EnergyCo

September 2023

Central-West Orana Renewable Energy Zone Transmission project

Technical paper 17 – Groundwater

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Central-West Orana Renewable Energy Zone Transmission project
Technical paper 17 – Groundwater

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WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Glossary

Term	Definition
Alluvial	Sediments deposited by flowing water.
Alluvium	A general term for unconsolidated deposits of inorganic materials (clay, silt, sand, gravel, boulders) deposited by flowing water.
Aquifer	Rock or sediment in a formation, group of formations or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.
Bore	Artificially constructed or improved groundwater cavity used to access, measure or recharge water from an aquifer. Interchangeable with borehole, piezometer.
Borehole	Includes a well, excavation, or other artificially constructed or improved groundwater cavity which can be used to access, measure or recharge water from an aquifer. Interchangeable with a bore, well, piezometer.
Central-West Orana Renewable Energy Zone (CWO REZ)	A geographic area of approximately 20,000 square kilometres centred on the regional towns of Dubbo and Dunedoo and extending west to Narromine and east beyond Mudgee and to Wellington in the south and Gilgandra in the north will combine renewable energy generation, storage and transmission infrastructure to deliver energy to electricity consumers.
Clay	Deposit of particles with a diameter of less than 0.002 mm, typically contains variable amounts of water within the mineral structure and exhibits high plasticity.
Confined aquifer	An aquifer bounded above and below by impervious (confining) layers. In a *confined aquifer*, the water is under sufficient pressure so that when wells are drilled into the aquifer, measured water levels rise above the top of the aquifer.
Construction area	The area that would be directly impacted by construction of the project including (but not limited to) transmission towers and lines, brake and winch sites, access roads to switching stations and energy hubs, access tracks, energy hubs, switching stations, communications infrastructure workforce accommodation camps, construction compounds and laydown and staging areas.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second. Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (e.g., metres per second).
Draw-down	The change in groundwater level in a bore, or the change in water table elevation in an unconfined groundwater system, due to the extraction of groundwater.
Detailed design	The stage of design where project elements are designed in detail, suitable for construction.
Earthworks	All operations involved in loosening, excavating, placing, shaping, and compacting soil or rock.

Term	Definition
EnergyCo	The Energy Corporation of New South Wales constituted by section 7 of the *Energy and Utilities Administration Act 1987* as the NSW Government-controlled statutory authority responsible for the delivery of NSW's REZs.
Energy hub/s	An energy hub is a substation where energy exported from renewable energy generators or storage is aggregated, transformed to 500 kV (where required) and exported to the transmission network. For the project, this includes Merotherie Energy Hub and Elong Elong Energy Hub.
Fluvial	Synonymous with alluvial. Refer to alluvial for definition.
Formation	A general term used to describe a sequence of soil or rock layers.
Groundwater	Water found in the subsurface in the saturated zone below the water table or piezometric surface, i.e. the water table marks the upper surface of groundwater systems.
Groundwater resource	Groundwater available for beneficial use, including human usage, aquatic ecosystems, and the greater environment.
Groundwater study area	The proposed study area for this groundwater EIS technical paper comprises a 500 metre buffer surrounding the construction area.
Highly productive	Highly productive groundwater areas are characterised by bores having a yield rates greater than of greater than 5 litres per second and total dissolved solids of less than 1,500 milligrams per litre (DPI 2013).
Hydrogeology	The study of the interrelationships of geological materials and processes with water, especially groundwater.
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Monitoring bore	A bore used to monitor groundwater levels or quality.
Permeability	The ease with which a fluid can pass through a porous medium and is defined as the volume of fluid discharged from a unit area of an aquifer under unit hydraulic gradient in unit time (metres per day).
operation area	The area that would be occupied by permanent components of the project and/or maintained, including transmission line easements, transmission lines and towers, energy hubs, switching stations, communications infrastructure, access roads to the switching stations and energy hubs, maintenance facilities, and permanent access tracks to the easements.
(the) project	The Central-West Orana REZ Transmission project as described in of the Environmental Impact Statement.
Perched	Perched groundwater forms above a layer of lower permeability material within the unsaturated soil zone where the migration of percolating recharge is slowed to the extent that it saturates the porous material.
Recharge	Groundwater recharge is a hydrologic process that involves the movement of water from the surface to the underground aquifers.

Term	Definition
Renewable Energy Zone (REZ)	A geographic area identified and declared by the NSW Government as a REZ
Run-off	All surface and subsurface flow from a catchment, but in practice refers to the flow in a river, i.e. excludes groundwater not discharged into a river.
Sensitive receivers	Land uses landscape features and activities that are sensitive to changes in the environment such as water quality and quantity, noise, vibration, air, and visual impacts. Sensitive receivers may include aquatic ecosystems, aquaculture areas, residential dwellings, schools, and recreation areas.
Standing water level	The height to which groundwater rises in a bore after it is drilled and completed, and after a period of pumping when levels return to natural atmospheric or confined pressure levels.
Unconfined	Where groundwater is in direct contact with the atmosphere through the open pore spaces of the overlying soil or rock.
Water affecting activity	Project activities that have the potential to affect surface water and groundwater.
Water table	The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric; it can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.
Water supply work approval	Water supply work approvals are issued under the NSW *Water Management Act 2000*, and allow the approval holder to construct and use a work which takes water from a river, lake or aquifer.

Abbreviations

Acronym	Definition
AIP	NSW Aquifer Interference Policy
BGL	below ground level
BoM	Bureau of Meteorology
CEMP	Construction and Environment Management Plan
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DPE	NSW Department of Planning and Environment
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	Environment Protection Licence
EIS	Environmental Impact statement
GIS	Graphical information systems
LEP	local environmental plan
LGA	local government area
MDB	Murray-Darling Basin
MNES	Matters of National Environmental Significance
NATA	National Association of Testing Authorities
NGIS	National groundwater information system
NSW EPA	New South Wales Environmental Protection Agency
pH	Unit of measurement for acidity and alkalinity
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
REZ	Renewable Energy Zones
SEARs	Secretary's environmental assessment requirements
SEPPs	state environmental planning policies
SWMP	Soil and Water Management Plan
TAD	Total available drawdown
TDS	Total dissolved solids
WAL	water access licence
WM Act	*Water Management Act 2000* (NSW)
WSP	WSP Australia Pty Ltd

Executive summary

This technical paper assesses the potential impacts to groundwater from the construction and operation of the Central-West Orana Renewable Energy Zone Transmission project (the project) and has been prepared to support and inform the Environmental Impact Statement (EIS) for the project.

The impacts have been assessed in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued by the NSW Department of Planning and Environment (DPE) and against the relevant legislation and guidelines as they apply to groundwater.

Project overview

The NSW Government is leading the development of Renewable Energy Zones (REZ) across NSW to deliver renewable energy generation and storage, supported by high voltage transmission infrastructure. Energy Corporation of NSW (EnergyCo) is proposing the construction and operation of new electricity transmission infrastructure and new energy hubs and switching stations required to connect new energy generation and storage projects within the Central-West Orana REZ to the existing electricity network (the project). The project is located within the Warrumbungle, Mid-Western Regional, Dubbo Regional and Upper Hunter local government areas (LGAs) and extends generally north to south from Cassilis to Wollar and east to west from Cassilis to Goolma.

The project would enable 4.5 gigawatts of new network capacity to be unlocked by the mid-2020s (noting the NSW Government's proposal to amend the Central-West Orana REZ declaration to allow for a transfer capacity of six gigawatts), and enable renewable energy generators within the Central-West Orana REZ who are successful in their bids to access the new transmission infrastructure to export electricity to the rest of the network. Importantly, the development of renewable energy generation projects in the Central-West Orana REZ is the sole responsibility of private generators and subject to separate planning and environmental approvals.

Legislative and policy context

Impacts to groundwater from construction and operation of the project have been assessed in accordance with the relevant legislation and guidelines as they apply to groundwater. Key legislation assessed as part of this assessment includes:

- Commonwealth *Environmental Protection and Biodiversity Act 1999*
- Commonwealth *Water Act 2007*
- NSW *Environmental Planning and Assessment Act 1979*
- NSW *Water Management Act 2000*
- NSW Water Management (General) Regulation 2018
- NSW *Protection of the Environment Operations Act 1997*
- NSW Water Sharing Plans
- NSW Aquifer Interference Policy 2012.

Methodology

The assessment of potential groundwater impacts arising from the project included the following key steps:

- desktop review of existing studies, and publicly available data relevant to the study area
- a review of field investigations completed for the project
- development of a site conceptual model
- an assessment of the potential impacts to groundwater, groundwater dependent ecosystems (GDEs) and groundwater users from construction and operation of the project
- identification of potential mitigation measures to avoid, mitigate and manage any potential impacts of the project to groundwater.

Existing environment

Throughout the study area groundwater occurs in alluvial, fractured, and porous rock aquifers, and as either highly productive or less productive. Highly productive groundwater areas are characterised by bores having yield rates greater than 5 litres per second (L/s) and total dissolved solids (TDS) of less than 1,500 milligrams per litre (mg/L) (DPI 2013). Where an aquifer fails to meet these criteria, it is classified as less productive.

The study area covers eight groundwater sources including:

- Sydney Basin Murray Darling Basin (MDB) Groundwater Source
- Gunnedah-Oxley Basin MDB Groundwater Source
- Liverpool Ranges Basalt MDB Groundwater Source
- Lachlan Fold Belt MDB Groundwater Source
- Sydney Basin-North Coast Groundwater Source
- Oxley Basin Coast Groundwater Source
- Liverpool Ranges Basalt Coast Groundwater Source
- Talbragar Alluvial Groundwater Source.

There are no available regional groundwater contour maps or proximal groundwater level information published within the study area. The depth to groundwater throughout the study area is spatially variable and ranges from 0.65 metres below ground level (mBGL) to 51 mBGL. The depth to groundwater depends on the underlying geology and the respective recharge and discharge of the aquifer(s) in the local areas. Groundwater flow in the shallow, unconfined aquifers is generally reflective of topography.

Measured groundwater quality across the study area is fresh to brackish, with salinity (as TDS) ranging from 400 mg/L to 4,970 mg/L.

There are 24 registered groundwater users identified within the study area. There are also 17 unique high priority terrestrial GDEs (that occur in 316 locations) and five high priority aquatic GDEs in the study area (six in the Macquarie-Bogan River catchment and two in the Hunter River catchment). Further assessment of the potential impacts of the project on GDEs is provided in the Technical paper 4 – Biodiversity Development Assessment Report.

Potential construction impacts

Excavation works would be primarily limited to above ground works such as surface leveling at energy hubs and switching stations from cut and fill activities, ground preparation to create work areas, surface leveling for access tracks, and excavation for drainage and utility works. Piling for the transmission tower components would require deep bore-piling (ranging from approximately 15 to 50 m deep) in some areas, which would not remain open and not result in permanent inflow or take of groundwater.

A groundwater supply system is required as a secondary rainfall independent water source during the construction period of the project at both Elong Elong and Merotherie energy hubs. If required, the proposed use of extracted groundwater would be for non-potable uses such as dust suppression, landscaping and compaction of access roads and project areas. Extraction volumes of up to 124 megalitres at Elong Elong Energy Hub and at Merotherie Energy Hub were assessed for the construction period. The extraction volumes were assessed in accordance with the bore dealing assessment criteria and no more than minimal harm would occur at sensitive receivers due to extraction of groundwater during the four year construction period of the project.

The key mitigation measures for the management of potential groundwater impacts during construction are the:

- control and management of potential contaminant spills to prevent contamination of groundwater
- managing incidental groundwater inflow to excavations appropriately
- limiting water supply extraction volumes to within the limits that have been approved.

Potential operational impacts

Operational activities would not result in permanent inflow or take of groundwater. The key mitigation measure for the management of potential groundwater impacts during operation is the control and management of potential contaminant spills during operation and maintenance activities, such as fuel and oils to prevent contamination of groundwater.

Management measures

The project is anticipated to have limited impact to groundwater during construction, which would be further reduced through the implementation of mitigation measures outlined within the Construction and Environmental Management Plan (CEMP) and the soil and water management sub-plan.

Typical provisions within the CEMP for the management of potential impacts to groundwater during construction of the project would include:

- procedures for the documentation and reporting of results related to the interception and extraction (take) of groundwater and potential impacts
- requirements for training, inspections, corrective actions, notifications and classification of environmental incidents, record keeping and performance objectives for handover on completion of construction.

A Soil and Water Management sub- plan as part of the CEMP would also be prepared for the project and contain appropriate mitigation measures to be implemented if groundwater is encountered during construction. The sub-plan would include but is not limited to:

- a procedure for managing any intercepted shallow groundwater
- procedures for soil storage (including contaminated soil) and erosion control.

1 Introduction

1.1 Background

New South Wales (NSW) is currently undergoing an energy sector transformation that will change how we generate and use energy. The NSW Government is leading the development of Renewable Energy Zones (REZs) across NSW to deliver renewable energy generation and storage projects, supported by transmission infrastructure. A REZ connects renewable energy generation and energy storage systems to transmission infrastructure via energy hubs, requiring the coordination of power generation, power storage and transmission infrastructure. By doing so, REZs capitalise on economies of scale to deliver clean, affordable and reliable electricity for homes, businesses and industry in NSW.

The Central-West Orana REZ was formally declared on 5 November 2021 under the *Electricity Infrastructure Investment Act 2020.* As NSW's first REZ, the Central-West Orana REZ will play a pivotal role in underpinning NSW's transition to a clean, affordable and reliable energy sector.

The proposed amendment is consistent with the NSW Network Infrastructure Strategy (EnergyCo, 2023) which identifies options to increase network capacity to 4.5 gigawatts initially under Stage 1 (which would be based on the infrastructure proposed in this assessment) and up to six gigawatts by 2038 under Stage 2 (which would require additional infrastructure beyond the scope of this assessment, and subject to separate approval). The proposed amendment also supports recent modelling by the Consumer Trustee in the draft 2023 Infrastructure Investment Objectives Report (AEMO, 2023) showing more network capacity will be needed to meet NSW's future energy needs as coal-fired power stations progressively retire.

Energy Corporation of NSW (EnergyCo), a NSW Government statutory authority, has been appointed as the Infrastructure Planner under the *Electricity Infrastructure Investment Act* 2020, and is responsible for the development and delivery of the Central-West Orana REZ. EnergyCo is responsible for coordinating REZ transmission, generation, firming and storage projects to deliver efficient, timely and coordinated investment.

EnergyCo is seeking approval for the construction and operation of new electricity transmission infrastructure and new energy hubs and switching stations that are required to connect energy generation and storage projects within the Central-West Orana REZ to the existing electricity network (the project).

1.2 Purpose of this paper

This technical paper assesses the potential impacts to groundwater from the construction and operation of the project and has been prepared to support and inform the Environmental Impact Statement (EIS).

1.2.1 Secretary's Environmental Assessment Requirements

This technical paper has been prepared to address the relevant Secretary's environmental assessment requirements (SEARs) for the project issued by the Secretary of the NSW Department of Planning and Environment (DPE) for the project on 7 October 2022, and the supplementary SEARs on 2 March 2023. The SEARs relevant to the assessment of groundwater are presented in Table 1-1.

Table 1-1 SEARs relevant to this paper

Reference	Assessment requirement	Location where it is addressed
Water	Details on water requirements, supply arrangements and wastewater disposal arrangements for construction and operation.	Technical paper 12 – Hydrology and water quality, and Chapter 3 of the EIS. Section 6.2.4 discusses impacts from groundwater extraction for water supply.
	An assessment of the impacts of the project on groundwater aquifers and groundwater dependent ecosystems having regard to the NSW Aquifer Interference Policy and relevant water sharing plans.	Chapter 5, 7 and 8 of this report Note: Technical paper 4 contains a further assessment of potential impacts on groundwater dependent ecosystems.

1.2.2 Related technical papers

Other technical papers that have been prepared to support the EIS that are relevant to this groundwater impact assessment include:

- Technical paper 4 – Biodiversity development assessment report: detailed impact assessment on vegetation, including groundwater dependent ecosystems
- Technical paper 14 – Hydrology and water quality: details on project water requirements, water supply arrangements and wastewater disposal arrangements for construction and operation
- Technical paper 16 – Contamination: groundwater quality and areas of contamination concern.

1.3 Project overview

The project comprises the construction and operation of new electricity transmission infrastructure, energy hubs and switching stations within the Central-West Orana REZ. The project would enable 4.5 gigawatts of new network capacity to be unlocked by the mid-2020s (noting the NSW Government's proposal to amend the Central-West Orana REZ declaration to allow for a transfer capacity of six gigawatts), and enable renewable energy generators within the Central-West Orana REZ who are successful in their bids to access the new transmission infrastructure to export electricity onto the National Electricity Market (NEM). A detailed description of the project, including a description of key project components, the construction methodology and how it would be operated is provided in Chapter 3 of the EIS.

1.3.1 Key features

The project would comprise the following key features:

- a new 500 kV switching station (the New Wollar Switching Station), located at Wollar to connect the project to the existing 500 kV transmission network
- around 90 kilometres of twin double circuit 500 kV transmission lines and associated infrastructure to connect two energy hubs to the existing NSW transmission network via the New Wollar Switching Station
- energy hubs at Merotherie and Elong Elong (including potential battery storage at the Merotherie Energy Hub) to connect renewable energy generation projects within the Central-West Orana REZ to the 500 kV network infrastructure
- around 150 kilometres of single circuit, double circuit and twin double circuit 330 kV transmission lines, supported on towers, to connect renewable energy generation projects within the Central-West Orana REZ to the two energy hubs

- thirteen switching stations along the 330 kV network infrastructure at Cassilis, Coolah, Leadville, Merotherie, Tallawang, Dunedoo, Cobbora and Goolma, to transfer the energy generated from the renewable energy generation projects within the Central-West Orana REZ onto the project's 330 kV network infrastructure
- underground fibre optic communication cables along the 330 kV and 500 kV transmission lines between the energy hubs and switching stations
- a maintenance facility within the Merotherie Energy Hub to support the operational requirements of the project
- microwave repeater sites at locations along the alignment, as well as outside of the alignment at Botobolar, to provide a communications link between the project and the existing electricity transmission and distribution network. The Botobolar site would be subject to assessment at the submissions report stage
- establishment of new, and upgrade of existing access tracks for transmission lines, energy hubs, switching stations and other ancillary works areas within the construction area, (such as temporary waterway crossings, laydown and staging areas, earthwork material sites with crushing, grinding and screening plants, concrete batching plants, brake/winch sites, site offices and workforce accommodation camps)
- property adjustment works to facilitate access to the transmission lines and switching stations. These works include the relocation of existing infrastructure on properties that are impacted by the project
- utility adjustments required for the construction of the transmission network infrastructure, along with other adjustments to existing communications, water and wastewater utilities. This includes adjustments to Transgrid's 500 kV transmission lines 5A3 (Bayswater to Mount Piper) and 5A5 (Wollar to Mount Piper) to provide a connection to the existing NSW transmission network, including new transmission line towers along the Transgrid network along the frontage of the New Wollar Switching Station, and other locations where there is an interface with Transgrid's network.

1.3.2 Location

The project is located in central-west NSW within the Warrumbungle, Mid-Western Regional, Dubbo Regional and Upper Hunter Local Government Areas (LGAs). It extends north to south from Cassilis to Wollar and east to west from Cassilis to Goolma. The location of the project is shown in Figure 1-1.

