquatic flora and fauna structure. Project activities considered to potentially increase sedimentation and erosion primary involve:
  - In-stream earthworks leading to changes in surface water quality due to the number of new bridge structures and culverts that will be required for the Project
  - Stockpiling of sediment (e.g. from cut and fill processes), mulch or other materials near waterways has the potential for runoff during rain events and impacts to the water quality of nearby waterways
  - Inappropriate rehabilitation of riparian vegetation work areas
- Introduction of contaminants from a variety of sources during construction is considered to be a direct impact from Project activities. The introduction of contaminants is considered to have direct impact on receptors through direct changes to surface water quality parameters. The direct changes to surface water quality parameters are considered to have the potential for indirect changes to aquatic ecosystem services, leading to the potential for further impacts on surface water quality receptors. Project activities considered to increase the potential introduction of contaminants include:
  - Chemical, fuel and oil spills due to inappropriate storage controls and refuelling/maintenance procedures
  - Heavy metals entering waterways from rail grinding and welding
  - Compounds leaching from ballast materials
  - Spills associated with train derailments or breakdowns
  - Salts mobilised from surface soils or shallow groundwater changes
  - Dewatering activities leading to liberation of toxicants from potentially contaminated land
  - Disturbance of contaminated lands near waterways resulting in contaminated runoff entering waterways
  - Inadequately treated dewatering of tunnel infrastructure may result in hydrocarbons being introduced to the Purga Creek tributaries, resulting in a potentially high impact to surface water quality.

7.1.2 Operational phase impacts

Potential impacts and the operational phase activities likely to impact the surface water quality include:

- Increased debris due to:
  - Potential for rubbish and debris from operations to be blown off or washed away from the Project into proximal watercourses.
- Altered hydrology and water chemistry (increase in salinity) due to:
  - Changes to receiving water quality from tunnel dewatering discharge and point discharge from culvert locations along the alignment. Principally, the intrusion of groundwater into the tunnel, and, the associated dewatering regime may impact on the receiving watercourse, particularly in regard to salinity
  - Changes to hydrological regime with Purga Creek catchment associated with tunnel discharge due to improper hydrological flows from the treated discharge water.

- Introduction of contaminants from a variety of sources during operation due to:
  - Oil and grease spills – there is the potential for oil and grease from rolling stock to enter the waterways after heavy rainfall events without appropriate controls.
  - Heavy metals from maintenance rail grinding and welding
  - Compounds leaching from ballast materials
  - Accidental spills from freight carriages during routine operations
  - Chemicals, including fuels and oils used for construction machinery (as an artefact of potential construction impact)
  - Structural failure – with the introduction of bridge or culverts within waterways, should these structures fail, there is the potential for impacts to water quality either from potential contaminants (debris) or from detained water flushing from collapsed structures. Furthermore, structural failure has the capacity to alter flow regimes and increase potential secondary salinity issues, with flow on issues resulting in surface water quality degradation.
  - Maintenance of the rail line or machinery near waterways (such as the crossing loops associated with Purga Creek at approximately Ch 36.13 km – Ch 36.87 km) has the potential to mobilise sediments from disturbed areas and increase the potential for litter or rubbish to enter waterways. Furthermore, oils and greases and other contaminants such as metals have the potential to enter waterways from spills, and for impact from the use of environmental toxicants (such as biocides) to maintain operating infrastructure areas. Maintenance activities may result in the potential introduction of biocides, resulting in a loss of ecosystem service and subsequent direct and indirect impacts on water quality. These activities have the potential to impact nearby waterways, through discharge points without appropriate mitigation.
- Increase in erosion and sedimentation resulting from:
  - Earthworks and erosion of exposed soils (as an artefact of potential construction impact)
  - Construction of culverts and bridges within or nearby waterways. Potential for continued erosion and sedimentation without appropriate rehabilitation in these areas exists. This can increase sediment loads and turbidity within waterways. Increased sedimentation may then also impact the functioning of culverts should deposition become too high.

7.2 Impact to surface water users

There is the potential to impact upon licenced users of surface water (refer Table 5.12) if the quality of water or the flow of water changes within offtake locations on Warrill Creek (as a proximal identifier of further impacts to downstream surface water users). The design of the alignment will ensure that the changes to flow are minimised and will not impact users.

A flooding and hydrology study has been undertaken separately to this report detailing potential impacts to flow. There may be small changes to flow during construction if barriers are placed within watercourses during high flow events, however the potential for this to occur is low. Whilst change to hydraulic regimes may occur (due to new infrastructure) at 1% AEP conditions, changes to base-flow and low-flow conditions are not expected (refer EIS Appendix N: Hydrology and Flooding Technical Report) and will not significantly impede current surface water resource use.

The impact to water plans (supply and conveyance) within the disturbance footprint will be minimal due to limited overland flow interference and minimal diversion of defined watercourses. Hydrological modelling has not indicated significant changes to the current flow regimes and as such, minimal impact is expected to occur from the Project on supply and conveyance.

Impact to water plans will derive from diversion of watercourses and will principally be concerned with five trapezoidal diversion drains at locations where the rail embankment falls on top of existing flow paths. The affected waterway flow path and runs from Ch 39.28 km to Ch 39.54 km. ARTC and/or the construction contractor will obtain the relevant approvals for diversion and works that take or interfere with watercourse, lake or spring prior to construction.

Potential further impact to water plans may be expected due to the requirement for construction water, however this is expected to be regulated by the necessary authorities and will be conducted in accordance with the strategy for sourcing construction water (refer Section 8.2).

Wyaralong Dam and Churchbank Weir (Warrill Creek) have been identified as potential construction water supply options (refer Section 2.7). It is expected that the proposed offtake of water from these impoundments will comply with water plans and will not result in a loss of water quality, from unregulated use of surface water resources, due to Project activities. However, it is noted that at the time of writing it was considered that supply to downstream users of Churchbank Weir will likely cease around December 2020, and therefore until significant rainfall occurs, it is unlikely there will be any water available at Churchbank Weir.Impact to the surface water users will revolve principally around the impact on water quality from the identified potential impacts in Section 7; including increased debris, altered water quality and hydrology, altered water chemistry, salinity increase, an increase in erosion and sedimentation and introduction of contaminants. When considered at a highly conservative level, impacts to water quality as a result of Project activities during construction may have transient impacts to local water users, potentially restricting access to human drinking water, stock water and crop irrigation. As significant hydraulic changes are not expected from take or conveyance of construction water, impact to surface water users are considered to be restricted to those mentioned above.

Access to water also has implications other than those identified though the Water Act. This includes impacts to Seqwater operations, recreational activities, neighbouring landowners and erosion of access tracks.

