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HumeLink

Surface Water and Groundwater Impact Assessment

EIS Technical Report 12

HumeLink

EIS Technical Report 12 – Surface Water and Groundwater Impact Assessment

Transgrid

August 2023

Bringing ideas to life

Executive Summary

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. The project would be located across five Local Government Areas (LGAs) including Wagga Wagga City, Snowy Valleys, Cootamundra-Gundagai Regional, Upper Lachlan Shire and Yass Valley.

The project footprint traverses four major surface water catchments: the Hawkesbury-Nepean River, Lachlan River, Murrumbidgee River and Upper Murray River catchments. The project footprint crosses many waterways ranging from ephemeral drainage lines to major rivers.

The project footprint overlies three groundwater units, including the Murrumbidgee alluvium, Lachlan Fold Belt and Goulburn fractured rock.

Erosion risk within the project footprint varies considerably depending on the soil type, terrain steepness and the average annual rainfall at specific locations.

The impact assessment considered surface water and groundwater risks from both construction and operation of the project.

Construction impacts on surface water

The following construction impacts on surface water were identified:

- **Erosion risk and sedimentation impacts** – Disturbance of the ground through vegetation removal, earthworks and other construction activities would pose the greatest risk to surface water. Construction activities in close proximity to waterways would increase erosion risk. For the purposes of the assessment, buffer distances were identified around waterways and the potential soil erosion categorised for areas within the project footprint. The sensitivity of a location was determined based on whether it was within a buffer zone of a waterway and its potential soil erosion category. Project components and the type of construction activities were then also considered in deriving an impact significance. For project components such as the access tracks, transmission line easement and structures, a range of impact ratings were identified depending upon specific locations. About 58 per cent of the project footprint is considered low risk of erosion and sedimentation impacts on surface waters, 29 per cent moderate risk and 13 per cent high risk. For other project components that have a discrete location (ie substations), a site-specific impact significance was determined – which were generally low to moderate impact significance. The different impact significance outcomes for different locations would be used to determine the soil and water management measures including erosion and sedimentation control during construction.
- **Geomorphology impacts** – Potential impacts on geomorphology would be primarily related to erosion risk and sedimentation impacts (ie sediment being washed into waterways) and therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. An additional risk to geomorphology would be waterway crossings associated with access roads. This would have a moderate risk of impacts and would be managed through implementing appropriate design guidelines.
- **Water quality impacts** – The major potential impacts on water quality would be primarily related to erosion risk and sedimentation. Therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. Another major risk to water quality would be the 14 construction compounds, some of which would include concrete batching plants and associated materials, chemicals and fuel storage and use. All construction compounds have been located outside vegetated riparian zones of Strahler order waterways classified 4 or higher – which are generally perennial waterways with a high likelihood of containing key fish habitat.

- **Water supply impacts** – About 510 megalitres of water is estimated to be required over the 2.5 year construction period of which about 13 per cent would need to be potable and remainder would be non-potable water. The total volume of water required for construction is only a fraction of a percentage of the total volume of water allocated under the Water Sharing Plans in the project footprint. Non-potable water would be sourced from farm dams, sedimentation ponds, potentially groundwater bores and through the purchase of allocations from other water users through water markets. The impact of project on non-potable water users and water availability would be negligible. About two thirds of the potable water requirements is for the proposed Tumbarumba accommodation facility (AC1) at Tumbarumba and this would be obtained from the Tumbarumba Water Treatment Plant. The other third of the potable water requirement would be for concrete batching and would be sourced from the local council's town water supply where the concrete batching plant is located. Final volumes will be confirmed by the construction contractors during detailed design.
- **Wastewater disposal** – The largest source of wastewater would be from the worker accommodation facility, and this would be connected to the existing Tumbarumba STP. Smaller volumes of wastewater from construction compounds would be collected and transported to appropriate wastewater disposal facilities. Final volumes will be confirmed by the construction contractors during detailed design.

Construction impacts on groundwater

Generally, important groundwater resources are located in discrete areas within the project footprint (eg Alluvium around major waterways) or at depths lower than the predicted below ground impacts of the project. Only one registered bore is within the project footprint and three bores are within 70 metres of the project footprint. Activities that could potentially impact groundwater resources mainly relate to the foundation construction of the transmission line structures, which require excavation to five metres below ground level or piles, which may extend greater than 20 metres below the surface level. While either of these activities may intercept groundwater where it is present, the impacts such as changes in groundwater level (eg from dewatering), interference to groundwater flow and impacts on groundwater quality on bores within or close to the footprint could be moderate to high. Substation modification and construction was also identified as potentially having moderate impacts on groundwater.

While there are other risks to groundwater during construction, overall the impacts of construction on groundwater would be minor.

Operational impacts on surface water

The operational impacts on surface water quality would be similar to the construction phase but with substantially lower likelihood of occurrence. This is because disturbed areas would have been stabilised, activities such as earthworks and concreting would be limited and there would be no substantial storage or use of chemicals and fuels except for at the substations, which would have appropriate bunding and storage.

Most of the impacts would relate to ongoing maintenance activities within the transmission line easement, transmission line structures and access tracks, however the potential significance of impacts would be generally low. The substations also pose a risk to water quality due to chemical and oil storage, but the impact would be low given that they are constructed within containment and systems.

Water use and wastewater disposal impacts would be negligible as the volume of water required and the volume of wastewater generated would be low.

Operational impacts on groundwater

The operation of the project would have negligible impacts on groundwater.

Mitigation measures

The key measures proposed to avoid, manage and/or mitigate impacts to surface water and groundwater include:

- preparation of a Soil and Water Management Plan (SWMP) as part of the Construction Environmental Management Plan to manage water quality impacts during construction of the project
- preparation of Erosion and Sediment Control Plans (ESCPs) and a Water Quality Monitoring Plan within the SWMP
- consideration of appropriately designed scour protection at new stormwater management points.

With the proposed management measures in place, impacts are expected to be negligible to minor.

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Glossary and abbreviations

Term	Abbreviation	Description
Australian and New Zealand Environment and Conservation Council	ANZECC	-
Australian and New Zealand Guidelines	ANZG	-
Bureau of Meteorology	BoM	The Bureau of Meteorology is a Commonwealth government agency, engaged in the recording of meteorological observations, forecasting weather and the issuing of specific weather warnings.
Construction Environmental Management Plan	CEMP	A CEMP describes how activities undertaken during the construction phase of development would be managed to avoid or mitigate environmental or nuisance impacts, and how those environmental management requirements would be implemented.
Critical State Significant Infrastructure	CSSI	Critical State Significant Infrastructure projects are high priority infrastructure projects that are essential to the State for economic, social, or environmental reasons.
Department of Primary Industries	DPI	-
Department of Planning and Environment	DPE	-
Easement	-	A legal right attached to a parcel of land that enables the non-exclusive use of the land by a third party other than the owner. For transmission lines, an easement defines the corridor area where the lines are located and that allows access, construction, and maintenance work to take place. The easements for the 500 kV transmission lines would typically be 70 metres wide. However, a few locations would require wider easements up to 110 metres wide at transposition locations and up to 130 metres wide where the new transmission line would parallel the relocated section of Line 51. The easement grants a right of access for construction, maintenance and operation of the transmission line and other operational assets.
Electrical conductivity	EC	The ability of a substance to conduct an electrical current. Used as a measure of the concentration of dissolved ions (salts) in water (ie water salinity). Measured in micro-Siemens per centimetre (µS/cm) or deci-Siemens per metre (dS/m) at 25°C. 1 dS/m = 1000 µS/c.
Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)	EPBC Act	The Commonwealth EPBC Act is administered by the Department of Climate Change, Energy, the Environment and Water and provides a legal framework to protect and manage nationally important flora, fauna, ecological communities, and heritage places defined as ‘matters of national environmental significance’.
Environmental Impact Statement	EIS	An Environmental Impact Statement is a publicly available document that provides information on a project, including its environmental impacts and mitigation measures, and is used to inform development consent decisions.
Environmental Planning and Assessment Act 1979	EP&A Act	The *Environmental Planning and Assessment Act 1979* is the primary land use planning statute in NSW. It governs matters such as planning administration, planning instruments, development assessments, building certification, infrastructure finance, appeals and enforcement.
Environment Protection Authority	EPA	-
Environment Protection Licence	EPL	EPL are issued to outline conditions related to pollution prevention and monitoring, and cleaner production through recycling and reuse and the implementation of best practice.

Term	Abbreviation	Description
Erosion and Sedimentation Control Plan	ESCP	
Fisheries Management Act 1994	FM Act	NSW legislation that manages, conserves and protects fisheries and fish habitat.
Groundwater Dependent Ecosystems	GDEs	Ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes, and ecosystem services.
Hydrostratigraphic units	HSUs	-
Key Fish Habitat	KFH	Aquatic habitats that are important to the sustainability of the recreational and commercial fishing industries, the maintenance of fish populations generally, and the survival and recovery of threatened aquatic species.
Kilometres	km	-
Kilovolt	kV	-
Metres above Australian Height Datum	mAHD	A common reference level used in Australia which is approximately equivalent to the height above sea level in meters.
Murray–Darling Basin	MDB	-
Murray–Darling Basin Authority	MDBA	-
NSW and ACT Regional Climate Modelling project	NARCliM	-
National Water Quality Management Strategy	NWQMS	-
Nephelometric Turbidity Unit	NTU	Unit for measuring turbidity
Neutral or Beneficial Effect	NorBE	-
NSW Aquifer Interference Policy	NSW AIP	-
Project	-	The construction and operation of high voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle, collectively referred to as HumeLink.
Project footprint	-	The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction and any easement required during operation.
Protection of the Environment Operations Act 1997	POEO Act	The *Protection of the Environment Operations Act 1997* sets up the NSW environmental regulatory framework and determines the need for an Environment Protection Licence (EPL).
River Flow Objectives	RFOs	-
State of the Environment	SoE	-
Secretary's Environmental Assessment Requirements	SEARs	These are issued by the Planning Secretary of the NSW DPE for State Significant projects. These SEARs provide the technical requirements for the impact assessment of each potential key issue, including the desired performance outcome, requirement, and current guidelines.
Sharing and Enabling Environmental Data	SEED	SEED is the NSW Government's central resource for Sharing and Enabling Environmental Data. It was developed for the NSW community in a collaborative effort between government agencies to provide an accessible and reliable platform for environmental data.
State Environmental Planning Policy (Biodiversity and Conservation) 2021	Biodiversity and Conservation SEPP	NSW Government policy to ensure that the coastal wetlands are preserved and protected; prepared under the *Environmental Planning and Assessment Act 1979.*

Term	Abbreviation	Description
Strahler stream order	-	Strahler stream order classification is a 'top down' system in which streams of the first order have no upgradient streams flowing into them (DPI 2018). If two streams of the same order merge, the resulting stream is given a number that is one higher. If two rivers with different stream orders merge, the resulting stream is given the higher of the two numbers. Under the Strahler stream order classification, 1st to 3rd order streams are called headwater streams. Streams classified as 4th through 6th order are medium streams and streams that are 7th order or larger are a river.
Soil and Water Management Plan	SWMP	-
Sydney Drinking Water Catchment	SDWC	-
Temporary ancillary facilities	-	These are temporary facilities to support construction including: ▪ access roads ▪ construction compounds ▪ laydown areas ▪ parking ▪ site offices and amenities.
Total Nitrogen	TN	The sum of the organic, nitrate, nitrite, and ammonia forms of nitrogen in a water or wastewater.
Total Phosphorus	TP	The sum of all phosphorous forms.
Transgrid	-	NSW Electricity Networks Operations Pty Ltd (referred to as Transgrid) is the operator and manager of the main high voltage transmission network in NSW and the ACT, and is the Authorised Network Operator for the purpose of an electricity transmission or distribution network under the provisions of the *Electricity Network Assets (Authorised Transactions) Act 2015*. Transgrid is the proponent of the project.
Transmission line route	-	The location of the transmission line structures along the middle of the transmission line easement.
Water Access Licence	WAL	A water access licence entitles its holder to specified shares in the available water within a specified water management area or from a specified water source (the share component), and to take water at specified times, at specified rates or in specified circumstances, or in any combination of these, and in specified areas or from specified locations, (the extraction component).
Water Act 1912	Water Act	*The Water Act 1912* established conditions by which users needed a water licence or authority to take water, these included: Taking water from a stream or river via a pump or other work, for all purposes other than for basic landholder rights. From river flow in a dam (any size) located on a river or stream.
Water Management Act 2000	WM Act	*The Water Management Act 2000* recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land.
Water Quality Objectives	WQO	Water Quality Objectives are long-term goals for water quality management. They are measures, levels, or narrative statements of indicators of water quality that protect environmental values. They define what the water quality should be to protect the environmental values —after consideration of the socio-economic assessment of protecting the water quality.

Term	Abbreviation	Description
Water Resource Plan	WRP	A plan made under the Commonwealth *Water Act 2007* that outlines how a particular area of the Murray–Darling Basin's water resources will be managed to be consistent with the Murray–Darling Basin Plan. These plans set out the water sharing rules and arrangements relating to issues such as annual limits on water take, environmental water, managing water during extreme events and strategies to achieve water quality standards and manage risks.
Water Sharing Plan	WSP	A plan made under the *Water Management Act 2000* which sets out the rules for sharing water between the environment and water users within whole or part of a water management area or water source.
Waterway buffer zone		Waterway buffer zones have been determined based upon the ratio of VRZ multiplied by a factor of five. Areas within the buffer zone of an individual waterway are considered to potentially have a high risk of impacting a sensitive environmental feature. The waterway buffer zones vary based upon the Strahler rating of the waterway and are: ▪ Strahler order 1 – within 50 metres of the waterway ▪ Strahler order 2 - within 100 metres of the waterway ▪ Strahler order 3 - within 150 metres of the waterway ▪ Strahler order 4 and above - within 200 metres of the waterway.
Vegetated Riparian Zones	VRZ	The area along the bank of a river or a stream, which often has water-dependent vegetation. The width of the VRZ within the riparian corridor has been based upon definitions of riparian zone for controlled activity approvals under the *Water Management Act 2000*. ▪ VRZ width for Strahler order 1 – 10 metres each side of watercourse ▪ VRZ width for Strahler order 2 – 20 metres each side of watercourse ▪ VRZ width for Strahler order 3 – 30 metres each side of watercourse ▪ VRZ width for Strahler order 4 – 40 metres each side of watercourse.

1 Introduction

1.1 Overview

The Australian energy landscape is transitioning to a greater mix of low-emission renewable energy sources, such as wind and solar. To support this transition, meet our future energy demands and connect Australian communities and businesses to these lower cost energy sources, the national electricity grid needs to evolve.

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. The project would be located across five Local Government Areas (LGAs) including Wagga Wagga City, Snowy Valleys, Cootamundra-Gundagai Regional, Upper Lachlan Shire and Yass Valley. The location of the project is shown on Figure 1-1.

HumeLink would involve construction of a new substation east of Wagga Wagga as well as connection to existing substations at Wagga Wagga and Bannaby and a future substation at Maragle in the Snowy Mountains (referred to as the future Maragle 500 kV substation). The future Maragle 500 kV substation is subject to a separate major project assessment and approval (reference SSI-9717, EPBC 2018/836).

The project would deliver a cheaper, more reliable, and more sustainable grid by increasing the amount of renewable energy that can be delivered across the national electricity grid, helping to transition Australia to a low carbon future. It would achieve this by supporting the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut Renewable Energy Zones (REZs). The project would provide the required support for the network in southern NSW, allowing for the increase in transfer capacity between new renewable generation sources and the state’s demand centres of Sydney, Newcastle, and Wollongong. The project would also improve the efficiency and reliability of the current energy transfer in this part of the network.

Furthermore, HumeLink would form a key part of the transmission line infrastructure that supports the transfer of energy within the National Electricity Market (NEM) by connecting with other major interconnectors. The NEM incorporates around 40,000 kilometres of transmission lines across Queensland (QLD), NSW, Australian Capital Territory (ACT), Victoria (VIC), South Australia (SA) and Tasmania (TAS).

Construction of the project is targeted to commence in 2024, subject to the required planning and regulatory approvals. Once construction has commenced, the project is estimated to take approximately 2.5 years to build and would become operational by the end of 2026.

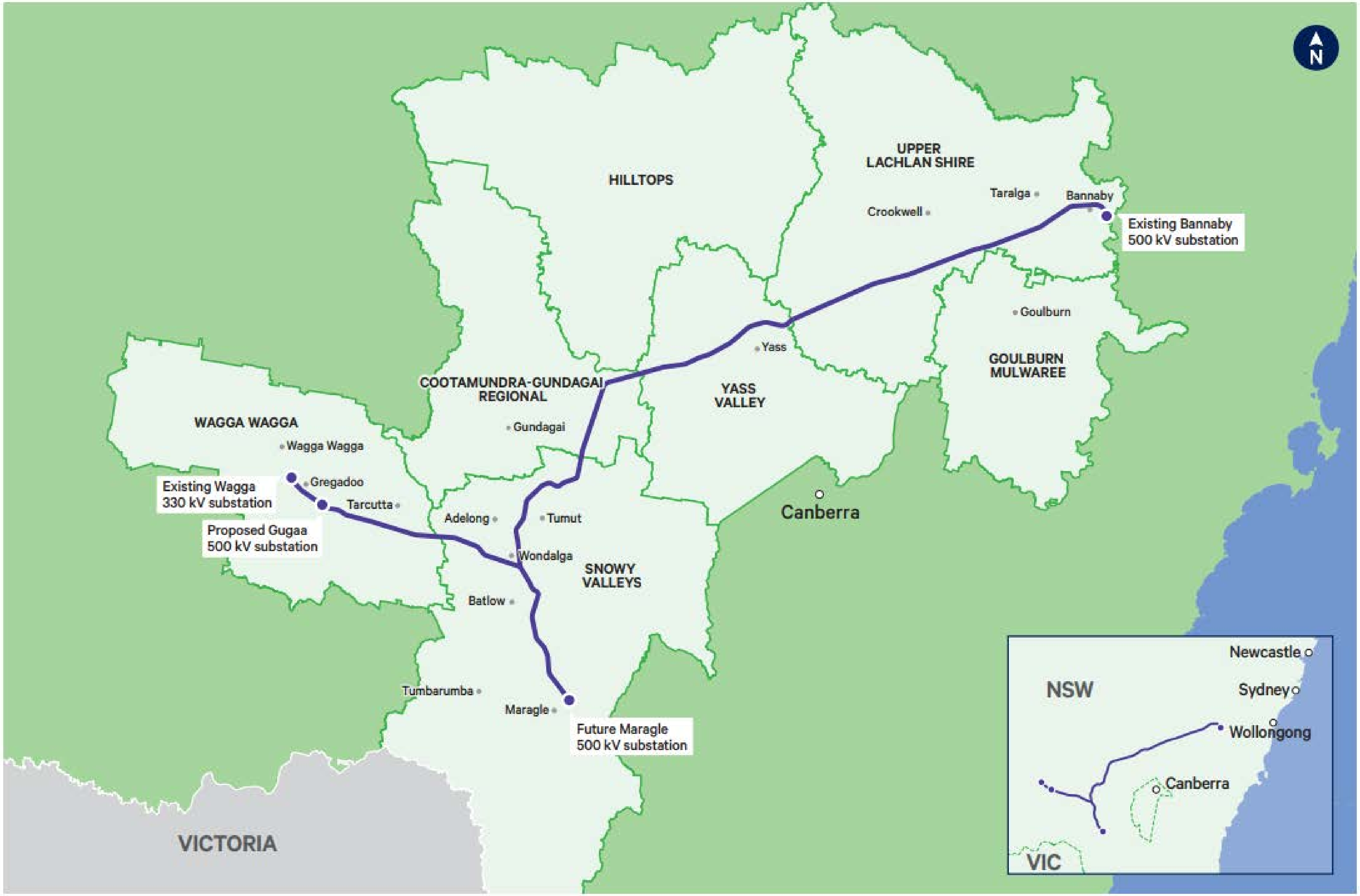
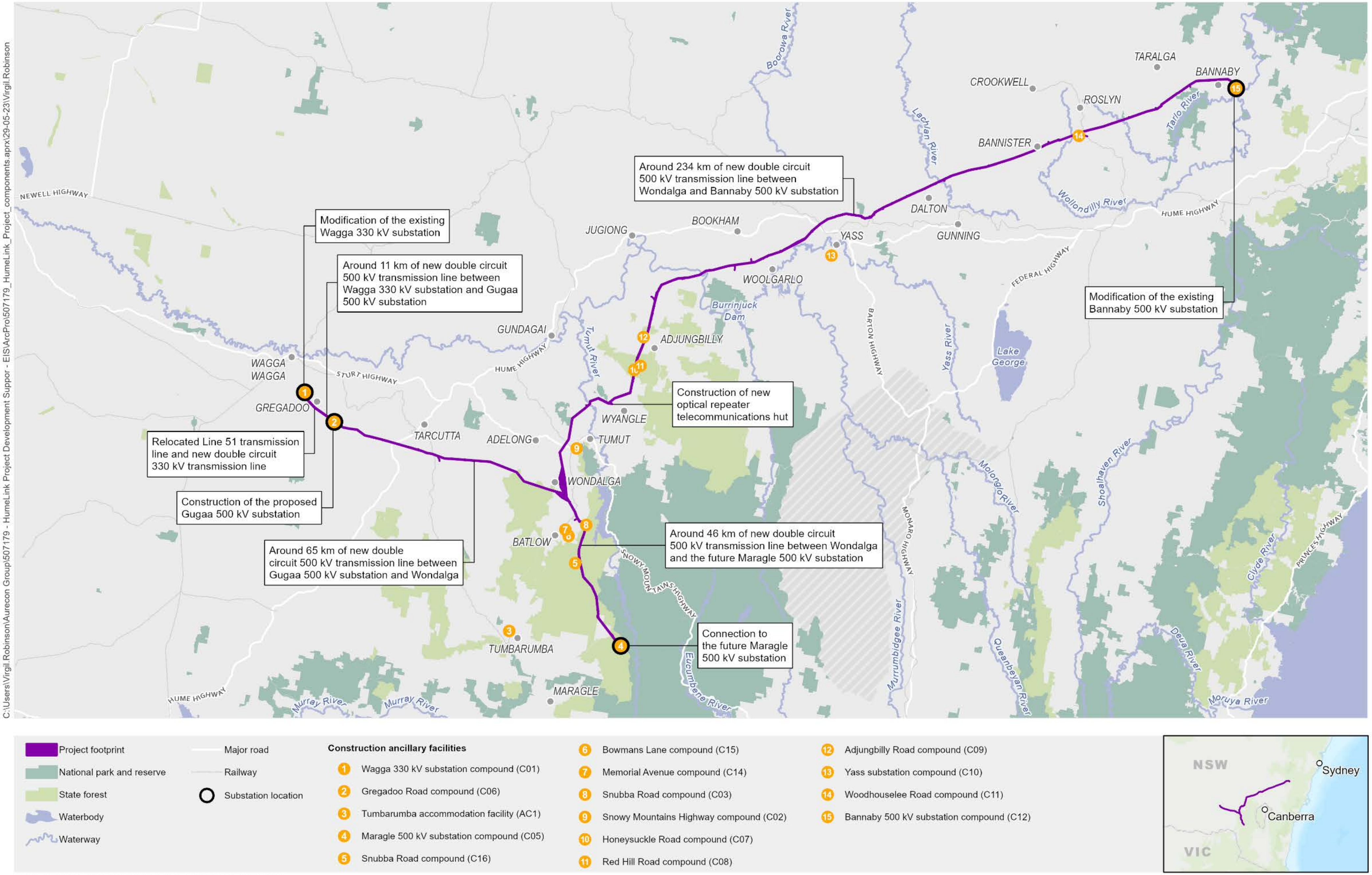


Figure 1-1 Location of the project

1.2 Key components

The project includes the following key components (refer to Figure 1-2):

- construction and operation of around 360 kilometres of new double circuit 500 kV transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle
- construction of a new 500/330 kV substation at Gregadoo (Gugaa 500 kV substation) approximately 11 kilometres south-east of the existing Wagga 330/132 kV substation (Wagga 330 kV substation)
- demolition and rebuild of a small section of Line 51 (around two kilometres in length) as a double circuit 330 kV transmission line connecting into the Wagga 330 kV substation
- modification of the existing Wagga 330 kV substation and Bannaby 500/330 kV substation (Bannaby 500 kV substation) to accommodate the new transmission line connections
- connection of transmission lines to the future Maragle 500/330 kV substation (Maragle 500 kV substation, approved under the Snowy 2.0 Transmission Connection Project (SSI-9717))
- provision of one optical repeater telecommunications hut and associated connections to existing local electrical infrastructure
- establishment of new and/or upgraded temporary and permanent access tracks
- ancillary work required for construction of the project such as construction compounds, worker accommodation facilities, utility connections and/or relocations, brake and winch sites, and helipad/helicopter support facilities.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:925,000

0 20 40km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

FIGURE 1-2: Key components of the project

1.3 Purpose and scope of this report

The main purpose of this report is to assess the potential surface water and groundwater impacts from construction and operation of the project to support the environmental assessment of the project in accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

1.4 Secretary's environmental assessment requirements

As stated in Section 4.2.1, the project is classified as Critical State Significant Infrastructure (CSSI) and therefore requires approval from the NSW Minister of Planning (or their delegate). The Planning Secretary's Environmental Assessment Requirements (SEARs) issued for the project include surface water and groundwater related matters, summarised in Table 1-1.

Table 1-1 Scope of work to address project SEARs

Requirement	Chapter of this report
An assessment of the impacts of the project on the quantity and quality of the region's surface water resources, including the Goobarragandra River, Lachlan River, Murrumbidgee River, Tarlo River, Tumut River, Wollondilly River, Yass River and Blowering Dam, Burrinjuck Dam and Wyangala Dam Water Catchment Areas, having regard to NSW Water Quality Objectives (WQO).	An assessment of the impacts of the project on the quantity and quality of the region's surface water resources is provided in Chapter 6 and Chapter 7. In particular, the surface water resources mentioned have been assessed in Section 6.2.6.
Details of water requirements, supply arrangements and wastewater disposal arrangements for construction and operation.	A preliminary water supply and disposal assessment has been conducted in Section 6.2.4 and Chapter 6 and Chapter 7 for construction and operation, respectively.
An assessment of the impacts of the project on groundwater aquifers and groundwater dependent ecosystems (GDEs) having regard to the NSW Aquifer Interference Policy (NSW AIP) and relevant WSPs.	An assessment of the impacts of the project on groundwater is provided in Section 6.3 and Section 7.2 in addition Chapter 8 addressing minimal impact considerations as required by the NSW AIP.
An assessment of the potential flooding impacts and risks of the project.	Please refer to *Technical Report 11 – Hydrology and Flooding Impact Assessment* for all flood-related assessment issues.
Where the project involves work within 40 metres of the high bank of any river, lake or wetlands (collectively waterfront land), identify likely impacts to the waterfront land, and how the activities are to be designed and implemented in accordance with the Department of Primary Industries (DPI) Guidelines for Controlled Activities on Waterfront Land (2012) and (if necessary) Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (DPI, 2003) and Policy & Guidelines for Fish Habitat Conservation & Management (Fisheries NSW, 2013)	Surface water impacts to waterfront land are presented in Section 6.2 and Section 7.1. Mitigation measures are presented in Chapter 11.
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with Managing Urban Stormwater: Soils & Construction (Landcom, 2004)	Erosion and sedimentation impacts during construction and operation are presented in Section 6.2.1 and Section 7.1.6, respectively, and mitigation measures presented in Chapter 11.

1.5 Structure of this report

The following list details the structure of this surface water and groundwater technical report:

- Chapter 1 Introduction
- Chapter 2 Project description summary
- Chapter 3 Legislative and policy context
- Chapter 4 Methodology
- Chapter 5 Existing environment
- Chapter 6 Construction impacts
- Chapter 7 Operational impacts
- Chapter 8 Minimal impact considerations
- Chapter 9 NorBE Assessment (construction and operation phase)
- Chapter 10 Cumulative impacts
- Chapter 11 Management of impacts
- Chapter 12 Conclusion
- Chapter 13 References.

1.6 Key project terms

The key project terms used in this report are as follows:

- Project footprint - The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction and any easement required during operation.
- Surface water and groundwater study area – The study area for the assessment includes the project footprint with a one-kilometre buffer. A larger areas was searched to allow for adequate interpretation of impacts to surface water and potentially sensitive groundwater users.

2 Project description summary

The project description in this chapter is based on a concept design and indicative construction methodology for the project. The design and construction methodology would continue to be refined and confirmed during detailed design and construction planning by the construction contractors. Further details on the project are provided in Chapters 3 and 4 of the EIS.

2.1 Summary of key components of the project

Key components of the project are summarised in Table 2-1.

Table 2-1 Summary of key components of the project

Component	Description
Transmission lines and supporting infrastructure	
Transmission lines and structures	The project includes the construction of new 500 kV transmission line sections between: ▪ Wagga 330 kV substation and Gugaa 500 kV substation (approximately 11 km) ▪ Gugaa 500 kV substation and Wondalga (approximately 65 km) ▪ Wondalga and Maragle 500 kV substation (approximately 46 km) ▪ Wondalga and Bannaby 500 kV substation (approximately 234 km). The transmission line section between the Wagga 330 kV substation and proposed Gugaa 500 kV substation would operate at 330 kV under HumeLink. The project also includes the rebuild of approximately 2 km of Line 51 as a new 330 kV transmission line between the Wagga 330kV substation and around Ivydale Road, Gregadoo. This would be adjacent to the new transmission line between the existing Wagga 330 kV and proposed Gugaa 500 kV substations. The 500 kV transmission lines would be supported on a series of free-standing steel lattice structures that would range between around 50 m up to a maximum of 76 m in height and generally spaced between 300 to 600 m apart. The typical transmission line structure height would be around 60 metres. Earth wire and communications cables would be co-located on the transmission line structures. The 330 kV structures for the rebuild of Line 51 would range between 24 m and 50 m in height and have a typical height of 40 m. Indicative configurations of transmission line structures that may be used as part of the project are shown in Figure 2-1. The type and arrangement of the structures would be refined during detailed design. The footings of each structure would require an area of 300 m^2 up to 450 m^2, depending on ground conditions and the proposed structure type. Additional disturbance at each structure site may be required to facilitate structure assembly and stringing.
Transmission line easements	The easements for the 500 kV transmission lines are typically 70 m wide. However, a number of locations may require wider easements of up to 110 m wide at transposition locations[1] and up to 130 m wide where the new transmission line would parallel the relocated section of Line 51. The easement provides a right of access to construct, maintain and operate the transmission line and other operational assets. The easement also generally identifies the zone of initial vegetation clearance and ongoing vegetation management to ensure safe electrical clearances during the operation of the lines. Vegetation management beyond the easement may also occur where nearby trees have the potential to fall and breach safety clearances.
Telecommunications huts	Telecommunications huts, which contain optical repeaters, would be required to boost the signal in the optical fibre ground wire (OPGW). One telecommunications hut would be required for the project. The telecommunications hut would be located adjacent to existing transmission line structures. Cables would be installed between the transmission line structure and the local power supply. The telecommunications hut would be surrounded by a security fence. A new easement would be established for the telecommunications hut power connection. The project also involves a telecommunications connection of OPGW between two proposed transmission line structures and the future Rye Park Wind Farm substation (SSD-6693). This removes the need for an additional telecommunications hut in this area of the project.

[1] Transposition is the periodic swapping of positions of the conductors of a transmission line in order to improve transmission reliability.

Component	Description
Substation activities	
Construction of the proposed Gugaa 500 kV substation	A new 500/330 kV substation would be constructed at Gregadoo, about 11 kilometres southeast of the Wagga 330 kV substation. The substation would include two new 500/330 kV transformers and two 500 kV reactors. The proposed Gugaa 500 kV substation is expected to occupy an area of approximately 22 ha.
Modification of the existing Bannaby 500 kV substation	The existing Bannaby 500 kV substation on Hanworth Road, Bannaby would be expanded to accommodate connections for new 500 kV transmission line circuits. The modification would include changes to the busbars, line bays, bench and associated earthworks, steelwork, drainage, external fence, internal/external substation roads, secondary containment dams, sediment containment dams, cabling, and secondary systems. All of the works would be restricted to the existing substation property.
Modification of the existing Wagga 330 kV substation	The existing Wagga 330 kV substation on Ashfords Road, Gregadoo would be reconfigured to accommodate new bays for two new 500 kV transmission line circuits within the existing substation property. This would include modifications to the busbars, line bays, existing line connections, bench and associated earthworks, relocation of existing high voltage equipment, drainage, external fence, internal substation roads, steelwork, cabling, and secondary systems.
Connection to the future Maragle 500 kV substation	The project would connect to the future Maragle 500 kV substation approved under the Snowy 2.0 Transmission Connection Project (SS1-9717). Construction of the Maragle substation is proposed to be undertaken between 2023 and 2026. Further detail on the Snowy 2.0 Transmission Connection project is available at the Department of Planning and Environment's Major Projects website: www.planningportal.nsw.gov.au/major-projects/project/10591.
Ancillary facilities	
Access tracks	Access to the transmission line structures and the substations would be required during construction and operation. Wherever possible, existing roads, tracks and other existing disturbed areas would be used to minimise vegetation clearing or disturbance. Upgrades to existing access tracks may be required. In areas where there are no existing roads or tracks, suitable access would be constructed. This may include waterway crossings.
Construction compounds	Construction compounds would be required during construction to support staging and equipment laydown, concrete batching, temporary storage of materials, plant and equipment and workers parking required to construct the various components of the project. Fourteen potential construction compound sites have been identified. The proposed use of the construction compounds and their proposed boundaries/layout would be refined as the project design develops in consultation with relevant stakeholders and the construction contractors.
Worker accommodation facility	Existing accommodation facilities within towns adjacent to the project would provide temporary accommodation for the majority of the construction workers. However, a potential shortage in accommodation has been identified close to the project footprint. A potential option to provide additional temporary worker accommodation during the construction period is the establishment of a temporary worker accommodation facility at the corner of Courabyra Road and Alfred Street, Tumbarumba to accommodate about 200 construction workers. The worker accommodation facility would consist of demountable cabins and would be connected to existing utilities. All required amenities for the accommodation facility would be provided including services and worker parking for light and heavy vehicles. However, the ultimate delivery of the project may include multiple temporary worker accommodation facilities in various forms, which would be outlined in the Worker Accommodation Strategy for the project. The strategy will be developed in consultation with councils, and other relevant stakeholders. Any new or changed worker accommodation facility would be subject to additional environmental assessment, as required.
Helipad/helicopter facilities	To facilitate construction of the project, helicopters may be used to deliver materials/equipment and transfer personnel to construction areas particularly within high alpine regions. To enable helicopters to operate safely and allow easy access to the site, a helicopter landing pad would be required. The helipad is expected to occupy an area of around 30 m by 30 m, and would be remediated after construction. These areas would typically be located on existing disturbed land not subject to inundation and a reasonable distance from waterways, sensitive receivers and drainage lines. Eight locations have been identified and assessed as potential helipad locations. The exact locations to be used would be confirmed during detailed design by the construction contractors. In addition to this, the existing facilities at the Wagga Wagga Airport and Tumut Airport may be used.

Component	Description
Utility connections, adjustments and protection	The project would require utility connections, adjustments and protection. Such works include interfaces with other transmission lines and connections to existing services for temporary facilities. Potential impacts to existing services and utilities would be confirmed during detailed design and any proposed relocation and/or protection works would be determined in consultation with the relevant asset owners.

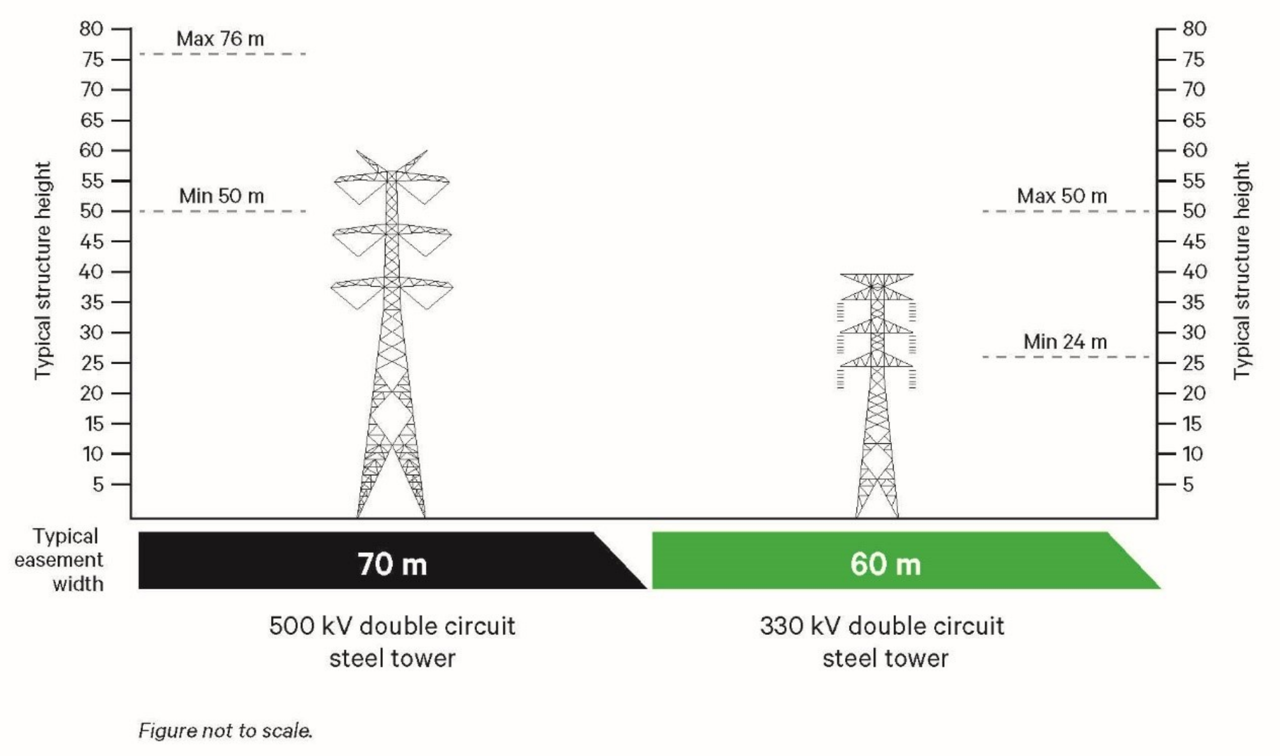


Figure 2-1 Indicative transmission line structures

2.2 Construction of the project

2.2.1 Construction activities

Key construction activities would generally include (but are not limited to):

- site establishment work, such as:
  - clearing of vegetation and topsoil
  - establishment of construction compounds and helipad/helicopter facilities
  - utility relocations and/or adjustments
  - construction of new access tracks and waterway crossings and/or upgrade of existing access tracks to transmission line structures
  - road improvement work
  - establishment of environmental management measures and security fencing
  - construction of temporary worker accommodation
- construction of the transmission lines, including:
  - earthworks and establishment of construction benches and brake and winch sites for each transmission line structure
  - construction of footings and foundation work for the new transmission line structures including boring and/or excavation, steel fabrication works and concrete pours
  - erection of the new transmission line structures
  - stringing of conductors, overhead earth wires and OPGW
  - installation of associated transmission line structure fittings inclusive of all earthing below ground level
- relocation of a section of Line 51, including:
  - demolition of the existing section of Line 51
  - erection of new transmission line structures for the rebuild of Line 51 in a new location
  - stringing of conductors, overhead earth wires and OPGW
  - installation of associated transmission line structure fittings inclusive of all earthing below ground level
- construction of the proposed Gugaa 500 kV substation, including:
  - bulk earthworks to form the substation bench, access roads, drainage and oil containment structures
  - installation of concrete foundations, bund walls, fire walls, noise walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment work and associated concrete pits, pipes and tanks including excavation
  - installation of new ancillary and equipment control buildings
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - erection of the substation site boundary security fencing, including site access gates
  - connection of the proposed transmission lines to the substation

- modification of the existing Wagga 330 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - demolition and removal of redundant electrical equipment, fencing and cabling
  - bulk earthworks to form the extended substation bench and modified drainage structures
  - installation of concrete foundations and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, and modified site stormwater drainage including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - testing and commissioning
  - connection of the proposed transmission lines to the substation
- modification of the existing Bannaby 500 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - bulk earthworks to form the extended substation bench, new access road, modified stormwater drainage, modified oil containment and modified sediment control structures
  - installation of concrete foundations, retaining walls, bund walls, fire walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment works and associated concrete pits, pipes and tanks including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - demolish redundant fencing including footings and kerbs
  - testing and commissioning
  - connection of the proposed transmission lines to the substation
- connection of the proposed transmission lines to the future Maragle 500 kV substation, including:
  - stringing conductors between transmission line structures and the future Maragle 500 kV substation gantry (including overhead earth wire (OHEW) and OPGW)
  - installing droppers from the future substation gantry to the switchgear
- construction of the telecommunications hut, including:
  - bulk earthworks to form the pad for the hut
  - excavation and preparation for concrete foundations
  - installation of reinforced concrete and piled foundations
  - excavation and installation of electrical equipment conduits, trenches and general site drainage work

– installation of the building, site wiring and electrical equipment

– installation of security fencing and site access gates

- installation of buried cabling from the 500 kV transmission line structures to Rye Park Wind Farm substation
- testing and commissioning of new electrical infrastructure
- demobilisation and rehabilitation of areas disturbed by construction activities.

A number of activities are expected to commence in accordance with the project conditions of approval before the key construction activities outlined above. These activities are considered pre-construction minor work and would comprise low impact activities that would begin after planning approval but prior to approval of the Construction Environmental Management Plan.

2.2.2 Construction program

Construction of the project is targeted to commence in 2024, and is estimated to take about 2.5 years to complete. The project is expected to be fully operational by the end of 2026 (refer to Figure 2-2).

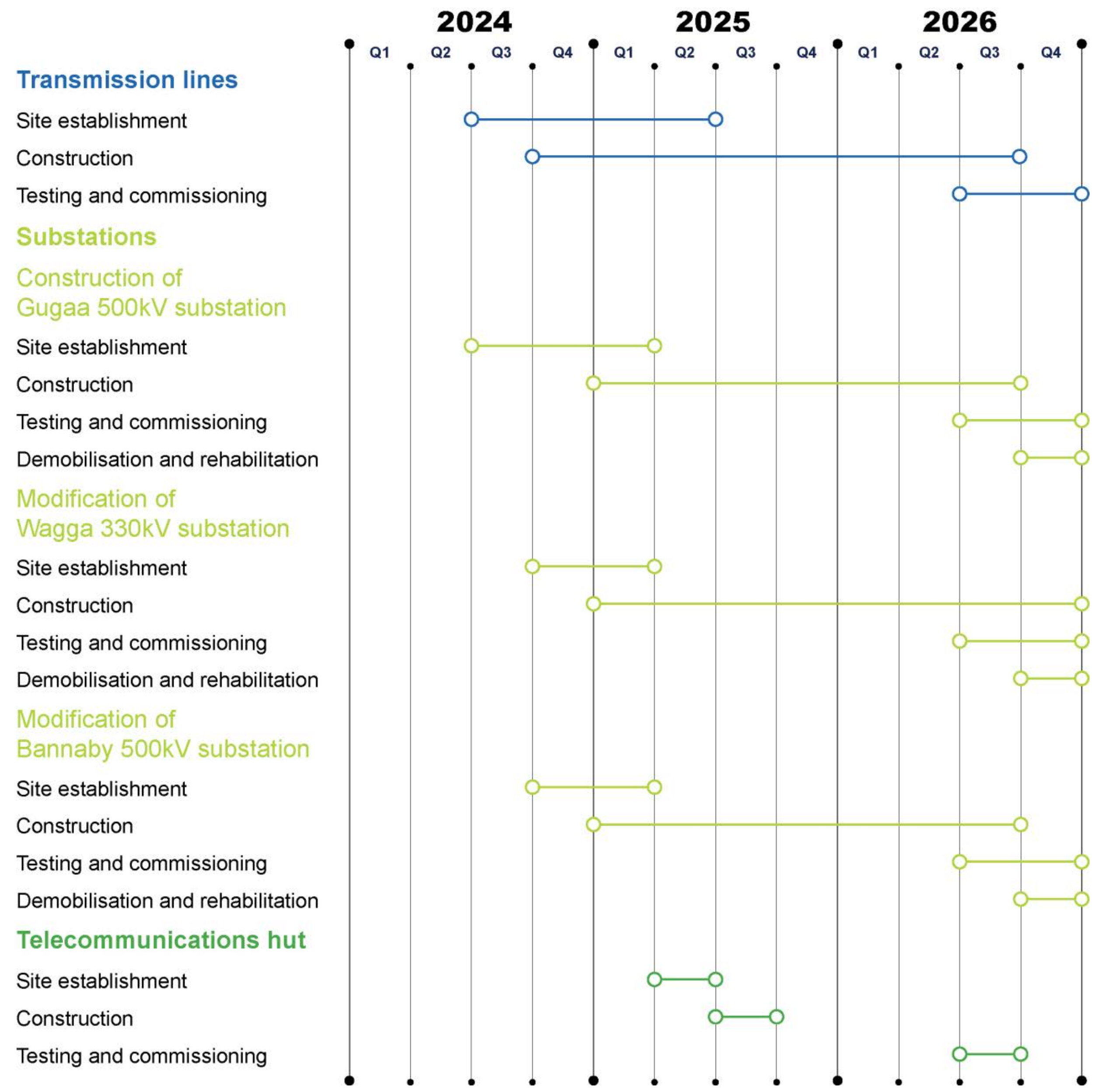


Figure 2-2 HumeLink indicative construction program

2.2.2.1 Indicative duration of construction activities

Construction at each transmission line structure would be intermittent and construction activities would not occur for the full duration at any one location. Durations of any particular construction activity, and inactive/respite periods, may vary for a number of reasons including (but not limited to):

- multiple work fronts
- resource and engineering constraints
- work sequencing and location.

Figure 2-3 presents an indicative duration of construction activities associated with an individual transmission line structure.

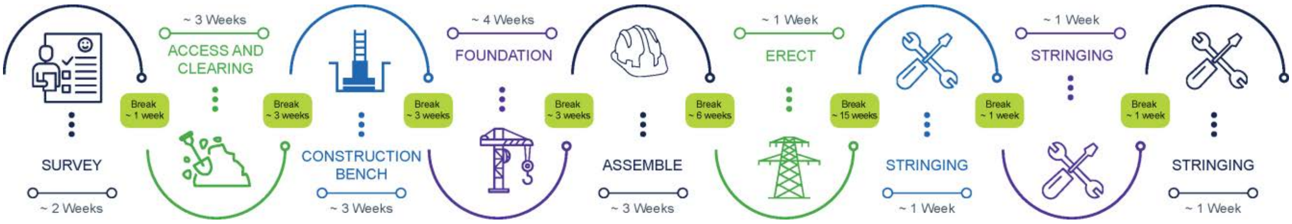


Figure 2-3 Indicative duration and sequence of construction activities for transmission line structures

Construction of the proposed Gugaa 500 kV substation could take up to 2.5 years.

2.2.3 Construction hours

It is expected that construction activities would largely be undertaken during standard construction hours. However, there would be times when working outside of standard construction hours would be required (as defined by the Interim Construction Noise Guideline (DECC, 2009)), subject to approval. As the details of construction methodology and project needs are developed, these hours will be refined for certain activities.

Where extended hours are proposed for activities in proximity to sensitive receivers, additional measures would be implemented and the work would be managed through an out-of-hours work protocol.

A series of work outside the standard construction hours is anticipated to include (but is not limited to) the following:

- transmission line construction at crossings of a main road or railway. These locations are expected to have restricted construction hours requiring some night work for activities such as conductor stringing over the crossing(s)
- work where a road occupancy licence (or similar) is required, depending on licence conditions
- transmission line cutover and commissioning
- the delivery of equipment or materials outside standard hours requested by police or other authorities for safety reasons (such as the delivery of transformer units)
- limited substation assembly work (eg oil filling of the transformers)
- connection of the new assets to existing assets under outage conditions (eg modification and/or connection work at Bannaby 500 kV substation, Wagga 330 kV substation and Maragle 500 kV substation), which is likely to require longer working hours
- emergency work to avoid the loss of lives and/or property and/or to prevent environmental harm
- work timed to correlate with system planning outages
- situations where agreement is reached with affected sensitive receivers
- activities that do not generate noise in excess of the applicable noise management level at any sensitive receiver.

2.2.4 Construction plant and equipment

An indicative list of construction plant and equipment likely to be required during construction is provided below.

- air compressor
- backhoe
- bobcat
- bulldozers
- concrete agitator
- concrete pump
- cranes (various sizes up to 400 tonnes)
- crawler crane with grab attachments
- drill and blast units and associated support plant/equipment
- drones
- dumper trucks
- elevated working platforms
- excavators (various sizes)
- flatbed Hiab truck
- fuel trucks
- generators
- graders
- helicopter and associated support plant/equipment
- mulchers
- piling rig
- pneumatic jackhammers
- rigid tippers
- rollers (10-15 and 12-15 tonne)
- semi-trailers
- tilt tray trucks
- trenchers
- transport trucks
- watercarts
- winches.

2.2.5 Construction traffic

Construction vehicle movements would comprise vehicles transporting equipment, waste, materials and spoil, as well as workers' vehicles. A larger number of heavy vehicles would be required during the main civil construction work associated with the substations. Non-standard or oversized loads would also be required for the substation work (eg for transformer transport) and transportation of transmission line structure materials and conductors.

Hume Highway, Sturt Highway, Snowy Mountains Highway, Batlow Road and Gocup Road are the main national and state roads proposed to provide access to the project footprint. These roads would be supported by regional and local roads throughout the LGAs of Wagga Wagga City, Snowy Valleys, Yass Valley, Cootamundra-Gundagai Regional and Upper Lachlan Shire that connect to the project footprint.

2.2.6 Construction workers

The construction worker numbers would vary depending on the stage of construction and associated activities. During peak construction activities, the project could employ up to 1,200 full-time equivalent construction workers across multiple work fronts. It is expected that the maximum number of construction workers at any one location would not exceed 200.

2.2.7 Testing and commissioning

Prior to energisation of the infrastructure, a series of pre-commissioning activities would be conducted. This would include testing the new transmission lines and substation earthing, primary and secondary equipment.

2.2.8 Demobilisation and rehabilitation

Demobilisation and site rehabilitation would be undertaken progressively throughout the project footprint and would include the following typical activities:

- demobilisation of construction compounds and worker accommodation facility
- removal of materials, waste and redundant structures not required during operation of the project
- removal of temporary fencing and environmental controls.

2.3 Operation of the project

The design life of the project is 50 years, which can be extended to more than 70 years for some assets.

The substations and transmission lines would be inspected by field staff and contractors on a regular basis, with other operational activities occurring in the event of an emergency (as required). The project would require about five workers (in addition to Transgrid's existing workers) during operation for ongoing maintenance activities. Likely maintenance activities would include:

- regular inspection (ground and aerial) and maintenance of electrical equipment
- general building, asset protection zone and access road/track
- vegetation clearing/trimming within the easement
- fire detection system inspection and maintenance
- stormwater drainage systems maintenance.

It is expected that these activities would only require light vehicles and/or small to medium plant (depending on the work required).

2.3.1 Operational water requirements

Water would be required for maintenance activities and operation of the substation sites. Table 2-2 details the estimated annual water requirements and water sources for each site.

Table 2-2 Estimated annual water requirements during operation

Site	Estimated annual water requirements during operation (kL)	Water source
Gugaa 500 kV substation	62	Rainwater tank feed from secondary systems building that allows for water to be trucked in for top-up.
Bannaby 500 kV substation	27	No changes to existing water supply arrangements are proposed.
Wagga 330 kV substation	27	No changes to existing water supply arrangements are proposed.

3 Legislative and policy context

This chapter summarises the current legislative requirements and guidelines relevant to this surface water and groundwater impact assessment.

3.1 Commonwealth legislation, policy, and guidelines

3.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) is administered by the Department of Climate Change, Energy, the Environment and Water and provides a legal framework to protect and manage nationally important flora, fauna, ecological communities, and heritage places defined as ‘matters of national environmental significance’.

Under the EPBC Act, proposed actions (ie activities or projects) with the potential to significantly impact matters protected by the EPBC Act must be referred to the Commonwealth Minister for the Environment to determine whether they are controlled actions, requiring approval from the Minister. No matters of national environmental significance in terms of groundwater or surface water would be directly impacted by the project however there may be indirect impacts on threatened species and communities listed under the EPBC Act through changes in water quality. These impacts are assessed in *Technical Report 1 – Biodiversity Development Assessment Report*.

3.1.2 Water Act 2007

The *Water Act 2007* (Commonwealth) (the Water Act) provides the legislative framework for ensuring that the Murray-Darling Basin (MDB), Australia’s largest water resource, is managed in the national interest. It transferred the powers and functions of the Murray-Darling Basin Commission to the Murray-Darling Basin Authority (MDBA) through the Murray-Darling Basin Agreement.

The purpose of the Agreement is to: ‘*promote and co-ordinate effective planning and management for the equitable, efficient and sustainable use of the water and other natural resources of the Murray-Darling Basin, including by implementing arrangements agreed between the Contracting Governments to give effect to the Basin Plan, the Water Act and state water entitlements*.’

The *Basin Plan 2012*, hereafter referred to as the Basin Plan, uses water resource plans (WRPs) as a tool to effectively meet the objectives of the agreement. The Basin Plan is discussed further in Section 3.1.3.

The project may temporarily purchase water allocations, which are detailed in a WRP for a catchment. However as these are existing allocations, the project has no direct implications for Basin Plan objectives, WRPs or other construction compounds of the MDBA.

3.1.3 Basin Plan 2012

3.1.3.1 Basin Plan Overview

The *Basin Plan 2012* (Commonwealth) aims to provide a coordinated approach to water use across the Murray–Darling Basin's four states and the ACT. It provides a framework to balance environmental, social, and economic considerations for water use and water quality to an environmentally sustainable level. The Plan addresses both surface and groundwater use and water quality. Components of the plan include:

- overall environmental management objectives and outcomes
- sustainable diversion limits on how much surface water and groundwater can be taken from the Basin and a mechanism for adjustments to these limits
- an environmental watering plan – to protect and restore the Basin's rivers and wetlands
- a water quality and salinity management plan that sets objectives and targets
- identifying the risks to continued water availability in the Basin, and strategies to manage them
- a monitoring and evaluation program, including an annual report on the effectiveness of the Basin Plan 2012.

The *Basin Plan 2012* sets water quality targets and objectives to protect water quality in the Basin's rivers for people and livestock as well as for wetlands and floodplains. The Basin Plan requires water managers to consider water quality targets when making decisions about environmental watering and running the river.

The NSW State of the Environment (SoE) report (EPA, 2012) demonstrated that there was little relationship between standard water quality targets and aquatic ecosystem health, due to the highly variable nature of natural water quality regionally. This highlighted a need for regional guidelines to be established, reflecting the natural regional variability noted.

Schedule 11 of the *Basin Plan 2012* outlines water quality zones and provides water quality targets which are used to assess water quality at inland monitoring stations. These replace the previous default trigger values for slightly disturbed ecosystems listed in the National Water Quality Management Strategy (NWQMS) and are reproduced in the WRPs for each sub catchment of the Murray–Darling Basin along with WQO for each catchment. These sub-catchment WQO contribute to the overall water quality objective for the MDB to maintain appropriate water quality, including salinity, for environmental, social, cultural, and economic activity and provide a context for the management of surface water quality from the project. The water quality zones relevant to this project include B3 and C3 and their target values are presented in Table 3-1. These guideline values would be considered in the planning of surface water monitoring.

Table 3-1 Target values for target application zones

Target application zones	Water-dependent ecosystem	Ecosystem Type	Turbidity (NTU) (annual median)	Total phosphorus (µg/L) (annual median)	Total nitrogen (µg/L) (annual median)	Dissolved oxygen (mg/L; or % saturation) (annual median within the range)	pH (annual median within the range)	Salinity	Temperature (monthly median within the range)	Pesticides, heavy metals, and other toxic contaminants (values in Table 3.4.1 of the ANZECC Guidelines)
B3 (Castlereagh, Macquarie, Lachlan and Murrumbidgee valleys; Upland zone)	Other water-dependent ecosystems	Streams, rivers, lakes, and wetlands	20	35	600	>8 mg/L; or 90-110%	7.0 - 8.0	ND	Between the 20 percentile and 80 percentile of natural monthly water temperature	95% species protection
C3 (Lachlan and Murrumbidgee valleys Montane zone)	Other water-dependent ecosystems	Streams, rivers, lakes, and wetlands	10	20	250	>8.5 mg/L; or 90-110%	6.5 - 7.5	ND	Between the 20 percentile and 80 percentile of natural monthly water temperature	95% species protection

Note: ND: No Data

3.1.3.2 Water resource plans

In accordance with the Basin Plan 2012, WRPs need to be prepared by the NSW DPE for the MDB. The WRPs set rules on how much water can be taken from the Basin, ensuring that the sustainable diversion limit is not exceeded over time. The MDBA is responsible for monitoring and enforcing compliance with WRPs. In April 2020, NSW submitted its 11 WRPs to the MDBA for assessment, with another nine surface water WRPs submitted in June 2020. The MDBA progressed the assessment of NSW WRPs and notified NSW on the outcome of this assessment. Where further work was required to address accreditation requirements, NSW WRPs were withdrawn and will be resubmitted. All 20 of these WRPs were withdrawn in 2021 with two pending resubmission, one accredited and 17 resubmitted, as of October 2022 (DPE, 2022h).

There is currently a bilateral agreement in place with NSW, while they continue drafting their 20 WRPs for resubmission. The agreement ensures that key elements of Basin Plan 2012, including sustainable diversion limits and measures to protect and better manage environmental water, were in place from 1 July 2019. The agreement promotes transparency and gives the MDBA and the community confidence in the consistent application of key Basin Plan elements across all Basin states (MDBA, 2021).

The surface WRPs are discussed in Section 5.3.3 and the groundwater resource plans are discussed in Section 5.5.1.

3.1.4 National Water Quality Management Strategy

The NWQMS has been developed by the Australian and New Zealand governments in cooperation with state and territory governments. Endorsed by the Australian and New Zealand Environment and Conservation Council (ANZECC), the strategy establishes objectives to achieve sustainable use of the nation’s water resources by protecting and enhancing their quality while maintaining economic and social development.

The NWQMS includes guidelines for protection of water resources across Australia. These guidelines have been used to determine the existing condition of rivers and WQO for the project.

3.1.5 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018), hereafter known as ANZG 2018, is a key guideline within the NWQMS that is used to identify catchment and waterway specific water quality management goals. These guidelines are an updated version of the previous guidelines referred to as the ANZECC and ARMCANZ 2000 guidelines.

ANZG 2018 provides a process for assessing existing water quality conditions and developing WQOs to sustain current or likely future community values for water resources. Default guideline values for parameters are provided for different community values as generic starting points for assessing water quality where site specific information is not available. The default guideline values are used to evaluate the existing water quality conditions against long term water quality goals.

ANZG 2018 provides the most up to date databases to derive guideline values for toxicants and sediments in aquaculture and aquatic foods, physical and chemical stressors, and guideline values for agricultural water users. Where the ANZG 2018 does not provide a value, the values as used in the previous ANZECC & ARMCANZ 2000 ANZECC 2000 guidelines still apply.

The default guideline values have not been designed for direct application in activities such as discharge licences, recycled water quality or stormwater quality. These values are provided for various levels of protection of waterways which are considered when describing the existing water quality and key indicators of concern. The level of protection applied in this assessment when assessing ambient water quality is for ‘slightly disturbed to moderately disturbed ecosystems.

3.2 State legislation, policy, and guidelines

3.2.1 Environmental Planning and Assessment Act 1979

The EP&A Act provides a framework for environmental planning and assessment in NSW. The project is classified as CSSI in accordance with Division 5.2, Part 5 of the EP&A Act and requires approval from the NSW Minister for Planning.

In accordance with Section 5.16 of the EP&A Act, the SEARs were issued for the project on 14 March 2022 with matters to be addressed in the project EIS. The SEARs require that the EIS consider potential impacts to surface water and groundwater associated with construction and operation of the project. The SEARs relevant to this assessment are included in Section 1.4.

3.2.2 Water Act 1912 and Water Management Act 2000

Water resources in NSW are administered under the *Water Act 1912* (Water Act) and the *Water Management Act 2000* (WM Act). The objective of the WM Act is the sustainable and integrated management of the state's water sources for the benefit of present and future generations.

The WM Act governs the issue of licences and approvals for those water sources (rivers, lakes, estuaries, and groundwater) in NSW where water sharing plans (WSPs) have commenced. WSPs establish rules for sharing water between water users and the environment, and areas rules for water trading.

The NSW Water Act is being progressively phased out and replaced with the WM Act. The NSW Water Act continues to apply in those remaining water sources where a WSP has not been enacted.

Some water from the project would be directly purchased from current water licence holders under relevant WSPs, however there would be no overall change in the volume of allocations or compliance with Sustainable Diversion Limits due to the project. Transgrid or the construction contractors would obtain a zero allocation water access licences (WALs) under relevant WSPs which would enable them to temporarily purchase water allocations from existing water users.

3.2.2.1 Licensing

Chapter 3, Part 2 of the WM Act establishes WALs for taking water within a particular water management area. Access licence exemptions are described within of Part 1 of Schedule 4, of the Water Management (General) Regulation 2018.

Chapter 3, Part 3 of the WM Act establishes three types of approvals that a proponent may be required to obtain. These are:

- water use approvals
- water management work approvals (water supply work approvals, drainage work approvals and flood work approvals)
- activity approvals (controlled activity approvals and aquifer interference approvals). Exemptions to controlled activity approvals are specified in Part 2 of Schedule 4 of the Water Management (General) Regulation 2018.

Under Section 5.23(1) of the EP&A Act, approved State Significant Infrastructure does not require a water use approval under Section 89, a water management work approval under Section 90 or an activity approval (other than an aquifer interference approval) under Section 91 of the WM Act if groundwater extraction activities are assessed and approved as part of CSSI projects.

Therefore, if groundwater extraction is assessed and approved as part of the CSSI project, only a WAL would be required. A WAL relevant to the applicable WSP is required for dewatering and any other taking of water from any water source. The WAL would list the entitled water volume and requires a nominated water supply work.

3.2.2.2 Water Sharing Plans

WSPs are established under the WM Act and are the primary tool for defining water-sharing arrangements in NSW. The plans establish rules for sharing water between water users and the environment, and rules for water trading. WSPs describe the annual surface and groundwater recharge volumes for each identified water source and the volumes of water that are available for sharing. Available water volumes are based on calculated long-term average annual extraction limit. Provisions are made for environmental water allocation, basic landholder rights, domestic and stock rights, and native title rights. WSPs are typically in place for ten years, however they may be suspended in times of severe water shortages. There are WSPs for ground water and surface water resources.

Due to the MDBA bilateral agreement, multiple new WSPs have commenced across NSW, even though the corresponding Basin Plan WRPs have not been accredited (refer to Section 3.1.3.2). The relevant WSPs to the project are discussed further in Section 5.3.3 and Section 5.5.1 for surface water and groundwater, respectively.

3.2.2.3 Water Management (General) Regulation 2018

The Water Management (General) Regulation 2018 specifies procedural, technical and licence requirements, and exemptions under the WM Act. It also defines the function and powers of water supply authorities.

If groundwater extraction or dewatering is required throughout the project, depending on the volume per year, the project may be exempt from a WAL. Under this regulation, a WAL or a water use approval is exempt if groundwater extraction (such as for excavation to construct or maintain a building, road, or infrastructure) is less than three megalitres in any one water calendar year (commencing on 1 July each year). Requirements for this exemption are set out in Clause 21(6) of the Water Management (General) Regulation 2018 and include:

- record the water take within 24 hours in the approved form and manner
- keep the water take records for a period of five years
- provide the water take records to the Minister (or Water NSW) by no later than 28 July for the year ending 1 July during which the water was taken.

At the time of writing this report and the progress of concept design, the water volumes required for abstraction is unknown. If these volumes exceed three megalitres a year, a licence would be applied.

Activities such as construction and excavation within a certain distance of a classified waterway are considered controlled activities under the WM Act and the WM Regulation and generally require approval from DPE. The WM Regulation identifies exemptions to controlled activity approval requirements which include activities associated with the construction and operation of electricity networks (Schedule 4 Division 2 Clause 43). Consequently, the project is exempt from requiring controlled activity approvals (DPE, 2022c).

Although the project is exempt from controlled activity approvals, the controlled activity guidelines (DPI, 2012) were used in the assessment of this project and should be considered in site selection for certain features where there is some flexibility in their location such as the transmission line structures, construction compounds and access tracks.

3.2.3 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) establishes, amongst other things, the procedures for issuing licences for environmental protection on aspects such as waste, air, water, and noise pollution control. An Environment Protection Licence (EPL) is required under Chapter 3 of the POEO Act to undertake a scheduled activity or scheduled development work. Scheduled activities are defined in Schedule 1 of the POEO Act.

Scheduled activities relevant to this assessment are (as per Schedule 1 of the POEO Act):

- contaminated soil treatment, if the project has the capacity to 'treat more than 1,000 cubic metres per year of contaminated soil received from off-site' or 'where it treats contaminated soil originating exclusively on site, it has a capacity to incinerate more than 1,000 cubic metres per year of contaminated soil, or to treat (otherwise than by incineration) and store more than 30,000 cubic metres of contaminated soil, or disturb more than an aggregate area of three hectares of contaminated soil'
- contaminated groundwater treatment, if the project has the capacity to 'treat more than 100 megalitres per year of contaminated water'
- road construction (the extraction or processing (over the life of the construction) of more than 150,000 tonnes of material
- extractive activities, meaning the extraction (by any method, including by excavation, dredging, blasting, or tunnelling) or processing of extractive materials. However, this clause does not apply to the following—(a) cut and fill operations, or the excavation of foundations or earthworks, that are ancillary to development that is subject to development consent or approval under the EP&A Act.

However, under Part 5.3 of the POEO Act it is an offence to pollute waters unless an EPL is held and the conditions of any discharge in the EPL are met. As the project would involve considerable clearing and would require sedimentation basins in some locations to manage erosion impacts, an EPL would be required to manage and discharge the basins.

Section 5.24(e) of the EP&A Act identifies approvals or authorisations that cannot be refused if they are necessary for carrying out approved State Significant Infrastructure (or CSSI) and are substantially consistent with the Division 5.2 approval, including the need for an EPL under Chapter 3 of the POEO Act (for any of the purposes referred to in Section 43 of that Act).

3.2.4 State Environmental Planning Policy (Biodiversity and Conservation) 2021

Under Division 3.2 Section 3.26 of the EP&A Act, provision is to be made in a State Environmental Planning Policy (SEPP) requiring consent authorities to refuse consent to development applications relating to any part of the Sydney drinking water catchment, unless the consent authority is satisfied that the proposed development would have a neutral of beneficial effect (NorBE) on water quality. The NorBE test also applies to continuing development that is extended or expanded under similar conditions as the existing development consent.

Part 6.5 'Sydney Drinking Water Catchment' of *State Environmental Planning Policy (Biodiversity and Conservation) 2021* has been made to satisfy this obligation. It sets out the planning and assessment requirements for all new developments in the Sydney drinking water catchment to have a neutral or beneficial effect on water quality. The project footprint traverses the Sydney Drinking Water Catchment east of Gurrundah as seen in Figure 5-8.

For projects being assessed under Part 5 of the EP&A Act, including SSI and CSSI, section 171A of the *Environmental Planning and Assessment Amendment (Water Catchments) Regulation 2022* requires determining authorities to take into account whether the activity would have a neutral or beneficial effect on water quality before they carry out an activity, and whether the activity is consistent with this guideline, including the incorporation of current recommended practices (Section 4.7). Specific assessment criteria are provided for a Part 5 activity NorBE assessment. Consultation with WaterNSW will be carried out as required.

3.2.5 NSW Aquifer Interference Policy

The *NSW Aquifer Interference Policy* (DPI, 2012) (NSW AIP) clarifies the requirements for obtaining water licences and the assessment processes for aquifer interference activities under the WM Act and other relevant legislative frameworks. The NSW AIP also defines considerations in assessing whether more than minimal impacts might occur to a key water-dependent asset.

An aquifer interference activity involves any of the following:

- penetration of an aquifer
- interference with water in an aquifer
- obstruction of the flow of water in an aquifer
- taking of water (referred to as water take) from an aquifer whilst mining or any other activity prescribed by the regulations
- disposal of water taken from an aquifer while mining or any other activity prescribed by the regulations.

The WM Act includes the concept of ensuring 'no more than minimal harm' for both the granting of WALs and the granting of approvals. Approvals under the AIP would provide adequate mitigation measures are in place to ensure that no more than minimal harm would be imposed on any water source or its dependent ecosystems. An assessment in accordance with the concept of 'no more than minimal harm' has been conducted and is presented in Chapter 8, it is not anticipated that the project would trigger any licence requirements under the AIP**.**

3.2.6 NSW Government Groundwater Framework Documents

The *NSW Government Groundwater Policy Framework Document* (DLWC 1997) aims to manage the State's groundwater resources to sustain their environmental, social and economic uses. The policy has three component policies:

- *NSW Groundwater Quality Protection Policy* (DLWC 1998)
- *NSW Groundwater Dependent Ecosystems Policy* (DLWC 2002)
- *NSW Groundwater Quality Management Policy* (DLWC 2007).

These framework policy documents have been incorporated, where relevant, into generation of the governing policies and legislations discussed above.

The beneficial use category of a groundwater source refers to a general categorisation of groundwater uses based on water quality, dependent upon groundwater salinity and the presence/absence of contamination. The beneficial use categories are defined in the NSW Groundwater Protection Policy. An overriding principle of the NSW Groundwater Protection Policy is that groundwater quality should be maintained within its beneficial use category, which is reflected in the NSW minimal impact considerations for groundwater quality under the AIP outlined in Section 3.2.5 above.

3.2.7 NRAR/NSW Government – Water Guidelines

The Natural Resources Access Regulator (NRAR) is an independent regulator established under the NSW *Natural Resources Access Regulator Act 2017*. The current regulatory focus of NRAR is water regulation, a key part of which is to prevent, detect and stop illegal water activities.

NRAR also approves and regulates work on waterfront land and manages water licences and approvals of larger entities. NRAR work closely with other parts of the DPE— Water, and with other agencies such as WaterNSW. As such, some of the guidelines are repeated through both NRAR and other agencies. These guidelines include:

- *Enforceable Undertakings Guideline* (NRAR, n.d.)
- Regulatory Policy (NRAR, 2019)
- Waterfront land e-tool (DPE, 2020)
- Controlled activity exemption e-tool (DPE n.d.)
- *Guidelines for controlled activities on waterfront land – riparian corridors* (DPI, 2012)
- *Guidelines for controlled activities on waterfront land - watercourse crossings* (DPE, 2022b)
- *Guidelines for controlled activities on waterfront land – instream works* (DPE, 2022a).