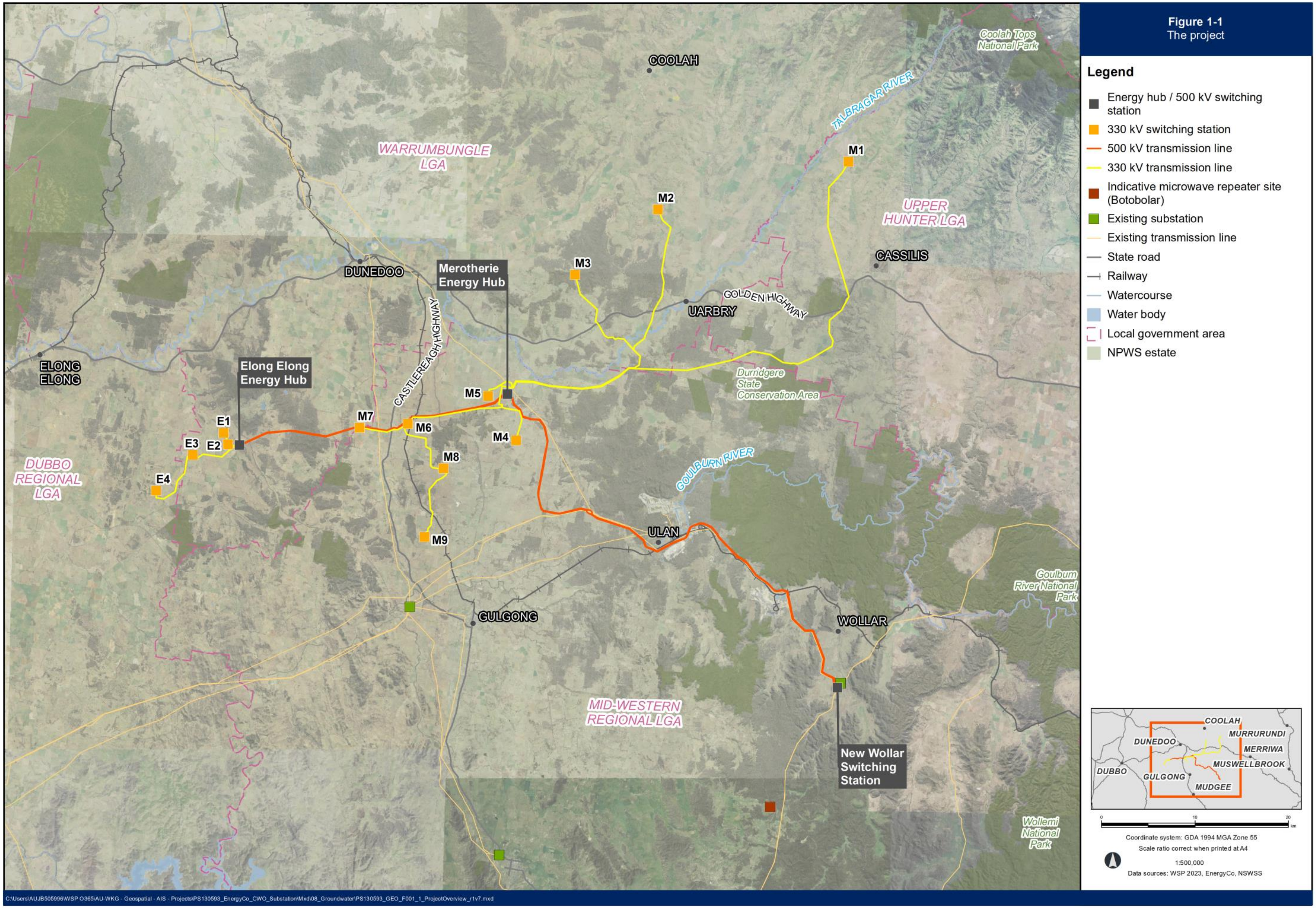


Figure 1-1
The project

1.3.3 Timing

Construction of the project would commence in the second half of 2024, subject to NSW Government and Commonwealth planning approvals, and is estimated to take about four years. The project is expected to be commissioned/energised (i.e. become operational) in late 2027.

1.3.4 Construction

Key construction activities for the project would occur in the following stages:

- enabling works
- construction works associated with the transmission lines
- construction works associated with energy hubs and switching stations
- pre-commissioning and commissioning of the project
- demobilisation and rehabilitation of areas disturbed by construction activities.

Excavation and land forming works within the construction area would be required for transmission line tower construction, site preparation works at the energy hubs and switching station sites to provide level surfaces, to create trenches for drainage, earthing, communications infrastructure and electrical conduits, and to construct and upgrade access tracks.

Construction vehicle movements would comprise heavy and light vehicles transporting equipment and plant, construction materials, spoil and waste from construction facilities and workforce accommodation camp sites. There would also be additional vehicle movements associated with construction workers travelling to and from construction areas and accommodation camp sites. These movements would occur daily for the duration of construction.

To support the construction of the project a number of construction compounds would be required including staging and laydown facilities, concrete batching plants, workforce accommodation camps and construction support facilities. The main construction compounds would be established as enabling works and demobilised at the completion of construction. The size of the construction workforce would vary depending on the stage of construction and associated activities. During the peak construction period, an estimated workforce of up to around 1,800 people would be required.

1.3.5 Operation

During operation, the project would transfer high voltage electricity from the Central West-Orana REZ to the NEM. Permanent project infrastructure 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). Regular inspection and maintenance activities are expected to include:

- regular inspection (ground and aerial) and maintenance of electrical equipment and easements
- fault and emergency response (unplanned maintenance)
- general building, asset protection zone and landscaping maintenance
- fire detection system inspection and maintenance
- stormwater maintenance
- remote asset condition monitoring
- network infrastructure performance monitoring.

Operation of the project would require the establishment of transmission line easements. These easements would be around 60 metres for each 330 kV transmission line and 70 metres for each 500 kV transmission lines. Where network infrastructure is collocated, easement widths would increase accordingly (for example, a twin double circuit 500 kV transmission line would have an easement about 140 metres wide). Vegetation clearing would be required to some extent for the full width of the transmission line easement, depending on the vegetation types present.

1.4 Structure of the paper

The structure and content of this groundwater technical paper is as follows:

- Chapter 1 – provides an introduction to this technical paper (this chapter)
- Chapter 2 – provides an overview of the regulatory context for the assessment, including an overview of the legislation, policy and guidelines that apply to the project
- Chapter 3 – outlines the methodology adopted for this groundwater impact assessment
- Chapter 4 – describes the existing environment of the study area as it relates to groundwater
- Chapter 5 – describes the risk assessment of potential groundwater impacts during construction and operation of the project
- Chapter 6 – describes the potential impacts to groundwater from construction of the project
- Chapter 7 – describes the potential impacts to groundwater from operation of the project
- Chapter 8 – assessment against the Aquifer Interference Policy
- Chapter 9 – provides recommended mitigation and management measures to avoid, minimise and manage any potential impacts to groundwater from construction and/or operation of the project
- Chapter 10 – identifies the key reports and documents used to generate this paper.

The appendices to this paper are:

- Appendix A – Surrounding registered groundwater bores
- Appendix B – Groundwater Dependent Ecosystems
- Appendix C – Bore dealing assessment

2 Legislative and policy context

Environmental planning approval for the project is required in accordance with the *Environmental Planning and Assessment Act 1979* (EP&A Act). The project is also a controlled action and therefore requires Commonwealth assessment and approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Sections 5.12 and 5.13 of the EP&A Act provide for the declaration of State significant infrastructure (SSI) and Critical State significant infrastructure (CSSI). On 23 November 2020, the Minister for Planning made the Environmental Planning and Assessment Amendment (Central-West Orana Renewable Energy Zone Transmission Order) 2020. The Order declares the whole Central-West Orana REZ Transmission project to be CSSI.

This section describes the Commonwealth and State legislation and policies relevant to the assessment of groundwater impacts.

2.1 Commonwealth legislation

2.1.1 Environmental Protection and Biodiversity Act 1999

The objective of the EPBC Act is to protect and manage prescribed Matters of National Environmental Significance (MNES). Impacts on groundwater from construction and/or operation of the project may be relevant under the EPBC Act in instances where groundwater is shown to support MNES, for example water resources or groundwater dependent ecosystems. Under the EPBC Act, proposed 'actions' that are likely to have a significant impact on MNES, on Commonwealth land, or caused by a Federal Government agency, must be referred to the Federal Minister for the Environment for assessment.

A referral was submitted for this project and it was determined to be a controlled action on 2 March 2023 on the basis of potential impacts to listed threatened species and communities and listed migratory species. The project will require assessment and approval under the EPBC Act before it can proceed. The project will be assessed under the assessment bilateral agreement with NSW Government.

2.1.2 Water Act 2007

The *Water Act 2007* allows the Commonwealth in conjunction with the Basin States (South Australia, Victoria, New South Wales, Queensland, and the Australian Capital Territory) to manage Australia's largest water resource, the Murray-Darling Basin (MDB), in the national interest. It promotes the use and management of the Basin water resources in a way that optimises economic, social and environmental outcomes. Notably 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 under the Act.

The Basin refers to water resources within or beneath the Murray-Darling Basin that extends across Australian Capital Territory, NSW, Queensland, SA and VIC. However, it excludes any groundwater that forms part of the Great Artesian Basin. Under the *Water Act 2007*, the MDBA was required to develop the Murray-Darling Basin Plan 2012 (Basin Plan). The Basin Plan provides limits on the quantity of water that may be taken from the Basin water resources as a whole and from the water resources of each water resource plan area. The Basin Plan sets the amount of water that can be taken from the Basin each year, while leaving enough for our rivers, lakes and wetlands and the plants and animals that depend on them. Water Resource Plans are the integral tool for implementing the Basin Plan and set new rules on how much water can be taken from the system, ensuring the sustainable diversion limit is not exceeded over time. Water resource plans within the study area are currently under review.

2.2 NSW legislation

2.2.1 *Environmental Planning and Assessment Act 1979*

The EP&A Act establishes a framework for the assessment and approval of developments in NSW. It also provides for the making of environmental planning instruments, including state environmental planning policies (SEPPs) and local environmental plans (LEPs), which determine the permissibility and approval pathway for development proposals and form a part of the environmental assessment process.

2.2.2 *Water Management Act 2000*

The objective of the *Water Management Act 2000* (WM Act) is the sustainable and integrated management of the state's water sources for the benefit of present and future generations and to ensure that no more than minimal harm will be done to the aquifer, or its dependent ecosystems, as a consequence of its being interfered with in the course of the activities. Water resources in the study area are administered under the WM Act. The WM Act governs the issue of Water Access Licences (WALs) and approvals for those water sources (rivers, lakes, estuaries, and groundwater) in NSW where water sharing plans have commenced.

Typically, if a project extracts (takes) groundwater directly, such as from groundwater pumping bores, or indirectly, such as excavations intercepting groundwater, the following approvals or licences under the WM Act would be required:

- water use approval under section 89
- water supply work approval (falls under a water management work approval) under section 90
- aquifer access licence with sufficient entitlement volume in the relevant water source to cover groundwater take under section 91.

However, under Section 5.23 of the EP&A Act, a water use approval under Section 89, water management works under Section 90, or an activity approval (including a controlled activity approval) under Section 91 of the WM Act is not required for State significant infrastructure.

Water access rights in each groundwater source are enabled under the WM Act. Where water is proposed to be extracted (taken) from a groundwater source, a WAL under the WM Act is required. A WAL must nominate a 'work' to satisfy section 60D of the WM Act and this is completed by a 'dealing application' under section 71W of the WM Act.

All dealings are assessed in accordance with the water management principles of the WM Act, the principles in the *Access Licence Dealing Principles Order 2004* and the access licence dealings rules established by the relevant water sharing plan. Dealings that can result in a change in the potential volume that can be extracted from a location and/or have the potential to cause third party impacts require a hydrogeological assessment. Applications may be approved subject to conditions, such as bore extraction limits, to minimise potential impacts to neighbouring bores. WALs would be required for this project, as water supply for construction may be required.

2.2.3 Water sharing plans and groundwater sources

Water sharing plans set rules for sharing water between water users and the environmental needs of the river or aquifer, and between different types of water use such as rural domestic supply, stock watering, industry, irrigation, and town supply. Water sharing plans bring water users into a single licensing system managed under the WM Act.

Water sharing plans have been developed for regulated and unregulated river catchments and groundwater sources across NSW. These plans protect the health of our rivers and aquifers while also providing water users with perpetual access licences, equitable conditions and increased opportunities to trade water through separation of land and water.
Water sharing plans describe the annual groundwater recharge volumes for each identified groundwater source and also the volumes of water that are available for sharing. Provisions are made for environmental water allocations, basic landholder rights, and native title rights. The purpose of a water sharing plan is to:

- provide water users with a clear picture of when and how water will be available for extraction
- protect the fundamental environmental health of the water source
- ensure the water source is sustainable in the long-term.

Groundwater sources are identified within each water sharing plan that define a long-term average annual extraction limit for each source. The volume of water a licence holder can extract each year is set by the entitlement held by the user, water account rules in the water sharing plan. It is by these groundwater sources that allocation and management of the groundwater resource is determined. Management zones are sub areas within a groundwater source which may have specific rules regarding management of extraction volumes or environmental protection.

The study area includes eight groundwater sources. Details of the water sharing plans and groundwater sources in the study area, are outlined in Table 2-1.

Table 2-1 Water sharing plan and groundwater source within the study area

Water Sharing Plan	Groundwater source	Management zone
NSW Murray Darling Basin Porous Rock Groundwater Sources 2020	Sydney Basin MDB Groundwater Source	Sydney Basin MDB (Other) Management Zone
	Gunnedah-Oxley Basin MDB Groundwater Source	Gunnedah-Oxley Basin MDB (Other) Management Zone
NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020	Liverpool Ranges Basalt MDB Groundwater Source	N/A
	Lachlan Fold Belt MDB Groundwater Source	Lachlan Fold Belt MDB (Other) Management Zone
North Coast Fractured and Porous Rock Groundwater Sources 2016	Sydney Basin-North Coast Groundwater Source	N/A
	Oxley Basin Coast Groundwater Source	N/A
	Liverpool Ranges Basalt Coast Groundwater Source	N/A
Macquarie-Castlereagh Groundwater Sources 2020	Talbragar Alluvial Groundwater Source	N/A

2.2.4 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the Environment Protection Authority (EPA). The POEO Act regulates air and water pollution, noise control and waste management. Environmental protection licences (EPLs) are issued and administered under the POEO Act to authorise and regulate pollution resulting from scheduled activities. Regardless of the need for an EPL, the project would still be required to comply with the provisions of the POEO Act. Section 120 of the POEO Act makes it an offence to cause water pollution.

2.3 Policy, standards and guidelines

2.3.1 NSW Aquifer Interference Policy 2012

The NSW Aquifer Interference Policy (AIP) was introduced in September 2012 (NSW DPI 2012) and forms part of the NSW 'Strategic Regional Land Use Policy'. The 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 WM Act includes the concept of ensuring 'no more than minimal harm' for both the granting of water access licences and the granting of approvals. The AIP also defines minimal impact considerations in assessing whether more than minimal impacts might occur to a key water-dependent asset.

For aquifer impact assessments, the AIP provides a framework for assessing the impacts of aquifer interference activities on groundwater resources. To assess potential impacts, groundwater sources are characterised as either into 'highly productive' or 'less productive' (DPI 2013), with sub-categories for alluvial, coastal sands, porous rock, and fractured rock aquifers. Highly productive groundwater areas are characterised by bores having yield rates greater than of greater than 5 L/s and total dissolved solids (TDS) of less than 1,500 mg/L (DPI 2013). Where an aquifer fails to meet the criteria, it is classified as less productive.

Details of the groundwater sources, type, and category in the study area are outlined in Table 2-2.

Table 2-2 Groundwater source productivity within the study area

Groundwater source	Management zone	Aquifer type	Productivity
Sydney Basin MDB Groundwater Source	Sydney Basin MDB (Other) Management Zone	Porous rock	Highly productive
Gunnedah-Oxley Basin MDB Groundwater Source	Gunnedah-Oxley Basin MDB (Other) Management Zone	Porous rock	Less productive
Liverpool Ranges Basalt MDB Groundwater Source	N/A	Fractured rock	Highly productive
Lachlan Fold Belt MDB Groundwater Source	Lachlan Fold Belt MDB (Other) Management Zone	Fractured rock	Highly productive
Sydney Basin-North Coast Groundwater Source	N/A	Porous rock	Less productive
Oxley Basin Coast Groundwater Source	N/A	Porous rock	Less productive
Liverpool Ranges Basalt Coast Groundwater Source	N/A	Fractured rock	Highly productive
Talbragar Alluvial Groundwater Source	N/A	Alluvial	Highly productive

The AIP refers to the beneficial use of an aquifer, which is outlined in the National Water Quality Management Strategy (Australian Government 2013); it is noted that within the management strategy, the term beneficial use is replaced with environmental value.

The AIP forms the basis of assessment and subsequent advice provided by the NSW Government at the various stages of an assessment under the EP&A Act. The WM Act defines an aquifer interference activity as that which involves any of the following:

- the penetration of an aquifer
- the interferes with groundwater in an aquifer
- changes or obstructs groundwater flow in an aquifer
- the taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations
- the disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.

2.3.2 Groundwater Dependent Ecosystems Policy

Groundwater dependent ecosystems (GDEs) are defined as 'ecosystems that need access to groundwater to meet all or some of their water requirements to maintain their communities of plants and animals, ecological processes, and ecosystem services'. The NSW State Groundwater Dependent Ecosystems Policy (DLWC 2002) provides guidelines on how to protect and manage GDEs. Ongoing work seeks to improve understanding of the location of these ecosystems and determine the extent of their reliance on groundwater and provide legislative frameworks that safeguard the ecosystem. The GDE Policy is designed to protect and maintain the processes and biodiversity of valuable ecosystems which rely on groundwater for survival.

2.3.3 Guidelines for Groundwater Quality Protection in Australia

The Guidelines for Groundwater Quality Protection in Australia (Australian Government 2013) support a national approach to groundwater quality protection and are designed to support the National Water Quality Management Strategy (NWQMS). The framework provides guidance to develop groundwater protection plans, which includes assigning an environmental value category to a groundwater system, setting water quality objectives and developing management strategies that are tailored to individual groundwater protection scenarios.

2.3.4 Groundwater assessment toolbox for major projects in NSW

The main objective of this guideline (DPE 2022) is to clarify and inform the requirements for groundwater assessment and documentation required for state significant development and state significant infrastructure projects in NSW. These projects can include activities located above the water table and below the water table. Those located above the water table are unlikely to have a major impact on groundwater systems and therefore the required groundwater impact assessment is less rigorous than those projects directly impacting groundwater. The guidelines are not specific to a particular project type and are applicable to all state significant development and state significant infrastructure projects in NSW.

3 Methodology

3.1 Overview

To understand the hydrogeological environment within the study area, the groundwater assessment included the following key steps:

- a desktop review of publicly available data, reports and existing studies was completed to develop an understanding of the existing hydrogeological environment within the study area
- identification of risks to sensitive receivers including GDEs and groundwater users
- development of a site conceptual model
- an assessment of the potential impacts to sensitive receivers from construction and operation of the project
- identification of potential mitigation measures to avoid, mitigate and manage any potential impacts of the project to groundwater.

3.2 Study area

The groundwater study area (herein referred to as the study area) encompasses a 500 m wide buffer of the construction area (see Figure 4-1). The construction area is the basis of the study area as it is the area that would be directly impacted by the construction of the project. The bore dealing assessments buffer area is 5 km around the nominated extraction bore location.

The study area has been selected to characterise the existing hydrogeological environment in context of the project and incorporate the potential extent of the project's influence on local groundwater sources and sensitive receivers (such as GDEs, third-party water supply works, third order or higher watercourses).

Given there is no permanent groundwater take as part of the project, the extent of the potential impact is expected to be small (if any) and limited to areas where groundwater is close to surface and aquifer interception might occur. Acid-sulfate soils and any significant (and known) soil and/or groundwater contamination are addressed in the contaminated land technical assessment (Technical paper 16).