Water quality protection of aquatic ecosystems will confer protection to current existing condition within the water quality study area, and water users downstream of the alignment. Therefore, identification of potential impact, mitigation measures (refer Section 8) and resulting impact assessment (refer Section 9) identifies any impact to surface water users. Noting that significant impacts on water quality are not considered within Project activities, a commitment to inform the resource operation licence holder (Seqwater) for the offtakes along Warrill Creek will be undertaken.

8 Mitigation

This section outlines both the mitigation measures included as part of the design and the mitigation measures that are proposed for application in future phases the Project to manage predicted impacts to water quality. Mitigation measures have been developed to minimise impacts associated with construction and operation of the Project. Mitigation strategies have been developed based on the following hierarchical criteria:

- Primary: avoid potential impacts where possible during Project design
- Secondary: minimise the severity and/or duration of the impact during Project design
- Last: apply mitigation measures for unavoidable impacts.

8.1 Design considerations

The mitigation measures and controls presented in Table 8.1 have been incorporated into the Project's design and will be factored into the detailed design phases for the Project. These design considerations are proposed to avoid and minimise potential environmental impact associated with the Project and therefore contribute to a lowering of the initial impact risk rating for each potential impact before the application of in situ mitigation.

Table 8.1 Initial mitigation through design responses

Aspect	Initial design measures
Interference with existing surface water, and, water quality	▪ Watercourse crossing structures (including culverts, viaducts and bridges) are designed to minimise the need for ongoing maintenance and inspection to maintain aquatic fauna (e.g. fish) passage and minimise the risk of blockages in reference to Accepted development requirements for operational work that is constructing or raising waterway barrier works (1 October 2018) (DAF, 2018) ▪ Bridges, viaducts and waterway crossings are designed to minimise impacts to bed, banks and environmental flows, in accordance with relevant regulatory requirements (as per requirements of DAF and the Fisheries Act) ▪ The design has been developed to avoid the need to permanently divert watercourses, as defined and mapped under the Water Act (it is noted that no current defined watercourse are identified to be diverted) ▪ The design has been developed to minimise impacts to watercourses, riparian vegetation and in-stream flora and habitats by adopting a crossing structure hierarchy where viaducts and bridges are preferred to culverts ▪ Bridge structures are provided in the design over the following watercourses, to minimise disturbance of aquatic habitats: Western Creek, Bremer River, Ebenezer Creek, Warrill Creek, Purga Creek, Sandy Creek, Dugandan Creek, Wild Pig Creek, Woollaman Creek and Teviot Brook ▪ Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments ▪ Scour protection measures have been included around culvert entrances and exits, on disturbed stream banks and around waterfront land to avoid erosion ▪ Cross-drainage structures have been incorporated into the design where the Project intercepts existing drainage lines and watercourses. The type of cross-drainage structure in the design depends on various factors such as the natural topography, rail formation levels, design flow and soil type ▪ The design includes 22 sediment basins. All sediment basins are passive which allows surface runoff from a catchment to flow into the sediment basin without the need for pumping.

8.2 Proposed mitigation measures

In order to manage Project risks during construction a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as presented in Table 8.2. These proposed mitigation measures have been identified to address to Project specific issues and opportunities, address legislative requirements, accepted government plans, policy and practice.

Table 8.2 identifies the relevant Project phase, the aspect to be managed, and the proposed mitigation measure, which is then factored into the assessment of residual significance in Table 9.1.

Within the water quality assessment of impacts and significance, pre-construction has been grouped with construction due to the similarity in potential impact. In addition to the proposed in situ mitigation measures indicated in Table 8.2, further management frameworks are proposed for discharge and runoff management, tunnel dewatering treatment, a surface water quality (receiving environment) monitoring and salinity management (refer Sections 8.3.2, 8.3.3 and 8.3.4).

In addition to the mitigation measures identified above and as part of the Detailed Design stage, when finalised positions of infrastructure elements (e.g. abutments/piers etc) are known and detailed soil studies are complete, geomorphological assessment of identified risk locations will be undertaken.

Chapter 23: Draft Outline Environmental Management Plan of the EIS provides further context and the framework for implementation of these proposed mitigation and management measures.

8.3 Management framework

Management frameworks described here are recommended to be developed during detailed design with implementation under pre-construction/construction phase and continuation into operation as required.

8.3.1 Discharge and runoff management

Under the surface water monitoring framework to be developed, discharge and runoff will be monitored as part of the surface water monitoring required for the CEMP. It will identify monitoring locations at discharge points, and selected locations in waterways where works are being undertaken.

Particular discharge and runoff management will be required for the release of collected water from within the tunnel infrastructure and will require specific management in regard to release into receiving waters. As discharge will likely involve a drainage feature proximal to the western tunnel portal, specific management of the hydrological regime of release will be required, in the form of periods of water/dewatering releases into the drainage feature to minimise a change in hydrological regime and ecological processes.

In the event that WQOs cannot be achieved for receiving waters, alternate treatment/disposal options as adaptive management actions (i.e. disposal options in line with potential down-time of water treatment plant) are to be implemented in accordance with any relevant and applicable condition of approval or legislation and regulations in place. The water treatment plant is expected to have holding tanks of sufficient size to allow for holding of raw water during potential down time of the water treatment plant, to remove instances of raw water release into receiving environments.