Considerations of the above guidelines assist this assessment to inform the mitigation measures of potential impacts. The guidelines are described further below.

3.2.7.1 Waterfront land tool PDF/e-tool

The waterfront land tool has been developed to help applicants to determine what is waterfront land under the controlled activity provisions of the WM Act. ‘Waterfront land’ means the bed of any river, lake or estuary, and the land within 40 metres of the riverbanks, lake shore or estuary mean high-water mark.

3.2.7.2 Guidelines for controlled activities on waterfront land - riparian corridors

As specified in Section 2.2.1, controlled activities approval is not required for the construction and operation of transmission lines. However, the SEARs (refer to Section 1.4) require that the project work within 40 metres of waterway or on waterfront land are in accordance with this guideline. Identification of waterfront land can be done using the Waterfront land e-tool as discussed in Section 3.2.7.1. The project would be assessed by DPE in accordance with these guidelines.

The new rules amend the riparian corridor widths that apply to waterways, providing more flexibility in how riparian corridors can be used and making it easier for applicants to determine the NRAR-controlled activity approval requirements. Key changes were:

- Greater flexibility in the allowable uses and work has been permitted within riparian corridors.
- The core riparian zone and vegetated buffer have been combined into a single Vegetated Riparian Zone (VRZ).
- The width of the VRZ within the riparian corridor has been pre-determined and standardised for first, second, third and fourth order and greater waterways.
- Where suitable, applicants may undertake non-riparian corridor work or development within the outer 50 per cent of a VRZ, as long as they offset this activity by connecting an equivalent area to the RC within the development site.
- A new ‘riparian corridors matrix’ has enabled applicants to determine what activities can be considered in riparian corridors.

3.2.7.3 Guidelines for controlled activities on waterfront land - watercourse crossings

These guidelines relate to the design and construction of waterway crossings and ancillary work, such as roads on waterfront land. Crossings have the potential to disrupt the hydrologic, hydraulic, and geomorphic functions of a waterway affecting flows, bed and bank stability and the ecological values and functions of the riparian corridor. Any waterway crossings would be constructed in accordance with these guidelines.

3.2.7.4 Guidelines for controlled activities on waterfront land – instream works

These guidelines relate to the design and construction of work within a waterway or on waterfront land. Instream work include modifications or enhancements to the waterway, channel realignment, bed control structures, pipe laying and cable trenching etc. Any instream work would be constructed in accordance with these guidelines.

3.2.8 NSW Water Quality Objectives and River Flow Objectives

The *NSW Water Quality Objectives and River Flow Objectives* (DECCW, 2006) (NSW WQOs and RFOs) are the agreed community values and long-term goals for NSW's surface waters.

3.2.8.1 NSW Water Quality Objectives

The NSW WQOs set out:

- the community's values and uses for rivers, creeks, estuaries, and lakes (eg healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water)
- a range of water quality indicators to help assess the current condition of waterways and whether they support those values and uses.

For the catchments that have interstate rivers, the NSW WQOs state that the Murray-Darling Basin Commission (and now the Basin Plan 2012) supersedes the NSW WQO for those catchments, discussed further in Section 3.1.3 (DECCW, 2006).

The Hawkesbury-Nepean catchment has no defined current WQOs, however interim WQOs for the Hawkesbury-Nepean catchment were defined by the *Independent inquiry into the Hawkesbury Nepean River system* (HRC, 1998) for nutrients and chlorophyll-a and approved by the NSW government in September 1999. The inquiry recommended that non-nutrient criteria be adopted from Environmental Values and WQOs.

The project is located within the Hawkesbury-Nepean, Lachlan, Murrumbidgee and Upper Murray catchments for the NSW WQOs (refer to Table 3-2).

Table 3-2 Water Quality Objectives for the Murrumbidgee, Lachlan, Hawkesbury Nepean and Upper Murray Catchments

Catchments	Aquatic ecosystems	Aquatic foods (cooked)	Drinking water at point of supply-Clarification and disinfection	Drinking water at point of supply-Disinfection only	Drinking water at point of supply-Groundwater	Homestead water supply	Irrigation water supply	Industrial water supply	Livestock water supply	Recreation (primary contact)	Recreation (secondary contact)	Visual amenity
Hawkesbury-Nepean*	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
Lachlan (uncontrolled streams)	✓	✓	✓	✓	✗	✓	✓	✗	✓	✓	✓	✓
Murrumbidgee (major regulated rivers)	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
Murrumbidgee (uncontrolled streams)	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓
Upper Murray	✓	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓

Note:

*Interim WQOs

Assessing and accounting for cultural and spiritual values in water quality management processes also forms part of the determination and evaluation of community values and supports consultation with indigenous engagement protocols. Generic guidance to assist in identifying possible guideline values that could meet part or all of a particular cultural or spiritual value are provided in Table 3-3 as presented by the Australian Government (Australian Government, n.d.).

Table 3-3 Cultural and spiritual values in the Water Quality Guidelines and other guidance (Australian Government, n.d.)

Aim	Indicator	Water Quality Guidelines and other guidance
‘Water-Country’ and ‘Sea-Country’ is healthy	Plants and animals that live in the water are healthy	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – deriving guideline values for water quality
	Water quality is unchanged or close to natural conditions	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values – stressors unrelated to water quality – guideline values for water/sediment quality
	Sands, silts and clays on creek and river beds and in lakes, estuaries and on the ocean floor are not polluted	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – Toxicant default guideline values for sediment quality
	'Water-Country' and ‘Sea-Country’ looks healthy	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values
Water quality is safe for drinking and the water is safe for sourcing food	Eating fish and other water animals is safe	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values
	Eating water-living food plants is safe	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – guidelines for water/sediment quality – default guideline values – guidelines for water/sediment quality
	Water is safe for drinking	■ drinking untreated water is not recommended unless the water meets Australian or New Zealand drinking water guidelines: – Australian Drinking Water Guidelines (2011) — Updated November 2016 – Drinking-Water Standards for New Zealand – Guidelines for Drinking-Water Quality Management for New Zealand.
Water quality is safe for recreational and ceremonial purposes	Water quality is safe for swimming or for ceremonies where people go under water	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values
	Water quality is safe to paddle in or go boating on	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values
Water quality supports economic wellbeing of Indigenous peoples	Healthy water supports tourism	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values – water quality for primary industries
	Healthy water supports farming	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values ■ water allocation plans.
	Healthy water supports aquaculture	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality:* – default guideline values ■ water allocation plans.
	Healthy water supports other economic uses	■ *Australia & New Zealand Guidelines for Fresh & Marine Water Quality* ■ water allocation plans.

3.2.8.2 River Flow Objectives

Flow patterns in many rivers have been significantly altered and will not return to natural flow regimes. The NSW Government is not attempting to restore completely natural flow patterns where the community significantly benefits from altered flow patterns. Communities and the NSW Government have identified important areas where we can make adjustments to maintain or improve river health while continuing to benefit from water use. RFOs are the agreed high-level goals for surface water flow management. They identify the key elements of the flow regime that protect river health and water quality for ecosystems and human uses Table 3-4.

WSPs where developed, will contain integrated actions and timeframes to achieve objectives and implement identified actions in consultation with the community. Different approaches and outcomes will apply across the catchment.

RFOs were not recommended for the regulated parts of the Murrumbidgee River or the Lachlan River. This is because as part of water reforms, in 1998 the Government established Environmental Flow Rules for these rivers, after consideration by River Management Committees. These flow rules considered the principles of the RFOs and generally applied from 1998 until 2004. River Management Committees developed WSPs for these rivers, which commenced in July 2004. These Plans contain updated environmental flow rules, which are generally based on the principles of the RFOs consistent with the State Water Management Outcomes Plan.

Table 3-4 River Flow Objectives for the Murrumbidgee, Lachlan and Hawkesbury Nepean Catchments

Catchments*	Protect pools in dry times	Protect natural low flows	Protect important rises in water levels	Maintain wetland and floodplain inundation	Mimic natural drying in temporary waterways	Maintain natural flow variability	Maintain natural rates of change in water levels	Manage groundwater for ecosystems	Minimise effects of weirs and other structures	Minimise effects of dams on water quality	Make water available for unforeseen events
Lachlan (uncontrolled streams)	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗	✗
Murrumbidgee (uncontrolled streams)	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✗
Upper Murray	✓	✓	✓	✓	✓	✓	✗	✓	✓	✗	✗

Note:

No RFOs have been defined for the Hawkesbury-Nepean River; Murrumbidgee River (major regulated streams) RFOs have been developed by the river management committee

4 Methodology

4.1 Overview of approach

The steps and tasks listed below were carried out as part of the surface and groundwater assessment:

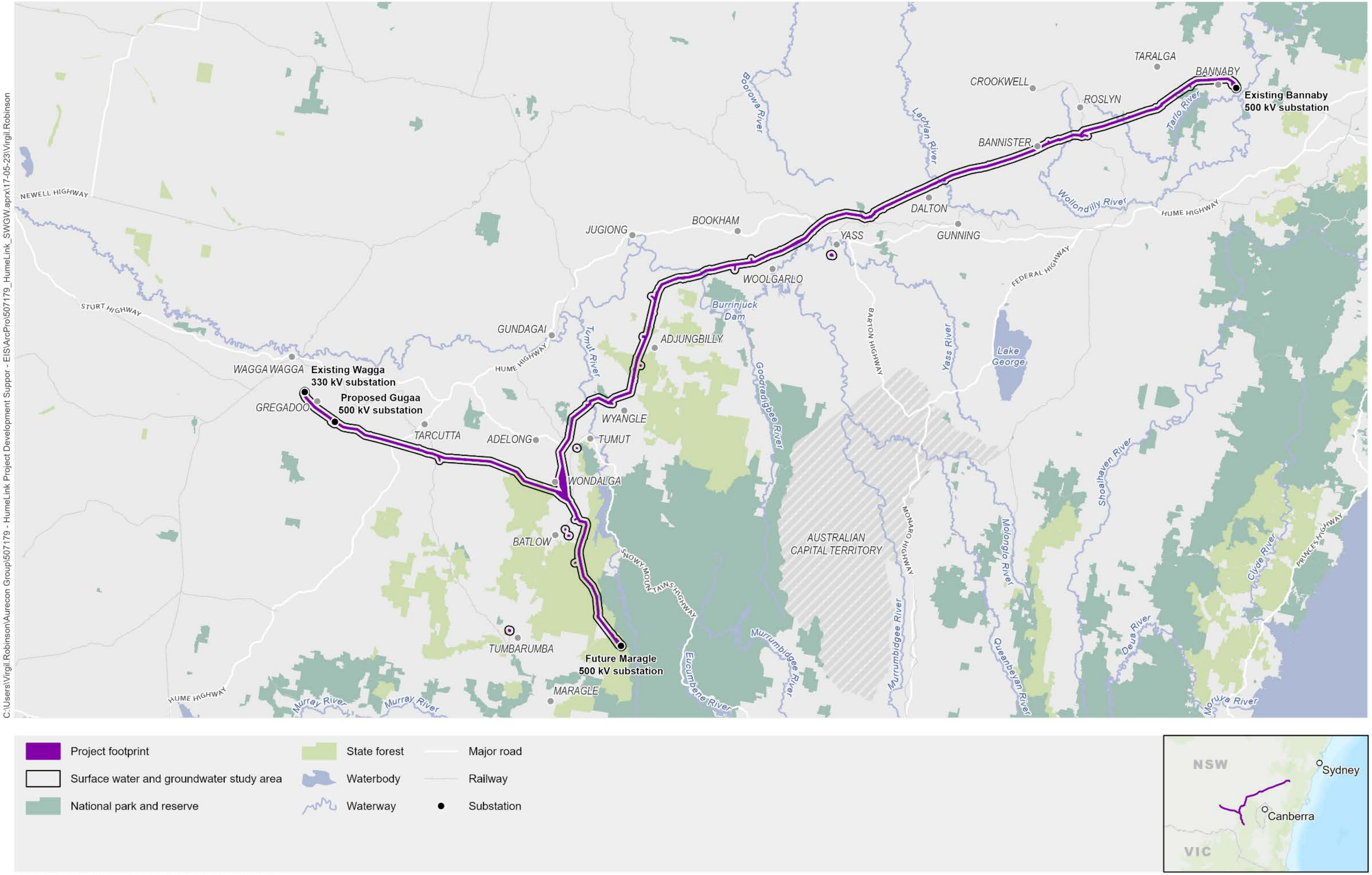
- desktop review of available information and data collation
- review of legislation and policy context for assessing surface water and groundwater impacts
- field verification including general walkover and targeted waterway geomorphological survey
- identification of the existing environment
- identification of relevant requirements and waterway objectives
- assessment of potential impacts (construction and operation)
- identification of project mitigation measures (construction and operation) to address any potential impacts.

Further to the above, the assessment methodology and scope has addressed the requirements of the SEARs (refer to Section 1.4). The approach used to complete each of the indicated tasks is detailed below.

4.2 Desktop review

4.2.1 Surface water and groundwater study area

The surface water and groundwater study area includes the project footprint and an additional one-kilometre extension on either side of the corridor has generally been applied for assessment of impacts to surface water, groundwater and potentially sensitive groundwater users. The surface water and groundwater study area is outlined in Figure 4-1.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

FIGURE 4-1: Surface water and groundwater study area

4.2.2 Data sources

The databases listed in Table 4-1 were searched and the relevant data extracted to inform both the description of the existing environment as well as the significance of the potential impacts resulting from the project.

Table 4-1 Data sources

Dataset	Data source	Website
Registered bores associated drilling, water depth and quality data.	Bureau of Meteorology (BoM) Australia Groundwater Explorer	http://www.bom.gov.au/water/groundwater/explorer/map.shtml
Temperature and Rainfall data	BoM Climate Data Online	http://www.bom.gov.au/climate/data/ https://www.longpaddock.qld.gov.au/silo/
Evaporation data	SILO	https://www.longpaddock.qld.gov.au/silo/
Elevation Data	Intergovernmental Committee on Surveying and Mapping Elvis - Elevation and Depth - Foundation Spatial Data	https://elevation.fsdf.org.au/
Modelled Hillslope Erosion	DPE The Central Resource for Sharing and Enabling Environmental Data (SEED) in NSW	https://datasets.seed.nsw.gov.au/dataset/modelled-hillslope-erosion-over-new-south-wales
GDE types and locations	BoM GDE Atlas	http://www.bom.gov.au/water/groundwater/gde/
Seamless Geology of NSW	NSW Government MinView	https://data.gov.au/dataset/ds-nsw-0e598ae6-f566-4036-aa61-3f1a1f73ade9/details?q=
Water Management (General) Regulation 2018 Hydro-Line	DPE	https://www.industry.nsw.gov.au/water/licensing-trade/hydroline-spatial-data
Hydrologic Soil Groups	SEED	https://datasets.seed.nsw.gov.au/dataset/hydrologic-groups-of-soils-in-nsw7f9e8
Key Fish Habitat (KFH)	DPI Fisheries Spatial Data Portal	https://www.dpi.nsw.gov.au/about-us/research-development/spatial-data-portal
Threatened species distribution	DPI Fisheries Spatial Data Portal	https://www.dpi.nsw.gov.au/about-us/research-development/spatial-data-portal
NSW River Styles	NSW River Style Database	https://water.dpie.nsw.gov.au/science-data-and-modelling/surface-water/monitoring-changes/river-styles-in-nsw
National dataset of Australia's Ramsar Wetlands	Australian Government Department of Climate Change, Energy, the Environment and Water Data	https://data.gov.au/dataset/ds-dga-8f4b957c-a5af-42c2-86bc-1bf967675f3f/details
NSW Wetlands	DPE Data NSW	https://data.nsw.gov.au/data/dataset/nsw-wetlands047c7
Protected Matters	Protected Matters Search Tool	https://www.awe.gov.au/environment/epbc/protected-matters-search-tool
MDB Water Resource Plans	MDBA Data	https://data.gov.au/dataset/ds-dga-7b0c274f-7f12-4062-9e54-5b8227ca20c4/details https://data.gov.au/dataset/ds-dga-b027244a-726b-4201-b641-538295183d48/details?q=Murray-Darling%20Basin%20Water%20Resource%20Plan%20Areas%20%E2%80%93%20groundwater
Water Sharing Plans	DPE The Central Resource for SEED in NSW	https://datasets.seed.nsw.gov.au/dataset/water-sharing-plans-spatial-data
WaterNSW real-time data	WaterNSW Real-time data	https://realtimedata.waternsw.com.au/

4.3 Field verification

Two field verification visits were conducted from 4 to 6 April 2022 and 24 to 26 August 2022 to verify information obtained from the publicly available datasets and mapping. The field verification also allowed the specialists to familiarise themselves with the surface water and groundwater study area (refer to Section 4.2.1) and capture relevant topographical and/or hydrological features that were not apparent in the desktop searches.

4.3.1 Site selection

The survey locations were selected based on the following criteria:

- waterways intercepting the project footprint as indicated in the Hydro-line dataset
- project activities within riparian corridors, as identified through Hydro-line dataset and aerial imagery representative locations of waterways for the full spectrum of waterway sizes (based on Strahler order)
- consideration of NSW KFH, threatened aquatic freshwater species mapping, GDEs, wetlands and protected matters.

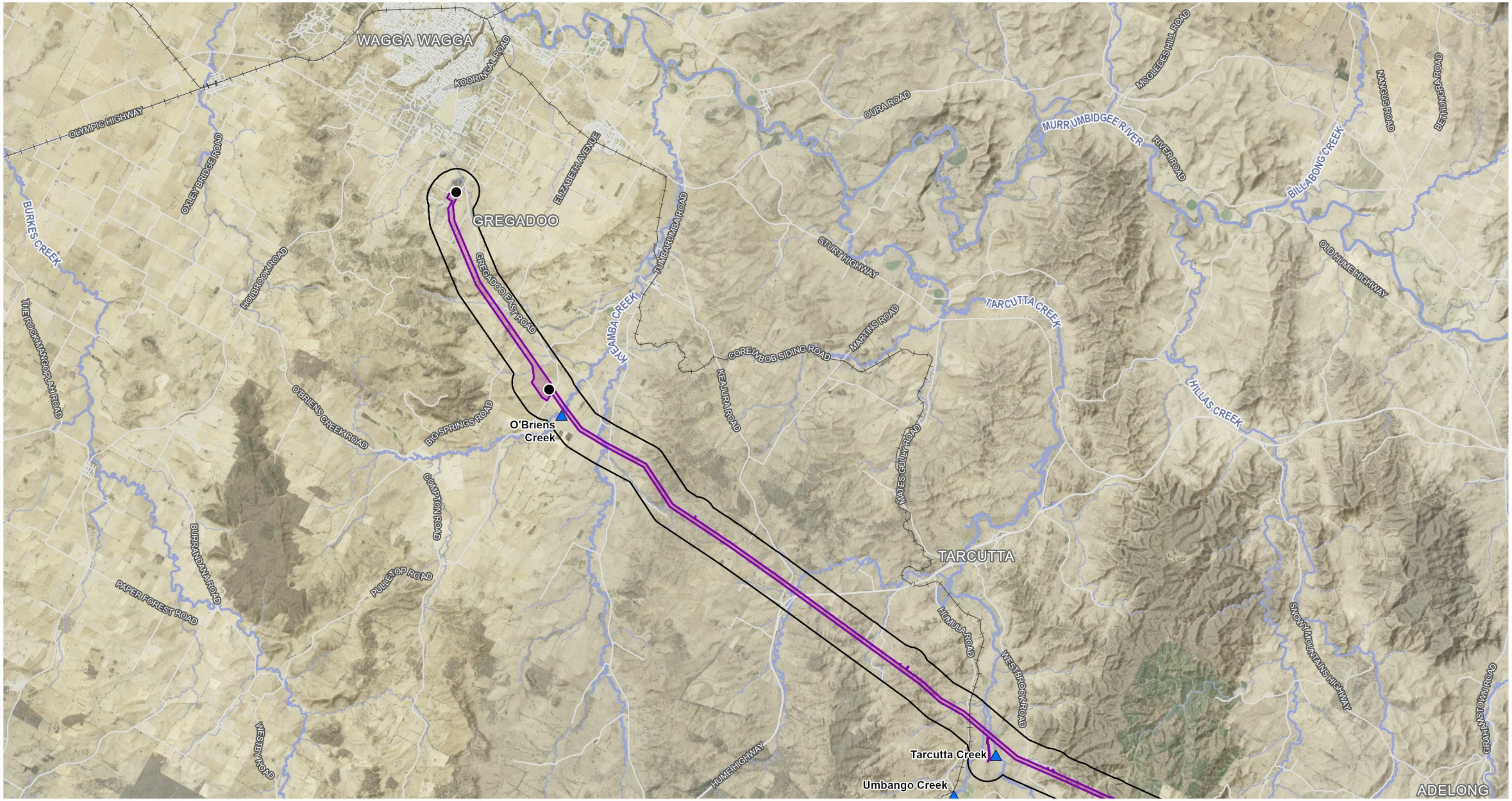
Classified VRZs were determined as defined by Table 1 of the *Guidelines for riparian corridors on waterfront land* (DPI, 2012). The width of the buffer zones is primarily informed by the Strahler order of the waterway as well as the bank full width. (DPI, 2022c).

The aforementioned guidelines (DPI 2012) were considered in site selection for certain project features, which have some flexibility in their location such as transmission line structures and access roads.

The selected field survey locations are listed in Table 4-2 and shown in Figure 4-2.

Table 4-2 Field survey locations (from west to east)

ID	Watercourse	Major catchment	Project feature potentially within VRZ	Strahler order
1	Unnamed tributary to O'Briens Creek	Murrumbidgee	Construction compound – Gregadoo Road compound (C06)	1
2	Snubba Creek	Murrumbidgee	Transmission line structure	4
3	Gilmore Creek	Murrumbidgee	Transmission line structure	6
4	Unnamed tributary to Sandy Creek	Murrumbidgee	Transmission line structure	2
5	Unnamed tributary to Gilmore Creek	Murrumbidgee	Construction compound – Snowy Mountains Highway compound (C02)	3
6	Killimicat Creek	Murrumbidgee	Access track	5
7	Murrumbidgee River	Murrumbidgee	Access track	9
8	Unnamed tributary to Oak Creek	Murrumbidgee	Transmission line structure	3
9	Derringullen Creek	Murrumbidgee	Access track	5
10	Wollondilly River/Pejar Dam	Hawkesbury-Nepean	Transmission line structure	5
11	Pejar Creek	Hawkesbury-Nepean	Transmission line structure	3
12	Tarcutta Creek	Murrumbidgee	Transmission line structure	6
13	Umbango Creek	Murrumbidgee	Transmission line structure	7
14	Pipeclay Gully	Upper Murray	Worker accommodation facility – Tumbarumba accommodation facility (AC1)	2
15	Adjungbilly Creek	Murrumbidgee	Transmission line structure	6



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Project footprint

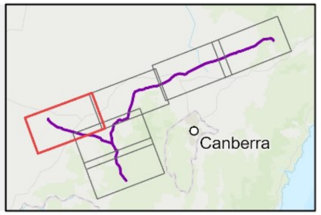
Surface water and groundwater study area

Railway

Watercourse

Substation

Field survey location



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 4-2a: Field survey locations

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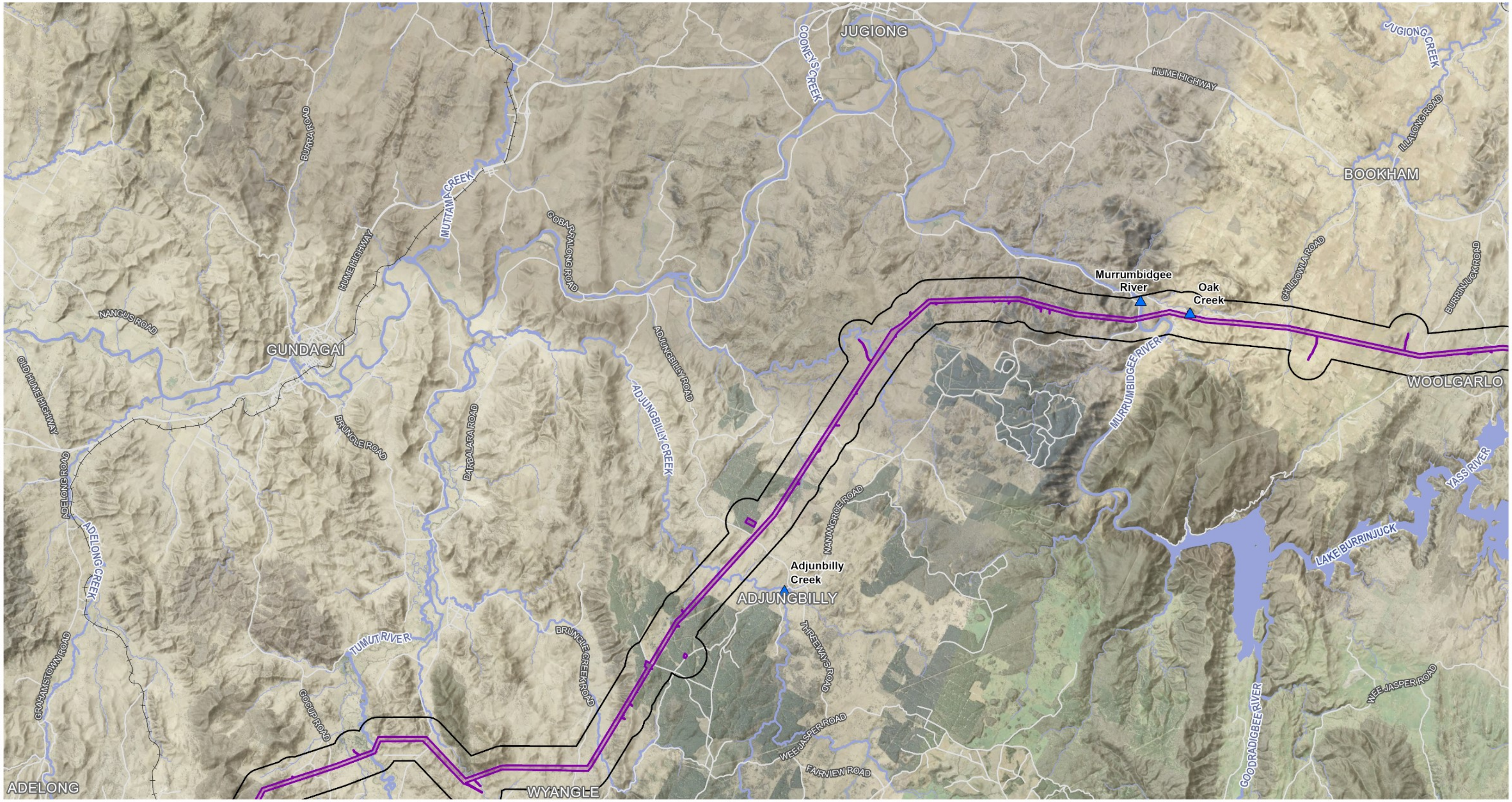
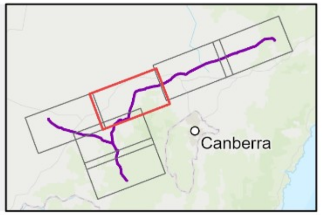


Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation
Field survey location



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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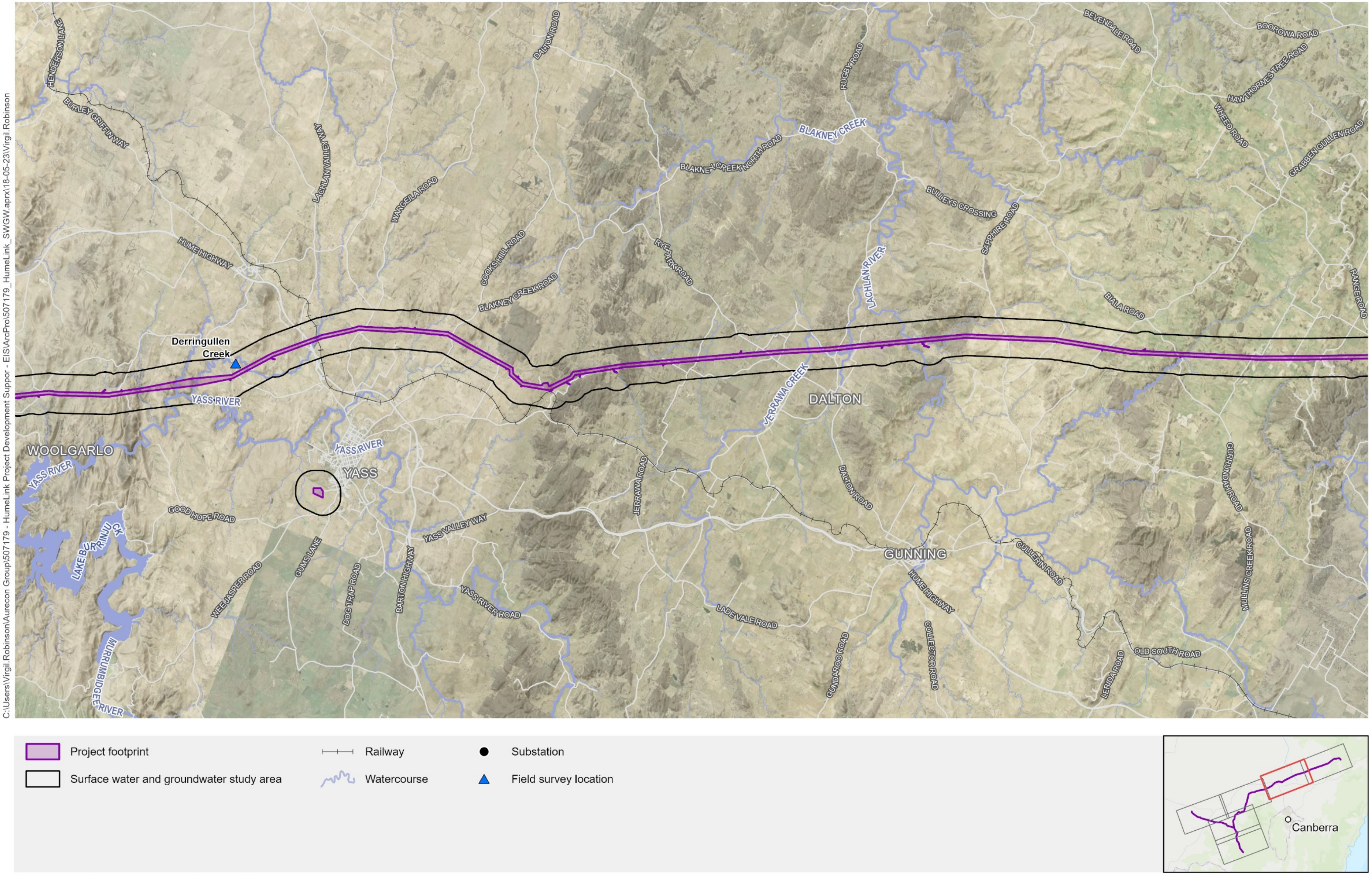
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 4-2b: Field survey locations



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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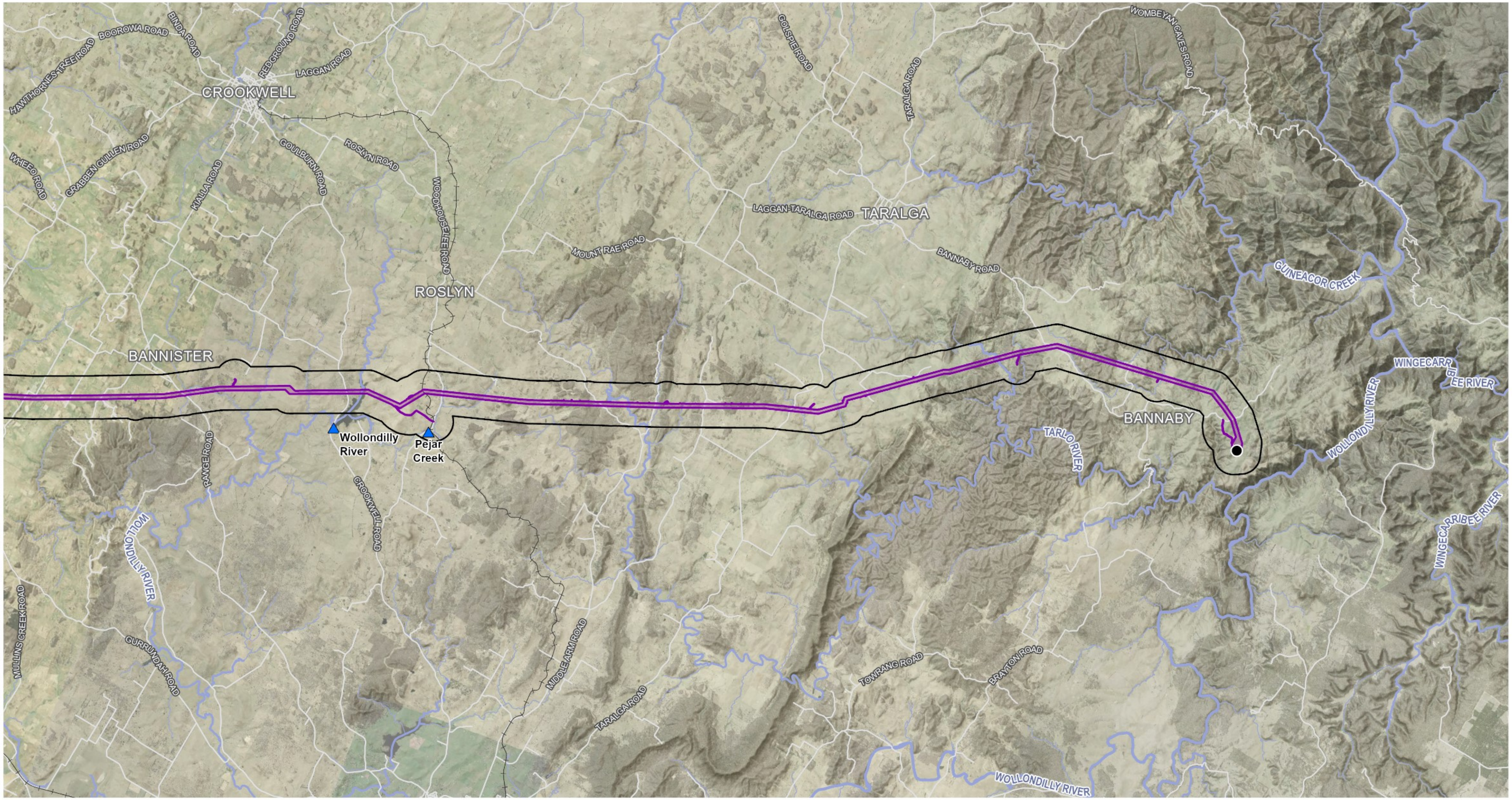
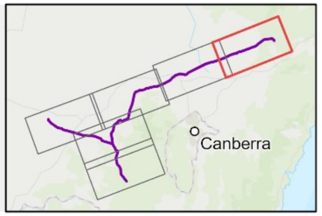
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 4-2c: Field survey locations



Project footprint	Railway	Substation
Surface water and groundwater study area	Watercourse	Field survey location



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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Projection: GDA 1994 MGA Zone 55

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Figure 4-2d: Field survey locations

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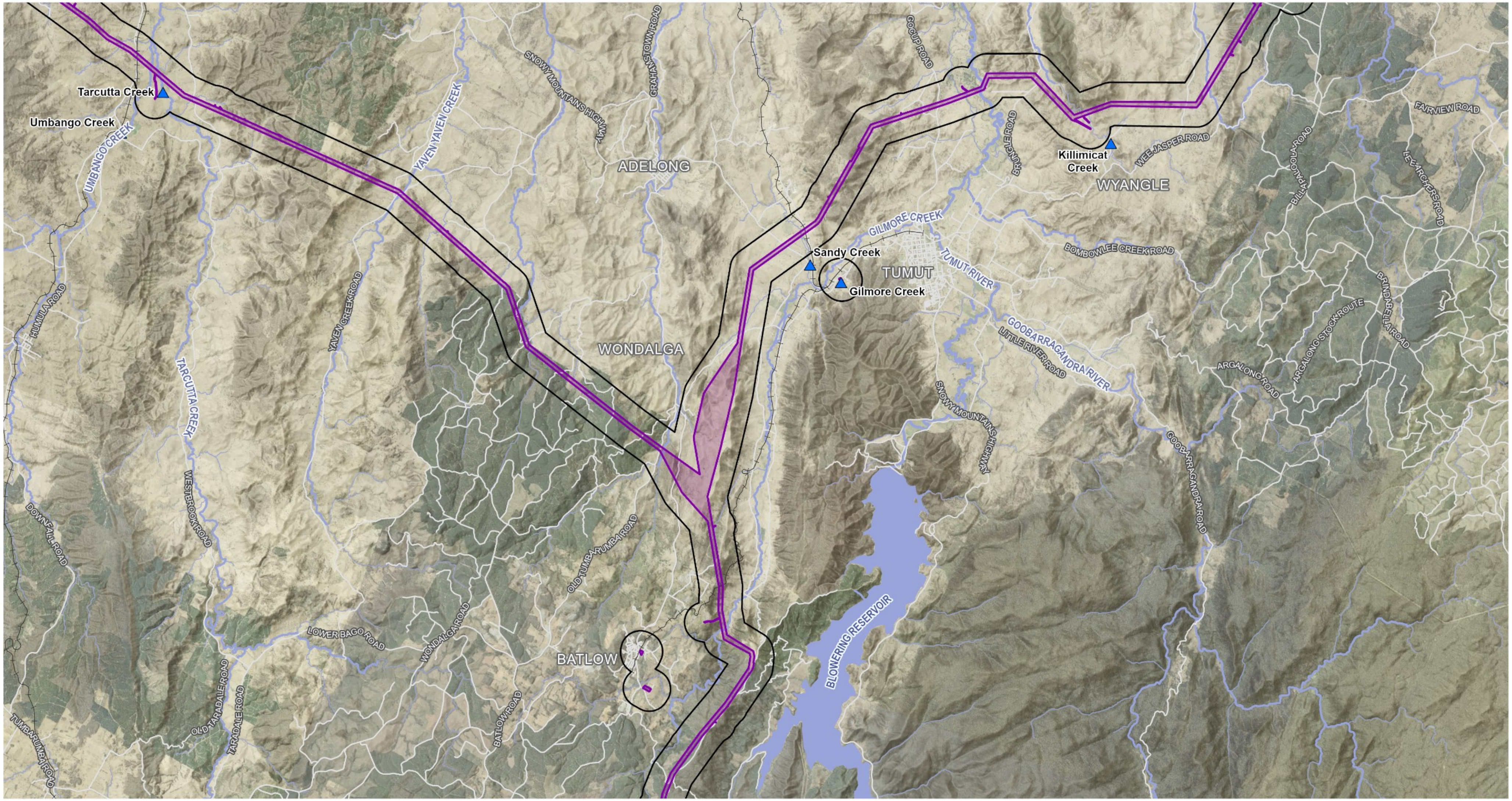
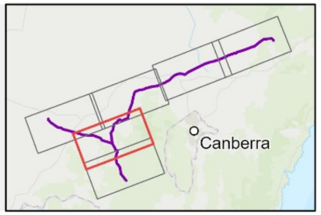


Project footprint	Railway	Substation
Surface water and groundwater study area	Watercourse	Field survey location



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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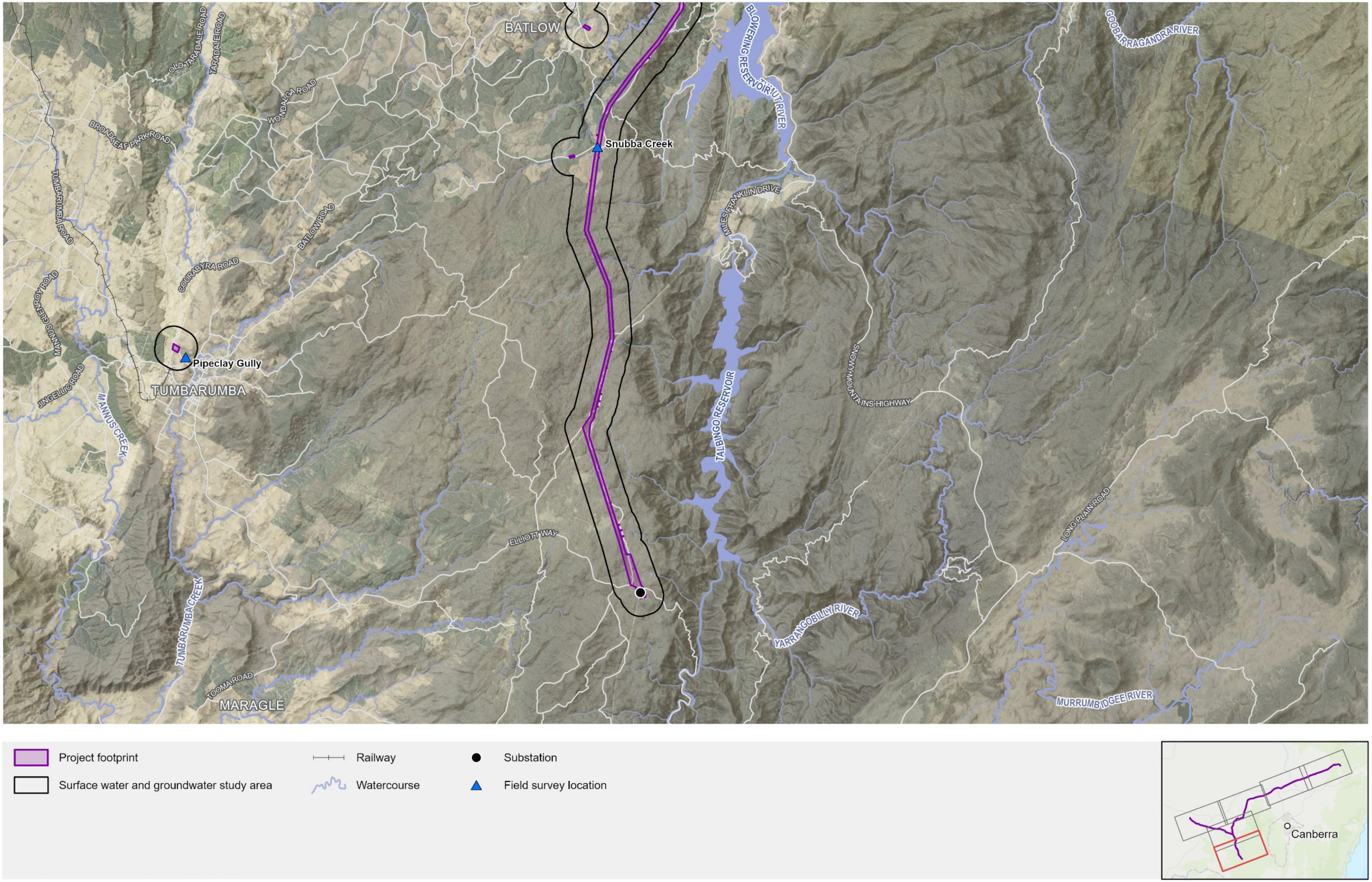
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 4-2e: Field survey locations



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 4-2f: Field survey locations

4.3.2 Works conducted

Site investigations were conducted in waterways thought to be representative of a range of waterways traversed or in proximity to the project. This included Strahler order 1 and 2 waterways, which are typically drainage lines or ephemeral waterways, and are typically dry.

The following tasks were conducted at all the survey locations:

- visual inspection and photographic survey of:
  - general geomorphology and topography
  - bank/soil condition and level of vegetation
  - evidence of previous or current erosion around the drainage areas
  - existing flow obstructions or flow diversions within the sub-catchment.

For the waterways containing water at the time of the survey the following additional tasks were conducted in general accordance with the AUSRIVAS Physical-Chemical protocol (Parsons *et al.*, 2002):

- visual inspection and photographic survey of:
  - general fluvial geomorphology
  - bank and bed substrate
  - floodplain condition and vegetation (where applicable)
- instream water quality measurements using a handheld meter (parameters included pH, temperature, conductivity, dissolved oxygen (mg/L), turbidity).

The findings and results of the field verification exercise are documented in Attachment C.

4.4 Impact assessment

4.4.1 Approach

A qualitative assessment of the potential surface water and groundwater impacts during construction and when operational was carried out based on a desktop review. Impact significance

The significance of any potential impact on the local surface water resources has been determined by considering the sensitivity of the receiving environment as well as the magnitude of the expected change as a result of the project.

While it is noted that there are many sensitive environmental features associated with waterways, such as KFH, wetlands and threatened aquatic ecosystems (refer to Section 4.2.2), the impacts of the project on these sensitive environmental features are assessed in the *Technical Report 1 – Biodiversity Development Assessment Report* including potential surface water impacts on these sensitive environmental features.

To determine a potential impact significance of a specific location from changes in surface water quality, the distance to a waterway has been used as a measure of the sensitivity of an area and is termed the waterway buffer zone. This has been defined by the width of VRZs as identified within *Guidelines for controlled activities on waterfront land Riparian corridors* (DPI, 2012) with a multiplication factor of five, namely:

- 50 metres from Strahler order 1 waterways
- 100 metres from Strahler order 2 waterways
- 150 metres from Strahler order 3 waterways
- 200 metres from Strahler order 4 waterways or higher.

For erosion risk and sedimentation, erosion risk was also considered using *Modelled Hillslope Erosion* (Yang *et al.*, 2017).

The Magnitude of Impact evaluation is influenced by the following criteria:

- expected duration of impact: short-term/temporary (during disturbance time only) or long-lasting/permanent (more than disturbance time)
- expected extent of impact: localised (immediate area) or regional/widespread (immediate area and continued downgradient for more than 500 metres)
- estimated degree of change from pre-development conditions.

The resultant matrix of impact significance is shown in Table 4-3.

Table 4-3 Matrix of impact significance

Magnitude of Impact	Sensitivity of environmental values		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

Table 4-4 Significance descriptions for surface water and groundwater

Significance	Surface water	Groundwater
Negligible	‘Negligible’ significance indicates a low potential for limited (in extent and/or time) impact to the local surface water environment may exist, including sensitive receiving environments. The impact would cause no perceptible change to the wider downstream catchments.	’Negligible’ significance indicates a low potential for limited (in extent and/or time) impact to the local hydrogeological environment may exist, including any GDEs and licensed users. No perceptible change to the regional hydrogeological environment.
Low	‘Low’ significance indicates a low potential for limited (in extent and/or time) impact to the surface water environment may exist, including any sensitive receiving environments in the immediate area. However, the potential impact would cause no permanent perceptible change to the wider downstream catchments.	’Low’ significance indicates a low potential for limited (in extent and/or time) impact to the hydrogeological environment may exist, including any GDEs and licensed users in the immediate area. However, the potential impact would cause no permanent perceptible change to the regional hydrogeological environment.
Moderate	‘Moderate’ significance indicates a potential for permanent, but limited, impact to the local surface water environment may exist, including any sensitive receiving environments in the immediate area. However, the potential impact would cause no perceptible change to the wider catchment.	’Moderate’ significance indicates a potential for permanent, but limited impact to the local hydrogeological environment may exist, including any GDEs and licensed users in the nearby area. However, the potential impact would cause no perceptible change to the regional hydrogeological environment.
High	‘High’ significance indicates a potential for permanent impact to the local surface water environment or temporary impact to the wider downstream catchments, including any sensitive receiving environments in the wider catchment.	’High’ significance indicates a potential for permanent impact to the local hydrogeological environment or temporary impact to the regional hydrogeological environment including any GDEs and licensed users.
Major	‘Major’ significance indicates a potential for permanent impact to the surface water environment at both the local and wider downstream catchment scales. The potential impact could cause major changes to surface water availability and/or quality.	’Major’ significance indicates a potential for permanent impact to the hydrogeological environment at both the local and regional scale including any GDEs and licensed users. The potential impact could cause major changes to groundwater availability and/or quality.

4.5 Neutral or Beneficial Effect on Water Quality Assessment

A preliminary Neutral or Beneficial Effect on Water Quality Assessment (NorBE) has to be conducted in accordance with the *Neutral or Beneficial Effect on Water Quality Assessment Guideline* (WaterNSW, 2022a) for the areas within the Sydney Drinking Water Catchment (refer to Figure 5-8). The project footprint extends approximately 65 kilometres into the Sydney Drinking Water Catchment, from near Bannister to Bannaby. Specifically, the below NorBE assessment was conducted utilising the template in Attachment 2 of the guidelines, which relates to Part 5 project activities.

A NorBE on water quality occurs when an activity impact one or more of the following three criteria:

- has no identifiable potential impact on water quality
- would contain any such impact on the site of the activity and prevent it from reaching any waterway, waterbody or drainage depression on the site
- would transfer any such impact outside the site by treatment in a facility and disposal approved by a public authority (but only if the public authority is satisfied that water quality after treatment would be of the required standard).

For practical application, a proposed activity would have a NorBE on water quality if it complies with one of the following:

- There are no factors involved that have any potential to impact on water quality. Changes to the site conditions and/or to the nature and location of the activity would not occur in any way that has the potential to:
  - directly change pollutant loadings by introducing or increasing substances into the hydrological cycle (such as waste flows, increased erosion, nutrients, and sediments)
  - indirectly change the quality of water in the hydrological system by changing the biophysical characteristics of the site in any way that reduces, or poses a major threat of reducing, the capacity of the site and related hydrological/ ecological components to assimilate, treat and otherwise produce water of at least equal quality to that contributed by the existing systems. Changes relate to the environmental values of the system, and may include:
    - major changes to flows (reductions or increases in flows)
    - clearing or degradation of waterways or of riparian corridors
    - changing the flow paths of water through these assimilative systems.
- The activity would not adversely affect water quality off the site because:
  - pollutant loads that occur as a result of the activity can be transported to acceptable downstream treatment and disposal facilities without adverse off-site water quality impacts
  - any water quality issues can be effectively managed on-site such that there are no adverse water quality impacts occurring off-site
  - there are no adverse water quality impacts that arise or are likely to arise indirectly as a result of changes to factors that affect the treatment, assimilation of pollutants, or affect the quality of water as part of the hydrological cycle (such as changes to flow or flow paths, waterways, or riparian corridors) that can adversely affect water quality off the site.

The preliminary NorBE assessment is presented in Chapter 9.

4.6 Aquifer Interference Policy minimal impact considerations

The AIP outlines minimal impact considerations that must be met as a result of the project. The minimal impact considerations are dependent upon the impacted aquifer type (alluvial, coastal, fractured rock or special cases such as the Great Artesian Basin) and whether the aquifer is 'highly productive' or 'less productive groundwater'. The impacts to be considered are to groundwater levels (or water pressure in artesian basins) and water quality as follows:

- Water table (drawdown) – impact is considered to be minimal where there is less than a cumulative two metre decline at any water supply work. If the impact is greater than two metres, then make good provisions apply.
- Water table (receivers) – impact is considered to be minimal where the water table change is less than 10 per cent of the cumulative variation in the water table 40 metres from any high priority GDE or high priority culturally significant site listed in the WSP.
- Water pressure – impact is considered to be minimal where the cumulative decline in head is less than two metres at any water supply work.
- Water quality – impact is considered to be minimal where the change in groundwater quality is within the current beneficial use category of the groundwater beyond the 40 metres of the activity.

If the predicted impacts are less than the Level 1 minimal impact considerations (as defined in the AIP), these impacts are considered acceptable. If, however, these predicted impacts exceed the Level 1 thresholds by no more than the accuracy of a robust model, the project would be accepted as suitable with appropriate monitoring during operation (NSW AIP, 2012). The accuracy of any model is unique based on the input data and calibration, but for simple models it is common practice to apply a 95% confidence interval.

To reduce the impacts, mitigation measures such as make good provisions may be required to protect a resource or receivers. Where the groundwater impacts are deemed not acceptable, the project may have to be modified to reduce the groundwater impacts to an acceptable level.

The minimal impact considerations are presented in Chapter 8.

5 Existing environment

This chapter describes the baseline environment relevant to surface water and groundwater including climate, topography, surface water, soils and geology, hydrogeology, surface water – groundwater interactions and sensitive receiving environments.

5.1 Climate and rainfall

5.1.1 Historical records

The BoM database was used to describe weather observations close to the surface water and groundwater study area. The identified climate stations were further assessed to determine the most representative set of records.

The climate across the surface water and groundwater study area ranges from cool temperate to hot, dry summers with cool winters. Climate zones in the LGAs that the project is located in are detailed in Table 5-1.

Table 5-1 Climate zones

Local Government Areas	Climate zone	Description
Wagga Wagga City Council	4	Hot dry summer, cool winter
Snowy Valleys Council	7	Cool temperate
Cootamundra-Gundagai Regional Council	4	Hot dry summer, cool winter
Yass Valley Council	6	Mild temperate
Upper Lachlan Shire Council	7	Cool temperate

Climate stations have been selected based on proximity to the project at the closest point, elevation, and climate zones.

Table 5-2 BoM climate stations

Gauge ID	Location	Climate zone	Distance (km)	Elevation (m)
72150	Wagga Wagga (AMO)	4	8.4	212
73007	Burrinjuck Dam	6	11.2	390
70263	Goulburn TAFE	7	22.2	670

Review of recent historical data (2010-2022) collected at the Wagga Wagga (AMO) station indicated a variable annual rainfall rate. Wetter years, ie 2010, recorded rainfall in excess of 1,000 millimetres, compared to drier years, ie 2013, 2017, 2018 and 2019, which recorded approximately 400 millimetres of rainfall. Pan evaporation data typically varied annually between approximately 1,500 millimetres and 1,900 millimetres, however, 2021 was anomalous as only 1,279 millimetres was recorded.

The monthly rainfall and potential evaporation data for the Wagga Wagga (AMO) station are presented in Figure 5-1. The data indicated rainfall was largely consistent throughout the year, with no obvious seasonal trend emerging. Average monthly rainfall ranged from 31 millimetres in April, to 73 millimetres in November. Conversely, average monthly potential evaporation is more variable, with a noticeable trough throughout the cooler months of May to August, with evaporation being higher in the drier months of September to April, indicating that temperature and sunlight may be the largest influence on evapotranspiration. The latter period suggests that a surface water deficit would typically occur at any one time, with potential evapotranspiration far exceeding the rainfall falling in these catchments.

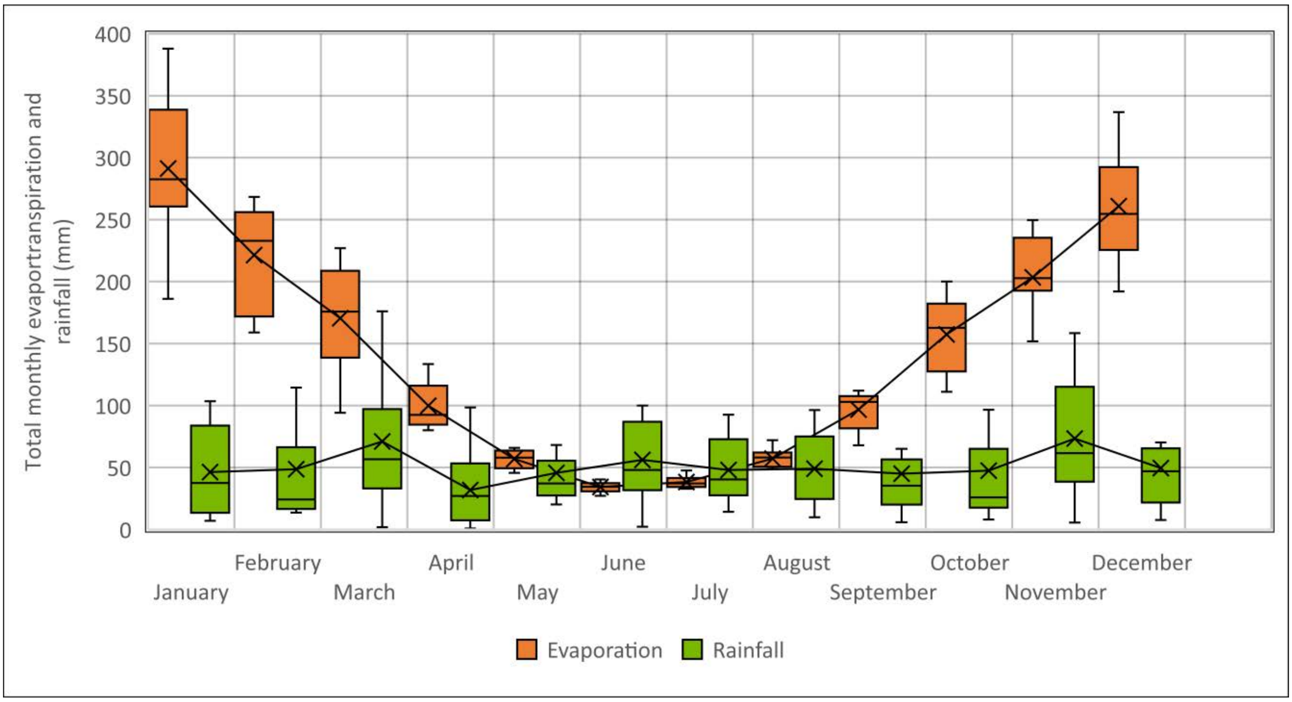


Figure 5-1 Wagga Wagga (AMO) average evaporation and rainfall (2010-2022)

A summary of temperature variation at Wagga Wagga (AMO) is provided in Figure 5-2. The station is within a warm, temperate climate with dry, hot summers (with average maximum temperatures ranging between approximately 28°C and 33°C) and cool winters with average maximum temperatures ranging between approximately 13°C and 15°C, and average minimum temperatures of 3°C. This aligns with the earlier climate zone classification for Wagga Wagga City Council (refer to Table 5-1).

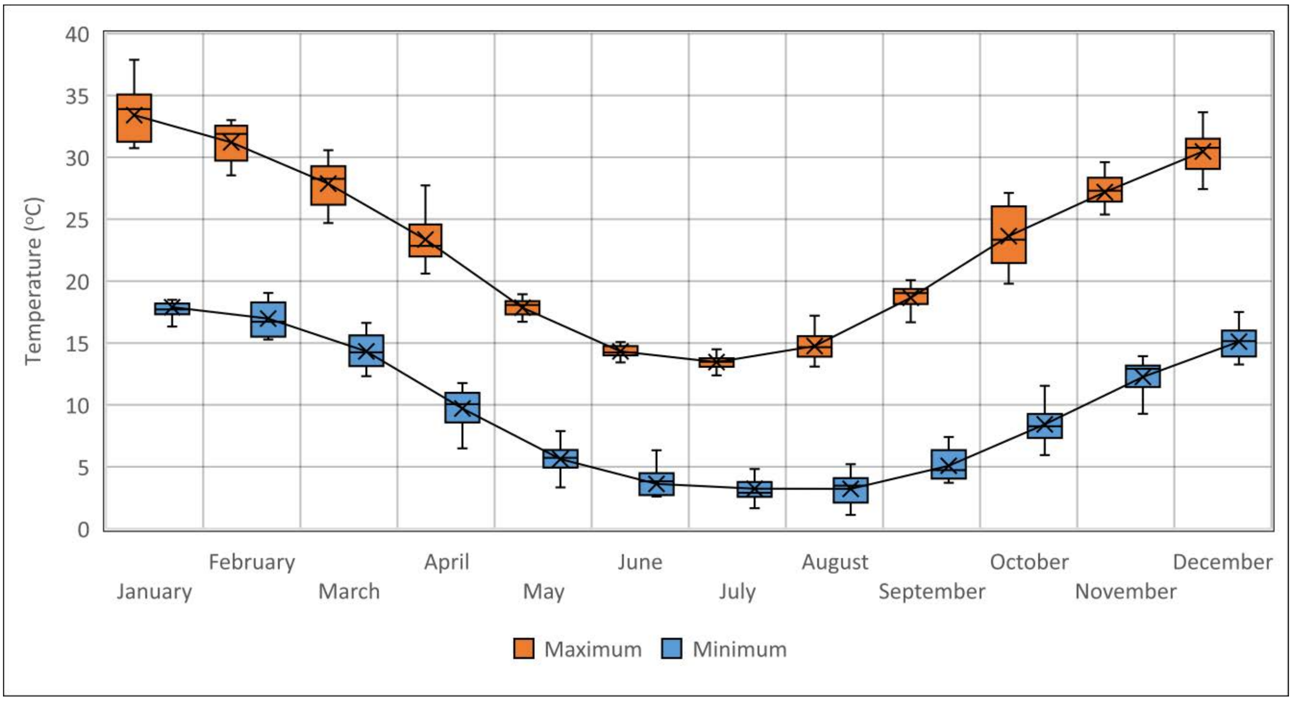


Figure 5-2 Wagga Wagga (AMO) monthly average temperature (2010-2022)

Review of the recent historical data (2010-2022) collected at the Burrinjuck Dam station indicated a variable annual rainfall rate. Wetter years, ie 2010, recorded rainfall in excess of 1,500 millimetres (higher than Wagga Wagga), compared to drier years, ie 2019, which recorded 500 millimetres of rainfall (slightly higher than Wagga Wagga). Pan evaporation data typically varied annually between approximately 1,000 millimetres and 1,350 millimetres (lower than Wagga Wagga).

The monthly rainfall and evaporation data for the Burrinjuck Dam station are presented in Figure 5-3. The data indicated mean rainfall was largely consistent throughout the year, but the monthly range was much more variable than at Wagga Wagga, with no obvious seasonal trend emerging. Average monthly rainfall ranged from 47 millimetres in April, to 103 millimetres in November. Conversely, average monthly evaporation is more variable, with a noticeable trough throughout the cooler, winter months, with potential evaporation being higher in the hotter summer months. However, the monthly ranges in potential evapotranspiration were low (compared to rainfall variation in the same month). Furthermore, the period of surface water deficit (October – March) was shorter and less pronounced than at Wagga Wagga.

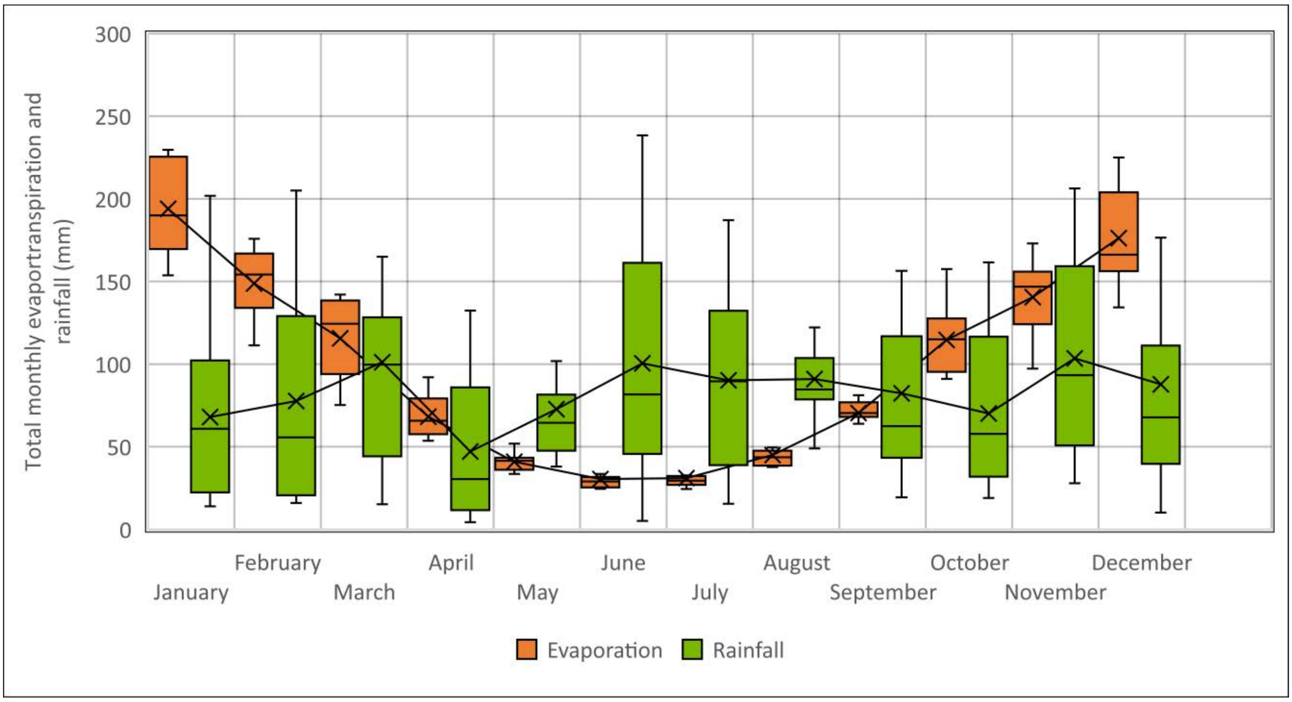


Figure 5-3 Burrinjuck Dam evaporation and rainfall (2010-2022)

A summary of temperature variation at Burrinjuck Dam is provided in Figure 5-4. The station is within a mild, temperate climate with warm summers (with average maximum temperatures ranging between approximately 26°C and 32°C) and cool winters with average maximum temperatures ranging between approximately 12°C and 18°C, and average minimum temperatures of approximately 3°C to 4°C. This aligns with the earlier climate zone classification for Yass Valley Council (refer to Table 5-1).

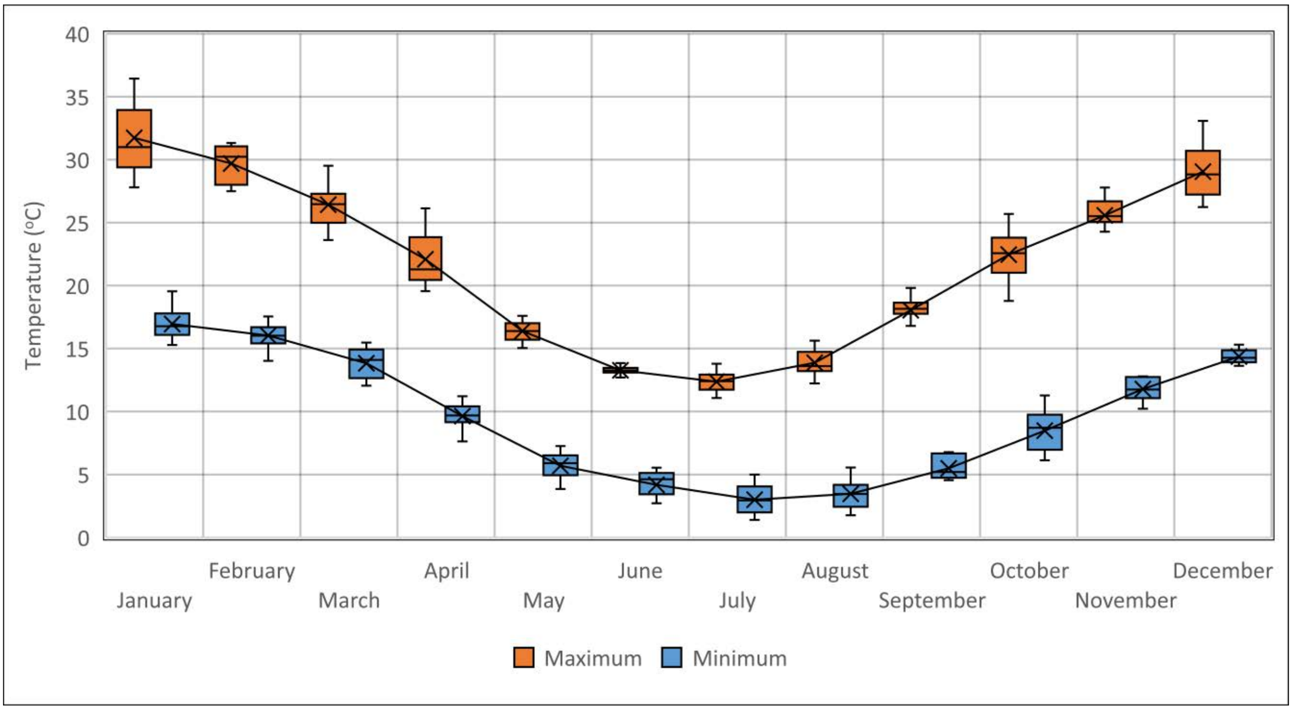


Figure 5-4 Burrinjuck Dam monthly average temperature (2010-2022)

Review of the recent historical data (2010-2022) collected at the Goulburn TAFE station indicated a variable annual rainfall rate. Wetter years, ie 2010 and 2021, recorded rainfall in excess of 900 millimetres (lower than Wagga Wagga and Burrinjuck), compared to drier years, ie 2011, 2015, 2017, 2018 and 2019, recording 500 millimetres of rainfall (similar to Burrinjuck and slightly higher than Wagga Wagga). Pan evaporation data typically varied annually between approximately 1,000 millimetres and 1,420 millimetres (similar to Burrinjuck and lower than Wagga Wagga).

The monthly rainfall and evaporation data for the Goulburn TAFE station are presented in Figure 5-5. The data indicated rainfall was largely consistent throughout the year. Unlike Wagga Wagga and Burrinjuck where no seasonal trend was apparent, a weak seasonal trend of higher mean and variability in monthly rainfall during November to March was recorded. Average monthly rainfall ranged from 32 millimetres in April to 85 millimetres in March. Conversely, average monthly potential evaporation was more variable, with a noticeable trough throughout the cooler/wetter winter months, with potential evaporation being higher in the hotter, drier, summer months.