3.3 Desktop review

To achieve the aims and objectives of this groundwater impact assessment, a desktop review of publicly available data was completed to develop an understanding of the hydrogeological environment within the study area. The review included determining the existing hydrogeological environment of the study area and identifying sensitive groundwater receivers, including waterways, GDEs and registered groundwater bores.

Information reviewed, included:

- legislation and policy relevant to groundwater including the WM Act, relevant water sharing plans, and the NSW AIP
- desktop review of existing studies, and publicly available data relevant to the study area
- geotechnical and hydrogeological data collected from site investigations
- geological data from NSW Seamless Geology (Colquhoun, et al. 2021)
- high potential groundwater dependent ecosystem information from the Bureau of Meteorology GDE Atlas (BoM 2021a) and the NSW GDE Ecological Value (HEVAE) spatial database (DPE 2020)
- registered groundwater bore data including groundwater levels, quality and yield, from WaterNSW real-time water data website (WaterNSW 2022).

3.3.1 Geology

Outcropping geological data within the study area was obtained from the NSW seamless geology project (Colquhoun, et al. 2021). Additional information was compiled from geotechnical investigations (WSP, 2022a; 2022b) and readily available governmental studies.

3.3.2 Hydrogeology

Assessment of the existing and potential changes to the hydrogeological conditions incorporated results from the geotechnical investigation conducted within the study area by WSP (2022a & 2022b), and a wider regional review of governmental hydrogeological studies and information provided in water sharing plan documents, published scientific journal papers and data obtained from the National Groundwater Information System (NGIS) (BoM 2022) and from registered works approvals (WaterNSW 2022).

3.3.3 Registered bore search

A registered bore search was conducted using data available from the NGIS database (BoM 2022) and a search of the WaterNSW real-time water data website (WaterNSW 2022). Groundwater bores within the study area are included in this assessment.

3.3.4 Groundwater dependent ecosystems

The GDE search was conducted by reviewing the relevant water sharing plan documents and their appendices that list identified high priority GDEs, and a search of high priority GDE data from the GDE atlas (BoM 2021a).

3.4 Risk assessment

Risks are characterised by making an informed decision as to the potential for adverse effects to arise to sensitive receivers due to water-affecting activities of the project during construction and operation activities. The risk management standard AS/NZS ISO 31000:2018 characterises risk as a function of the likelihood and consequence of an outcome, where the consequences (impacts) of the management options should be characterised with related likelihoods (uncertainties). The qualitative risk assessment has examined the various aspects of the groundwater system in context of potential impacts to the groundwater environment during construction and operation of the project.

3.5 Conceptual groundwater model

A conceptual groundwater model was developed showcasing the hydrogeological environment and its interactions with the project. A conceptual groundwater model is a descriptive representation of a groundwater system that incorporates an interpretation of the geological and hydrological conditions. It describes a way of consolidating the current understanding of the key processes of the groundwater system to assist in the understanding of possible future changes. The conceptual groundwater model allows for the communication of risk and potential impacts to the groundwater environment.

3.6 Impact assessment

The aim of the impact assessment is to identify the potential impacts on the existing groundwater sensitive receivers due to the project development. Direct effects encompass the changes to physical and/or quality aspects of groundwater due to aquifer interference activities, or the changes to the physical characteristics of aquifers affected by project related construction and operation activities.

The construction and operational impact assessments (Chapter 6 and Chapter 7 respectively) identify the potential impacts from water-affecting activities, and an assessment of the actual consequences in terms of direct effects (e.g. altered water resource condition) and potential receiver response (such as reduced water access).

The approach to, and type of, groundwater impact assessment required for the project follows the workflow outlined in the "Groundwater assessment toolbox for major projects in NSW" (DPE 2022), as shown in Figure 3-1. Although the construction area for the project is large in extent, the potential for the project to intercept groundwater is expected to be minor given the types of infrastructure that will be constructed, the proposed construction methodology and the varying depth to the water table within the study area. As construction and operation of the project are expected to result in minor (if any) interception of the groundwater, a risk-based assessment approach was completed, in accordance with the groundwater assessment toolbox workflow.

The potential for groundwater interception and water take to occur during construction from activities such as piling and shallow excavations has been assessed in accordance with the minimal impact considerations outlined in the AIP. The potential impacts from groundwater extraction from bores used for water supply have been assessed using the bore dealing assessment. The aquifer interference assessment framework and the bore dealing assessment are outlined in Section 3.6.1, and 3.6.2 respectively.

Where potential adverse effects to the groundwater systems were identified due to the project, recommended mitigation measures have been provided to minimise these potential impacts (refer to Chapter 9).

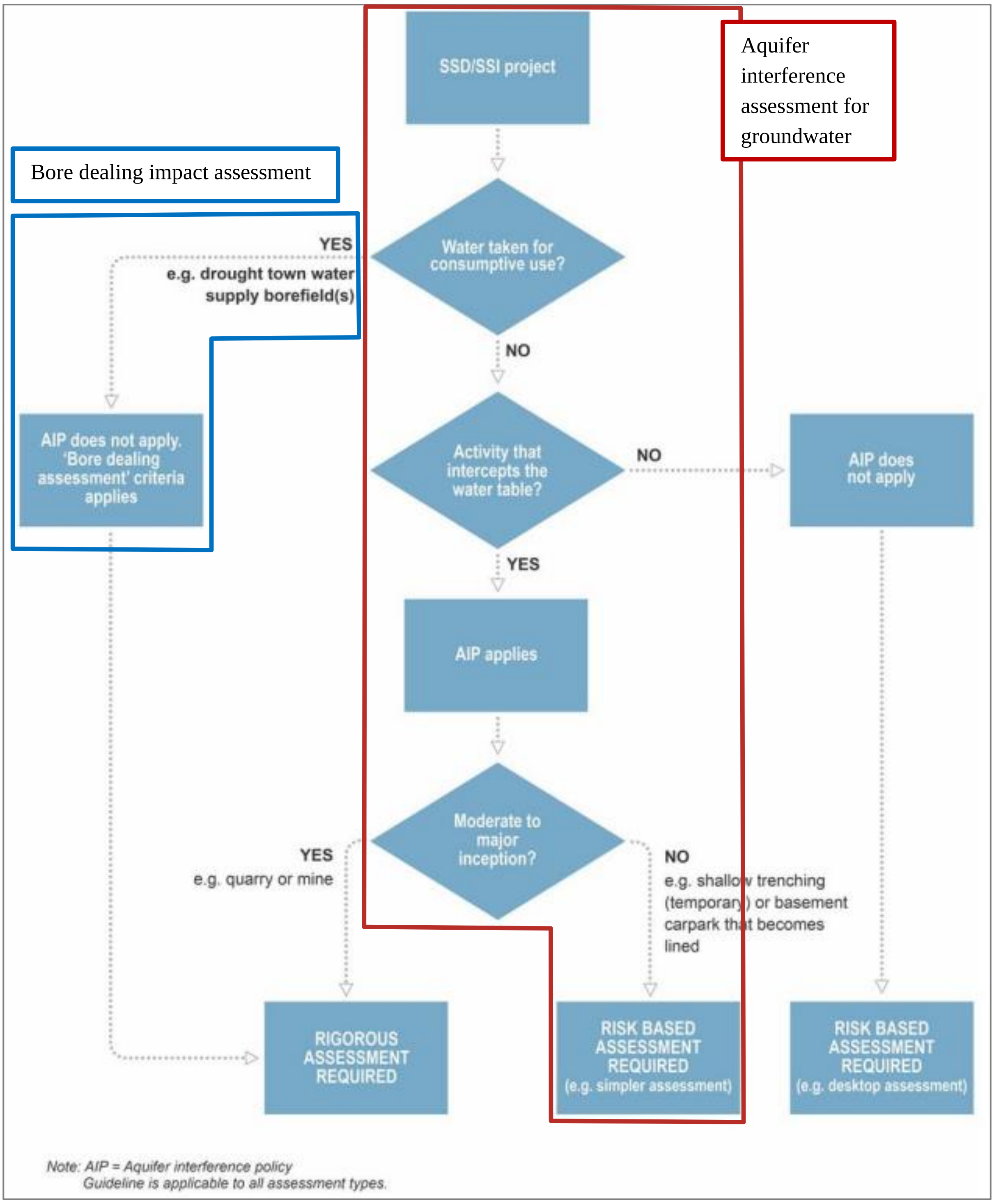


Figure 3-1 Workflow for selecting the type of groundwater assessment required for the project (DPE 2022)

3.6.1 Aquifer interference assessment framework

The AIP sets out the Aquifer Interference Assessment Framework for assessing projects in NSW. The framework outlines the approach to assessing and accounting or preventing the take of water, addressing the minimal impact considerations, and proposing remedial action where impacts are greater than predicted.

3.6.1.1 Assessment criteria

The AIP outlines requirements for obtaining water licences for aquifer interference activities and outlines the minimal impacts considerations for assessing potential groundwater impacts in NSW. The minimal impact considerations are a series of thresholds that define minimal impacts from aquifer interference activities. There are several prescribed minimal impact considerations relating to water table and groundwater pressure drawdown, and changes to groundwater quality. Two levels of minimal impact considerations are specified. If the potential impacts are less than the Level 1 minimal impact considerations, then these impacts would be considered as acceptable.

The assessment criteria for acceptable level of impacts used for this assessment is outlined in Table 3-1. An assessment on the minimal impact considerations is provided in Chapter 8.

Table 3-1 Minimal impact considerations for highly productive water sources

Assessment	Level 1	Level 2
Water table	Less than or equal to 10 per cent cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority: — high priority groundwater dependent ecosystem (GDE) — high priority culturally significant site listed in the schedule of the relevant water sharing plan. A maximum of a 2 m cumulative decline 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 m from any: — high priority groundwater dependent ecosystem; or — high priority culturally significant site listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m 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 2 m decline, at any water supply work.	If the predicted pressure head decline is greater than requirement 1, 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 works 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 m from the activity 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 (alluvial water sources only).	If condition level 1 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 works.

Table 3-2 Minimal impact considerations for less productive porous and fractured rock water sources

Assessment	Level 1	Level 2
Water table	Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 m from any high priority: — high priority groundwater dependent ecosystem (GDE) — high priority culturally significant site listed in the schedule of the relevant water sharing plan. A maximum of a 2 m cumulative decline 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 m from any: — high priority groundwater dependent ecosystem; or — high priority culturally significant site; listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work then make good provisions should apply.
Water pressure	A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.	If the predicted pressure head decline is greater than requirement level 1, 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 works 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.	If condition level 1 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 works.

3.6.2 Bore dealing assessment

The potential impacts associated with groundwater extraction are managed through the assessment of all applications for groundwater dealings (trade) and water supply work approvals (bores). The long-term sustainable extraction from each bore and scheme is assessed within the constraints of acceptable impacts on the environment, cultural values, surface water resources and other existing authorised groundwater supply bores (including basic landholder rights) in accordance with the criteria set out in the "Assessing groundwater applications fact sheet" (DPI 2018). The hydraulic assessment involves the analysis of expected drawdown impacts compared to the acceptable levels of impact specified for each groundwater source.

Total available drawdown (TAD) is used to determine acceptable impact on the aquifer system. The calculation of TAD is based on data from surrounding bores within 5 km of the proposed water supply bore with available bore depth information.

3.6.2.1 Assessment criteria

The assessment criteria for acceptable level of impacts used for this assessment are for a confined aquifer in porous rock and fractured rock groundwater sources (DPI 2018). The assessment criteria for confined aquifers are:

1. A cumulative drawdown of not more than 40 per cent of the pre-development TAD at a distance of 200 metres from any water supply works including the pumping bores.
2. An additional drawdown of not more than 3 metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties.

4 Existing environment

4.1 Watercourses

The project is located within the Macquarie and Hunter River catchments, including all major and minor tributaries within these catchments. Within the Macquarie River catchment, the Talbragar River is the major tributary intersecting the project. The Cudgegong River, which is a tributary of the Macquarie River, does not intersect the project but several of its tributaries intersect the project and drain into Wialdar Creek and then into the Cudgegong River. The Hunter River is made up of a number of large tributaries with the eastern portion of the project located within the Goulburn River catchment. The project also intersects Wollar Creek which is a tributary of the Goulburn River. Further detail is provided in Technical paper 14 – Hydrology and water quality.

4.2 Climate and rainfall

The climate and rainfall for the study area has been separated into three sections due to the expanse of the project. The central to western section, which includes, Elong Elong and Merotherie energy hubs, and the eastern section which includes the New Wollar switching station. There are several weather stations located near and around the project that have been identified to inform an understanding of the prevailing climate for each section of the project.

Towards the central area of the proposed alignment, near Elong Elong and Merotherie energy hubs, the closest weather stations are Gulgong (062013) and Dunedoo (064009). These stations have an annual (non-seasonal) mean maximum temperature 23.2 to 24.1°C and an annual (non-seasonal) mean minimum temperature of 9.6 to 9.7°C. The mean annual rainfall is 651.2 millimetres at Gulgong and 615.4 millimetres for Dunedoo (BoM 2022). The stations are located at elevations of 475 metres Australian Height Datum (mAHD) and 388 mAHD respectively which is within the range of elevations that the project will traverse and therefore are suitable for providing an understanding of the prevailing climate for the project.

Towards the New Wollar switching station, the closest weather stations are Mudgee (062101) and Merriwa (061287). The recorded (non-seasonal) mean maximum temperatures for Mudgee and Merriwa are 22.7 and 24°C with corresponding annual mean minimum temperatures of 8.3 and 9.2°C respectively. The recorded mean annual rainfall is 666.9 millimetres and 613.9 millimetres respectively (BoM 2022). Further detail is provided in Technical paper 14 – Hydrology and water quality.

4.3 Topography

The project is situated at the top of the Macquarie and Hunter River catchments with the catchment divide occurring between the New Wollar switching station and the Merotherie Energy Hub. From the catchment divide the land slopes away to the west towards the Talbragar and Macquarie Rivers and towards the east the land slopes towards the Goulburn and Hunter Rivers. The slopes vary across the site for the transmission line due to it traversing several catchments as well as the catchment divide. The elevation across the project varies from a minimum of 350 mAHD to a maximum of 700 mAHD.

4.4 Geology

Surface geology covers the geological layers between the ground surface and bedrock. Deeper geological layers were not considered relevant to the assessment. Reference to the NSW seamless geology dataset (Colquhoun, et al. 2021) indicates that the surface geology in the study area consists of geological units listed and described in Table 4-1 and shown on Figure 4-1. The surface geology located within the study area is further summarised below.

Cenozoic sedimentary alluvial surface sediments are associated with creeks and drainage lines. The alluvium tends to be present in relatively discontinuous stringer deposits along the valley floors and generally consists of fine to coarse grained sands and gravels in a silt/clay matrix, although some clean sand and gravel deposits are also present. In some areas, such as along the Coolaburragundy and Talbragar Rivers, the alluvial deposits form extensive alluvial fans and can be up to 2 km wide in some areas.

The Cenozoic Igneous Province lies in the north-eastern sections of the study area. This province contain basalt due to volcanic activity during the Cenozoic period. The fractured basalt of the Liverpool Ranges Basalt is highly dissected and overlies the Sydney Basin sandstone units in the north-western region of the Hunter Valley.

The Permo-Triassic basin sediments exist at surface in the eastern half of the study are near Wollar, and near the Elong Elong energy hub. The typical lithology of the Permo-Triassic basin sediments includes pebbly to medium grained quartz sandstone, red-brown and green mudstone, and lenses of quartz conglomerate. The contact between the Permian and Triassic is marked by an erosional unconformity. Extensive coal-bearing sequences of Late Permian age overlie marine strata of the MDB. Coal bearing rocks are located close to surface in the south-eastern parts of the study area (near Wollar), and near the Ulan, Moolarben and Wilpinjong coal mines.

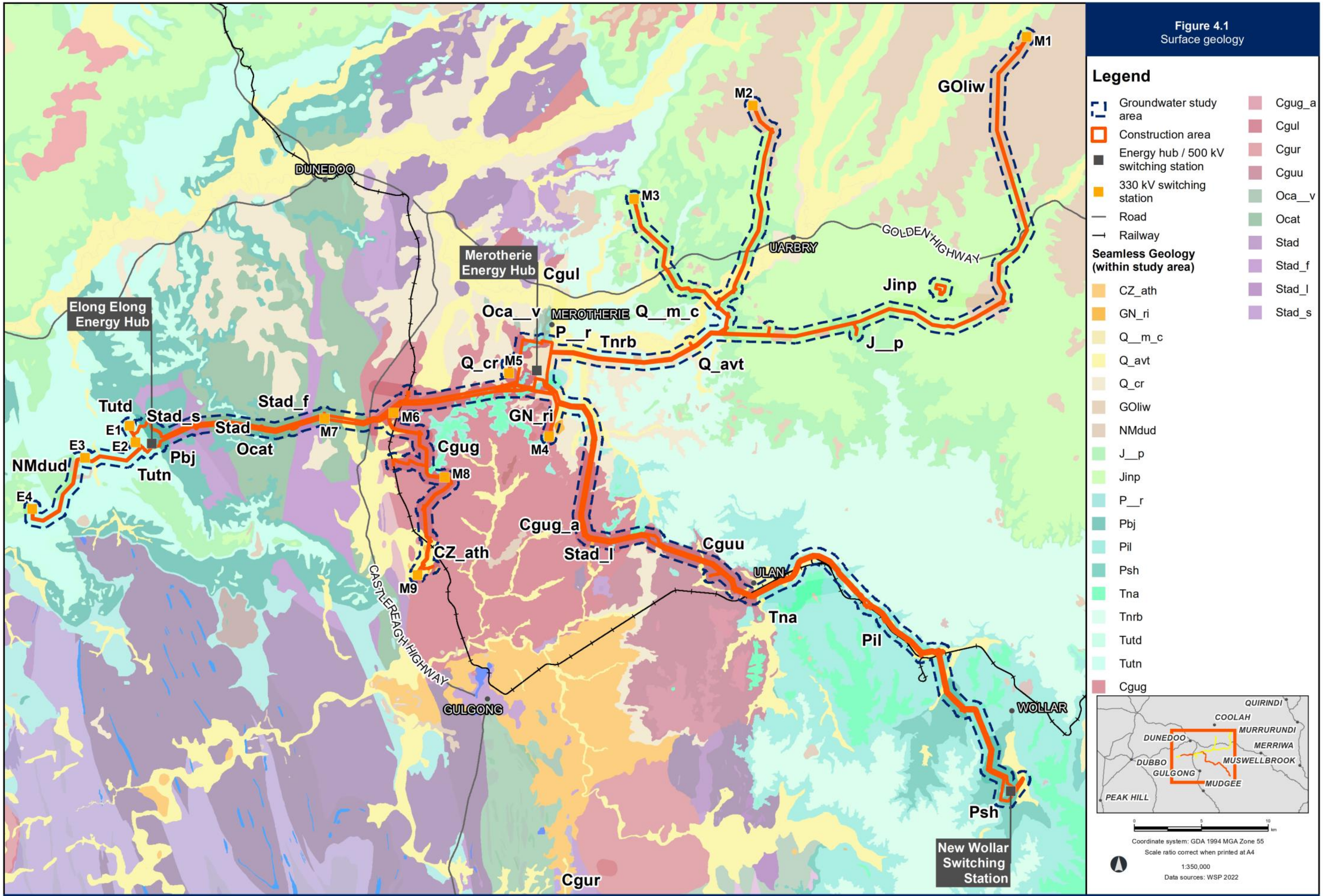
The Lachlan Fold Belt, part of the Lachlan Orogen, is present at surface in the central part of the construction area. The surface geology consists of strongly deformed/metamorphosed marine sedimentary rocks, cherts, siltstones and mafic volcanic basalts and rhyolites, and plutonic granitic intrusions.