Table 8.2 Proposed surface water quality mitigation measures

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Water quality of waterways	Seek to further refine the disturbance footprint identified and assessed in the EIS, to avoid, and where avoidance is not possible, further minimise impacts to all waterways including defined watercourses, currently unmapped waterways and drainage features (defined by *Water Act 2000* (Qld)) and water quality of Western Creek, the Bremer River, Warrill Creek, Sandy Creek, Purga Creek, Woollaman Creek, Undullah Creek, Teviot Brook, their tributaries and downstream impoundments or users by: ▪ Avoiding, then minimising the extent and duration of temporary waterway diversions ▪ Avoiding, then minimising the extent of permanent waterway diversions or realignments. Where unavoidable, permanent waterway realignment/diversion design to include simulation of natural features e.g. meanders, pools, riffles, shaded and open sections, deep and shallow sections and different types of sub-strata, depending on the pre-disturbance environmental values. ▪ Planning and defining maintenance activity locations, construction compounds and storage areas, and management procedures ▪ Undertaking pre-construction water quality monitoring and detailed design hydraulic modelling to inform temporary and permanent drainage design. Requirements for treatment train controls, scour protection etc., to be incorporated where necessary to achieve modelled compliance with established water quality objectives. Temporary and permanent measures must be appropriate to the site conditions, responding to the erosion risk assessment, environmental receptors, climatic zone and seasonal factors. ▪ Developing ESCP, in accordance with International Erosion Control Association Best Practice Erosion and Sediment Control (2008) for implementation during pre-construction, construction and commissioning, which will establish and specify the monitoring and performance objectives for handover on completion of construction ▪ Ensuring the disturbance footprint defined during detailed design allows sufficient space for provision of the required temporary and permanent erosion and sediment control measures/pollution control measures ▪ Designing batters, cuts and other exposed surfaces to reduce erosion risk ▪ Designing watercourse crossing structures (including culverts and bridges) to minimise the need for ongoing maintenance and inspection to maintain aquatic fauna (e.g. fish) passage and minimise the risk of debris deposition during large flow events in accordance with relevant regulatory requirements.
	Monitoring	Develop the surface water monitoring framework to inform the development of the CEMP and the construction water quality monitoring program. It will identify monitoring locations including upstream, downstream and at the intersection of the Project disturbance footprint and watercourse. It will include the relevant water quality objectives, parameters, criteria and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality. The water quality monitoring program will include (as a minimum): ▪ Analysis of the representative background monitoring dataset. ▪ Identification of Project works and activities during construction and operation , including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points) ▪ A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures ▪ The identification of locality specific and construction activity erosion and sediment control and stormwater management requirements relating to surface waters during construction, commissioning and operation

Delivery phase	Aspect	Proposed mitigation measures
		▪ The presentation of Water Quality Objective (WQO) trigger values, standards and parameters against which changes to water quality will be assessed, having regard to the ANZECC/ARMCANZ 2000/2018 Guidelines, or other suitable guidelines. As a minimum this should include values for: – TSS - Equivalent to corresponding background (milligrams per litre (mg/L)) – Turbidity - Equivalent to corresponding background (Nephelometric Turbidity Units (NTU)) – pH 6.5-8. ▪ Oils and grease (no visible films). If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis. Establishment of construction surface water monitoring locations including waterways, waterbodies and wetlands (e.g. upstream of, downstream of, and at the intersection of the Project disturbance footprint and watercourse and tunnel dewatering into the Purga Creek sub-catchment) and discharge points, which are representative of the potential extent of impacts from the Project, including relevant analytes and frequency of monitoring. ▪ Identification of seasonal factors with the potential to influence water quality at the monitoring sites ▪ A minimum monitoring period following the completion of construction completion criteria (. Surface water quality during baseflow conditions, that meet representative pre-construction up and downstream background monitoring, and/or WQOs will confirm adequate rehabilitation. ▪ The post-construction monitoring will assess the efficacy of constructed water control measures, as defined as part of drainage during detailed design of the Project (such as vegetated buffer strips basins and vegetated swales). ▪ Contingency and ameliorative measures in the event that adverse impacts to water quality are identified, with reference to the impact triggers defined as part of the water quality monitoring program ▪ Surface water quality samples are to be collected and analysed in accordance with industry-accepted standards and quality assured procedures, with laboratory analysis undertaken by NATA accredited facilities. Commence the baseline water quality monitoring to obtain a suitable dataset, prior to construction, at waterway crossing locations to establish baseline water conditions and provide a sufficient seasonal variation.
	Drainage design, erosion sediment control	Water quality modelling will be undertaken to inform permanent drainage design for the rail and road realignments (i.e. requirements for treatment train controls, where necessary to comply with established water quality objectives, scour protection) and to inform erosion and sediment control plans. Design defines temporary and permanent stormwater, erosion and sediment/pollution control measures in ESCPs and Reinstatement and Rehabilitation Plans, that comply with IECA Best Practice Erosion and Sediment Control (2008). The aforementioned plans are to also establish and specify the monitoring and performance objectives for handover on completion of construction.

Delivery phase	Aspect	Proposed mitigation measures
	Construction water	Developing a dewatering strategy where dewatering of artificial impoundments is required (e.g. dewatering of artificial impoundment at Ch 2.90 km and Ch 4.60 km) to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality) and in accordance with any required aquatic fauna species management plans. Requirements for construction water (volumes, quality, demand curves, approvals requirements and lead times) will be defined during detailed design and construction planning. This should include identification of opportunities to utilise dewatered artificial impoundments (where impacted along the alignment) for construction purposes. Construction water sources and demand will utilise a hierarchical approach to confirm the suitability of water sources, with a focus on utilising existing sustainable allocated water entitlements from private water-holders. Licenses, approvals and agreements to access water from sources identified in the finalised construction water strategy will be obtained. These may include water licenses under the Water Act or access agreements with bulk water suppliers or private landholders. Specify performance criteria in the CEMP for construction water requirements to minimise the risk of adverse water quality, environmental or health impacts and avoid the use of potable water where non-potable sources can be applied.
	Tunnel dewatering	Groundwater quality and hydraulic modelling will be undertaken to inform the design for the Teviot Range tunnel dewatering treatment facility. Develop a treatment and discharge plan, consistent with the water quality monitoring framework for implementation at the tunnel dewatering plant. The collected water will be required to meet the water quality objectives (to be established during baseline water quality monitoring) for release to Purga Creek, and schedule release periods so as to minimise changes in hydrological regime, physical and chemical characteristics and ecological processes. The treatment and discharge plan will also establish criteria and protocols in the event that releases during no-flow conditions is required.
	Flooding and hydrology	Incorporate outcomes from consultation with stakeholders including directly impacted landholders, local government authorities, State Government departments and recognised subject matter experts to inform and refine the Project design. Continue to refine Project design in response to hydraulic modelling outcomes. This includes addressing flood impact objectives which include consideration of peak water levels, flow distribution, velocities and duration of inundation. This will confirm bridge lengths, culvert sizing and numbers, localised scour and erosion protection measures for both rail, road and other permanent Project infrastructure. Undertake a Project flood risk assessment to inform the siting and scale of temporary construction areas (including stockpiles, construction compounds, access, laydown areas etc.). Construction planning reviews of the design to locate plant and equipment maintenance activities and chemical/hazardous goods storage facilities in accordance with the risk assessment and incorporate appropriate location specific controls and procedures to minimise the risk and avoid impacts to waterways, aquatic habitats, and groundwater. Impacts must be determined at all drainage structures and waterways affected by Project works. The change in flood levels and impacts on infrastructure and properties outside the rail corridor must be justified for a range of events up to and including the 1% AEP event.