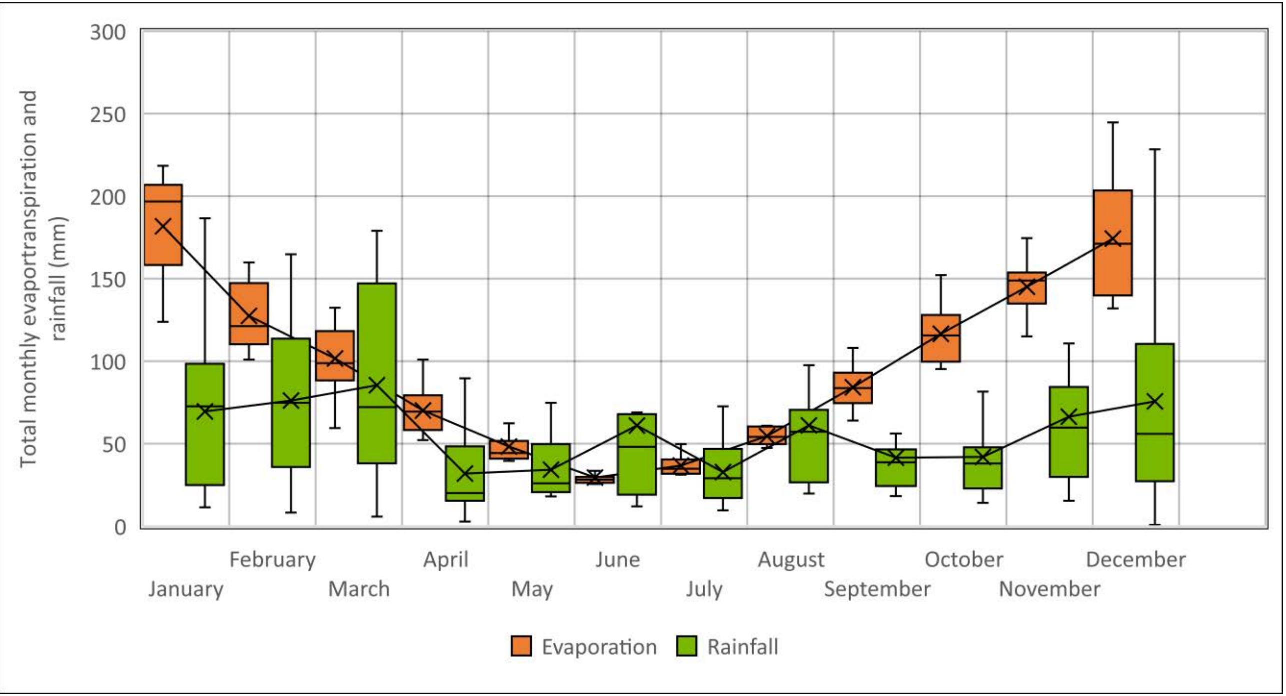


Figure 5-5 Goulburn TAFE evaporation and rainfall

A summary of temperature variation at Goulburn TAFE is provided in Figure 5-6. The station is within a cool, temperate climate with cool summers (with average maximum temperatures ranging between approximately 23°C and 29°C) and cold winters with average maximum temperatures being approximately 12°C, and average minimum temperatures of approximately 2°C to 3°C.

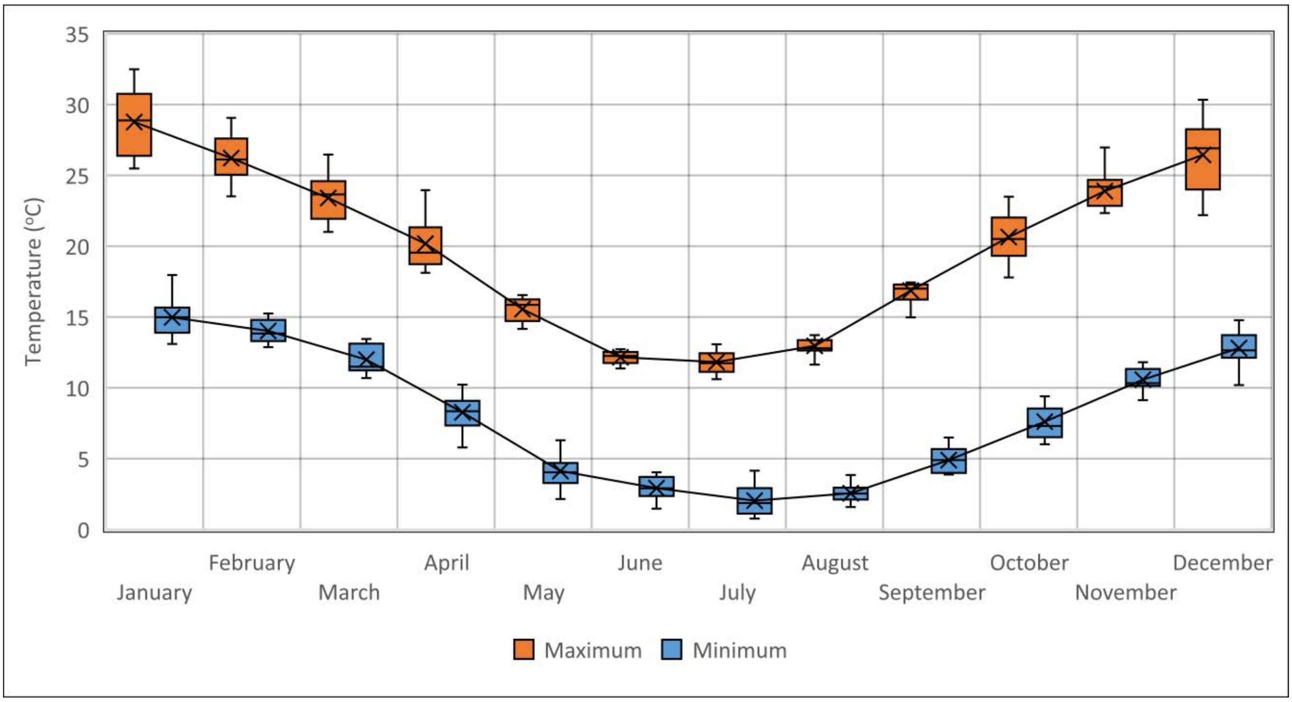


Figure 5-6 **Goulburn TAFE monthly average temperature**

5.1.2 Climate change

Consideration of climate change is important in assessing the project's potential impacts on environmental water balance, groundwater availability, soil and water salinity and water quality. Study results documented in *Climate change impacts on surface runoff and recharge to groundwater* (Mark Littleboy, John Young and Joel Rahman, 2015) have been used in this working paper to assess expected local climatic changes in the surface water and groundwater study area.

NSW and ACT Regional Climate Modelling project (NARCliM) predicted near future (2020-2039) and far future (2060-2079) changes to rainfall, runoff and recharge to groundwater (Mark Littleboy, John Young and Joel Rahman, 2015). This assessment focusses on longer term chronic changes to surface water and groundwater systems. Table 5-3 presents a summary of the statistical analysis for the project footprint regions, ie the Murray Murrumbidgee and South East and Tablelands regions. The per cent change is compared to the baseline period from 1990 to 2009.

Table 5-3 **Per cent changes to multi-model mean annual rainfall, surface runoff and recharge per state planning region (Mark Littleboy, John Young and Joel Rahman, 2015)**

State planning region	Per cent change in near future (%) (2020-2039)			Per cent change in far future (%) (2060-2079)		
	Rainfall	Runoff	Recharge	Rainfall	Runoff	Recharge
Murray Murrumbidgee	-1.1	-0.4	-5.6	+2.3	+17.5	-3.4
South-East and Tablelands	-1.8	-6.1	-12.4	+1.3	+7.0	-6.7

Table 5-4 presents a summary of the statistical analysis for the catchments that the project would be constructed in, ie Hawkesbury Nepean, Lachlan and Murrumbidgee. The per cent change is compared to the baseline period from 1990 to 2009.

Table 5-4 Per cent changes to multi-model mean annual rainfall, surface runoff and recharge per catchment (Mark Littleboy, John Young and Joel Rahman, 2015)

Catchment	Per cent change in near future (%) (2020-2039)			Per cent change in far future (%) (2060-2079)		
	Rainfall	Runoff	Recharge	Rainfall	Runoff	Recharge
Hawkesbury-Nepean	-0.1	0.9	-9.3	6.1	13.4	5.8
Lachlan	-0.3	0.8	-4.0	6.1	29.2	4.4
Murrumbidgee	-1.4	-2.1	-8.0	1.8	13.0	-5.8
Upper Murray	-1.2	0.6	-4.7	0.7	13.9	-6.3

In summary, the study predicted a reduction in all three parameters for the near future scenario (rainfall, surface runoff and recharge to the groundwater). For the far future scenario, the model predicted an increase in rainfall and surface runoff whilst a decrease in recharge to the groundwater was predicted.

The model projections indicate with high confidence a future increase in the intensity of extreme rainfall events, although the magnitude of this increased intensity cannot be confidently forecasted. The study (Mark Littleboy, John Young and Joel Rahman, 2015) does not provide details regarding changes to flood-producing rainfall events other than to confirm that changes to rainfall intensity are predicted.

Practical Consideration of Climate Change (DECC, 2007) showed a trend of increased rainfall intensities for the 40-year Average Recurrence Internal one-day rainfall event across NSW (refer to Table 5-5).

Table 5-5 CSIRO indicative change in rainfall and evaporation one-day total (CSIRO, 2007)

Catchment	40 Year 1-day rainfall total projected change 2030	40 Year 1-day rainfall total projected change 2070	Evaporation projected change 2030	Evaporation projected change 2070
Hawkesbury-Nepean	-3% to 12%	-7% to 10%	+1% to +8%	+2% to +24%
Lachlan	-3% to +25%	-7% to +29%	+2% to +13%	+4% to +40%
Murrumbidgee	+7%	+5%	+1% to +3%	+2% to +40%
Upper Murray	-3 to +25%	-7% to +29%	+2% to 13%	+4% to +40%
NSW Average	-2% to +15%	-1% to +15%	+1% to +12%	+3% to +38%

The findings from DECC (2007) largely support the NARCliM predictions (refer to Table 5-3) of increased rainfall and evaporation. Higher intensity storms would result in higher runoff volumes, whereas the increased evaporation rates would likely lead to reduced recharge, as suggested in the future results.

Understanding the effect of these climate change predictions on hydrological behaviour is important in considering the surface water and groundwater operational impacts for the project (Chapter 7).

Temperature projections for Murray Murrumbidgee and South East and Tablelands regions indicate higher average maximum and minimum temperatures for the near future (2030) and far future (2070), compared to baseline modelled climate from 1990-2009. The average maximum and minimum temperatures across the entire project footprint are expected to rise by 1°C and 4°C by 2030 and 2070, respectively (Mark Littleboy, John Young and Joel Rahman, 2015). As average temperatures are predicted to increase due to climate change, evaporation rates can be assumed to rise correspondingly which might further decrease recharge to groundwater.

5.2 Topography

The topography of the project footprint is widely variable, with elevation ranging from approximately 220 metres above the Australian height datum (mAHD) to 1,232 mAHD.

At the west end of the project around Wagga Wagga the topography is relatively flat, with elevation ranging from approximately 220 mAHD to 338 mAHD. Between Tumut and Yass, the topography is considerably hilly, with elevation ranging from approximately 261 mAHD to 768 mAHD. The east end of the project footprint between Yass and Bannaby has more hills and areas of steep terrain, particularly between Dalton and Bannaby, with elevation ranging between 537 mAHD and 928 mAHD. The area with the highest elevation, ranging between approximately 1,012 mAHD and 1,232 mAHD, is located between Batlow and the Maragle State Forest.

The topography of the project footprint is shown in Figure 5-7.

Project footprint

Surface water and groundwater study area

Railway

Watercourse

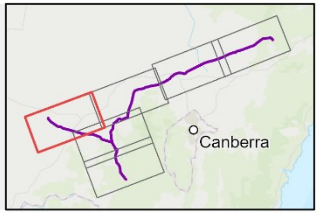
Substation

World Hillshade

Digital elevation (mAHD)

2227.3

-129.563



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

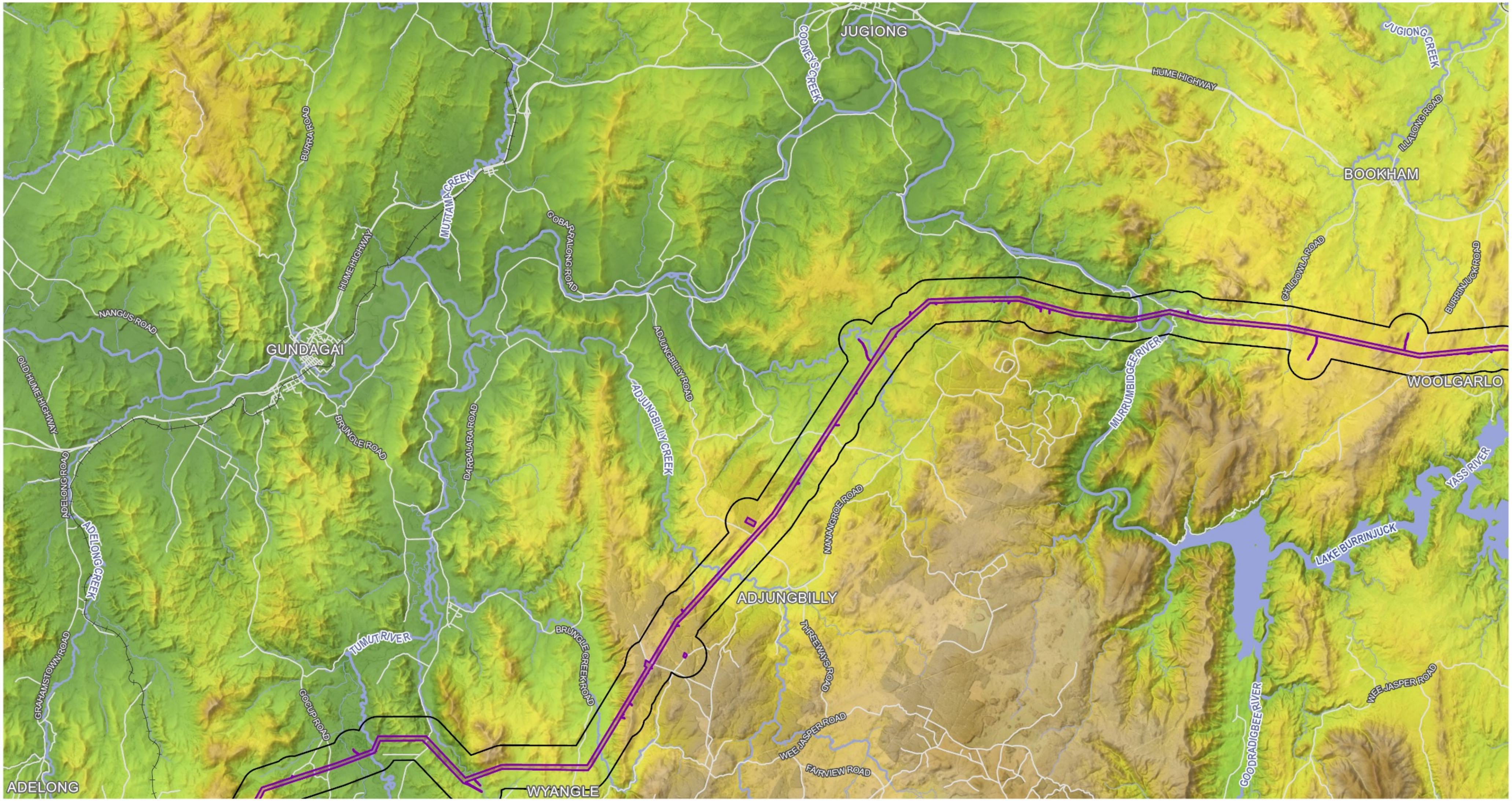
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-7a: Topography



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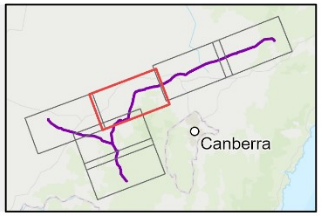
Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation
World Hillshade
Digital elevation (mAHD)
2227.3
-129.563



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:200,000
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-7b: Topography

Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

World Hillshade

Digital elevation (mAHD)

2227.3

-129.563

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8 km

Projection: GDA 1994 MGA Zone 55

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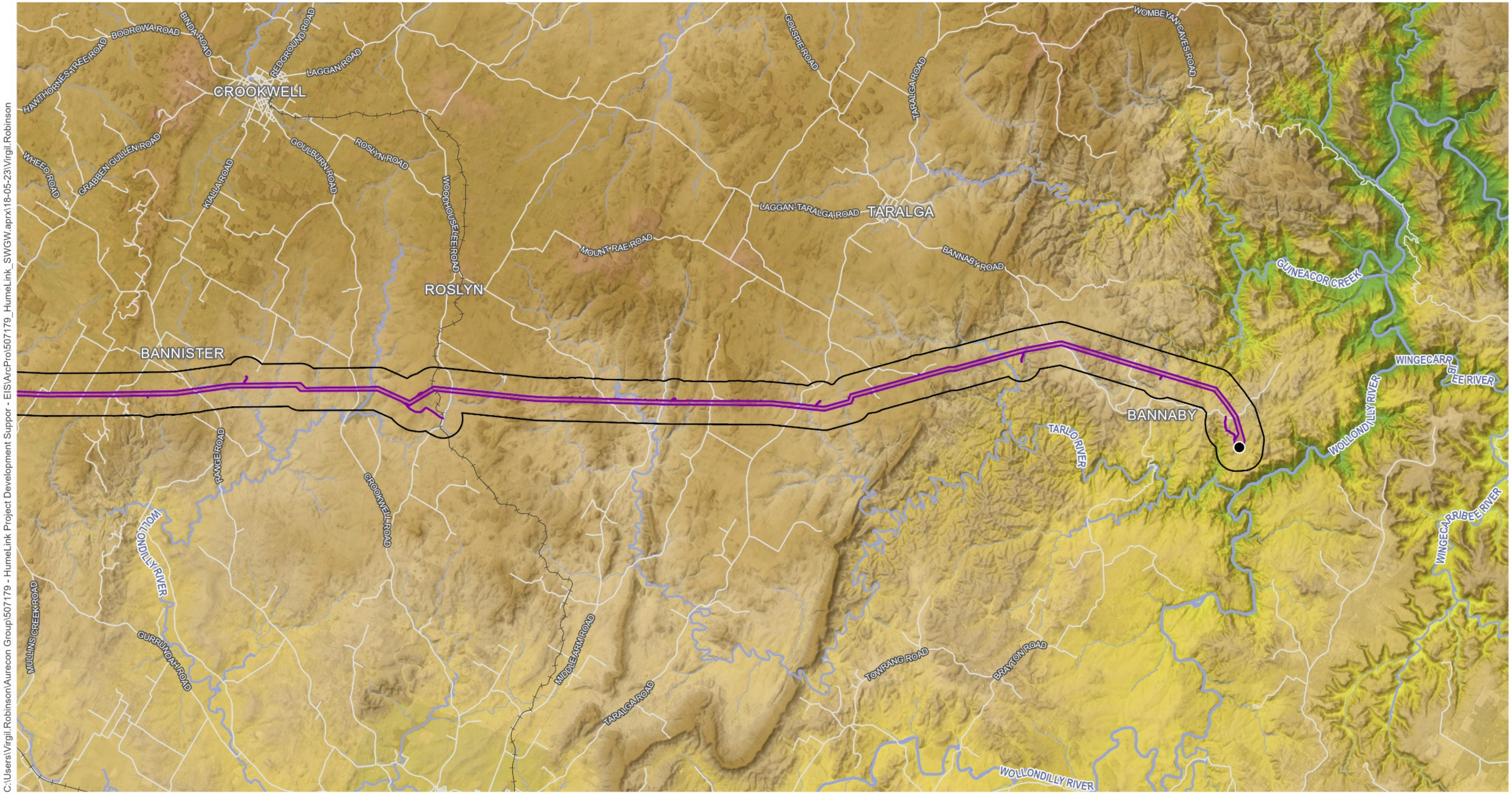
Figure 5-7c: Topography



Project footprint

Surface water and groundwater study area

Railway

Watercourse

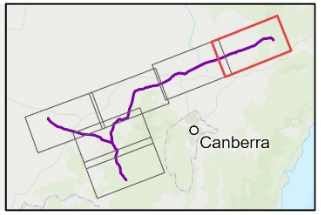
Substation

World Hillshade

Digital elevation (mAHD)

2227.3

-129.563



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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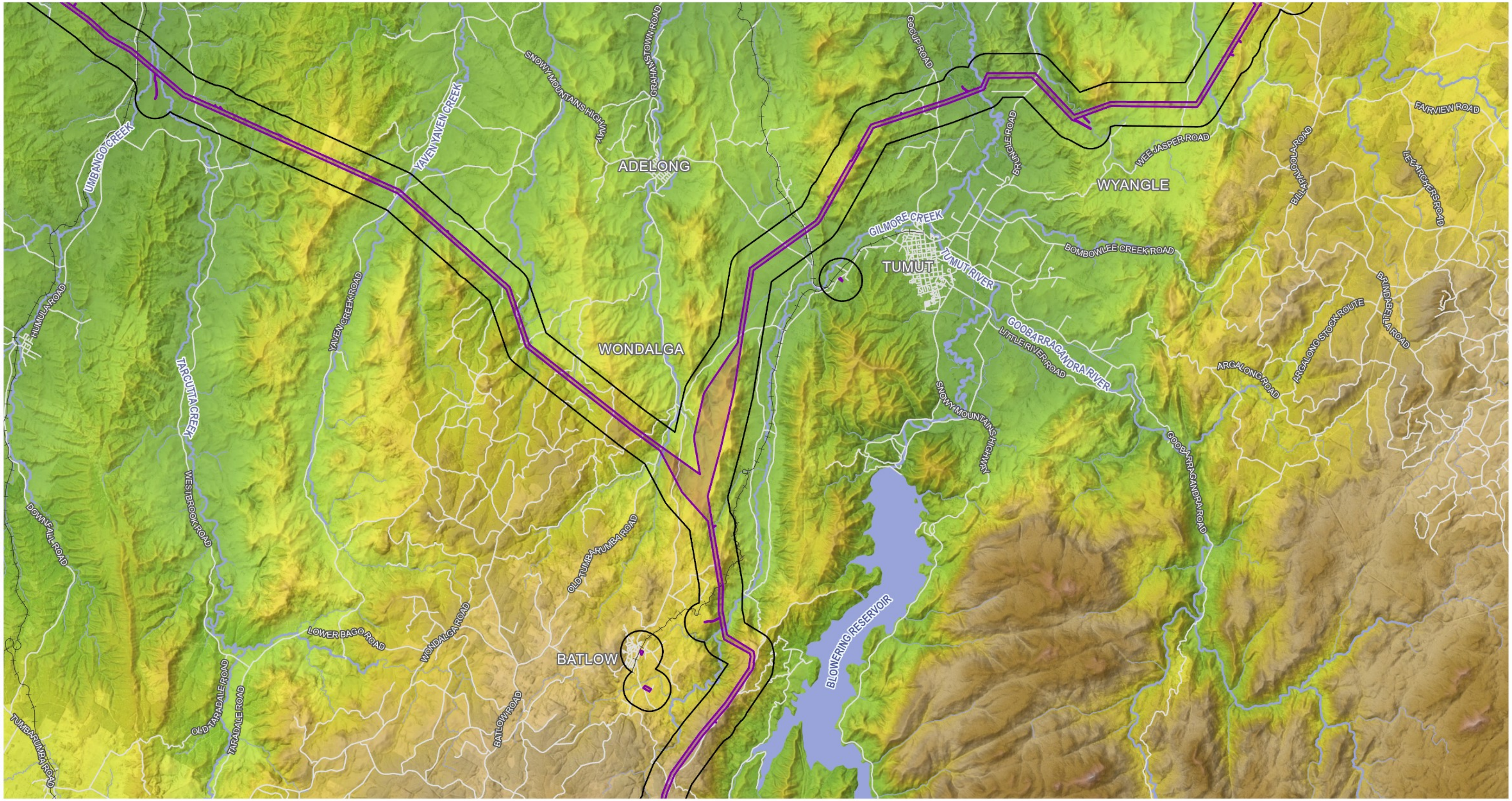
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-7d: Topography



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Project footprint

Surface water and groundwater study area

Railway

Watercourse

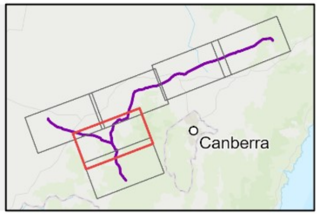
Substation

World Hillshade

Digital elevation (mAHD)

2227.3

-129.563



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

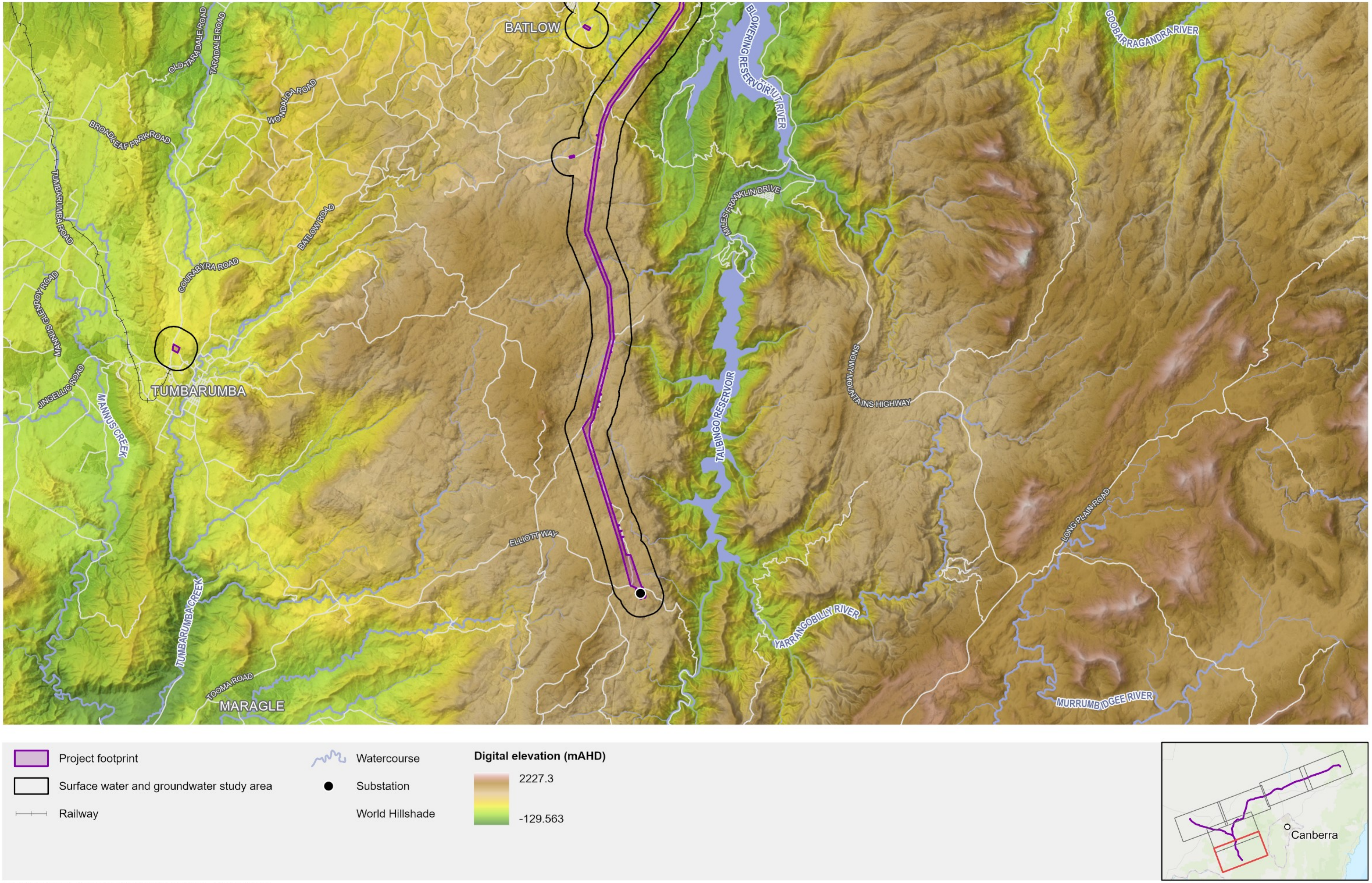
1:200,000

0 4 8 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-7e: Topography



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-7f: Topography

5.3 Surface water

5.3.1 Catchments overview

The project and associated structures are located in four major surface water catchments (refer to Figure 5-8). From east to west, these are the Hawkesbury-Nepean River, Lachlan River, the Murrumbidgee River and Upper Murray River catchments.

The approximate lengths of the project in the respective catchments are:

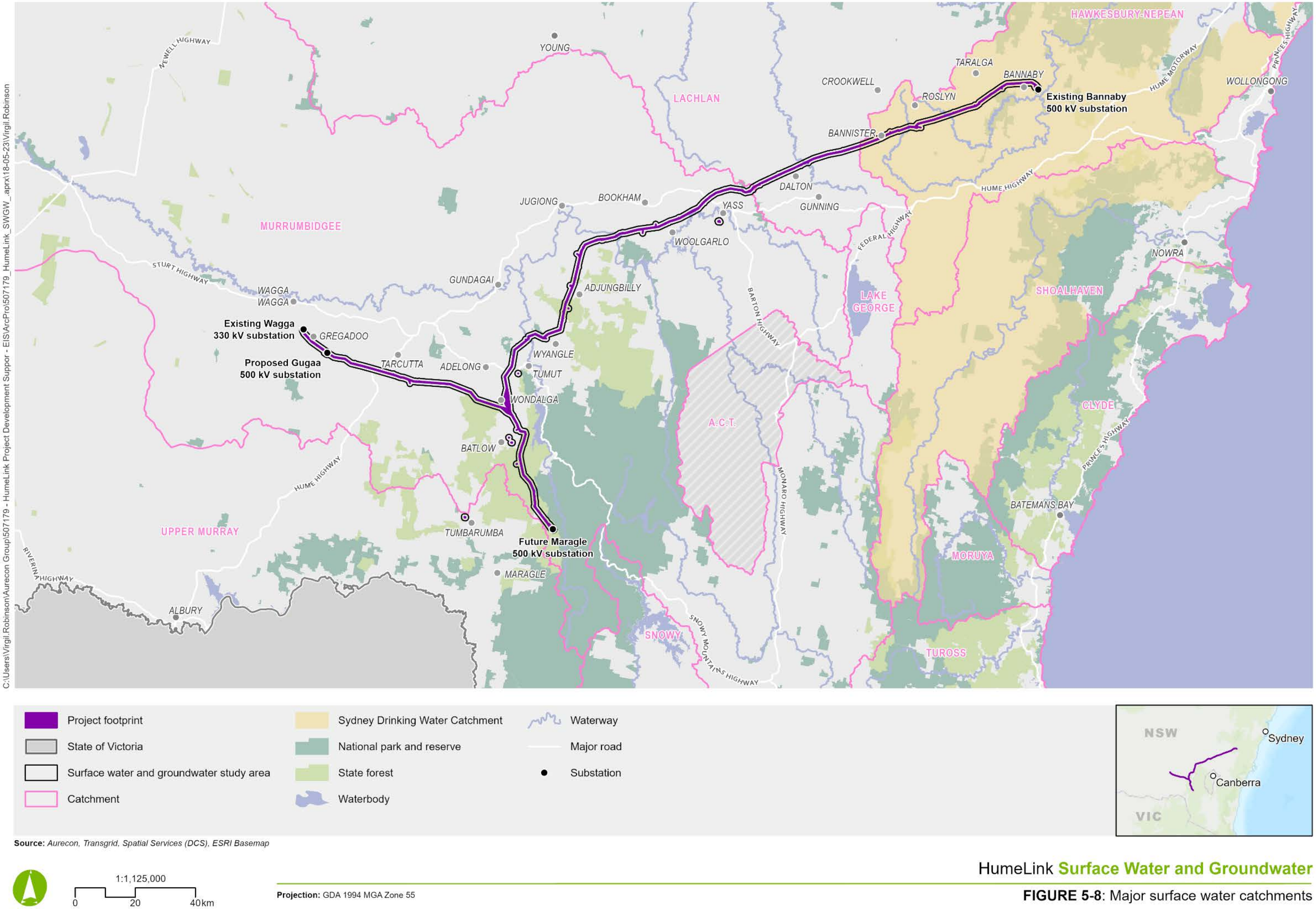
- Hawkesbury-Nepean River catchment – 65 kilometres
- Lachlan River catchment – 38 kilometres
- Murrumbidgee River catchment – 261 kilometres
- Upper Murray River catchment – Tumbarumba worker accommodation facility.

The Hawkesbury-Nepean River catchment is one of the longest coastal catchments in NSW with an area of 21,400 square kilometres. Over 70 per cent of the catchment consists of hilly terrain. The Nepean River is the longest river within this catchment. The Nepean River's headwaters are located near Robertson, NSW at around 766 metres above sea level before flowing northerly through the Nepean Dam around 178 kilometres to its confluence with the Grose River where it becomes the Hawkesbury River at around 1.8 metres above sea level. The Nepean River is fed from a number of westerly flowing tributaries, including the Avon, Cordeaux, and Cataract Rivers. Other major tributaries of the Nepean River include the Wollondilly River, Nattai River, Bargo River and Coxs River. Major water users in this catchment include WaterNSW, local councils, agriculture irrigation, tourism, fishing and oyster industries, and various recreational users (DPE, 2022d).

The Lachlan River catchment occupies an area of around 90,000 square kilometres. Its landscape varies markedly from east to west as it moves from the headwaters and tablelands through the slope of the middle catchment to the flat western plains (DPE, 2022e). The main waterway, Lachlan River, flows in a northern direction within the surface water and groundwater study area, with multiple minor tributaries contributing to it as it heads downstream. Major water users are local councils, water utilities, mining and agriculture, including dairy, wool, beef and lamb, as well as irrigated crops such as cereals, lucerne and cotton (DPE, 2022e).

The Murrumbidgee River is one of the major tributaries of the Murray–Darling basin, with the Murrumbidgee River catchment covering an area of approximately 84,000 square kilometres (DPE, 2022f). The catchment upstream limits are generally the Great Dividing Range to the east, the Lachlan catchment to the north, and the Murray River catchment to the south. Yass River and Tumut River are two of the major tributaries within the catchment, which contributes to Murrumbidgee River flow. Major water users include local councils and water utilities, forestry, tourism, and agriculture, including rice, dairy, wool, wheat, beef, lamb, grapes and citrus (DPE, 2022f).

The Upper Murray River catchment is within rugged mountain country with an area of approximately 35,170 square kilometres. It is bounded by the Murray River to the south, the Murrumbidgee River catchment divide to the north and the Australian Alps to the east (DPE, 2022g). Headwaters from the Murray River and tributaries flow into this catchment. No major waterbodies are crossed within the surface water and groundwater study area. Major water uses include tourism, forestry activities for timber and paper, and agricultural activities such as cattle, sheep, dairying, pasture seed production, wine grapes, and niche crops (DPE, 2022g).



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

FIGURE 5-8: Major surface water catchments

5.3.2 Waterways and waterbodies

There are many waterways and waterbodies intercepted by the project. Attachment B lists the named waterways crossed by or located near the project footprint. The Strahler stream order of each waterway is also provided. These waterways are presented in Figure 5-9.

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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

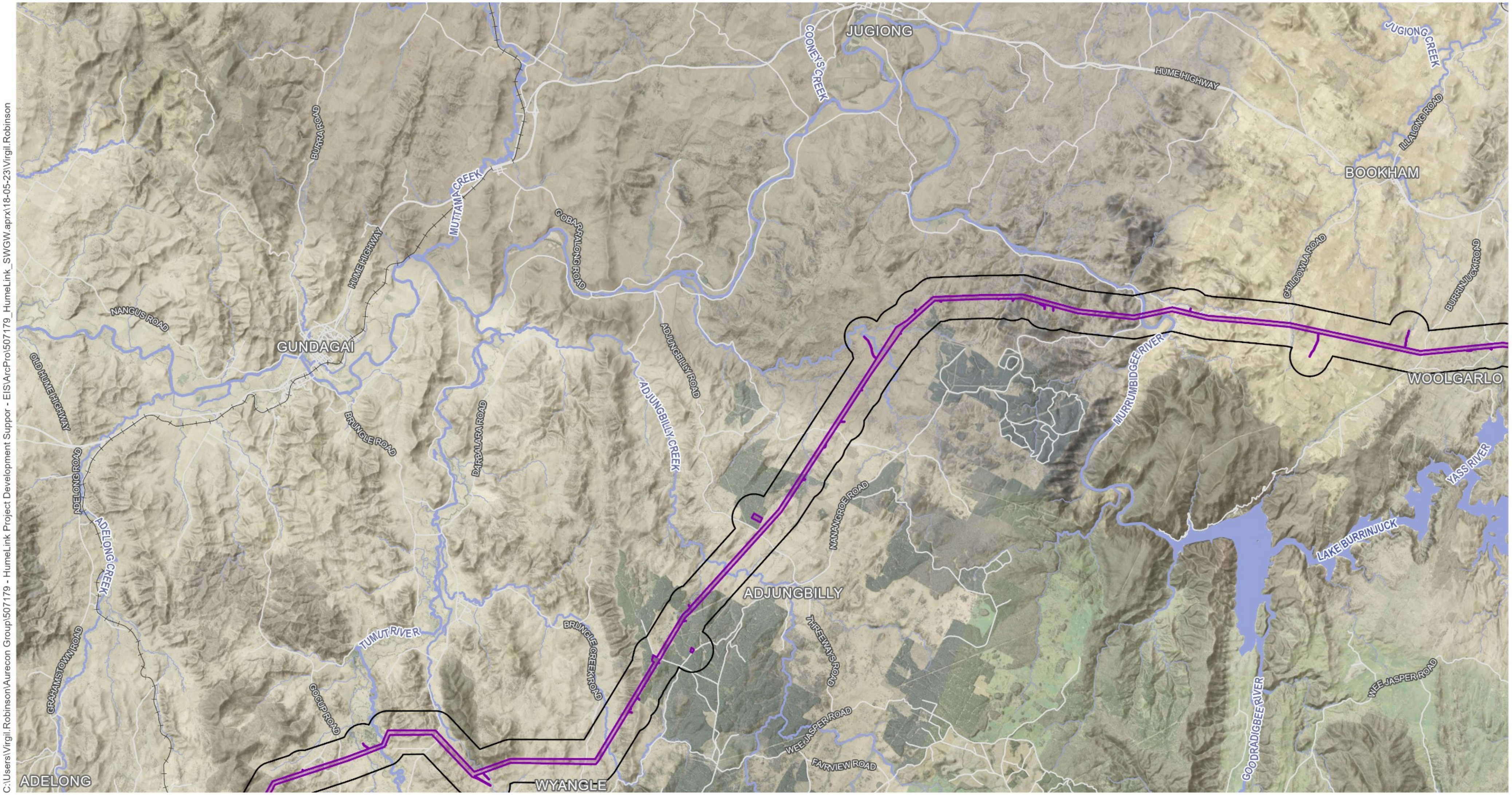
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9a: Waterways and waterbodies



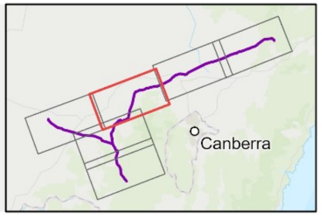
Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9b: Waterways and waterbodies

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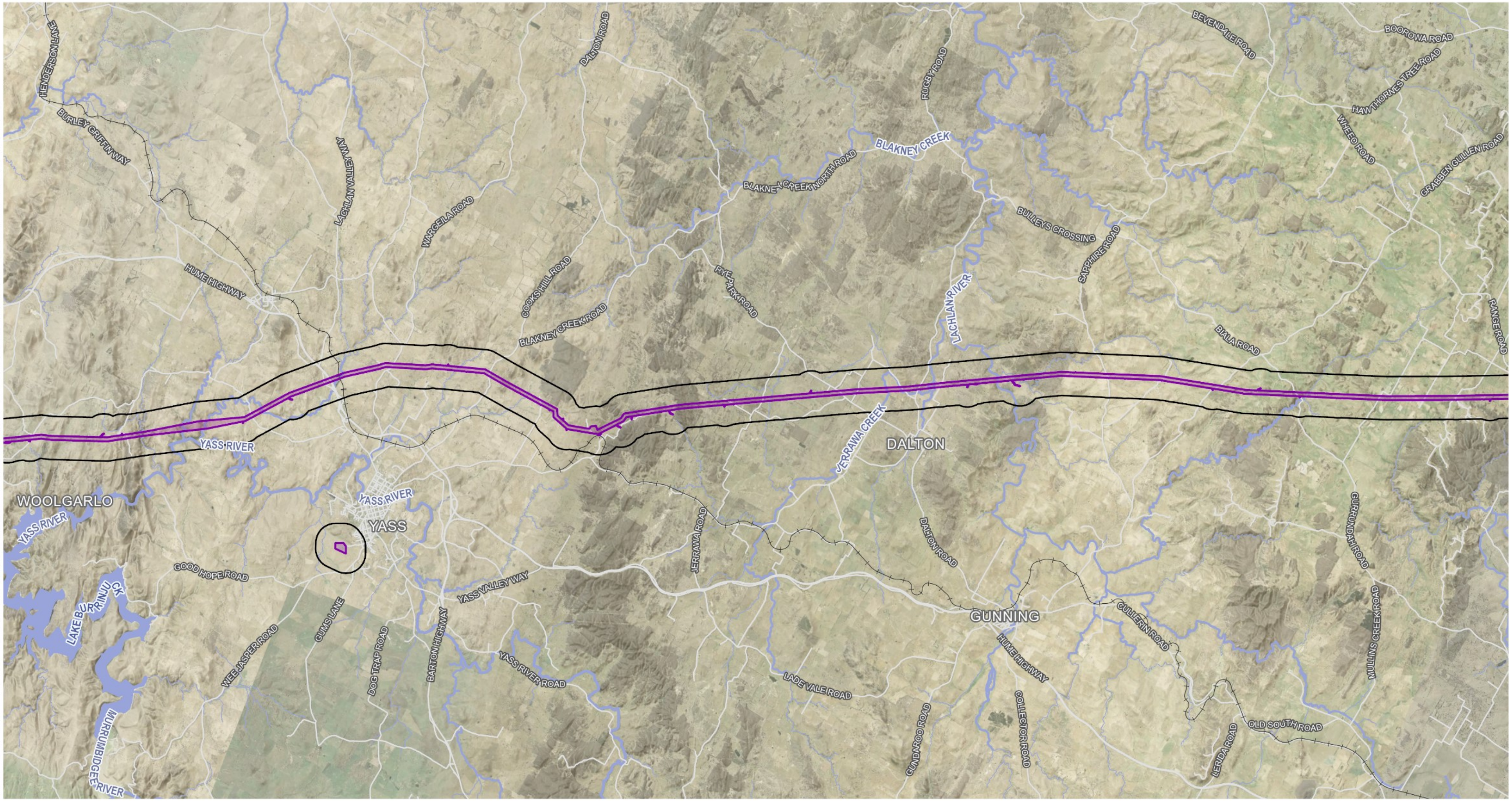


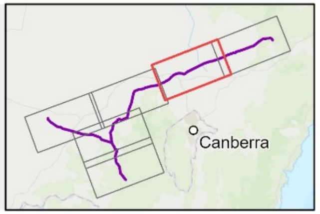
Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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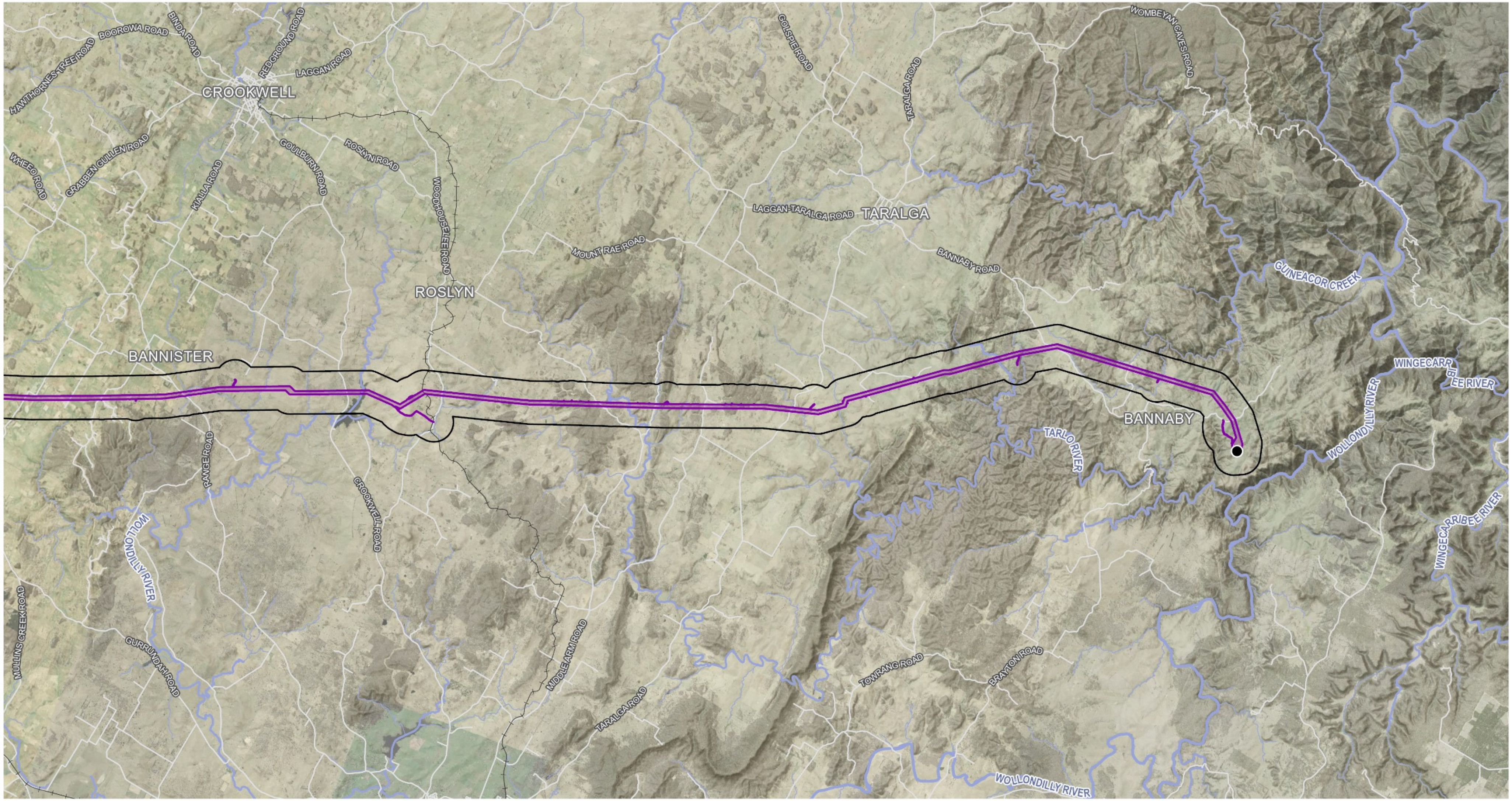
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9c: Waterways and waterbodies



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9d: Waterways and waterbodies

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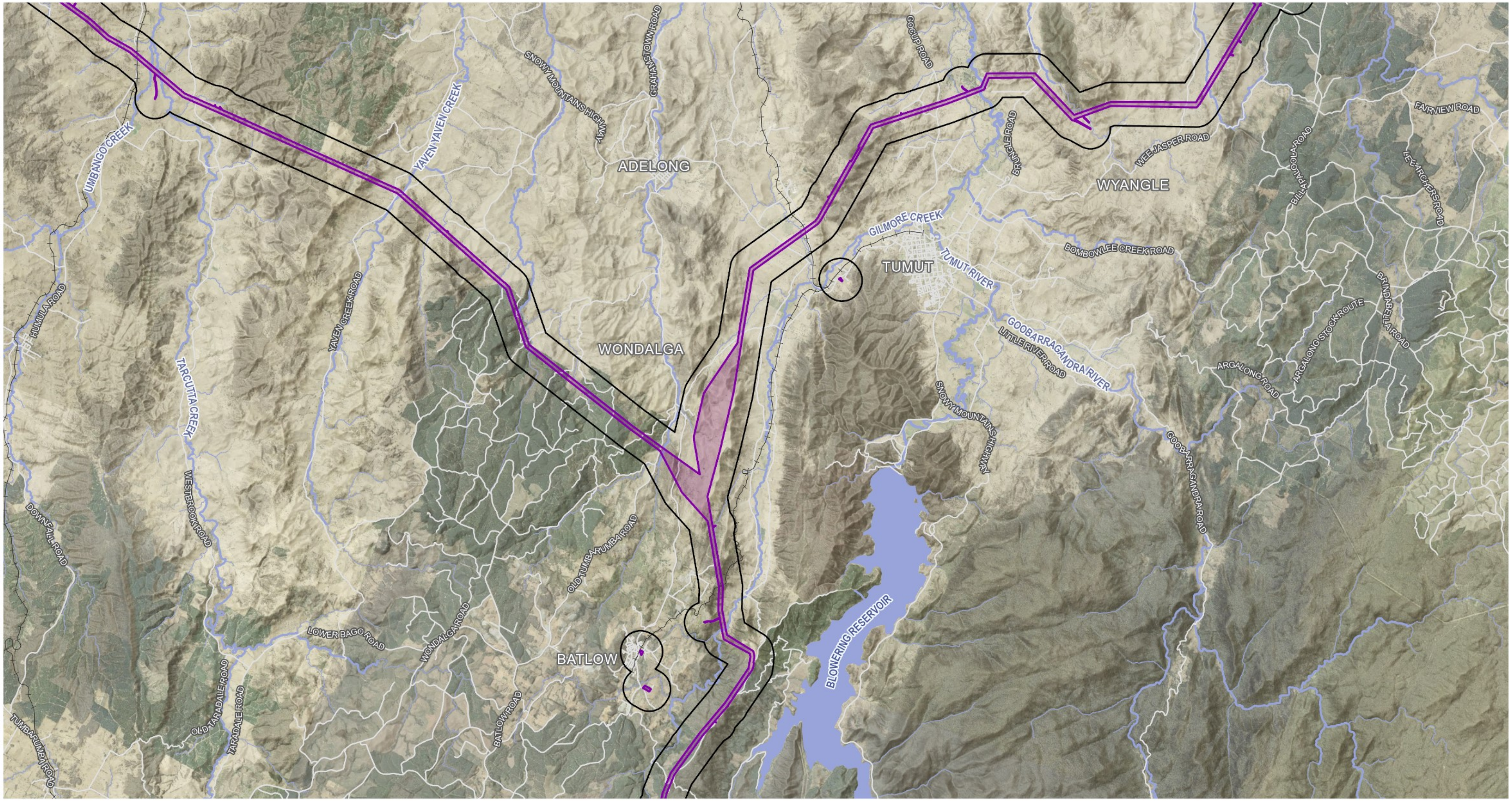


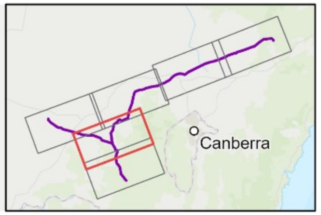
Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

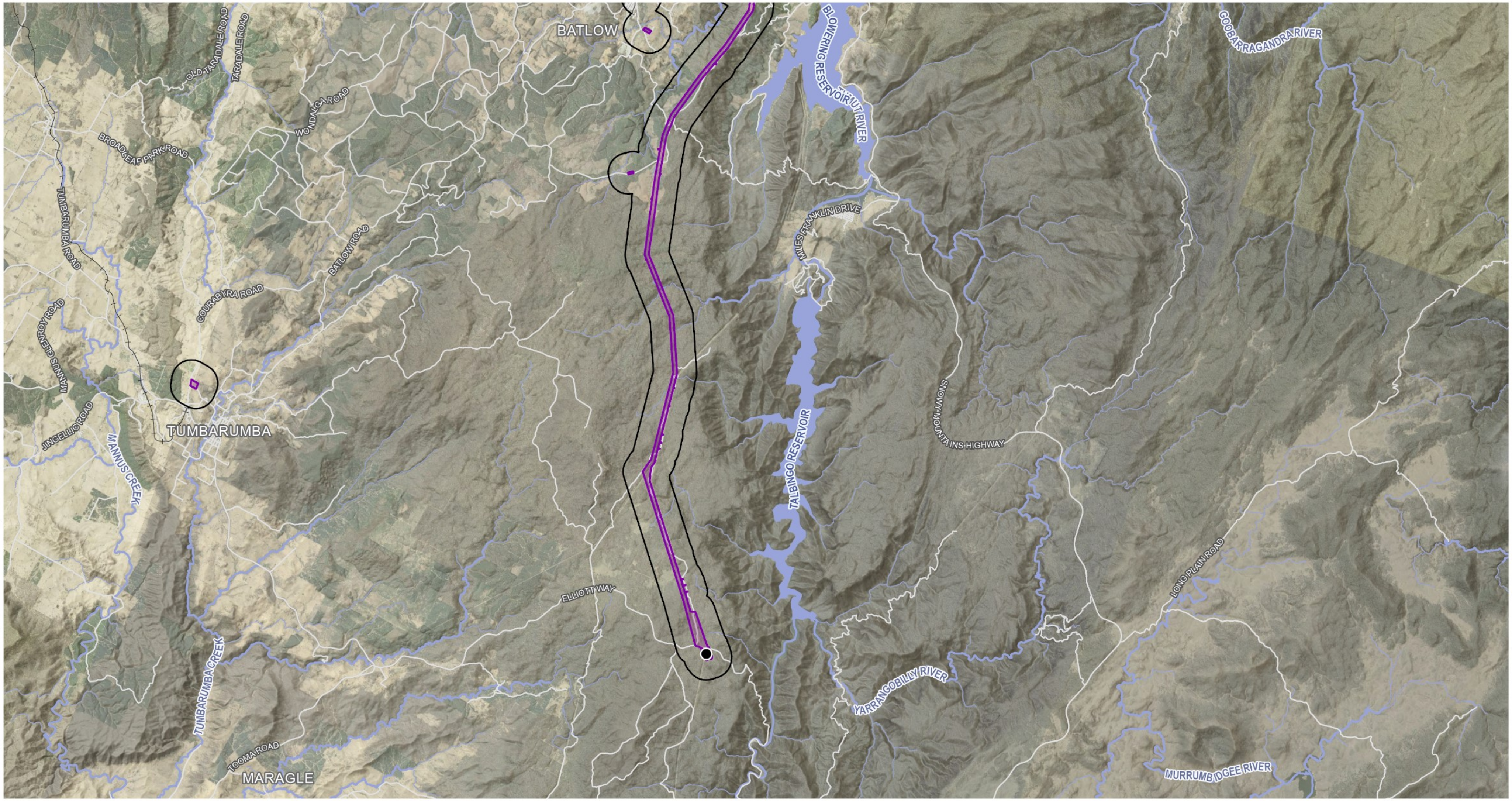
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9e: Waterways and waterbodies



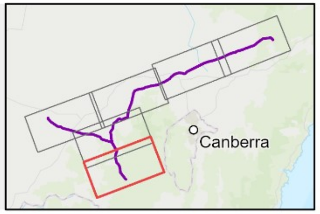
Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

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0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-9f: Waterways and waterbodies

5.3.3 Surface water supply and water resources

For all catchments within the project footprint WSPs are in place. The relevant WSPs are listed in the following sections.

5.3.3.1 Murrumbidgee River catchment

Potable water in Wagga Wagga is managed by Riverina Water and is sourced from the Murrumbidgee River and a network of groundwater bores (Riverina Water, 2022).

The WRP for the Murrumbidgee River catchment is the Murrumbidgee surface water WRP, which was submitted in June 2020, withdrawn in April 2021 and was resubmitted in September 2022 (DPE, 2022h).

The relevant WSPs are Murrumbidgee Regulated River Water Source 2016 and Unregulated Rivers Water Sources 2012 (DPE 2022f; NSW Government, 2016a; NSW Government, 2012a).

The share components of the different water allocations in the Murrumbidgee Regulated River Water Source 2016 are:

- domestic and stock access licences – 35,041 ML/year
- local water utility access licences – 23,816 ML/year
- high security access licences – 417,631 unit shares
- general security access licences – 1,891,815 unit shares
- conveyance access licence – 375,968 unit shares
- supplementary WALs – 945,780 unit shares.

The share components of the different water allocations in the Murrumbidgee Unregulated Rivers Water Sources 2012 WSP are allocated to specific waterways in the catchment and include:

- domestic and stock access licences – 3,459 ML/year.
- local water utility access licences – 4,960 ML/year.
- unregulated WALs – 87,073 unit shares.

5.3.3.2 Lachlan River catchment

The WRPs for the Lachlan River catchment include the Lachlan Alluvium WRP which was submitted in April 2020 but withdrawn in August 2021 and was resubmitted September 2022 and the Lachlan surface water WRP, which was submitted in June 2020 and withdrawn in November 2020 and was resubmitted March 2022 (DPE, 2022h).

The relevant WSPs are Lachlan Regulated River Water Source 2016 and Unregulated Rivers Water Sources 2012 (DPE 2022e; NSW Government, 2016b; NSW Government, 2012b).

The share components of the different water allocations in Lachlan Regulated River Water Source 2016 WSP are:

- domestic and stock access licences – 12,502 ML/year
- local water utility access licences – 15,545 ML/year
- high security access licences – 27,680 unit shares
- general security access licences – 592,801 unit shares
- conveyance access licence – 17,911 unit shares
- supplementary WALs – there are no supplementary WALs authorised to take water from this water source.

The share components of the different water allocations in the Lachlan Unregulated Rivers Water Sources 2012 WSP are allocated to specific waterways in the catchment and include:

- domestic and stock access licences – 792 ML/year
- local water utility access licences – 5,923 ML/year
- unregulated WALs – 46,671 unit shares.

5.3.3.3 Hawkesbury-Nepean River catchment

The Hawkesbury-Nepean River is an important part in the potable water supply for the Greater Metropolitan Sydney area.

The relevant WSP is the Greater Metropolitan Region Unregulated River Water Sources 2011 (DPE 2022d; NSW Government, 2011a).

The share components of the different water allocations in the Greater Metropolitan Unregulated Rivers Water Sources 2011 WSP are allocated to specific waterways in the catchment and include:

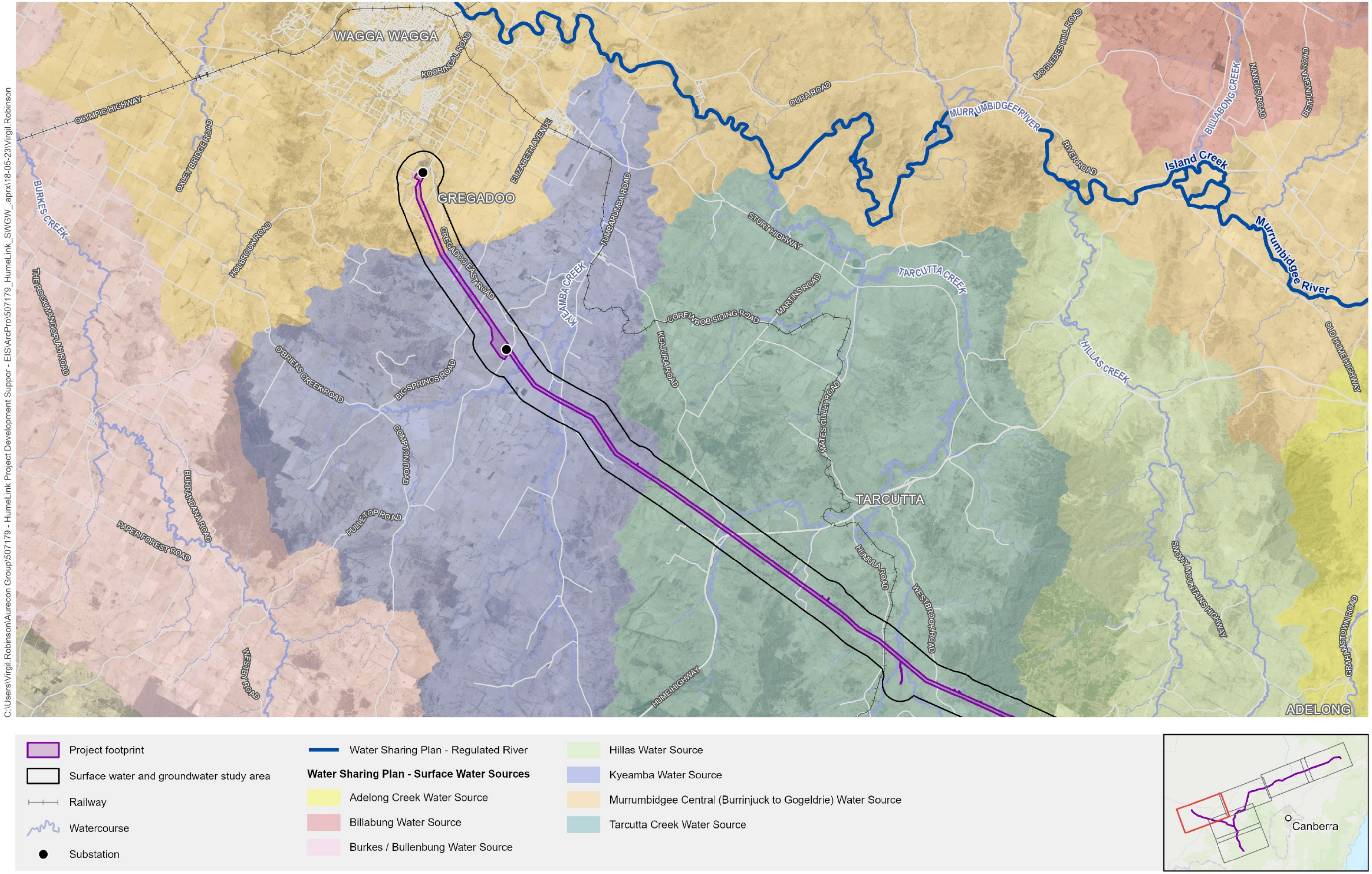
- domestic and stock access licences – 2,445 ML/year
- local water utility access licences – 36,544 ML/year
- unregulated WALs – 126,591 unit shares
- major utility licences – 1,032,075 ML/year.

5.3.3.4 Upper Murray River catchment

The WRP for the Upper Murray River catchment is the NSW Murray and Lower Darling Surface WRP which was submitted June 2020, withdrawn May 2021 and resubmitted September 2022 (DPE, 2022h).

The relevant WSPs are the Murray Unregulated River Water Sources 2011 and Murray and Lower Darling Regulated Rivers Water Sources 2016 (DPE 2022g; NSW Government, 2011b; NSW Government, 2016c)

The share components in the Murray and Lower Darling Regulated Rivers Water Sources 2016 WSP relevant to the project comprises local water utility access licences – 33,497 ML/year.



Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation

Water Sharing Plan - Regulated River

Water Sharing Plan - Surface Water Sources

Adelong Creek Water Source
Billabung Water Source
Burkes / Bullenbung Water Source
Hillas Water Source
Kyeamba Water Source
Murrumbidgee Central (Burrinjuck to Gogeldrie) Water Source
Tarcutta Creek Water Source

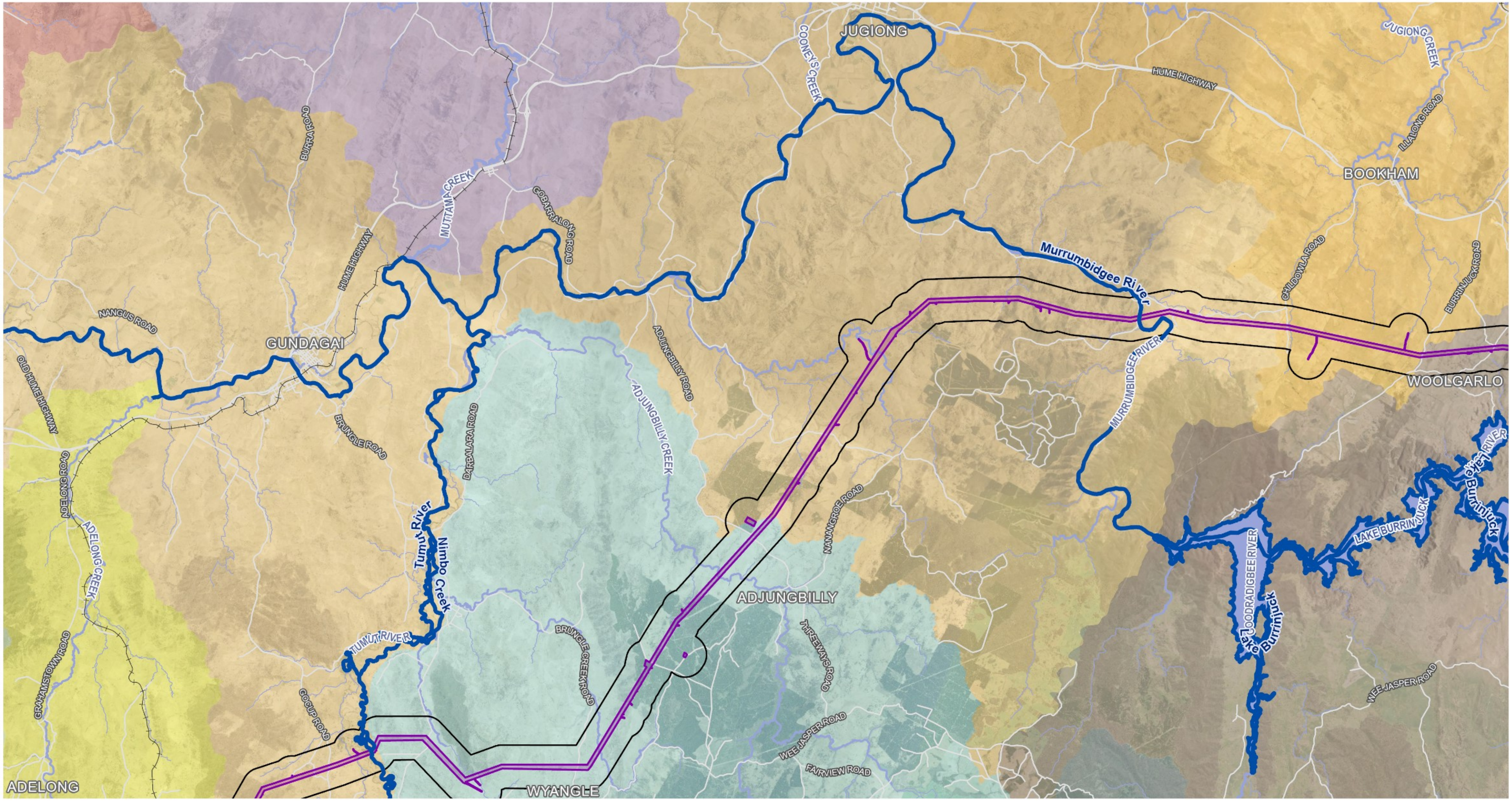
Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

1:200,000
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

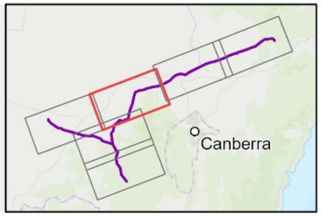
Figure 5-10a: Water Sharing Plan - Surface Water Sources



Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation
Water Sharing Plan - Regulated River

Water Sharing Plan - Surface Water Sources

Adelong Creek Water Source
Adjungbilly / Bombowlee / Brungle Water Source
Billabung Water Source
Burrinjuck Dam Catchment Water Source
Gilmore / Sandy Water Source
Goodradigbee Water Source
Hillas Water Source
Jugiong Water Source
Murrumbidgee Central (Burrinjuck to Gogeldrie) Water Source
Muttama Water Source



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

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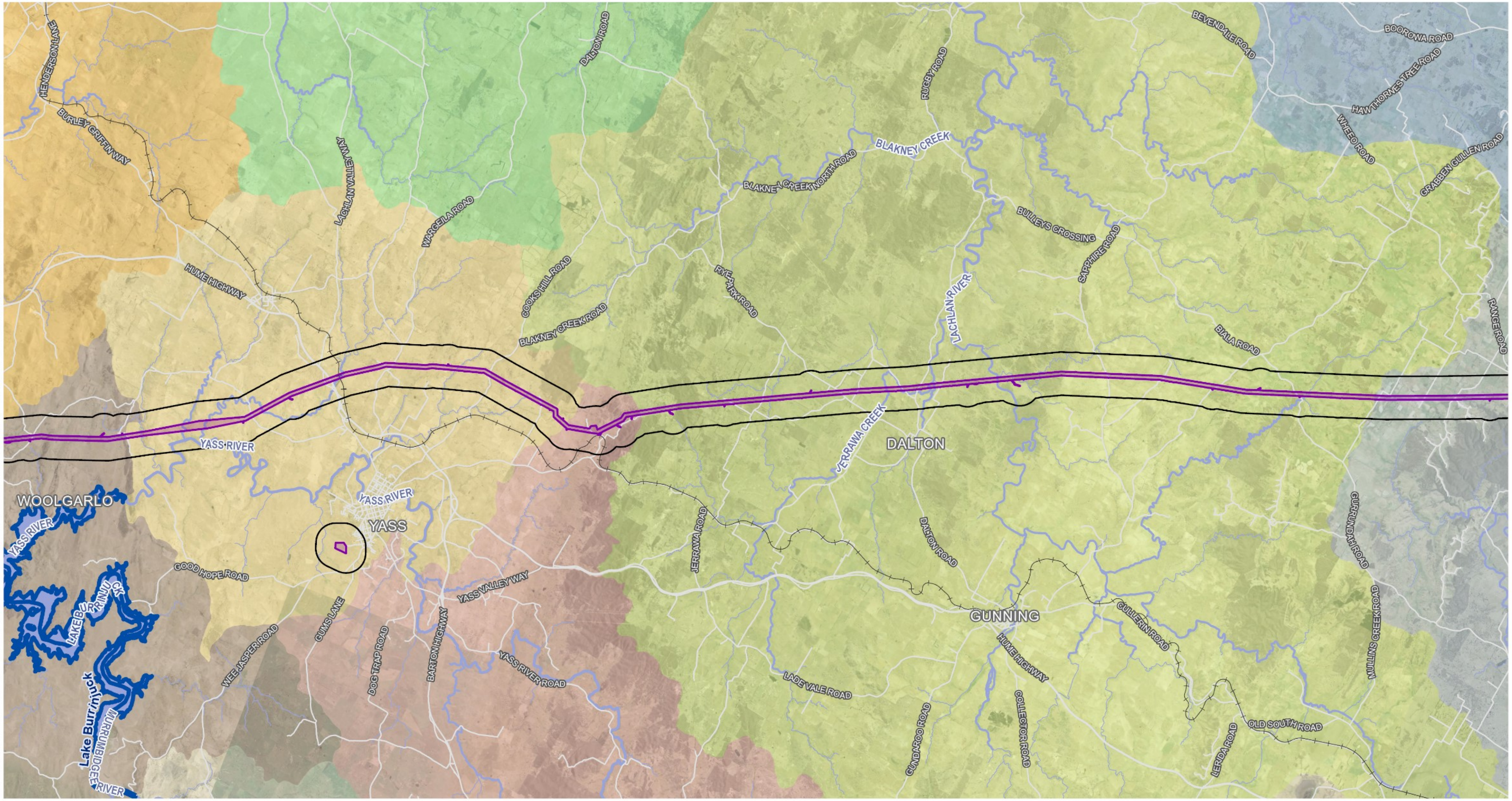
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-10b: Water Sharing Plan - Surface Water Sources



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

Water Sharing Plan - Regulated River

Water Sharing Plan - Surface Water Sources

Boorowa River and Hovells Creek Water Source

Burrinjuck Dam Catchment Water Source

Crookwell River Water Source

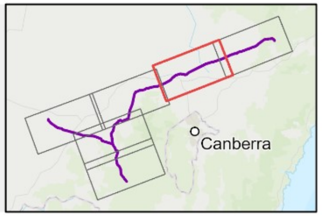
Jugiong Water Source

Lachlan River above Reids Flat Water Source

Upper Nepean and Upstream Warragamba Water Source

Yass Lower Water Source

Yass Upper Water Source



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

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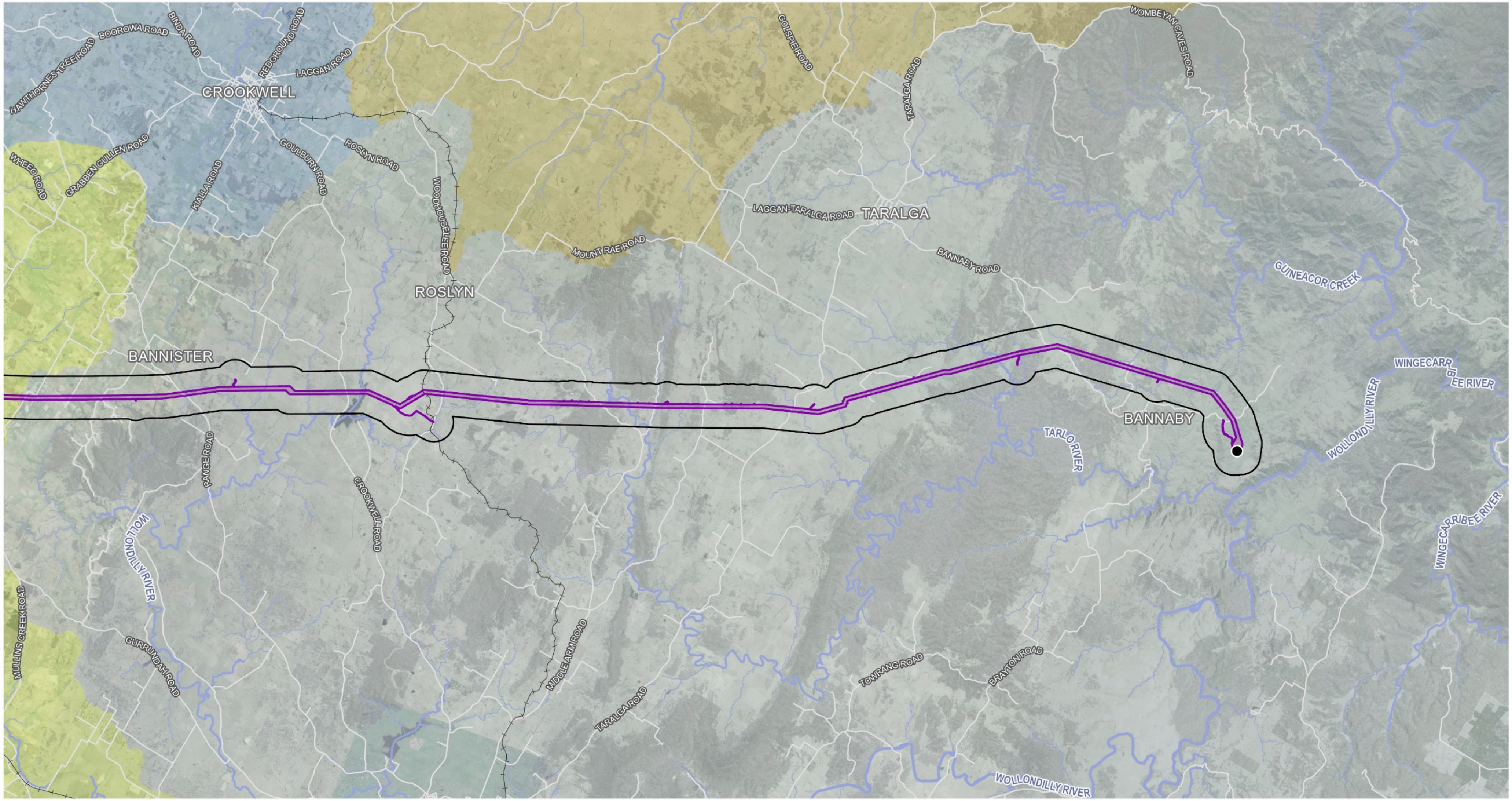
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

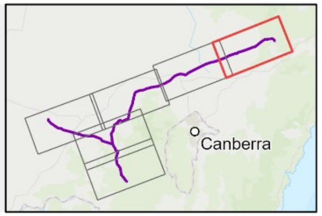
Figure 5-10c: Water Sharing Plan - Surface Water Sources



- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation
- Water Sharing Plan - Regulated River

Water Sharing Plan - Surface Water Sources

- Abercrombie River above Wyangala Water Source
- Crookwell River Water Source
- Lachlan River above Reids Flat Water Source
- Upper Nepean and Upstream Warragamba Water Source



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

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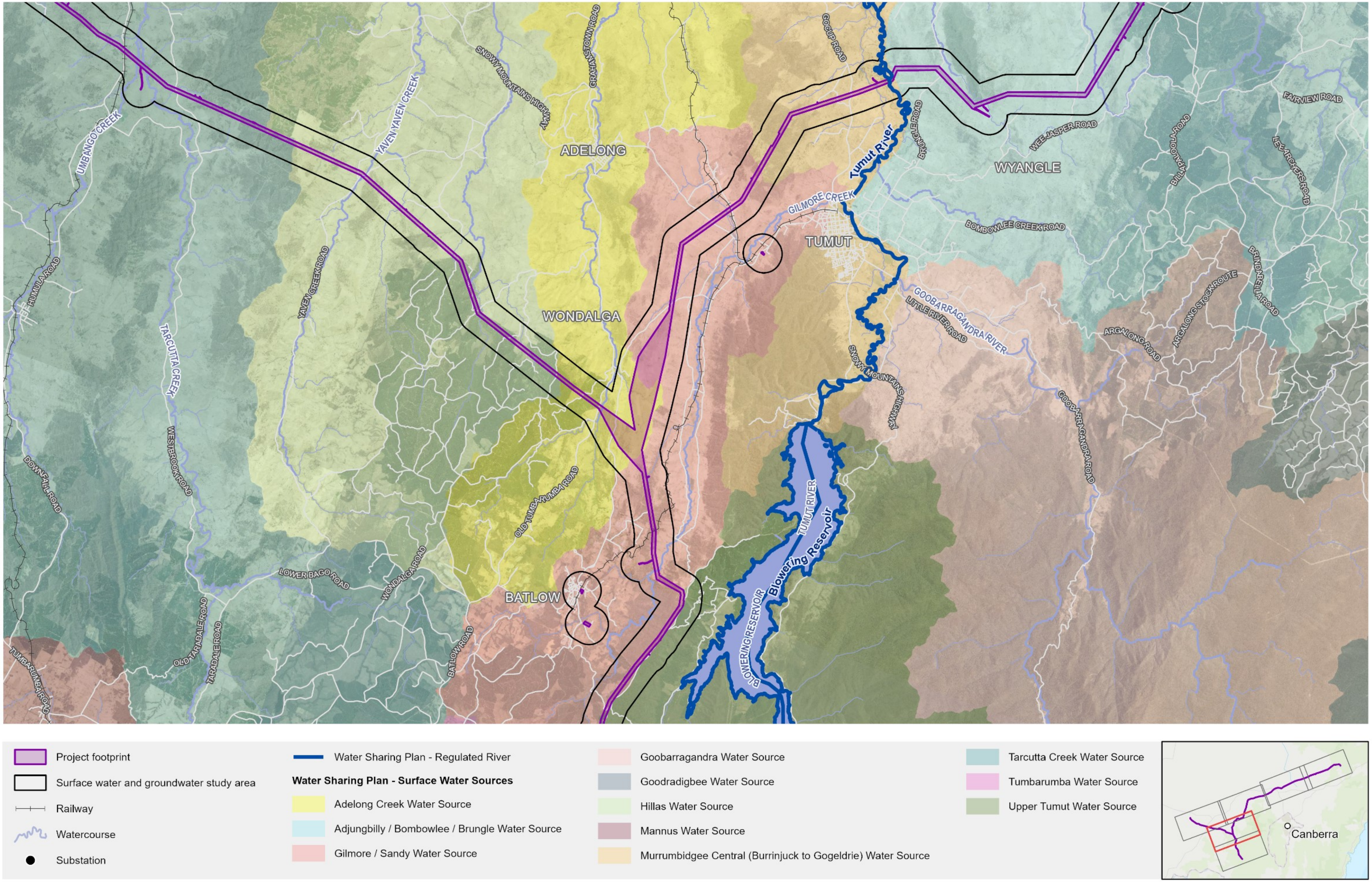
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-10d: Water Sharing Plan - Surface Water Sources



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Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

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0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-10e: Water Sharing Plan - Surface Water Sources

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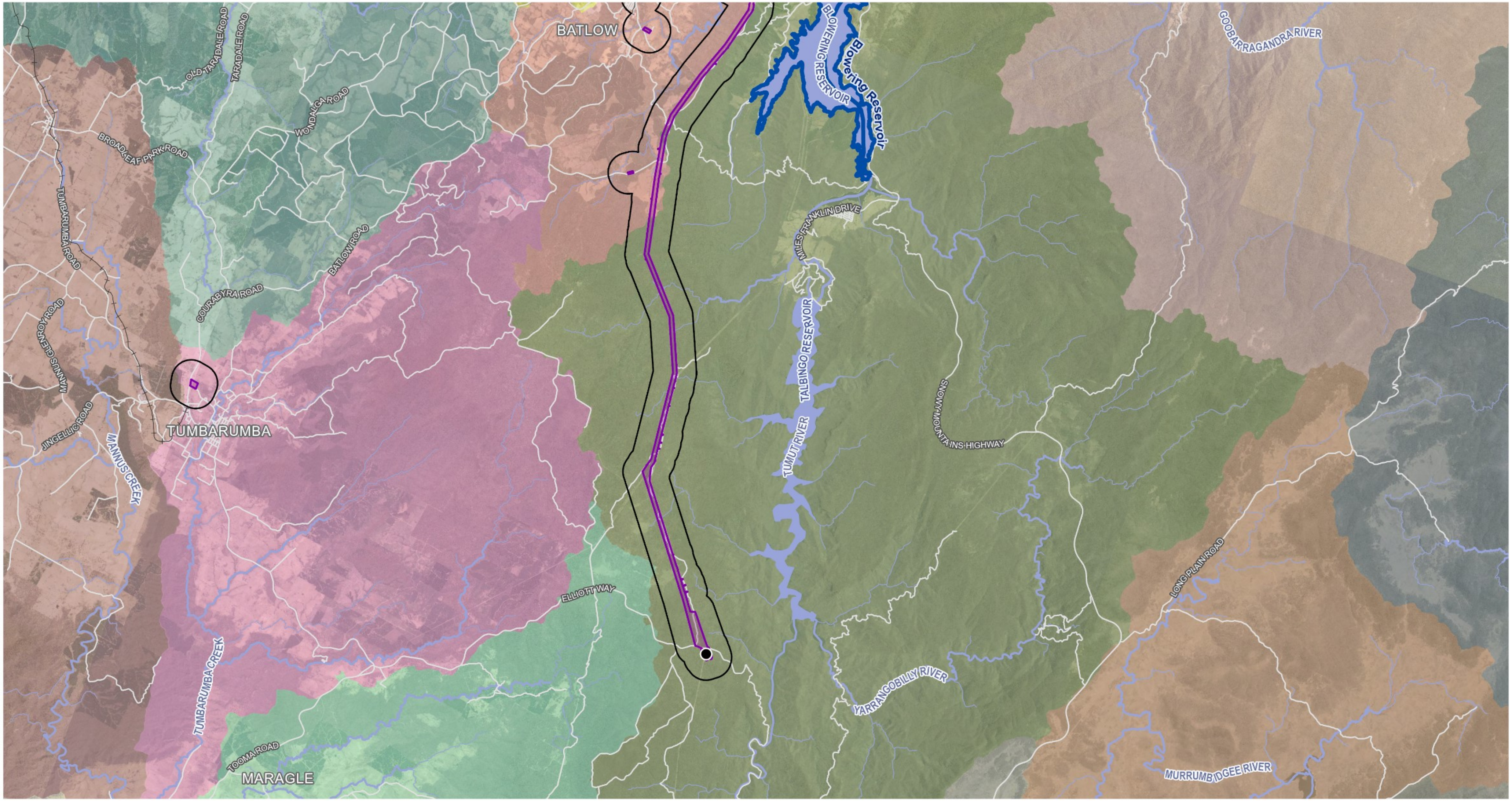
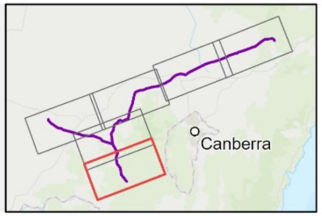


Project footprint	Substation	Goobarragandra Water Source	Tarcutta Creek Water Source
Surface water and groundwater study area	Water Sharing Plan - Regulated River	Goodradigbee Water Source	Tumbarumba Water Source
Railway	**Water Sharing Plan - Surface Water Sources**	Mannus Water Source	Upper Tumut Water Source
Watercourse	Adelong Creek Water Source	Maragle Water Source	
	Gilmore / Sandy Water Source	Tantangara Water Source	



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

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Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-10f: Water Sharing Plan - Surface Water Sources

5.3.4 Surface water quality

5.3.4.1 Murrumbidgee River catchment

The *State of the Catchments 2010: Murrumbidgee Region* (DECCW, 2010a) reports on the condition and pressures of the catchment and analyses the performance of turbidity and total phosphorous (TP) against ANZECC 2000 guidelines as indicators of water quality performance between 2005 – 2008.

The monitoring locations included in the report that were closest to the project footprint were Tumut River at Oddy's Bridge and Murrumbidgee River at Gundagai. The exceedance of the TP guideline value from these sites were 55 per cent and 51 per cent respectively, whilst exceedance of the turbidity guideline value was one per cent and three per cent respectively. The report also found a rising trend in turbidity within the upper catchment such as in the Goodradigbee River at Wee Jasper.

The *National Water Quality Assessment* (SKM, 2011) provides a snapshot of water quality across inland waters in Australia. The assessment presented a comparison between water quality data against relevant ANZECC 2000 WQO for the region. The water quality parameters assessed were:

- cyanobacteria
- microbial quality
- nutrients, including TP and total nitrogen (TN)
- pH
- salinity
- turbidity.

This report found turbidity exceedances were generally low at 12 per cent. Nutrients exceeded the guidelines, ranging from 'fair' to 'poor'. TN was rated 'poor' with 74 per cent exceedance and TP was rated 'fair' with 50 per cent exceedance. Three water quality variables (turbidity, salinity, and pH) were rated 'good' with greater than 75 per cent of samples within the ANZECC 2000 relevant guideline value range.

The condition of the Murrumbidgee River below Burrinjuck was rated as 'poor' to 'excellent' in the Murrumbidgee Water Resource Plan (DPIE, 2019). Dissolved oxygen concentrations were mostly within the target range; however, they were highly variable during low flow conditions. The pH levels were mostly within the target range but with occasional pH levels outside the target range in the Tumut River and Jugiong Creek. Salinity levels were mostly low, however, some sub-catchments, such as Jugiong Creek contributed to the high salinity readings. Sub-catchments in the mid Murrumbidgee yielded some of the highest salinity results and salt loads in NSW. Nutrients frequently exceeded targets in tributaries to the Murrumbidgee River below Burrinjuck Dam. In the Murrumbidgee River, however, nutrient levels were generally low. Elevated levels of turbidity occurred due to a number of factors including the widespread conversion of land for cropping and grazing, riverbank and riparian condition, presence of carp, and grazing practices. Algal blooms occurred occasionally in the Murrumbidgee River below Burrinjuck Dam and are common in lakes within the catchment.

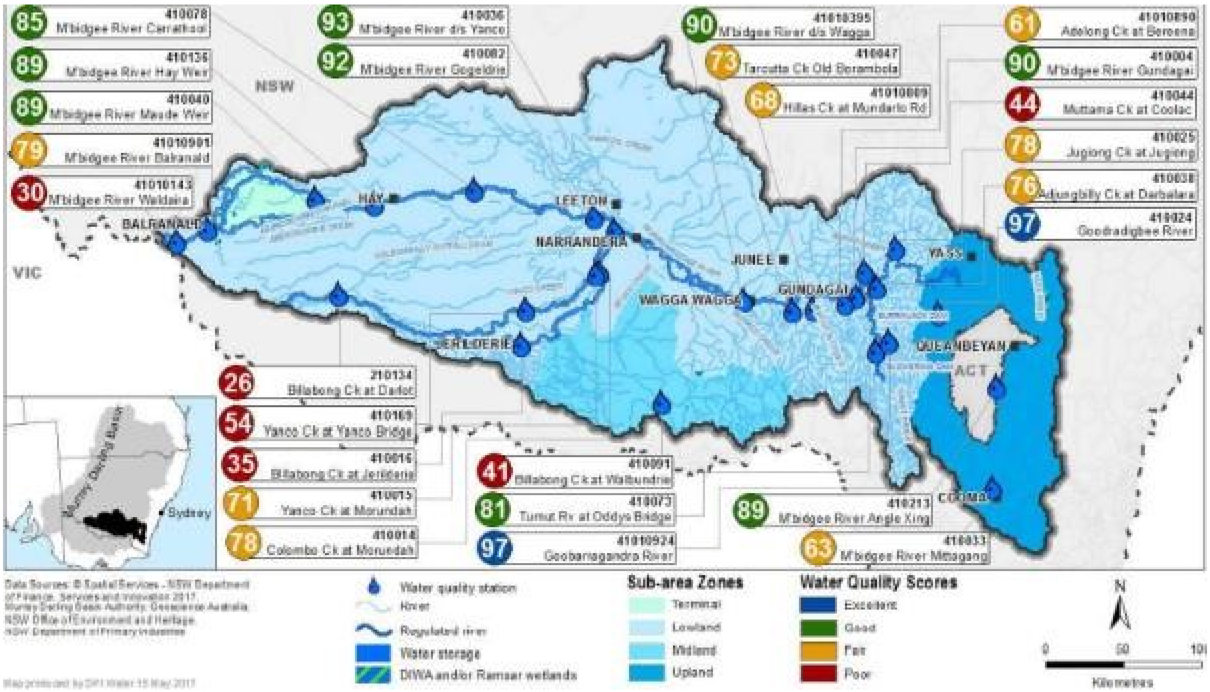


Figure 5-11 Regional water quality snapshot for Murrumbidgee River (DPIE, 2019)

The NSW SoE reports every three years on the status of key environmental issues facing NSW including waterway health. The percentage of samples from each monitoring site that exceed the ANZECC 2000 nutrient WQO are shown in Figure 5-12. The TN and TP significances varied within the project footprint along Tumut River and Murrumbidgee River, with 'good' (less than 25 per cent exceedance) to 'very poor' (more than 75 per cent exceedance).

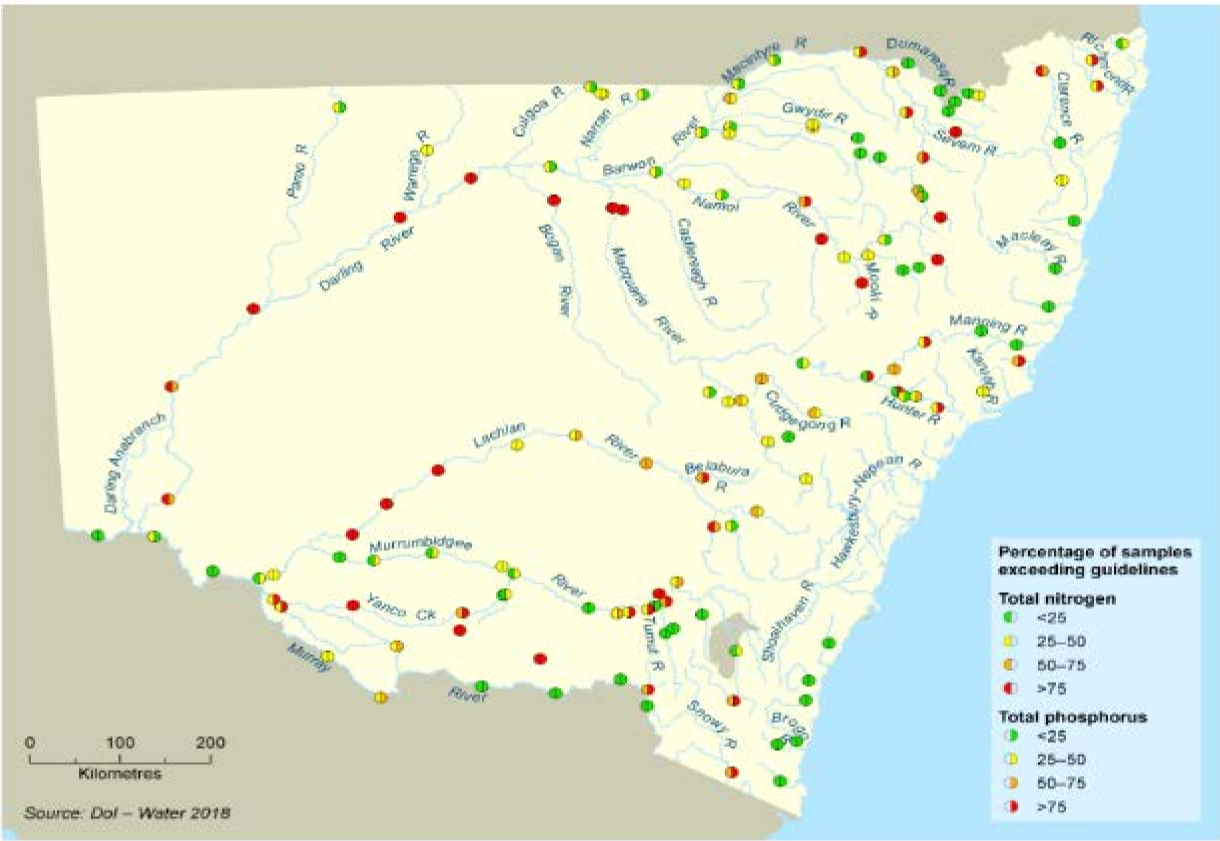


Figure 5-12 Proportion of sample exceedance for TN and TP values across NSW major waterways (Environment Protection Authority, 2012)

Table 5-6 shows water quality data collected from WaterNSW real time quality monitoring sites on the Murrumbidgee River closest to the project footprint.

Table 5-6 **Summary statistics from WaterNSW water monitoring sites within Murrumbidgee River catchment compared to WQOs**

Percentile	Temperature (°C)			Conductivity (µS/cm)		
	ANZECC/ANZG Guideline WQO value	Tumut River at Oddys Bridge (# 410073)	Murrumbidgee River at Glendale (#410068)	Guideline value	Tumut River at Oddy's Bridge (# 410073)	Murrumbidgee River at Glendale (#410068)
10%	15-35	10.3	10.1	30–350	25.1	134.0
Median		12.0	15.0		32.9	189.3
90%		16.2	19.6		38.2	258.2

Key: = Within guideline value range = Outside guideline value range

Temperature and salinity generally remained within acceptable range to maintain WQOs for the Murrumbidgee River catchment from the period between 2010 and 2022, with less than 10 per cent of values below the temperature range in the Murrumbidgee River and below the conductivity range in the Tumut River. Both 10 per cent and median temperature values in the Tumut River were below the guideline range. This is not surprising as the Tumut drains the snowmelt and other runoff from a large proportion of the northern Snowy Mountains and also receives bottom of the dam discharges from the outlet of Blowering Dam.

5.3.4.2 Lachlan River catchment

The *State of the Catchments 2010: Lachlan Region* (DECCW, 2010b) found TP samples at five out of the seven sites exceeded the ANZECC guideline values 100 per cent of the time. Only the Lachlan River at Hillston Weir (14 per cent exceedance) and the Lachlan River at Reids Flat (88 per cent exceedance) did not exceed all the time. Five sites had turbidity data, with the monitoring location closest to the project footprint, Lachlan River at Reids Flat, recording 46 per cent of the samples exceeding the ANZECC guideline value. There was also a rising trend in turbidity identified with three sites in the upper catchment.

In the *National Water Quality Assessment 2011* (SKM, 2011), 11 sites in the Lachlan River catchment were used and the findings are summarised below:

- Turbidity and salinity were rated as 'fair', with 31 per cent and 50 per cent of samples exceeding guideline values, respectively.
- pH was rated 'good', with 85 per cent of samples within the upper and lower guideline values.
- TN and TP were rated as 'very poor' and 'poor' with 96 per cent and 72 per cent of samples, respectively, exceeding the guideline values. Median concentrations for TN ranged from 450 to 860 µg/L, whilst TP had median concentrations ranging from 12 to 83 µg/L. TN concentrations were generally lower in tributaries such as the Abercrombie River at Camping Area, than in the lowland zone of the Lachlan River. Low TP concentrations were generally associated with low turbidity, possibly indicating that a large proportion of the nutrient load was particulate-bound, transported to the river in overland stormwater during heavy rainfall events.

Similarly, with the *National Water Quality Assessment 2011* (SKM, 2011) and *State of the Catchments 2010: Lachlan Region* (DECCW, 2010b), the Lachlan Water Resource Plan (DPIE, 2020a) assigned water quality index (WaQI) scores based off indicators including TN, TP, pH, turbidity and dissolved oxygen at main monitoring locations. The scores were calculated using the frequency and amplitude of exceedance of water quality targets. The WaQI significance categories are shown in Table 5-7.

Table 5-7 **WaQI significance classifications**

Significance	% of samples exceeding guideline values
Excellent	95 – 100
Good	80 – 94
Fair	60 – 79
Poor	1 - 59

The project footprint is situated within the upland region, where the condition was rated to be ‘fair’ to ‘poor’. Dissolved oxygen and pH concentrations were within the targeted range during the analysis period, in alignment with the findings reported earlier (SKM, 2011). Salinity in the upland was mostly low and negatively correlated to discharge with the samples with highest salinity values occurring during low flow periods. Turbidity and suspended sediment were ‘fair’ to ‘poor’ due to factors including widespread conversion of land for cropping, riverbank and riparian condition, and the presence of carp. Harmful algal blooms are rare in this part of the catchment. Nutrients such as nitrogen and phosphorus were low to medium. However, at the monitoring site along the Lachlan River closest to the project footprint were allocated TN and TP scores of ‘very poor’ and ‘poor’, respectively (refer to Figure 5-13).

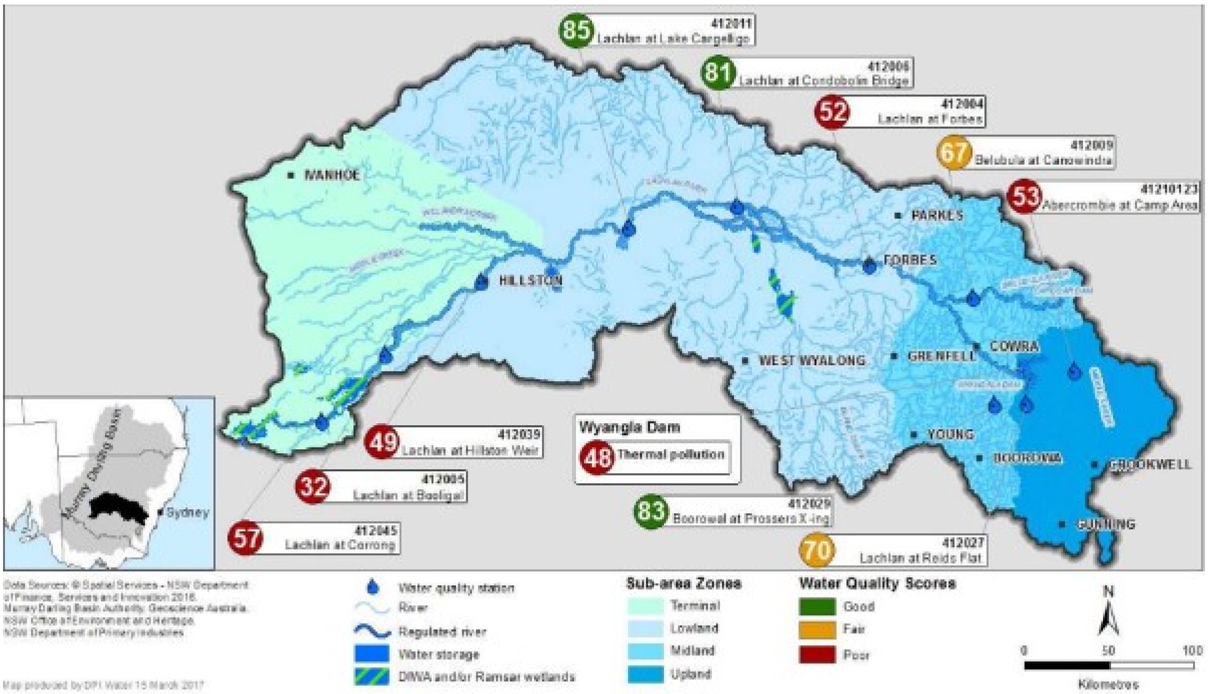


Figure 5-13 Regional water quality snapshot for Lachlan River (DPIE, 2020a)

Data from the site nearest the project footprint was collected from the WaterNSW real time quality monitoring site (WaterNSW, 2022). The site (ID: 412027) is located at Reid’s Flat, 117 kilometres downstream from the project footprint as presented in Figure 5-15. Table 5-8 presents the temperature and conductivity from the project footprint, comparing to the guideline values of the Lachlan River catchment.

Table 5-8 Summary statistics from WaterNSW water monitoring site (ID: Lachlan River at Reid’s Flat) compared to WQOs

Percentile	Temperature (C)	Conductivity (μ S/cm)
ANZECC/ANZG Guideline value	**15-35**	**30–350**
10%	8.4	387
Median	16.5	619
90%	24.7	839

Key: = Within guideline value range = Outside guideline value range

Median temperature values were within the guideline value; however salinity values exceeded the guideline value for the Lachlan River.

5.3.4.3 Hawkesbury - Nepean River catchment

Currently, the Hawkesbury Nepean River catchment has no defined WQOs, however according to the *Independent Inquiry into the Hawkesbury- Nepean system* (HRC, 1998), the Healthy Rivers Commission have proposed interim guideline values for nutrients and chlorophyll-a. The inquiry also recommended that non-nutrient criteria be adopted from ANZECC 2000 (now ANZG 2018).

In the State of Catchment report (DECCW, 2010a), the monitoring locations closest to the project footprint were on the Wollondilly River, which is a major waterway that the project footprint is proposed to cross. The sites are located at Golden Valley and Murray Flats. The TP exceedance from both sites were 20 per cent and 59 per cent of samples, respectively, and turbidity exceedance was three per cent at both sites.

The *Annual Water Quality Monitoring Report 2020-21* (WaterNSW, 2021) provides an overview of WaterNSW's water quality sampling and results from between 1 July 2020 to 3 June 2021. The project is situated in the Warragamba system catchments within the Hawkesbury Nepean catchment. The sites selected were on the Wollondilly River at Upper Tarlo and Golden Valley. Table 5-10 shows the percentage of samples outside of the ANZECC 2000 guideline values. The report noted that samples from all upstream parts of the catchment frequently exceeded the guidelines, particularly for nutrients and conductivity. However, there was a slight improvement in the Warragamba catchment from the previous year, indicating the recovery after the fires and floods in 2020 and early 2021.

Data from the site nearest the project footprint was collected from the WaterNSW real time quality monitoring site (WaterNSW, 2022b). The sites (ID: 2122713 and ID: 2122711) are on the Tarlo River at Towrang and the Wollondilly River at Murray Flats, which are located downstream from the project footprint. Table 5-11 and Table 5-12 shows water quality data collected from 2010 to 2022 by WaterNSW's real time quality monitoring sites closest to the project footprint. The monitoring site locations are presented in Figure 5-15.

5.3.4.4 Upper Murray River catchment

The Upper Murray River catchment is an interstate catchment, spanning into both NSW and Victoria. Thus Consequently, the Murray-Darling Basin Plan 2012 supersedes the NSW WQOs (DECCW, 2006). The target values for the target application zones, as presented in Section 3.1.3, are applicable.

The Upper Murray catchment WRP assigned water quality index (WaQI) scores based off indicators including TN, TP, pH, turbidity, and dissolved oxygen at main monitoring locations are presented in Figure 5-14.

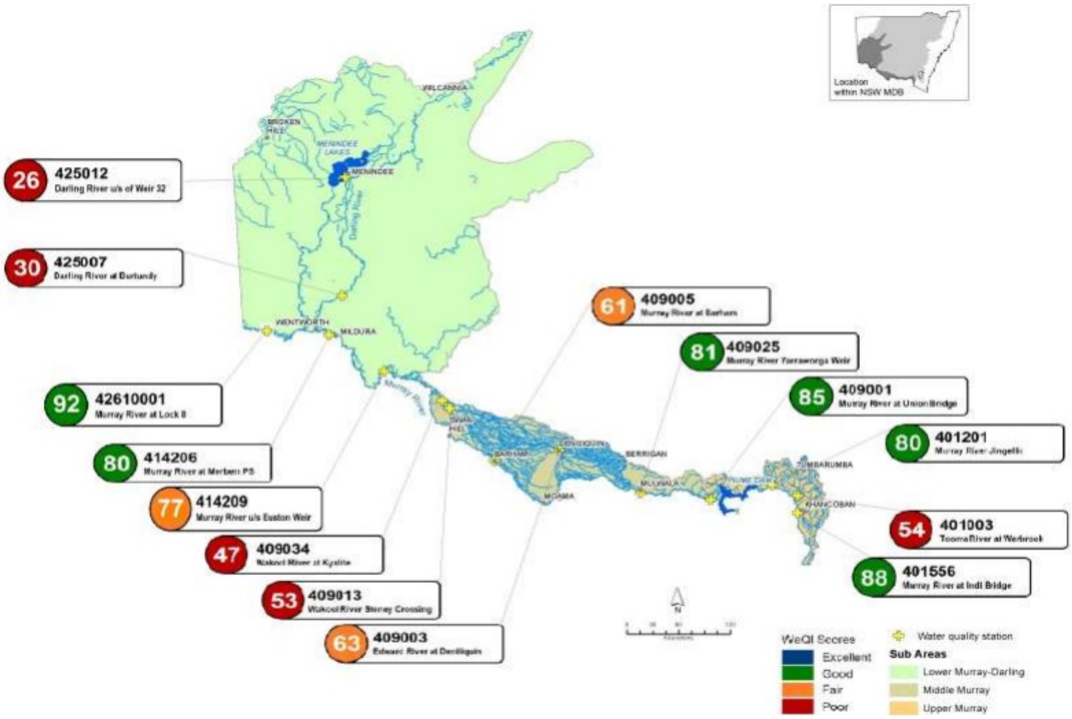


Figure 5-14 Regional water quality snapshot for the Murry Lower Darling river (Department of Planning, 2020b)

In the State of Catchment 2010: Murray Region (Department of Environment, 2010c), the monitoring location closest to the project footprint was Tooma River at Warbrook, which is 23 kilometres away. The TP exceedance sampled at the site was 100 per cent of samples whilst the turbidity exceedance was three per cent.

Data from the site nearest the project footprint was collected from the WaterNSW real time quality monitoring site. The nearest site is Tumbarumba at Tumba2 (ID: 401007) which is located downstream from the project footprint (Tumbarumba accommodation facility (AC1)). Table 5-12 shows water quality data collected from 2010 – 2022 by WaterNSW real time quality monitoring sites closest to the project footprint. The monitoring site locations are presented in Figure 5-15.

Table 5-9 Summary statistics from WaterNSW water monitoring site (ID: Tumbarumba at Tumba2) compared to guidelines

Percentile	Temperature (C)	Conductivity (μ S/cm)
ANZECC/ANZG Guideline value	**15-35**	**30–350**
10%	6.22	31
Median	12.2	44
90%	19.4	81.1

Key: = Within guideline value range = Outside guideline value range

Table 5-10 Percentage of samples from 2020 - 2021 exceeding trigger values – Hawkesbury Nepean Warragamba system catchments

Monitoring site	Dissolved Oxygen (% Saturation)	pH	Turbidity	Conductivity	TN	TP	Filtered Reactive Phosphorus	Oxidised Nitrogen	Ammoniacal Nitrogen	Total Aluminium	Manganese	Chlorophyll-a
Trigger values	85-110	7.5-8.0	2-50 NTU	30-2200µS/cm	250-500µg N/L	20-50µg P/L	15-20µg P/L	15-40 µg N/L	13-20 µg N/L			5µg/L
Wollondilly at Upper Tarlo (Station: E4122)	92	0	8	67	92	50	0	42	67	67	0	42
Wollondilly River @ Golden Valley (Station: E450)	33	42	0	58	100	50	0	42	25	83	0	83

Table 5-11 Summary statistics from WaterNSW water monitoring site (ID: Tarlo River at Towrang) compared to WQOs

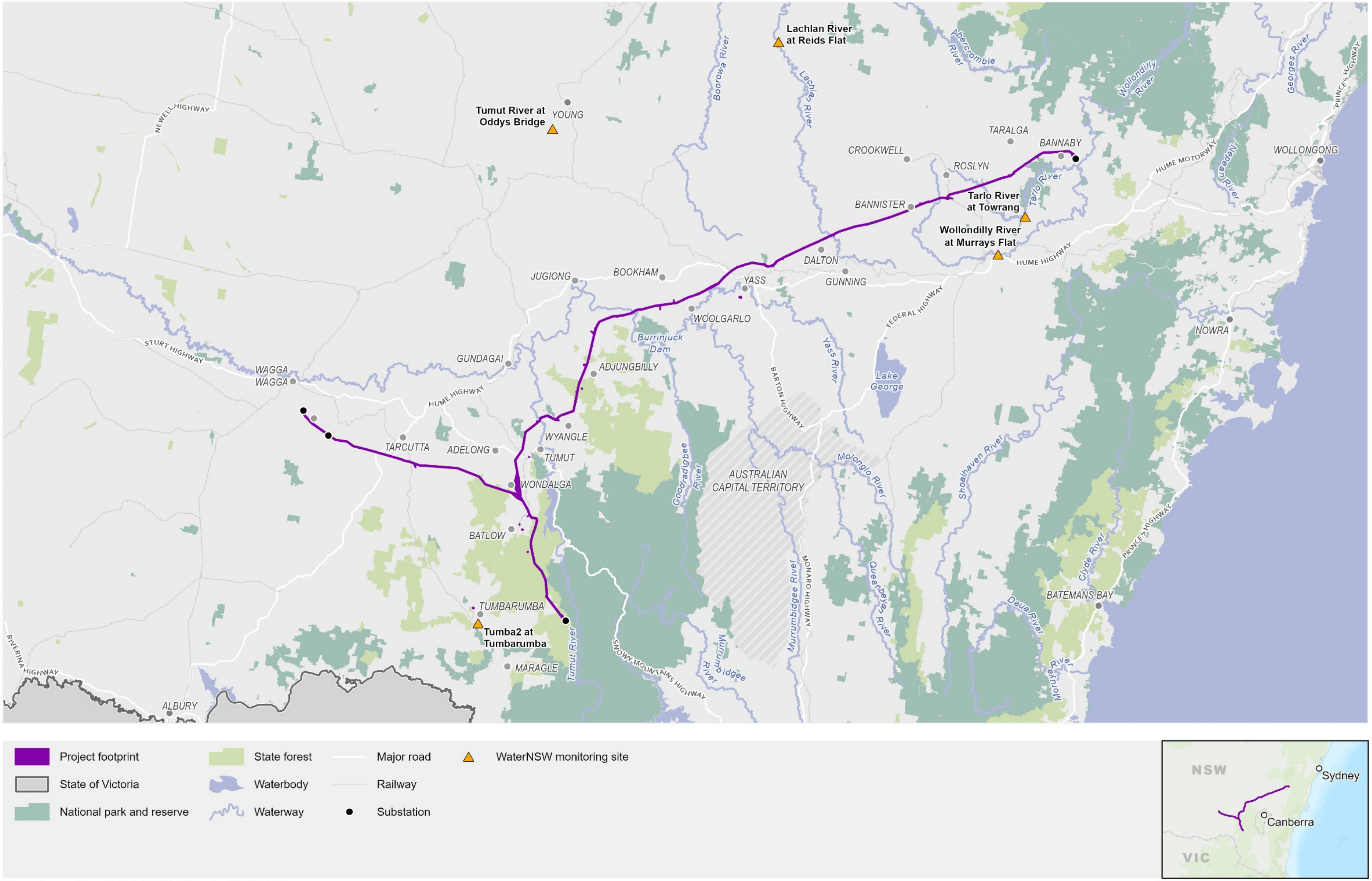
Site ID: Tarlo River at Towrang	Temperature (°C)	Conductivity (μ S/cm)	NTU	pH
WQOs	**15-35**	**30–350**	**2-25**	**6.5-7.5**
10%	6.9	243	1.7	7.0
Median	14.2	409	3.8	7.4
90%	20.4	3,668	19.6	7.7

Key: = Within guideline value range = Outside guideline value range

Table 5-12 Summary statistics from WaterNSW water monitoring site (ID: Wollondilly River at Murray Flats) compared to WQOs

Site ID: Wollondilly River at Murray Flats	Temperature (°C)	Conductivity (μ S/cm)	NTU	pH
WQOs	**15-35**	**125-2,200**	**2-25**	**6.5-7.5**
10%	7.6	280	0.9	7.1
Median	16.1	529	5.8	7.6
90%	23.2	884	23.3	8.2

Key: = Within guideline value range = Outside guideline value range



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Source: *Aurecon, Transgrid, WaterNSW, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

FIGURE 5-15: WaterNSW water quality monitoring sites

5.3.5 Geomorphology

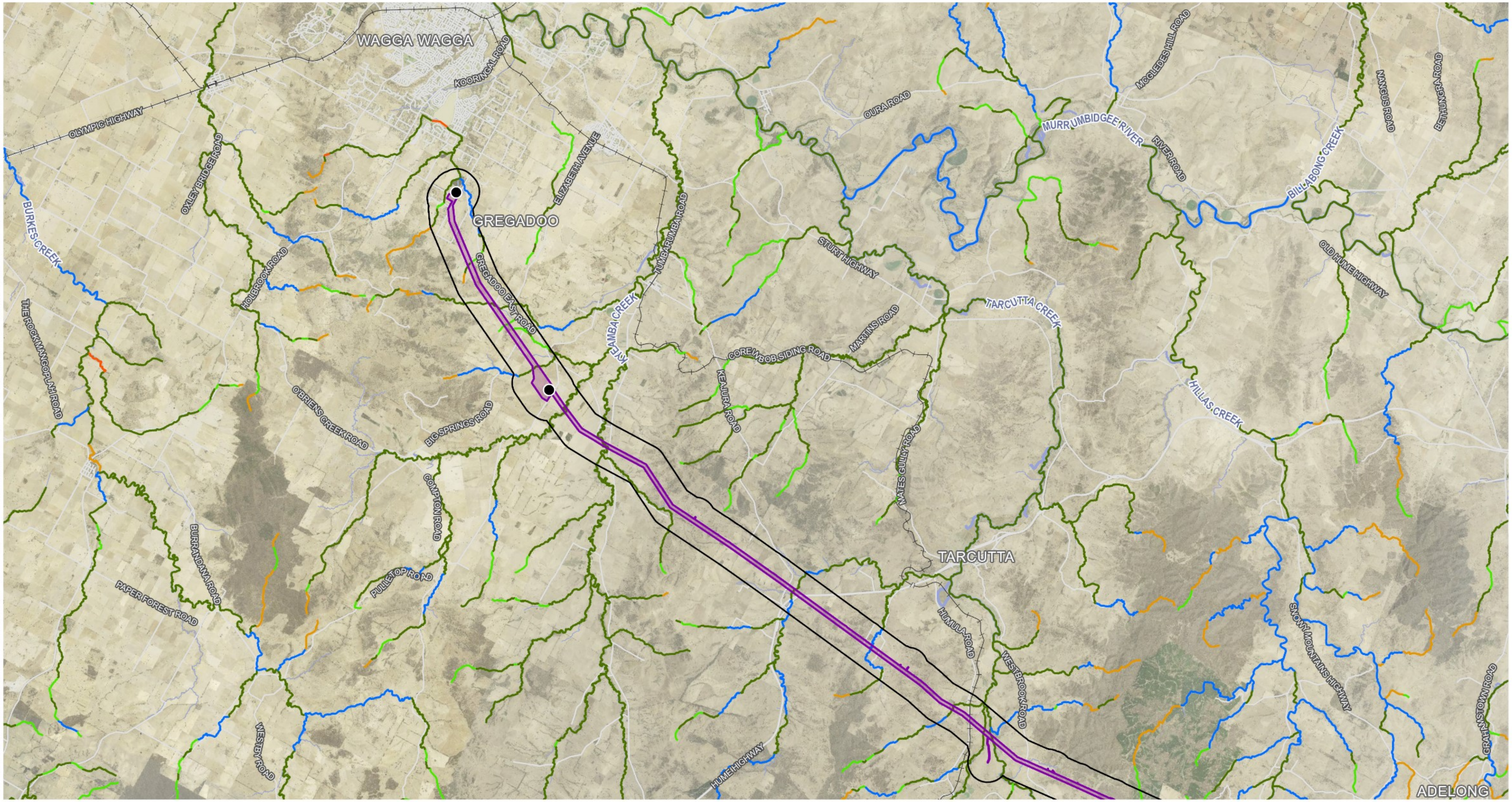
River geomorphology refers to how the surrounding landscape and its natural processes, including sediment transport, vegetation, water flow and erosion, shape and form rivers. To manage rivers effectively, it is paramount to understand the existing condition of the river, its inherent fragility (sensitivity to change) and likelihood of recovery. This all requires a consistent method to characterise the types of rivers we are working with and how they function.

The River Styles Framework is a system for understanding and managing rivers in all their diverse geomorphic characteristics and behaviours. Developed at Macquarie University, the framework is a method for classifying river character, behaviour, condition, and recovery potential. The recovery potential refers to the likelihood that a river reach will improve its geomorphic condition over management timeframes, from the construction and operational impacts from new developments.

Major waterways, mostly with Strahler order 6 and above, with the exception of a few key Strahler order 6 waterways, Wollondilly and Tarlo River. These are located in the surface water and groundwater study area and crossed by the project footprint and their respective classifications are presented in Table 5-13 and shown in Figure 5-16. The data in Table 5-13 was analysed as part of the field verification (refer to Section 4.3.1).

Table 5-13 River Styles of major waterway crossings

Waterway	Stream order	NSW river style	Existing condition	Recovery potential
Murrumbidgee River	9	Bedrock controlled, gravel	Moderate condition Moderate fragility	Moderate
Lachlan River	6	Floodplain pockets, gravel	Moderate condition Moderate fragility	High
Wollondilly River	5	Water storage – dam or weir pool	Low fragility	None
Tumut River	8	Meandering, gravel	Poor condition High fragility	Moderate
Tumut River (near Killimicat)	8	Low sinuosity, gravel	Moderate condition Moderate fragility	Moderate
Gilmore Creek	6	Planform controlled, low sinuosity, gravel	Moderate condition Moderate fragility	Moderate
Umbango Creek	7	Low sinuosity, fine grained	Poor condition Moderate fragility	Moderate
Kyeamba Creek	7	Meandering, fine grained	Moderate condition High fragility	High
Keajura Creek	6	Meandering, fine grained	Poor condition High fragility	Low
O’Briens Creek	6	Meandering, sand	Poor condition High fragility	Moderate
Tarcutta Creek	6	Low sinuosity, sand	Poor condition High fragility	Low
Adjungbilly Creek	6	Planform controlled, low sinuosity, sand	Poor condition High fragility	Moderate
Tarlo River	5	Planform controlled, low sinuosity, fine grained	Moderate condition Moderate fragility	Moderate



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Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

NSW River Styles

CVS

LUV CC

LUV DC

PCVS

SMG

Anthropogenic

None

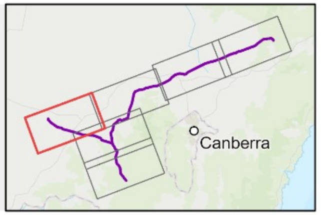
CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16a: NSW River styles

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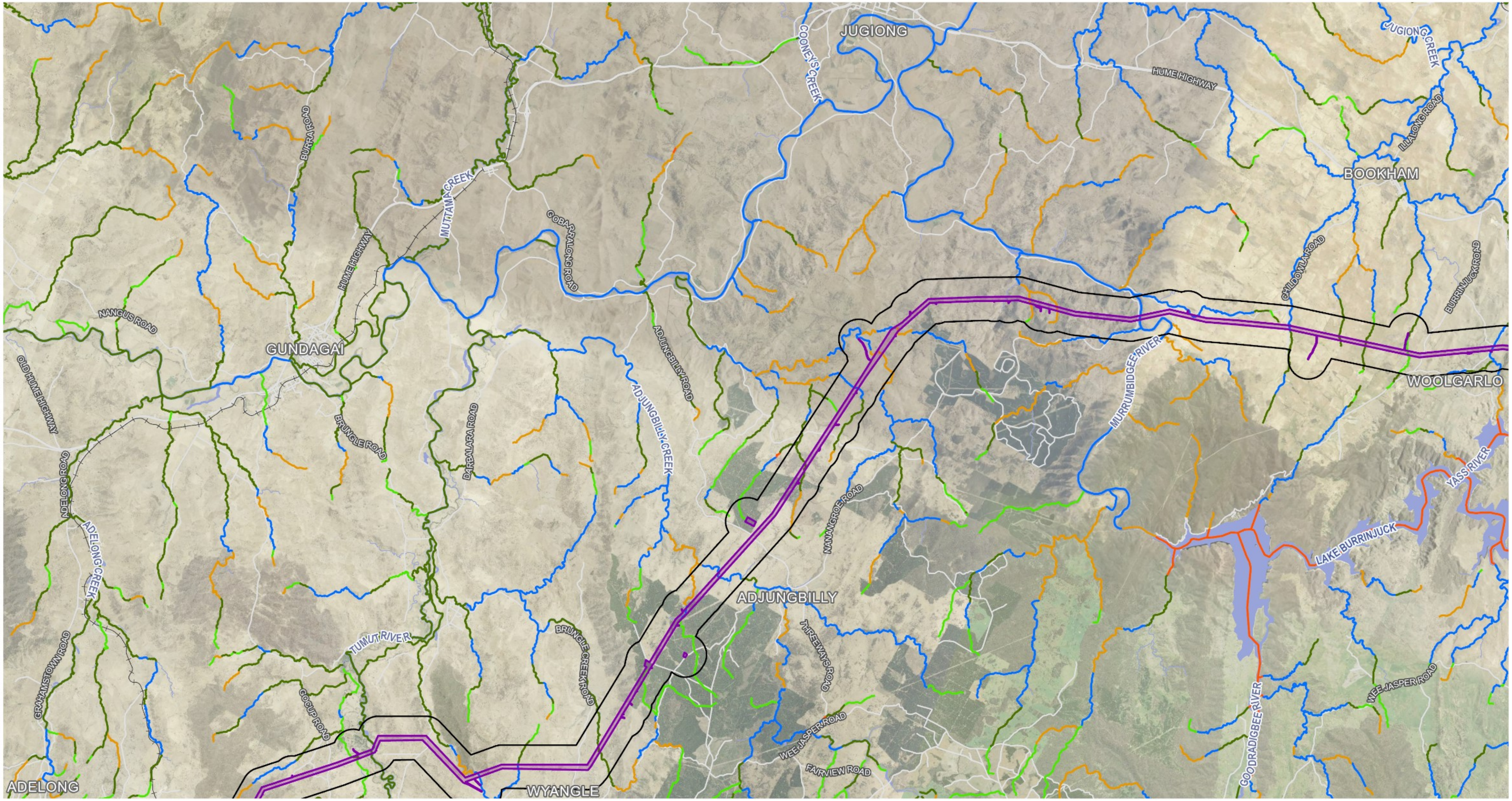


Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation

NSW River Styles

CVS
LUV CC
LUV DC
PCVS
SMG
Anthropogenic
None

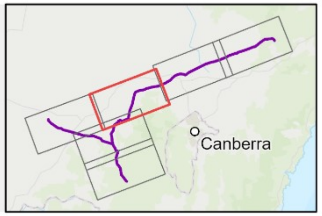
CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

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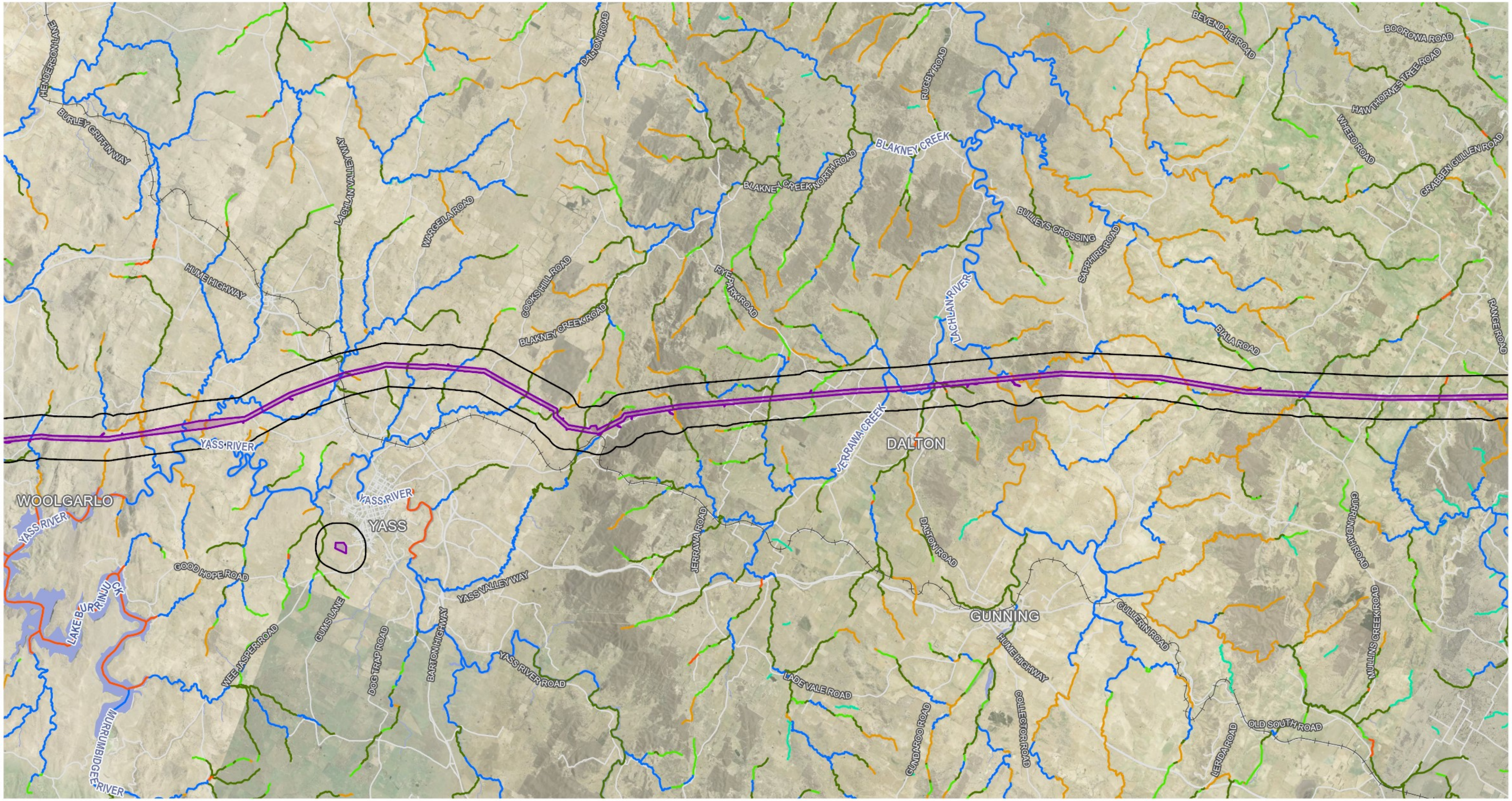
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16b: NSW River styles



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

NSW River Styles

CVS

LUV CC

LUV DC

PCVS

SMG

Anthropogenic

None

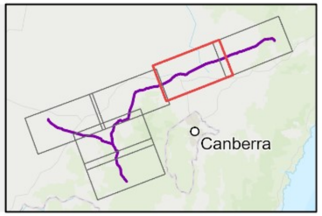
CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

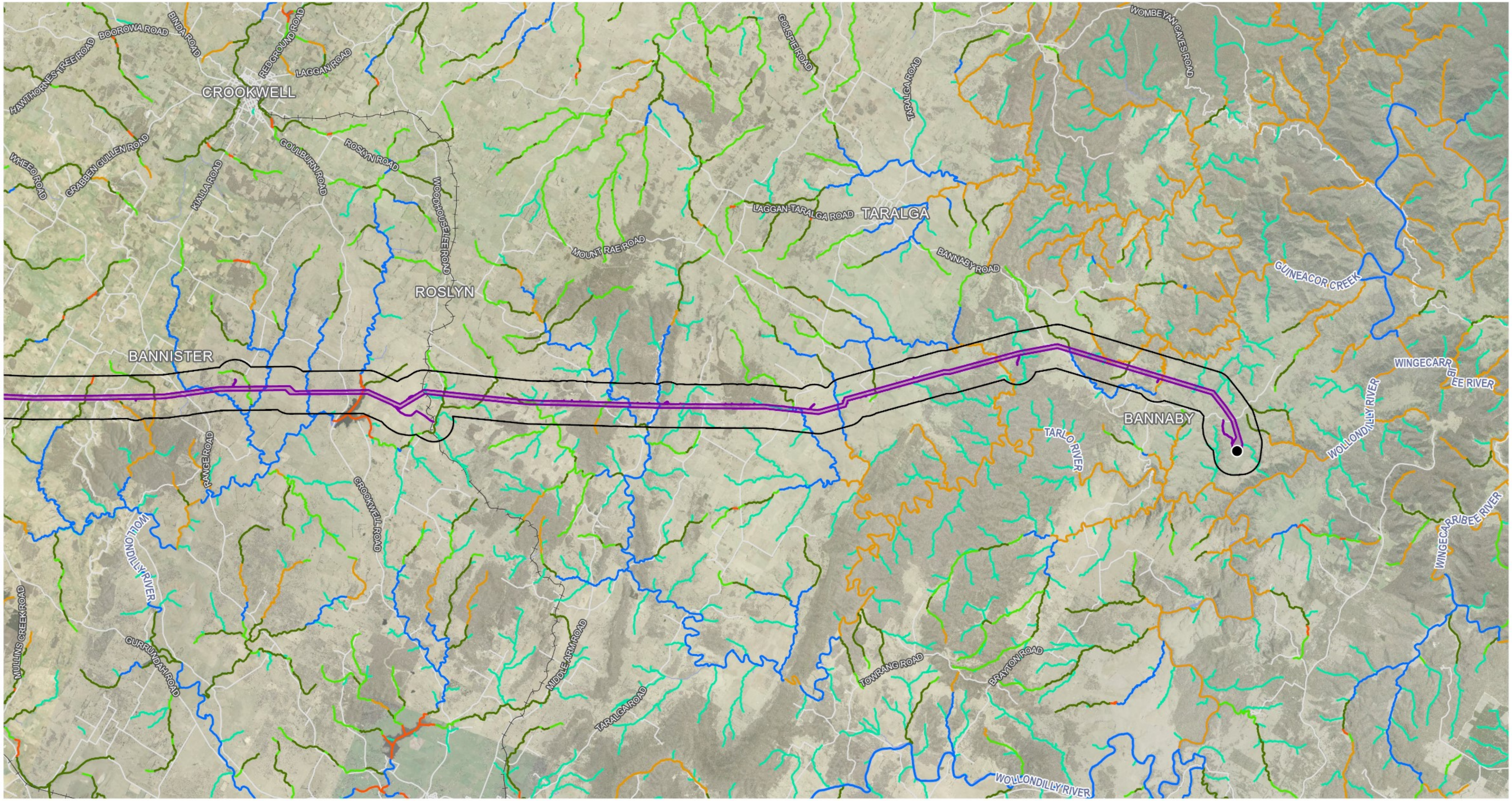
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16c: NSW River styles



Project footprint	Substation	PCVS
Surface water and groundwater study area	**NSW River Styles**	SMG
Railway	CVS	Anthropogenic
Watercourse	LUV CC	None
	LUV DC	

CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage

Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

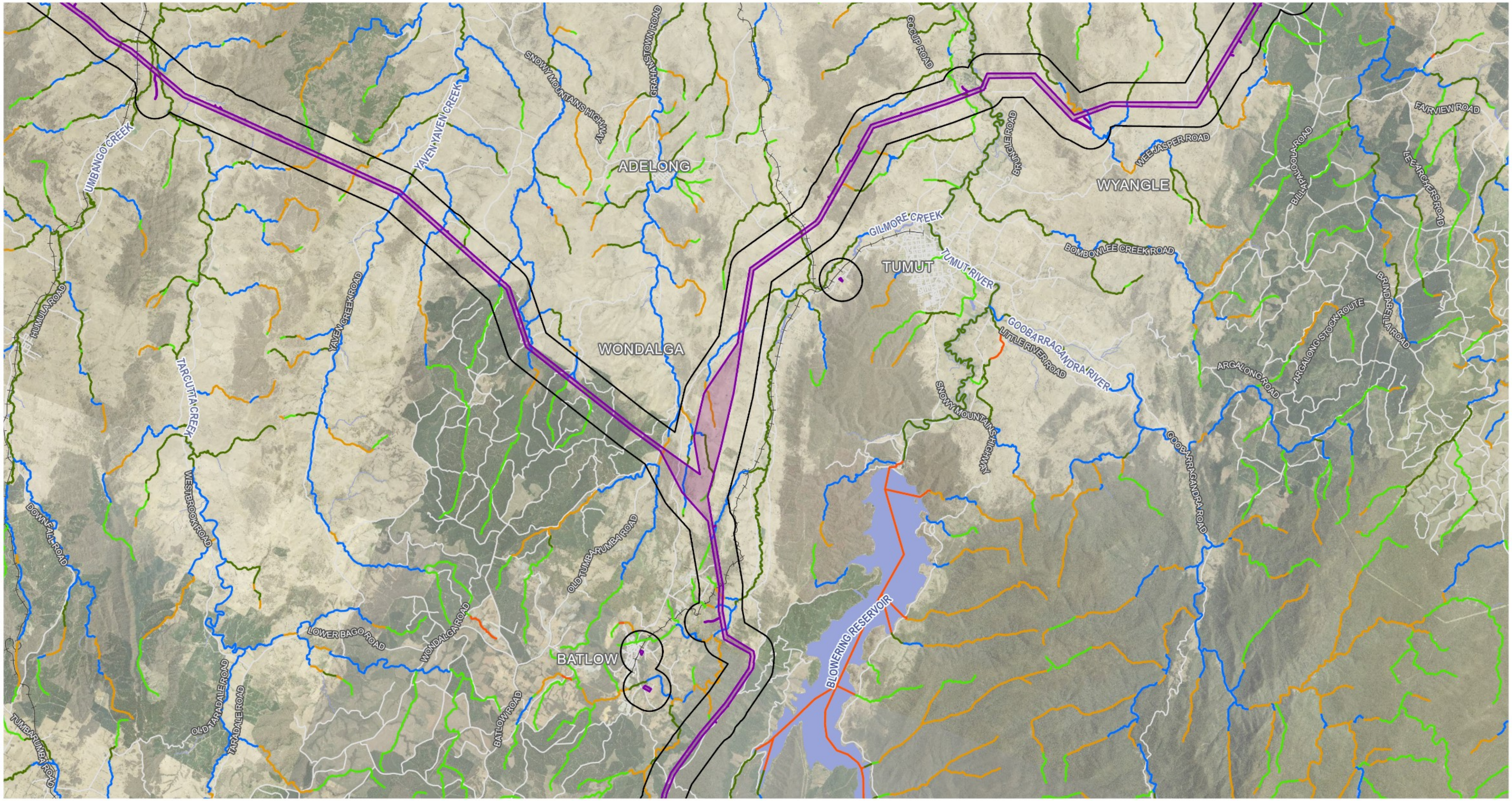
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16d: NSW River styles



Project footprint	Substation	PCVS
Surface water and groundwater study area	**NSW River Styles**	SMG
Railway	CVS	Anthropogenic
Watercourse	LUV CC	None
	LUV DC	

CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage

Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

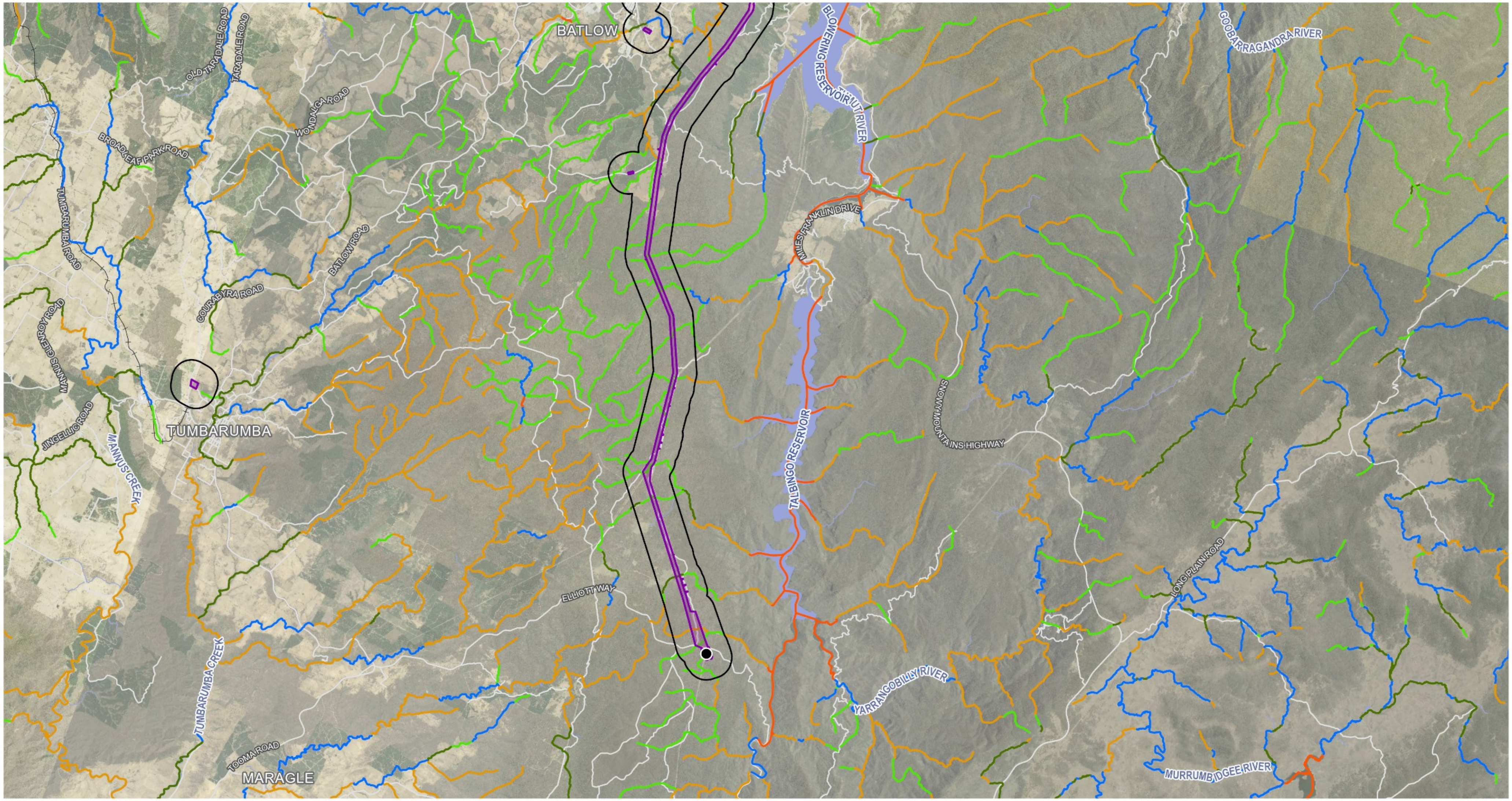
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16e: NSW River styles



- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation

NSW River Styles

- CVS
- LUV CC
- LUV DC
- PCVS
- SMG
- Anthropogenic
- None

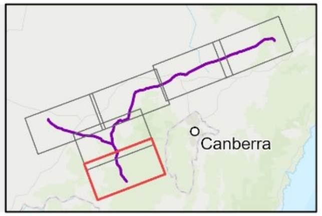
CVS - Confined Valley Setting

LUV CC - Laterally Unconfined Valley Setting – Continuous Channel

LUV DC - Laterally Unconfined Valley Setting – Discontinuous Channel

PCVS - Partly Confined Valley Setting

Anthropogenic - Water Storage



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

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0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-16f: NSW River styles

5.4 Soils and geology

5.4.1 Acid sulfate soils

Acid sulfate soils and potential acid sulfate soils are naturally occurring soils that contain iron sulfides. On exposure to air, these iron sulfides oxidise and create sulfuric acid. This acidity can result in the mobilisation of aluminium, iron, and manganese from soils. They typically occur in coastal environments at elevations less than 10 mAHD.

The Australian Soil Resource Information System (CSIRO, 2014) indicates that there is a low or extremely low probability of acid sulfate soils for much of the project footprint. There is an area of high acid sulfate soils potential within the section of the project footprint between Maragle and Yass at the crossing of the Wollondilly River and at the crossing of the Murrumbidgee River.