Table 4-1 Regional geological units

Unit name	Code	Description
Marra Creek Formation – channel facies	Q__m_c	Unconsolidated pale to dark grey, in places pale brown-grey, silty clay. Some channels are lined with boulders and pebbles. Carbonate nodules present in places.
Alluvial valley deposits – terraced	Q_avt	Fluvially-deposited clay, silt, sand, gravel.
Colluvial and residual deposits	Q_cr	Undifferentiated colluvial and residual deposits.
Alluvial terrace deposits – high-stand facies	CZ_ath	High-level terrace deposits of sand and gravel.
Residual deposits – Silcrete	GN_ri	Silicified gravel. Commonly found in association with Cenozoic basalt.
Dubbo Volcanics	NMdud	Dominantly high potassium (high-K) alkali olivine basalts and transitional to tholeiites with uncommon hawaiite and rare mugearites.
Liverpool West Basalt	GOliw	Olivine phyric tholeiitic to transitional basalt with common amygdales.
Pilliga Sandstone	Jinp	Medium to very coarse-grained, well sorted, angular to subangular quartzose sandstone and conglomerate. Minor interbeds of mudstone, siltstone and fine-grained sandstone and coal. Common carbonaceous fragments and iron staining. Rare lithic fragments.

Unit name	Code	Description
Purlawaugh Formation	J__p	Fine- to medium-grained, lithic to labile sandstone, thinly interbedded with siltstone, mudstone and thin coal seams. Abundant carbonaceous fragments, thin beds of flint clay.
Napperby Formation	Tutn	Finely laminated quartzose sandstone, claystone and siltstone interbedded with thick, massive or cross-bedded sandstone; minor conglomerate. Common bioturbation and mudcracks.
Banks Wall Sandstone	Tnrb	Quartzose sandstone.
Narrabeen Group	Tna	Quartz-lithic to quartzose sandstone, conglomerate, mudstone, siltstone, rare coal.
Digby Formation	Tutd	Poorly sorted, pebble to boulder orthoconglomerate, rare sandstone.
Rylstone Volcanics	P__r	Rhyolitic to dacitic pyroclastic rock(s); tuffaceous sandstone, breccia, conglomerate, siltstone, thin airfall tuff horizons; flow banded rhyolite lavas.
Black Jack Group	Pbj	Fine to medium-grained lithic sandstone, medium to coarse-grained quartzose sandstone, siltstone, mudstone, tuff, carbonaceous claystone, coal, coal with minor tuff bands, conglomerate.
Illawarra Coal Measures	Pil	Shale, quartz-lithic sandstone, conglomerate, chert, sporadically carbonaceous mudstone, coal and torbanite seams.
Shoalhaven Group	Psh	Polymictic pebble paraconglomerate, fine-grained muddy lithic sandstone, sandy micaceous siltstone, minor shale, sporadic minor carbonate and evaporite; sandstone sporadically bioturbated, abundant fossil shell fragments, dropstones.
Ulan Quartz Monzonite	Cguu	Megacrystic biotite sub-porphyritic quartz monzonite.
Gulgong Granite	Cgug	Leucocratic medium to coarse-grained porphyritic megacrystic granite, minor aplite phases, minor quartz monzonite.
Gulgong Granite – aplite	Cgug_a	Aplite.
Leadville Quartz Monzonite	Cgul	Porphyritic quartz monzonite.
Home Rule Quartz Monzonite	Cgur	Leucocratic coarse-grained to megacrystic porphyritic quartz monzonite, minor granite.
Dungeree Volcanics – shale, felsic volcanic sandstone	Stad_f	Shale, slate, quartz and felsic volcanic-rich sandstone.
Dungeree Volcanics	Stad	Green-grey almost aphanitic rhyolite and white altered rhyolite; brecciation is common.
Dungeree Volcanics – limestone	Stad_l	Limestone and limestone breccia.
Dungeree Volcanics – shale	Stad_s	Shale, slate and minor volcanic-rich sandstone.
Cabonne Group – volcanics	Oca__v	Mafic volcaniclastic sandstone, siltstone, banded cherty siltstone, minor limestone.
Tucklan Formation	Ocat	Dark mudstone, basalt to latite boulder conglomerate or breccia, lithic sandstone; basalt, andesite, dolerite, latite, limestone and rare chert.

Figure 4.1
Surface geology



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4.5 Hydrogeology

4.5.1 Groundwater sources

The study area includes eight groundwater sources. Details of the groundwater sources (and water sharing plans) are listed in Table 2-2, including aquifer type and productivity category. Groundwater throughout the study area is characterised as either highly productive or less productive (DPI 2013), and exists in alluvial, fractured, and porous rock aquifers. Groundwater sources are shown on Figure 4-2 and groundwater productivity is shown on Figure 4-3.

4.5.2 Aquifer categories

4.5.2.1 Alluvial

The Talbragar Alluvial Groundwater Source, which is managed by the Macquarie-Castlereagh Groundwater Sources 2020 Water Sharing Plan is made up of alluvial sediments (refer to Table 2-2). These sediments form an extensive alluvial fan deposited along the Coolaburragundy and Talbragar Rivers, comprised of clay, silt, sand and coarse gravel. These deposits are generally shallow, forming unconfined aquifers that are responsive to rainfall and streamflow. This groundwater source covers a small area in the central part of the construction area near the Merotherie Energy Hub.

4.5.2.2 Porous rock

Porous rock aquifers are part of a Permo-Triassic sedimentary basin system. Four porous rock groundwater sources are present in the study area, and managed by the NSW MDB Porous Rock Groundwater Sources 2020 and North Coast Fractured and Porous Rock Groundwater Sources 2016 Water Sharing Plans (refer to Table 2-2).

The Oxley Basin Coast Groundwater Source has overlying systems that include several units, such as the Liverpool Ranges Basalt. There is limited information on the degree of connection between the Oxley Basin Coast Groundwater Source and the overlying strata. There is expected to be potential for groundwater exchange to occur in areas where the basalt and alluvial systems interface. There has been minimal demand for groundwater from the Gunnedah-Oxley Basin MDB Groundwater Source due to the limited bore yields.

Due to the high variation in relief and the incised nature of the Permo-Triassic sedimentary basin which makes up part of the North Coast Fractured and Porous Rock Groundwater Sources in the eastern part of the construction area, local groundwater flow may provide a degree of baseflow to streams and creeks. The bore yields from rocks of the porous rock aquifers are typically in the order of 1 L/s and of variable salinity dependent on the strata being intercepted by the bore.

4.5.2.3 Fractured rock

Three fractured rock groundwater sources are present in the study area and managed by the NSW MDB Fractured Rock Groundwater Sources 2020 and North Coast Fractured and Porous Rock Groundwater Sources 2016 (refer to Table 2-2). Typically, the surface water systems within the area are considered to be in low hydraulic connection with groundwater in the fractured rock aquifers. The Liverpool Ranges Basalt MDB and Coast Groundwater Source is highly productive and typically has low salinity, while the Lachlan Fold Belt MDB Groundwater Source is one of the most extensive of the groundwater systems and ranges from the Great Dividing Range through to the western rangelands around Cobar and mainly provides stock and domestic groundwater supplies.

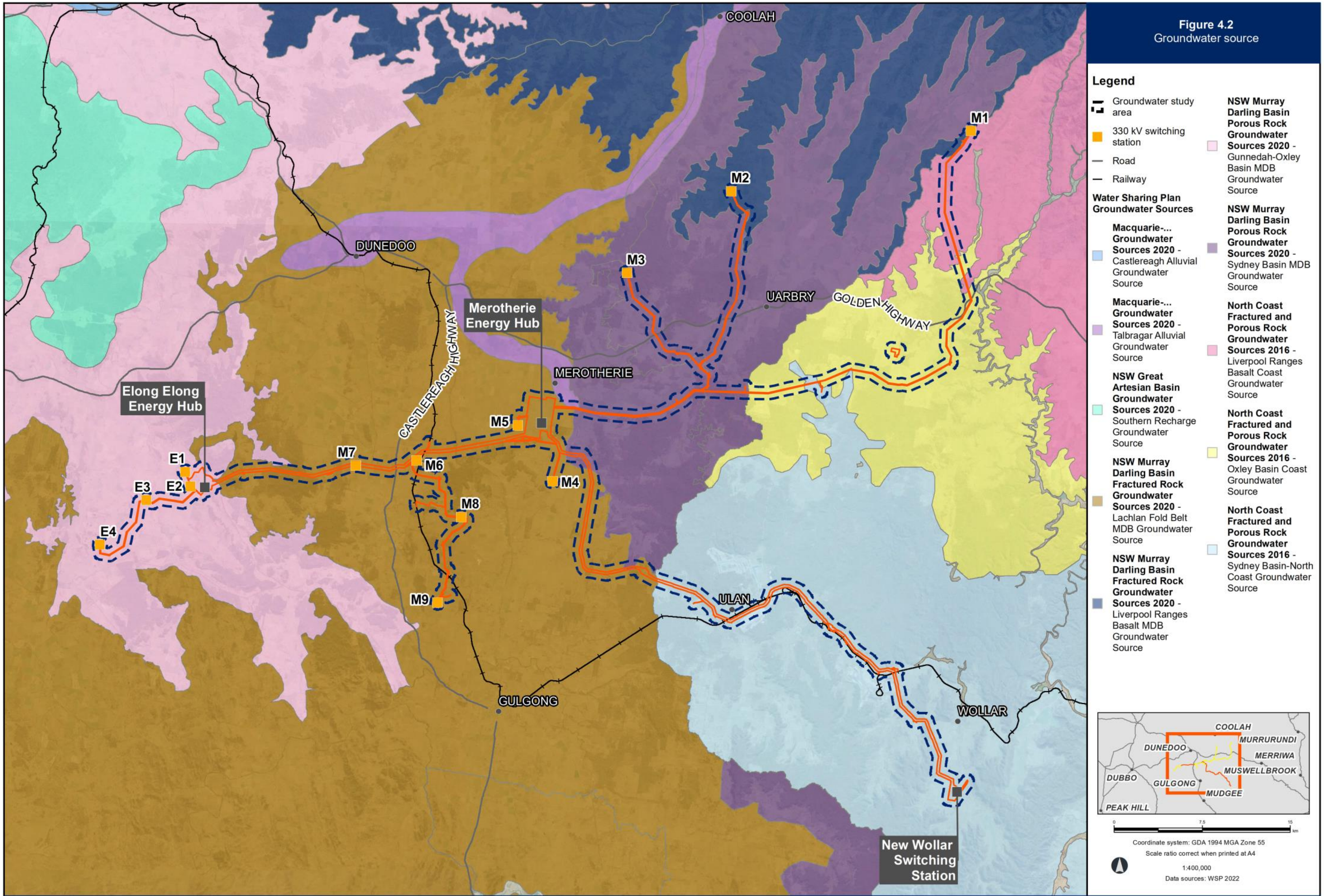

Figure 4.2
Groundwater source

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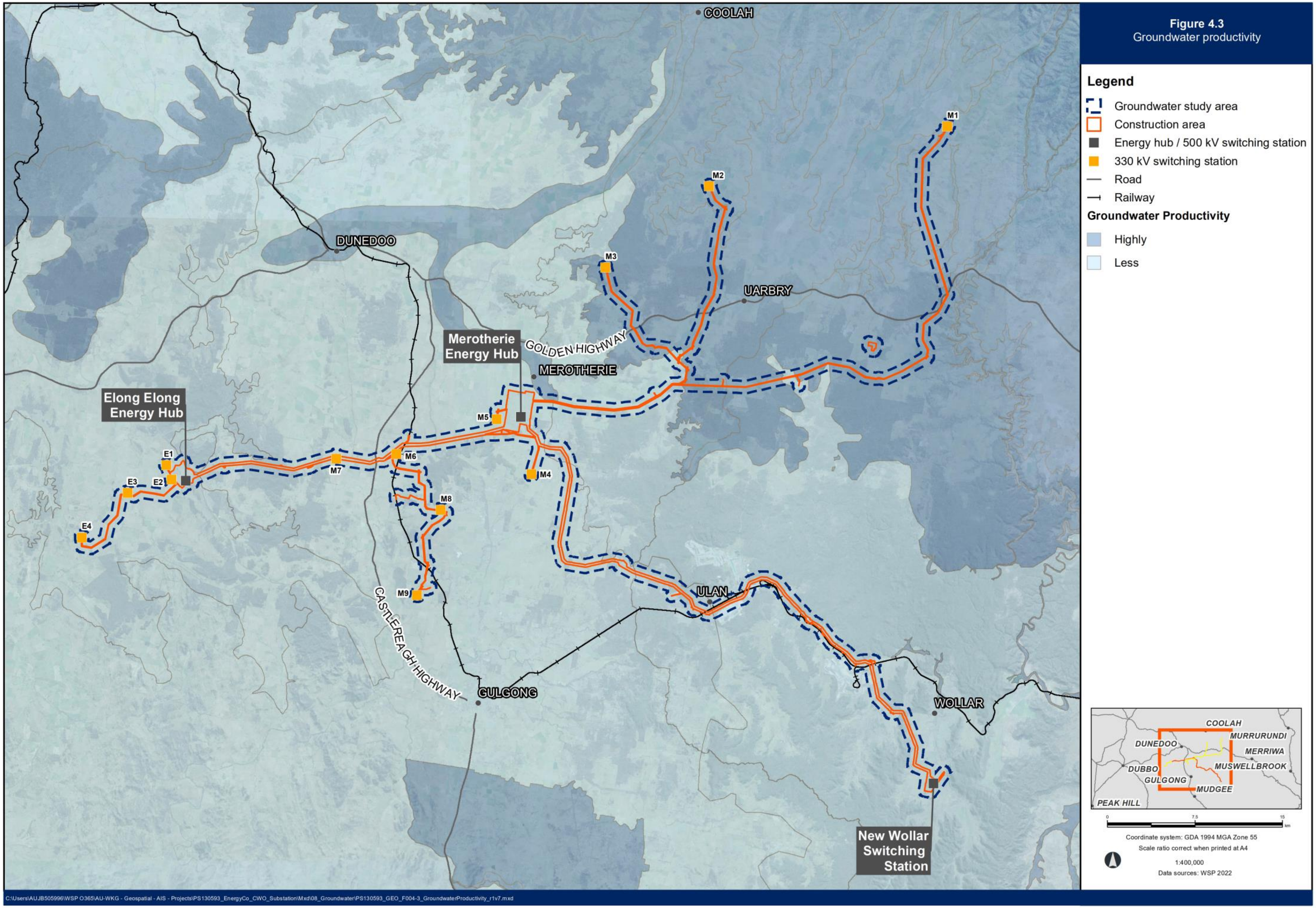


Figure 4.3
Groundwater productivity

4.5.3 Groundwater levels

4.5.3.1 Regional groundwater levels

There are no available regional groundwater contour maps or proximal groundwater level information published within the study area.

4.5.3.2 Groundwater levels from registered bores

Available groundwater level information from registered works approvals (WaterNSW 2022) and the geotechnical and contaminated land site investigations completed as part of the project provide an indication of the groundwater levels across the study area. Groundwater level information throughout the study area is sparse, with a search of the WaterNSW real-time water data website identifying 17 private water bores with groundwater level measurements recorded on driller logs and are provided in Table 4-2. Groundwater level measurements from project geotechnical and contaminated land site investigations, completed in 2022, are provided in Table 4-3. The location of the sites is shown on Figure 4-4.

The depth to water throughout the study area, is spatially variable and ranges from 0.2 mBGL to 52.63 mBGL. The depth to water depends on the underlying geology and the recharge and discharge in local areas. Groundwater flow in the shallow, unconfined aquifers is generally reflective of topography, with topographic high and low points within the study area dictating groundwater flow directions. Groundwater levels in the south-eastern section of the study area are influenced by coal extraction from the Ulan, Wilpinjong and Moolarben coal mines. There is insufficient data to comment on seasonal variation of groundwater levels within the study area.

Table 4-2 Groundwater levels recorded from drillers logs (WaterNSW 2022)

GW number	Easting[1]	Northing[1]	Use type	Depth to water (mBGL)
GW024776	769870	6421057	Stock watering	1
GW078165	772661	6416820	Stock watering	1.92
GW080124	769060	6421572	Unknown	0.2
GW080401	773008	6416178	Monitoring bore	2.63
GW080403	772865	6416461	Monitoring bore	1.35
GW080404	772447	6417465	Monitoring bore	1.58
GW080408	769664	6421161	Monitoring bore	1.82
GW080410	769924	6420991	Monitoring bore	2.6
GW080411	770635	6419801	Monitoring bore	2.62

Note: mBGL – metres below ground level.

(1) Coordinates relate to GDA94 Zone MGA55

Table 4-3 Groundwater levels recorded from project field investigations

Groundwater monitoring bore	Depth to water (mBGL)
BH05-PR	5.9
BH06-PR	14.8
Borehole number	**Estimated depth to water during drilling[1] (mBGL)**
BH01-PR	4.0
BH03-CFG	2.6
BH04-CFG	0.8
BH05-CFG	3.0
BH05-PR	10.4
BH06-PR	1.5
BH09-M2U	2.0
BH09-U2B	2.4
BH10-CFG	8.9
BH11-EEEH	1.5
BH13-EEEH	2.0
BH14-EEEH	4.0

Note: mBGL – metres below ground level.

(1) Groundwater depth noted from geotechnical logs

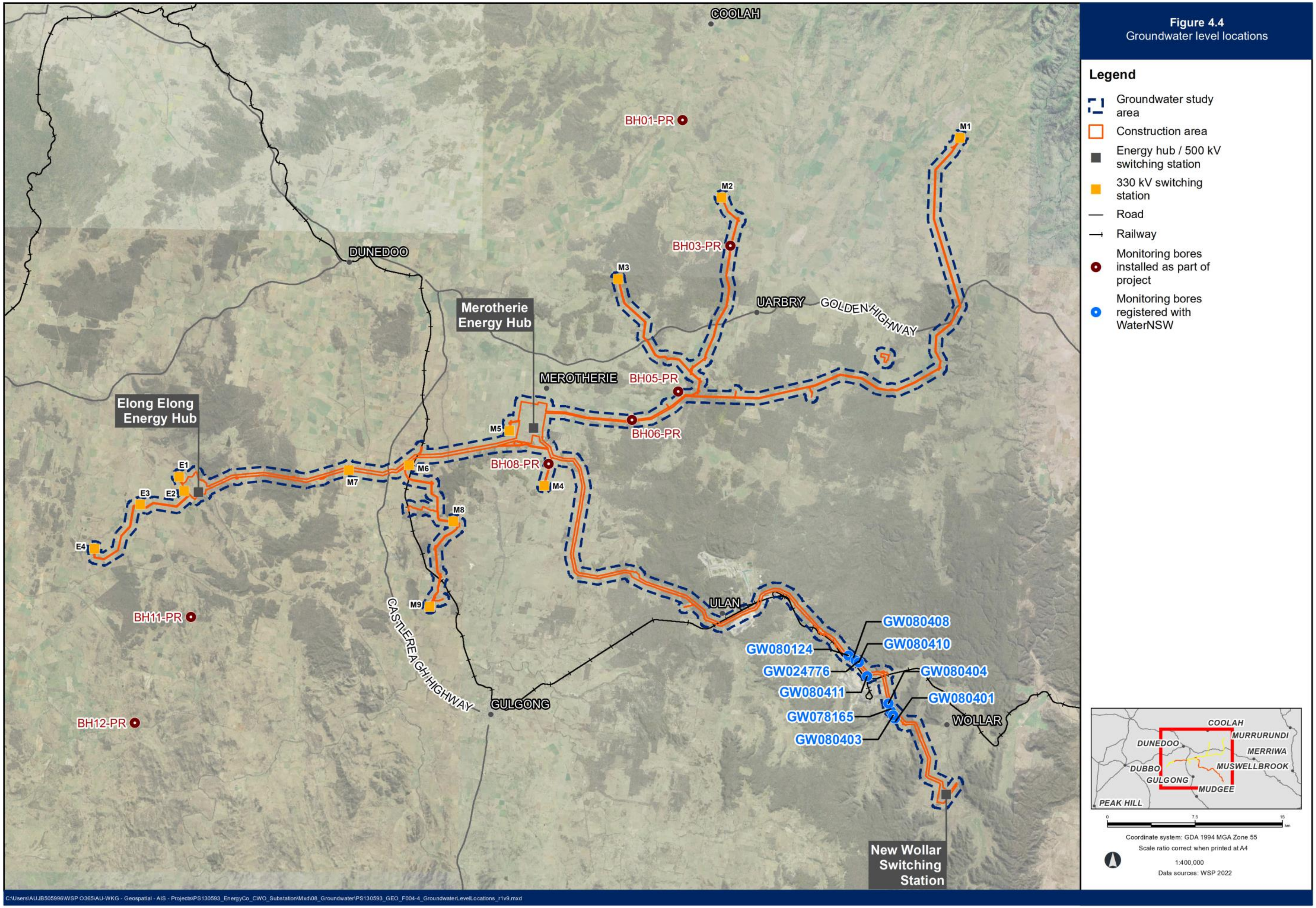


Figure 4.4
Groundwater level locations

4.5.4 Groundwater quality

Available groundwater quality information from registered works approvals (WaterNSW 2022) and contaminated land site investigations (WSP 2022c) provide an indication of the groundwater quality across the study area. The search of the WaterNSW real-time water data website identified six private bores with groundwater quality recorded on driller logs. These are provided in Table 4-4 and shown on Figure 4-5. The data available is limited and is concentrated close to the mining areas around Ulan, Wilpinjong and Moolarbeen coal mines. Groundwater salinity from the project site investigation completed in 2022 is provided in Table 4-5. Further detail on groundwater quality, including contaminated areas is provided in the Technical paper 16 – Contamination.