Delivery phase	Aspect	Proposed mitigation measures
Pre-construction	Erosion and sediment control (water quality related)	ESCPs will be developed as part of the CEMP, in accordance with IECA Best Practice Erosion and Sediment Control (2008). The ESCP will include the following procedures and protocols relevant to potential impacts on water quality values: ▪ Soil/land conservation objectives for the Project ▪ Management of problem soils, such as: – Acid sulfate soils, which may occur in proximity to artificial waterbodies or impoundments – Erosive or dispersive soils, such as sodosols that are expected to be encountered at Ch 10.00 km (associated with Ebenezer) – Cracking clays (vertosols) that are expected to be encountered in the disturbance footprint associated with the alignment in proximity of Purga and Willowbank – Saline soils, particularly in high salinity hazard areas such as between Che 7.50 km and Ch 22.50 km. ▪ Specification of the type and location of erosion and sediment controls. The erosion and sediment control measures will be developed by a CPESC and be in accordance with the IECA Best Practice Erosion and Sediment Control (2008). ▪ A Soil Management Plan that will include: – Locations for specific temporary/permanent erosion and sediment control measures, such as: – Sediment retention basins – Scour protection (included in the design) – Sediment fencing – Berms and other surface flow redirection through disturbance areas. ▪ Nomination of location-specific erosion controls will include consideration of site conditions, proximity to environmental receptors, adjoining land uses, climatic and seasonal factors, and will be based on an erosion risk assessment ▪ Minimise the area of disturbance during each stage to that required to enable the safe construction, operation and maintenance of the rail corridor ▪ Scheduling of works in areas proximal to waterways (as risk water quality receptors) with consideration to periods of higher rainfall (summer months), where practical ▪ Establish and specify the monitoring and performance objectives for handover on completion of construction ▪ Stockpiling and management/segregation of topsoil, where it contains native plants seedbank or weed material ▪ Vehicle, machinery and imported fill hygiene protocols and documentation, in accordance with the requirements of the *Biosecurity Act 2014* (Qld) ▪ Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction. The ESCPs are to include a process for site and activity specific preparation when forecasted large or high intensity wet weather events are predicted. This may include but not be limited to removing plant and equipment out of riparian zones, stabilising/covering live work areas, additional application of soil binders/veneers and pre event treatment and dewatering of sediment basins.
	Water quality	Review and adjust (as required) the surface water monitoring framework and develop the water quality monitoring program as part of the Surface Water Sub-plan of the CEMP, with reference to the baseline (representative background) monitoring dataset. Dewatering/extraction of water from artificial impoundments will be undertaken after consultation with relevant stakeholders.

Delivery phase	Aspect	Proposed mitigation measures
		To the extent possible and where required, stage Project works to utilise dewatered artificial impoundments to reduce external water requirements. Dewatering strategies will be required to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measures to avoid the spread of pest species (with capacity to affect water quality).
Construction and commissioning	Erosion and sediment control	Clearing extents are limited to the disturbance footprint, and clearing is scheduled to minimise the exposure time of unprotected materials to prevent sedimentation of receiving waterways. Appropriate erosion and sediment control measures are to be implemented for each stage or element of the Project works, in accordance with the progressive revisions of the ESCPs that are undertaken by a CPESC in accordance with IECA Best Practice Erosion and Sediment Control (2008). Stages/elements are expected to include (but not be limited to): ▪ Vegetation clearing and grubbing ▪ Temporary access tracks and/or temporary waterway crossings ▪ Early installation of stormwater drainage and clean water catch drains to divert clean water flows through/around the construction site ▪ Bulk earthworks and interim topography changes ▪ Waterway diversions ▪ Bridge and culvert works ▪ Ballast placement ▪ Reinstatement activities ▪ Rehabilitation and landscape activities. Temporary waterway crossings are rehabilitated in accordance with the Reinstatement and Rehabilitation Plan. Where practical and or in accordance with specific flora and fauna management plans, vegetation clearing and ground disturbing works will be staged sequentially across the Project to minimise areas exposed to erosion and sediment risk of receiving waterways and drainage lines in accordance with the general environmental duty of the *Environmental Protection Act 1994* (Qld).
	Water quality	Implementation of the Surface Water Management Sub-plan. The surface water monitoring framework will include the relevant water quality objectives, parameters, criteria and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality. To the extent possible, schedule works to utilise dewatered artificial impoundments along the alignment to reduce external water requirements. Dewatering strategies will be required to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality). In the event that water quality objectives cannot be achieved for waters to be released, alternate treatment/disposal options are to be implemented prior to release or re-use. Water will need to meet the established water quality objectives for receiving waterways before being released/discharged into local waterways. Water that does not comply with relevant water quality objectives will either be: ▪ Treated on-site to enable discharge ▪ Used for construction water purposes that is not quality dependent, if safe to do so and adequate environmental controls are in place ▪ Removed from site for disposal at an appropriately licensed facility.

Delivery phase	Aspect	Proposed mitigation measures
		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 SPP. Appropriate register and records of chemicals, hydrocarbons and hazardous substances and materials on site will be maintained up to date as required by the CEMP. Where appropriate this should include a relevant risk assessment prior to the substance coming to, and being used on site, plus a Safety Data Sheet Register. Licensed transporters operating in compliance with Australian Code for the Transport of Dangerous Goods by Road & Rail will be utilised for the transportation of dangerous goods Chemicals stored and handled as part of construction activities will be managed in accordance with: ▪ The *Work Health Safety Act 2011* (Qld) and Regulation ▪ AS 2187 Explosives – storage, transport and use ▪ AS 1940:2017 Storage and Handling of Flammable and Combustible Liquids ▪ AS 3780:2008 The Storage and Handling of Corrosive Substances ▪ The requirements of chemical safety data sheets ▪ Any relevant ERA conditions. Procedures will be established for safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas. The bunding will have floors and walls that are lined with an impermeable material to prevent leaching and spills. Construction tasks will be scheduled to avoid, where possible, bulk earthwork activities within the 1% AEP during periods of elevated flood risk. Where works cannot be scheduled outside of this time period, activity-specific flood readiness and response planning will be required. This planning will be developed in consultation with the relevant local government and QFES. Laydown areas and other construction facilities that are located within the 1% AEP will be temporary. Their planning and function in supporting construction will reflect the local flood risk. For example, hazardous goods will not be bulk stored in these locations. Mobile plant will not be stored in the 1% AEP when not scheduled to be in use for construction purposes. Plant maintenance and refuelling will be carried out with appropriate interception measures in place to avoid impacts to waterways, aquatic habitats and groundwater. Appropriate spill control materials including booms and absorbent materials will be onsite at refuelling facilities at all times. Appropriate waste bins will be located in laydown areas to facilitate segregation and appropriate containment of waste materials.
	Construction water	The extraction of water will occur in accordance with licenses, approvals and/or agreements. Volume monitoring during extraction will be required for each source point, with extraction logs maintained. Extraction reporting will occur, as required, in accordance with requirements of relevant licenses, approvals and/or agreements obtained to cover this activity.
	Waterways	Maintenance activities and refuelling will be carried out at an appropriate distance from riparian vegetation and waterways, with appropriate measures in place to avoid impacts to surface water quality. Where this is not achievable due to type of activities (e.g. piling activities within a riparian zone), additional mitigation measures must be implemented to prevent impacts on water quality.