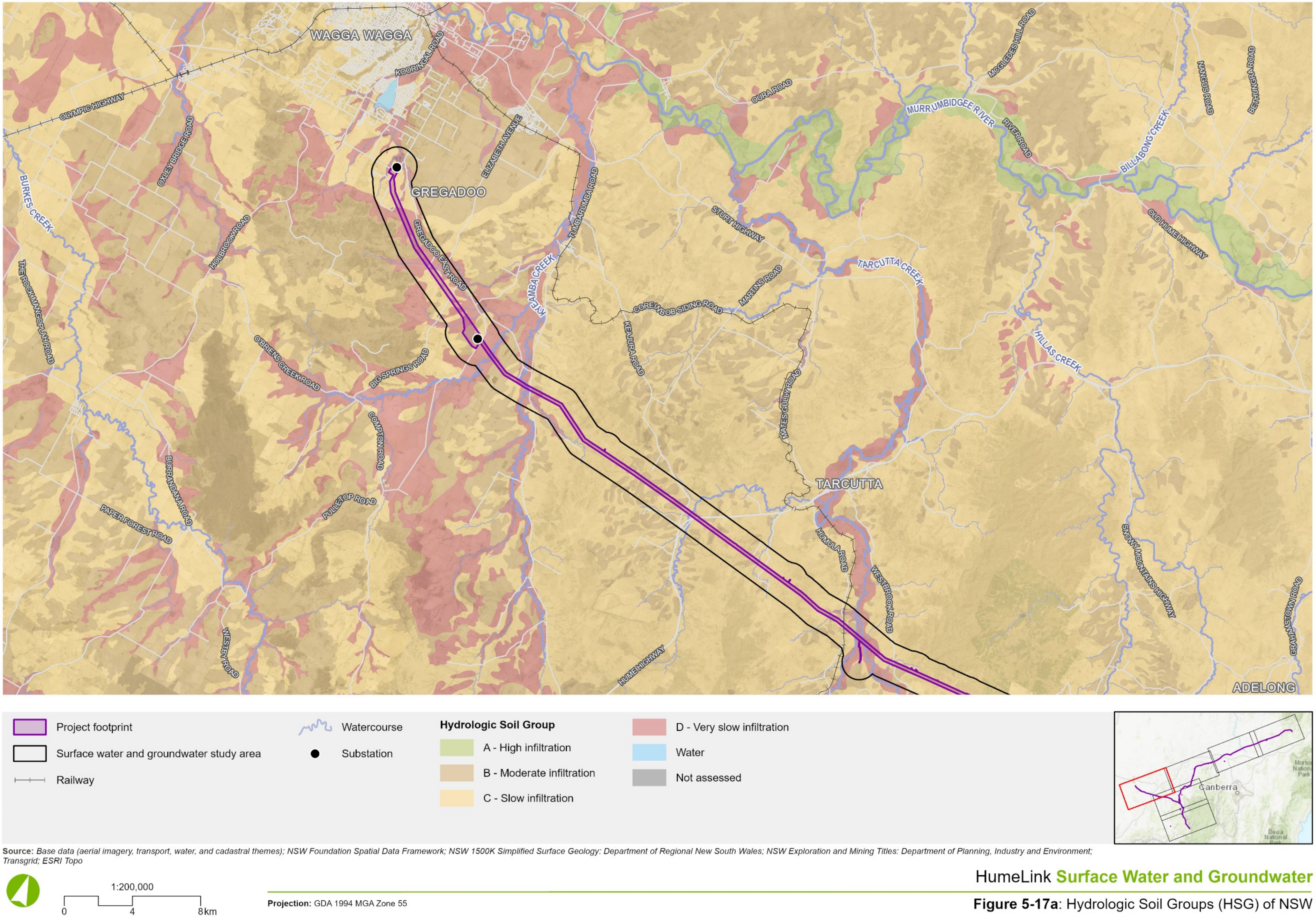
It is noted that the geological landscape of the surface water and groundwater study area may contain naturally occurring pyrite (iron (II) disulfide) veins and dykes, which may generate acidity when wet.

5.4.2 Hydrologic Soil Groups

Hydrologic groups of soil in NSW distinguish soils into four classes (A-D) based on their infiltration rates:

- Group A is sand, loamy sand or sandy loam types of soils. They have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.
- Group B is silt loam or loam. They have a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
- Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
- Group D soils are clay loam, silty clay loam, sandy clay, silty clay, or clay. This Hydrologic Soil Group has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high-water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material. Group D soils have the least recharge capacity in the catchments. They favour overland flow pathways rather than recharge to groundwater.

Hydrologic Soil Groups within the project footprint are presented in Figure 5-17.



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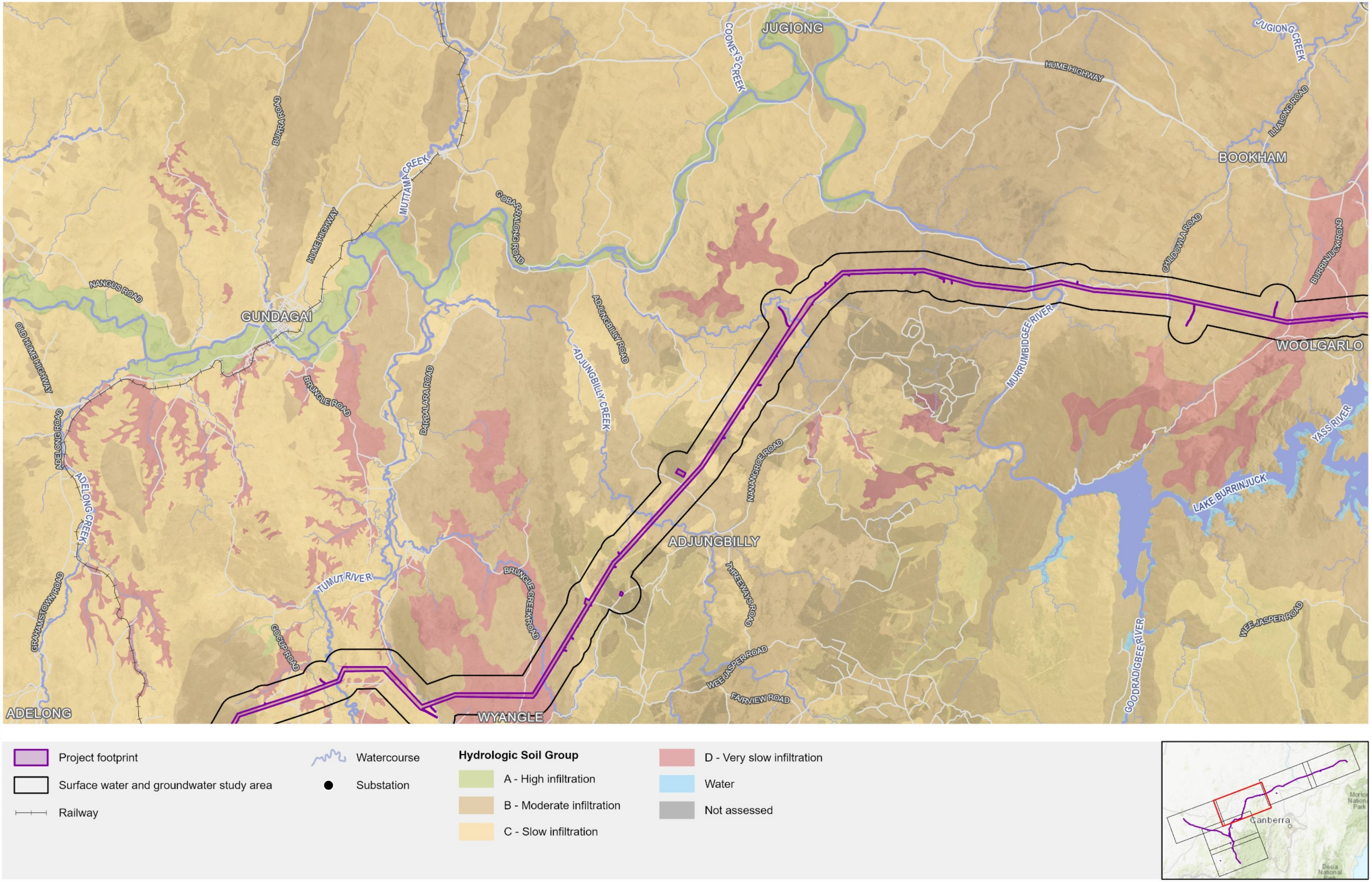
Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-17a: Hydrologic Soil Groups (HSG) of NSW



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Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

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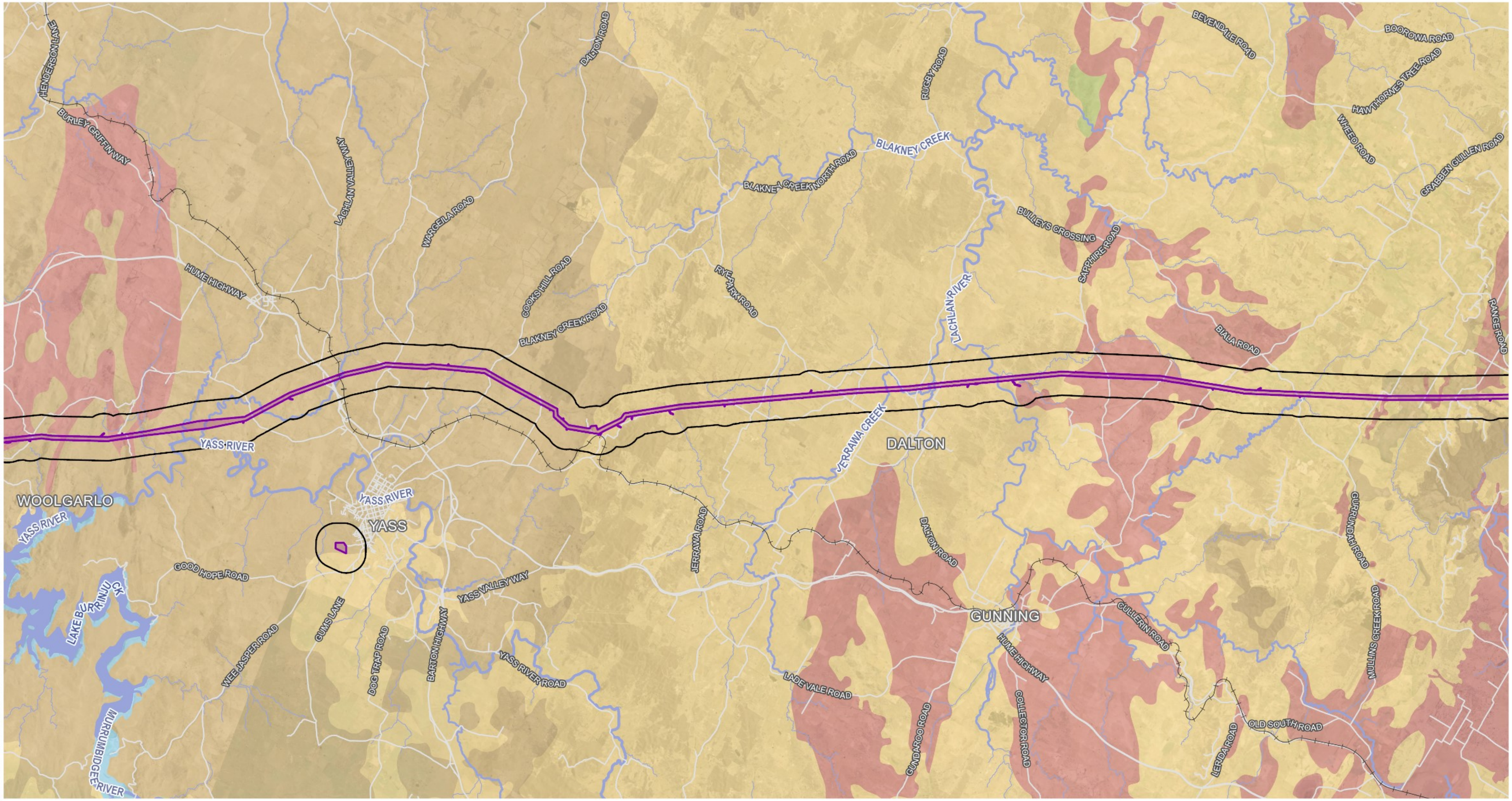
Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-17b: Hydrologic Soil Groups (HSG) of NSW



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

Hydrologic Soil Group

A - High infiltration

B - Moderate infiltration

C - Slow infiltration

D - Very slow infiltration

Water

Not assessed

Canberra

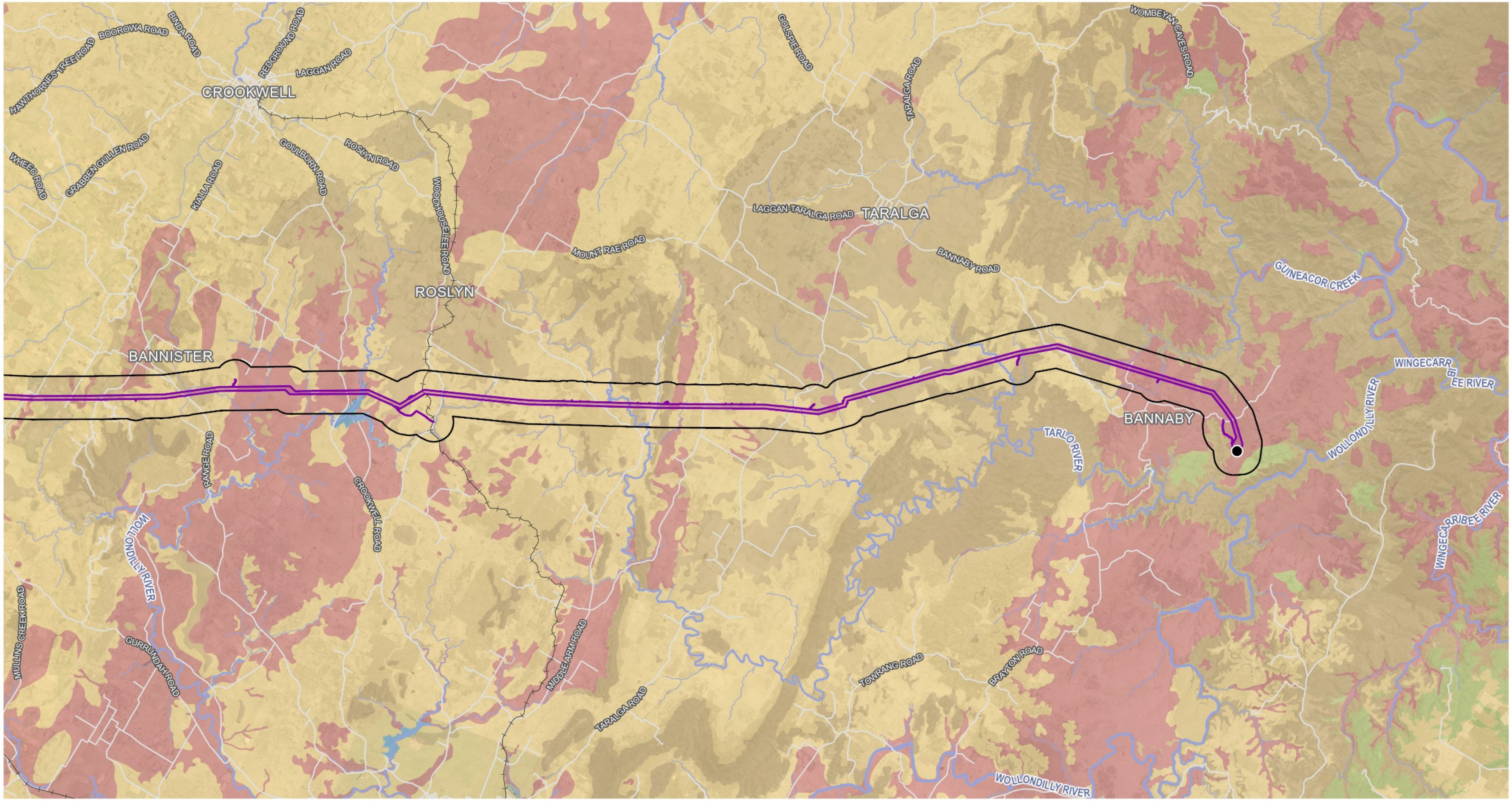
Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

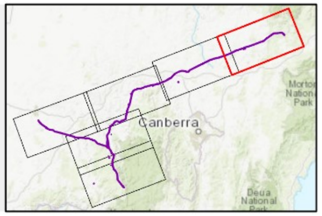
Figure 5-17c: Hydrologic Soil Groups (HSG) of NSW



Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation

Hydrologic Soil Group

A - High infiltration
B - Moderate infiltration
C - Slow infiltration
D - Very slow infiltration
Water
Not assessed



Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

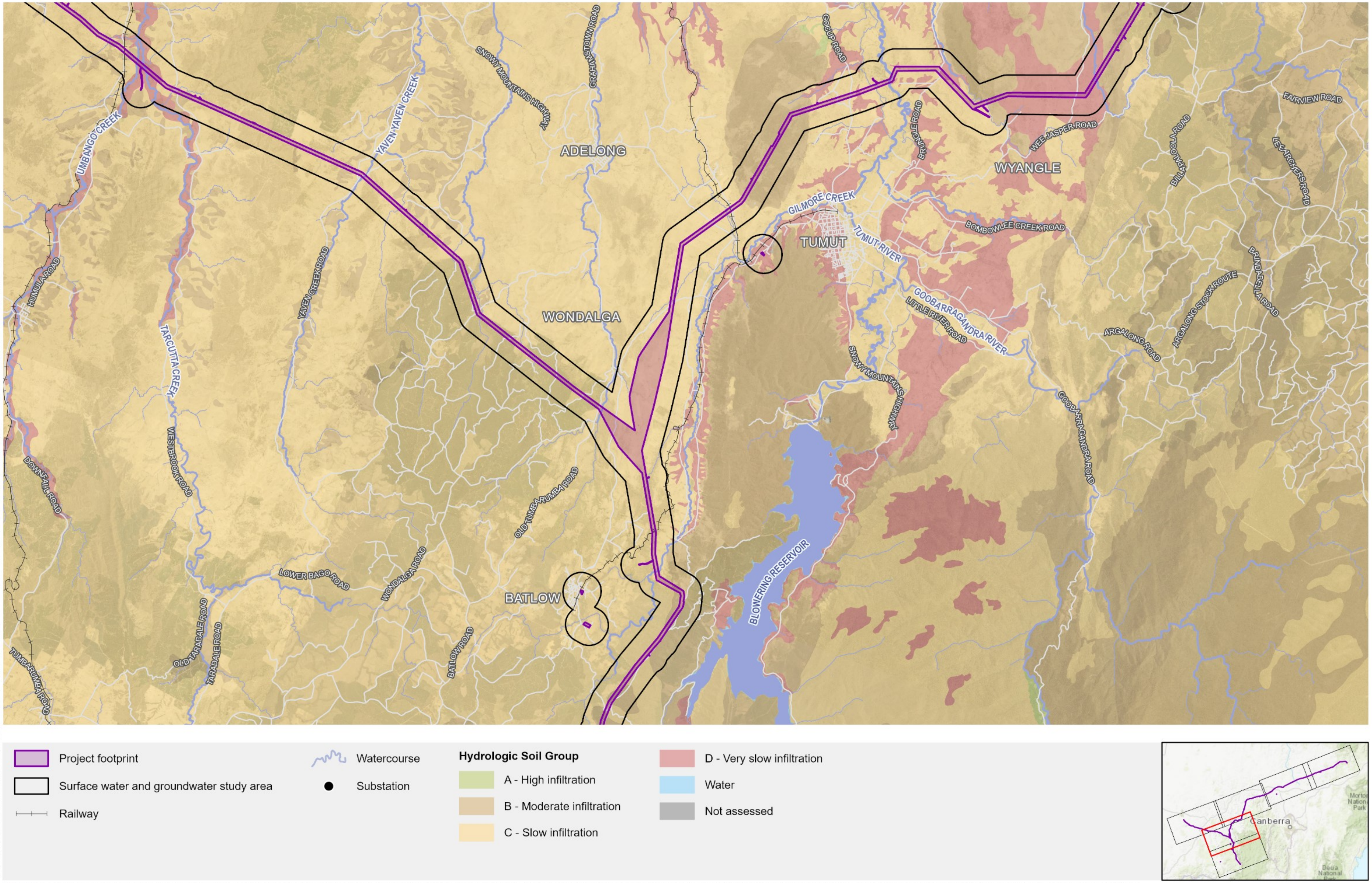
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-17d: Hydrologic Soil Groups (HSG) of NSW



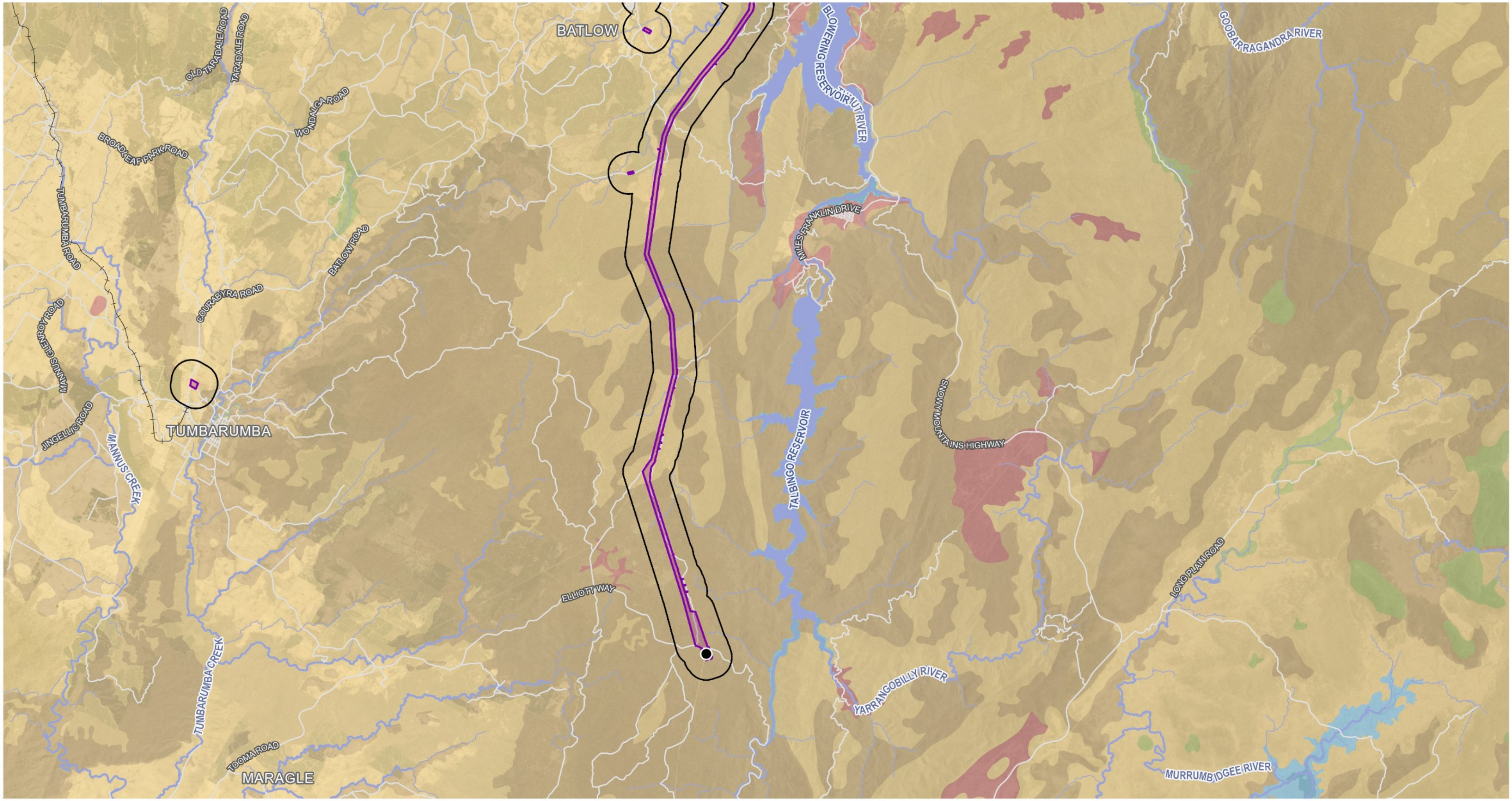
Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

1:200,000

0 4 8km

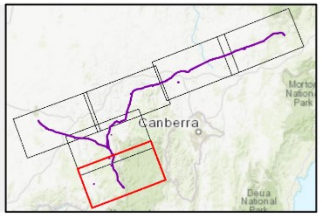
Projection: GDA 1994 MGA Zone 55

Figure 5-17e: Hydrologic Soil Groups (HSG) of NSW



Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation

Hydrologic Soil Group
A - High infiltration
B - Moderate infiltration
C - Slow infiltration
D - Very slow infiltration
Water
Not assessed



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Source: *Base data (aerial imagery, transport, water, and cadastral themes); NSW Foundation Spatial Data Framework; NSW 1500K Simplified Surface Geology: Department of Regional New South Wales; NSW Exploration and Mining Titles: Department of Planning, Industry and Environment; Transgrid; ESRI Topo*

1:200,000
0 4 8 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-17f: Hydrologic Soil Groups (HSG) of NSW

5.4.3 Modelled soil erosion

Soil erosion potential is calculated using the Revised Universal Soil Loss Equation (RUSLE), which is also used in designing sediment and erosion control measures in Managing Urban Stormwater: Soils and Construction (Landcom, 2004), the NSW guideline for sediment and erosion control. RUSLE estimates soil loss (t ha^{-1} yr^{-1}) from runoff using the following factors:

- Rainfall-runoff erosivity ® factor (MJ mm ha^{-1} hr^{-1} yr^{-1}) is estimated using a daily rainfall erosivity modelling for NSW and long-term rainfall records (Yang and Yu, 2015).
- Soil erodibility (K) factor (t hr MJ^{-1} mm^{-1}) is estimated from digital soil mapping products and soil profile data (Yang *et al.*, 2017).
- Slope length and steepness (LS, unitless) factor is calculated on catchment basis from hydrologically corrected digital elevation model (SRTM DEM-H) based on comprehensive algorithms considering cumulative overland flow length (Yang and Yu, 2015).

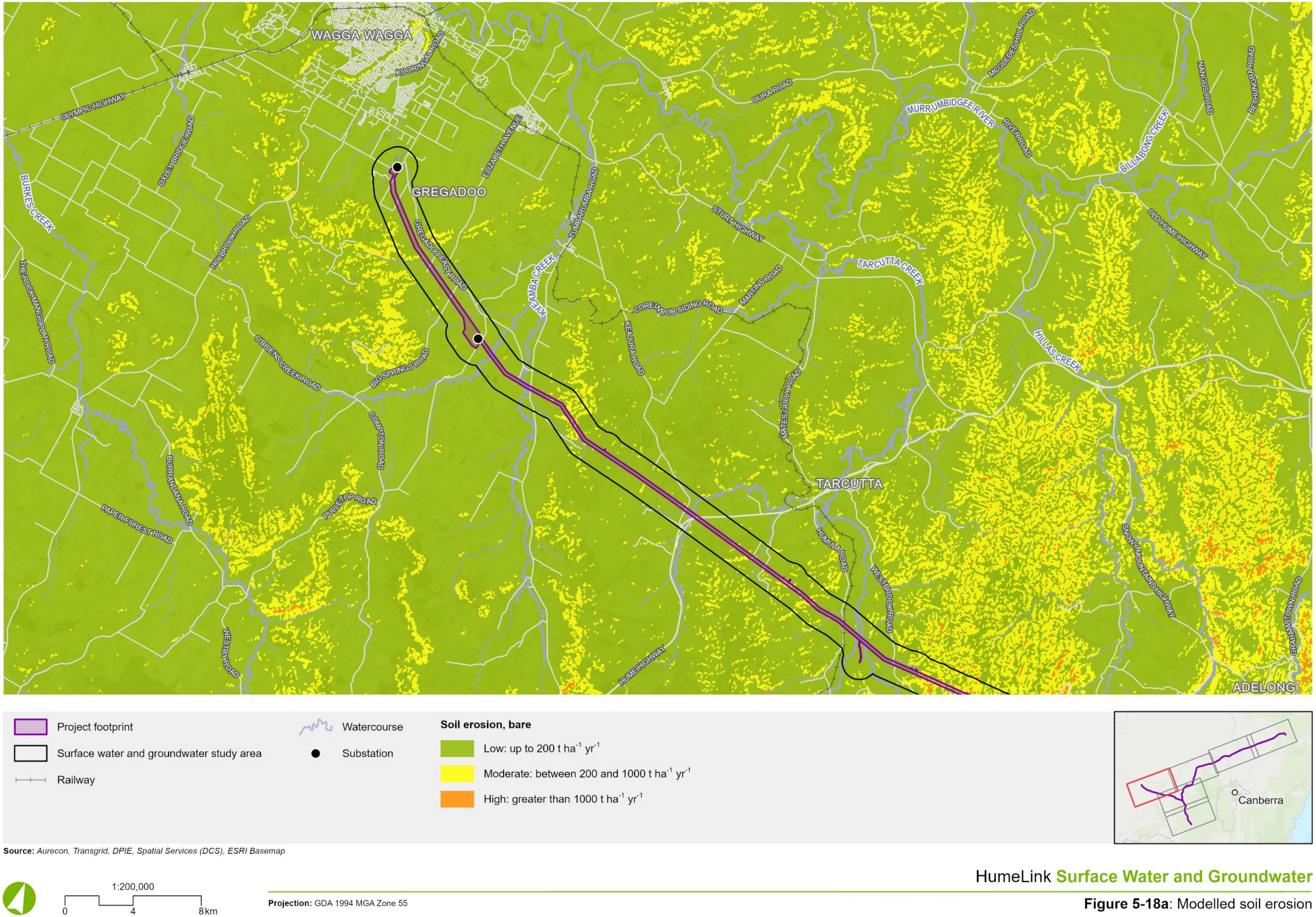
RUSLE has also factors relating to vegetation cover and its management, however for the purposes of this assessment it has been assumed that the ground is bare (ie vegetation has been cleared) – which is a conservative approach. Estimated potential soil loss in the project footprint is presented in Figure 5-18.

Erosion risk for the risk assessment has been categorised as the following:

- low: up to 200 t ha^{-1} yr^{-1}
- moderate: between 200 and 1000 t ha^{-1} yr^{-1}
- high: greater than 1000 t ha^{-1} yr^{-1}.

The project footprint from the Wagga 330 kV substation to the proposed Gugaa 500 kV substation and the proposed Gugaa 500 kV substation to Wondalga is generally situated within low erosion risk areas. However, the transmission line from Wondalga to the future Maragle 500 kV substation traverses through moderate to high erosion risk areas. The transmission line between Wondalga and the existing Bannaby 500 kV substation is located within areas that have low to high erosion risk.

These erosion risks are influenced primarily by the topography of the project footprint as presented in Figure 5-18 . While there are other factors that influence erosion risk, steepness is highly correlated with the erosion risk, eg the steeper land results in a higher erosion risk and flatter land results in lower erosion risks.



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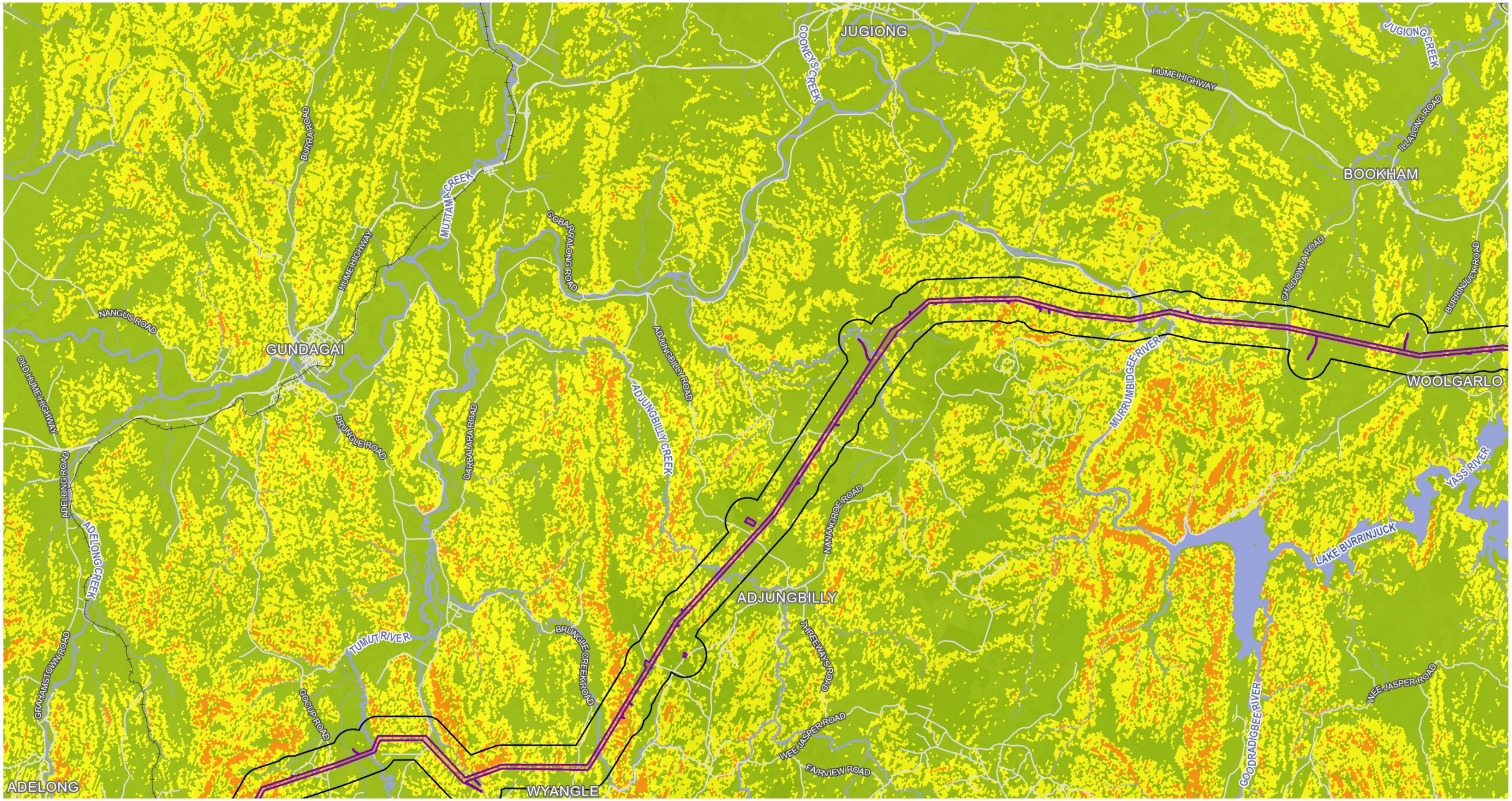
Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18a: Modelled soil erosion



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Project footprint

Surface water and groundwater study area

Railway

Watercourse

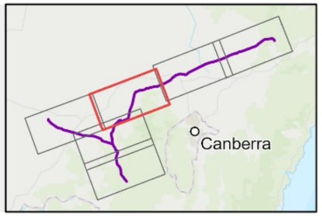
Substation

Soil erosion, bare

Low: up to 200 t ha^{-1} yr^{-1}

Moderate: between 200 and 1000 t ha^{-1} yr^{-1}

High: greater than 1000 t ha^{-1} yr^{-1}



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18b: Modelled soil erosion

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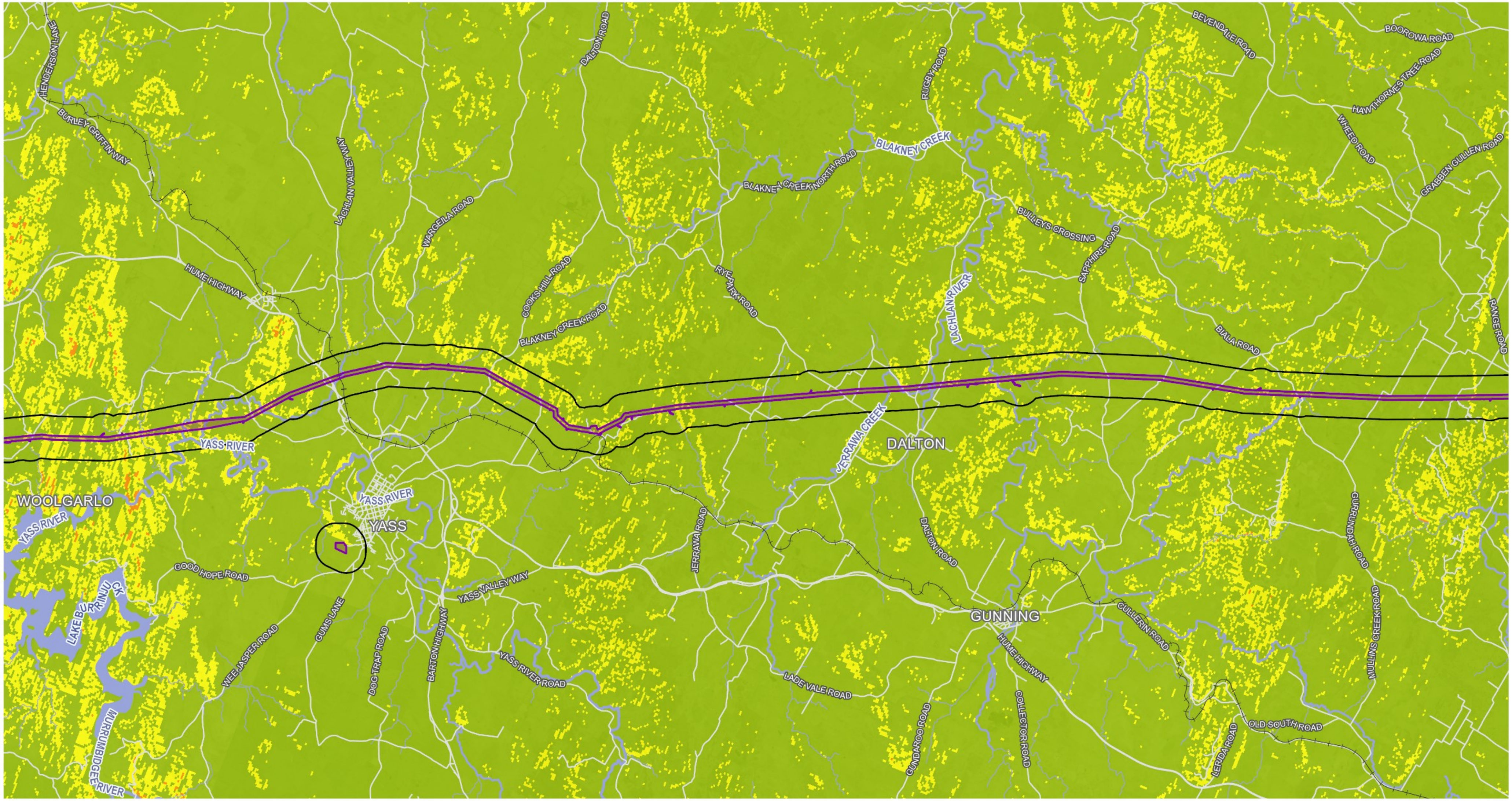


Project footprint

Surface water and groundwater study area

Railway

Watercourse

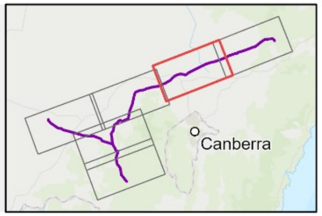
Substation

Soil erosion, bare

Low: up to 200 t ha^{-1} yr^{-1}

Moderate: between 200 and 1000 t ha^{-1} yr^{-1}

High: greater than 1000 t ha^{-1} yr^{-1}



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

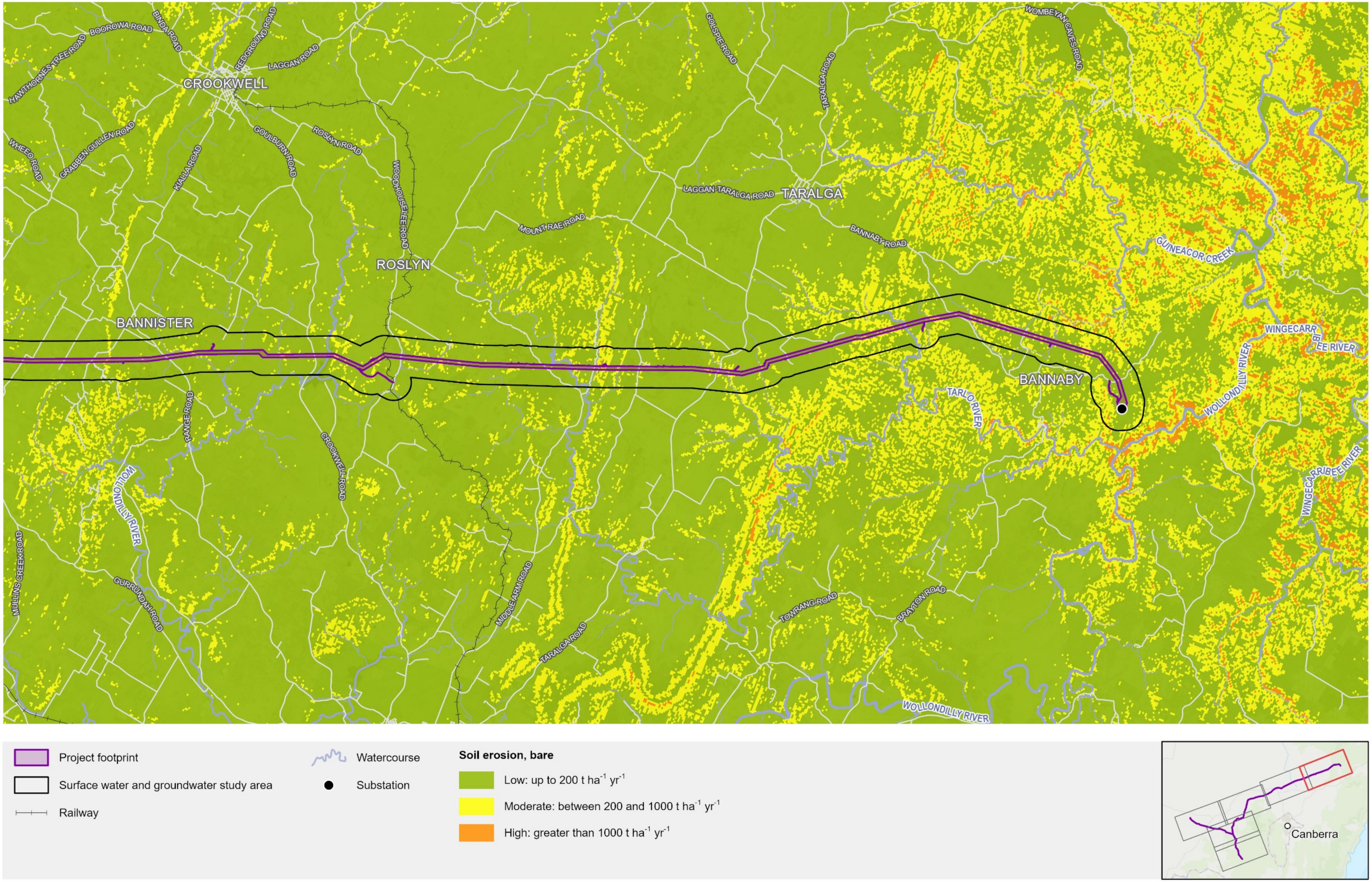
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18c: Modelled soil erosion

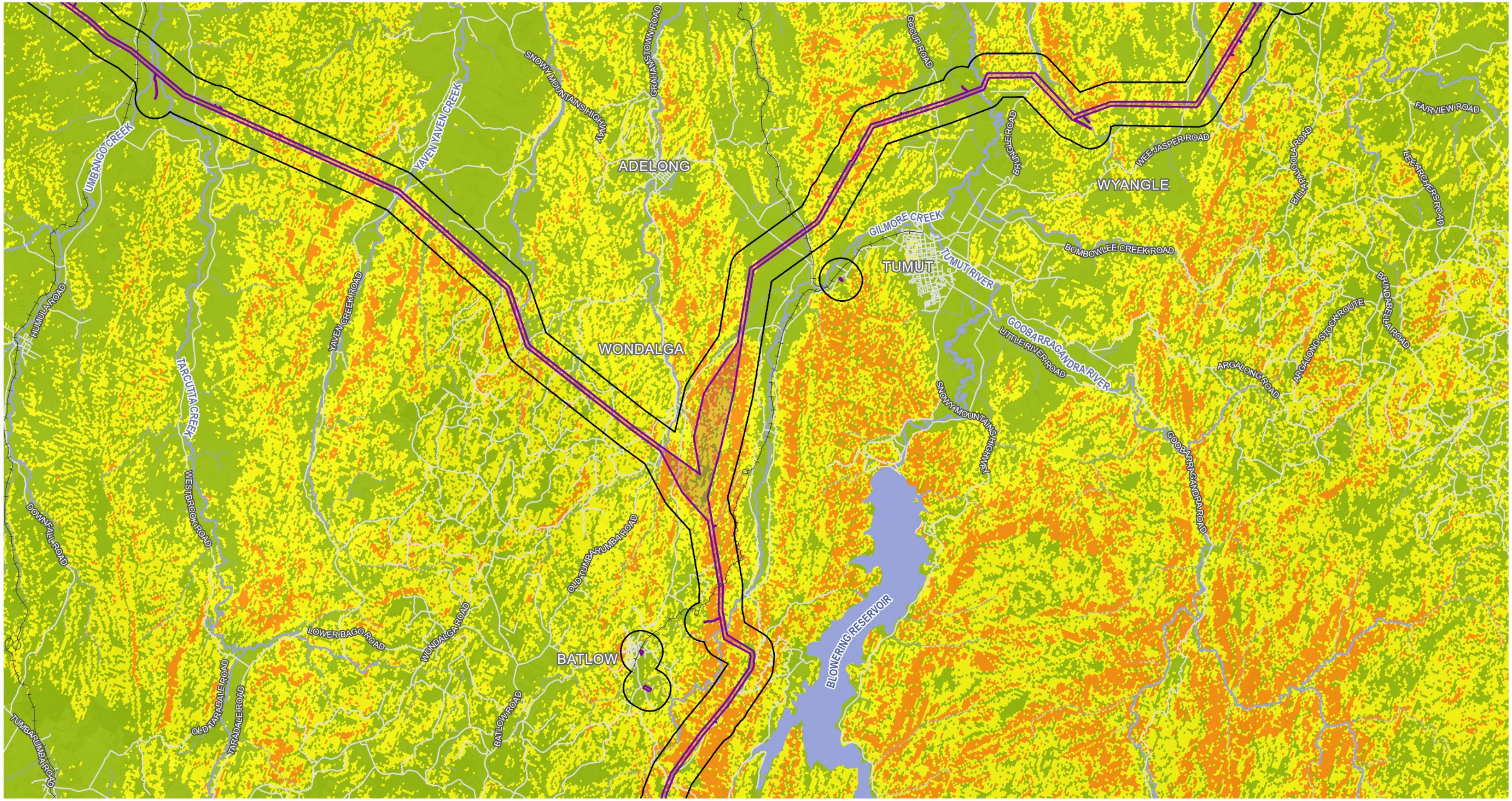


Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18d: Modelled soil erosion



Project footprint

Surface water and groundwater study area

Railway

Watercourse

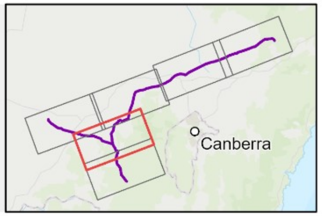
Substation

Soil erosion, bare

Low: up to 200 t ha^{-1} yr^{-1}

Moderate: between 200 and 1000 t ha^{-1} yr^{-1}

High: greater than 1000 t ha^{-1} yr^{-1}



Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

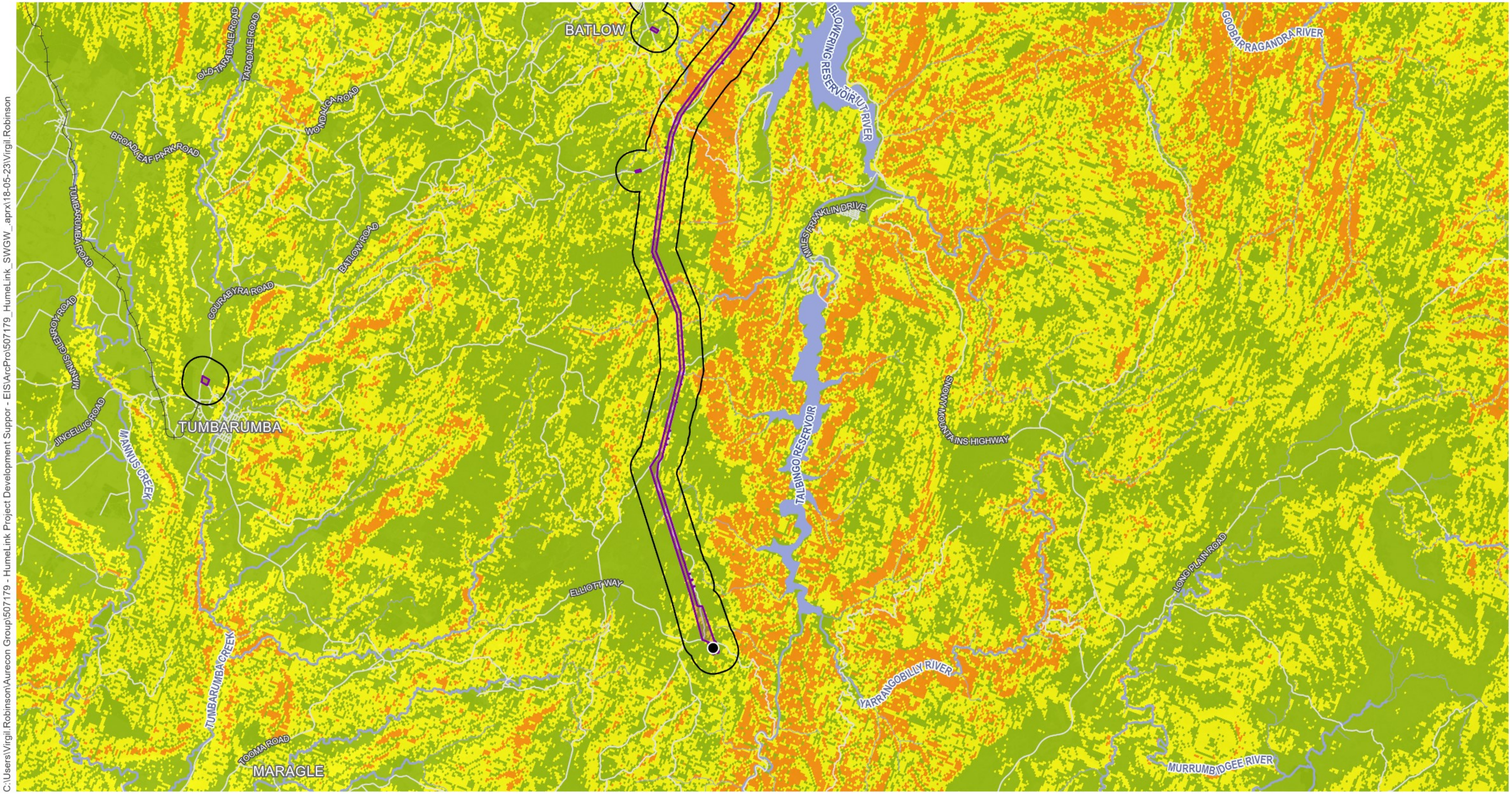
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18e: Modelled soil erosion



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

Soil erosion, bare

Low: up to 200 t ha^{-1} yr^{-1}

Moderate: between 200 and 1000 t ha^{-1} yr^{-1}

High: greater than 1000 t ha^{-1} yr^{-1}

Source: *Aurecon, Transgrid, DPIE, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-18f: Modelled soil erosion

5.4.4 Geology

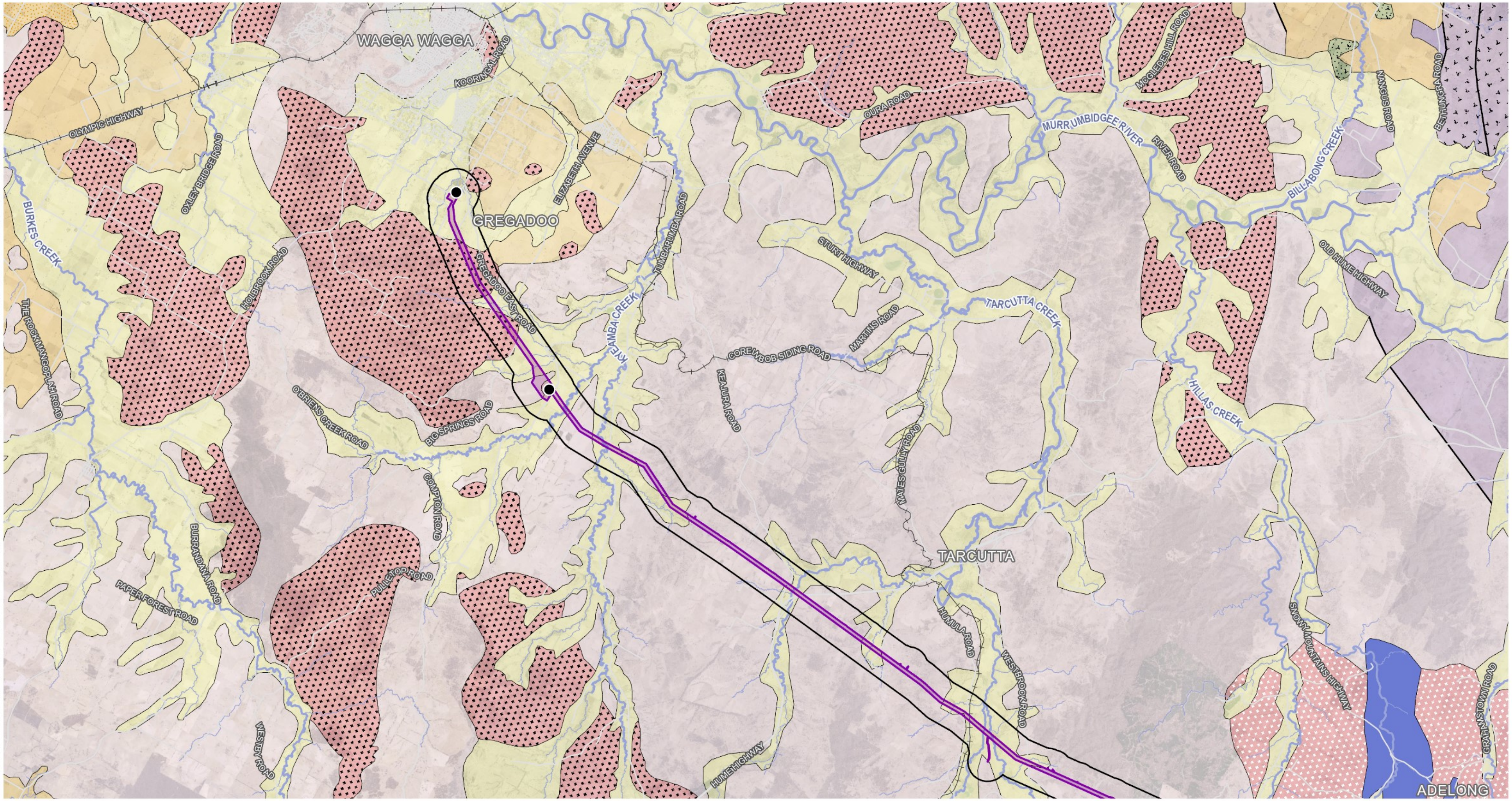
A detailed discussion of the geology across the project footprint has been presented in *Technical Report 10 – Phase 1 Contamination Assessment*. The surface outcrops of geological units within the project footprint have been determined from a review of the NSW Seamless Geology dataset. The surface water groundwater study area extends through and across highly variable landscapes and geological history given the scale of the project (refer to Table 5-14).

Of the 97 formations underlying the surface water and groundwater study area, Quaternary aged alluvial deposits make up the largest proportion at 7.6 per cent, with other Silurian, Ordovician, and Devonian aged formations making up the larger proportions. There are 83 formations that underlie the surface water and groundwater study area, each with a proportion less than two per cent.

An extract of the seamless geology map (Department of Regional New South Wales, 2021) across the surface water and groundwater study area is presented in Figure 5-19.

Table 5-14 Dominant regional surface geology within the surface water and groundwater study area

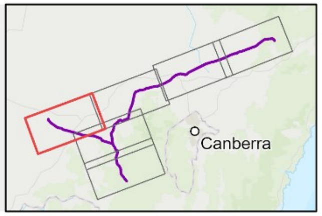
NSW Seamless Geology Description	Geological history	Area (ha)	Proportion (%)
Quaternary alluvial deposits	0 to 2 million years old	7,081	7.6
Silurian S-type volcanics rocks	419 to 443 million years old	6,159	6.6
Silurian IS transitional-type granite	419 to 443 million years old	6,114	6.6
Silurian sedimentary rocks	419 to 443 million years old	5,910	6.4
Silurian IS transitional-type granite	419 to 443 million years old	5,563	6.0
Ordovician sedimentary rocks	443 to 491 million years old	4,453	4.8
Ordovician sedimentary rocks	443 to 491 million years old	3,853	4.2
Silurian I-type granites	419 to 443 million years old	3,656	3.9
Silurian S-type volcanics rocks	419 to 443 million years old	3,349	3.6
Ordovician sedimentary rocks	443 to 491 million years old	2,644	2.9
Silurian sedimentary rocks	419 to 443 million years old	2,537	2.7
Ordovician sedimentary rocks	443 to 491 million years old	2,480	2.7
Devonian I-type volcanic rocks	359 to 419 million years old	2,005	2.2
Ordovician sedimentary rocks	443 to 491 million years old	1,877	2.0
Others	-	35,058	37.8



- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation

NSW Simplified Surface Geology (1:1500k)

- Fault
- Geological boundary
- Igneous felsic intrusive (I-type)
- Igneous felsic intrusive (S-type)
- Igneous mafic volcanic (Ordovician)
- Regolith
- Igneous silicic to intermediate volcanic (S-type)
- Sedimentary & volcanic
- Quaternary alluvial deposits
- Ordovician sedimentary rocks
- Silurian sedimentary and volcanic rocks
- Silurian-Devonian sedimentary and volcanic rocks
- Ordovician sedimentary and volcanic rocks
- Quaternary colluvial deposits
- Cenozoic undifferentiated sediments/sedimentary rocks
- Silurian silicic to intermediate intrusives



Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-19a: Seamless geology

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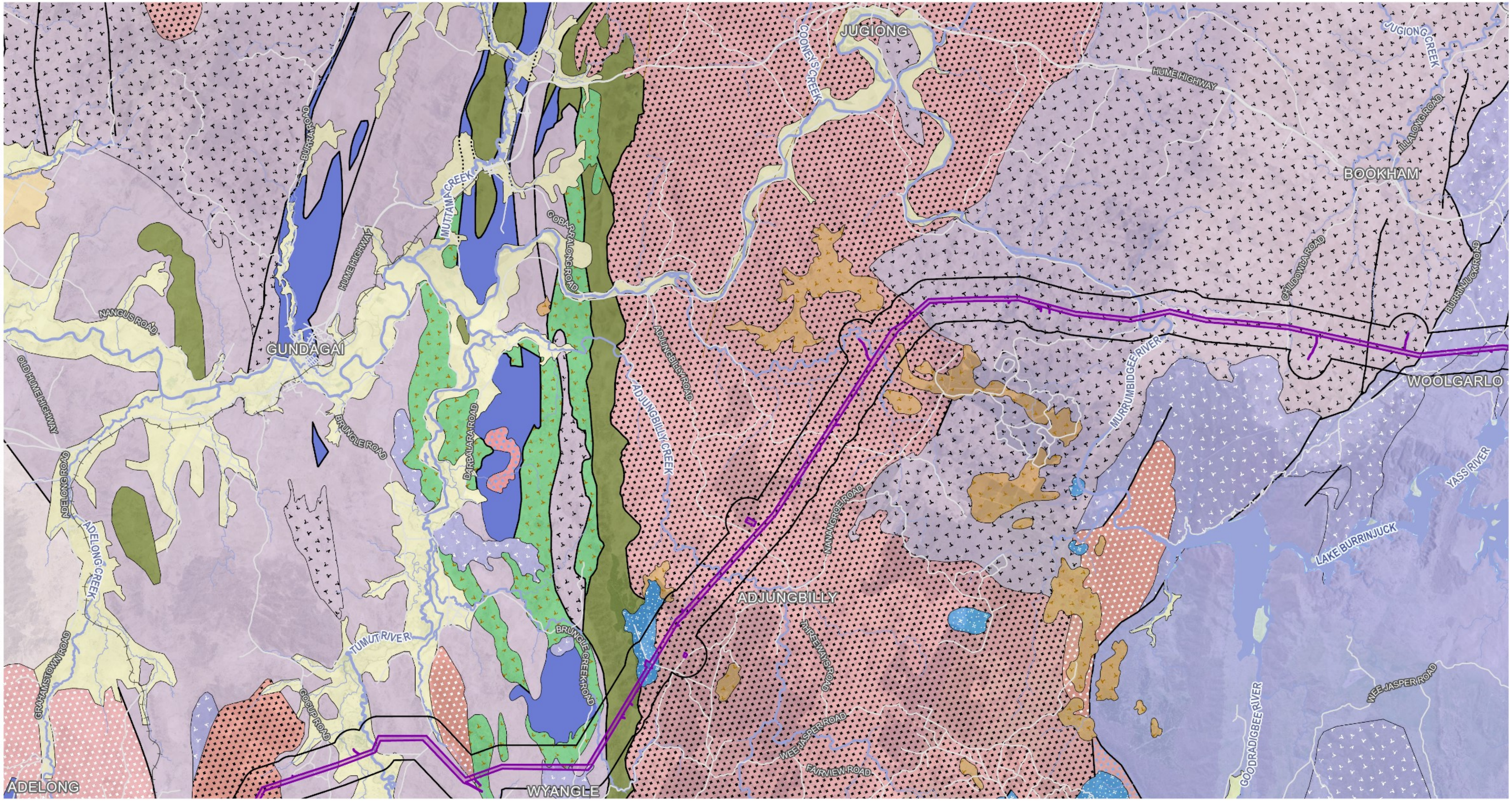
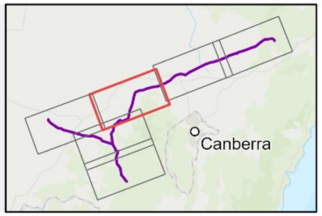


- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation

NSW Simplified Surface Geology (1:1500k)

- Dyke or vein
- Fault
- Fault, concealed
- Geological boundary
- Shear zone
- Shear zone - concealed
- Water feature
- Igneous felsic intrusive (I-type)
- Igneous felsic intrusive (S-type)
- Igneous felsic intrusive (undifferentiated)
- Igneous mafic volcanic
- Igneous mafic volcanic (Ordovician)
- Igneous mafic intrusive
- Igneous silicic to intermediate volcanic (I-type)
- Igneous silicic to intermediate volcanic (S-type)
- Quaternary alluvial deposits
- Silurian mafic volcanic rocks
- Ordovician mafic intrusives
- Devonian sedimentary and volcanic rocks
- Ordovician sedimentary rocks
- Silurian sedimentary and volcanic rocks
- Silurian-Devonian sedimentary and volcanic rocks
- Cenozoic mafic volcanic rocks
- Ordovician sedimentary and volcanic rocks
- Palaeozoic ultramafic rocks and serpentinized ultramafic rocks
- Cenozoic undifferentiated sediments/sedimentary rocks
- Devonian silicic to intermediate intrusives
- Silurian silicic to intermediate intrusives
- Carboniferous to Ordovician silicic to intermediate intrusives
- Water



Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

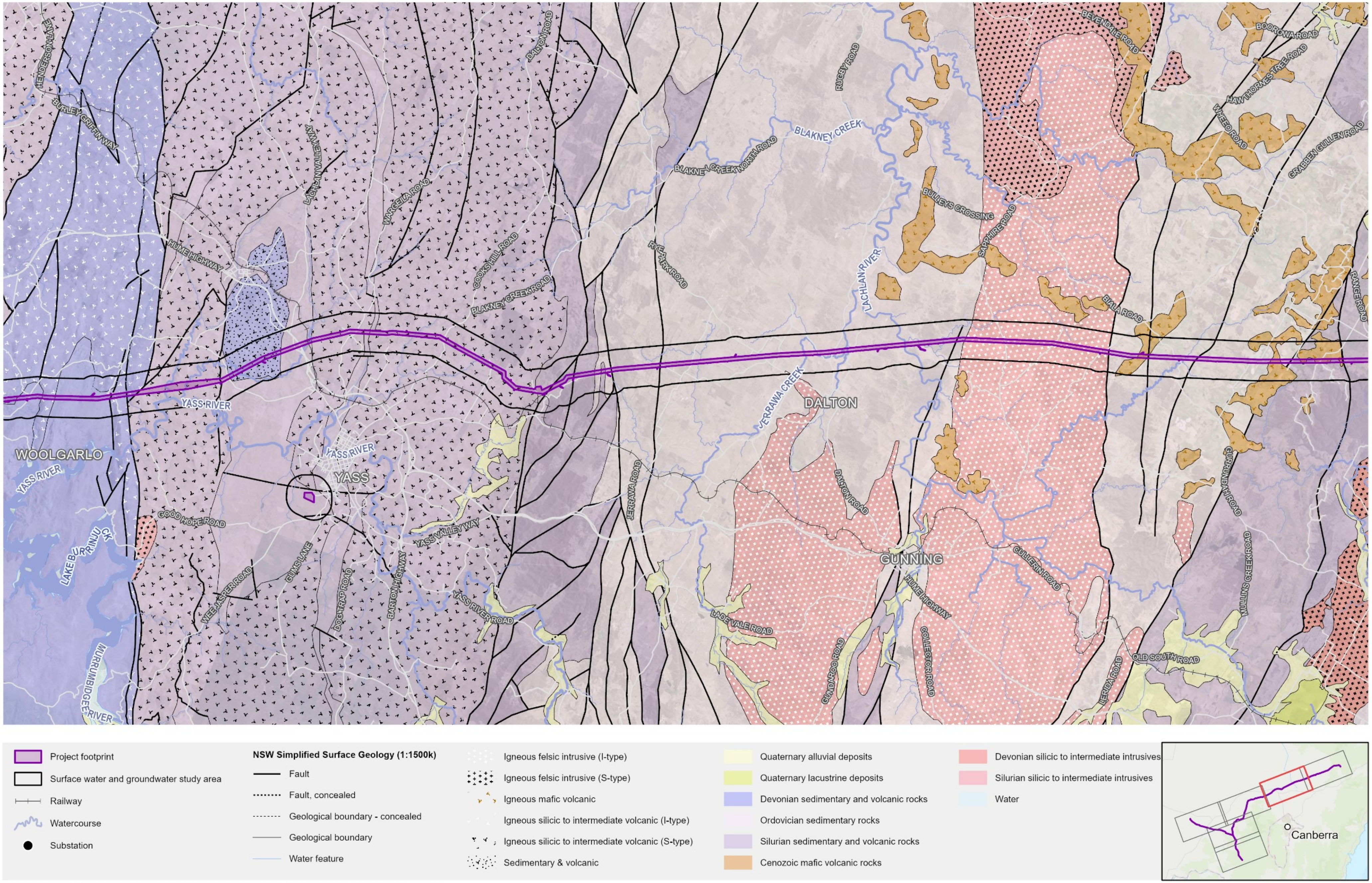
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-19b: Seamless geology



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Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

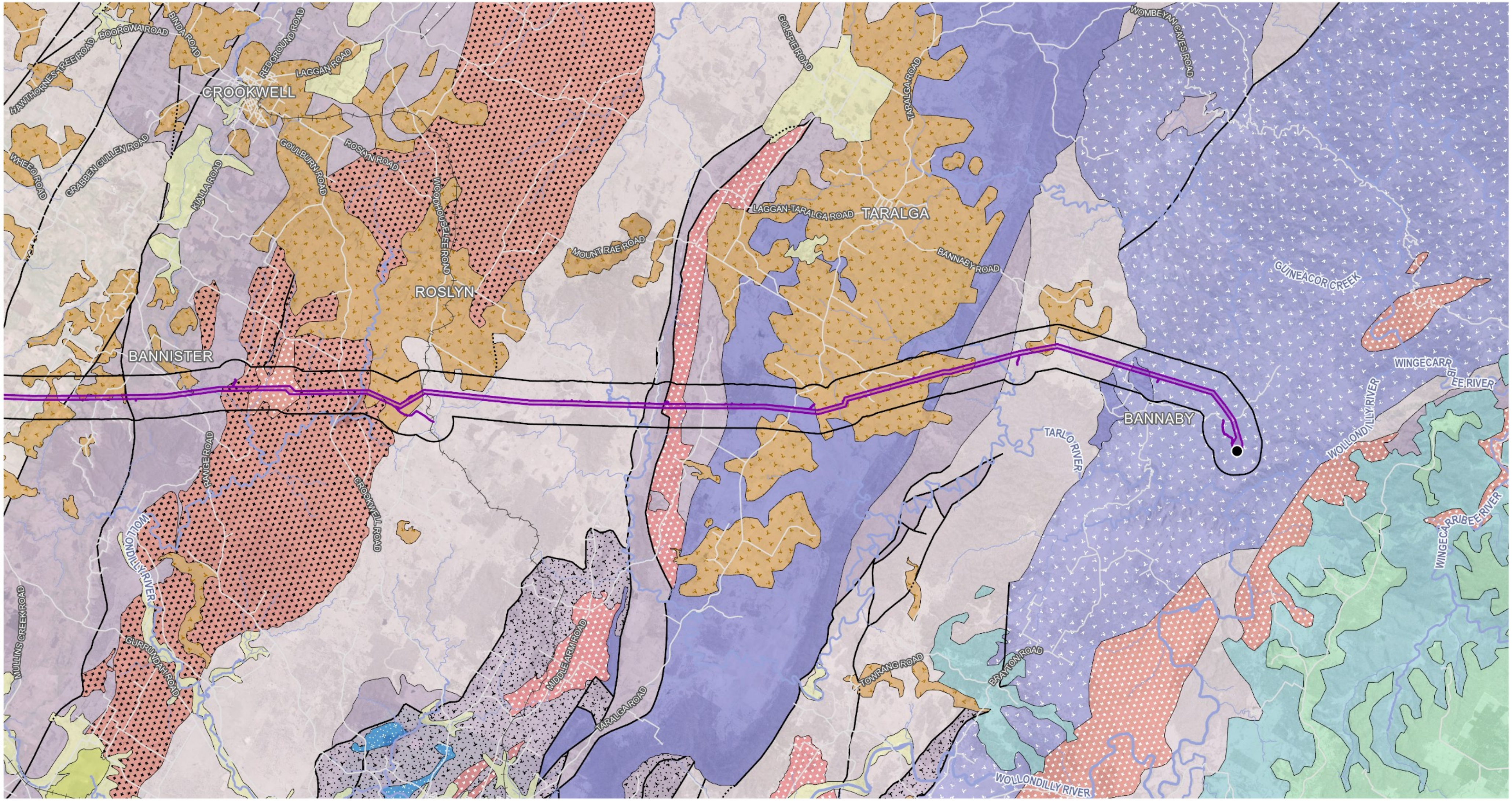
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

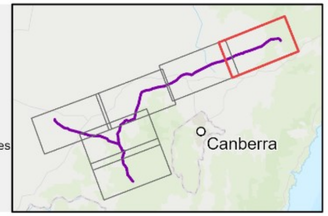
Figure 5-19c: Seamless geology



Project footprint
Surface water and groundwater study area
Railway
Watercourse
Substation

NSW Simplified Surface Geology (1:1500k)

Fault
Fault, concealed
Geological boundary - concealed
Geological boundary
Igneous felsic intrusive (I-type)
Igneous felsic intrusive (S-type)
Igneous mafic volcanic
Igneous mafic intrusive
Igneous silicic to intermediate volcanic (I-type)
Sedimentary & volcanic
Quaternary alluvial deposits
Quaternary lacustrine deposits
Triassic sedimentary rocks
Permian sedimentary rocks
Ordovician mafic intrusives
Devonian sedimentary and volcanic rocks
Late Devonian sedimentary rocks
Ordovician sedimentary rocks
Silurian sedimentary and volcanic rocks
Cenozoic mafic volcanic rocks
Devonian silicic to intermediate intrusives
Carboniferous to Ordovician silicic to intermediate intrusives



Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

1:200,000
0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-19d: Seamless geology

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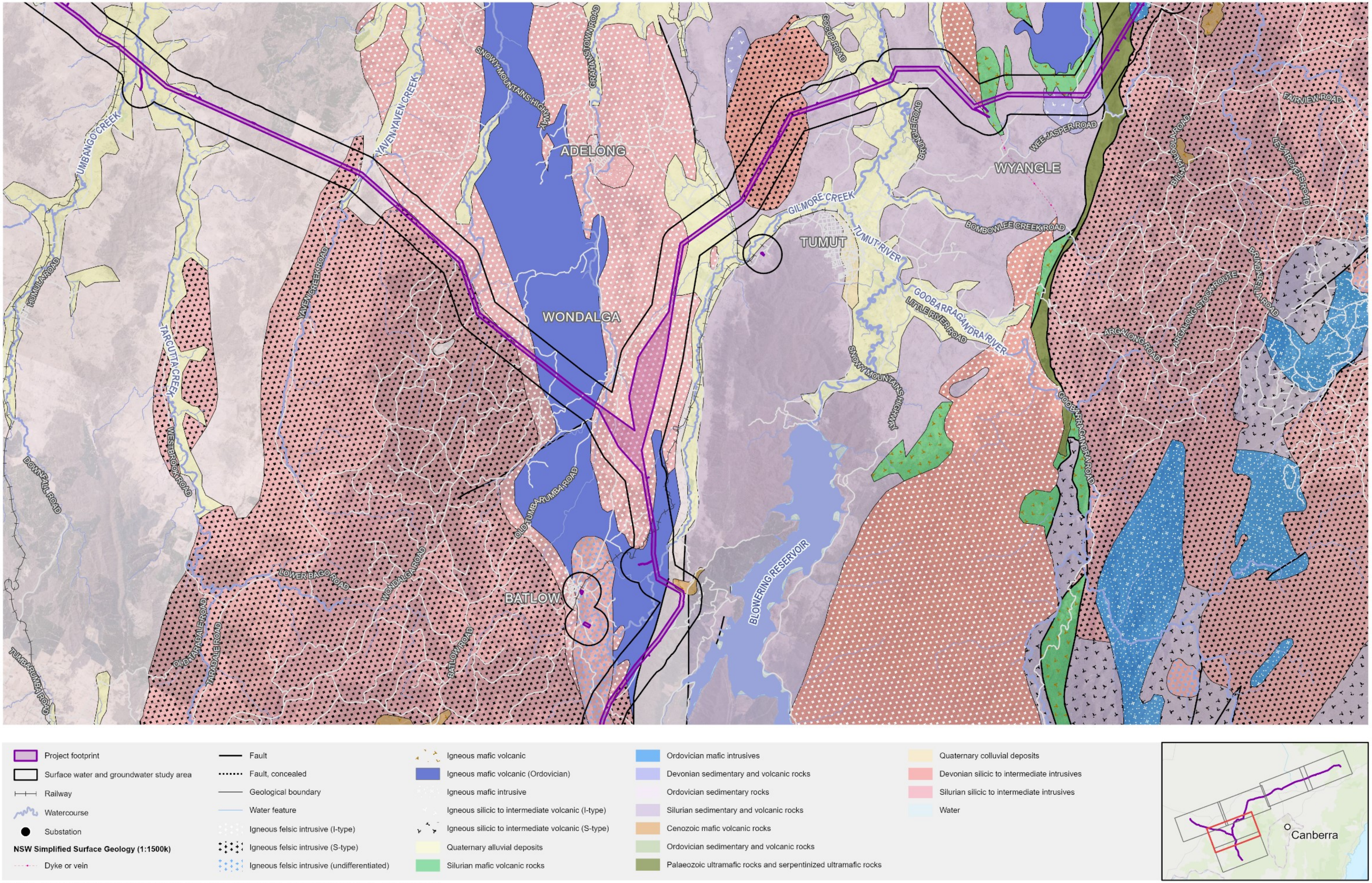

Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-19e: Seamless geology

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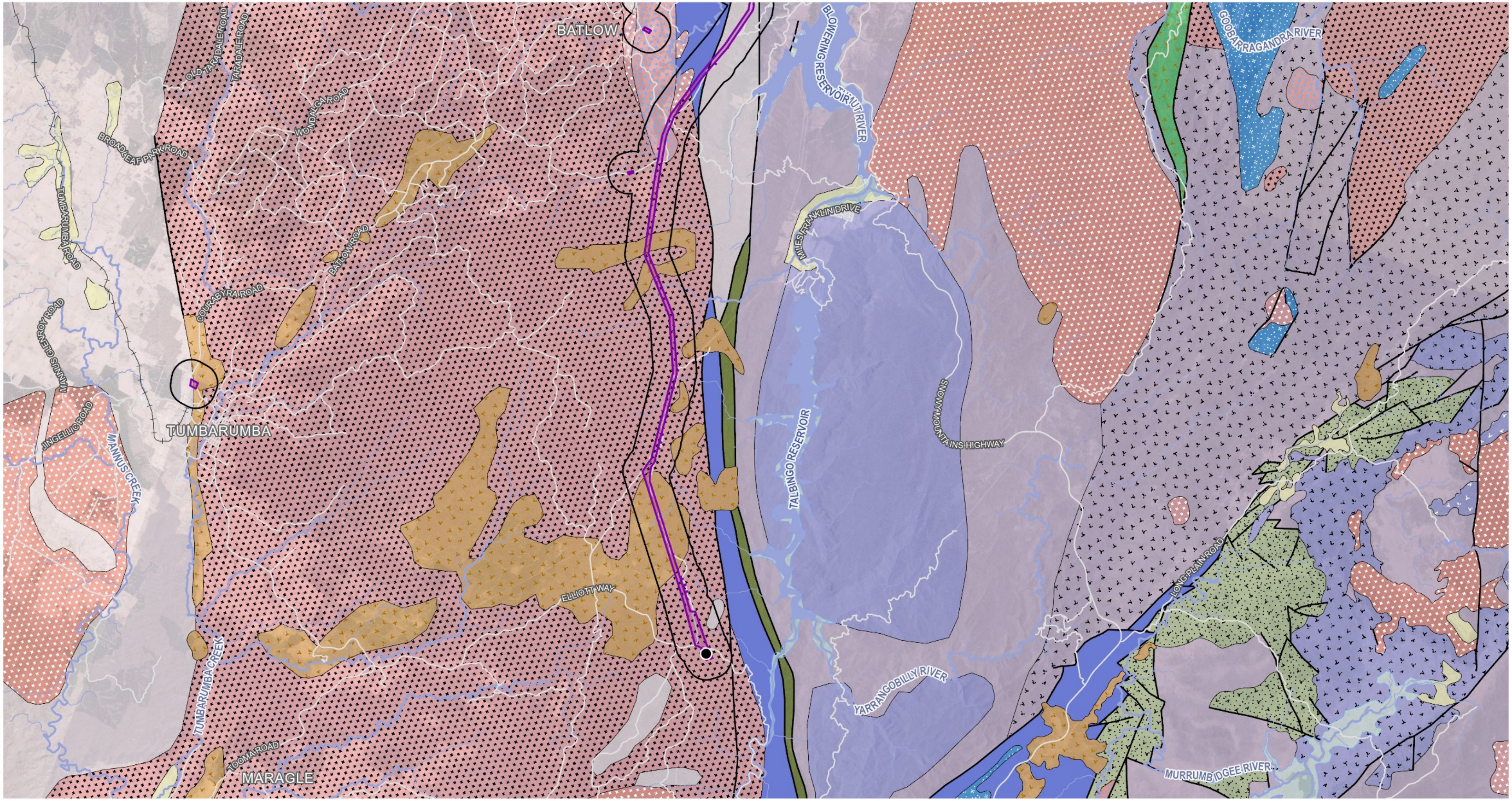

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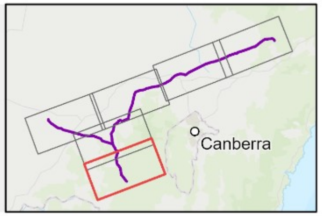
- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation
- **NSW Simplified Surface Geology (1:1500k)**
- Dyke or vein
- Fault
- Fault, concealed
- Geological boundary
- Water feature
- Igneous felsic intrusive (I-type)
- Igneous felsic intrusive (S-type)
- Igneous felsic intrusive (undifferentiated)
- Igneous mafic volcanic
- Igneous mafic volcanic (Ordovician)
- Igneous mafic intrusive
- Igneous silicic to intermediate volcanic (I-type)
- Igneous silicic to intermediate volcanic (S-type)
- Sedimentary & volcanic
- Quaternary alluvial deposits
- Silurian mafic volcanic rocks
- Ordovician mafic intrusives
- Devonian sedimentary and volcanic rocks
- Ordovician sedimentary rocks
- Silurian sedimentary and volcanic rocks
- Cenozoic mafic volcanic rocks
- Ordovician sedimentary and volcanic rocks
- Palaeozoic ultramafic rocks and serpentinized ultramafic rocks
- Devonian silicic to intermediate intrusives
- Silurian silicic to intermediate intrusives
- Water



Source: *Aurecon, Transgrid, Department of Regional New South Wales, Spatial Services (DCS), ESRI Basemap*

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0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-19f: Seamless geology

5.5 Hydrogeology

5.5.1 Groundwater sources

The project footprint intercepts the WRPs and WSPs listed in Table 5-15. They include bore counts within the surface water and groundwater study area. The WRPs are not in force at the time of this investigation, however their documentation provides valuable insight to groundwater occurrence, usage and regulation across the project footprint.