Measured groundwater quality across the study area is fresh to brackish with salinity (as TDS) ranging from 400 mg/L to 4,970 mg/L. Groundwater quality depends on various factors such as the geology groundwater travels through and surface water runoff quality (that is recharged into the underlying aquifers) in the local areas. Groundwater in the study area is used for a variety of purposes including, stock and domestic, industrial, irrigation and water supply. There is insufficient data to comment on seasonal variation of groundwater quality within the study area.

Table 4-4 Registered bores with quantitative groundwater quality records (average)

Work number	Salinity as TDS (mg/L)
GW024778	1,300
GW080410	407
GW080404	406
GW080408	400

Notes: TDS – total dissolved solids. mg/L – milligrams per litre

Table 4-5 Groundwater quality recorded from project field investigations

Borehole number	Salinity as TDS (mg/L)
BH05-PR	4,970
BH06-PR	625

Notes: TDS – total dissolved solids. mg/L – milligrams per litre

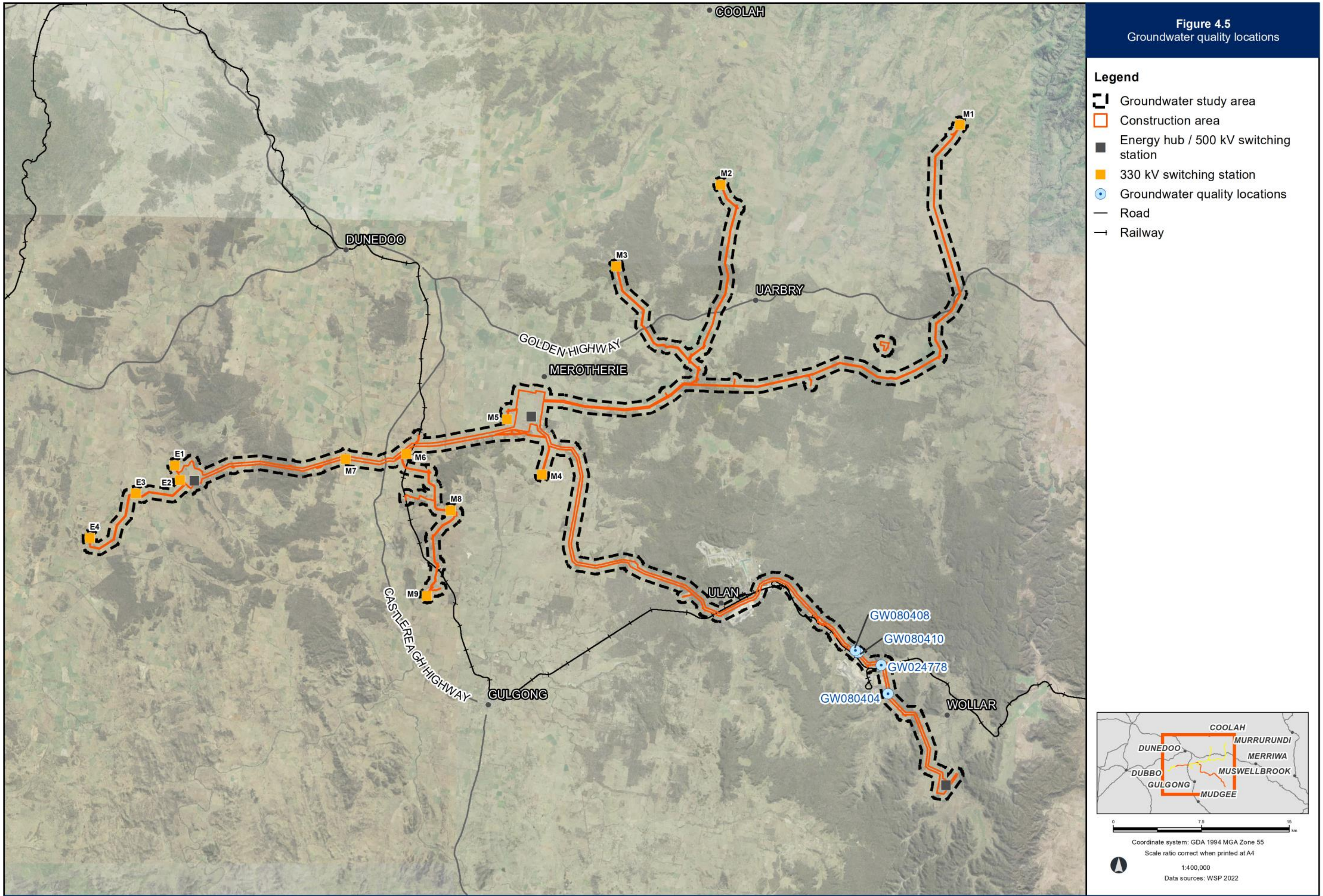
4.5.4.1 Contamination

The contamination assessment, provided in Technical paper 16 – Contamination, identified areas of contamination concern located within the study area. The areas of contamination concern are based on historical records and existing land uses and represents a worst-case scenario. The areas of contamination concern are associated with surface activities and infrastructure but contaminants have the potential to migrate into the surrounding groundwater. Further detail is provided in Technical paper 16 – Contamination.

Table 4-6 Identified areas of contamination concern

Areas of contamination concern	Causes
Existing Wollar substation site	Spills from maintenance activities on-site and leaks from site transformers. Potential leaks associated with fuel/transformer oil storage.
Existing towers and transmission line infrastructure	Spills from maintenance activities on site and asbestos paints on tower infrastructure.
Farm structures	Historical uncontrolled earthworks/filling and building structures previously demolished/degraded. Storage of agricultural chemicals and potential leaks associated with site works.
Farm dams	Historical uncontrolled earthworks/filling. Accumulation of nutrients and pesticides from adjacent cropping activities.
Areas of active cropping/cleared agriculture land	Historical uncontrolled earthworks/filling. Potential leaks associated with site works, and nutrients and pesticides from cropping activities.
Existing roadways and rail corridors	Spills from vehicles and maintenance activities on site.
Mining leases areas – Coal (Ulan, Wilpinjong and Moolarben coal mines)	Uncontrolled earthworks, spills from activities on-site and disposal and storage of wastes and mine tailings.

Figure 4.5
Groundwater quality locations



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4.6 Sensitive receivers

A groundwater sensitive receiver for the purpose of this groundwater assessment is defined as any identified receiver that utilises groundwater. Registered bores with a registered use as water supply are therefore considered as a sensitive receiver as they rely on groundwater to supply their water requirements across household, stock, irrigation, and commercial uses. GDEs are also classified as sensitive receivers as they need access to groundwater to meet some or all their water requirements to maintain their communities, processes, and ecosystem services.

4.6.1 Registered groundwater users

Registered groundwater works within the study area were identified using WaterNSW's continuous water monitoring network website (WaterNSW 2022) and the BoM's national groundwater information system (BoM 2022). There are 24 registered groundwater users identified within the study area, and two within the construction area. The registered groundwater works and types within both the study area and the construction area are presented in Table 4-7.

Table 4-7 Groundwater users identified within the study area and construction area

Beneficial use	Study area	Construction area
Stock and domestic	20	2
Unknown[1]	1	0
General use	1	0

(1) Unknown: groundwater use not listed or known (WaterNSW 2022) or (BoM 2022)

A full list of registered groundwater works is provided in Appendix A.

4.6.2 Groundwater Dependent Ecosystems

High potential GDEs from the BoM's Groundwater Dependent Ecosystems Atlas (GDE Atlas) (BoM 2022) are shown on Figure 4-6. The GDE Atlas was developed as a national dataset of Australian GDEs to inform groundwater planning and management. There are also 17 unique high priority terrestrial GDEs (that occur in 316 locations) and five high priority aquatic GDEs, occurring in nine locations (three in the Macquarie-Bogan River catchment and two in the Hunter River catchment). Further assessment of the potential impacts of the project on GDEs is provided in the Technical paper 4 – Biodiversity Development Assessment Report.

The GDEs in the study area are shown on Figure 4-6. A detailed list is provided in Appendix B.

Figure 4-6
Groundwater sensitive receivers
Page 1 of 4

Legend

- Groundwater study area
- Construction area
- Construction compound
- Energy hub / 500 kV switching station
- 500 kV transmission line
- Existing transmission line
- Road
- Railway
- Watercourse
- Water body

Registered groundwater bores

- Outside the construction area

High potential Groundwater Dependent Ecosystems

- Aquatic
- Terrestrial

Coordinate system: GDA 1994 MGA Zone 55
Scale ratio correct when printed at A4
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Data sources: WSP 2023

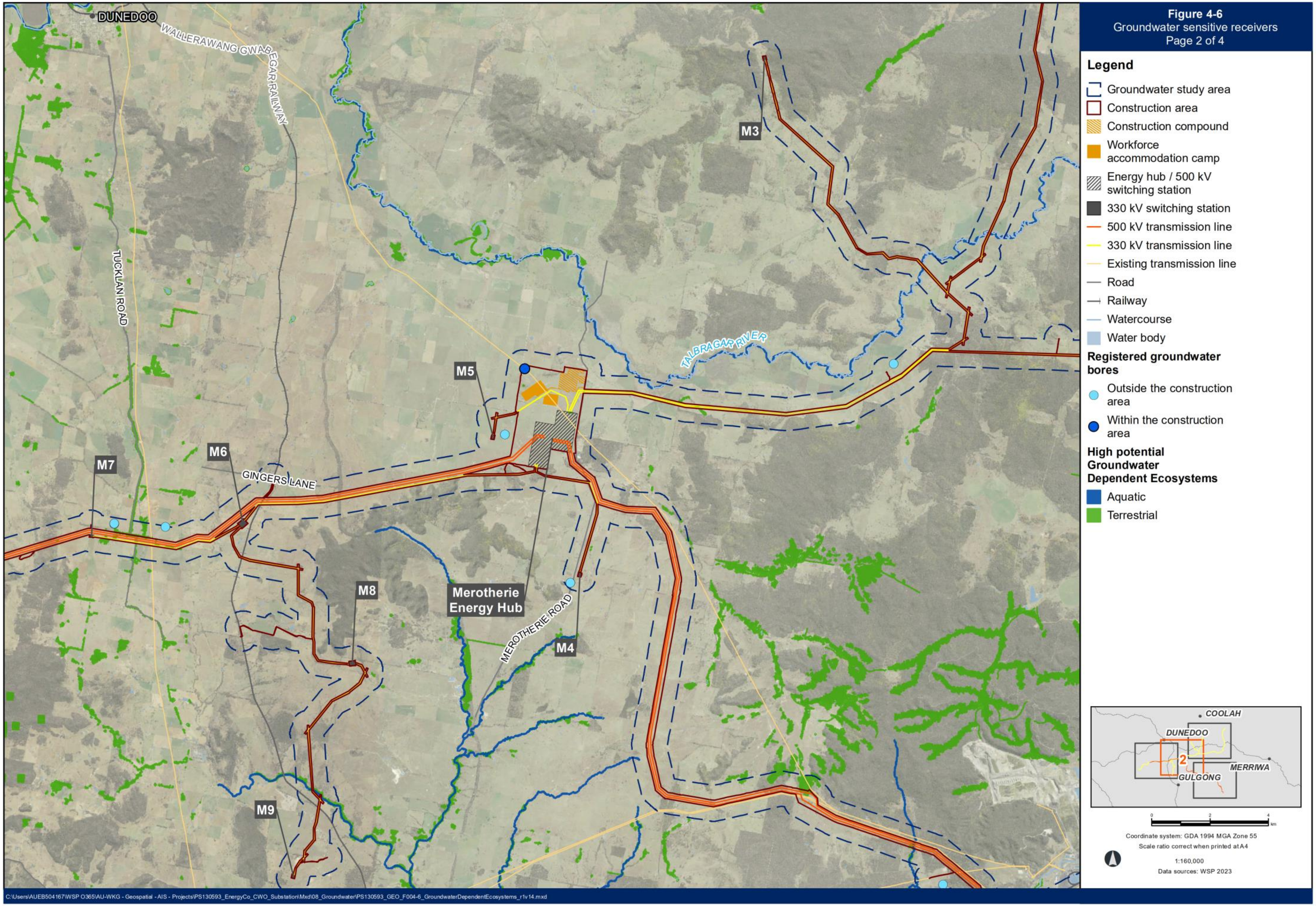
Figure 4-6
Groundwater sensitive receivers
Page 2 of 4
Legend
Groundwater study area
Construction area
Construction compound
Workforce accommodation camp
Energy hub / 500 kV switching station
330 kV switching station
500 kV transmission line
330 kV transmission line
Existing transmission line
Road
Railway
Watercourse
Water body
Registered groundwater bores
Outside the construction area
Within the construction area
High potential Groundwater Dependent Ecosystems
Aquatic
Terrestrial
DUNEDOO
WALLERAWANG GWABEGAR RAILWAY
TUCKLAN ROAD
GINGERS LANE
TALBRAGAR RIVER
MEROTHERIE ROAD
Merotherie Energy Hub
M3
M4
M5
M6
M7
M8
M9
COOLAH
DUNEDOO
MERRIWA
GULGONG
2
Coordinate system: GDA 1994 MGA Zone 55
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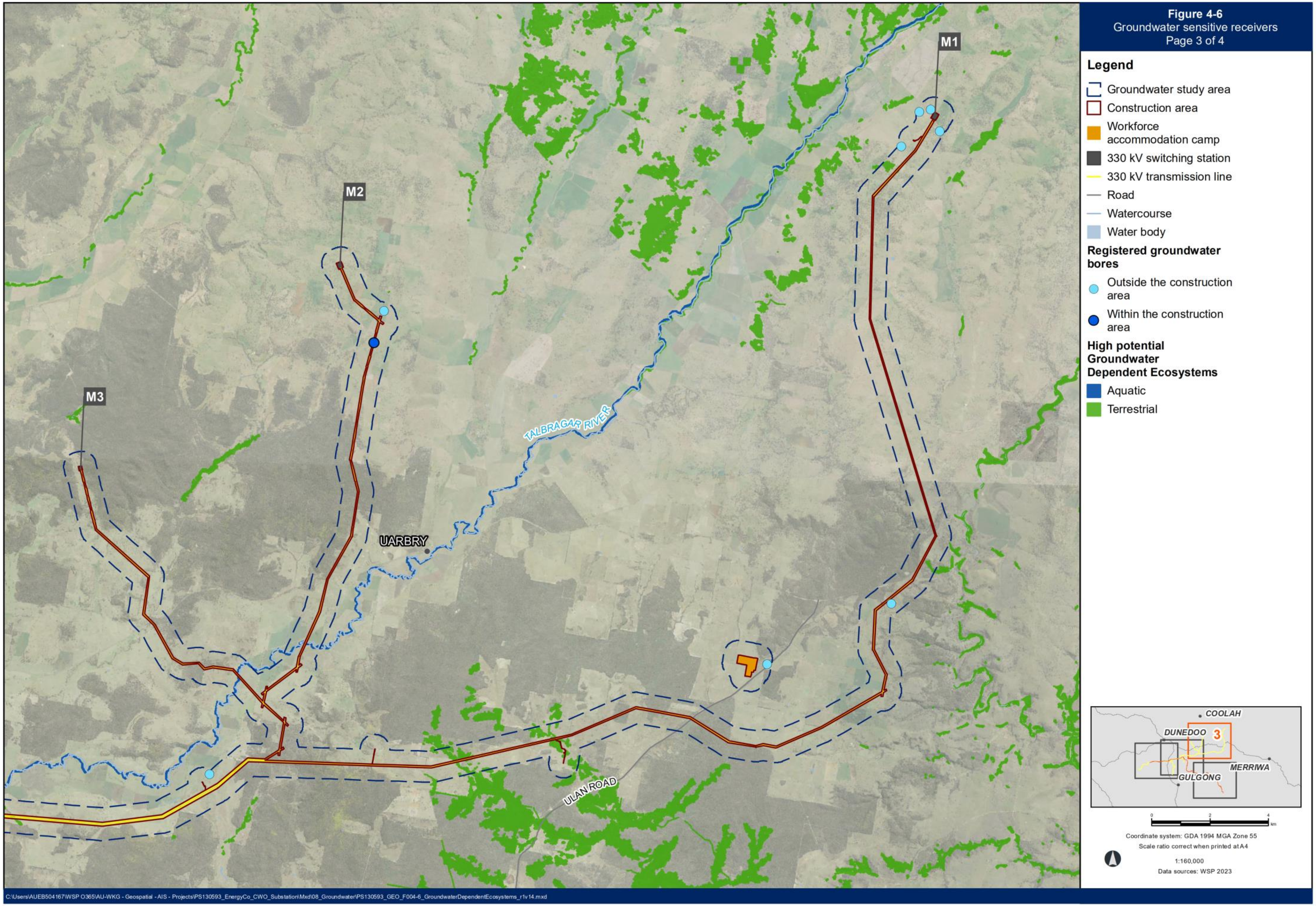
Figure 4-6
Groundwater sensitive receivers
Page 3 of 4
Legend
Groundwater study area
Construction area
Workforce accommodation camp
330 kV switching station
330 kV transmission line
Road
Watercourse
Water body
Registered groundwater bores
Outside the construction area
Within the construction area
High potential Groundwater Dependent Ecosystems
Aquatic
Terrestrial
M1
M2
M3
TALBRAGAR RIVER
UARBRY
ULAN ROAD
COOLAH
DUNEDOO
3
MERRIWA
GULGONG
Coordinate system: GDA 1994 MGA Zone 55
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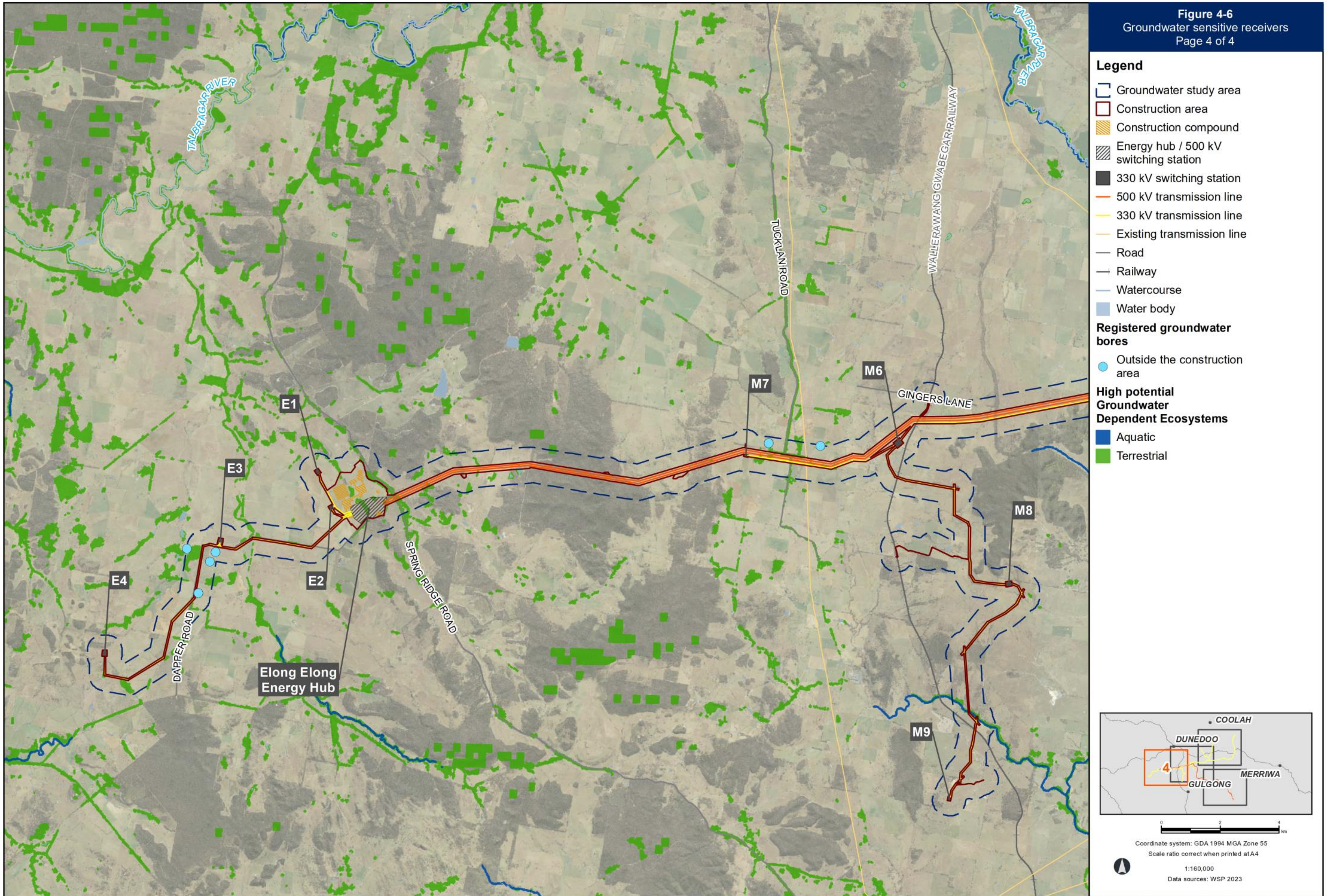
Figure 4-6
Groundwater sensitive receivers
Page 4 of 4