Delivery phase	Aspect	Proposed mitigation measures
Operation	Water quality	Operational tunnel dewatering into the Purga Creek sub-catchment will be required to meet the established water quality objectives (or interim water quality guidelines) for receiving waterways before being released/discharged into local waterways. Water that does not comply with relevant water quality objectives will either be: ▪ Treated on-site to enable discharge ▪ Removed from site for disposal at an appropriately licensed facility. The effectiveness of permanent erosion controls (e.g. scour protection or vegetated swales) will be monitored as part of the maintenance inspection schedule for the Project, as prescribed in the Operation EMP: ▪ Controls that are found to be failing or not performing as intended will either be modified or replaced, as required ▪ Vegetation on the rail embankment slopes will be maintained to prevent slope face degradation. Maintenance of surface and subsurface drains will be required to ensure continued effectiveness and to minimise risk of impact to surrounding and downstream environments and structures.
	Flooding	Cross drainage structures will be inspected to assess physical condition and performance, structural integrity and corrective measures in accordance with ARTC's Structures Inspection Engineering Code of Practice (ETE-09-01).

8.3.2 Tunnel dewatering treatment

Water quality characteristics of groundwater tunnel drainage are expected to generally meet (EPP (Water and Wetland Biodiversity)) discharge criteria as regional WQOs for Purga Creek (refer Table 3.3 and Table 3.4). However, the salinity of groundwater drainage and total nitrogen may exceed salinity of receiving stream and required discharge criteria. This water will likely be processed through a WTP and include hydrocarbon and first flush separation before being released to Purga Creek. The discharged water will be expected to meet the WQOs for the protection of aquatic ecosystems of Purga Creek (under Schedule 1 of the EPP (Water and Wetland Biodiversity)) (refer Section 3.2.4).

A WTP has been included in the design for consideration as part of the disturbance footprint and power consumption requirements. Particular discharge and runoff management will be required for the release of collected water from within the tunnel infrastructure and will require specific management in regard to release into receiving waters. Preliminary assessment of tunnel dewatering suggests that salinity and total nitrogen concentrations of tunnel inflows could exceed criteria for receiving surface water bodies.

The water treatment facilities that may be required include:

- Screening treatment
- Detention tanks
- Aeration/flocculation tanks
- Chemical treatment
- Water pumping facilities
- Sludge storage.

As discharge will likely involve a drainage feature (as an overland flow route to Purga Creek) proximal to the western portal, specific management of the hydrological regime of release will be required. This is expected in the form of periods of water/dewatering releases into the drainage feature to minimise a change in hydrological regime and ecological processes.

The collected water will be required to meet the WQOs for Purga Creek (refer Section 3.2.4) and will likely require processing through a WTP include hydrocarbon separation.

Water from the WTP may require further pre-discharge to meet WQOs, as the water may become overtreated. In order to mitigate significant impact on the receiving waters, discharge will need to be monitored to ensure discharge does not result in the release of over-cleaned (water that is not representative of localised water quality parameters under WQO), treated water into the receiving waters.

8.3.3 Surface water quality (receiving environment) monitoring recommendations

A Water Quality Monitoring Program (WQMP) (as a sub-plan discharge and runoff management) is proposed to monitor the effectiveness of mitigation measures for surface water quality. This will be required to be conducted prior to and throughout construction and during the commencement of operation of the Project. During operations, it is expected the WQMP will be limited to monitoring discharge from the WTP into Purga Creek.

The WQMP would be developed concurrently with the detailed CEMP and would include:

- Identification of works and activities during construction and operation of the Project, including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points)
- A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures

- The identification of environmental management measures relating to surface waters during construction, and operation including erosion and sediment control and stormwater management measures
- The presentation of WQO trigger values, standards and parameters against which any changes to water quality will be assessed, having regard to the relevant water quality guidelines and ANZECC/ARMCANZ 2000/2018 guidelines. Where alternate guidelines are used to establish water quality goals, justification for this shall be provided.
- Representative background monitoring data for surface water quality to establish baseline water conditions prior to the commencement of construction
- Identification of construction and operational phase surface water monitoring locations (pending non-acceptance of current water quality monitoring locations) including waterways, waterbodies and wetlands, which are representative of the potential extent of impacts from the Project, including relevant analytes and frequency of monitoring
- Commitment to a monitoring period following the completion of construction or until the affected waterways and/or groundwater quality are certified by a suitably qualified and experienced independent expert as being rehabilitated to an acceptable condition, unless otherwise approved or directed by regulatory authorities. Surface water quality during baseflow conditions that meet background monitoring and/or WQOs will confirm adequate rehabilitation.
- The monitoring must also confirm the establishment of operational water control measures which will be identified as part of drainage during detailed design of the Project (such as vegetated buffer strips basins and vegetated swales)
- Contingency and ameliorative measures in the event that adverse impacts to water quality are identified, with reference to the impact triggers defined as part of the water quality monitoring program
- Surface water quality samples are to be collected in accordance with industry-accepted standards and quality assured procedures, including the Queensland Monitoring and Sampling Manual (DES 2018).

Noting that the current Project environment is under drought declaration, a contingency plan proposes to consider utilising water quality objectives under the EPP (Water and Wetland Biodiversity) as a contingent to site-specific water quality objectives derived from baseline monitoring. These would be expected to allow for the same process of assessment of impact to occur (as per the baseline collection of water quality data) if no flow conditions continue into the detailed design phase of the Project.

8.3.4 Salinity management

Salinity management (in regard to surface water quality) will be addressed by implementation of the Erosion and Sediment Control Plan and through characterisation of soil conditions across the water quality study area at a suitable scale in accordance with the CEMP prior to construction to inform design and environmental management measures. This includes identification of potential/actual acid sulfate soils, reactive soils, erosive soils, dispersive soils, saline soils, acidic soils, alkaline soils and contaminated land. The characterisation is considered to be used within the Erosion and Sediment Control Plan to identify problematic soils and assist the management of salinity during works and following the implementation of the Rehabilitation and Reinstatement Plan.