Table 5-15 Groundwater sources

Groundwater source	Name of plan	Bore count
Kyeamba Alluvial Groundwater Source	Water Sharing Plan for the Murrumbidgee Alluvial Groundwater Sources Order 2020	2
Gundagai Alluvial Groundwater Source	Water Sharing Plan for the Murrumbidgee Alluvial Groundwater Sources Order 2020	3
Mid Murrumbidgee Alluvium (GS31)	Murrumbidgee Alluvium Water Resource Plan (submitted April 2020 but withdrawn August 2021 and was resubmitted September 2022)	N/A
Lachlan Fold Belt MDB Groundwater Source	Water Sharing Plan for the NSW Murray–Darling Basin Fractured Rock Groundwater Sources Order 2020	159
Yass Catchment Fractured Rock Groundwater Sources	Water Sharing Plan for the Murray Alluvial Groundwater Sources Order 2020	26
Lachlan Fold Belt (GS20)	NSW Murray–Darling Basin Fractured Rock Water Resource Plan (submitted April 2020 but withdrawn September 2021 and resubmitted June 2022)	N/A
Goulburn Fractured Rock Groundwater Source	Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011	16

Note: N/A refers to WRPs not in force at the time of writing, therefore bore count analysis for some plans could not be undertaken.

5.5.2 Hydrostratigraphy

This section describes the hydrostratigraphic units (HSUs) which underlie the surface water and groundwater study area. HSUs are defined as geological material of similar hydrogeological properties. HSUs are generally based on stratigraphic units, although units of similar groundwater storage and transmissive properties are often classified together as a single HSU.

For the surface water and groundwater study area, HSUs are delineated as per groundwater sources listed within the WSPs (refer to Table 5-15) as this provides a consistent classification approach for the groundwater impact assessment. Details on the HSUs, taken from the groundwater resource descriptions within the surface water and groundwater study area are provided in Table 5-16.

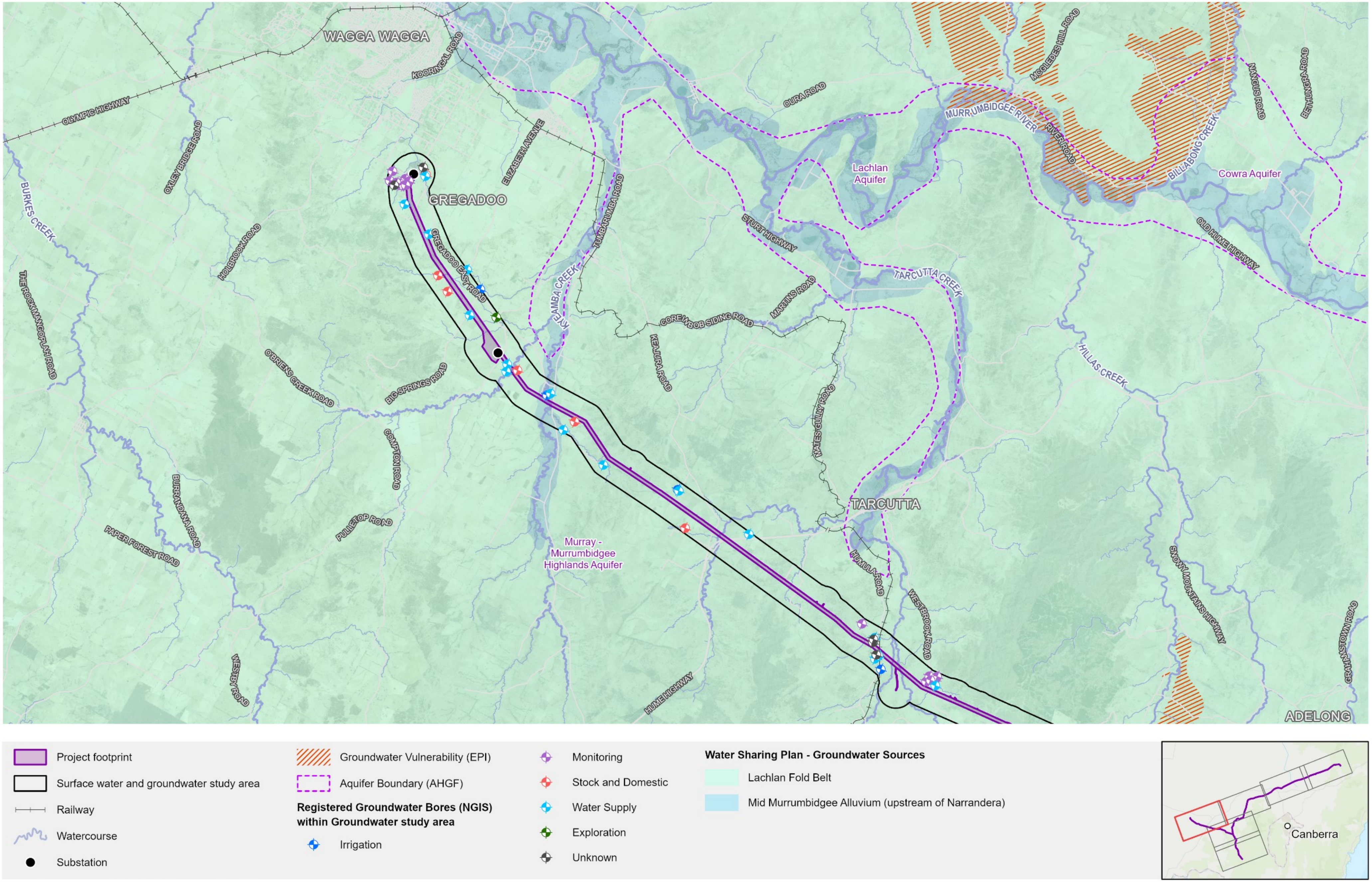
The depths expressed in Table 5-16, represent how deep below ground level the HSU is and do not represent water levels of the HSU.

For the purpose of this assessment, the depth distinction between the shallow and deep aquifers of the corresponding HSUs have been simplified to:

- Murrumbidgee Alluvium (NSW Government, 2020)
  - Shallow: includes all water bearing zones up to 40 metres below ground level
  - Deep: includes all water bearing zones deeper than 40 metres below ground level
- Lachlan Fold Belt MDB including the Yass Catchment (NSW Government, 2021)
  - Shallow: includes all water bearing zones up to 30 metres below ground level
  - Deep: includes all water bearing zones deeper than 30 metres below ground level
- Goulburn Fractured Rock (NSW Government, 2015)
  - Both shallow and deep fractured rock systems are heterogenous systems with water levels dependent on the fracture depth, location and spatial orientation of the fracture, which mean they are too complex to simplify.

Table 5-16 Hydrostratigraphic units within the surface water and groundwater study area and their thickness, depths, and characteristics

HSU	Aquifer	Estimated thickness (m)	Encountered depth (mBGL)	Corresponding MDB geology	Characteristics
Murrumbidgee Alluvium	Shallow	40	0 - 40	Cowra formation	▪ Cenozoic alluvial deposits that occur within creeks and rivers and have been derived largely from weathering of the Palaeozoic bedrock. ▪ Yields from the shallow and the deep aquifer systems have in general been reported as high as 40 and 150 L/s respectively. ▪ Recharge to the Mid Murrumbidgee Alluvium occurs through leakage from the Murrumbidgee River and its various tributaries and anabranches, and infiltration from rainfall and irrigation activity. ▪ Yields from the shallow and deep aquifer systems have in general been reported as high as 40 and 150 L/s respect ▪ Recharge may also occur as discharge from the underlying bedrock ▪ In some areas in the vicinity of Wagga Wagga, and particularly further upstream, the shallowest alluvial aquifer is in direct hydraulic connection with the rivers, allowing direct recharge from the river into the aquifer system. It is the main discharge where there is little or no groundwater extractions.
	Deep	50	40-90	Lachlan formation	
Lachlan Fold Belt	Shallow	0-30	Varies	Pre-Cainozoic Basement and associated overlying sediments	▪ Unconfined to confined aquifer depending on location and overlying geology. ▪ Yields within the Yass catchment groundwater source are generally low supplying less than 3 L/s ▪ Groundwater is stored and moves through fractures, joints, bedding plains, faults and cavities within the rock mass or weathered zone (for the shallow aquifer). ▪ Groundwater flow is generally controlled by topography but would be influenced by localised fracture systems and regional geological structures. ▪ Hydraulic connectivity between surface water features, other overlying aquifers and between the shallow and deep fractured rock aquifers is limited to the degree of fracturing extending between the aquifers or the bed of the surface water features. ▪ The fractured rock aquifers are considered to generally contain low hydraulic connection with overlying aquifers and surface water features throughout the groundwater study area.
	Deep	100+	Varies	Pre-Cainozoic Basement	
Goulburn Fractured Rock	ND	ND	ND	ND	▪ Rock types are a mixture of Palaeozoic rocks which are mainly volcanic in origin. ▪ Most of the groundwater found within these rocks is suitable for some domestic, agricultural and limited industrial uses. ▪ Although groundwater may be in supply, the water quality may limit potential uses.



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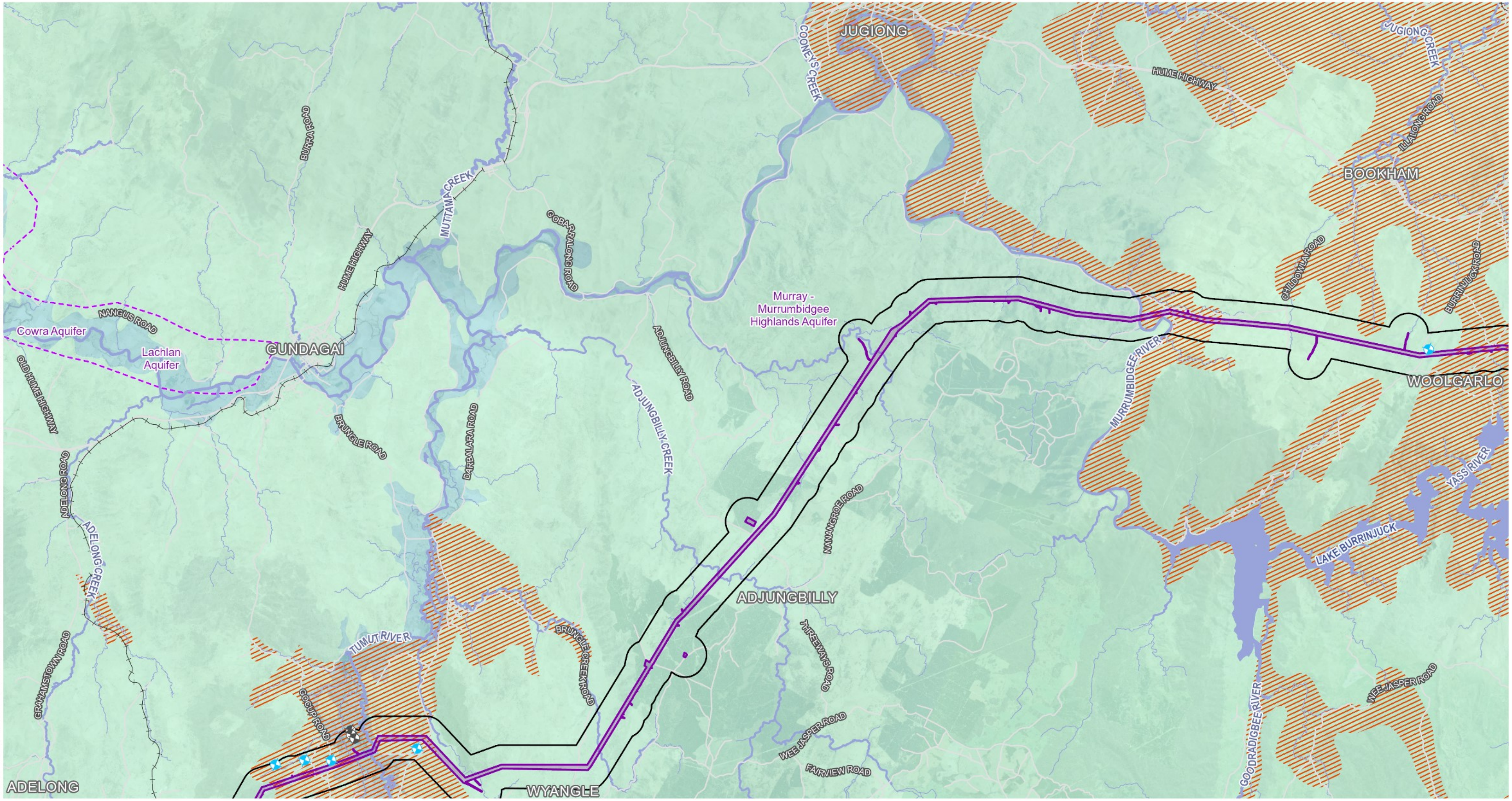
Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20a: Water Sharing Plan - Groundwater Sources



Project footprint

Surface water and groundwater study area

Railway

Watercourse

Substation

Groundwater Vulnerability (EPI)

Aquifer Boundary (AHGF)

Registered Groundwater Bores (NGIS) within Groundwater study area

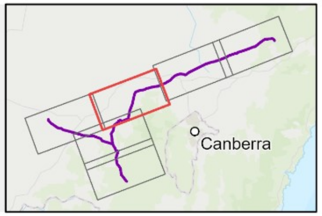
Water Supply

Unknown

Water Sharing Plan - Groundwater Sources

Lachlan Fold Belt

Mid Murrumbidgee Alluvium (upstream of Narrandera)



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

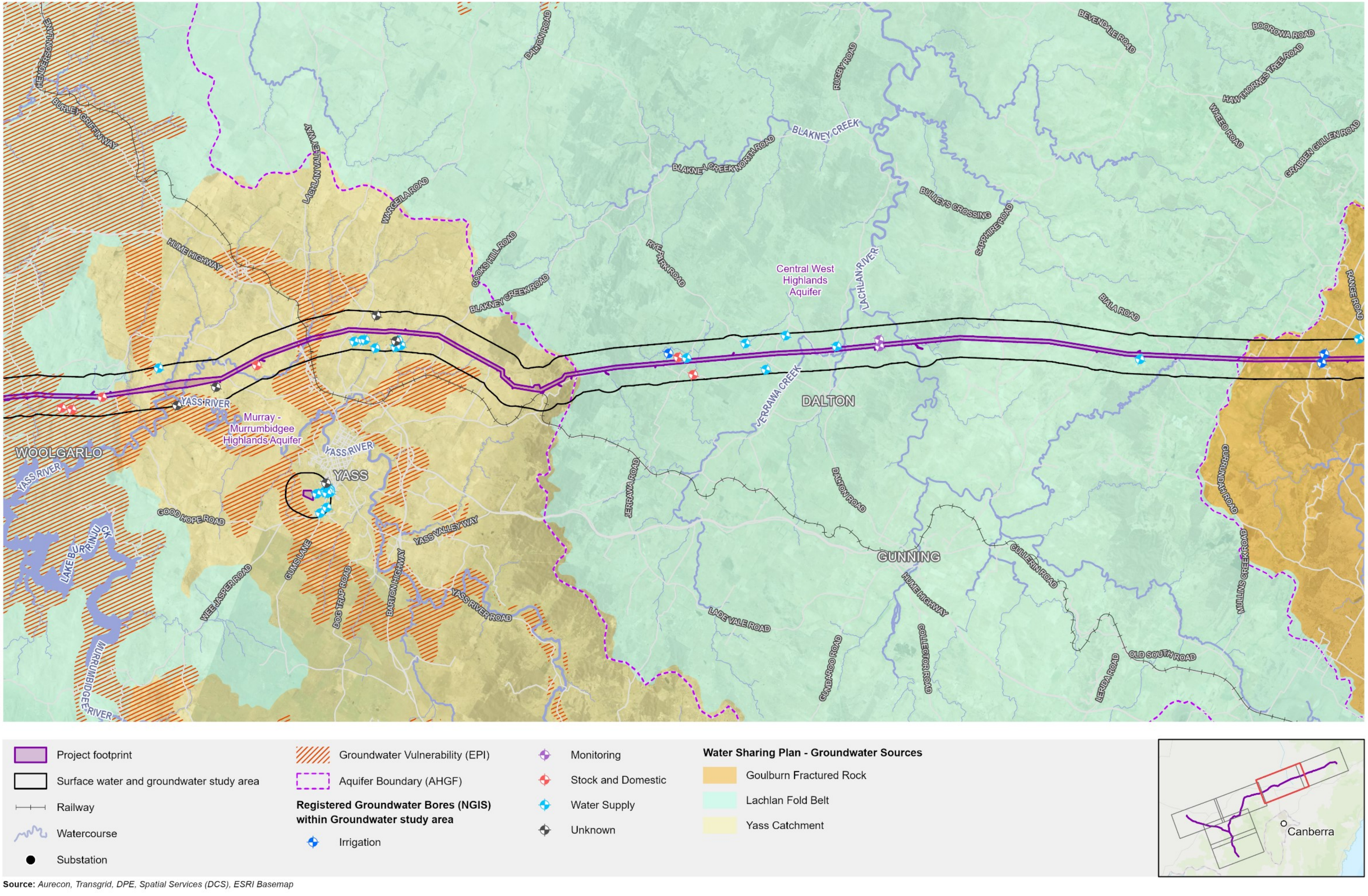
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20b: Water Sharing Plan - Groundwater Sources



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20c: Water Sharing Plan - Groundwater Sources

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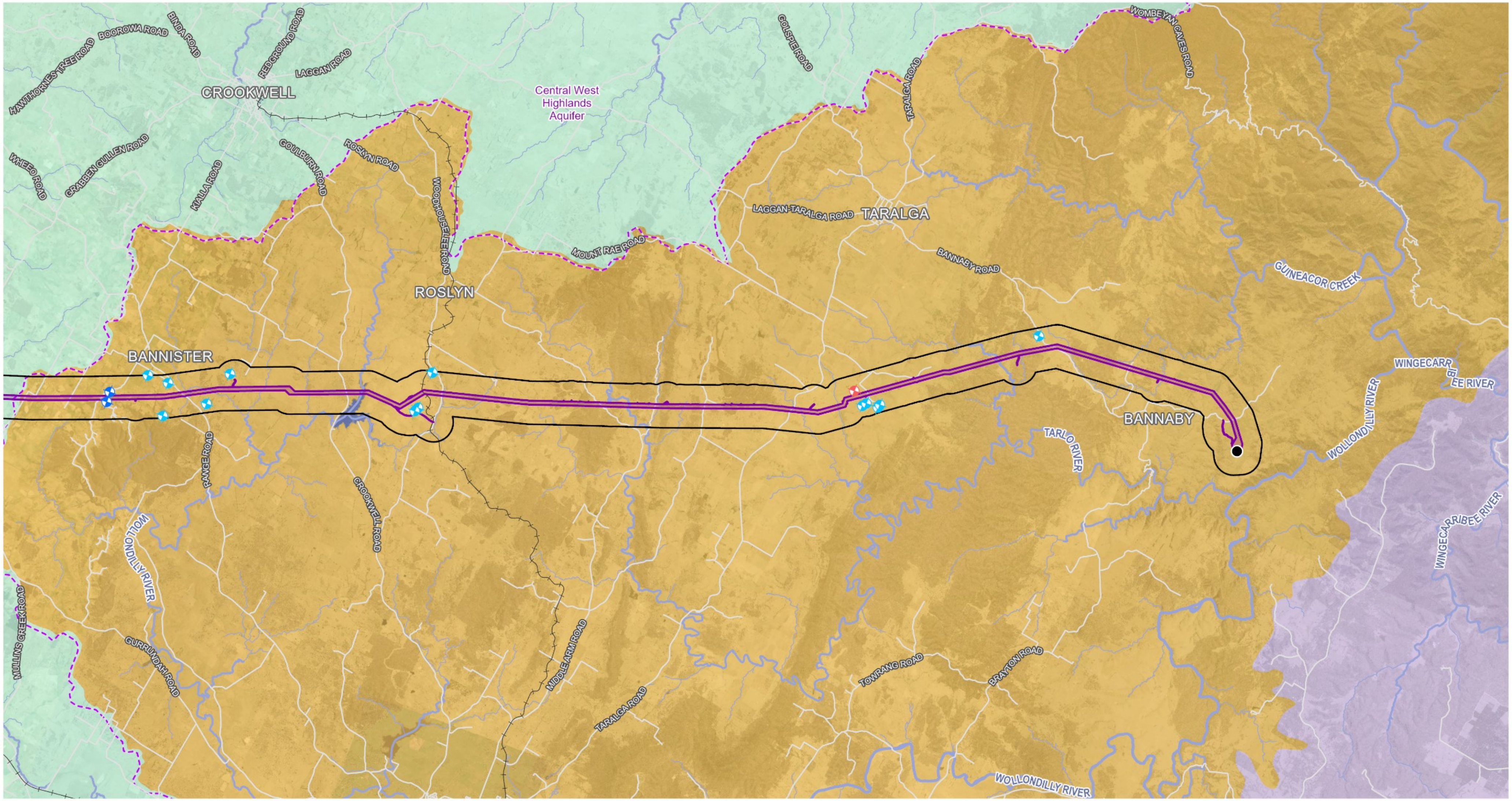


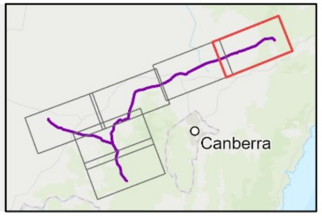
- Project footprint
- Surface water and groundwater study area
- Railway
- Watercourse
- Substation
- Aquifer Boundary (AHGF)

Registered Groundwater Bores (NGIS) within Groundwater study area

- Irrigation
- Stock and Domestic
- Water Supply

Water Sharing Plan - Groundwater Sources

- Goulburn Fractured Rock
- Lachlan Fold Belt
- Sydney Basin - Nepean Sandstone
- Water



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

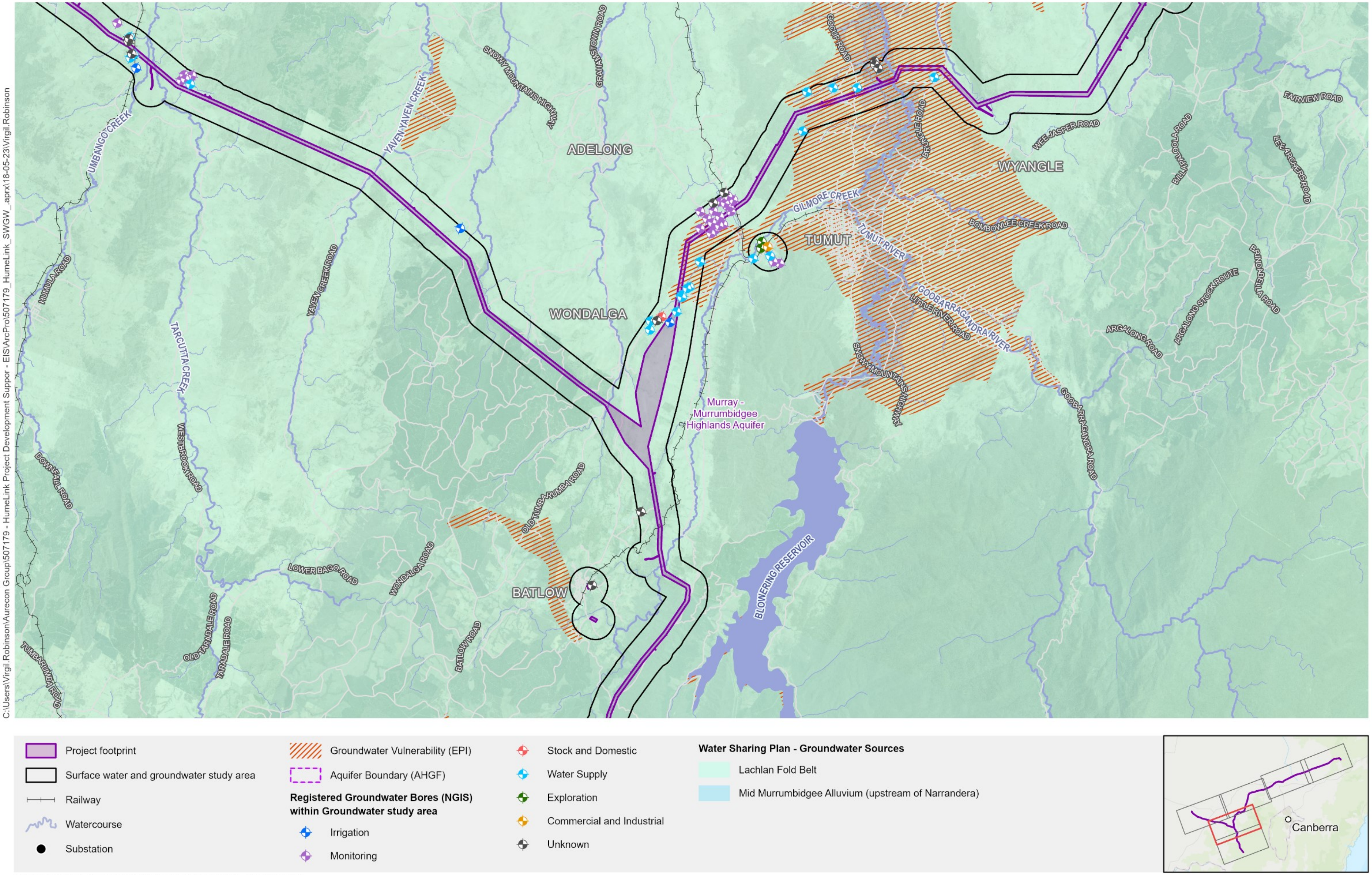
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20d: Water Sharing Plan - Groundwater Sources



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

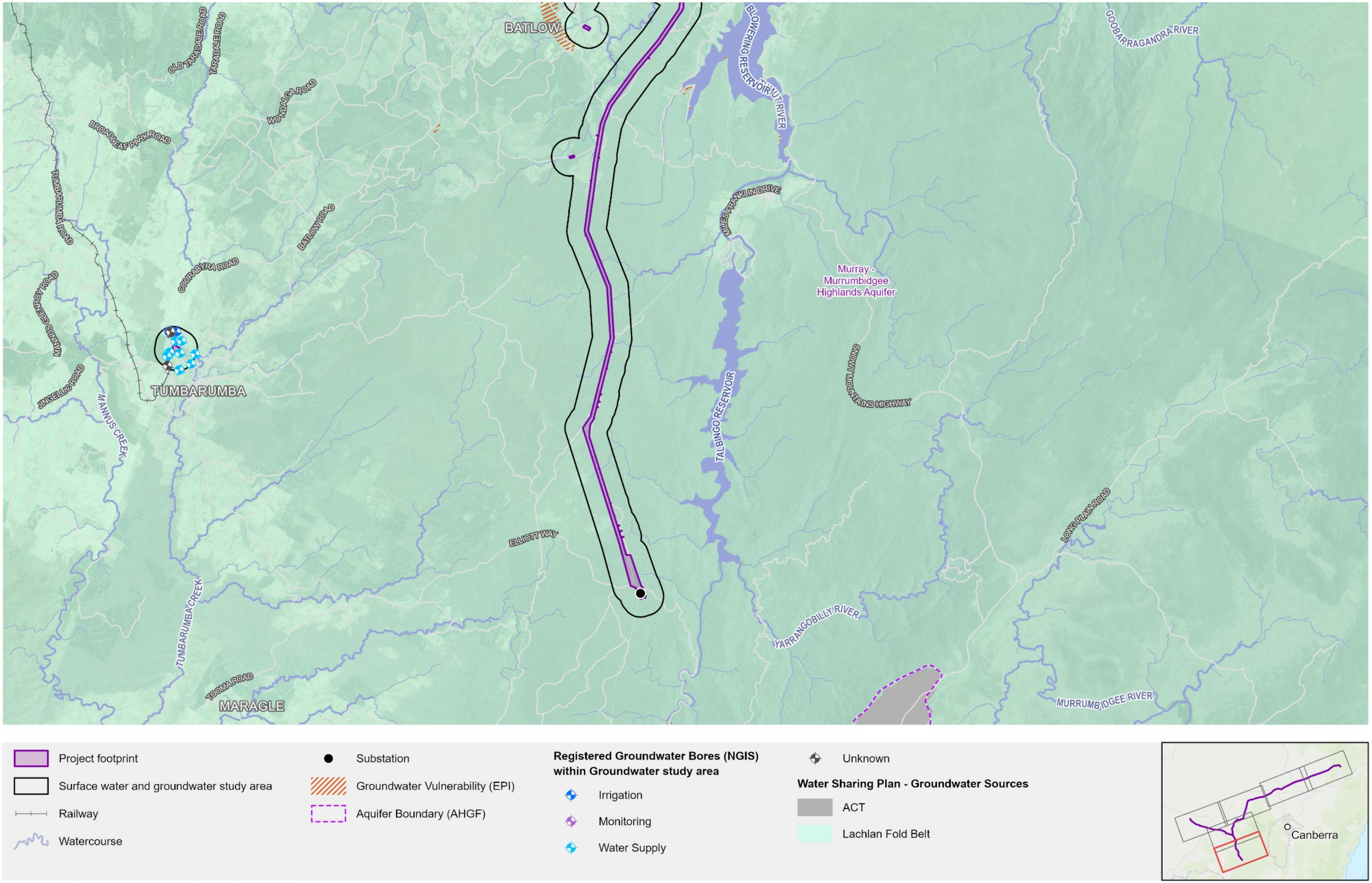
1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20e: Water Sharing Plan - Groundwater Sources



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Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

1:200,000

0 4 8km

Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

Figure 5-20f: Water Sharing Plan - Groundwater Sources

5.5.3 Groundwater levels

Groundwater level information was collated from relevant regional studies, available local information (such as registered bores) and site-specific data are provided in the following sections.

5.5.3.1 Published regional groundwater levels

The Mid Murrumbidgee Alluvium extends along the Murrumbidgee River from the Jugiong area downstream to Narrandera, and also includes the Tumut River, Tarcutta Creek and Kyeamba Creek tributary alluvial systems. Groundwater extraction from the alluvial system is primarily for irrigation.

The Mid Murrumbidgee Alluvium is composed of sands and gravel and is divided into two main aquifer systems:

- Cowra formation, which is a shallow aquifer system that (based on bore records) varies in depth from approximately 25 metres deep in the Gundagai area and increases to 40 metres near Narrandera.
- Lachlan formation, which is the underlying deeper aquifer system with an approximate depth of 90 metres.

There are no available regional groundwater contour maps or proximal groundwater level information published for the Lachlan and Goulburn fractured rocks.

5.5.3.2 Groundwater levels from registered bores

Table 5-17 summarises the available groundwater level records from reviewed registered bore data within the surface water and groundwater study area. The complete list of reviewed registered bore data is provided in Attachment D.

Table 5-17 Registered groundwater bores and their groundwater level statistics

Bore applications	Number of bores	Range of standing water level (m)
Commercial and Industrial	1	0 – 0*
Exploration	3	0 – 0*
Irrigation	13	12 – 14
Monitoring	71	1 – 23.4
Stock and Domestic	15	2.5 – 2.5*
Unknown	21	2.3 – 19.2
Water Supply	82	1.5 – 85
Total	206	

Note: * limited information available from WaterNSW

5.5.4 Groundwater quality

Water quality describes the condition of water within a water source and its related suitability for different purposes. The water quality characteristic of a groundwater system influences how that water is used by humans for town water or stock and domestic supply, or for commercial purposes such as farming and irrigation as well as environmental uses such as aquatic and terrestrial GDEs. If water quality is not maintained, it can impact on the environment as well as the commercial and recreational value of a groundwater resource.

One measure of quality most relevant to the end use is the level of salt present in groundwater, or groundwater salinity. This is determined by measuring the electrical conductivity (EC) and is generally reported in microsiemens per centimetre (µS/cm), whereby water with an EC of 1,000 µS/cm has an approximate salt concentration of 640 milligrams per litre.

In NSW, groundwater salinity levels can range from that of rainwater (less than 250 µS/cm) to greater than that of sea water (approximately 60,000 µS/cm). Groundwater with salinity suitable for a range of productive uses is generally found in the large unconsolidated alluvial systems associated with the major westward draining rivers.

The beneficial use category of a groundwater source refers to a general categorisation of groundwater uses based on water quality, dependent upon groundwater salinity and the presence or absence of contamination. The beneficial use categories are defined in the NSW Groundwater Protection Policy. The salinity thresholds for each beneficial use category and the associated groundwater uses are outlined in Table 5-18.

Table 5-18 Beneficial uses of groundwater (based on salinity)

Beneficial use category	A	B	C	D
Total Dissolved Solids (mg/L)	0 – 1,200	1,201 – 3,000	3,001 – 10,000	> 10,000
Electrical Conductivity (µS/cm)	0 – 1,791	1,792 – 4,478	4,479 – 14,925	> 14,925
Aquatic ecosystem protection	✓	✓	✓	✓
Irrigation	✓	✓		
Stock drinking water	✓	✓	✓	
Recreation and aesthetics	✓	✓	✓	✓
Raw drinking water	✓			
Industrial water	✓	✓	✓	✓
Cultural and spiritual	✓	✓	✓	✓

Groundwater quality information, considering relevant regional studies and available local information (such as registered bores), is provided in the following sections.

5.5.4.1 Regional quality

Mid Murrumbidgee Alluvium

Across the Mid Murrumbidgee Alluvium, salinity in groundwater samples from groundwater monitoring bores at the time of bore construction ranged generally from 150 µS/cm close to the rivers to about 950 µS/cm in the deep aquifer. However, salinity readings of greater than 1,500 µS/cm have been recorded in the western area towards Narrandera. The quality in the shallow aquifer is quite variable but is generally below 1,660 µS/cm and fresh adjacent to the Murrumbidgee River. Overall, those values remain those of fresh water (in most places) to slightly brackish water. These readings relate to beneficial use categories A and B.

Lachlan Fold Belt

Water quality within the Lachlan Fold Belt varies based on rock type, fracture density, aquifer depth, and climate. Salinity can range across all beneficial use classes from fresh to saline. The Lachlan Fold Belt is the host rock for a number of ore bodies and so the background trace metal chemistry of the groundwater is heavily influenced by these deposits.

There are areas where the water quality has been monitored intensely on a local scale such as the Wellington Caves and there are also large areas where there is no information with few to no groundwater users or mines.

Analysis of groundwater quality data sampled from bores in the Yass Catchment groundwater source indicates there is a broad range of groundwater salinities throughout the catchment, ranging from 300 to 6,100 microsiemens per centimetre. These values relate to beneficial use categories of A, B and C depending on the location. The hardness of the water (the $CaCO_3$ concentration) ranges between 230 and 1,100 milligrams. This indicates that it is very hard to extremely hard water based on the ANZG for fresh and marine water quality (2018). Water quality results for NSW Government monitoring bores located in the Murrumbateman area shows a neutral pH, a salinity range of between 800 and 5,360 microsiemens per centimetre with an average of 1940 microsiemens per centimetre. Sodium is the dominant cation, while bicarbonate and chloride being the dominant anion, which is considered to reflect the volcanic geology.

Goulburn Fractured Rock

There is no regional groundwater quality data published.

5.5.4.2 Quality from registered bores

Registered groundwater bores within the surface water and groundwater study area that contain water quality data such as salinity have been included in Table 5-19. Note that the data for the registered bores was extracted from WaterNSW and measurements for salinity have been recorded differently across the various bores. Their locations are presented on Figure 5-20.

Table 5-19 Registered groundwater bores and their salinity

Bore	Use	Salinity	WSP	Potential aquifer
GW010812	Water Supply	Very Good	Murrumbidgee River Unregulated and Alluvial Water Sources 2012	Kyeamba Alluvial Groundwater Source
GW052743	Unknown	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW051973	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW051820	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW060718	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW038617	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW043100	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW047966	Irrigation	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW068808	Unknown	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW409592	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW402876	Unknown	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW401219	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW400026	Irrigation	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW051870	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW402690	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source

Bore	Use	Salinity	WSP	Potential aquifer
GW038083	Commercial and Industrial	Fresh	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW403801	Monitoring	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW043217	Water Supply	Very Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW403802	Monitoring	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW037600	Water Supply	Very Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW050964	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW025450	Irrigation	0-500 ppm	Murrumbidgee River Unregulated and Alluvial Water Sources 2012	Kyeamba Alluvial Groundwater Source
GW416663	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW013408	Stock and Domestic	Very Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW416662	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW014707	Water Supply	501-1000 ppm	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW401336	Water Supply	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Yass Catchment Groundwater Source
GW054861	Stock and Domestic	Good	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Yass Catchment Groundwater Source
GW404658	Water Supply	Fresh	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Yass Catchment Groundwater Source
GW044813	Water Supply	501-1000 ppm	NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011	Lachlan Fold Belt MDB Groundwater Source
GW072886	Irrigation	0-500 ppm	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW109289	Irrigation	Fresh	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW109133	Water Supply	Fresh	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW037697	Water Supply	Good	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW072882	Water Supply	Good	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW115701	Stock and Domestic	Fresh	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source
GW059774	Water Supply	Good	Greater Metropolitan Region Groundwater Sources 2011	Goulburn Fractured Rock Groundwater Source

5.6 Surface water and groundwater interactions

There is limited groundwater connectivity to surface water features within the surface water and groundwater study area. The connectivity is predominately limited to recharge via leakage from overlying surface water features. Smaller Strahler order waterways are generally ephemeral and receive majority of the water during high rainfall events.

5.6.1 Mid Murrumbidgee Alluvium

The Mid Murrumbidgee Alluvium is considered to be in hydraulic connection with the regulated Murrumbidgee River and its tributaries.

Upstream of Tarcutta Creek junction to Jugiong it is considered to be highly connected to the regulated Murrumbidgee River. Downstream of Blowering Dam, it is also considered to be highly connected to the Tumut River. This high level of hydraulic connection is recognised in the WSP rules for the Gundagai Alluvial Groundwater Source.

The narrow and shallow nature of the Mid Murrumbidgee Alluvium means it is likely to experience both losing conditions and gaining conditions where the alluvium loses or gains water to and from the streambeds due to a lower or higher relative water level along its length depending on geology, topography, river flow and local conditions. CSIRO (2008) interpreted that the Murrumbidgee River:

- above Wagga Wagga is a gaining stream
- at Wagga Wagga is a losing stream
- downstream near Narrandera is a gaining stream.

It is also interpreted that at Wagga Wagga, prior to groundwater development, the Murrumbidgee River was gaining, and that downstream of Wagga Wagga a losing reach has increased since the mid-1970s due to extraction of groundwater (CSIRO, 2008).

Although the Murrumbidgee Alluvium downstream of Tarcutta Creek Junction is considered to be hydraulically connected to the Murrumbidgee River, due to the depth and width of the alluvium groundwater pumping impacts at the river are subdued and/or delayed. This lag time of groundwater pumping impacts is acknowledged in setting the extraction limit of the resource and this part of the alluvium is managed independently from the river.

5.6.2 Lachlan Fold Belt

The connection between both groundwater and surface water systems in the Lachlan Fold Belt is dependent on the degree of fracturing (cracking and breaking) of the bed of the overlying surface water features, or to the base of more permeable (allowing liquids or gases to pass through it) weathered profile that connects with surface water feature.

The aquifers with higher elevated areas, having high rainfall, are expected to be discharging water as springs providing some baseflow along the upper catchments of Lachlan and the Murrumbidgee River systems. Much of the Lachlan Fold Belt is buried beneath porous rock systems and therefore is considered as not having a major connection with the overlying surface water systems and other contiguous groundwater systems. Typically, the surface water systems within the area are considered to be in low hydraulic connection with groundwater in the fractured rock. Hence the surface and groundwater systems are managed separately (NSW Government, 2021).

5.6.3 Goulburn Fractured Rock

Although the main groundwater source in this catchment (relevant to the project) is Goulburn Fractured Rock, alluvial deposits occur along the valleys, creeks, and floodplains of the main rivers in the Hawkesbury – Nepean catchment including the Wollondilly River. These alluvial deposits provide areas of localised groundwater-surface water interactions.

5.7 Sensitive receiving environments

Sensitive receiving environments, which may be impacted by the project in relation to groundwater and surface water are presented in the following sections.

Sensitive receivers include:

- KFHs and threatened aquatic species
- licensed groundwater users
- Wetlands, including RAMSAR wetlands and NSW wetlands
- GDEs.

A count of bores and their respective applications within the surface water and groundwater study area is shown in Table 5-20. Attachment D has a comprehensive list and description of the licensed groundwater users and bores that are within one kilometre radius of the project footprint.

Table 5-20 Count of bores and their application within the surface water and groundwater study area

Bore applications	Number of bores
Commercial and Industrial	1
Exploration	3
Irrigation	13
Monitoring	71
Stock and Domestic	15
Unknown	21
Water Supply	82
Total	**206**

A desktop review of vegetation mapping and field data conducted as part of the *Technical Paper 1 – Biodiversity Development Assessment Report* identified potential GDEs within the project footprint. Only aquatic groundwater dependant ecosystems were considered in this review as they were considered most at risk. Aquatic ecosystems rely on the surface expression of groundwater, which includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands, and springs.

The aquatic GDEs identified with the vegetation communities that have a high potential to be a GDE and are located within the project footprint, as summarised in Table 5-21, are more likely to be impacted by construction activities of the project. Additionally, the vegetation communities identified with larger areas have an increased risk of being impacted by the construction activities. Operation activities are unlikely to cause any impacts. More information on construction and operation impacts are outlined in Chapter 6 and Chapter 7.

Table 5-21 Areas and associated risk of vegetation communities within project footprint

Area (ha)	Moderate Risk	High Risk
White Box, Yellow Box, Blakelys Red Gum, Grassy Woodland, and Dryland Native Grass	1.9	4.9
Non-TEC	1.9	3.5

Refer to *Technical Report 1 – Biodiversity Development Assessment Report* for more information on impacts to KFH and aquatic species, GDEs and wetlands.

6 Construction impacts

Key construction activities which have the potential to impact surface water and groundwater are discussed in Section 6.1. Surface water and groundwater impacts are assessed separately in Section 6.2 and Section 6.3, respectively.

6.1 Project components, associated construction activities and environmental risks

Project components, their respective activities and the associated risks on key environmental aspects are summarised in Table 6-1. Additional information on key environmental aspects potentially impacted is provided in Section 6.2 and Section 6.3.

Table 6-1 Summary of project components, construction activities and potential risks

Construction activity	Surface and groundwater risks	Project component							
		Transmission lines structures	Transmission line easements	Substations	Telecommunications hut	Access tracks including waterway crossings	Construction compounds	Worker accommodation	Utility connections, adjustments and protection
Vegetation removal	Surface water risks: Erosion and sedimentation, Geomorphology and water quality	X	X	X	X	X	X	X	X
	Groundwater risks: Groundwater recharge/flow paths, levels, quality, and existing groundwater users.	X	X	X	X	X			
Earthworks – excavation, compaction and/or piling	Surface water risks: Erosion and sedimentation, Geomorphology, and water quality	X		X	X	X	X	X	X
	Groundwater risks: Groundwater recharge/flow paths, levels, quality, and existing groundwater users.	X	X	X	X	X	X		X
Stockpiling of soil and construction materials	Surface water risks: Erosion and sedimentation, Geomorphology, and water quality	X	X	X	X	X	X	X	X
	Groundwater risks: Groundwater quality and existing groundwater users.	X	X	X			X		
Machinery/ vehicle use	Surface water risks: Water quality	X	X	X	X	X	X	X	X
	Groundwater risks: None identified.								
Water demand/use	Surface water risks: Water supply		X	X		X	X	X	
	Groundwater risks: Groundwater recharge/flow paths, levels, quality, and existing groundwater users.	X	X	X		X	X		X
Wastewater disposal	Surface water risks: Water quality			X			X	X	
	Groundwater risks: None identified.								
Concreting	Surface water risks: Erosion and sedimentation, geomorphology and water quality, water disposal	X		X	X	X	X	X	X
	Groundwater risks: Groundwater recharge/flow paths, levels, quality, and existing groundwater users.	X		X	X		X		X
Demolition	Surface water risks: Water quality	X		X				X	X
	Groundwater risks: None identified.								

6.2 Potential construction impacts on surface water

The construction activities discussed in this section are considered to pose the greatest potential impact to surface water based on existing environment and identified project tasks. There are five main aspects of surface water that could be impacted by construction of the project, namely:

- erosion risk and resulting sedimentation impacts on waterways
- geomorphology
- water quality
- wastewater disposal
- water supply.

The other aspect of surface water that could be impacted by the project is flooding. Flooding risks are covered in *Technical Report 11 – Hydrology and Flooding Impact Assessment.*

Apart from water supply impacts, the potential impact significance for different project components and activities would vary depending on the location – and consequently a range of impact significances have been identified for some project components and activities. The impact significance is based upon:

- Magnitude of impact – This has been determined qualitatively based upon the scale of activity and any other specific risks associated with the activity eg extensive vegetation clearing would be required for the transmission line easement and a high overall magnitude of risk would apply to this project element and activity.
- Proximity to sensitive environmental features – This is further discussed below but the closer an activity is to a sensitive environmental feature, the greater the risk of impacts. The inverse is true, with the greater distance from project footprint, the lower the impact risk.
- Other inherent environmental factors – For example, erosion and sedimentation risks can be influenced by soil type, terrain steepness and annual average rainfall and these vary between different locations.

Sensitive environmental features include:

- waterways
- KFH
- wetlands
- drinking water catchments
- threatened aquatic ecological communities.

For the purpose of this assessment, proximity of an area to a waterway has been used as a conservative measure to determine the potential risk of impacts on a sensitive environmental feature.

Waterway buffer zones have been determined based upon the ratio of VRZ multiplied by a factor of five. Areas within the buffer zone of an individual waterway are considered to potentially have a high risk of impacting a sensitive environmental feature. The waterway buffer zones vary based upon the Strahler rating of the waterway and are:

- Strahler order 1 – within 50 metres of the waterway
- Strahler order 2 - within 100 metres of the waterway
- Strahler order 3 - within 150 metres of the waterway
- Strahler order 4 and above - within 200 metres of the waterway.

About 38 per cent of the project footprint is within the buffer zone of a waterway.

Detailed assessment of the impacts of all aspects of the project on biodiversity (including KFHs, wetlands and threatened ecological communities) are presented in *Technical Report 1 – Biodiversity Development Assessment Report* for impacts to these sensitive environmental features.

6.2.1 Erosion risk and sedimentation impacts

Construction activities would increase the risk of sedimentation and erosion impacts on adjacent land, waterways, and other sensitive environmental receivers. Key construction activities that would increase the risk of sedimentation and erosion impacts include:

- vegetation removal or clearing, as vegetation plays a key role in reducing erosion potential of a land area by:
  - stabilising upper soil layers via their root zone
  - slowing the velocity of surface runoff
  - using water for transpiration and growth
- earthworks as they may:
  - expose more erodible subsoil layers
  - change surface drainage patterns which could include concentrating or redirecting surface runoff
  - involve stockpiling of soil which if not managed appropriately is an erosion risk
  - result in the compaction of soils which can increase runoff volumes
  - increase in the surface area of soils exposed to runoff.

The impacts of increased erosion and sedimentation could include:

- impacts to waterways from sediment laden runoff including:
  - elevated turbidity
  - a decrease in dissolved oxygen (due to oxygen demand associated with organic loading in the sediment)
  - an increase in contaminant concentrations
  - smothering of aquatic habitat and impacts on aquatic organisms
  - changes in the geomorphology and flow in a waterway
- impacts to adjacent land areas from sediment laden runoff including:
  - smothering of terrestrial vegetation:
  - changing surface runoff flow patterns due to deposition of sediment.
  - depletion of the soil nutrient pool causing difficulties in revegetation work.

As discussed in Section 5.4.3, detailed erosion risk information has been sourced and erosion risk for the risk assessment has been categorised as the following:

- low: up to 200 t ha^{-1} yr^{-1}
- moderate: between 200 and 1000 t ha^{-1} yr^{-1}
- high: greater than 1000 and 3000 t ha^{-1} yr^{-1}.

This combined information can be used to determine the sensitivity of potential impacts at any location within the project footprint. The sensitivity risk for a particular location has been determined based upon Table 6-2. All locations within the buffer zone of a waterway would have a minimum of moderate sensitivity. The percentage of project footprint in sensitivity categories is displayed in Table 6-3.

Table 6-2 Sensitivity risk based on erosion category and proximity to waterways

	Erosion risk category		
	Low	**Moderate**	**High**
Outside waterway buffer zone	Low sensitivity	Low sensitivity	Moderate sensitivity
Inside waterway buffer zone	Moderate sensitivity	High sensitivity	High sensitivity

Table 6-3 Percentage of project footprint in sensitivity categories

	Sensitivity category		
	Low	**Moderate**	**High**
Outside waterway buffer zone	57.9%	4.6%	None
Inside waterway buffer zone	None	24.6%	12.9%

Of the total project footprint area, an area comprising 37.5 per cent is within the buffer zone of a waterway, of which 24.6 per cent is considered to have moderate sensitivity due to its low erosion risk and 12.9 per cent is considered to have high sensitivity due to its moderate or high erosion risk.

Outside the waterways buffer zones, 57.9 per cent of the project footprint is considered to have low sensitivity due to its low or moderate erosion risk and 4.6 per cent is considered to have moderate sensitivity due to its high erosion risk.

No figures have been produced showing the interaction between waterway buffer zones and erosion risk category as the scale of the figures would not show meaningful information. The erosion risk mapping in Figure 5-18 indicate where the erosion risks are most significant.

The impact significance for each project component has been determined using the methodology described in Chapter 4 and is shown in Table 6-4. As noted previously, project components which have a large footprint (ie vegetation clearing for the transmission line easement) would have a range of impact significances depending on the location and individual locational characteristics. For example if an area of the transmission line easement is cleared adjacent to a waterway with high erosion risk soils would have a high impact significance – whereas an area of the transmission line easement on land cleared of vegetation, away from a waterway and low risk erosion risk would have low impact significance. Also the sensitivity of the waterway would need to be considered. Perennial waterways containing KFH would generally have a higher potential impact significance compared to an ephemeral drainage line. Generally waterways with a Strahler order 4 or higher are perennial and consequently work within these waterway buffer zones would have a potentially moderate or high impact significance. Waterways and their associated Strahler order are presented in Attachment B.

The impact significance of a specific location would determine the approach to erosion and sedimentation control. This is further discussed in Chapter 9.

Table 6-4 Erosion risk and sedimentation impacts to surface water

Project component and activities	Impact magnitude	Sensitivity	Impact significance without mitigation
Transmission line easement – involves vegetation removal	Vegetation removal would be required within the new transmission line easement, which would generally be 70 m in width except for some select locations. In some locations, vegetation removal would be negligible (eg where the transmission line route is through cleared pasture land), whereas vegetation removal in other locations would be more substantial where the existing vegetation is tall in height and is required to be cleared. *Technical Report 1 – Biodiversity Development Assessment Report* details clearing requirements for the transmission line easement. The magnitude of the impact of vegetation removal to erosion risk would vary depending on the specific location, ranging from low to high.	Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2.	Low to high based on location
Construction of access tracks - involves vegetation removal and earthworks	New and upgraded access tracks would be required outside the transmission easement to connect to existing roads and other access points. Wherever possible, existing roads, tracks and other existing disturbed areas would be used to minimise vegetation clearing or disturbance. Upgrades to existing access tracks may be required. The construction of access tracks would have the similar location-based variation in the magnitude in risk as the transmission line easement. Areas of higher modelled erosion risks (refer to Section 5.4.3) are likely to have higher magnitude of impacts but generally ranging from low to moderate.	Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2.	Low to high based on location
Construction for transmission line structures – involves vegetation removal and earthworks, material storage	Each transmission line structure would require about 350 m^2 to up to 450 m^2 in area of earthworks to install the footings. Transmission line structures would be required about every 300 to 600 m apart. Overall, the impact magnitude of the earthworks required for the transmission line structures is low given the relatively small area of earthworks in comparison to the overall transmission line easement area.	Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2. However as there is some flexibility in locating the transmission line structures, areas of high sensitivity may be able to be avoided in some locations.	Low to high based on location
Construction compounds and material storage – involves vegetation removal and earthworks, material storage	The 14 construction compounds proposed as part of the project vary in size from less than 2 ha to over 20 ha (although the exact area to be used at each construction compound would be confirmed by the construction contractor). The smaller construction compounds (< 4 ha) would have a low impact magnitude and the larger construction compounds (4 ha or greater) would have a moderate impact magnitude.	Low or high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2. However, construction compounds have been located wherever possible to avoid areas immediately adjacent to environmentally sensitive waterways ie waterways with Strahler order 4 or higher.	Low to high based on location.

Project component and activities	Impact magnitude	Sensitivity	Impact significance without mitigation
Construction of the proposed Gugaa 500 kV substation – involves vegetation removal and earthworks, material storage	A moderate impact (magnitude) is expected for the construction of the proposed Gugaa 500 kV substation given the significant volumes of earthworks, the location is near a waterway and the size of the substation.	Moderate based on proximity to waterways and soil erosion risk – refer to Table 6-2.	Moderate
Modification of the existing Bannaby 500 kV substation – involves vegetation removal and earthworks, material storage, demolition.	Low impact is expected for the modification of the existing Bannaby 500 kV substation as it is located on cleared land, with a generally flat topography resulting in low soil erosion risk and the area of land to be impacted is relatively small and localised.	Moderate based on proximity to waterways and soil erosion risk – refer to Table 6-2.	Low
Modification of the existing Wagga 330 kV substation - involves vegetation removal and earthworks, material storage	Low impact is expected for the modification of the existing Wagga 330 kV substation as it is located on cleared land and the area of land to be impacted is relatively small and localised.	Low based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2.	Negligible
Worker accommodation facility - involves vegetation removal and earthworks	The Tumbarumba Accommodation Facility (AC1) site is cleared of most vegetation and the area of impact is about 20 ha. The potential impact magnitude is moderate.	Moderate based on proximity to waterways and soil erosion risk – refer to Table 6-2.	Moderate

6.2.2 Geomorphology

Geomorphology impacts on waterways would result from:

- excessive sedimentation and erosion from construction activities adjacent to waterways
- direct disturbance to waterways from construction activities.

Excessive sedimentation and erosion from construction activities adjacent to waterways may cause siltation of waterways and changes to waterway geomorphology downstream of construction areas.

While most construction activities would avoid direct disturbance of waterways, some access tracks would be required to cross waterways and some disturbance would be required to install appropriate waterway crossing structures. Snowy Mountains Highway compound (C02) is proposed directly adjacent to a third order stream (tributary of Gilmore Creek). There is a risk that that establishment of the construction compound near the waterways could result in changes in flow and bank stability, which in turn would lead to impacts to the geomorphology of the affected waterway.

Transmission line structures would avoid direct disturbances to higher order streams (fourth order and higher) but may be unable to avoid smaller order (first to third order) ephemeral streams, thus having direct impacts to their flows/banks and channels.

The key construction activities that have the potential to increase geomorphology risk to nearby waterways are discussed in Table 6-5. Mitigation measures are outlined in Section 11.2.

Table 6-5 Geomorphology risk impacts to surface water

Construction activity	Impact magnitude	Sensitivity	Impact significance without mitigation
Construction compounds	The construction compounds would vary in size and would have a low to moderate impact magnitude depending on the size of the construction compound and the type of activities undertaken at each construction compound	Low to high – depending on the location of the construction compounds relative to waterways. Higher Strahler order waterways are generally more sensitive as they are more likely to be perennial and contain KFH. The distance between construction compounds and waterways is presented in Table 6-.	Low to high based on location
Transmission line structures	The area required for the construction of each transmission line structure would require access for assembly and stringing work. At a typical site, this would include a temporary area of up to 50 metres by 70 metres at each transmission line structure location.Transmission line structures would be required about every 300 to 600 m apart. Overall the impact would be moderate given the number of transmission line structures.	Low to high based on proximity to waterways and soil erosion risk – refer to Table 6-2. Locations of the transmission line structures would be refined during detailed design. Transmission line structures would avoid direct disturbances to higher order streams (4th order and higher) but may be unable to avoid smaller order (1st to 3rd order) ephemeral streams thus having direct impacts to their flows/banks and channels.	Low to high based on location
Waterway crossings	Due to the number of potential waterways crossings, the overall impact would be moderate.	Low to high based on proximity to waterways and soil erosion risk – refer to Table 6-2 and the requirements for waterway crossings.	Low to high based on location

6.2.3 Water quality

Potential impacts to the water quality of surrounding waterways may result from:

- accidental spillages of chemicals, fuels, hydrocarbons and heavy metals from storage, use, refuelling and maintenance of equipment and construction machinery
- elevated levels of contaminants of potential concern related to previous land uses and contaminated sites, caused by disruption of soils and subsequent leaching/desorption into soluble phases encouraging transfer to waterways including the following (refer to the *Technical Report 10 – Phase 1 Contamination Assessment* for further information regarding contamination):
  - benzene, toluene, ethylbenzene, and xylenes
  - heavy metals such as zinc, lead, copper, nickel, cadmium, and chromium
  - organochlorine pesticides and organophosphorus pesticides
  - polycyclic aromatic hydrocarbons
  - total recoverable hydrocarbons
- gross pollutants such as paper and plastic packaging and materials from material use on the construction footprint and general construction staff litter
- tannins released during vegetation removal
- acid sulfate soil, potential acid sulfate soils or saline soils exposure (refer to the *Technical Report 10 – Phase 1 Contamination Assessment* for further information regarding acid sulfate soils)
- sediment and particulate-bound contaminants from vegetation and topsoil clearing, soil excavation, movement and storage and stormwater runoff through disturbed sites. The predicted increases in sedimentation and nutrients in runoff may also lead to indirect impacts such as increased turbidity, lower dissolved oxygen levels (due to incursion of organic loading with associated oxygen demand) and algal blooms in the waterways
- nutrients (nitrogen and phosphorus) – commonly present in agricultural areas that may become mobilised by overland flow from disturbance of agricultural land for vegetation clearing and earthworks
- various pollutants from concrete batching operations and materials storage at construction compounds
- runoff from concrete work
- disposal of wastewater.

Apart from the water quality risk from erosion and sedimentation impacts, the most significant risk to water quality would be from the construction compounds, particularly those that contain concrete batching plants and concrete work near or adjacent to waterways.

The project components and activities that have the potential to increase water quality risk to nearby waterways are discussed in Table 6-6. Mitigation measures are outlined in Section 11.2.

Table 6-6 Water quality risk impacts to surface water

Project component and activity	Impact magnitude	Sensitivity	Impact significance without mitigation
Transmission lines and structures - involves vegetation clearing, earthworks, machinery/vehicle use and concreting	Given the large number of transmission line structures and that earthworks and concreting would be required at each structure, the magnitude of impact is moderate.	Low to high based on a location's proximity to a waterway	Low to high based on location
Transmission line easements – involves vegetation clearing, land machinery/vehicle use	Any potential impacts are likely to be minor and localised. The water impacts associated with activities are also likely to be low in scale. The overall potential impact is low in magnitude.	Low to high based on a location's proximity to a waterway	Low to high based on location
Telecommunications hut - involves vegetation clearing, earthworks, concreting and machinery/vehicle use	Due to the small size of the area required for the telecommunications hut and relatively minor work, the potential impact is low.	Low – not close to a waterway	Negligible
Construction of the proposed Gugaa 500 kV substation – involves vegetation clearing, earthworks and machinery/ vehicle use	Given the amount of earthworks and concrete work for the proposed Gugaa 500 kV substation, the potential magnitude of impact is high.	Low – not close to a waterway classified as Strahler order 4 or higher	Moderate
Modification of the existing Bannaby 500 kV substation – involves vegetation clearing, earthworks and machinery/ vehicle use, demolition	Due to the size of the area required for modification of the existing substation and the types of work, the potential impact is low.	Moderate - in drinking water catchment.	Low
Modification of the existing Wagga 330 kV substation - involves vegetation clearing, earthworks and machinery/ vehicle use	Due to the size of the area required for modification of the existing substation and the types of work, the potential impact is low.	Low – not close to a waterway	Negligible
Access tracks - involves vegetation clearing, earthworks and machinery/ vehicle use	Given the extensive extent of access tracks and the type of work, the magnitude of impact is potentially moderate.	Low to high based on proximity to waterways and soil erosion risk – Refer to Table 6-2	Low to high based on location
Construction compounds - involves vegetation clearing, earthworks, storage of material, concreting and machinery/vehicle use	The construction compounds which some may include concrete batching plants and would also involve the storage of other chemicals, fuels, and material. Consequently, the magnitude of potential impacts are moderate.	Low for all compounds except Snowy Mountains Highway compound (C02) which is located adjacent to Strahler order 3 waterway.	Low – C02 which is high
Worker accommodation - involves vegetation clearing, earthworks, machinery/vehicle use	The worker accommodation facility proposed at Tumbarumba would also generate domestic wastewater which would require disposal. Due to the relatively large amount of domestic wastewater generated, the potential impacts are moderate.	Low – not close to any environmentally sensitive features	Low
Utility connections, adjustments, and protection	The main source of water quality impacts is general construction related ie accidental spills, leaks, improper disposal of waste (including concrete) as discussion at the beginning of Section 6.2.3. These potential impacts are likely to be small, localised (within the construction areas) and temporary. Due to the size of the area required for utilities work, the potential impact is low.	Low to high based on proximity to waterways and soil erosion risk – Refer to Table 6-2	Low to moderate depending upon location

6.2.4 Water supply and disposal

During construction, the project would require potable and non-potable water and generate wastewater. The following section assesses the:

- volumes and potential sources of water required for construction
- volumes of wastewater generated and potential options for management and disposal
- potential impacts on other water users and water supply infrastructure
- potential impacts from the disposal of wastewater.