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4.7 Conceptual groundwater model

A conceptual groundwater model incorporates the interpretation of the geological and hydrological conditions. It describes a way of consolidating the current understanding of the key processes of the groundwater system to assist in the understanding of possible future changes.

As described in Section 4.5.1, there are eight groundwater sources in the study area, which are categorised into alluvial, porous and fractured rock aquifers. To help understand the groundwater environment during and after construction, and in the context of the project activities, a conceptual groundwater cross-section is provided on Figure 4-7.

4.7.1 Groundwater flow

Groundwater flow in shallow alluvial aquifers is generally a subdued reflection of topography and follows the surface water drainage systems.

Flow of groundwater in porous rock aquifers is largely governed by primary porosity which is associated with water movement around the rock grains, as well as secondary porosity which is associated with water movement through fractures within the rock mass. The ability to transmit usable quantities of water in this type of groundwater source depends on the continuous interconnection of these higher permeability features. These aquifers can be unconfined where close to surface or confined where aquifers exist at depth and are beneath confining units.

Groundwater in fractured rock groundwater sources is stored and moves through fractures, joints, bedding plains, faults and cavities within the rock mass. Fractured rock aquifers may be discontinuous at a scale of a few to tens of metres and not locally interconnected or may be continuous at a regional scale because some local fractures can be connected to a regional fracture network.

4.7.2 Recharge and discharge

Recharge to the groundwater systems in the study area is primarily through infiltration from rainfall, runoff and surface water within the outcropping (i.e. surface exposure) areas of the aquifer. Recharge can also occur from downward percolation of groundwater from overlying permeable strata that coincides with layers of the sedimentary sequences that have sufficient permeability for groundwater exchange to occur.

Discharge from groundwater systems in the study area is likely to primarily occur via evapotranspiration from shallow alluvial groundwater systems. Where there is high variation in relief and incised creeks, local groundwater flow may discharge to streams and creeks, potential groundwater springs and flow through the aquifer. Localised groundwater withdrawals would also occur from groundwater bores, although these are limited in number throughout the study area.

4.7.3 Aquifer interception

Aquifer interception throughout the construction area would be limited to where construction activities have the potential to intersect groundwater, and in locations where shallow groundwater levels or local perched aquifers exist. Water affecting activities, such as shallow excavations at the Elong Elong and Merotherie energy hubs, and piling for the transmission tower foundations, may intercept groundwater in some areas.

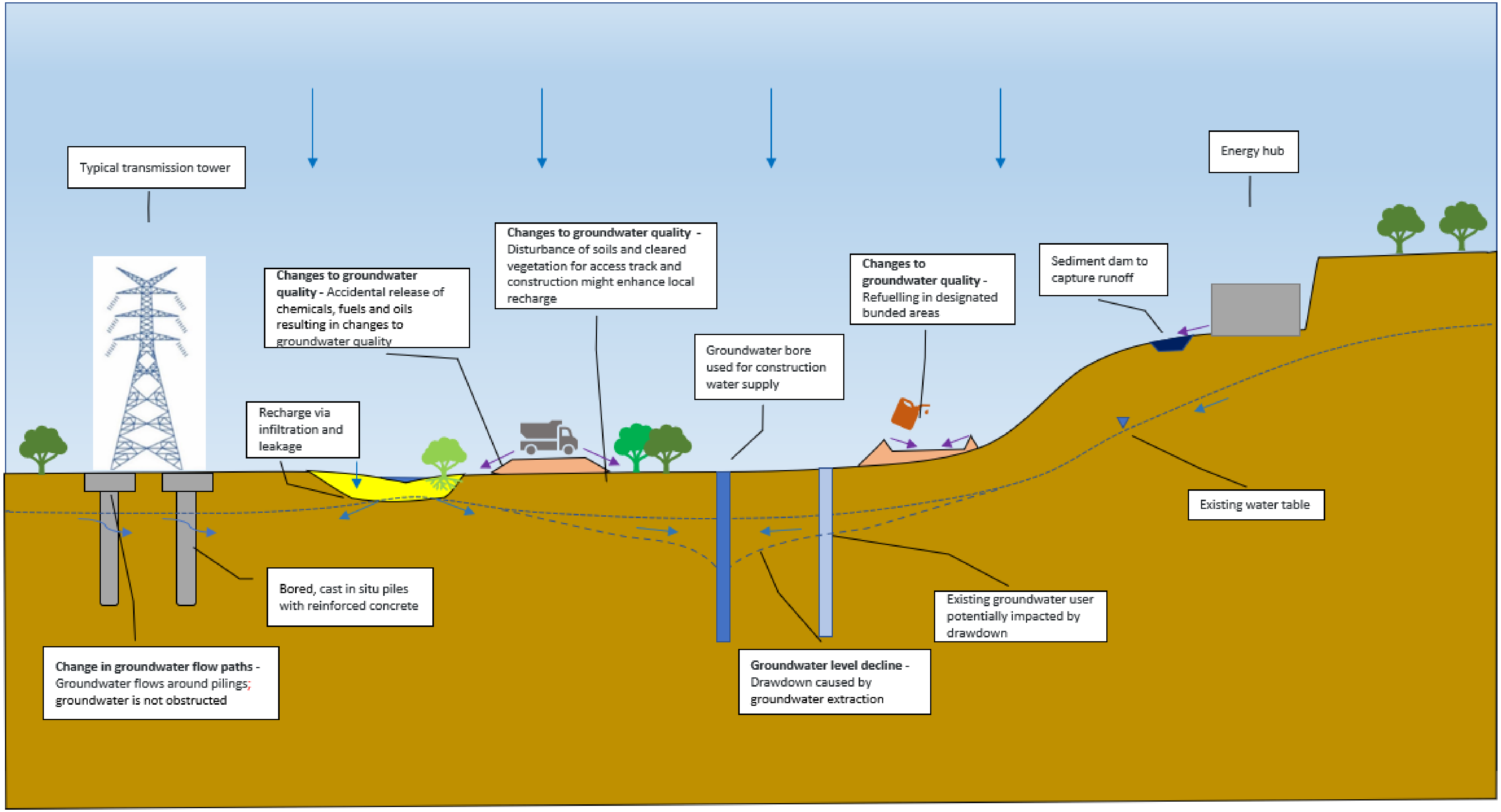

Figure 4-7 Conceptual groundwater model and interactions with project activities (not to scale)

5 Risk assessment

The risk assessment includes a preliminary risk evaluation to understand the potential risk of the groundwater impacts due to project related construction and operation activities. Potential risks are changes to physical and/or quality aspects of groundwater, or changes to the physical characteristics of water resources because of an activity or change to the existing environment. Examples include changes in water levels or changes in water quality of aquifers. The potential risks identified before implementation of appropriate controls or remediation are described in Table 5-1.

Table 5-1 Qualitative risk assessment

Risk	Water affecting activity	Consequence	Likelihood
Reduction of water quantity at sensitive receivers	Shallow excavations (e.g. for structural footings or concrete pilings, energy hubs and switching station construction) that intercept the water table may incur some groundwater inflow. Blasting, where undertaken for transmission tower footings, energy hubs or switching stations in areas of shallow hard rock.	Groundwater level decline could cause less water to be available to other users or sensitive receivers such as GDEs.	Unlikely Limited to areas where the water table is close to surface and shallow excavations would occur. None (or very limited and temporary) groundwater take during construction and no permanent groundwater take during operations.
	Groundwater extraction from bores used for construction water supply.		Likely Some drawdown would likely occur while groundwater extraction occurs. Extraction and drawdown would be temporary during construction period only.
	General construction activities that result in changes to surface infiltration, such as the creation of construction camps, building and laydown areas and access tracks and earthwork material sites, and removal of vegetation. Construction of transmission line tower foundations or shallow excavations or other shallow excavations changing groundwater flow paths.	Recharge might increase in cleared areas and decrease where hardstand areas exist. Change in flow paths may occur on a small scale around tower foundation pilings.	Unlikely Construction activities are unlikely to change recharge across the regional groundwater sources due to construction works being temporary and confined to the construction area.
Change in water quality at sensitive receivers	Infiltration of chemicals used in construction, such as fuel and oils from incidental spills or leaks.	Contamination of groundwater sources could affect the quality of groundwater available for use and change the beneficial use of the resource.	Unlikely Construction activities, procedures and requirements would manage risks associated to contaminated soils, and chemical/fuel refuelling and containment to limit any infiltration occurring.

6 Construction impact assessment

6.1 Overview

This chapter considers the potential impacts of the project on sensitive receivers identified in Section 4.6 (e.g. registered groundwater users and GDEs) with respect to groundwater quantity and quality during construction.

During the construction phase of the project, potential impacts are expected to be short-term and localised, and limited to areas with a shallow water table where interception might occur.

Table 6-1 summarises the potential impacts to the hydrogeological environment resulting from water affecting activities during construction. Consideration of these potential impacts is provided in the following sections. The response for each potential impact with regard to the AIP is provided in Chapter 8.

Table 6-1 Potential impact summary during construction

Potential impact	Water affecting activity
Reduced availability of water quantity at sensitive receivers such as GDEs.	— Shallow excavations (e.g. for structural footings or concrete pilings, energy hubs and switching station construction) that intercept the water table may incur some groundwater inflow. — Blasting, where undertaken, for transmission tower footings, energy hubs or switching stations in areas of shallow hard rock. — Groundwater extraction from bores used for construction water supply.
Changed recharge or groundwater flow paths.	— General construction activities that result in changes to surface infiltration, such as the creation of construction camps, building and laydown areas and access tracks and earthwork material sites, and removal of vegetation. — Construction of transmission line tower foundations or shallow excavations changing groundwater flow paths.
Changes to groundwater quality (salinity and contamination) available for use and change the beneficial use of the resource.	— Infiltration of chemicals used in construction, such as fuel and oils from incidental spills or leaks.

6.2 Potential impacts to groundwater quantity and level

6.2.1 Transmission line towers

Excavation works at each transmission line tower would be required, including the installation of foundations, levelling around the individual tower foundations, drainage, and grading or preparation for construction at the transmission line tower structure.

Transmission line tower piles would typically consist of bored, cast-in-situ piles with reinforced concrete. Pile depth would range from five metres to 20 mBGL. Pile diameters would range from 0.6–1.5 metres. Piling designs through rehabilitated mining areas, will be a cruciform piled foundation. The cruciform foundation will minimise the effect of differential settlement on the tower structure. The final depth and diameter of piles would depend on ground conditions (e.g. greater piling depths would be required where soft soil types are present), and the type of transmission tower required. The typical locations and dimensions of soil boring required for the tower foundations is outlined in Table 6-2.

Table 6-2 Soil boring locations and dimensions

Components	Depths
Transmission line towers within construction area, excluding within mine areas	Piles: up to between 5.0 m to 20.0 m below ground level Pile cap: up to 1.5 metres below ground level
Transmission line towers within mine areas	Piles: up to 50 m below ground level Pile cap: cruciform piled foundation

If groundwater is encountered or the excavations are filled by rainwater, the excavation would be dewatered and managed as appropriate.

The concrete pilings may intercept the local water table where the water table is close to surface. Concrete would be poured into the excavated pile, and water removed from the pile as it is displaced by the concrete. There is no permanent take of water, and therefore, there is no permanent change to groundwater levels and associated sensitive receivers during the project construction or operation.

6.2.2 Energy hubs and switching stations

Following a period of enabling works, construction for the energy hub and switching stations would (depending on the site specific electrical infrastructure requirements) typically consist of the following key activities:

- vegetation removal
- bulk earthworks to form the energy hub or switching station pad including the placement of fill, where required
- excavation and preparation of the site for concrete foundations
- installation of reinforced concrete and piled foundations for the electrical equipment
- excavation and installation of electrical equipment conduits, trenches and general site drainage works
- other construction activities specific to the site.

The typical locations and dimensions of excavations required at the different sites is outlined in Table 6-3. The excavation depths for the energy hubs are conservative estimates based on the reference design. The final design would be optimised to minimise excavation depths at the energy hubs.

Table 6-3 Shallow excavations locations and dimensions

Components	Depths
Merotherie Energy Hub	Up to 15 m below ground level
Elong Elong Energy Hub	Up to 10 m below ground level
New Wollar switching station	Up to 4 m below ground level
13 330 kV switching stations	Up to 4 m below ground level

6.2.2.1 Elong Elong Energy Hub

Shallow excavations at the Elong Elong Energy Hub would be approximately 10 mBGL (refer to Table 6-3). Depths to water in hillslope areas are generally deeper and limited (if any) groundwater interception would be expected to occur in the hillside cutbacks. The underlying geology comprises of unconsolidated material overlying alternating siltstone, claystone, shale, coal and sandstone of the Black Jack Group. The energy hub is located in the Gunnedah Oxley Basin MDB Groundwater Source.

The groundwater level near Elong Elong Energy Hub is available from one registered works approval (groundwater bore GW001142) (WaterNSW 2022). The bore is located about 4 km west of the site and encounters a water bearing zone at 54.5 mBGL in sandstone, with a standing water level of 15.2 mBGL (refer to Table 4-2), indicating confined aquifer conditions. There are no groundwater levels measured from project site investigations.

Groundwater level decline at surrounding sensitive receivers is unlikely to occur as a result of the hillside excavation at the Elong Elong Energy Hub. If shallow groundwater is encountered, it is likely to be perched, non-permanent and localised (that is, not connected regionally). Therefore, there would be very limited to no groundwater inflow to the hillslope cuttings and no change in groundwater levels at nearby receivers.

6.2.2.2 Merotherie Energy Hub

Shallow excavations at the Merotherie Energy Hub would be up to approximately 15 mBGL (refer to Table 6-3). Depths to water in hillslope areas are generally deeper and limited groundwater interception would be expected to occur in the hillside cutbacks. The underlying geology is the Gulgong Granite, and the energy hub is in the Lachlan Fold Belt MDB Groundwater Source.

The groundwater level near the Merotherie Energy Hub is available from one registered works approval (WaterNSW 2022). GW800590, located about 1,200 metres west of the site. A water bearing zone was encountered at 66–67 mBGL, in intercepted granite, with a standing water level of 10.5 mBGL (refer to Table 4-2), indicating confined aquifer conditions. There are no groundwater levels available from project site investigations.

Groundwater level decline at surrounding sensitive receivers is unlikely to occur as a result of the hillside excavation at the Merotherie Energy Hub. If shallow groundwater is encountered, it is likely to be perched, non-permanent and localised. Therefore, there would be very limited or no groundwater inflow to the hillslope cuttings and therefore no change in groundwater levels at nearby receivers.

6.2.2.3 Switching stations

Shallow excavations are also required in areas of the New Wollar Switching Station and the 330 kV switching stations, for building structural footings, with depths ranging from 3–4 mBGL. Groundwater is unlikely to be intercepted during shallow earthworks for the construction phase of the project. If shallow groundwater is encountered, it is likely to be perched, non-permanent and localised. Due to the existing groundwater levels being lower than the proposed excavation depths there would be no (or very limited) change in groundwater levels at any nearby receivers.

6.2.3 Blasting

Blasting may be required for construction of some transmission line towers and for the establishment of energy hubs and switching stations in areas of shallow hard rock. This would most likely include the transmission line from Merotherie Energy Hub towards switching stations M1, M2 and M3, and the transmission line between the Merotherie and Elong Elong Energy Hubs. The exact locations requiring blasting would be defined during detailed design following additional geotechnical investigations.

Blasting was identified as a water affecting activity during construction that could potentially impact groundwater levels. However, as the associated blasting halo is expected to be minor and not extend more than 10 metres from the origin of the blast(s), and not result in any take of groundwater, it is unlikely to result in an impact to the groundwater environment within the construction area or adjacent sensitive receivers.

6.2.4 Water supply for construction

Non-potable water would be required during construction for:

- dust suppression on the energy hub and switching station construction sites, transmission line structure construction sites, and on access tracks through the use of a water spray attached to a tanker vehicle
- on-site concrete batching
- wetting backfill material (if it is too dry for effective compaction)
- irrigation for landscaping.

In the event surface water availability does not meet the project's non-potable water requirements during construction, a groundwater supply would be established at the Merotherie and Elong Elong energy Hubs. Water would be transported to the relevant construction work area, compound or workforce accommodation camp from the appropriate source via tanker truck and stored in storage tanks located at the workforce accommodation camps, construction compounds and switching stations.