9 Significance impact assessment

A significance assessment has been undertaken following the impact assessment framework (refer Sections 7 and 8). The significance impact assessment was generated using a conservative approach aligned with a conceptual model of projected impacts. This was coupled with all Project activities that may have a detrimental impact on the quality of surface water quality via proximal discharge points associated with the Project.

The high sensitivity value of MNES and MSES associated environments within the Project have been assessed separately with the remainder of the Project environments in relation to water quality. In order to account for habitat disturbance to MNES through changes to water quality, the high sensitivity is linked to sections of Western Creek, Bremer River, Warrill Creek and Teviot Brook that intersect with the Project alignment.

Impacts on water quality are based on a model of expected occurrences, regarding projected impacts (potential and specific) from Project activities. As such, critical failure of infrastructure is not considered a viable impact for impact significance assessment.

In summary, potential impacts were grouped into six general potential impacts:

- Increased debris
- Changes to receiving water quality and hydrology
- Increase in salinity
- Increases in erosion and sedimentation
- Increase in contaminants
- Exacerbation of listed impacts above, from inadequate rehabilitation processes.

It is expected these categories may interface and have the capacity to compound existing or new impacts as they arise (e.g. increased erosion resulting in compounding effect of contaminant leachate and water chemistry changes).

Within Table 9.1, each specific impact (sectioned under the potential impact category) is assessed as a qualitative significance of impact with the design considerations (or initial mitigations) factored into the Project design..

Additional mitigation and management measures (in situ mitigation), including those listed in relevant subplans, were then applied as appropriate to the phase of the Project to reduce the level of potential impact. These are documented under the heading proposed additional mitigations.

The residual significance of the potential impacts was then reassessed after mitigation and management measures were applied. The initial significance levels were compared to the residual significance levels in order to assess the effectiveness of the mitigation and management measures.

Table 9.1 Impact assessment for potential impacts associated with water quality

Aspect	Potential impact	Specific impact	Phase	Sensitivity	Initial impact significance[1]		Residual impact significance of risk[2]	
					Magnitude	Significance	Magnitude	Significance
Erosion and sediment control	Increased debris	Contamination of waterway from debris from the Project to be blown into or washed into waterway	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Low	Moderate	Negligible	Low
			Operation					
		Restriction of flow within the waterways if too much debris is introduced to waterway or is stuck in culverts or creek crossings	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
			Operation					
Water quality Waterways	Changes to receiving water quality and hydrology	Routine tunnel dewatering operations resulting in a reduction of receiving water quality and changes to hydrological regimes specific to Purga Creek	Pre-construction and construction	Moderate	Major	High	Negligible	Low
			Operation					
		Diversion of overland flow (on unmapped waterway) influencing local hydrological regime and subsequent water quality specific to Purga Creek	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
			Operation					
		Changes to receiving water quality from dewatering of artificial waterbodies	Pre-construction and construction	Moderate	Low	Low	Low	Low
			Pre-construction and construction	High[3]	Low	Moderate	Low	Low
Erosion and sediment control Water quality	Increase in salinity	Increased salinity in proximal watercourses from land disturbance	Pre-construction and construction	Moderate	High	High	Negligible	Low
				High[3]	High	Major	Negligible	Low

Aspect	Potential impact	Specific impact	Phase	Sensitivity	Initial impact significance[1]		Residual impact significance of risk[2]	
					Magnitude	**Significance**	**Magnitude**	**Significance**
Erosion and sediment control General interference with existing surface water	Increases in erosion and sedimentation	Disturbance of the bed, banks and riparian zone of waterways	Pre-construction and construction	Moderate	High	High	Negligible	Low
			Operation		Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High[3]	High	Major	Negligible	Low
			Operation		Moderate	High	Negligible	Low
		Increased turbidity and sedimentation; and potential mobilisation of contaminants through erosion from disturbance activities near waterways	Pre-construction and construction	Moderate	High	High	Negligible	Low
			Operation		Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High[3]	High	Major	Negligible	Low
			Operation		Moderate	High	Negligible	Low
		Increased turbidity and potential mobilisation of contaminants from stockpiled areas	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
		Increased turbidity and potential mobilisation of contaminants from dewatering activities near excavations	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
		Increased sedimentation can impact the function of culverts/creek crossing and impede flow of the waterway	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation		Low	Low	Negligible	Low
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
			Operation		Low	Moderate	Negligible	Low
Erosion and sediment control Water quality Waterways	Increase in contaminants	Contamination of waterway from inadequate storage of fuels, oils and contaminants	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Low	Moderate	Negligible	Low
			Operation					
		Runoff from areas of disturbed contaminated lands nearby waterways	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Pre-construction and construction	High[3]	Low	Moderate	Negligible	Low
		Introduction of contaminants from stockpiled areas	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Pre-construction and construction	High[3]	Low	Moderate	Negligible	Low

Aspect	Potential impact	Specific impact	Phase	Sensitivity	Initial impact significance[1]		Residual impact significance of risk[2]	
					Magnitude	Significance	Magnitude	Significance
		Contaminants can enter waterways after rainfall events from rolling stock or after weed control activities	Operation	Moderate	Moderate	Moderate	Negligible	Low
			Operation	High[3]	Moderate	High	Negligible	Low
		Potential contamination of waterways from failed equipment or from failed infrastructure	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
			Operation					
Erosion and sediment control	Exacerbation of listed impacts above, from inadequate rehabilitation processes	Potential for sedimentation and increased turbidity within waterways if areas are either not rehabilitated or inadequate rehabilitation occurs	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
			Operation					
		Inadequate rehabilitation increasing erosion and sedimentation within waterways impacting the function of culverts/creek crossing and impeding flow of the waterway	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation					
			Pre-construction and construction	High[3]	Moderate	High	Negligible	Low
			Operation					

Table notes:

1 Includes implementation of design mitigation specified in Table 8.1
2 Includes proposed mitigation measures specified in Table 8.2
3 Western Creek, Bremer River, Warrill Creek and Teviot Brook

10 Cumulative impacts

Cumulative impacts were assessed using the methodology identified in Section 4.3, incorporating the projects identified in Figure 4.2 and Table 10.1 . The cumulative impacts of multiple projects occurring in the vicinity of the water quality study area may contribute to impacts to water quality if not managed appropriately. The majority of potential impacts identified as a result of the Project are common to all projects throughout the region and are therefore cumulative in nature. Seven projects have been identified within the cumulative impact area of influence (refer Section 4.3), which are either currently underway or are going through the EIS process, all of which will likely result in some extent of:

- Riparian vegetation loss from vegetation clearing/removal
- Potential impacts to aquatic fauna species both through impacts to water quality and barrier works
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of waterways
- Increase in erosion and sedimentation in the waterways
- Increase in litter (waste)
- Saline discharge into proximal waterways
- Increase in surface salinity around alluvial waterways.