6.2.5 Water supply

An estimate of the total volumes of water required for the construction of the project are detailed in Table 6-7 and Table 6-8 respectively. The largest need for water during construction (about 85 per cent of total water need) is for dust suppression, which would be generally non-potable water. Potable water would only be used for dust suppression if there was no other option. The largest potable water requirements are for the worker accommodation facility and for concrete production.

Table 6-7 Estimated total volume required for transmission line construction

Activity/Item	Estimated total volume required (ML)	Type of water
Dust suppression	450	Preferably non-potable
Concrete batching	19.2	Potable
Vehicle washdown and workers at transmission line structure sites	1.05	Non-potable
Workers at construction compound/laydown areas	0.968	Potable
Accommodation facility site	40	Potable
Total	**511.2**	

Table 6-8 Estimated total volume required for substation construction

Activity/Item	Estimated total water volume required (ML)			Type of Water
	Proposed Gugaa 500 kV substation construction	Bannaby 500 kV substation modification	Wagga 330 kV substation modification	Non-Potable/Potable
Concrete production	2.7	0.9	0.6	Potable
Workers on site	1.4	0.7	0.7	Potable
Civil work	19.8	14.6	12.1	Non-potable
Total	**23.9**	**16.2**	**13.4**	

The water source is dependent on the location and nature of the construction activity and whether potable or non-potable water is required. Water sources would include:

- construction sedimentation basins
- farm dams
- rainwater tanks
- council standpipes or connection to council water supply systems
- groundwater bores
- negotiations with landowners with riparian rights for access to their existing licence
- purchasing water allocations from existing water user allocations.

6.2.5.1 Non-potable water supply

Where possible, non-potable water would be sourced from construction sedimentation basins and farm dams in agreement with the relevant landowners. However, these sources of water would not meet all the non-potable requirements in all locations.

A more predictable and likely source of non-potable water would be the temporary purchase of water allocations from other water users. Stock and domestic allocations could be one option; however, these would need to be nominated allocations within a WSP and could not be unspecified stock and domestic riparian rights.

A more dependable and higher volume of non-potable water would be general security licence allocations. Transgrid or the construction contractor could purchase a zero allocation WAL in a specific WSP area, which would enable them to buy water from other water users who wish to temporarily sell their water allocation (or a volume of water). Active water trading and markets exist in most NSW catchments. To provide an estimate of the available water and impact of the project on water availability, the following assessment was undertaken:

- General security licence water allocations for each WSP were identified. While there are other types of water licences (eg high security), general security licence water is the most commonly traded water allocation.
- The balance of general security licence allocations at the last reporting period of each year was used as estimates of available water. Average allocations for each year are not a good indication of available water as general security licence holders are able to carry over (ie bank) a proportion of their water allocation over one or more years to manage variations in annual rainfall.
- The balance of general security licence allocations between 2004 and 2019 was used to calculate an average availability. This period contained droughts as well as a number of years of above average rainfall. Before 2004, most catchments operated under different water licensing arrangements which make comparisons of water availability impractical.

The Greater Metropolitan Region catchment does not have general security allocations within its WSPs as the majority of water is allocated for Sydney's and Wollongong's potable water supply. However, it does have substantial unregulated (about 26,525 annual units) and stock and domestic allocations (about 683 annual units) within relevant catchments (Shoalhaven and Upper Nepean) which can be allocated up to 200 per cent per unit in a year. Also, rainfall in the coastal catchments is generally higher and more reliable than inland catchments. For the purpose of this assessment an average annual allocation of water to licence holders of around 75 per cent of their total allowable allocation has been assumed.

Demand for non-potable water supply for the transmission line has been averaged over the entire length of the line and over the construction period of 2.5 years. This provided a metric of megalitre per kilometre per year (ML/km/yr) used to calculate the impact on the respective WSPs, which is outlined in Table 6-9.

As shown in Table 6-9, the project would require very small percentage of available water allocations under relevant surface WSPs for the non-potable water supply. Consequently, there would be sufficient water available with negligible impact on surface water users.

There are also groundwater resources along the transmission line route, which could also be a source of non-potable water for construction. No detailed analysis of potential groundwater sources has been undertaken given that surface water sources could easily meet the project demand for construction non-potable water. In using groundwater, consideration of the quality of groundwater would also need to be considered, particularly its salinity, to avoid contamination or salinisation of surface soils from land application. However, the risk of this occurring would be relatively low as land application of groundwater would be short term until groundcover is established (unlike irrigated agriculture).

Table 6-9 Impact of construction activities non - potable water demands on surface water sharing plans

Water Sharing Plan	Length (km)	Water demand for transmission Lines (ML/yr)	Water demand for substation (ML/yr)	Estimated total for allocation potentially available (ML/yr)	% of total allocation required
Greater Metropolitan Region Unregulated River Water Sources 2011	65.3	32.36	5.84	20,415*	0.16%*
Lachlan Regulated River Water Source 2016	37.6	18.63	-	326,041**	0.006%
Murrumbidgee Regulated River Water Source 2016	261.2	129.43	12.76	1,191,843***	0.02%
Total	**364.1**	**180.42**	**18.60**		

Notes:

* *Based on estimated of unregulated river and stock and domestic licence allocations in the Shoalhaven and Upper Nepean catchments.*

** Estimate *annual volume under the Lachlan Regulated River Water Source 2016 for general security licence with 592,801 unit shares and 55% allocation.*

*** Estimate *annual volume under the Murray and Lower Darling Regulated Rivers Water Sources 2016 for general security licence with 1,891,815 unit shares and 63% allocation.*

6.2.5.2 Potable water supply

Potable water requirements have been assessed in a similar manner to non-potable water except construction requirements have been assessed against local utility licence allocations as opposed to other types of allocations (refer to Table 6-10).

The proportion of local utility licence allocations required to provide for construction potable water demands would be very low and demand would be easily able to be met. The largest source of potable water would be for the worker accommodation facility. Further consultation would be undertaken with Snowy Rivers Regional Council to ensure there is sufficient capacity within the existing Tumbarumba Water Treatment Plant to meet the proposed demand.

Table 6-10 Impact of construction activities potable demands on surface water sharing plans

Water Sharing Plan	Length (km)	Water demand for transmission lines (ML/yr)	Water demand for substation (ML/yr)	Total allocation local utilities (ML/yr)	% of total allocation required
Greater Metropolitan Region Unregulated River Water Sources 2011	65.3	1.39	0.64	36,544	0.01%
Lachlan Regulated River Water Source 2016	37.6	0.80		15,545	0.01%
Murrumbidgee Regulated River Water Source 2016	261.2	5.58	2.16	4,960	0.16%
Murray and Lower Darling Regulated Rivers Water Sources 2016	NA	16	NA	33,497	0.05%
Total	**364.1**	**23.7768**	**2.8**		

6.2.5.3 Water disposal

Proper management and disposal of wastewater is essential in protecting the health and quality of surrounding waterways and environment. The volume of wastewater estimated to be generated for the construction of project is outlined in Table 6-11.

Table 6-11 Wastewater to be generated during construction activity

Activity	Estimate of wastewater volume (ML)	Volume per year (ML/year)
Field portaloos (line construction work)	0.37	0.15
Transmission line construction compounds (assume 4 construction compounds on average)	0.73	0.29
Proposed Gugaa 500 kV substation construction	1.08	0.43
Bannaby 500 kV substation modification	0.55	0.22
Wagga 330 kV substation modification	0.49	0.2
Worker accommodation facility (200 staff)	18.8	7.52

The annual volumes to be generated by all the construction activities apart from the accommodation facility would be generally low. Wastewater would be collected in tanks or field portaloos – which would be pumped out in a tanker. The tanker would dispose of any wastewater at local sewage treatment plants.

Wastewater generated at the worker accommodation facility would require a connection into the town sewerage network. The Tumbarumba STP has a capacity of 2,500 equivalent persons. Current population of Tumbarumba is 1,915 (Australian Bureau of Statistics, 2022), and therefore the wastewater to be generated by the estimated 200 workers over the construction period of the project would be within capacity of the Tumbarumba STP.

6.2.6 Impacts on specific waterways identified in the SEARs

The SEARs for the project identify major waterways that are potentially impacted by the project. These are presented and assessed in Table 6-12 and are shown in Figure 5-9.

Table 6-12 Potential impacts to major waterways

Waterway	Distance to project footprint	Assessment
Goobarragandra River	6.6 km	The project footprint is located about 6.6 km downstream of the Goobarragandra River. Therefore, no impacts are anticipated on the river from the project.
Lachlan River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Dalton. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.
Murrumbidgee River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Bookham. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.
Tarlo River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Bannaby. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.

Waterway	Distance to project footprint	Assessment
Tumut River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Batlow. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.
Wollondilly River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Bannister. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.
Yass River	Crosses river	The project footprint (ie transmission line corridor) crosses the waterway near Yass. The type of work to be undertaken immediately adjacent to the waterway would be typical of activities described in Table 6-1. Any such work within 200 m of the waterway would be considered high risk and require the preparation and implementation of site-specific ESCPs. The area impacted by any work would be relatively small in comparison to river catchment and with implementation of mitigation measures, the overall impacts are expected to be minor.
Blowering Dam	1.3 km	A small section of transmission line corridor is within the dam catchment (about 1.3 km from the dam), however does not cross the dam itself. There is increased sedimentation and erosion risk associated with construction. However, given the small area of land impacted and mitigation measure that would be implemented, the risk of impacts is low.
Burrinjuck Dam	1.3 km	A small section of transmission line corridor is within the dam catchment (about 1.3 km from the dam), however does not cross the dam itself. There is increased sedimentation and erosion risk associated with construction. However, given the small area of land impacted and mitigation measure that would be implemented, the risk of impacts is low.
Wyangala Dam	69 km	The transmission line corridor would traverse the upper catchment of Wyangala Dam – about 69 km upstream of the dam itself. Given the relatively small area of transmission corridor within the catchment and the distance upstream of the dam, there are unlikely to be any impacts on Wyangala Dam.

Substation sites and construction compounds pose the highest risk to surface water as fuel, chemicals and waste are stored and used, and construction may be more intensive in terms of activities and vehicle movements. The distance between a construction compound or substation site and the nearest waterway indicates the degree of risk to surface water. For assessing risks, the distances between substation sites or construction compounds and waterways, and whether they are within the respective VRZ were determined, and are presented in Table 6-13. Generally, streams with a Strahler order of 4 or higher are perennial waterways and potentially contain aquatic ecosystems and species - and the consequence of any impacts would be higher. Strahler order 1 and 2 waterways are generally minor ephemeral drainage lines and do not contain KFH or aquatic species.

The sites that are within VRZs of Strahler order 1 and 2 waterways include:

- Bowmans Lane compound (C15)
- Gregadoo Road compound (C06)
- Maragle 500 kV substation compound (C05)
- Memorial Avenue compound (C14)
- Tumbarumba Accommodation Facility (AC1)
- Yass substation compound (C10).

The only site that is within the VRZ of a higher order waterway is Snowy Mountains Highway compound (C02).

Although the sites outside the VRZ are unlikely to directly impact on waterways, management of the sites are still required to minimise impact to lower order waterways, which eventually drain into significant waterways.

All substations and construction compounds would have a site-specific Erosion and Sedimentation Control Plan (ESCP) or Soil and Water Management Plan (SWMP).

Table 6-13 Potential impacts to waterways from construction compounds and substation sites

Project component	Distance to nearest waterway (m)			
Strahler order	**1**	**2**	**3**	**4+**
Adjungbilly Road compound (C09)	17	267	553	1,654
Bannaby 500 kV substation and Bannaby 500 kV substation compound (C12)	16	73	224	820
Bowmans Lane compound (C15)	0	125	-	165
Proposed Gugaa 500 kV substation and Gregadoo Road compound (C06)	0	0	527	629
Honeysuckle Road compound (C07)	82	295	1,010	1,272
Maragle 500 kV substation and Maragle 500 kV substation compound (C05)	0	189	801	1,714
Memorial Avenue compound (C14)	2	308	451	1,294
Red Hill Road compound (C08)	335	-	441	1,823
Snowy Mountains Highway compound (C02)	-	-	11	525
Snubba Road compound (C03)	364	685	1,191	1,354
Snubba Road compound (C16)	15	266	-	378
Tumbarumba Accommodation Facility (AC1)	-	0	140	1,222
Wagga 330 kV substation and Wagga 330 kV substation compound (C01)	-	-	99	274
Woodhouselee Road compound (C11)	72	431	1,196	1,362
Yass substation compound (C10)	-	12	573	624

6.2.7 Summary of construction impacts on surface water

The potential impacts on a specific waterway would depend upon the types of work, the distance of the work from the waterway and the mitigation measures implemented.

As described in Section 6.2 and Table 6-2, all work within the waterway buffer zone would present a moderate or high risk of sedimentation and erosion impacts. The size of the waterway buffer zone is determined by the Strahler order of the waterway with the larger waterways having a more significant buffer zone.

As the detailed design of the project has yet to be completed, the type and location of work relative to specific waterways has not yet been determined, however one of the key decisions in the design and location of any work would be to minimise direct impacts on waterways and other environmentally sensitive features.

The largest potential impact on geomorphology and water quality is from sedimentation and erosion of an area disturbed by construction or operation which drains directly into a waterway. Potential impacts on waterways are described in Sections 6.2.1, 6.2.2 and 6.2.3. Sedimentation and erosion control risks can be managed through the development and implementation of sediment and erosion control measures based by best practice guidelines in NSW ie the Blue Book. A hierarchy of controls based on sedimentation and erosion risks is proposed in Section 11.1.1 including SWMPs and ESCPs.

In summary, the following impacts were identified for construction impacts on surface waters:

- Erosion risk and sedimentation impacts – Disturbance of the ground through vegetation removal, earthworks, and other construction activities would pose the greatest risk to surface water. Activities to be undertaken in close proximity to a waterway would increase the erosion risk. For the purposes of the assessment, buffer distances were identified around waterways and the potential soil erosion categorised for areas within the project footprint. The sensitivity of a location was determined based on whether it was within a buffer zone of a waterway and its potential soil erosion category. Project components and the type of construction activities were then also considered in deriving an impact significance. For project components such as the access tracks, transmission line easement and structures, a range of impact significances were identified depending upon specific locations. About 58 per cent of the project footprint is considered low risk of erosion and sedimentation impacts on surface water, 29 per cent is moderate risk and 13 per cent is high risk. For other project components that have a discrete location (ie substations), a site-specific impact significance was able to be determined – which were generally low to moderate impact significance. The different impact significance outcomes for different locations would be used to determine the soil and water management measures including erosion and sedimentation control during construction.
- Geomorphology – Potential impacts on geomorphology would be primarily related to erosion risk and sedimentation impacts (ie sediment being washed into waterways) and therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. An additional risk to geomorphology would be waterway crossings associated with access roads. This would have a moderate risk of impacts and would be managed through implementing appropriate design guidelines.
- Water quality – The major potential impact on water quality would be primarily related erosion risk and sedimentation impacts (ie sediment being washed into waterways) and therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. Another potential major risk to water quality would be the 14 construction compounds where some of the concrete batching plants may be located and materials, chemicals and fuels would be stored and used. However apart from two construction compounds, Wagga 330 kV substation compound (C01) and Snowy Mountains Highway (C02) all compounds have been located outside waterway buffer zones. Concrete work with a waterway buffer zone would also be a risk to water quality.
- Water supply – About 510 ML of water would be required over the 2.5-year construction period of which about 13 per cent would need to be potable and remainder would be non-potable water. The total volume of water required for construction is only a fraction of a percentage of the total volume of water allocated under the WSPs in the project footprint. Non-potable water would be sourced from farm dams, sedimentation ponds, potentially groundwater bores and through the purchase of allocations from other water users through water markets. The impact of project on non-potable water users and water availability would be negligible. About two thirds of the potable water requirements is for the worker accommodation facility proposed at Tumbarumba and this would be obtained from the Tumbarumba Water Treatment Plant. The other third of the potable water requirement would be for concrete batching and would be sourced from other local council's town water supply.
- Wastewater disposal – The largest source of wastewater would be from the worker accommodation facility, and this would be connected to the existing Tumbarumba STP. Smaller volumes of wastewater from construction compounds and transmission line construction work would be collected and tankered to appropriate wastewater disposal facilities.

6.3 Potential construction impacts on groundwater

The construction activities identified in this section are based on the hydrogeological setting of the project, proposed construction methodology and the activities that are considered to pose the greatest potential impact to groundwater.

There are four main categories of risks to groundwater are considered in this assessment and how they relate to the NSW AIP:

- groundwater flow paths/recharge
- groundwater levels
- groundwater quality
- registered groundwater users.

Ultimately the risk that the project poses to groundwater resources is likely to be low to moderate, as the main disturbance will be the construction of the five-metre-deep concrete bases for the transmission line structures and the potential to damage one registered groundwater bore as well as the construction of the proposed Gugaa 500 kV substation. Excavations for the bases or substations are unlikely to make significant flow during the short construction period and it is only during this short window that there is any potential to impact groundwater quality. This however can be effectively managed though standard site environmental controls.

The following sections discuss the groundwater impacts as a result of the construction activities defined in Section 2.2.1. Mitigation measures are outlined in Section 11.2.

6.3.1 Changes to groundwater flow paths/recharge

The key construction activities that have the potential to increase the risk to groundwater recharge/flow paths are discussed in Table 6-14.

Table 6-14 Risks to groundwater recharge/flow paths

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Earthworks and construction for transmission line structure footings, laydown and staging areas, construction compounds, helipad, access tracks and substation	These work would require the removal of vegetation, compaction of surfaces, concreting, shallow earthworks, deep earthworks/piling, water use and disposal (dewatering). Alternative methods include bored pile, driven screw pile or helical screw anchor (refer details in Attachment D). The construction of access tracks would require the following tasks which may contribute to groundwater flow paths/recharge impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ shallow earthworks.	Removal of vegetation and compaction of surfaces would change the behaviour of infiltration and groundwater recharge. Compaction of surfaces would cause localised changes to topsoil infiltration rates. Impacts associated with the transmission line structures would be through bulk excavations which may intercept groundwater. Shallow earthworks may intercept perched or high unconfined aquifers, or groundwater near waterways in alluvial areas with high connectivity between groundwater and surface water. As such, dewatering may be required within excavated areas which may impact the flow paths of the surrounding areas. Groundwater is not anticipated to be intersected for shallow excavation in most HSUs, however may be intersected in the Murrumbidgee Alluvium. Groundwater may be intersected during piling, but the limited piling diameter would only cause slight deviations of groundwater flow paths.	Localised changes to topsoil infiltration rates, however these impacts are low. Permanent access tracks are discussed in Section 7.2.4.	Moderate but may vary, dependent on depth to groundwater.	Low based on the quantity of other groundwater users and GDEs within the area.
Substation modification	Substation modification would require the following tasks which may contribute to groundwater flow paths/recharge impacts: ▪ compaction of surfaces ▪ concreting ▪ potential blasting ▪ shallow earthworks ▪ vegetation removal ▪ water use and disposal.	Removal of vegetation and compaction of surfaces would change the behaviour of infiltration and groundwater recharge. Shallow earthworks for cut and fill may intercept perched or high unconfined aquifers, or groundwater near waterways in alluvial areas with high connectivity between groundwater and surface water. As such, dewatering may be required within excavated areas which may impact the flow paths of the surrounding areas.	Localised and permanent. Magnitude of impact would be moderate. Localised and permanent. Magnitude of impact would be low.	Moderate but may vary, dependent on depth to groundwater.	Moderate based on the quantity of other groundwater users and GDEs within the area.
Service relocation and protection work	The following tasks would be required for service relocation and protection work and may contribute to groundwater flow paths/recharge impacts: ▪ compaction of surfaces ▪ shallow earthworks ▪ vegetation removal ▪ water use and disposal.	Shallow earthworks for trenching for the services may intercept perched or high unconfined aquifers, or groundwater near waterways in alluvial areas with high connectivity between groundwater and surface water. As such, dewatering may be required within excavated areas which may impact the flow paths of the surrounding areas.	Localised and temporary impacts. Magnitude of impact would be low.	Moderate but may vary, dependent on depth to groundwater.	Low based on the quantity of other groundwater users and GDEs within the area.

6.3.2 Changes to groundwater levels

The key construction activities that have the potential to increase the risk to groundwater levels are discussed in Table 6-15.

Table 6-15 Risks to groundwater levels

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Earthworks and construction for transmission line structure footings	The construction of transmission line infrastructure would require the following tasks which may contribute to groundwater level impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ concreting ▪ shallow earthworks ▪ deep earthworks/piling ▪ water use and disposal.	Removal of vegetation and compaction of surfaces and shallow earthworks would decrease the recharge conditions and therefore groundwater levels. Groundwater mounding may occur when soils are compacted. It can occur by using driven steel pile methodology for deep foundations as the pile is driven into the underlying sediments using force, causing compaction of the aquifer at, and surrounding the compaction force (compaction halo) at the base of the pile. Groundwater level rises from compaction may be as a result of reduction in storativity/aquifer compression. Where piling is undertaken using bored pile/cast in-situ methodology and intersects the groundwater table, concrete would be poured wet into the pile footings. This would result in minimal water being removed from the top of the concrete, as required and of driven or screw pile methodology would also not result in dewatering. Wastewater disposal would be via a treatment plant and would therefore have no impact on groundwater levels. At the time of writing, there are no plans to use groundwater as a source of water supply for the project. All water supplies will be from previously allocated water sources and will comply with the relevant WSP. As a result there will be no additional impacts from project on water supplies.	Localised and permanent. Magnitude of impact would be low.	Low but may vary, dependent on depth to groundwater.	Negligible
Access track construction	Access track construction would require the following tasks which may groundwater level impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ shallow earthworks.	Removal of vegetation and compaction of surfaces and shallow earthworks would change the recharge conditions and therefore groundwater levels. Groundwater mounding may occur when soils are compacted. This may occur during the construction of the project where it may be necessary to improve the shallow soils ability to support structures or vehicles. The compaction may cause changes in the permeability of the sediments, impacting groundwater flow resulting in groundwater level rise.	Localised and temporary impacts. Magnitude of impact would be low.	Low but may vary, dependent on depth to groundwater.	Negligible based on the size and the rate of change of recharge and amount of required dewatering required.

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Substation modification and construction	Substation modification and construction would require the following tasks which may contribute to groundwater level impacts: ■ compaction of surfaces ■ concreting ■ potential blasting ■ shallow earthworks ■ vegetation removal ■ water use and disposal.	Removal of vegetation and compaction of surfaces and shallow earthworks would change the recharge conditions and therefore groundwater levels. Shallow earthworks for cut and fill may intercept perched or high unconfined aquifers, or groundwater near waterways in alluvial areas with high connectivity between groundwater and surface water. As such, dewatering may be required within excavated areas which may impact the flow paths of the surrounding areas which may cause localise changes in groundwater levels. Groundwater mounding may occur when soils are compacted. The compaction may cause changes in the permeability of the sediments, impacting groundwater flow resulting in groundwater level rise. Substation construction may intercept the regional groundwater table through bulk excavations required for foundations and potential localised controlled blasting. Where blasting is undertaken, it has the potential to fracture the surrounding rock, which may result in localised groundwater level decline.	Localised and permanent. Magnitude of impact would be moderate	Moderate but may vary, dependent on depth to groundwater.	High/ moderate based on the quantity of other groundwater users and GDEs within the area.
Laydown and staging areas, construction compounds, helipad and material storage	The following tasks would be required and may contribute to groundwater level impacts: ■ compaction of surfaces ■ shallow earthworks ■ vegetation removal ■ water use and disposal.	Removal of vegetation and compaction of surfaces and shallow earthworks would change the recharge conditions and therefore groundwater levels. Groundwater mounding may occur when soils are compacted. The compaction may cause changes in the permeability of the sediments, impacting groundwater flow resulting in groundwater level rise.	Localised and temporary impacts. Magnitude of impact would be low.	Low but may vary, dependent on depth to groundwater.	Negligible based on the size and the rate of change of recharge and amount of required dewatering required.
Service relocation and protection work Helipad construction	The following tasks would be required for helipad construction service relocation and protection work and may contribute to groundwater level impacts: ■ compaction of surfaces ■ concreting ■ shallow earthworks ■ vegetation removal ■ water use and disposal.	Removal of vegetation and compaction of surfaces and shallow earthworks would change the recharge conditions and therefore groundwater levels. Mounding may occur when soils are compacted. The compaction may cause changes in the permeability of the sediments, impacting groundwater flow resulting in groundwater level rise. Shallow earthworks for trenching for the services and helipad construction may intercept perched or high unconfined aquifers, or groundwater near waterways in alluvial areas with high connectivity between groundwater and surface water. As such, dewatering may be required within excavated areas which may impact the flow paths of the surrounding areas, dewatering may have an impact of localised groundwater levels.	Localised and temporary impacts. Magnitude of impact would be low.	Low but may vary, dependent on depth to groundwater.	Negligible based on the size and the rate of change of recharge and amount of dewatering required.

6.3.3 Changes to groundwater quality

The key construction activities that have the potential to increase the risk to groundwater quality are discussed in Table 6-16.

Table 6-16 Risks to groundwater quality

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Earthworks and construction for transmission line structure footings Access track construction Laydown and staging areas, construction compounds and material storage	The construction of transmission line infrastructure would require the following tasks which may contribute to groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ concreting ▪ shallow earthworks ▪ deep earthworks/piling ▪ storage of material. Access track construction would require the following tasks which may groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ shallow earthworks. The following tasks would be required for laydown and staging areas and compounds and material storage, and may contribute to groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ shallow earthworks ▪ storage of material.	Vegetation clearance and shallow earthworks would not directly impact groundwater quality. Pollutants may be transported from surface water through infiltration to groundwater however in most of the project footprint, connectivity between surface water and groundwater is low (refer to Section 6.2.3 for further discussion). Groundwater quality may potentially be impacted through degradation of the infrastructure foundation (piles) or footing material if inappropriately selected to withstand the salinity and aggressivity of the groundwater (and soil) environment. However, this impact is unlikely as the materials selected for the project would consider the existing environment, including any areas of elevated salinity. Saline groundwater may impact the durability of construction materials through degradation of cementitious foundation substrate, potential leaching into and impacting the surrounding groundwater quality. The impact would be related to the rate of corrosion and surface area of the impacted material.	Localised and permanent. Magnitude of impact would be low.	Moderate but may vary, dependent on depth to groundwater.	Low based on groundwater resources that are of unknown/varying qualities throughout the project as well as there are existing groundwater users.

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Substation modification and construction	Substation modification and construction would require the following tasks which may contribute to groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ concreting ▪ shallow earthworks ▪ water use and disposal ▪ potential blasting.	Vegetation clearance and shallow earthworks would not directly impact groundwater quality. Pollutants may be transported from surface water through infiltration to groundwater however in most of the project footprint, connectivity between surface water and groundwater is low (refer to Section 6.2.3 for further discussion). Saline groundwater may impact the durability of construction materials through degradation of cementitious foundation substrate, potential leaching into and impacting the surrounding groundwater quality. The impact would be related to the rate of corrosion. Where blasting is required in areas of shallow hard rock, it has the potential to fracture the surrounding rock, potentially altering groundwater flow paths. This could lead to mobilising existing groundwater contamination plumes and saline groundwater or increased seepage to the groundwater aquifer from overlying contaminated sediments. The potential impact to groundwater quality would be related to the extent and degree of the contaminated groundwater plume, saline groundwater or overlying contaminated sediments. However, as the blast halo is anticipated to be limited and such the impact is considered low, it is unlikely that controlled blasting would result in changes to groundwater quality as the existing groundwater would be comparable within the blasting halo.	Localised and permanent. Magnitude of impact would be low.	Moderate but may vary, dependent on depth to groundwater.	Low based on groundwater resources that are of unknown/varying qualities throughout the project as well as there are existing groundwater users.
Service relocation and protection work Helipad construction	The following tasks would be required for service relocation and protection work and may contribute to groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ shallow earthworks ▪ storage of material. The following tasks would be required for helipad construction and may contribute to groundwater quality impacts: ▪ vegetation removal ▪ compaction of surfaces ▪ concreting ▪ shallow earthworks ▪ water use and disposal.	Vegetation clearance and shallow earthworks would not directly impact groundwater quality. Pollutants may be transported from surface water through infiltration to groundwater however in most of the project footprint, connectivity between surface water and groundwater is low (refer to Section 6.2.3 for further discussion).	Localised and permanent. Magnitude of impact would be low.	Moderate but may vary, dependent on depth to groundwater.	Low based on groundwater resources that are of unknown/varying qualities throughout the project as well as there are existing groundwater users.

6.3.4 Changes to existing groundwater users

Construction activities can potentially interface with the groundwater in nearby bores, particularly where groundwater levels are shallow, which could impact on existing groundwater users. The users likely to be impacted are those within or close to the project footprint. Registered bores within one kilometre of the project footprint and their respective standing water levels are shown in Table 5-17. Specific details of each bore are discussed in Attachment D. Additionally, the final depth categories of 206 bores within one kilometre of the project footprint are detailed in Table 6-17.

Table 6-17 Depths of bores within one kilometre of project footprint

Final depth categories (m)	Commercial and industrial	Exploration	Irrigation	Monitoring	Stock and domestic	Unknown	Water supply	Total
<10	0	1	2	41	1	5	0	50
10-50	0	1	4	27	13	9	50	104
50+	1	1	7	3	1	7	32	52
Total	**1**	**3**	**13**	**71**	**15**	**21**	**82**	**206**

Registered bores within the project footprint (refer to Table 6-18) are considered to be likely impacted by being physically damaged or the likely need to be removed and/ or replaced, if structures are or construction causes direct damage to the bores by machinery, vibrations or infrastructure.

Table 6-18 Bores identified within project footprint

Bore ID	Bore type	Bore depth (m)
GW027978	Stock and Domestic	15.5
GW400409	Water Supply	24
GW402618	Irrigation	0
GW403471	Monitoring	9
GW403486	Monitoring	13.5
GW415977	Monitoring	25
GW415978	Monitoring	10.6
GW416662	Water Supply	56
GW417071	Stock and Domestic	150

The key construction activities that have the potential to increase the risk to groundwater quality are discussed in Table 6-19.

Table 6-19 Risks to groundwater users

Activity	Description	Effect/s	Impact magnitude	Sensitivity	Impact significance (without mitigation)
Earthworks and construction for transmission line structures such as footings, access tracks, laydown and staging areas, and material storage areas	The construction activities would require the following tasks which may contribute to groundwater impacts to existing users: ▪ vegetation removal ▪ compaction of surfaces ▪ concreting ▪ shallow earthworks ▪ deep earthworks/piling/foundations and footings ▪ storage of material.	As discussed in Table 6-10, connectivity between surface water and groundwater is low, therefore impact from vegetation clearance and earthworks is low. Groundwater quality may potentially be impacted through degradation of the infrastructure foundation (piles) or footing material if inappropriately selected to withstand the salinity and aggressivity of the groundwater (and soil) environment. However, this impact is unlikely as the materials selected for the project would consider the existing environment, including any areas of elevated salinity.	Localised and permanent. Magnitude of impact would be low.	Sensitivity of the activities depends on location and depth to groundwater. If bores are located outside of the project footprint, the sensitivity would be low. The one registered groundwater bore (GW027978, stock and domestic) that is both within the footprint and accesses groundwater from a relatively shallow depth, was considered to be of a higher sensitivity than other bores that were deeper and or out of the footprint. Water supply, irrigation and stock and domestic bores would be more sensitive than monitoring bores. If bores are within project footprint and groundwater levels are shallow (<5m), high sensitivity as there is potential that earthworks could encounter groundwater.	Low to high based on location and groundwater level.

6.3.5 Summary of potential construction impacts to groundwater

During construction, substation construction/modification would have the potential to cause the greatest impact to groundwater on the project. Substation construction/ modification have the greatest impact to groundwater flow paths/recharge and groundwater levels. This is primarily due to the moderate to high magnitude of the work as a result of large areas needing to have vegetation removed, filled, compacted, and concreted. Substation modification is predicted to have minimal impact on water quality with an initial significance rating of low.

All other activities during construction would have negligible to low impact initial significance level ratings, including deep transmission line structure piles, as these have a small surface area and are unlikely to restrict groundwater flows or alter water quality.

7 Operational impacts

This section assesses the potential impacts of the project to surface water and groundwater during the operational phase of the project. Project components which have potential to influence and impact on surface water and groundwater are discussed in Chapter 2.

7.1 Potential operational impacts to surface water

The operational activities discussed in this section are considered to pose the greatest potential impact to surface water, including:

- erosion risk and sedimentation of surface water
- geomorphology
- water quality
- water supply and wastewater disposal.

The degree of impacts would vary depending on the location of the project component and proximity to sensitive receiving environments, as discussed further in Section 5.7.

The magnitude of the impacts increases as project components are located closer to surface water and groundwater features as well as sensitive receiving environments. This can be summarised in three main locations, with increasing potential for impacts:

- within a waterway catchment with direct overland flow to waterway
- on the waterfront land (refer to Section 3.2.7)
- within the waterway.

Other aspects related to surface water such as flooding are assessed in detail in *Technical Report 11 – Hydrology and Flooding Impact Assessment*.

Operational surface water mitigation measures are outlined in Section 11.2.

7.1.1 Erosion risk and sedimentation impacts

Similar to construction impacts, soil erosion may arise from vegetation removal and maintenance during the operation of the project. These potential risks are outlined in Table 7-1.

As discussed in Section 5.4.3, detailed erosion risk information has been sourced and erosion risk for the risk assessment has been categorised as the following:

- low: up to 200 t ha^{-1} yr^{-1}
- moderate: between 200 and 1000 t ha^{-1} yr^{-1}
- high: greater than 1000 t ha^{-1} yr^{-1}.

Erosion risk information has been overlain by the project footprint and waterway buffer zones. This combined information were used to determine the sensitivity of potential impacts at any location within the project footprint. The sensitivity risk for a particular location has been determined based upon Table 6-2**.** All locations within the buffer zone of a waterway would have a minimum of moderate sensitivity.

Table 7-1 Erosion risk impacts to surface water from operation activities

Project component	Impact magnitude	Sensitivity	Impact significance without mitigation
Transmission line structures – involving vegetation maintenance	Vegetation decreases the velocity of overland flow. Storage/uptake of water sourced from rainfall by vegetation reduces surface runoff being generated, which in turn reduces rill initiation and gully erosion. In the absence of vegetation protecting the soil, erosion could be elevated. This effect would be more pronounced where there is a combination of higher rainfall intensity and high erosion risk areas as presented in Figure 4.16. Groundcover would be maintained and encouraged wherever possible. Overall, the potential impact magnitude would be low.	Low to high based on location and erosion risk presented in Figure 5-18 and Table 6-2	Low to high based on location and erosion risk
Operation of permanent access tracks (waterway crossings) – vegetation clearing	Permanent access tracks within surface water catchments, more specifically ones that intersect the VRZ of waterways, would increase local runoff. Increased runoff during wet weather events may increase erosion and sediment conveyancing capacity, thus impacting the transfer of exposed soils from the tracks to waterways. Areas of higher modelled erosion risks (refer to Section 5.4.3) are likely to have higher magnitude of impacts but generally ranging from low to moderate.	Low to high based on location and erosion risk presented in Figure 5-18 and Table 6-2	Low to high based on location and erosion risk
Operation of new substation – involves vegetation removal and maintenance	Negligible impact is expected for the operation of the proposed Gugaa 500 kV substation. Major vegetation work would have been completed in the construction phase, and only maintenance work would be required for operation. Erosion risk would increase with less vegetation to intercept rainfall, however, due to the distance to waterway, low modelled soil erosion and flat topography, impact is negligible.	Low based on location and erosion risk presented in Figure 5-18 and Table 6-2	Low

7.1.2 Geomorphology

Geomorphology impacts from operations would arise from the direct disturbance caused by modification of the Bannaby 500 kV substation (the other substations are not located close enough to waterways to have geomorphology impacts), permanent waterway crossings, access tracks and roads that would remain after construction. Some access tracks established during construction may remain across waterways during operation. These permanent structures may further alter the flow and bank stability and consequently affect the geomorphology of the waterways.

The potential for waterway crossings to increase geomorphology risk during operation of the project is discussed in Table 7-2.

Table 7-2 Geomorphology risk impacts to surface water from operation activities

Project component	Impact magnitude	Sensitivity	Impact significance without mitigation
Permanent waterway crossings, access roads and tracks	The level of impact on waterway crossings is dependent on the number of structures that remain, bank conditions after construction, flow rates and location of the work. The impact to the geomorphology where waterway crossings would be localised, however the magnitude of the impact would be moderate.	Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2.	Low to high
Bannaby 500 kV substation	The modification of the Bannaby 500 kV substation would be located adjacent to an unnamed tributary to Wollondilly River approximately 45 km north-east of Goulburn. Based on the current footprint of the expansion, the work would be conducted on waterfront land and thus may have direct impact on the geomorphology of an unnamed tributary to Wollondilly River as well as increased erosion of channels due to change of land cover (increased impervious surface) and therefore larger volumes of runoff.	Moderate (localised yet permanent)	Moderate

7.1.3 Water quality

In addition to the risks posed by erosion, other potential hazards that will increase water quality risks during the operation of the project may include:

- accidental spillage of chemicals, fuels and heavy metal from refuelling and operation of equipment and vehicles
- gross pollutants such as paper and plastic packaging brought by personnel and not properly disposed of
- stormwater runoff may increase with the removal of vegetation and increase in hardstand areas for the telecommunications hut and substations. Water quality risks arise from runoff carrying additional nutrients and chemicals to localised waterways. This in turn may lead to indirect impacts such as increased turbidity, lower dissolved oxygen levels and algal bloom.

The key operation activities that have the potential to increase water quality risk to nearby waterways are discussed in Table 7-3.

Table 7-3 Water quality risks from operation activities

Project component	Activities and impact magnitude	Sensitivity	Impact significance
Transmission lines and structures	Incidents such as accidental spills, leaks from vehicle use and improper disposal of waste may pose minor, localised and temporary impacts. Vegetation maintenance activities may have result in erosion risks. The magnitude of impact is low.	Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2	Low to high
Waterway crossings	Surfaces with low perviousness may lead to oils, fuels, and waste from traffic use to be collected on the tracks and then transported during a wet weather event into the nearby waterway. The waterway crossings may also cause stagnation of water on the upstream side of the structure at cease-to-flow levels, leading to an accumulation of oxygen-poor water. Potential impacts would be low, localised, and temporary.	Low to high Low to high based on a location's proximity to waterways and soil erosion risk – refer to Table 6-2.	Low to high
Telecommunications hut	Incidents such as accidental spills, leaks from vehicle use and improper disposal of waste may pose minor, localised and temporary impacts. Also, the small increase in hardstand area for telecommunications hut would result in minimal increase in stormwater runoff. Therefore, the potential impact is low.	Low based on location and soil erodibility.	Low
Substations	The increased area of impervious area of the modified Bannaby 500 kV substation would result in more stormwater runoff to carry pollutants on the concreted surfaces to the nearby waterway. Spills and litter from the operation and maintenance of the substation may cause water quality impacts to the unnamed tributary of Wollondilly River (approximately 45 kilometres north-east of Goulburn). However, any predicted water quality impacts would be addressed through the drainage and stormwater design.	Low to moderate based on location.	Moderate

7.1.4 Water supply

The expected volumes for the operation and maintenance of the substations and water sources are presented in Table 7-4.

Table 7-4 Estimated annual water required for operation of substations

Substation	Estimated annual water (kL)	Water supply	Comments
Proposed Gugaa 500 kV substation	62	Rainwater tank feed from secondary systems building that allows for water to be trucked in for top-up.	Not expecting connection to mains water.
Bannaby 500 kV substation	27	No changes to existing water supply arrangements are proposed.	Annual water requirements are in addition to existing requirements.
Wagga 330 kV substation	27	No changes to existing water supply arrangements are proposed.	Annual water requirements are in addition to existing requirements.

Given the very low annual demands from each substation, the operations of the project would have negligible impact on water resources.

7.1.5 Wastewater disposal

Wastewater generated throughout the project's operation would only be from the substations. The annual volumes of wastewater estimated to be generated by the substations is shown in Table 7-5.

No additional infrastructure that produces wastewater would be constructed at either the Bannaby 500 kV substation or Wagga 330 kV substation, however a free-standing toilet is proposed for the proposed Gugaa 500 kV substation. Disposal of wastewater from the substations would be via connection to a town sewage system or an on-site aerated water treatment system. During operation of the substation, there is a potential for contaminated water resulting from accidental spills or leaks of equipment. These would be contained in the substation containment system and transported to a licensed water disposal facility. The disposal of contaminated water is outside the scope of this assessment.

Table 7-5 Annual wastewater volume generated by substation operation

Project component	Volume generated (kL)
Proposed Gugaa 500 kV substation operation	60.8
Bannaby 500 kV substation operation	26.0
Wagga 330 kV substation operation	26.0
Total	**112.8**

7.1.6 Summary of potential operational impacts on surface water

The potential impacts on surface water due to operational activities are summarised below:

- Erosion risk – **Low to high** for vegetation clearance for transmission line structures and permanent access tracks and roads. **Low** for the operation of substations.
- Geomorphology – **Low to high** for permanent waterway crossings and access tracks. **Moderate** for modification of the Bannaby 500 kV substation.
- Water quality – **Low to high** along transmission line easement and transmission line structures and waterway crossings. **Low** for operation of the substations and the telecommunications hut.
- Water supply and disposal – **Low** for all substations.

7.2 Potential operational impacts on groundwater

The operational activities identified in this section were assessed in a similar manner to that used for the construction impacts, by outlining what is considered to pose the greatest potential impact to groundwater resources.

There are four main categories of impacts to groundwater are considered in this assessment and how they relate to the NSW AIP:

- groundwater flow paths/recharge
- groundwater levels
- groundwater quality
- registered groundwater users.

As with the construction phase, the likely impact of the project to groundwater resources would be negligible to low during its operational life. The concrete bases established for the proposed Gugaa 500 kV substation or deep piles constructed for the transmission line structures are unlikely to restrict groundwater levels/flow directions or change water quality in the long term.

7.2.1 Changes to groundwater flow paths

Changes to groundwater flow paths may arise from stormwater runoff and groundwater interference from the substations and transmission line structures respectively. These potential impacts are outlined in Table 7-6.

Table 7-6 Changes to groundwater flow path/recharge due to operation activities

Project component	Effect/s	Impact magnitude	Sensitivity	Impact significance
Transmission line structures - piling and footings	Piles for the transmission line structures may cause localised changes to groundwater flow paths.	Localised and permanent. Magnitude is low.	Low to moderate based on depth to groundwater and location.	Negligible to low
Substations and access tracks – impervious surfaces	The localised increase of impervious surfaces due to construction of concrete bases at the new substation and substation modifications would potentially reduce localised recharge to the below groundwater resources. Surface runoff may transport the water to another area before infiltration/recharge occurs.	Localised and permanent. Magnitude is low.	Low to moderate based on depth to groundwater and location.	Negligible to low

7.2.2 Changes to groundwater levels

Changes to groundwater levels may arise from an increase of impervious surfaces from the substations and transmission line structures. The potential impacts are outlined in Table 7-7.

Table 7-7 Changes to groundwater level due to operation activities

Project component	Effect/s	Impact magnitude	Sensitivity	Impact significance
Transmission line structures, substation, and access tracks – impervious surfaces	Groundwater levels may also be impacted through changing the natural pervious land surface into impermeable layers such as concrete pavement as part of the transmission line structures, substation modification and construction as well as access tracks. This can reduce infiltration of rainfall and surface water recharge to the underlying aquifer. This potential impact could result in the lowering of groundwater levels and would be greatest at the transmission line structure.	Localised and permanent. Magnitude is low.	Low	Negligible

7.2.3 Changes to groundwater quality

Changes to groundwater quality may arise from stormwater runoff and groundwater interference from the substations, access tracks and transmission line structures. These potential impacts are outlined in Table 7-8.

Table 7-8 Risks to groundwater quality during operation

Project component	Effect/s	Impact magnitude	Sensitivity	Impact significance
Transmission line structures – piling and footing materials	Groundwater quality may potentially be impacted through degradation of the infrastructure foundation (piles) or footing material if inappropriately selected to withstand the salinity and aggressivity of the groundwater (and soil) environment. The water quality of underlying aquifers and lower gradients in the project footprint would have the potential to be degraded as a result of the project. The operational activities that may impact water quality are related to maintenance activities along the transmission lines and would be a result of infiltration.	Localised and permanent. Magnitude is low.	Low	Negligible
Substations and access tracks – runoff from impervious surfaces	New impervious areas at the substations may result in the mobilisation of underlying salts and contaminants to the aquifers. This would occur through surface water contamination and the disturbance of contaminated soils or problem soils (saline, potential acid sulfate soils or acid sulfate soils) as part of maintenance activities. Saline groundwater can impact the durability of construction materials through degradation of cementitious foundation substrate, potential leaching into and impacting the surrounding groundwater quality.	Localised and permanent. Magnitude is low.	Low	Negligible

7.2.4 Changes to groundwater users

Changes to groundwater flow paths may arise from water quality from the substations, transmission line structures and access tracks, impacting existing groundwater users. These potential impacts are outlined in Table 7-9.

Table 7-9 Changes to groundwater users due to operation activities

Project component	Effect/s	Impact magnitude	Sensitivity	Impact significance
Transmission line structures, substations, and access tracks – water quality impacts	As discussed in Table 6-16, shallow groundwater quality may be slightly degraded due to the potential for a chemical or fuel spill from plant and machinery during operation. These operations would have mitigation measures in place to reduce the likelihood of occurrence and therefore harm. In the unlikely event of a spill groundwater users would have to obtain groundwater from another resource if the groundwater quality is impacted	Localised and permanent. Magnitude is low.	Low	Negligible

8 Minimal impact considerations

As stated in Section 3.2.5, the Aquifer Interference Policy includes minimal impact considerations for assessing the impacts of all aquifer interference activities. The methodology described in Section 4.6 was followed. NSW groundwater sources need to be categorised as being either highly productive or less productive, based on the general character of the water source meeting or not meeting the criteria of 1,500 mg/L total dissolved solids and a bore yield rate of greater than 5 L/s. This categorisation applies to a whole groundwater source as it is defined in a WSP, not to the specific groundwater conditions at a specific location.

In the surface water and groundwater study area, the categorisation is as follows:

- Mid Murrumbidgee Alluvium Groundwater Sources – highly productive. The water source is considered as highly productive given the water quality is expected to be fresh, with an EC range of 150 - 950 µS/cm. As there is limited information on groundwater yield, a conservative approach has been applied and this groundwater source is classified as a highly productive alluvial groundwater source that is highly connected to surface water sources.
- Goulburn Fractured Rock – highly productive. As there is limited information on the total dissolved solids and groundwater yield, a conservative approach has been applied and this groundwater source is classified as a highly productive fractured rock water source that is highly connected to surface water sources.
- Lachlan Fold Belt – less productive. These groundwater sources are categorised as less productive as the bore yields are generally low, supplying less than 3 L/s. The water table in the Lachlan Fold Belt is typically deep and not linked to surface water flow.

AIP minimal impacts considerations are shown in Table 8-1, Table 8-2 and Table 8-3.

Table 8-1 Aquifer Interference Policy Minimal impact considerations for 'highly productive alluvial water sources' – Murrumbidgee Alluvium (Mid Murrumbidgee Alluvium groundwater source)

Feature	Minimal impacts considerations	Response
Water table	Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem ▪ high priority culturally significant site ▪ listed in the schedule of the relevant WSP ▪ a maximum of a two-metre decline cumulatively at any water supply work.	No groundwater take is anticipated for the construction or operation of the project.
	|f more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem ▪ high priority culturally significant site ▪ listed in the schedule of the relevant WSP then appropriate studies would need to demonstrate to the Minister's satisfaction that the variation would not prevent the long-term viability of the dependent ecosystem or significant site. If more than two metre decline cumulatively at any water supply work, then make good provisions should apply.	
Water pressure	A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a two-metre decline, at any water supply work.	Pressure heads are not anticipated to be lowered (or raised) due to the expected depth of the confined aquifers in the surface water and groundwater study area and selection of appropriate construction methodologies.
	If the predicted pressure head decline is greater than the water pressure requirement above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline would not prevent the long-term viability of the affected water supply work unless make good provisions apply.	
Water quality	(a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity: and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected surface water source that is defined as a "reliable water supply" is not an appropriate mitigation measure to meet considerations (a) and (b) above. (c) No mining activity to be below the natural ground surface within 200 metres laterally from the top of high bank or 100 metres vertically beneath (or the three-dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a "reliable water supply". (d) Not more than 10% cumulatively of the three-dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 metres laterally from the top of high bank and 100 metres vertically beneath a highly connected surface water source that is defined as a "reliable water supply".	The project is not anticipated to result in: ▪ a change in groundwater quality which would lower the beneficial use category ▪ increase of more than 1% per activity in long-term average salinity in connected surface water sources. The project is not a mining activity.

Feature	Minimal impacts considerations	Response
	If condition (a) above is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work. If condition (b) or (d) above are not met, then appropriate studies are required to demonstrate to the Minister's satisfaction that the River Condition Index category of the highly connected surface water source will not be reduced at the nearest point to the activity. If (c) or (d) above are not met, then appropriate studies are required to demonstrate to the Minister's satisfaction that: there will be negligible riverbank or high wall instability risks; ▪ during the activity's operation and post-closure, levee banks and landform design should prevent the Probable Maximum Flood from entering the activity's site; and ▪ low-permeability barriers between the site and the highly connected surface water source will be appropriately designed, installed, and maintained to ensure their long-term effectiveness at minimising interaction between saline groundwater and the highly connected surface water supply;	

Table 8-2 Aquifer Interference Policy Minimal impact considerations for a 'lowly productive fractured rock aquifer' – Lachlan fractured rock

Feature	Minimal impacts considerations	Response
Water table	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 metres from any: - high priority groundwater dependent ecosystem - high priority culturally significant site - listing in the schedule of the relevant WSP. A maximum of a two-metre decline cumulatively at any water supply work unless make good provisions should apply.	There is generally low risk of the project causing equal to or greater than 10% cumulative variation in the water table from any high priority (equivalent to high potential) GDE or culturally significant site or over two metre decline cumulatively at any water supply work as no groundwater take is anticipated for the construction or operation of the project. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, the project is not expected to result in equal to or greater than 10% cumulative variation in the water table from any high priority (equivalent to high potential) GDE or culturally significant site or over two metre decline cumulatively at any water supply work.
	If more than 10% cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 metres from any: - high priority groundwater dependent ecosystem - high priority culturally significant site - listing in the schedule of the relevant WSP then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will prevent the long-term viability of the dependent ecosystem or significant site - if more than a two-metre decline cumulatively at any water supply work, then make good provisions should apply.	
Water pressure	A cumulative pressure head decline of not more than 40% of the "post-water sharing plan" pressure head above the base of the water source to a maximum of a two metres decline, at any water supply work.	There is generally low risk of the project causing a cumulative pressure head decline of two metres at any supply work as groundwater take is not anticipated for the construction or operation of the project. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, is not expected to result in a cumulative pressure head decline of two metres at any supply work.
	If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply work unless make good provisions apply.	
Water quality	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	The project is generally not anticipated to result in a change in groundwater quality which would lower the beneficial use category. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, is not expected to result in a change in groundwater quality which would lower the beneficial use category.
	If the above condition is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work.	

Table 8-3 **Aquifer Interference Policy Minimal impact considerations for 'highly productive alluvial water sources' – Goulburn Fractured Rock**

Feature	Minimal impacts considerations	Response
Water table	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem ▪ high priority culturally significant site ▪ listing in the schedule of the relevant WSP. A maximum of a two-metre decline cumulatively at any water supply work. If more than 10 per cent cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 metres from any: ▪ high priority groundwater dependent ecosystem ▪ high priority culturally significant site ▪ listing in the schedule of the relevant WSP then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will prevent the long-term viability of the dependent ecosystem or significant site ▪ if more than a two-metre decline cumulatively at any water supply work, then make good provisions should apply.	There is generally low risk of the project causing equal to or greater than ten per cent cumulative variation in the water table from any high priority (equivalent to high potential) GDE or culturally significant site or over two metre decline cumulatively at any water supply work as no groundwater take is anticipated for the construction or operation of the project. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, is not expected to result in equal to or greater than ten per cent cumulative variation in the water table from any high priority (equivalent to high potential) GDE or culturally significant site or over two metre decline cumulatively at any water supply work.
Water pressure	A cumulative pressure head decline of not more than a two-metre decline, at any water supply work. If the predicted pressure head decline is greater than requirement 1 above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply work unless make good provisions apply.	There is generally low risk of the project causing a cumulative pressure head decline of two metres at any supply work as groundwater take is not anticipated for the construction or operation of the project. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, is not expected to result in a cumulative pressure head decline of two metres at any supply work.
Water quality	Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. If the above condition is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work.	The project is generally not anticipated to result in a change in groundwater quality which would lower the beneficial use category. Subject to the appropriate mitigation measures identified in Section 11.2, if blasting is undertaken in areas of shallow hard rock, is not expected to result in a change in groundwater quality which would lower the beneficial use category.

9 NorBE Assessment (construction and operation phase)

NorBE assessments apply to all releases of water, wastewater and other contaminants from the sites within the Sydney Drinking Water Catchment (SDWC) that may affect water quality, during both construction and operation. Approximately 65 kilometres or about 17 per cent of the proposed transmission line is located in the SDWC. While the transmission line would cross waterways including the Wollondilly River, about 80 per cent of the length of the transmission line in the SDWC is located on cleared, undulating agricultural land – which significantly reduces the risks of sedimentation and erosion impacts. In steeper and vegetated land within the SDWC, measures such as retaining vegetation in steep areas where the required clearances to the transmission line can be maintained would be implemented. This may significantly reduce sedimentation and erosion control impacts.

As the detailed design of the project is yet to be completed, the exact location of work relative to specific waterways has not yet been determined. However, any work within the waterway buffer zones would have a moderate or high risk of sedimentation and erosion impacts and would require the preparation of site-specific ESCPs given the sensitivity of the waterways.

The Bannaby 500 kV substation, which is located in the SDWC, would be upgraded. This would include new concrete bunded bench areas on which electrical transmission infrastructure would be installed. Any runoff from or spills on the bunded bench area would be captured and treated before either discharge off-site (eg uncontaminated runoff) or disposal at an appropriately licenced location (eg water contaminated by a fuel spill) as per existing operations.

The processes set out in the *Neutral or Beneficial Effect on Water Quality Assessment Guideline 2022* (WaterNSW, 2022a) detail a methodology for determining the potential impact a project may have on the receiving catchment. As the transmission lines and associated structures are located within the SDWC, a NorBE assessment has been completed for the project footprint and is provided in Table 9-1.

Table 9-1 NorBE Assessment for Sydney Drinking Water Catchment

NorBE assessment – is there likely to be a neutral or beneficial effect on water quality?	
Are there any identifiable potential impacts on water quality?	Potential impacts to surface water quality may occur from erosion and sedimentation, accidental spills, physical damage to waterways and changes in surface runoff patterns.
What pollutants are likely?	Nutrients (nitrogen and phosphorus), sediment and particle-bounds contaminants, hazardous chemicals (such as oil/fuel/hydrocarbons/heavy metals), acid sulfate soils, gross pollutants eg paper and plastic materials from construction footprint material and litter, tannins, construction materials. Further discussion is presented in Section 6.2.3 and Section 7.1.3.
At what stage do the impacts occur?	During construction and operation.
For each pollutant list the safeguards needed to prevent or mitigate potential impacts on water quality? These may be WaterNSW endorsed current recommended practices (CRPs) and/or equally effective other practices)	For construction, a SWMP would be prepared to manage and mitigate risks from sediments, nutrients, hazardous chemicals, acid sulfate soils and gross pollutants. The SWMP would include the following sub-plans: ▪ ESCPs for specific sites and activities ▪ Emergency Spill Procedure ▪ Unexpected Contaminants Finds Protocol ▪ Acid Sulfate Soils Management Plan. The following guidelines would be used in the mitigation of potential impacts including: ▪ Developments in the Sydney Drinking Water Catchment - Water Quality Information Requirements (WaterNSW, 2020) ▪ Managing Urban Stormwater: Soils and Construction - Volume 1 (Landcom, 2004) ▪ Managing Urban Stormwater: Soils and Construction - Volume 2C (DECC, 2008b) For operation, appropriate environmental management plans and procedures would be developed for the maintenance of the transmission line infrastructure to mitigate water quality impacts. These could include: ▪ Land and rehabilitation management procedures ▪ Maintenance of waterway crossings ▪ Emergency spill procedure A gap analysis would be undertaken to review existing plans and procedures (including those at the Bannaby 500 kV substation and Wagga 330 kV substation) to ensure all aspects water quality management is addressed within these plans. A site-specific plan would be developed for the proposed Gugaa 500 kV substation.
Will the safeguards be adequate for the time required? How will they need to be maintained?	Safeguards would be implemented for the length of time necessary to mitigate impacts. For construction this would until all construction activities had been completed and relevant disturbed areas have been rehabilitated. For operations, all mitigation measures would be in place for the life of the project. Further discussion presented in discussed in Chapter 11.
Will all impacts on water quality be effectively contained on the site by identified safeguards (above) and not reach any waterway, waterbody, or drainage depression? Or will impacts on water quality be transferred outside the site for treatment? How? Why?	The majority of impacts would be contained on site with the implementation of appropriate mitigation measures identified in Chapter 11. Due to their inherent nature, waterway crossing impacts would not be fully contained away from all waterways, waterbodies, or drainage depressions. The project would apply best practice in construction of these crossings to minimise risk. If impacts on sensitive waterbodies cannot be reasonably avoided, specialist geomorphology and biodiversity advice would be sought at detailed design phase.
Is it likely that NorBE on water quality will occur? Justify	With the implementation of mitigation measures provided in Chapter 11, the project is expected to have an overall neutral impact on water quality during construction and an overall neutral impact during operation.

10 Cumulative impacts

Assessing cumulative impacts involves the consideration of the proposed impact in the context of surface water and groundwater disturbance. The assessment of cumulative impacts also considers projects that are currently under development, or at the planning state that may also influence the assessment of this project's potential impacts. Cumulative impacts can potentially arise from the interaction of the construction and operation activities of the project and other future projects nearby.

The cumulative impact assessment was prepared in accordance with the *Cumulative Impact Assessment Guidelines for State Significant Projects* (DPE, 2022). Projects with the potential for cumulative impacts with the project were identified through a review of publicly available information and environmental impact assessments from the following data sources in March 2023:

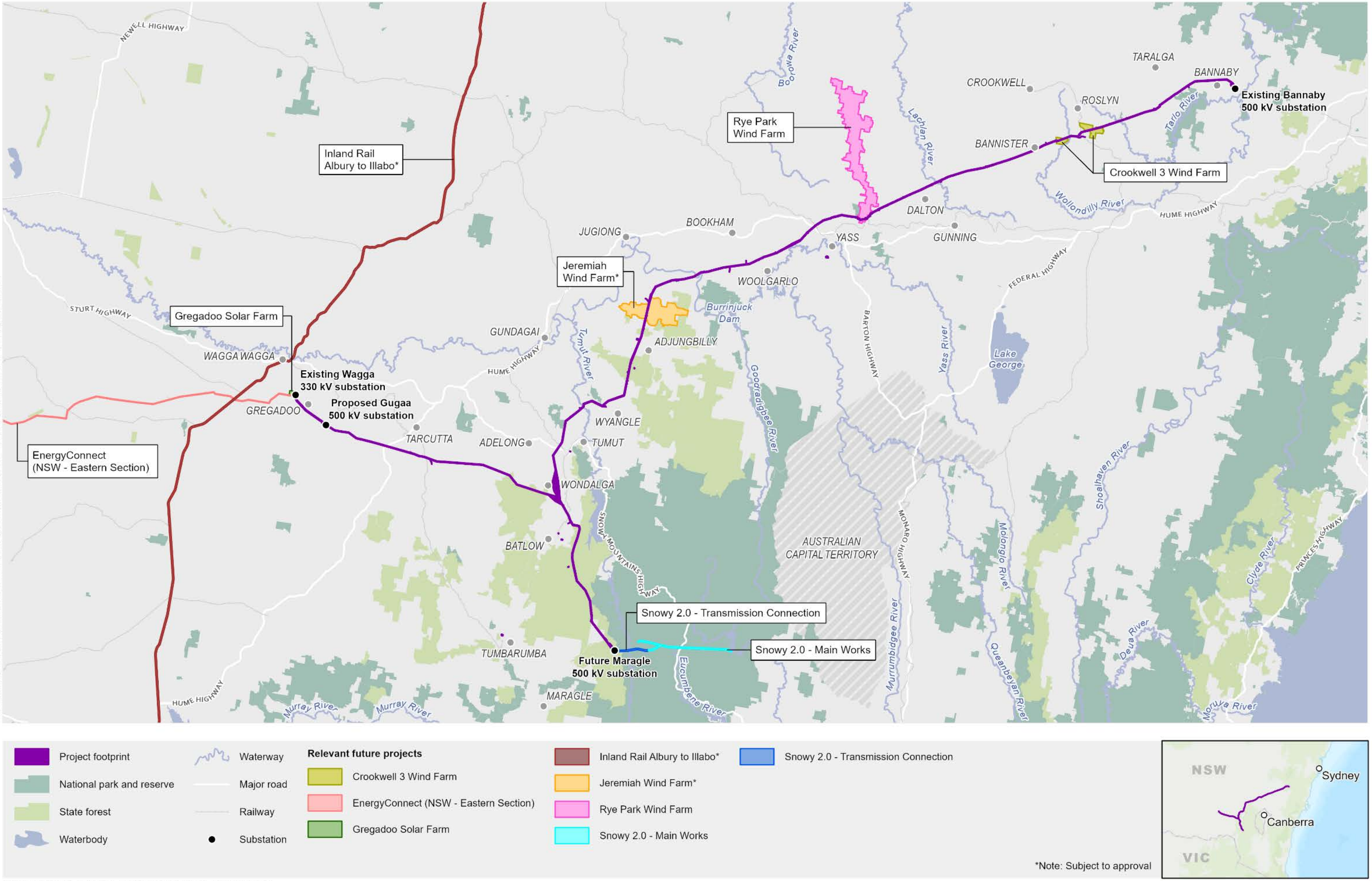
- DPE's Major Projects register
- NSW Government's Southern Regional Planning Panel project register
- NSW Independent Planning Commission project register
- EPBC Act Public Portal
- Transport for NSW Projects Map.

Searches were limited to the LGAs of Wagga Wagga City, Snowy Valleys, Yass Valley, Cootamundra-Gundagai Regional Upper Lachlan Shire, Goulburn-Mulwaree, and Hilltops.

Based on the above searches, the following projects are to be considered in the cumulative impact assessment for each of the key matters:

- EnergyConnect (NSW – Eastern Section)
- Gregadoo Solar Farm
- Jeremiah Wind Farm
- Rye Park Wind Farm
- Victoria to NSW Interconnector West (VNI West)
- Snowy 2.0 - Transmission Connection
- Snowy 2.0 - Main Works
- Inland Rail – Albury to Illabo
- Crookwell 3 Wind Farm.

The relevant key projects to be considered and their potential cumulative impacts in relation to surface and groundwater are shown in Figure 10-1 and summarised in Table 10-1.



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:925,000

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Projection: GDA 1994 MGA Zone 55

HumeLink **Surface Water and Groundwater**

FIGURE 10-1: Relevant future projects

Table 10-1 Summary of relevant key projects and potential cumulative impacts

Project	Details	Distance/interface	Timing	Potential impacts	Cumulative impacts
EnergyConnect (NSW – Eastern Section)	The project includes a new transmission line connecting the existing Buronga substation and existing Wagga 330 kV substation, and construction of the new Dinawan substation (170 km west of Wagga Wagga).	HumeLink and EnergyConnect (NSW – Eastern Section) both require upgrades of the existing Wagga 330 kV substation. Consecutive construction programs with upgrade and expansion of the existing Wagga 330 kV substation as part of EnergyConnect (NSW – Eastern Section) to be complete by August 2024.	▪ early 2023 – late 2024	The EIS EnergyConnect (NSW – Eastern Section) Technical Paper 8 – Hydrology, flooding and water quality (WSP, 2021) idenified potential impacts to surface and ground water. These included: ▪ degradation to water quality due to vegetation clearing ▪ earthworks leading to exposure and subsequent transfer of chemical contamination into waterways ▪ low potential impacts to groundwater sourced within existing infrastructure/ licences and because of the minimal area for blasting.	No cumulative impacts are expected with low potential for interaction with groundwater and mitigation measures outlined in the EIS (WSP, 2021)
Gregadoo Solar Farm	The Gregadoo Solar Farm development site covers about 150 hectares (ha) of land and includes around 122,000 solar panels mounted on single axis tracking system.	The Gregadoo Solar Farm is located on land adjacent the existing Wagga 330 kV substation No overlapping construction programs with the solar farm expected to commence mid-2023 and take 9 months to construct. Likely consecutive construction programs or slight overlap given expected commencement date and work at Wagga 330 kV substation are likely to commence in Q4 2024.	▪ construction expected to commence mid-2023 ▪ 9 months to construct	An assessment of the potential water quality hazards for this project in the Gregadoo Solar Farm EIS (NGH Environmental, 2018) identified that mitigation measures for soil erosion and chemical contamination (fuels, oils and other chemicals) would be applied to manage surface water impacts and there would be negligible to minimal impact on groundwater during the construction and operation of the project. No groundwater would be extracted for the construction and there is low pollution potential from solar farms on groundwater quality.	No cumulative impacts are expected with mitigation measures identified in EIS (NGH Environmental, 2018)

Project	Details	Distance/interface	Timing	Potential impacts	Cumulative impacts
Jeremiah Wind Farm	The project proposes a 65-turbine wind farm with a maximum tip height of 300 m, battery energy storage system and associated ancillary infrastructure	The HumeLink project footprint will go through the Jeremiah Wind Farm development area	▪ project approval anticipated in 2023 ▪ construction expected to be 24 – 30 months.	The Jeremiah Scoping report (Eco Logical Pty Ltd, 2014) identifies potential surface and groundwater impacts arising from the Jeremiah Wind Farm construction activities. These impacts include: ▪ degradation of surface water quality due to erosion and sediment, dust deposition, pollution from spills and waste contamination ▪ degradation of groundwater quality through infiltration processes or construction intersecting aquifers ▪ water supply and availability due to altered water demands, alteration of overland flow paths and reduction in environment health from groundwater drawdown or reduced streamflow.	No cumulative impacts are expected
Rye Park Wind Farm	Modified project includes maximum 80 wind turbines with a maximum tip height of 200 m. The project also includes construction of associated infrastructure (substations, operation, and maintenance facilities) and upgrades to local roads. A 330 kV switching station is proposed to the north of the HumeLink transmission line at Bango.	The HumeLink project footprint go through the southern end of the wind farm project boundary at Bango (near Bango Nature Reserve) Short term overlap of construction programs (Rye Park Wind Farm expected to take 18 – 24 months to construction commenced December 2021) and likely moderate to high level of interaction.	▪ under construction since December 2021 with commissioning scheduled for June 2023 ▪ original EIS suggested an 18-24 month construction period.	An environmental assessment (EA) for the Rye Park Wind Farm project (Epuron, 2014) identified negligible groundwater impacts during construction and operation as local groundwater would not be used as a water source and there would be a major elevation difference between groundwater level and the turbines. Potential surface water quality impacts during construction and operation include the degradation of water quality due to vegetation clearing, chemical contamination from earthworks and heavy machinery traversing waterway.	No cumulative impacts are expected with Construction Environmental Management Plan (CEMP) to be prepared as identified in the EA (Epuron, 2014).
Victoria to NSW Interconnector West (VNI West)	The project involves targeted interconnector expansion between Victoria and NSW to address transmission network limitations, and improve supply reliability	VNI West may require connection at existing Wagga 330kV substation (depending on the preferred option). The current scope that interfaces with HumeLink includes a new double circuit transmission line between Wagga 330 kV substation and Gugaa 500 kV substation to extend the EnergyConnect lines, upgrade above lines to 500 kV and at Gugaa a cut in line 51 and one additional transformer.	▪ construction proposed to commence in 2026 with commissioning by 2028.	Limited information as EIS has not yet been prepared as still in the scoping/market modelling phase.	Unlikely to have cumulative impacts as construction programs do not overlap.

Project	Details	Distance/interface	Timing	Potential impacts	Cumulative impacts
Snowy 2.0 – Transmission Connection	New transmission connection between the proposed Snowy 2.0 pumped hydro and generation project to the existing high voltage transmission network. This includes construction of a new substation in Bago State Forest (new Maragle substation), new access tracks and upgrade of existing access tracks and ancillary work to support construction	HumeLink to connect to the future Maragle 500 kV substation being constructed as part of the Snowy 2.0 – Transmission Connection project Consecutive construction programs	▪ construction expected to begin in late 2023 with expected completion by end of 2025	According to the Snowy 2.0 – Transmission Connection EIA (Jacobs, 2020), there would be low cumulative impacts to groundwater and surface water users, with no groundwater being affected during operation. Potential impacts to surface and groundwater included: ▪ tannin leachate due to vegetation clearing during construction and operation ▪ erosion of soils and sedimentation of waterways ▪ accidental leaks or spills of chemicals and fuels from incidents and accidents into waterways ▪ dispersal of residual ash from bushfires into waterways ▪ low potential construction impacts to groundwater because local water table is expected to be below depths for excavation and limited blasting required.	No cumulative impacts are expected as low potential for interaction with groundwater and mitigation measures proposed in the EIS (Jacobs, 2020), decrease the likelihood of cumulative impacts.
Snowy 2.0 - Main Works	The project includes an underground pumped hydro power station and ancillary infrastructure. Main works at Talbingo Reservoir site include excavated rock placement, portal construction and tunnelling, access roads and ancillary facilities for emplacement activities and tunnelling support.	Talbingo Reservoir site is approximately 5 km east of transmission lines between the future Maragle 500 kV substation and Bannaby 500 kV substation. Potential overlap of construction programs.	▪ construction began in October 2020 with expected completion by 2026.	According to the Snowy 2.0 – Main Works EIS (EMM, 2020), there would be low cumulative impacts to groundwater and surface water users and identified appropriate measures to further reduce potential impacts to surface and groundwater. The EIS identified potential surface water and groundwater impacts which included: ▪ erosion of soils and sedimentation from excavated rock placement ▪ onsite water and wastewater management and discharge ▪ accidental leaks or spills of chemicals and fuels from incidents and accidents into waterways ▪ underground excavation intercepting the groundwater table. There would be potential impacts to terrestrial and aquatic communities as a result of decreased baseflow along some stream segments, but they are expected to be localised and minor, thereby not interacting with HumeLink.	No cumulative impacts are expected given low impacts and minor interactions given the distance. Mitigation measures are identified in the EIS (EMM, 2020), further decreasing likelihood of cumulative impacts.