6.2.4.1 Proposed water supply locations

The proposed bore locations and extraction volumes are provided in Table 6-4 and Table 6-5 respectively. The proposed bore locations are shown on Figure 6-1 and Figure 6-2.

The Elong Elong Energy Hub is in the Gunnedah-Oxley Basin MDB Groundwater Source managed by the Water Sharing Plan for the NSW MDB Porous Rock Groundwater Sources 2020, The plan specifies a long-term average annual extraction limit of 127,500 megalitres per year (ML/year) for the Gunnedah-Oxley Basin MDB Groundwater Source.

The Merotherie Energy Hub is in the Lachlan Fold Belt MDB Groundwater Source managed by the Water Sharing Plan for the NSW MDB Fractured Rock Groundwater Sources 2020. The plan specifies a long-term average annual extraction limit of 253,788 ML/year for the Lachlan Fold Belt MDB Groundwater Source.

Table 6-4 Property details

Location	Lot/DP	Easting	Northing	Groundwater source	Proposed depth (m)
Elong Elong Energy Hub	2//DP532844	713800	6436145	NSW MDB Porous Rock	100
Merotherie Energy Hub	1//DP854876	742278	6442669	Lachlan Fold Belt MDB	

Note: Coordinate reference system: EPSG – 28355 (GDA zone 55).

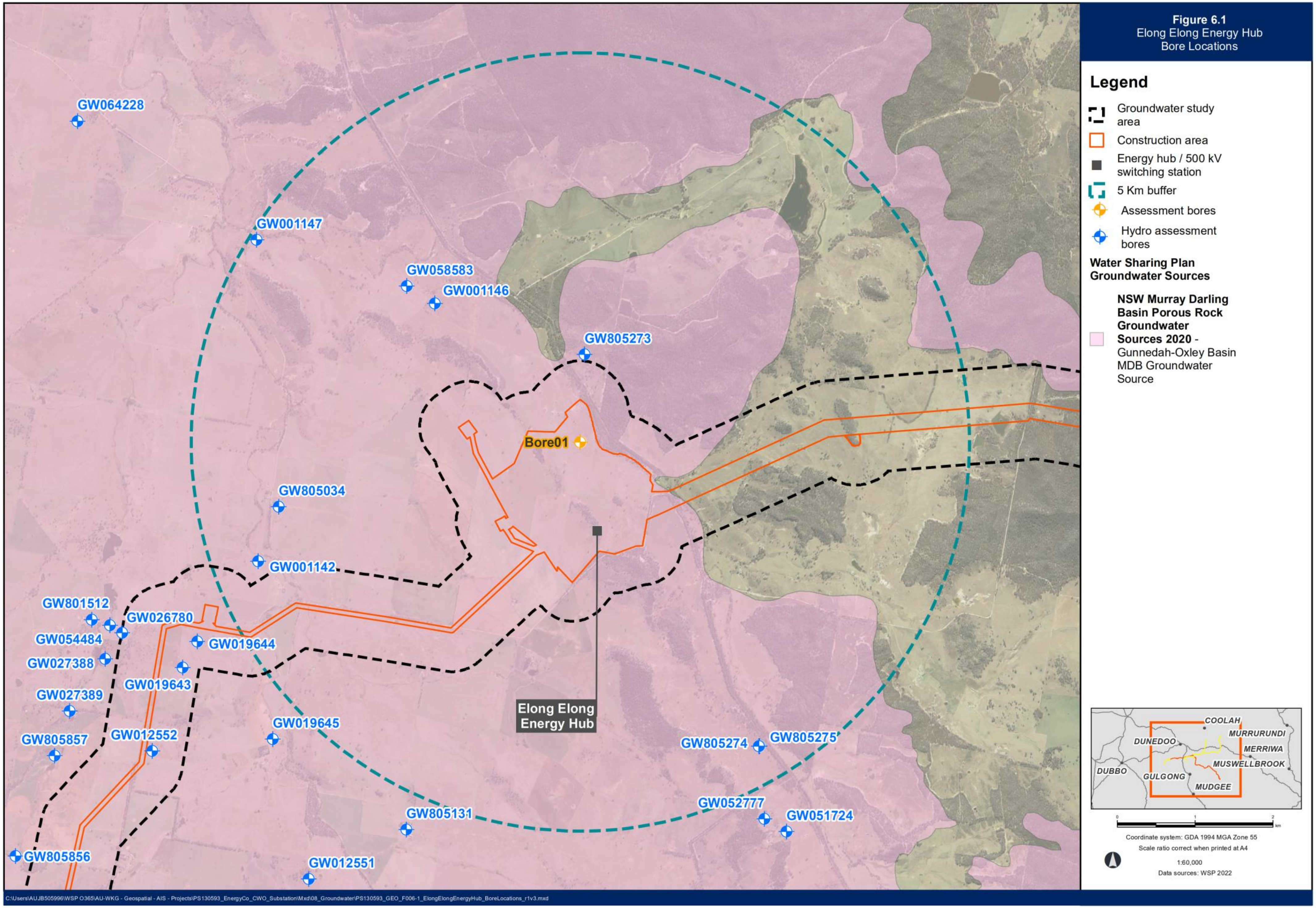

Figure 6.1
Elong Elong Energy Hub
Bore Locations

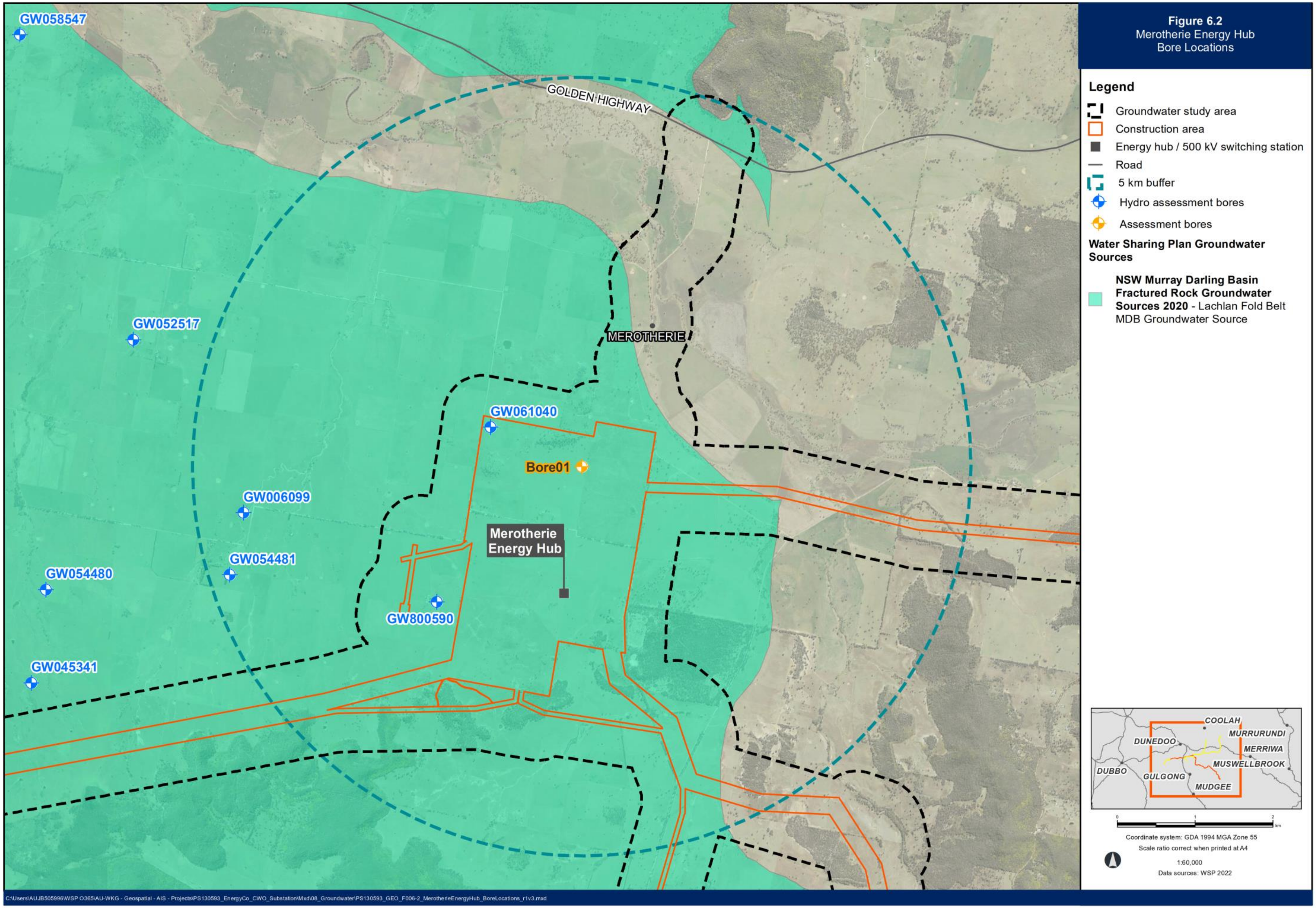

Figure 6.2
Merotherie Energy Hub Bore Locations

6.2.4.2 Extraction rate

The project construction water demand varies over the four year construction period. The extraction rate required from the groundwater supply system (if required) at each energy hub site is provided in Table 6-5. The highest demands are during the second and third year of construction.

Table 6-5 Construction non-potable water demand

Proposed extraction point	Annual water demand (ML/yr) during construction				
	Year 1	Year 2	Year 3	Year 4	Total
Elong Elong Energy Hub	5	76	40	3	124
Merotherie Energy Hub	5	76	40	3	124

6.2.4.3 Bore dealing assessment

The groundwater drawdown at surrounding receivers was simulated for the four year construction period with a varying extraction rate as required for the project construction schedule. A detailed bore dealing assessment for each energy hub is provided in Appendix C, with a summary provided below.

6.2.4.4 Assessment criteria

The assessment criteria for acceptable level of impacts used for this assessment is for a confined aquifer in porous rock and fractured rock groundwater sources (DPI 2018). The assessment criteria for confined aquifers are:

1. a cumulative drawdown of not more than 40% of the pre-development TAD at a distance of 200 metres from any water supply works including the pumping bores
2. an additional drawdown of not more than 3 metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties.

Assessment criterion 1 – Cumulative drawdown

The cumulative simulated drawdown cannot exceed 40 per cent of the pre-development total available drawdown (TAD) (mBGL) at a distance of 200 m from any water supply works including the applicant's bore within the assessment area. At the energy hubs, there are no surrounding water supply bores with a linked WAL. Therefore, only the proposed water supply bores have been included in this assessment criterion.

Results of assessment for cumulative drawdown are provided in Table 6-6. The results for cumulative drawdown do not exceed 40 per cent of the pre-development TAD (mBGL) at a distance of 200 m from the proposed water supply bores. Therefore, both proposed bore locations for construction water supply pass this assessment criteria.

Table 6-6 Results for cumulative drawdown

Extraction point	40 per cent TAD (mBGL)	Cumulative drawdown at 200 m from water supply bore during construction (mBGL)			
		Year 1	Year 2	Year 3	Year 4
Elong Elong Energy Hub	46.3	10.5	13.4	11.9	10.4
Merotherie Energy Hub	34.1	15.3	18.0	16.6	15.1

Note: mBGL – metres below ground level, TAD – total available drawdown

Assessment Criterion 2 – Additional drawdown

Additional drawdown cannot exceed 3 metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties. Results of assessment for additional drawdown at surrounding water supply works are provided in Table 6-7. The additional drawdown at surrounding bores is within the assessment criteria for additional drawdown.

Table 6-7 Results for additional drawdown at bores within 5 km of the proposed extraction point

Proposed extraction point	Bore GW number	Bore type	Distance (m)	Additional drawdown during construction period (m)			
				Year 1	Year 2	Year 3	Year 4
Elong Elong Energy Hub	GW058583 (80WA711302)	Stock	3,000	0.1	1.5	1.1	0.4
	GW805034	Stock, domestic	3,963	0.1	1.3	0.9	0.4
	GW001142	Stock	4,414	0.1	1.2	0.9	0.4
Merotherie Energy Hub	GW800590	Stock, domestic	1,278	0.1	2.1	1.4	0.4
	GW006099	Stock	2,547	0.1	1.6	1.1	0.4
	GW054481	Stock, domestic	4,386	0.1	1.2	0.9	0.3
	GW052517	Stock, domestic	4,730	0.1	1.1	0.8	0.3

6.2.4.5 Summary of assessment

The analytical groundwater models developed for the Elong Elong and Merotherie Energy Hubs construction water supply used publicly available information from surrounding bores. The proposed production bores depths are 100 m, and would be screened into the deeper sandstone water bearing zones, that are (based on available information) typically greater than 50 m depth. The top 20 m would be sealed with a cement/grout mixture to prevent inflow from any shallow water bearing zones. The assessments used the confined aquifer assessment criteria and showed that cumulative and additional drawdown is within the assessment criteria and that no more than minimal harm would occur to surrounding sensitive receivers such as other groundwater users or GDEs, due to extraction of groundwater during the four year construction period of the project.

6.2.5 Potential damage to existing water supply infrastructure

Ground clearing for transmission lines and establishment of energy hubs and switching stations would be required throughout the project area. Where clearing or blasting is proposed, applicable land holders would be consulted, and relevant searches of public bore registers undertaken prior to the blasting to confirm the presence of any bores or other water supply works within 50 m of the proposed blast or ground clearing locations. There are two basic landholder bores registered within the construction area (Table 4-7). Where identified, appropriate mitigation measures would be implemented on a site specific basis to prevent damage to the water supply infrastructure. If the bores are not required to be removed during construction, then they would be clearly demarcated.

6.3 Potential impacts to changed recharge or groundwater flow paths

Groundwater is not anticipated to be intersected by earthworks for building work pad areas, construction compounds, accommodation camps, or access tracks. Therefore, no impacts to groundwater flow paths are expected. Recharge from infiltration may be affected through changes in land use and vegetation clearing or changes to the permeability of the underlying soils through compaction in the area beneath the work pads used for construction activities.

Where concrete pilings for transmission tower construction intercept the local water table, small scale changes in flow paths would occur. The concrete pilings beneath the water table would not obstruct groundwater flow or reduce the available water at sensitive receivers. None of the structures or construction activities within the construction area would result in any permanent groundwater take that would alter the groundwater flow in the study area.

Building work pads and access tracks are listed as minimal impact activities (Section 3.3 of the AIP). As per the AIP framework, no further impact assessment is required for these types of construction activities. The AIP framework response is provided in Table 6-8.

Table 6-8 Aquifer interference assessment framework

Consideration	Response
Is the activity defined as an aquifer interference activity?	No – Building work pads and access tracks are not an aquifer interference activity.
Is the activity a defined minimal impact aquifer interference activity according to section 3.3 of the AIP?	Yes – No further assessment against the AIP is required.

6.4 Potential impacts to groundwater quality

Changes to groundwater quality can occur from disturbance of contaminated groundwater or soils, or accidental release of chemicals used in construction, such as fuel and oils. Potential impacts to groundwater can also potentially occur by the migration of contaminants into surrounding aquifers via infiltration of poor quality water, reducing the quality and lowering the beneficial use of local groundwater sources. The potential impact is dependent on the extent and type of contamination, and the volume of chemical and hazardous material spilled.

Contaminated groundwater from identified areas of contamination concern poses a low risk to the environment with regards to the construction of the project. This is because the volumes of groundwater expected to interact with project infrastructure during project construction would be negligible or are not expected to require management.

Potential adverse impacts on groundwater quality are unlikely to occur due to project construction activities. This would be managed through the implementation of standard procedures near areas of known soil contamination, and chemicals and hazardous material stored on site, and staff training. Refuelling and storage of hazardous chemicals would be carried out within constructed hardstand areas above natural ground surface. These practices would be detailed in the Construction and Environmental Management Plan (CEMP). A detailed review and risk rating of potential contaminated soil disturbance is provided in the Technical paper 16 – Contamination.

7 Operational impact assessment

7.1 Overview

This chapter considers the potential impacts of the project with respect to groundwater quantity and quality during operation. The potential impacts during operation, including on identified receivers such as registered groundwater users and GDEs, are expected to be lower than during construction

Table 7-1 summarises the potential impacts to the hydrogeological environment during operation of the project. Consideration of these potential impacts is provided in the following sections. The response for each potential impact with regard to the AIP is provided in Chapter 8.

Table 7-1 Potential impact summary during operation

Potential impact	Water affecting activity
Changed recharge or groundwater flow paths.	— Permanent infrastructure that results in changes to surface infiltration, such as new energy hubs and switching stations. — Permanent associated subsurface foundations and footings for infrastructure, such as transmission tower foundations.
Changes to groundwater quality (salinity and contamination) available for use and change the beneficial use of the resource.	— Permanent associated subsurface foundations and footings for infrastructure, which may degrade and impact groundwater quality. — Storage, spillage and leaks of hazardous substances used during operation. — Permanent subsurface foundations and footings for infrastructure that alter groundwater flow paths, distributing existing contaminants. — Leaching of contaminants from contaminated fill.

7.2 Potential impacts to changed recharge or groundwater flow paths

The project would have permanent infrastructure that results in changes to surface infiltration, such as new energy hubs, switching stations and transmission tower footings. The increase in impervious areas due to the permanent infrastructure would result in a negligible decrease in surface infiltration. Infiltration may also increase in areas with reduced vegetation due to management withing easements.

Where concrete pilings for transmission tower construction intercept the local water table, small scale changes in flow paths would occur. The concrete pilings beneath the water table would not obstruct groundwater flow or reduce the available water at sensitive receivers. The risk of the piling causing impact to the groundwater environment is low as the piling diameter (up to 2.5 metres) is negligible compared to the overall extent of regional groundwater flow. None of the structures or construction activities within the operation area would result in any permanent groundwater take that would alter the groundwater flow in the study area.

7.3 Potential impacts to groundwater quality

Changes to groundwater quality can occur from accidental release of chemicals used in operation and maintenance, such as fuel and oils. These contaminants can interact with groundwater through surface infiltration, reducing the quality of local groundwater sources.

Impact could occur through the infiltration of spilled pollutants into the ground surface and migration to underlying groundwater. However, due to the likely small volumes stored and used on site, the potential impact to groundwater from chemicals and hazardous materials would be appropriately managed via the implementation of standard operating procedures, and staff will receive training on proper handling of hazardous chemicals. Also, refuelling and storage of hazardous chemicals will be within constructed hardstand areas above natural ground surface. These practices will be detailed in the Operation Environmental Management Plan (OEMP) for the project.

8 Aquifer interference policy – minimum impact considerations

The AIP is used to guide proponents and DPE in assessing aquifer interference activities. The AIP provides a framework for assessing the impacts of aquifer interference activities on groundwater resources and defines minimal impact considerations to ensure no more than minimal harm occurs to key water-dependent assets. Two levels of minimal impact considerations are specified. If the potential impacts are less than the Level 1 minimal impact considerations, then these impacts would be considered as acceptable.

An assessment of the potential impacts of the project during construction and operation has been completed in regards to the AIP minimal impact considerations for less and highly productive groundwater sources and is provided in Section 8.1 and Section 8.2, respectively. The construction water supply is assessed by a bore dealing assessment in Section 6.2.4 and Appendix C.

The assessment complies with Level 1 minimal impact considerations indicating that the project is anticipated to have minimal impact to the underlying groundwater environment.

8.1 Less productive assessments

The AIP minimal impact considerations for less productive porous and fractured rock water sources in the study area are presented in Table 8-1.