Of the list of potential projects, the projects assessed for the CIA are typically major infrastructure or primary industry operations. Of the seven potential interacting projects, the following were identified to have the highest potential for cumulative impact:

- Kagura to Acacia Ridge and Bromelton (K2ARB)
- Helidon to Calvert (H2C)
- Bromelton State Development Area
- Greater Flagstone Priority Development Area.

All of these projects are subject to environmental controls either through EIS assessment processes, operational licences such as an Environmental Authority under the EP Act or through the implementation of detailed environmental management plans. Noting that proximal projects within the cumulative area of influence have been assessed as operating/constructing as 'business-as-usual' (i.e. likelihood of occurrence of impact with standard operating procedures), the CIA was compiled with the consideration of other projects abiding by environmental authorities and specified conditions of approval.

The results of the significance assessment of these cumulative impacts are presented in Table 10.3. Following consideration of the probability of impact, duration of impact, magnitude of impact and sensitivity of the receiving environment, the significance has been assessed to be low in terms of significant risk rating.

Table 10.1 Projects considered within the cumulative impact assessment

Project and proponent	Location	Description	Source	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria[1]	Relationship to the Project
Kagaru to Acacia Ridge and Bromelton (K2ARB) (ARTC)	Rail corridor from Kagaru to Acacia Ridge and Bromelton	Enhancing and connecting the existing rail corridor (approximately 49 km) from North-east of Kagaru to Acacia Ridge and from south of Kagaru to Bromelton	Application for coordinated project status currently under consideration by the Coordinator-General	Proponent awaiting coordinated project decision by the Coordinator-General	2023 to 2025 Jobs TBA	> 50 years Jobs TBA	c)	Potential overlap of construction for C2K and K2ARB
Helidon to Calvert (H2C) (ARTC)	Rail alignment from Helidon to Calvert	The H2C project will include the following: ▪ 47 km single-track dual-gauge freight rail line to accommodate double stack freight trains up to 1,800 m long ▪ Tunnel through the Little Liverpool Range ▪ Construction of rail infrastructure, culverts, bridges, viaducts and crossing loops ▪ Connection to the existing West Moreton Railway Line ▪ Ancillary works including road and public utility crossings and realignments	http://eisdocs.dsdip.qld.gov.au/Inland%20Rail%20Helidon%20to%20Calvert/IAS/h2c-initial-advice-statement.pdf	Proponent currently preparing EIS	2021 to 2026 Average 193 full-time construction jobs	> 50 years Jobs 20 FTE	b) and c)	Potential overlap of construction for H2C and C2K
Greater Flagstone Priority Development Area (PDA) (Queensland Government)	Located within Logan City, west of Jimboomba and the Mount Lindesay Highway, along the Brisbane-Sydney rail line	When fully developed, it is anticipated that the Greater Flagstone PDA will provide approximately 50,000 dwellings to house a population of up to 120,000 people	https://dsdmip.qld.gov.au/edq/greater-flagstone.html	PDA declared by the Queensland Government on 8 October 2011	2011 to 2041 Jobs TBA	TBA	c) and d)	Potential overlap of construction times, demand for resources and traffic volumes in the Kagaru area

Project and proponent	Location	Description	Source	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria[1]	Relationship to the Project
Bromelton State Development Area (SDA) (Queensland Government)	South of Kagaru in Bromelton	Delivery of critical infrastructure within the Bromelton SDA will support future development and economic growth. This includes a trunk water main and the Beaudesert Town Centre Bypass. This infrastructure provides opportunities to build on the momentum of current development activities by major landowners in the SDA.	https://www.statedevelopment.qld.gov.au/resources/project/bromelton/bromelton-sda-development-scheme-dec-2017.pdf	The current version of the Bromelton SDA Development Scheme was approved by Governor in Council, December 2017 The Development Scheme is managed by the Coordinator-General	2016 to 2031 Jobs TBA	TBA	c) and d)	Ongoing development north of Kagaru in the Bromelton SDA could result in a conflict for construction resources and see an increase of traffic volumes in the Kagaru area.
Ripley Valley PDA (Queensland Government)	Approximately 5 km south-west of the Ipswich CBD and south of the Cunningham Highway	The Ripley Valley PDA covers a total area of 4,680 ha and is an opportunity to provide approximately 50,000 dwellings to house a population of approximately 120,000 people. It is located in one of the largest industry growth areas in Australia and offers opportunities for further residential growth to meet the region's affordable housing needs.	https://dsdmip.qld.gov.au/edq/ripley-valley.html	PDA declared by State Government on 8 October 2011	2009 to 2031 Jobs TBA	TBA	c) and d)	Development could result in potential conflict for construction resources and see an increase in vehicle traffic and vegetation clearing.
South West Pipeline: Bulk Water Connection to Beaudesert (Seqwater)	East of Kagaru, running north from Beaudesert	The proposal is investigating a bulk water pipeline connection from the Southern Regional Water Pipeline to Beaudesert, connecting Beaudesert to the South-east Queensland Water Grid. The pipeline will pass through the site of the future Wyaralong Water Treatment Plant.	http://buildingqueensland.qld.gov.au/projects/south-west-pipeline-bulk-water-connection-to-beaudesert/	Currently completing Detailed Business Case	2021 Jobs TBA	TBA	c)	Potential conflict with demand for construction resources

Project and proponent	Location	Description	Source	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria[1]	Relationship to the Project
Royal Australian Air Force (RAAF) Base Amberley future works (Department of Defence)	RAAF Base Amberley	White paper dedicated future upgrades to RAAF Base Amberley at a cost of $1 billion.	http://www.defence.gov.au/id/_Master/docs/Economic/KPMGRAAFAmberleyReport.pdf	N/A	2016 to 2022 7,000 jobs	TBA	c)	Ongoing development at RAAF Base Amberley may see an increase in road traffic with heavy vehicles and further increase as C2K construction occurs as well as vegetation clearing

Table note:

1 a Currently being assessed under Part 1 of Chapter 3 of the Environmental Protection Act 1994 (Qld) and, as a minimum, have an initial advice statement available on the DES website.
b Have been declared a 'coordinated project' by the Coordinator-General under the SDPWO Act and an EIS is currently being prepared or is complete, or an initial advice statement is available on the DSDMIP website.
c May use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the Project.
d Could potentially compound residual impacts that the Project may have on environmental values.