Project	Details	Distance/interface	Timing	Potential impacts	Cumulative impacts
Inland Rail – Albury to Illabo	Upgrade 185 km of rail track from Albury to Illabo passing through Wagga Wagga.	Roughly 9 km north-west of existing Wagga 330 kV substation.	- construction is proposed to commence in early 2024 and is expected to take about 16 months	As outlined in the Albury to Illabo (A2I) Project Technical Paper 11 – Hydrology, Flooding and Water Quality (WSP, 2022a), surface water quality impacts include: - chemical, fuel and hydrocarbon from accidental spills and leaks - erosion of soil from excavation and increased impervious areas increasing run off volume and sediments, nutrients entering waterways - stockpiling and general litter. As outlined in the Albury to Illabo (A2I) Project Technical Paper 12 – Groundwater(WSP, 2022b), groundwater impacts include: - dewatering temporarily altering localised groundwater levels and flow paths therefore may disturb and migrate potential existing contamination and/or saline groundwater - excavation work intercepting groundwater table therefore increased risk of contaminants from spoils entering groundwater.	Both technical papers by WSP state no cumulative impacts are expected given distance between both projects. Impacts from Inland Rail are minimal and highly localised and mitigation measures are outlined in the papers.
Crookwell 3 Wind Farm	16 wind turbines up to 157 m in height, connected to the grid via the 330 kV transmission line.	Project site is under the project footprint.	- detailed design and pre-construction activities are being carried out with main construction work expected to take about 18 months once commenced.	Surface and groundwater impacts are not considered or assessed in the Crookwell 3 Wind Farm Environmental Assessment (Tract Consultants, 2012) or in the Crookwell 3 Wind Farm Addendum Environmental Impact Statement (Mecone, 2016). Therefore, negligible impacts are expected.	No cumulative impacts are expected.

11 Management of impacts

11.1 Overview of approach

11.1.1 Construction

A SWMP would be prepared and implemented as part of the CEMP. The SWMP would identify all reasonably foreseeable risks relating to soil erosion and water pollution during construction and describe how these risks would be managed. The SWMP would contain appropriate measures (as a minimum) to:

- minimise the extent of ground disturbance
- divert surface water runoff around construction locations
- install erosion controls within construction locations
- collect and filter sediment from surface water runoff within construction locations
- store/stockpile materials away from receiving waters and overland flow paths
- manage stockpiles to minimise erosion and sediment transport
- manage saline and acid sulfate soils (if present)
- minimise the potential of soil and water quality impacts during storage of project wastes and potentially polluting substances
- minimise the duration of soil exposure and progressively rehabilitate and stabilised disturbed areas
- manage unexpected finds of contaminated materials
- record groundwater inflow and disposal volumes should excavations make groundwater
- management of dewatering processes, expected groundwater take/ impact and licencing requirements against the minimal impact criteria listed within the NSW Aquifer Interference Policy and relevant WSPs
- procedures for the appropriate handling, storage, transport and disposal of groundwater
- manage spills to reduce and address soil and water contamination.

Site-specific SWMPs may also be prepared where project components may have greater impacts than just erosion and sedimentation. Site specific SWMPs may be developed including:

- substation sites
- construction compounds
- worker accommodation facility.

SWMPs would include ESCPs to detail erosion and sediment controls to be implemented at specific sites and for specific construction activities and would include rehabilitation requirements. SWMPs and ESCPs would be prepared in accordance with *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom, 2004) other relevant volumes and other relevant guidelines.

ESCPs would include both site-specific and activity ESCPs depending on the erosion risk. Construction in low erosion risk areas would generally use activity based ESCPs whereas construction in a high erosion risk area would require a site-specific ESCP (eg waterway crossings of higher order streams). In areas where there is a moderate risk of erosion and sedimentation impacts, further assessment would be required to determine whether a site specific or activity based ESCPs would be used.

A Water Quality Monitoring Plan (WQMP) would be prepared and would detail routine water quality monitoring and other monitoring to be undertaken during certain construction activities (eg Construction of major project elements adjacent to waterways) to detect any potential water quality impacts. The WQMP objectives and guideline values would be specific to the major catchments and consider relevant legislation and include surface water and groundwater monitoring depending on the construction activity.

An Emergency Spill Procedure would be developed to manage spill events during construction as part of the CEMP. The procedure would include spill emergency response measures. Refer to *Technical Report 10 – Phase 1 Contamination Assessment* for management of contamination impacts.

Water supply options and management would be undertaken in accordance with agreements between the construction contractor and relevant existing license holders or water suppliers.

11.1.2 Operation

Operational impacts would be further considered and mitigated during detailed design for the following infrastructure:

- substations
- permanent access roads
- permanent waterway crossings
- telecommunications hut
- transmission line structures.

Relevant guidelines, legislation and standards would be considered during this process.

Transgrid has operational procedures and management plans to manage and mitigate environmental impacts and risks from the ongoing management and maintenance of its assets and these would be implemented during operation.

11.2 Summary of mitigation measures

A summary of mitigation measures to reduce the potential impacts on each activity for detailed design, construction and operation phase is presented in Table 11-1.

Table 11-1 Summary of mitigation measures for surface and groundwater impacts

Impact/s	Mitigation measures	Timing	Relevant location
Water quality, erosion risk – erosion and sedimentation	Erosion and Sediment Control Plans will be developed and implemented in consultation with a Certified Professional in Erosion and Sediment Control during construction for the activities and areas that are considered higher risk. The plan will detail the processes, responsibilities, and measures to manage potential soil and water quality impacts in accordance with the principles and requirements in: ▪ *Managing Urban Stormwater – Soils and Construction, Volume 1* (Landcom, 2004) and Volume 2A (DECC, 2008a) and Volume 2C (DECC, 2008b) commonly referred to as the 'Blue Book' ▪ *Best Practice Erosion and Sediment Control* (IECA, 2008) ▪ Transgrid's Environmental Guidance Notes ▪ *Guidelines for Controlled Activities on Waterfront Land*.	Construction	All locations
Water quality and geomorphology	Design of scour protection will be included in any infrastructure that is within a waterway channel. The design will incorporate features that minimise impact on flow conditions and natural functioning of the waterway, where possible. For work within or near waterways consider and adhere to the following guidelines: ▪ *Guidelines for controlled activities (Riparian corridors and Watercourse crossings)* (DPI, 2012) ▪ *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPI, 2003) ▪ *Policy and Guidelines for Fish Habitat Conservation and Management* (Update 2013) (DPI, 2013)	Detailed design and construction	Waterways
Surface and groundwater quality - monitoring	Water quality monitoring will be implemented to establish baseline water quality conditions in waterways of high sensitivity that may be impacted by nearby construction and to detect any changes in water quality that may be attributable to the project during construction. The frequency, location and duration of sampling will be detailed in a monitoring program. Monitoring locations will include: ▪ at a minimum two monitoring locations (one located upstream and one downstream of the transmission line crossing) for waterways with a Strahler order 4 or higher within the SDWC where construction activities within 200 metres of the waterway will be carried out and could result in impacts ▪ monitoring for total dissolved solids, total suspended solids, total nitrogen, and total phosphorus.	Detailed design and construction	All locations
Water supply	Water supply options and management will be undertaken in accordance with agreements between the construction contractors and relevant water users and suppliers.	Detailed design and construction	All locations
Groundwater flow paths, levels, and users	Alternative construction methodologies will be investigated and implemented as required to minimise impacts to GDEs and registered groundwater bores, if identified to be directly impacted during detailed design. Make good provisions will need to be made to the groundwater user(s) for bores that will be affected.	Detailed design and construction	All locations

12 Conclusion

The assessment includes desktop reviews of available information and public databases, field surveys, consolidation, and interpretation of the data to identify potential risk to water resources and recommendations for mitigation measures during the construction and operation of the project.

The construction and operation of the project has the potential to impact the local surface water and groundwater resources. Most impacts are expected to occur during the construction phase. The following impacts were identified for construction impacts on surface water:

- Erosion risk and sedimentation impacts – Disturbance of the ground through vegetation removal, earthworks and other construction activities posed the greatest risk to surface water. Activities to be undertaken in close proximity to a waterway increased the erosion risk.
- Geomorphology – Potential impacts on geomorphology would be primarily related to erosion risk and sedimentation impacts (ie sediment being washed into waterways) and therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. An additional risk to geomorphology would be waterway crossings associated with access roads. This would have a moderate risk of impacts and would be managed through implementing appropriate design guidelines.
- Water quality – The major potential impact on water quality would be primarily related erosion risk and sedimentation impacts (ie sediment being washed into waterways) and therefore the risk profile, impact significance and mitigation measures would be the same as erosion risk and sedimentation impacts. Another major risk to water quality would be the 14 construction compounds, some of which concrete batching plants may be located and materials, chemicals and fuels would be stored and used.
- Water supply – About 510 megalitres of water is estimated to be required over the 2.5-year construction period of which about 13 per cent would need to be potable and remainder would be non-potable water. The total volume of water required for construction is only a fraction of a percentage of the total volume of water allocated under the WSPs in the project footprint. Non-potable water would be sourced from farm dams, sedimentation ponds, potentially groundwater bores and through the purchase of allocations from other water users through water markets. The impact of project on non-potable water users and water availability would be negligible.
- Wastewater disposal – The largest source of wastewater would be from the worker accommodation facility, and this would be connected to the existing Tumbarumba STP. Smaller volumes of wastewater from construction compounds would be collected and transported to appropriate wastewater disposal facilities.

The following impacts were identified for construction impacts on groundwater:

- Activities that could potentially impact groundwater resources mainly relate to the foundation construction of the transmission line structures, which require excavation to five metres below ground level or piles, which may extend greater than 20 metres below the surface level. While either of these activities may intercept groundwater where it is present, the impacts such as changes in groundwater level (eg from dewatering), interference to groundwater flow and impacts on groundwater quality on bores within or close to the footprint could be moderate to high.
- Substation modification and construction was also identified as potentially having moderate impacts on groundwater due to concrete and foundation work.

The operational impacts on surface water quality would be similar to the construction phase but with substantially lower risk of impacts. This is because disturbed areas would have been stabilised, activities such as earthworks and concreting would be limited and there would be no substantial storage or use of chemicals and fuels except for at the substations. The impacts would relate to:

- Ongoing maintenance activities within the transmission line easement, transmission line structures and access tracks, however the potential significance of impacts would be generally low. The substations also pose a risk to water quality due to chemical and oil storage, but the impact would be low given that they are constructed within containment and treatment systems.
- Water use and wastewater disposal risks would be negligible as the volume of water required and the volume of wastewater generated would be low.

The operation of the project would have negligible impacts on groundwater.

To minimise impacts to surface water and groundwater, a range of measures would be implemented during the detailed design, construction and operational phases of the project including:

- considering locations of waterways within the project footprint and higher risk erosion areas when choosing locations for construction activities and infrastructure
- preparation of Soil and Water Management Plans as part of the CEMP to manage water quality impacts during construction of the project
- preparation of ESCPs and Water Quality Monitoring Plan within the SWMP
- consideration of appropriately designed scour protection at new stormwater management points.

Overall, with the implementation of the proposed mitigation measures, the project is expected to have acceptable and minimal impacts on existing surface water, groundwater resources and environmental values during both the construction and operation phases.

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Attachments

Attachment A
WQOs trigger value identification

Table A-1 Summary of WQOs and selected values for Hawkesbury-Nepean catchment

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000) / ANZG (2018)	Hawkesbury Nepean (HRC)	Adopted Aquatic Ecosystem Criteria			
Temperature	°C	N/A	N/A	N/A	16 – 34	N/A	16 – 34
Total Phosphorus (TP)	mg/L	0.05	0.05	0.03	N/A	N/A	0.04
Total Nitrogen (TN)	mg/L	0.5	0.7	0.5	N/A	N/A	0.74
Oxides of nitrogen	mg/L	0.04		0.04	N/A	N/A	0.66
Chlorophyll-a	mg/L	0.005	0.007	0.005	N/A	N/A	0.01
Turbidity	NTU	6 - 50		6-50	N/A	N/A	50
Salinity (electrical conductivity)	µS/cm	125 -2200		125-2200	N/A	N/A	125-2200
Dissolved Oxygen (DO)	mg/L	N/A		N/A	N/A	N/A	N/A
Dissolved Oxygen (DO)	%SAT	85 – 110		85-110	>80	N/A	85-110
Total Suspended Solids (TSS)	mg/L	N/A		N/A	N/A	N/A	N/A
pH		6.5 – 8.0		6.5-8.0	6.5 – 8.5	N/A	6.5-8.0
Enterococci	Count/100mL	N/A		N/A	200	N/A	200
Arsenic (As III)	mg/L	0.024		0.024	0.007	N/A	0.007
Arsenic (As V)	mg/L	0.013		0.013		N/A	0.007
Cadmium	mg/L	0.0002		0.002	0.002	N/A	0.0002
Chromium (Cr III)	mg/L	0.0033		0.0033	0.05	N/A	0.0033
Chromium (Cr VI)	mg/L	0.001		0.001		N/A	0.001
Copper	mg/L	0.0014		0.0014	1	N/A	0.0014
Iron	mg/L	N/A		N/A	0.3	N/A	0.3
Lead	mg/L	0.0034		0.0034	0.01	N/A	0.0034
Manganese	mg/L	1.9		1.9	0.1	N/A	0.1
Mercury	mg/L	0.00006		0.00006	0.001	N/A	0.00006

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000) / ANZG (2018)	Hawkesbury Nepean (HRC)	Adopted Aquatic Ecosystem Criteria			
Nickel	mg/L	0.011		0.011	0.02	N/A	0.011
Zinc	mg/L	0.008		0.008	3	N/A	0.008
Ammonia	mg/L	0.9		0.9	0.5	N/A	0.08
Oil and Grease	N/A	N/A		N/A	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour

ANZEC 2000 & ANZG 2018: Physical and chemical stressors were based upon the South-east Australian lowland rivers of the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand water quality guidelines (ANZECC & ARMCANZ 2000). Toxicants were based upon the default guideline values for Slightly to Moderately Disturbed Rivers of the Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018).

Primary and Secondary Contact: Guidelines for Managing Risks in Recreational Water (NHMRC 2008)

Visual Amenity: ANZECC & ARMCANZ 2000

Hawkesbury Nepean : Independent Inquiry into the Hawkesbury Nepean River System (HRC 1998) urban areas – main stream criteria

Enterococci value based on category C and lower relating from NHMRC 2000 representing a substantial elevated risk.

Table A-2 Environmental values and guidelines for the Lachlan catchment (HRC, 1998)

Environmental Value	Indicator	Guideline value	Key applicability to the proposal
Aquatic ecosystems – maintaining or improving the ecological condition of waterbodies and riparian zones over the long term. *ANZECC Guideline Trigger Values for lowland rivers in south-east Australia with slightly disturbed ecosystems indicated.*	Total Phosphorus (TP)	30 µg/L	Road runoff during operation
	Total Nitrogen (TN)	500 µg/L	Road runoff during operation
	Chlorophyll-a	10-15 µg/L	Waterway impact due to elevated nutrients in road runoff
	Turbidity	6 - 50 Nephelometric Turbidity Unit (NTU)	Sediment laden runoff during construction and operation.
	Salinity (electrical conductivity)	125 – 2,200 µS/cm	Construction discharges
	Dissolved Oxygen (DO)	85 - 110% saturation	Road runoff during operation
	pH	6.5 – 8.0	Construction discharges
	Toxicants	As per ANZG 2018 toxicant guidelines for slightly to moderately disturbed ecosystems	Heavy metals in road runoff
Visual amenity – aesthetic qualities of waters	Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%.	Road runoff flowing into drainage lines flowing into South Creek.
	Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and matter.	Oils and petrochemicals in road runoff
	Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts No quantitative value specified	Potential impact in waterway as a result of nutrient impacts.

Environmental Value	Indicator	Guideline value	Key applicability to the proposal
Secondary contact recreation – maintaining or improving water quality of activities such as boating and wading, where there is a low probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the Guidelines for managing risks in recreational water (NHMRC, 2008)	N/A
	Nuisance organisms	As per the visual amenity guidelines. Large numbers of midges and aquatic works are undesirable.	As per the visual amenity relevance.
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucous membranes are unsuitable of recreation. Toxic substances should not exceed values provided in the Guidelines for managing risks in recreational water (NHMRC, 2008)	Heavy metals in road runoff
	Visual clarity and colour	As per the visual amenity guidelines.	As per the visual amenity relevance.
	Surface films	As per the visual amenity guidelines.	As per the visual amenity relevance.
Primary contact recreation – maintaining or improving water quality for activities such as swimming where there is a high probability of water being swallowed	Faecal coliforms, enterococci, algae and blue-green algae	As per the Guidelines for managing risks in recreational water (NHMRC, 2008)	N/A
	Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water.	N/A
	Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed values provided in the Guidelines for managing risks in recreational water (NHMRC, 2008)	Road runoff flowing into drainage lines flowing into South Creek.
	Visual clarity and colour	As per the visual amenity guidelines.	As per the visual amenity relevance.
	Temperature	16° - 34°C for prolonged exposure.	Road runoff and construction discharges

Table A-3 Summary of WQOs and selected values for Lachlan catchment

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000)/ ANZG (2018)	Hawkesbury Nepean	Adopted Aquatic Ecosystem Criteria			
Temperature	°C	N/A	N/A	N/A	16 – 34	N/A	16 – 34
Total Phosphorus (TP)	mg/L	0.05	0.03	0.03	N/A	N/A	0.04
Total Nitrogen (TN)	mg/L	0.5	0.5	0.5	N/A	N/A	0.74
Oxides of nitrogen	mg/L	0.04	N/A	0.04	N/A	N/A	0.66
Chlorophyll-a	mg/L	0.005	0.01-0.015	0.005	N/A	N/A	0.01
Turbidity	NTU	6 - 50	N/A	6-50	N/A	N/A	50
Salinity (electrical conductivity)	µS/cm	125 -2200	N/A	125-2200	N/A	N/A	125-2200
Dissolved Oxygen (DO)	mg/L	N/A	N/A	N/A	N/A	N/A	N/A
Dissolved Oxygen (DO)	%SAT	85 – 110	N/A	85-110	>80	N/A	85-110
Total Suspended Solids (TSS)	mg/L	N/A	N/A	N/A	N/A	N/A	N/A
pH		6.5 – 8.0	N/A	6.5-8.0	6.5 – 8.5	N/A	6.5-8.0
Enterococci	Count/100mL	N/A	N/A	N/A	200	N/A	200
Arsenic (As III)	mg/L	0.024	N/A	0.024	0.007	N/A	0.007
Arsenic (As V)	mg/L	0.013	N/A	0.013		N/A	0.007
Cadmium	mg/L	0.0002	N/A	0.002	0.002	N/A	0.0002
Chromium (Cr III)	mg/L	0.0033	N/A	0.0033	0.05	N/A	0.0033
Chromium (Cr VI)	mg/L	0.001	N/A	0.001		N/A	0.001
Copper	mg/L	0.0014	N/A	0.0014	1	N/A	0.0014
Iron	mg/L	N/A	N/A	N/A	0.3	N/A	0.3
Lead	mg/L	0.0034	N/A	0.0034	0.01	N/A	0.0034
Manganese	mg/L	1.9	N/A	1.9	0.1	N/A	0.1
Mercury	mg/L	0.00006	N/A	0.00006	0.001	N/A	0.00006

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Selected Water Quality Objective
		ANZECC (2000)/ ANZG (2018)	Hawkesbury Nepean	Adopted Aquatic Ecosystem Criteria			
Nickel	mg/L	0.011	N/A	0.011	0.02	N/A	0.011
Zinc	mg/L	0.008	N/A	0.008	3	N/A	0.008
Ammonia	mg/L	0.9	N/A	0.9	0.5	N/A	0.08
Oil and Grease	N/A	N/A	N/A	N/A	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour

ANZEC 2000 & ANZG 2018: Physical and chemical stressors were based upon the South-east Australian lowland rivers of the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand water quality guidelines (ANZECC & ARMCANZ 2000). Toxicants were based upon the default guideline values for Slightly to Moderately Disturbed Rivers of the Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018).

Primary and Secondary Contact: Guidelines for Managing Risks in Recreational Water (NHMRC 2008)

Visual Amenity: ANZECC & ARMCANZ 2000

Hawkesbury Nepean: Independent Inquiry into the Hawkesbury Nepean River System (HRC 1998) urban areas – main stream criteria

Enterococci value based on category C and lower relating from NHMRC 2000 representing a substantial elevated risk.

The WQOs for major regulated rivers within the Murrumbidgee catchment include the protection of:

- Aquatic ecosystems
- Visual amenity
- Secondary contact recreation
- Primary contact recreation
- Livestock water supply
- Irrigation water supply
- Homestead water supply
- Drinking water at point of supply - Disinfection only
- Drinking water at point of supply-Clarification and disinfection
- Drinking water at point of supply - Groundwater
- Aquatic foods (cooked)

The WQOs for uncontrolled streams within the Murrumbidgee catchment include the protection of:

- Aquatic ecosystems
- Visual amenity
- Secondary contact recreation
- Primary contact recreation
- Livestock water supply
- Irrigation water supply
- Homestead water supply
- Drinking water at point of supply-Disinfection only
- Drinking water at point of supply-Clarification and disinfection
- Drinking water at point of supply-Groundwater
- Aquatic foods (cooked)

Table A-4 Summary of WQOs and selected values for Murrumbidgee catchment – unregulated streams and Lake George catchment & Major regulated rivers

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Drinking Water	Selected Water Quality Objective
		ANZECC (2000)/ ANZG (2018)	Basin Pan 2012	Adopted Aquatic Ecosystem Criteria				
Temperature	°C	N/A	N/A	N/A	15 - 35	N/A	N/A	16 – 34
Total Phosphorus (TP)	mg/L	0.05	0.03	0.02	N/A	N/A	N/A	0.04
Total Nitrogen (TN)	mg/L	0.5	0.5	0.25	N/A	N/A	N/A	0.74
Oxides of nitrogen	mg/L	0.04	N/A	N/A	N/A	N/A	N/A	0.66
Chlorophyll-a	mg/L	0.005	0.01-0.015	N/A	N/A	N/A	N/A	0.01
Turbidity	NTU	6 - 50	N/A	2-25	N/A	N/A	Site-specific	50
Salinity (electrical conductivity)	µS/cm	125 -2200	N/A	30-350	N/A	N/A	<1500 >800 (taste)	125-2200
Dissolved Oxygen (DO)	mg/L	N/A	N/A	N/A	N/A	N/A	>6.5	N/A
Dissolved Oxygen (DO)	%SAT	85 – 110	N/A	90 -110	>80	N/A	>80	85-110
Total Suspended Solids (TSS)	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	N/A
pH		6.5 – 8.0	N/A	6.5-8.0	5.0 - 9.0	N/A	6.5 - 8.5	6.5-8.0
Enterococci	Count/100mL	N/A	N/A	N/A	230	N/A	N/A	200
Arsenic (As III)	mg/L	0.024	N/A	0.024	0.007	N/A	N/A	0.007
Arsenic (As V)	mg/L	0.013	N/A	0.013		N/A	N/A	0.007
Cadmium	mg/L	0.0002	N/A	0.002	0.002	N/A	N/A	0.0002
Chromium (Cr III)	mg/L	0.0033	N/A	0.0033	0.05	N/A	N/A	0.0033
Chromium (Cr VI)	mg/L	0.001	N/A	0.001		N/A	N/A	0.001
Copper	mg/L	0.0014	N/A	0.0014	1	N/A	N/A	0.0014
Iron	mg/L	N/A	N/A	N/A	0.3	N/A	N/A	0.3
Lead	mg/L	0.0034	N/A	0.0034	0.01	N/A	N/A	0.0034

Indicator	Units	Aquatic Ecosystem Criteria			Primary and Secondary Contact Criteria	Visual Amenity Criteria	Drinking Water	Selected Water Quality Objective
		ANZECC (2000)/ ANZG (2018)	**Basin Pan 2012**	**Adopted Aquatic Ecosystem Criteria**				
Manganese	mg/L	1.9	N/A	1.9	0.1	N/A	N/A	0.1
Mercury	mg/L	0.00006	N/A	0.00006	0.001	N/A	N/A	0.00006
Nickel	mg/L	0.011	N/A	0.011	0.02	N/A	N/A	0.011
Zinc	mg/L	0.008	N/A	0.008	3	N/A	N/A	0.008
Ammonia	mg/L	0.9	N/A	0.9	0.5	N/A	N/A	0.08
Oil and Grease	N/A	N/A	N/A	N/A	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour	Oil and petrochemicals should not be noticeable as a visible film on the water nor should they be detectable by odour

ANZEC 2000 & ANZG 2018: Physical and chemical stressors were based upon the South-east Australian lowland rivers of the Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand water quality guidelines (ANZECC & ARMCANZ 2000). Toxicants were based upon the default guideline values for Slightly to Moderately Disturbed Rivers of the Australian and New Zealand guidelines for fresh and marine water quality (ANZG 2018).

Primary and Secondary Contact: Guidelines for Managing Risks in Recreational Water (NHMRC 2008)

Visual Amenity: ANZECC & ARMCANZ 2000

Hawkesbury Nepean : Independent Inquiry into the Hawkesbury Nepean River System (HRC 1998) urban areas – main stream criteria

Enterococci value based on category C and lower relating from NHMRC 2000 representing a substantial elevated risk.

Attachment B

Sensitivity analysis statistics

A spatial sensitivity analysis was conducted using the modelled soil erosion potential of Strahler 1 to 4 waterways and their proximity to the project footprint. The following tables present the percentage of footprint and their sensitivity. Waterways within the 1-kilometre buffer surface water and groundwater study area were identified. First to fourth order streams were extracted and given the following buffer distances:

- 50 metres from Strahler order 1
- 100 metres from Strahler order 2
- 150 metres from Strahler order 3
- 200 metres from Strahler order 4 or higher.

Where there were overlapping buffers, the higher order stream was given precedence ie fourth order stream was assigned the buffer over the third order stream. These buffers were overlaid onto the project footprint and soil erosion risk models to calculate with their respective areas and erosion risk. These results are provided in **Table B1 and Table B2**.

Table B1 Percentage of waterway buffer within project footprint by area

Name	Area (ha)	% of footprint
Footprint (excluding Strahler order 1-4 buffers)	5342.3	62.49%
Strahler order 1 buffer within footprint	1141.0	13.35%
Strahler order 2 buffer within footprint	922.0	10.78%
Strahler order 3 buffer within footprint	596.1	6.97%
Strahler order 4 buffer within footprint	547.9	6.41%

Table B2 Soil erosion classification within waterway buffer by area

Buffer	Soil erosion (t/ha/yr)	Area (ha)	% of total project footprint	Sensitivity
Strahler order 1 (50m buffer)	<20	115.97	1.36%	Low
	20 - < 50	179.20	2.10%	Low
	50 - < 200	431.43	5.05%	Low
	200 - < 500	208.61	2.44%	Moderate
	500 - < 1000	107.05	1.25%	High
	1000 - < 2000	79.05	0.92%	High
	2000 - < 3000	18.72	0.22%	High
	<3000	0.99	0.01%	High
Strahler order 2 (100 m buffer)	<20	90.79	1.06%	Low
	20 - < 50	137.03	1.60%	Low
	50 - < 200	380.24	4.45%	Low
	200 - < 500	190.78	2.23%	Moderate
	500 - < 1000	80.03	0.94%	Moderate
	1000 - < 2000	42.14	0.49%	High
	2000 - < 3000	1.04	0.01%	High

Buffer	Soil erosion (t/ha/yr)	Area (ha)	% of total project footprint	Sensitivity
Strahler order 3 (150 m buffer)	<20	68.43	0.80%	Low
	20 - < 50	84.20	0.98%	Low
	50 - < 200	229.34	2.68%	Low
	200 - < 500	144.27	1.69%	Moderate
	500 - < 1000	42.39	0.50%	Moderate
	1000 - < 2000	24.53	0.29%	High
	2000 - < 3000	2.94	0.03%	High
Strahler order 4 (200m buffer)	<20	89.62	1.05%	Low
	20 - < 50	94.44	1.10%	Low
	50 - < 200	202.01	2.36%	Low
	200 - < 500	111.97	1.31%	Moderate
	500 - < 1000	39.17	0.46%	Moderate
	1000 - < 2000	10.69	0.13%	High
Footprint (outside of buffer)	<20	947.21	11.08%	Low
	20 - < 50	873.40	10.21%	Low
	50 - < 200	1758.05	20.56%	Low
	200 - < 500	857.76	10.03%	Moderate
	500 - < 1000	513.71	6.01%	High
	1000 - < 2000	336.22	3.93%	High
	2000 - < 3000	55.96	0.65%	High
	<3000	1.19	0.01%	High

Table B3 Strahler order and location of waterways with respect to Sydney Drinking Water Catchment (SDWC)

Waterway	Catchment	Strahler order	Within SDWC?
Adelong	Murrumbidgee	4-5	No
Adjungbilly	Murrumbidgee	6	No
Alton	Lachlan	1-2	No
Back	Hawkesbury-Nepean	1-3	Yes
Bango	Murrumbidgee	3-4	No
Bannaby	Hawkesbury-Nepean	3-4	Yes
Big Rock	Murrumbidgee	2	No
Big Spring	Murrumbidgee	4	No
Black Range	Murrumbidgee	2	No
Bogolong	Murrumbidgee	2-3	No
Boiling Down	Murrumbidgee	3-5	No
Booroo	Murrumbidgee	3-4	No
Bowning	Murrumbidgee	5	No
Broadhursts	Murrumbidgee	3	No
Brungle	Murrumbidgee	5	No
Buchanans	Murrumbidgee	2-3	No
Buddong	Murrumbidgee	5	No
Bunton	Lachlan	3	No

Waterway	Catchment	Strahler order	Within SDWC?
Bunton	Lachlan	3	No
Burgess	Hawkesbury-Nepean	4	Yes
Burnt Hut	Murrumbidgee	2-3	Yes
Cart Road	Murrumbidgee	2-4	No
Catherines	Lachlan	3	No
Cockatoo	Murrumbidgee	1-4	No
College	Murrumbidgee	5	No
Comatawa	Murrumbidgee	2-4	No
Connors	Hawkesbury-Nepean	3-4	Yes
Cooks	Murrumbidgee	4	No
Cotway	Murrumbidgee	2	No
Cotway	Murrumbidgee	3	No
Cotway	Murrumbidgee	2	No
Cotway	Murrumbidgee	3	No
Cotway	Murrumbidgee	3	No
Cotway	Murrumbidgee	2	No
Cotway	Murrumbidgee	2	No
Cow Horn	Hawkesbury-Nepean	2-3	Yes
Cowpers	Hawkesbury-Nepean	3-4	Yes
Cowridge	Murrumbidgee	1-3	No
Coxs	Murrumbidgee	2-4	Yes
Darlows	Murrumbidgee	4-5	No
Dawsons Flat	Hawkesbury-Nepean	2-3	Yes
Deep	Murrumbidgee	2	Yes
Derringullen	Murrumbidgee	4-5	No
Dicks	Murrumbidgee	2	No
Dowlings	Lachlan	1-3	No
Excursion	Murrumbidgee	1	No
Fairy Hole	Murrumbidgee	2-3	No
Felled Timber	Lachlan	2-4	No
First	Hawkesbury-Nepean	3	Yes
Flacknell	Lachlan	3-4	No
Foleys	Murrumbidgee	1-4	No
Forest	Hawkesbury-Nepean	2-3	Yes
Foxes	Murrumbidgee	3	No
Galvins	Murrumbidgee	1-3	No
Gannons	Murrumbidgee	2	No
Gatleys	Murrumbidgee	1	No
Gilmore	Murrumbidgee	5-6	No
Gocup	Murrumbidgee	1-4	No
Grays	Hawkesbury-Nepean	2	Yes
Gregadoo	Murrumbidgee	1-4	No
Gunningdelballa	Lachlan	1	No

Waterway	Catchment	Strahler order	Within SDWC?
Gurrundah	Hawkesbury-Nepean	1-2	Yes
Heffernans	Hawkesbury-Nepean	1-2	Yes
Hindmarsh	Murrumbidgee	4	No
Hingertys	Murrumbidgee	1-2	No
Honeysuckle	Murrumbidgee	4	Yes
Humes	Lachlan	3-4	No
Jerrawa	Lachlan	5	No
Jugiong	Murrumbidgee	4	No
Keajura	Murrumbidgee	6	No
Kerrawary	Hawkesbury-Nepean	4	Yes
Kialla	Hawkesbury-Nepean	3	Yes
Kiley	Murrumbidgee	2-3	No
Killimicat	Murrumbidgee	5	No
Kyeamba	Murrumbidgee	6-7	No
Lachlan	Lachlan	6	No
Leech	Murrumbidgee	2-3	No
Licking Hole	Murrumbidgee	1	No
Limestone	Murrumbidgee	4	Yes
Little Gilmore	Murrumbidgee	5	No
Logbridge	Murrumbidgee	1-3	No
Long	Murrumbidgee	3-4	Yes
Macnamaras	Murrumbidgee	4	No
Mandys	Murrumbidgee	4	No
Mantons	Murrumbidgee	2-3	No
Mccullums	Murrumbidgee	3	No
Mcgregors	Murrumbidgee	1-3	No
Meadow	Murrumbidgee	3-4	Yes
Melamalong	Hawkesbury-Nepean	1-5	Yes
Merrill	Lachlan	1-4	No
Mettys	Murrumbidgee	1-2	No
Middle	Lachlan	1-2	Yes
Middle	Hawkesbury-Nepean	5	Yes
Middle	Lachlan	2	Yes
Mount Pleasant	Murrumbidgee	2-3	No
Mudhole	Murrumbidgee	3	No
Murrays	Murrumbidgee	2-3	No
Murrumbidgee	Murrumbidgee	9	No
Myrtle	Hawkesbury-Nepean	4	Yes
Nacki Nacki	Murrumbidgee	4-5	No
Native Dog	Murrumbidgee	1-2	Yes
New Zealand	Murrumbidgee	1-2	No
Oak	Murrumbidgee	1-5	Yes
Oaky	Murrumbidgee	2-3	Yes

Waterway	Catchment	Strahler order	Within SDWC?
O'Briens	Murrumbidgee	1-6	No
Oolong	Lachlan	4	No
Pejar	Hawkesbury-Nepean	3-5	Yes
Pipeclay	Upper Murray	1-2	Yes
Plain	Murrumbidgee	2-3	No
Poison Rock	Murrumbidgee	1	No
Reedy Flat	Murrumbidgee	3-4	Yes
Ridings	Murrumbidgee	1-2	No
Right Arm	Murrumbidgee	3-4	No
Rocky	Murrumbidgee	2-4	Yes
Ryans	Hawkesbury-Nepean	1	Yes
Sams	Lachlan	2	No
Sandy	Murrumbidgee	5	Yes
Sandy	Murrumbidgee	1-5	Yes
Saw Mill	Murrumbidgee	3-4	No
Sawpit	Murrumbidgee	4	Yes
Sawpit	Hawkesbury-Nepean	1-3	Yes
Sharpening Stone	Murrumbidgee	3	No
Sharps	Murrumbidgee	2-4	No
Sheep Station	Murrumbidgee	1-2	Yes
Sheepyard	Murrumbidgee	4	No
Snubba	Murrumbidgee	1-4	No
Sod Hut	Murrumbidgee	1-4	No
Spring Grove	Murrumbidgee	3	No
St Pauls	Hawkesbury-Nepean	2-3	Yes
Steeves	Hawkesbury-Nepean	3-4	Yes
Stockmans	Murrumbidgee	3-4	No
Stony	Murrumbidgee	1-3	Yes
Tarcutta	Murrumbidgee	6-7	No
Tarlo	Hawkesbury-Nepean	5	Yes
Three Waterholes	Murrumbidgee	1-3	No
Tomneys Plain	Murrumbidgee	1-4	No
Tooles	Murrumbidgee	4-6	No
Tullerah	Murrumbidgee	2	No
Tumut	Murrumbidgee	8	No
Turners	Murrumbidgee	1-4	No
Turrallo	Hawkesbury-Nepean	5	Yes
Tywong	Murrumbidgee	4	No
Umbango	Murrumbidgee	7	No
Uncles	Murrumbidgee	3	No
Washpen	Murrumbidgee	4	No
Weir	Murrumbidgee	1-3	No
Wills	Hawkesbury-Nepean	1-2	Yes

Waterway	Catchment	Strahler order	Within SDWC?
Wilsons	Murrumbidgee	1-4	Yes
Windowie	Murrumbidgee	1-4	No
Wollondilly	Hawkesbury-Nepean	5-6	Yes
Woolgarlo	Murrumbidgee	3-4	No
Yass	Murrumbidgee	6	No
Yaven Yaven	Murrumbidgee	5	No
Yellow	Murrumbidgee	3	No
Yellow Clay	Murrumbidgee	3	No
Yellowin	Murrumbidgee	3	No
Yellowin	Murrumbidgee	2-3	No
Yorkers	Murrumbidgee	2-3	No

Attachment C
Field verification information

<u>Tributary to O'Briens Creek</u> <u>Time:</u> 12pm 4th April 2022 <u>GPS Coordinates</u>: S 35° 35.3853' E 148° 11.5358'

Dry and moderately vegetated channel

Channel running alongside road leading into culvert

Partially blocked upstream culvert

Water Quality Parameters - Unable to sample as creek was dry at time of site visit.

Description

<u>Riparian Vegetation</u> - Extreme disturbance to riparian vegetation, with major clearing for grazing on both sides of the banks.

<u>Banks</u> - Flat terrain (<10) towards the tributary. Most likely flows from into tributary are from the channel alongside road rather than the farmlands.

<u>Local impacts on stream</u> - Agricultural land upstream and downstream of culvert. Culvert is partially blocked.

Snubba Creek Time: 3:00pm 4th April 2022 GPS Coordinates: S 35° 35.3853' E 148° 11.5358'

Culvert downstream

Snubba Creek upstream of culvert

Riparian vegetation along banks of Snubba Creek

Water Quality Parameters

Temperature (°C)	11.78
Conductivity (µS/cm)	80
Dissolved Oxygen (mg/L)	10.24
pH	11.37 (?)/ ND
Turbidity (NTU)	171
Oxygen Reduction Potential (mV)	60.1
Total Dissolved Solids (mg/L)	50
Salinity (PSU)	0.02
Oils	Not detected
Odours	Not detected

Description

Local impacts on streams

Road, culvert/bridge, litter, recreation. Local land use is native forest (Bago State Forest)

Riparian Vegetation

Low disturbance with continuous riparian vegetation along Snubba Creek

Approximate zone composition	%
Trees (Height >10m)	10
Trees (Height < 10m)	10
Shrubs	30
Grasses/ferns/sedges	50

Banks

Left and right bank have concave and moderate sloped (30 – 60°) profile with no artificial bank protection measure.

Gilmore Creek | Time: 4:50pm 4th April 2022 | GPS Coordinates: S 35° 28.413' E 148° 11.6417'

Downstream Gilmore Creek

Upstream Gilmore Creek

Water Quality Parameters

Temperature (°C)	11.78
Conductivity (µS/cm)	80
Dissolved Oxygen (mg/L)	10.24
pH	ND
Turbidity (NTU)	171
Oxygen Reduction Potential (mV)	60.1
Total Dissolved Solids (mg/L)	50
Salinity (PSU)	0.02
Oils	Not detected
Odours	Not detected

Description

Local impacts on waterways

Located near a road and bridge. Grazing land on both side of banks.

Riparian Vegetation

Very highly disturbed vegetation with land cleared for agriculture/grazing on both sides on Gilmore Creek. Occasional clumps of vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	0
Trees (Height < 10m)	5
Shrubs	0
Grasses/ferns/sedges	95

Banks - Rock wall to protect bank on right bank of river. Low bank slope (10-30°)

Tributary to Sandy Creek | Time: Visit: 8:15am 5th April 2022 | GPS Coordinates: S 35°19.5794' E 148°09.6989'


Under bridge, rock wall on both sides of creek


Downstream of tributary to Sandy Creek


Exposed vertical left bank of tributary to Sandy Creek

Water Quality Parameters

Temperature (°C)	13.9
Conductivity (µS/cm)	902
Dissolved Oxygen (mg/L)	7.70
pH	7.19
Turbidity (NTU)	417
Oxygen Reduction Potential (mV)	221.1
Total Dissolved Solids (mg/L)	584
Salinity (PSU)	0.37
Oils	Not detected
Odour	Not detected

Description

Local land use and impacts to stream - Land on both sides used for grazing. Located near a road, bridge and culverts.

Riparian Vegetation - Extreme disturbance to vegetation, with only isolated and scattered vegetation along banks

Approximate zone composition	**%**
Trees (Height >10m)	0
Trees (Height < 10m)	5
Shrubs	0
Grasses/ferns/sedges	95

Banks - Wide lower bench profile and vertical angle on left bank and a concave shape with a moderate (30-60°) on right bank. Cleared vegetation and grazing has affected the bank stability. Rock wall constructed on both banks under the bridge.

Snowy Hwy Compound – Tributary to Gilmore Creek Time: 11am 5th April 2022 GPS Coordinates: S

Informal fencing structure

Informal fencing structure

Water Quality Parameters – Unable to sample as creek was dry at time of site visit.

Description

Local impacts – grazing, unsealed road, wire fencing with corrugated iron sheeting attached

Riparian vegetation – low disturbance with continuous vegetation along both sides of banks.

Approximate zone composition	**%**
Trees (Height >10m)	5
Trees (Height < 10m)	5
Shrubs	0
Grasses/ferns/sedges	90

Banks – wide lower bench with vertical (80-90) slope. Left bank has an undercut shape on upstream end of the road.

Killimicat Creek | Time: 11am 5th April 2022 | GPS Coordinates: S 35° 13.508' E 148°17.717'

Downstream of Killimicat Creek

Unsealed road with grazing land use on both channel

Gabion baskets on left bank of Killimicat Creek

Water Quality Parameters

Temperature (°C)	18.2
Conductivity (µS/cm)	1009
Dissolved Oxygen (mg/L)	10.79
pH	8.31
Turbidity (NTU)	262
Oxygen Reduction Potential (mV)	29.6
Total Dissolved Solids (mg/L)	665
Salinity (PSU)	0.49
Oils	Not detected
Odour	Not detected

Description

Local impacts on stream

Located near bridge and road, grazing used on both sides of creek.

Riparian Vegetation

Very highly disturbed riparian vegetation resulting in isolated/scattered vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	5
Trees (Height < 10m)	5
Shrubs	0
Grasses/ferns/sedges	90

Banks

Vertical banks with gabion baskets installed on the left bank of Killimicat Creek.

Murrumbidgee River Time: 12:30pm 5th April 2022 GPS Coordinates: S 34°54.224' E 148°31.885'

Murrumbidgee River

Murrumbidgee River

Water Quality Parameters

Temperature (°C)	19.6
Conductivity (µS/cm)	3.16
Dissolved Oxygen (mg/L)	9.12
pH	9.45
Turbidity (NTU)	416
Oxygen Reduction Potential (mV)	168.5
Total Dissolved Solids (mg/L)	206
Salinity (PSU)	0.1
Oils	Not detected
Odour	Not detected

Description

Local land use - Cattle grazing on both side of river

Riparian Vegetation - High disturbance of vegetation with semi-continuous vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	60
Trees (Height < 10m)	20
Shrubs	0
Grasses/ferns/sedges	20

Banks – Convex shape with low (10-30°) bank slope

Oak Creek | Time: 1:40pm 5th April 2022 | GPS Coordinates: S 34° 54.0320' E 148° 33.4095'

Rock wall protection of creek banks, facing downstream of Oak Creek

Rock wall underneath bridge crossing Oak Creek

Water Quality Parameters

Temperature (°C)	20.33
Conductivity (µS/cm)	1.657
Dissolved Oxygen (mg/L)	9.56
pH	7.93
Turbidity (NTU)	82
Oxygen Reduction Potential (mV)	88.9
Total Dissolved Solids (mg/L)	1082
Salinity (PSU)	0.82
Oils	Not detected
Odour	Not detected

Description

Local land use and impacts on stream - Bridge, native grassland

Riparian Vegetation – Very high disturbance and scattered vegetation along both sides of banks.

Approximate zone composition	**%**
Trees (Height >10m)	60
Trees (Height < 10m)	10
Shrubs	0
Grasses/ferns/sedges	30

Banks – convex shape with moderate (30-60) slope. Rock wall on both sides under the bridge, with left rock wall extended further 10m downstream.

Derringullen Creek Time: 3pm 5th April 2022 GPS Coordinates: S 34° 48.9617' E 148° 49.7140'

Downstream of Derringullen Creek

Upstream of Derringullen Creek

Water Quality Parameters

Temperature (°C)	20.81
Conductivity (µS/cm)	1456
Dissolved Oxygen (mg/L)	9.34
pH	7.90
Turbidity (NTU)	612
Oxygen Reduction Potential (mV)	189.4
Total Dissolved Solids (mg/L)	9.48
Salinity (PSU)	0.69
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – grazing, road

Riparian vegetation – very high disturbance with isolated vegetation along right side of bank and semi – continuous vegetation on left bank

Approximate zone composition	**%**
Trees (Height >10m)	5
Trees (Height < 10m)	15
Shrubs	0
Grasses/ferns/sedges	80

Banks – Looking downstream, convex shape with steep (60 – 80) slope on both sides.

Wollondilly River | Time: 10am 6th April 2022 | GPS Coordinates S 34° 35.1876' E 149° 34.8118'

Pejar Dam spillway into Wollondilly River

Wollondilly River within the Pejar Dam Reserve

Water Quality Parameters

Temperature (°C)	16.5
Conductivity (µS/cm)	650
Dissolved Oxygen (mg/L)	8.67
pH	8.89
Turbidity (NTU)	472
Oxygen Reduction Potential (mV)	163.7
Total Dissolved Solids (mg/L)	422
Salinity (PSU)	0.27
Oils	Not detected
Odour	Not detected

Description

Local land use and impacts on stream Reserve – litter and recreation, dam

Riparian Vegetation -

Very high disturbance to the riparian vegetation, with clearing on both sides for the road and dam. Semi-continuous vegetation along right bank only.

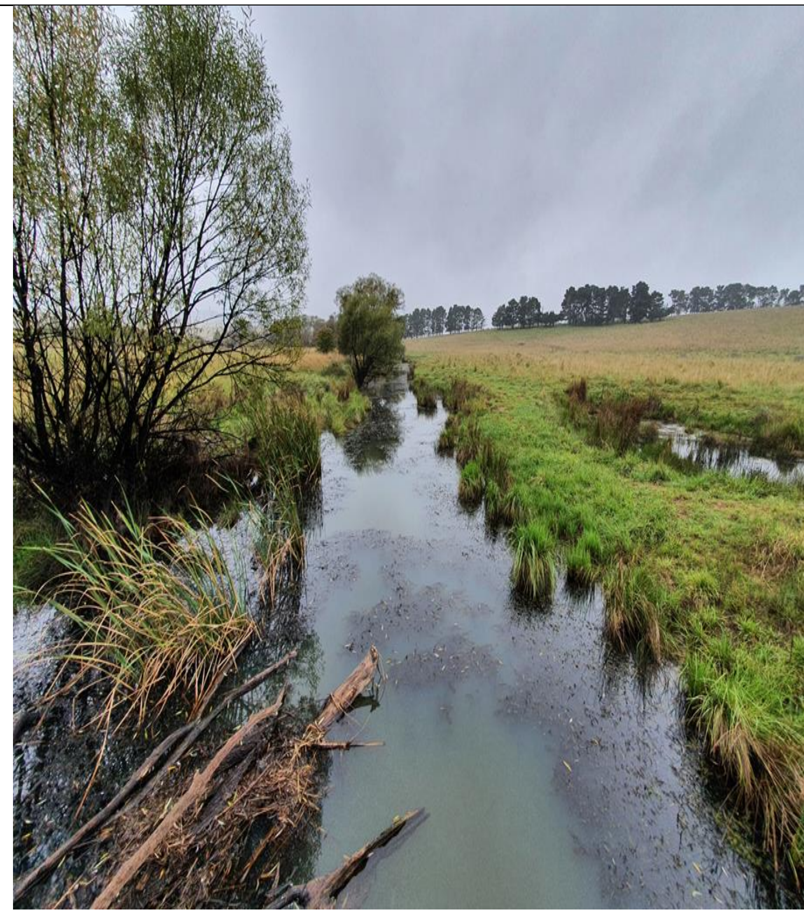
Approximate zone composition	**%**
Trees (Height >10m)	5
Trees (Height < 10m)	15
Shrubs	0
Grasses/ferns/sedges	80

Banks – concave banks with steep (60-80°) slope. Rock wall along the banks of the Pejar Dam park.

Pejar Creek Time: 10:30am 6th April 2022 GPS Coordinates S 34° 34.3361' E 149° 37.8052'

Oil sheen in Pejar Creek and barrel discarded in creek (possible source of oil sheen)

Road and bridge



Upstream of Pejar Creek

Water Quality Parameters

Temperature (°C)	14.80
Conductivity (µS/cm)	1321
Dissolved Oxygen (mg/L)	7.71
pH	8.75
Turbidity (NTU)	972
Oxygen Reduction Potential (mV)	34.4
Total Dissolved Solids (mg/L)	855
Salinity (PSU)	0.62
Oils	Sheen
Odour	Not detected

Description

Local impacts to stream – land use for grazing on both sides, road

Riparian vegetation – extreme disturbance with land cleared on both sides upstream of Pejar Creek, and isolated/scattered vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	10
Trees (Height < 10m)	10
Shrubs	0
Grasses/ferns/sedges	80

Banks – convex shape and moderate slopes (10 - 30°)

O'Briens Creek Time: 10:50am 24th August 2022 GPS Coordinates S 35° 16.7789' E 147° 29.5616

Facing downstream of O'Brien's Creek

Bridge crossing O'Brien's Creek

Eroded right bank

Water Quality Parameters

Temperature (°C)	10.33
Conductivity (µS/cm)	610
Dissolved Oxygen (mg/L)	10.74
pH	8.44
Turbidity (NTU)	35.4
Oxygen Reduction Potential (mV)	18.8
Total Dissolved Solids (mg/L)	855
Salinity (PSU)	N/A
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – land use for grazing on both sides of banks

Riparian vegetation – low disturbance with semi continuous vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	80
Trees (Height < 10m)	20
Shrubs	0
Grasses/ferns/sedges	0

Banks – facing downstream, convex shape and moderate slopes (30 - 60°) on left bank, concave shape with vertical banks (80-90°)

Tarcutta Creek | Time: 10am 25th August 2022 | GPS Coordinates S 35° 21.3966' E 147° 47.2479'


Facing downstream of Tarcutta Creek


Vertical banks of Tarcutta Creek


Facing upstream of Tarcutta Creek

Water Quality Parameters

Temperature (°C)	10.53
Conductivity (µS/cm)	590
Dissolved Oxygen (mg/L)	11.17
pH	8.17
Turbidity (NTU)	77.4
Oxygen Reduction Potential (mV)	33.7
Total Dissolved Solids (mg/L)	386
Salinity (PSU)	0.25
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – land use for grazing on both sides, road

Riparian vegetation – high disturbance with land cleared on both banks, and occasional clumps of vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	50
Trees (Height < 10m)	50
Shrubs	0
Grasses/ferns/sedges	80

Banks – concave shape with vertical banks (80-90°) on both banks looking downstream

Umbango Creek | Time: 11am 25th August 2022 | GPS Coordinates S 35° 22.8534' E 147° 46.4029'

Facing downstream

Road/bridge crossing Umbango Creek

Bank protection structure underneath bridge/road

Water Quality Parameters

Temperature (°C)	10.8
Conductivity (µS/cm)	954
Dissolved Oxygen (mg/L)	10.75
pH	8.27
Turbidity (NTU)	14.5
Oxygen Reduction Potential (mV)	27.7
Total Dissolved Solids (mg/L)	623
Salinity (PSU)	0.41
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – land use for grazing on both sides, road/bridge

Riparian vegetation – moderate disturbance with land cleared on both sides, with occasional clumps of vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	75
Trees (Height < 10m)	20
Shrubs	0
Grasses/ferns/sedges	5

Banks – looking downstream, left side - concave shape with vertical banks (80-90°), right side- convex shape and moderate slopes (10 - 30°)

Pipeclay Gully Time: 2pm 25th August 2022 GPS Coordinates S 35° 45.7900’ E 147° 59.9278’


Pipeclay Gully


Surrounding vegetation


Surrounding vegetation

Water Quality Parameters

Temperature (°C)	11.00
Conductivity (µS/cm)	151
Dissolved Oxygen (mg/L)	10.14
pH	6.53
Turbidity (NTU)	174
Oxygen Reduction Potential (mV)	31.6
Total Dissolved Solids (mg/L)	96
Salinity (PSU)	0.05
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – land use for grazing on both sides, BMX track nearby, litter

Riparian vegetation – very low disturbance on both sides with continuous vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	80
Trees (Height < 10m)	20
Shrubs	0
Grasses/ferns/sedges	0

Banks concave shape with low banks (10-30°) on both banks looking downstream

Adjungbilly Creek | Time: 11am 26th August 2022 | GPS Coordinates S 35° 05.1641’ E 148° 24.0057’

Bridge crossing Adjungbilly Creek and looking down stream

Facing downstream

Facing upstream

Water Quality Parameters

Temperature (°C)	8.60
Conductivity (µS/cm)	310
Dissolved Oxygen (mg/L)	11.30
pH	6.52
Turbidity (NTU)	231
Oxygen Reduction Potential (mV)	183.4
Total Dissolved Solids (mg/L)	204
Salinity (PSU)	0.10
Oils	Not detected
Odour	Not detected

Description

Local impacts to stream – land use for grazing and forestry on both sides, road/bridge

Riparian vegetation – moderate disturbance on both sides with occasional clumps of vegetation along the banks.

Approximate zone composition	**%**
Trees (Height >10m)	30
Trees (Height < 10m)	30
Shrubs	40
Grasses/ferns/sedges	0

Banks concave shape with moderate slope banks (30-60°) on left side, convex shape and steep slopes (60 - 80°)

Attachment D

Registered bores

Table D1 Percentage of waterway buffer within project footprint by area

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW010812	547325	6095676	11.0		Very Good		Water Supply	Murrumbidgee
GW007851	665470	6142732	13.0				Unknown	Murrumbidgee
GW505404	590199	6041047	47.0	9.000		5.000	Water Supply	Murray
GW505466	590208	6041065	24.0	3.100		1.260	Water Supply	Murray
GW052743	589497	6041065	55.8		Good		Unknown	Murray
GW051973	590708	6041608	31.7		Good		Water Supply	Murray
GW504843	589290	6041548	31.5				Water Supply	Murray
GW059760	589353	6041714	24.4				Water Supply	Murray
GW051820	589354	6041806	31.7		Good		Water Supply	Murray
GW505440	589908	6041961	62.0			10.000	Water Supply	Murray
GW060718	590739	6042193	45.7		Good		Water Supply	Murray
GW038617	589436	6042514	35.3		Good		Water Supply	Murray
GW043100	589764	6042634	30.1		Good		Water Supply	Murray
GW500856	589016	6042862	60.0	5.280		8.000	Unknown	Murray
GW501009	588899	6042890	115.0				Irrigation	Murray
GW501008	588953	6042899	72.0				Irrigation	Murray
GW500204	588961	6042906	100.0			3.500	Monitoring	Murray
GW500857	589000	6042917	102.0	19.200		7.000	Unknown	Murray
GW501010	588975	6042918	127.0			5.000	Irrigation	Murray
GW047966	589315	6043008	13.4		Good		Irrigation	Murray
GW068808	604425	6068750	37.0	10.000	Good	1.390	Unknown	Murrumbidgee
GW057844	605602	6073613	2.0				Unknown	Murrumbidgee
GW416394	602550	6083474	60.0	4.000			Water Supply	Murrumbidgee
GW409592	602403	6083959	37.5	1.500	Good	1.500	Water Supply	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW402876	602745	6084106	25.6	5.100	Good	0.700	Unknown	Murrumbidgee
GW402618	603472	6084263				1.500	Irrigation	Murrumbidgee
GW058114	602927	6084398	24.0				Stock and Domestic	Murrumbidgee
GW400409	603620	6084969	24.0	1.700		2.000	Water Supply	Murrumbidgee
GW057454	603625	6085838	66.0				Water Supply	Murrumbidgee
GW058727	603550	6085870	36.0				Water Supply	Murrumbidgee
GW057455	603602	6085992	20.0				Water Supply	Murrumbidgee
GW401219	603738	6086409	21.3	3.050	Good	0.380	Water Supply	Murrumbidgee
GW035745	603835	6086544	21.3				Water Supply	Murrumbidgee
GW400026	590479	6085208	61.0		Good		Irrigation	Murrumbidgee
GW051870	603904	6088084	15.2		Good		Water Supply	Murrumbidgee
GW057693	606670	6089284	36.0				Water Supply	Murrumbidgee
GW401130	608177	6089543	43.5	23.400		3.000	Monitoring	Murrumbidgee
GW401131	607798	6089517	10.0				Monitoring	Murrumbidgee
GW401132	607783	6089517	46.0	15.000		1.800	Monitoring	Murrumbidgee
GW402690	607526	6089760	42.0	11.000	Good	1.100	Water Supply	Murrumbidgee
GW038832	606880	6089990	54.8				Exploration	Murrumbidgee
GW403474	603942	6089797	9.0	5.450			Monitoring	Murrumbidgee
GW038083	607211	6090202	68.5		Fresh		Commercial and Industrial	Murrumbidgee
GW403475	603269	6089855	7.1	3.800			Monitoring	Murrumbidgee
GW043356	606809	6090361					Exploration	Murrumbidgee
GW403473	604076	6090049	7.6	3.800			Monitoring	Murrumbidgee
GW403472	604236	6090375	4.8	1.300			Monitoring	Murrumbidgee
GW403471	603788	6090400	9.0	1.500			Monitoring	Murrumbidgee
GW401557	604421	6090515	31.0	4.000			Monitoring	Murrumbidgee
GW401558	604421	6090515	10.5	4.000			Monitoring	Murrumbidgee
GW401559	603446	6090514	31.0	5.000			Monitoring	Murrumbidgee
GW403468	604073	6090864	7.4	3.680			Monitoring	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW403476	602951	6090754	8.9	6.250			Monitoring	Murrumbidgee
GW403466	603622	6091054	7.2	5.850			Monitoring	Murrumbidgee
GW401201	573280	6087646	31.0	12.500		0.625	Water Supply	Murrumbidgee
GW400592	572713	6087685	5.2				Monitoring	Murrumbidgee
GW403486	604566	6091366	13.5				Monitoring	Murrumbidgee
GW404929	570086	6087461	51.0	12.000		4.380	Irrigation	Murrumbidgee
GW400589	572913	6087835	8.5				Monitoring	Murrumbidgee
GW403801	604410	6091557	56.0	4.000	Good	1.500	Monitoring	Murrumbidgee
GW403469	603463	6091475	5.9	2.300			Unknown	Murrumbidgee
GW400586	573163	6087985	3.7				Monitoring	Murrumbidgee
GW403481	604239	6091594	15.4				Monitoring	Murrumbidgee
GW400590	572777	6088026	4.8				Monitoring	Murrumbidgee
GW400591	572773	6088026	8.4				Monitoring	Murrumbidgee
GW403800	604103	6091694	50.0	5.500		6.000	Monitoring	Murrumbidgee
GW403465	603803	6091669	4.9	1.000			Monitoring	Murrumbidgee
GW400587	573198	6088155	4.9				Monitoring	Murrumbidgee
GW400588	573193	6088160	6.6				Monitoring	Murrumbidgee
GW043217	569571	6087891	33.8		Very Good		Water Supply	Murrumbidgee
GW403802	604454	6091928	50.0	6.000	Good	1.500	Monitoring	Murrumbidgee
GW401561	604482	6092029	18.0	6.000			Monitoring	Murrumbidgee
GW020927	569699	6088137	39.6				Water Supply	Murrumbidgee
GW403799	604129	6092115	56.0	13.800		6.000	Monitoring	Murrumbidgee
GW029086	569573	6088137	25.6				Unknown	Murrumbidgee
GW403798	603838	6092243	56.0	4.800		1.400	Unknown	Murrumbidgee
GW029087	569148	6088726	19.5				Unknown	Murrumbidgee
GW402853	569121	6088899	55.8	14.020		13.638	Unknown	Murrumbidgee
GW037600	569151	6089003	15.8		Very Good		Water Supply	Murrumbidgee
GW400600	568203	6089498	7.4				Monitoring	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW029289	557022	6091152	28.0				Stock and Domestic	Murrumbidgee
GW417071	558942.7	6091506.8					Stock and Domestic	Murrumbidgee
GW050964	606837	6097047	30.0		Good		Water Supply	Murrumbidgee
GW011519	560512	6092054	46.6		S.Brackish		Water Supply	Murrumbidgee
GW400802	555973	6092997	60.0	20.000		1.250	Water Supply	Murrumbidgee
GW059747	555897	6093039	45.0				Irrigation	Murrumbidgee
GW064581	606307	6099210	24.0				Water Supply	Murrumbidgee
GW404941	551492	6092913	84.0	14.000		1.100	Water Supply	Murrumbidgee
GW059781	607630	6099934	25.0		Fair		Water Supply	Murrumbidgee
GW402693	608906	6100398	80.0	27.100		0.230	Water Supply	Murrumbidgee
GW401861	548698	6094000	48.8	9.750		1.770	Water Supply	Murrumbidgee
GW016032	549138	6094649	45.1				Stock and Domestic	Murrumbidgee
GW042297	609650	6101851	2.1				Unknown	Murrumbidgee
GW042298	609399	6101977	2.4				Unknown	Murrumbidgee
GW402392	612810	6102451	52.0	8.000		2.500	Water Supply	Murrumbidgee
GW042299	609325	6102163	2.3				Unknown	Murrumbidgee
GW025450	547172	6095522	37.5		0-500 ppm		Irrigation	Murrumbidgee
GW416663	544567	6095984	56.0	38.000	Good	5.000	Water Supply	Murrumbidgee
GW013408	545130	6096272	30.5		Very Good		Stock and Domestic	Murrumbidgee
GW416662	544473	6096395	56.0	38.000	Good	0.500	Water Supply	Murrumbidgee
GW409415	541541	6098264	96.0			3.159	Water Supply	Murrumbidgee
GW030382	542994	6098655	35.0				Exploration	Murrumbidgee
GW416921	539921.5	6099083.4	162.0				Stock and Domestic	Murrumbidgee
GW014706	541609	6099832	5.2				Irrigation	Murrumbidgee
GW016406	539107	6099751	11.6				Stock and Domestic	Murrumbidgee
GW416309	540531	6100614	85.0	30.000		5.000	Water Supply	Murrumbidgee
GW405096	537824	6101752	165.0	85.000		0.740	Water Supply	Murrumbidgee
GW068774	535960	6102875	32.6		Fair		Water Supply	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW415974	535061	6103677	22.0				Unknown	Murrumbidgee
GW415970	535342	6103779	22.0	14.000			Monitoring	Murrumbidgee
GW415969	535539	6103826	20.0				Monitoring	Murrumbidgee
GW401412	535663	6103910	16.0				Monitoring	Murrumbidgee
GW401402	535663	6103910	9.0	7.000			Monitoring	Murrumbidgee
GW401408	535663	6103910	9.6				Monitoring	Murrumbidgee
GW401413	535663	6103910	8.5				Monitoring	Murrumbidgee
GW401410	535663	6103910	11.5				Monitoring	Murrumbidgee
GW401401	535663	6103910	5.0	3.400			Monitoring	Murrumbidgee
GW401419	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401406	535663	6103910	10.3				Monitoring	Murrumbidgee
GW401403	535663	6103910	9.0	6.000			Monitoring	Murrumbidgee
GW401417	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401421	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401400	535663	6103910	7.3				Monitoring	Murrumbidgee
GW401409	535663	6103910	9.7				Monitoring	Murrumbidgee
GW401407	535663	6103910	12.7				Monitoring	Murrumbidgee
GW401411	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401418	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401416	535663	6103910	11.6				Monitoring	Murrumbidgee
GW401427	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401404	535663	6103910	8.2				Monitoring	Murrumbidgee
GW401424	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401420	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401405	535663	6103910	13.5				Monitoring	Murrumbidgee
GW401415	535663	6103910	8.6				Monitoring	Murrumbidgee
GW401425	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401422	535663	6103910	8.2				Monitoring	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW401426	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401423	535663	6103910	8.0				Monitoring	Murrumbidgee
GW401414	535663	6103910	8.7				Monitoring	Murrumbidgee
GW415972	535310	6103885	23.0				Monitoring	Murrumbidgee
GW415971	535110	6103862	20.0				Monitoring	Murrumbidgee
GW415973	535293	6103884	12.0				Monitoring	Murrumbidgee
GW415975	534732	6103824	25.0				Monitoring	Murrumbidgee
GW415975	534732	6103824	25.0				Monitoring	Murrumbidgee
GW415977	535764	6104180	25.0				Monitoring	Murrumbidgee
GW415978	535766	6104182	10.6				Monitoring	Murrumbidgee
GW415979	535505	6104226	19.0				Monitoring	Murrumbidgee
GW415980	534688	6104383	7.0				Monitoring	Murrumbidgee
GW415982	534690	6104385	22.0				Monitoring	Murrumbidgee
GW014707	536524	6104752	76.2		501-1000 ppm		Water Supply	Murrumbidgee
GW016258	536550	6104844	48.8		Stock		Stock and Domestic	Murrumbidgee
GW033557	536248	6105184	121.3				Unknown	Murrumbidgee
GW403450	675127	6139793	72.0				Water Supply	Murrumbidgee
GW416268	675380	6140218	65.0	30.000		1.000	Water Supply	Murrumbidgee
GW403831	674576	6140748	120.0				Water Supply	Murrumbidgee
GW404132	675117	6140972	43.0	26.000	V.Salty	50.000	Water Supply	Murrumbidgee
GW402282	674970	6141028	90.0				Water Supply	Murrumbidgee
GW403553	674953	6141031	43.0	36.000	Salty	10.000	Water Supply	Murrumbidgee
GW402281	674994	6141049	49.0	18.000		0.563	Water Supply	Murrumbidgee
GW401336	675263	6141084	36.4	9.000	Good	1.800	Water Supply	Murrumbidgee
GW402279	675166	6141088	74.0			0.400	Water Supply	Murrumbidgee
GW401200	675113	6141084	30.0	14.000		1.290	Water Supply	Murrumbidgee
GW404247	675215	6141222	23.0	10.000		1.248	Water Supply	Murrumbidgee
GW402183	675160	6141231	38.0			1.600	Water Supply	Murrumbidgee

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW401932	674871	6141494	60.8				Unknown	Murrumbidgee
GW405393	654341	6139227	76.0				Water Supply	Murrumbidgee
GW025920	659408	6140374	20.4				Stock and Domestic	Murrumbidgee
GW024605	659969	6140488	30.8				Stock and Domestic	Murrumbidgee
GW027978	661337	6141727	15.5				Stock and Domestic	Murrumbidgee
GW020824	667179	6144458	31.7				Unknown	Murrumbidgee
GW414690	663769	6144355	125.0			0.500	Water Supply	Murrumbidgee
GW054861	668917	6146399	22.9		Good		Stock and Domestic	Murrumbidgee
GW416449	674871	6149603	102.0			1.000	Water Supply	Murrumbidgee
GW404407	673635	6149549	64.0				Water Supply	Murrumbidgee
GW404658	674028	6149786	60.0	32.000	Fresh	0.625	Water Supply	Murrumbidgee
GW403816	674178	6149836	61.0			1.300	Water Supply	Murrumbidgee
GW402324	675917	6150042	48.0	8.500		1.770	Water Supply	Murrumbidgee
GW408737	676181	6150242	90.0	14.000		2.500	Water Supply	Murrumbidgee
GW020826	675831	6150368	46.0				Unknown	Murrumbidgee
GW403939	675931	6150456	80.0				Water Supply	Murrumbidgee
GW020863	674298	6151353	44.2				Unknown	Murrumbidgee
GW058430	692242	6154324	30.4		Fair		Stock and Domestic	Lachlan
GW019366	691110	6154964	27.4				Stock and Domestic	Lachlan
GW054827	691570	6155078	32.6		Fair		Water Supply	Lachlan
GW019370	690525	6154976	26.8				Irrigation	Lachlan
GW700018	695993	6156002	16.6				Water Supply	Lachlan
GW044813	694410	6156991	30.5		501-1000 ppm		Water Supply	Lachlan
GW700858	696388	6158184	30.0	9.000		0.562	Water Supply	Lachlan
GW703450	699301	6158595	18.6	4.200		0.502	Water Supply	Lachlan
GW703832	715629	6163756	86.0	11.000			Water Supply	Lachlan
GW100992	728264	6167376	41.0	20.000		1.250	Water Supply	Greater Metropolitan
GW072886	725329	6167075	54.0		0-500 ppm		Irrigation	Greater Metropolitan

Bore ID	Easting	Northing	Final depth (m)	SWL (m)	Salinity description	Yield (L/s)	Bore use	WSP
GW109289	725304	6167598	66.0	14.000	Fresh	0.375	Irrigation	Greater Metropolitan
GW109146	730146	6168721	54.0	9.000		0.875	Water Supply	Greater Metropolitan
GW110438	727941	6169047	60.0	12.000		0.250	Water Supply	Greater Metropolitan
GW109133	726840	6169061	48.0	10.000	Fresh	0.563	Water Supply	Greater Metropolitan
GW111777	730752	6170563	50.0			0.019	Water Supply	Greater Metropolitan
GW111210	740260	6172000	54.0	12.000		0.075	Water Supply	Greater Metropolitan
GW064229	740353	6172219	41.1				Water Supply	Greater Metropolitan
GW109931	740427	6174155	180.0	11.000		0.300	Water Supply	Greater Metropolitan
GW037697	761621	6180062	37.7		Good		Water Supply	Greater Metropolitan
GW026033	762392	6180256	23.8				Water Supply	Greater Metropolitan
GW072882	761766	6180251	61.0		Good		Water Supply	Greater Metropolitan
GW107610	762440	6180417	48.0	16.000		2.500	Water Supply	Greater Metropolitan
GW115701	760971	6180642	18.0	2.500	Fresh	2.125	Stock and Domestic	Greater Metropolitan
GW059774	768855	6186487	45.7		Good		Water Supply	Greater Metropolitan

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