Table 10.2 Potential cumulative water quality impacts

Potential cumulative impact	Kagura to Acacia Ridge and Bromelton (ARTC) Helidon to Calvert (ARTC) Bromelton State Development Area Greater Flagstone Priority Development Area
Riparian vegetation loss from vegetation clearing/removal	Potential overlapping loss of sensitive receptor (riparian vegetation communities) with works involving watercourse and associated crossings. Impact may be compounded with interface between the Project and other listed projects in regard to decreased resilience to biotic and abiotic factors. Potential consequence involves loss of bank stability, loss of diversity and consequential reduction in water quality values due to decreased performance of localised system services.
Potential impacts to aquatic fauna species both through impacts to water quality and barrier works.	Potential for cumulative downstream impacts (from overlapping projects – in regard to watercourses flowing within and between projects) from water quality issues associated with overland works and waterway barrier works. Cumulative impacts would be expected to occur in relatively short spatial distances (as cumulative point-source impacts) and would be expected to 'dilute' with increasing distance downstream from point source impact.
Displacement of flora and fauna species from invasion of weed and pest species	Potential for significant cumulative impacts between projects, with increasing risk associated with impact occurring on single watercourse (sub-catchment). Displacement from invasive species will result in further impact on aquatic water quality values downstream. Limited spatial interface between projects is not considered to be an inherent mitigating factor in regard to this impact, as cumulative impact will be increased (specifically in regard to proliferation of invasive flora downstream of impact) with each progressive source of impact associated with these projects.
Reduction in the connectivity of waterways	Potential for impact to be realised with improper work practices associated with waterway crossings, with progressive accumulation of impact between each project. Whole catchment may be impacted from separate projects on separate watercourses, however the greatest cumulative impacts would be expected with spatial interface between separate projects. Water quality degradation likely from impediment of waterway connectivity with associated decrease in ecosystem resilience.
Increase in erosion and sedimentation in the waterways	Potential of cumulative impact of watercourse sedimentation increase from simultaneous activities within hydrological catchments (particularly de-watering activities and stockpiling of spoil/resources). Cumulative impacts in regard to erosion may arise from impaction of watercourse structure/hydrological regimes and may be further impacted by cumulative impacts on riparian vegetation loss. Cumulative impact is expected to gain in potential and magnitude with downstream movement of impact, particularly in regard to erosive process and associated sedimentation impacts on hydrological regime change, increasing further impacts.
Increase in litter (waste)	Potential for cumulative impact from waste on water quality issues, in regard to contamination of watercourse from in-blow or direct deposition of waste into watercourses. Expectation of cumulative impacts associated with similar hydrological catchments (primarily sub-catchments) with greatest potential for cumulative impact with spatial interface between projects. Expectation of reduced environmental resilience with increasing waste load and waste type within watercourses.
Saline discharge into proximal watercourses	Overlapping construction activities related to high salinity risk rating areas along the alignment with potential for poor erosion and sediment control management to increase potential of erosive sodosol discharge. Limited spatial difference between the projects increases potential cumulative impact.
Increase in surface salinity around alluvial watercourses	Overlapping construction activities in regard to clearing of vegetation within alluvial-based watercourses increases potential of highly-localised groundwater rise and salinity risk during high-rainfall events. Limited spatial difference between the projects increases potential cumulative impact.

Table 10.3 Summary of the cumulative impact assessment

Cumulative impact	Phase	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Magnitude	Duration	Sensitivity		
Riparian vegetation loss from vegetation clearing/removal	Construction	2	1	2	2	7	Medium
	Operations	1	1	1		5	Low
Potential impacts to aquatic fauna species both through impacts to water quality and barrier works	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
Displacement of flora and fauna species from invasion of weed and pest species	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
Reduction in the connectivity of waterways	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
Increase in erosion and sedimentation in the waterways	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
Increase in litter (waste)	Construction	1	1	1	2	5	Low
	Operations	1	1	1		5	Low
Saline discharge into proximal watercourses	Construction	1	1	2	2	6	Low
	Operations	1	2	1		6	Low
Increase in surface salinity around alluvial watercourses	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low

Table notes:

1. Table 4.11 defines the consequences of the impact significance ratings, as follows:
   Low (sum of relevance factors = 1 to 5): Negative impacts need to be managed by standard environmental management practices. Special approval conditions unlikely to be necessary. Monitoring to be part of general Project monitoring program
   Medium (sum of relevance factors = 6 to 9): Mitigation measure likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required
   High (sum of relevance factors = 10 to 12): Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary

11 Conclusions

The water quality study area covers the Bremer River and Logan River catchments, with several sub-catchments intersecting the Project alignment. Historic and field assessed water quality was identified as not currently meeting all WQOs for the protection of aquatic ecosystems within each catchment.

The surface water quality assessment addressed a range of surface water resource ToR. These included ToR relating to existing environment (11.36 to 11.40), impact assessment (11.41 to 11.46), mitigation measures (11.47 to 11.51) and water resource impact assessment (11.52 to 11.53, 11.58 to 11.60).

All waterways within the water quality study area have been identified as sensitive receptors within the receiving environment which have the potential to be subject to significant impacts.

These were nominated as moderate water quality receptors for:

- Identification of potential impacts,
- Associated mitigation measures and
- Identification of residual impact after implementation of mitigation.

Due to the moderate and high sensitivity of the water quality receptors within the water quality study area, significance of impact was assessed against these criteria.

A significance assessment was undertaken and assessed the residual impact of identified potential impacts after assessment of design considerations and additional mitigation measures. The assessment identified:

- During the construction phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate most potential impacts, such that the residual significance would be low.
- For the operational phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate most potential impacts, such that the residual significance would be low.

The significant impact assessment has identified that with design considerations and mitigation measures in place, the risk of significance of impact from construction (including pre-construction) and operation phase activities is low. It is not expected that significant residual impact on surface water quality will be a result of the Project.

A CIA considering the impact of four other projects was considered. The cumulative impacts of several projects within the water quality study area included: riparian vegetation loss from vegetation clearing/removal, potential impacts to aquatic fauna species both through impacts to water quality and barrier works, displacement of flora and fauna species from invasion of weed and pest species, reduction in the connectivity of waterways, an increase in erosion and sedimentation in the waterways, an increase in litter (waste), saline discharge into proximal waterways and an increase in surface salinity around alluvial waterways. These impacts were all considered to have carry on impacts to surface water quality within the CIA area.

The CIA identified a medium risk of potential impact occurring during construction phase activities through riparian vegetation loss from vegetation clearing/removal. The riparian vegetation loss was considered to have potential to impact water quality through erosion and sedimentation. It is considered that mitigation measures are likely to be necessary and specific management practices to be applied.

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