Table 8-1 AIP minimal impact considerations – less productive porous and fractured rock water sources

Minimal impact consideration	Response
Water sharing plan and groundwater sources	— **North Coast Fractured and Porous Rock Groundwater Sources 2016** — Sydney Basin-North Coast Groundwater Source — Oxley Basin Coast Groundwater Source — **NSW Murray Darling Basin Porous Rock Groundwater Sources 2020** — Gunnedah-Oxley Basin MDB Groundwater Source
<u>Water table</u> Less than or equal to a 10 per cent cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan or A maximum of 2 m decline cumulatively at any water supply work.	There are no high priority GDE's or culturally sensitive sites near shallow excavations. If groundwater is encountered in temporary shallow excavations, it would be very limited and for a short period. Therefore, no project activities will cause water table changes at nearby receivers. **Conclusion: Does not exceed Level 1 minimal impact consideration thresholds**

Minimal impact consideration	Response
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.	There will be no changes to the existing groundwater quality or beneficial use category. Changes to groundwater quality due to contamination can occur from leaks and spills of hazardous substances. Chemicals of primary concern include hydrocarbons, or leaks and spills associated with road traffic. Site specific controls, such as proper storage and bunding of chemicals, site drainage and sedimentation basins at key locations would be used around the project to control site runoff. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

8.2 Highly productive assessments

The AIP minimal impacts considerations for highly productive water sources in the study area are presented in Table 8-2 for alluvial water sources, Table 8-3 for porous rock water sources and Table 8-4 for fractured water sources.

Table 8-2 AIP minimal impact considerations – highly productive alluvial water sources

AIP minimal impact consideration	Response
Water sharing plan and groundwater sources	— **Macquarie-Castlereagh Groundwater Sources 2020** — Talbragar Alluvial Groundwater Source.
Water table Less than or equal to a 10 per cent cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan or A maximum of a 2 m decline cumulatively at any water supply work.	There are no high priority GDE's or culturally sensitive sites near shallow excavations. If groundwater is encountered in temporary shallow excavations, it would be very limited and for a short period. Therefore, no project activities will cause water table changes at nearby receivers. **Conclusion: Does not exceed Level 1 minimal impact consideration thresholds**
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. No increase of more than 1 per cent per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity.	There will be no change to the existing groundwater quality or beneficial use category. Changes to groundwater quality due to contamination can occur from leaks and spills of hazardous substances. Chemicals of primary concern include hydrocarbons, or leaks and spills associated with road traffic. Site specific controls, such as proper storage and bunding of chemicals, site drainage and sedimentation basins at key locations would be used around the project to control site runoff. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

Table 8-3 AIP minimal impact considerations – highly productive porous (except Great Artesian Basin) rock water sources

AIP minimal impact consideration	Response of the potential impacts
Water sharing plan and groundwater sources	— **NSW Murray Darling Basin Porous Rock Groundwater Sources 2020** — Sydney Basin MDB Groundwater Source
<u>Water table</u> Less than or equal to a 10 per cent cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan or A maximum of a 2 m decline cumulatively at any water supply work.	There will be no change to the existing groundwater quality or beneficial use category. If groundwater is encountered in temporary shallow excavations, it would be very limited and for a short period. Therefore, no project activities will cause water table changes at nearby receivers. **Conclusion: Does not exceed Level 1 minimal impact consideration**
<u>Water quality</u> Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	There will be no change to the existing groundwater quality or beneficial use category. Changes to groundwater quality due to contamination can occur from leaks and spills of hazardous substances. Chemicals of primary concern include hydrocarbons, or leaks and spill associated with road traffic. Site specific controls, such as proper storage and bunding of chemicals, site drainage and sedimentation basins at key locations would be used around the project to control site runoff. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

Table 8-4 AIP minimal impact considerations – highly productive fractured water sources

AIP minimal impact consideration	Response of the potential impacts
Water sharing plan and groundwater sources	— **NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020** — Liverpool Ranges Basalt MDB Groundwater Source — Lachlan Fold Belt MDB Groundwater Source — **North Coast Fractured and Porous Rock Groundwater Sources 2016** — Liverpool Ranges Basalt Coast Groundwater Source.
<u>**Water table**</u> Less than or equal to a 10 per cent cumulative variation in the water table, allowing for typical climatic "post water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan or A maximum of a 2 m decline cumulatively at any water supply work.	There are no high priority GDE's or culturally sensitive sites near shallow excavations. If groundwater is encountered in temporary shallow excavations, it would be very limited and for a short period. Therefore, no project activities will cause water table changes at nearby receivers. **Conclusion: Does not exceed Level 1 minimal impact consideration thresholds**
<u>**Water quality**</u> Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.	There will be no changes to the existing groundwater quality or beneficial use category. Changes to groundwater quality due to contamination can occur from leaks and spills of hazardous substances. Chemicals of primary concern include hydrocarbons, or leaks and spills associated with road traffic. Site specific controls, such as proper storage and bunding of chemicals, site drainage and sedimentation basins at key locations would be used around the project to control site runoff. **Conclusion: does not exceed Level 1 minimal impact consideration thresholds**

9 Recommended management and mitigation measures

9.1 Environmental management

This chapter describes how the project would be managed to reduce potential environmental impacts throughout detailed design, construction and operation. The approach to environmental management and mitigation of potential impacts for the project would be carried out through the development of a project specific CEMP for main construction works. Mitigation and management measures during operation of the project are not needed for groundwater as there is no permanent groundwater take from any of the project operational activities.

The project is anticipated to generally have a limited impact to groundwater, which would be further reduced with the implementation of mitigation measures outlined within the CEMP. Groundwater controls would be part of the CEMP and be included within the soil and water management sub-plan.

The mitigation measures would be implemented and monitored for their effectiveness during construction. Typical provisions within the CEMP would include:

- procedures for the documentation and reporting of results related to the interception and extraction (take) of groundwater and potential impacts
- requirements for training, inspections, corrective actions, notifications and classification of environmental incidents, record keeping and performance objectives for handover on completion of construction.

A Soil and Water Management sub-plan would also be prepared for the project and contain details of appropriate measures in the event that groundwater is encountered during construction. The sub-plan would include but is not limited to:

- appropriate design of fuel and oil storage areas
- use nominated and bunded fuel and chemical storage areas
- provision of spill kits for cleaning up chemical, oil and fuel spillages
- training for personnel
- procedure for managing any intercepted shallow groundwater
- procedures for soil storage (including any potential contaminated soil) and erosion control.

9.2 Mitigation measures

Mitigation measures to minimise potential impacts to groundwater quality during construction and operation are outlined in Table 9-1. Mitigation measures in other technical papers that are relevant to the management of groundwater include:

- Technical paper 14 – Hydrology and water quality; specifically measures which address surface water quality impacts
- Technical paper 16 – Contamination; specifically measures which address interaction with contaminated soils and water.

Table 9-1 Proposed mitigation measures

Reference	Impact	Mitigation measures	Timing	Applicable location(s)
GW1	Lowering of groundwater levels due to interception and take of water	In the event that groundwater is encountered during excavations, any dewatering volumes will be recorded and managed in accordance with the *Water Management Act 2000*.	Construction	Areas of intercepted groundwater
GW2	Lowering of groundwater levels due to water extraction	Monitoring and recording of extraction volumes from water supply bores will be undertaken and regular analysis of extracted volumes will be completed against predicted volumes in this technical paper (refer to Table 6-5), applicable water access licence and approval requirements.	Construction	Water supply bores at energy hubs
GW3	Impacts due to blasting	Control measures will be identified prior to blasting activities in relevant areas to avoid adverse impacts to sensitive groundwater receivers.	Construction	Finalised blasting locations if within 50 metres of high potential GDEs or existing bores
GW4	Damage to bore infrastructure	Direct impacts to registered bores will be avoided, where practicable. If the bores are not required to be removed during construction, then they will be clearly demarcated to protect the infrastructure. Where impact is unavoidable and a bore will require decommissioning, it will be replaced in a similar nearby location in consultation with landowner.	Construction	All locations

10 References

Australian Government. 2013. *Guidelines for Groundwater Quality Protection in Australia. National Water Quality Management* . Canberra: Department of Agriculture and.

BoM. 2022. *Australian Groundwater Explorer.* 20 09. Accessed 09 20, 2022. http://www.bom.gov.au/water/groundwater/explorer/index.shtml.

—. 2022. *Climate data online.* 14 October. Accessed October 14, 2022. http://www.bom.gov.au/climate/data/.

—. 2022. *Groundwater Dependent Ecosystems Atlas.* Commonwealth of Australia. August. Accessed September 20, 2022. http://www.bom.gov.au/water/groundwater/gde/map.shtml.

—. 2021a. *Groundwater Dependent Ecosystems Atlas.* Commonwealth of Australia. Accessed November 1, 2021. http://www.bom.gov.au/water/groundwater/gde/map.shtml.

Colquhoun, G P, K S Hughes, L Deyssing, J C Ballard, C B Folkes, G Phillips, A L Troedson, and J A Fitzherbert. 2021. *NSW Seamless Geology Data Package.* Vers. 2.1. Resources and Geoscience Division of NSW Department of Planning and Environment. Accessed November 1, 2021. https://search.geoscience.nsw.gov.au/product/9232.

DPE. 2022. *Groundwater assessment toolbox for major projects in NSW - Overview document. Technical guideline.* NSW Department of Planning and Environment.

DPE. 2020. *Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE) framework.* NSW Department of Panning and Environment.

DPI. 2018. *Assessing groundwater applications.* NSW Department of Industry.

DPI. 2018. *Assessing groundwater applications.* NSW Department of Industry.

DPI. 2013. *Groundwater Productivity in NSW.* Report, Department of Primary Industries. https://www.planningportal.nsw.gov.au/opendata/dataset/highly-productive-groundwater-in-nsw.

NSW DPI. 2012. *NSW Aquifer Interference Policy.* Policy, NSW Department of Primary Industries, NSW Department of Trade and Investment, Regional Infrastructure and Services, NSW Department of Primary Industries.

WaterNSW. 2022. *Continuous water monitoring network.* Edited by WaterNSW. 20 September. Accessed September 20, 2022. https://realtimedata.waternsw.com.au/.

WSP. 2022c. "Central-West Orana Renewable Energy Zone, Contamination Factual Report - Energy Hubs (Packages A and C)."

WSP. 2022d. "Central-West Orana Renewable Energy Zone, Contamination Factual Report - Energy Hubs (Packages B, D and E)."

WSP. 2022a. "Central-West Orana Renewable Energy Zone, Geotechnical Factual Report - Energy Hubs (Packages A and C)."

WSP. 2022b. "Central-West Orana Renewable Energy Zone, Geotechnical Factual Report - Energy Hubs (Packages B, D and E)."

11 Limitations

The preparation of this technical paper has involved a desktop exercise that has relied upon information from the proponent, together with freely available reports, data, figures and existing investigations. Freely available data and reports included the available background water sharing plan documents published by DPE, water resource plans and supporting documents published by DPE, groundwater levels, quality and registered bore data published by WaterNSW and collated by the Bureau of Meteorology. The latest spatial data for the location of GDEs and water sharing plans, used in this assessment at the time of reporting was obtained from the NSW Government SEED database. Where this data is out of date, this assessment has, within reason, attempted to assess the spatial location of high priority GDEs from available low-quality images within the water sharing plan legislation.

Existing investigations include the latest geotechnical and preliminary site investigation reports (WSP, 2022) which were used to obtain information on the existing environment within the study area, predominantly the geology, with groundwater observations also recorded when encountered. The impact assessment is limited to a qualitative assessment based on the reference design and proposed construction methodology at the time of preparation of this report.

The level of characterisation of hydrogeological conditions and potential impacts are limited to the data available and the preliminary nature of the project design. Assumptions have been reasonably applied in areas of limited data based on expected hydrogeological conditions derived from the interpretation of field data collected by third parties and information sourced during the desktop review. The impact assessment conclusions may differ from those reported in this report if encountered conditions differ from those assumed.

This assessment is adequate to assess typical environmental impacts and provide recommendations for mitigation measures. Recommendations would be subject to refinement as the design of the project is finalised and validation is undertaken during construction.

Appendix A

Surrounding registered groundwater bores

Table A-1 Registered groundwater bore users within study area

State Bore ID	Type	Easting	Northing	Bore depth (m)
GW011978	Stock and Domestic	777452	6464878	18.3
GW012552	Stock and Domestic	707640	6432761	42.6
GW019643	Stock and Domestic	708029	6433831	19.2
GW019644	Stock and Domestic	708219	6434166	76.2
GW031159	Stock and Domestic	778062	6466064	–
GW031160	Stock and Domestic	778459	6466146	–
GW031161	Stock and Domestic	778754	6465398	–
GW033527 (20WA214735)	Stock and Domestic	777105	6449195	207.3
GW044137	Stock and Domestic	759376	6458139	96
GW048983	Stock and Domestic	759719	6459240	109.7
GW057144	Stock and Domestic	727034	6437861	43.3
GW078165	Stock and Domestic	772661	6416820	–
GW080124	Unknown	769060	6421572	–
GW024776	Stock and domestic	769870	6421057	48.8
GW026780	General use	707252	6434279	9.1
GW059683	Stock and domestic	757763	6423655	61.5
GW061040	Stock and domestic	741105	6443176	42
GW066582	Stock and domestic	728788	6437760	60.9
GW080355	Stock and domestic	755438	6425499	–
GW800590	Stock and domestic	740413	6440934	72
GW801625	Stock and domestic	753743	6443344	39
GW805088	Stock and domestic	727025	6437865	55
GW805723	Stock and domestic	742660	6435846	22
GW080197	Stock and domestic	772846	6447116	–

Appendix B

Groundwater Dependent Ecosystems

Table B-1 High priority GDE's (BoM 2022)

Type	GDE name	Catchment	Area (ha)
Terrestrial	Angophora floribunda, Eucalyptus blakelyi, Eucalyptus melliodora/ Acacia implexa, Dodonaea visco	Macquarie-Bogan Rivers	61.5
Terrestrial	Angophora floribunda, Eucalyptus melliodora, Brachychiton populneus subsp. populneus, Callitris e	Hunter River	0.7
Terrestrial	Angophora floribunda, Eucalyptus melliodora, Brachychiton populneus subsp. populneus, Callitris e	Macquarie-Bogan Rivers	6.6
Terrestrial	Black Sallee – Tussock Grass open woodland of the South Eastern Highlands Bioregion	Macquarie-Bogan Rivers	0.1
Terrestrial	Blakelys Red Gum – Rough-barked Apple shrubby woodland of central and upper Hunter	Hunter River	42.9
Terrestrial	Blakelys Red Gum – Rough-barked Apple shrubby woodland of central and upper Hunter	Macquarie-Bogan Rivers	37.0
Terrestrial	Blakelys Red Gum – Yellow Box grassy tall woodland of the NSW South Western Slopes Bioregion	Macquarie-Bogan Rivers	21.5
Terrestrial	Eucalyptus blakelyi, Eucalyptus melliodora, Eucalyptus bridgesiana/ Acacia dealbata/Themeda aus	Macquarie-Bogan Rivers	7.9
Terrestrial	Eucalyptus camaldulensis, Casuarina cunninghamiana/ Callistemon sieberi, Leptospermum polygalifol	Macquarie-Bogan Rivers	9.3
Terrestrial	Eucalyptus conica, Eucalyptus blakelyi, Eucalyptus melliodora, Callitris glaucophylla/Acacia de	Macquarie-Bogan Rivers	15.6
Terrestrial	Eucalyptus fibrosa, Callitris endlicheri, Eucalyptus sparsifolia, Acacia linearifolia/Phyllanth	Macquarie-Bogan Rivers	2.0
Terrestrial	Eucalyptus melliodora, Eucalyptus blakelyi, Angophora floribunda/ Acacia implexa, Geijera parvif	Macquarie-Bogan Rivers	5.3
Terrestrial	Eucalyptus melliodora/Acacia decora, Maireana microphylla/ Bothriochloa macra, Austrostipa bige	Macquarie-Bogan Rivers	0.2
Terrestrial	Eucalyptus melliodora/Pimelea curviflora var. curviflora, Acacia implexa, Acacia decora, Solanu	Macquarie-Bogan Rivers	5.2
Terrestrial	Eucalyptus microcarpa, Callitris glaucophylla, Allocasuarina luehmannii/Maireana microphylla, A	Macquarie-Bogan Rivers	42.7
Terrestrial	River Oak/Purple Wiregrass/Plains Grass grassy riparian forest of the Merriwa Plateau	Hunter River	3.1
Terrestrial	River Red Gum riparian tall woodland/open forest wetland in the Nandewar Bioregion and Brigalow Be	Macquarie-Bogan Rivers	11.7
Terrestrial	Rough-Barked Apple – red gum – Yellow Box woodland on alluvial clay to loam soils on valley flats in	Hunter River	18.6
Terrestrial	Rough-Barked Apple – red gum – Yellow Box woodland on alluvial clay to loam soils on valley flats in	Macquarie-Bogan Rivers	2.4

Type	GDE name	Catchment	Area (ha)
Terrestrial	Western Hunter Flats Rough-barked Apple Forest	Hunter River	238.9
Terrestrial	Western Hunter Flats Rough-barked Apple Forest	Macquarie-Bogan Rivers	7.5
Aquatic	Rouses	Hunter River	0.03
Aquatic	Sportsmans Hollow	Hunter River	4.1
Aquatic	Sportsmans Hollow	Hunter River	6.9
Aquatic	Stubbo	Macquarie-Bogan Rivers	0.7
Aquatic	Talbragar River	Macquarie-Bogan Rivers	5.1
Aquatic	Talbragar River	Macquarie-Bogan Rivers	3.4
Aquatic	Talbragar River	Macquarie-Bogan Rivers	1.4
Aquatic	Talbragar River	Macquarie-Bogan Rivers	1.6
Aquatic	Tallawang	Macquarie-Bogan Rivers	4.7

Appendix C

Bore dealing assessment

Design
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Central-West Orana Renewable Energy Zone Transmission project

Bore Dealing Assessment

September 2023

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Rev	Date	Details
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Reviewed by:	Ellen Kwantes	20/09/2023	pp T Wilkinson
Approved by:	Paul Greenhalgh	20/09/2023	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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1 Overview

A groundwater supply system may be required as a secondary rainfall independent water source during the construction period of the project at both Elong Elong and Merotherie energy hubs. The proposed use of extracted groundwater would be for non-potable uses such as dust suppression, landscaping and compaction of access roads and project areas. Water would be transported to the relevant construction work area, compound or workforce accommodation camp from the appropriate source via tanker truck and stored in storage tanks located at the workforce accommodation camps, construction compounds and switching stations.

The potential impacts from groundwater extraction from bores used for water supply have been assessed using the bore dealing assessment approach in accordance with the groundwater assessment toolbox workflow (DPE 2022) and the Assessing groundwater applications (DPI, 2018).

New bores would be established at each energy hub to source the groundwater. The proposed bore locations for use during construction are provided in Table 1-1.

Table 1-1 Property details for proposed bore locations

Location	Lot/DP	Easting	Northing	Proposed use
Elong Elong Energy Hub	2//DP532844	713800	6436145	Dust suppression, landscaping and compaction works during construction.
Merotherie Energy Hub	1//DP854876	742278	6442669	

Note: Coordinate reference system: EPSG – 28355 (GDA zone 55)

1.1 Extraction rates

The project construction water demand varies over the four year construction period. The extraction rate required from the groundwater supply system at each energy hub site is provided in Table 1-2. The highest demands are during the second and third year of construction.

Table 1-2 Energy hub construction non-potable water demand

Location	Annual water demand (ML/year)				
	Year 1	Year 2	Year 3	Year 4	Total
Elong Elong Energy Hub	5	76	40	3	124
Merotherie Energy Hub	5	76	40	3	124

Note: ML = megalitre

1.2 Analytical modelling approach

The modelling approach has been used to assess the drawdown impacts that may occur because of groundwater extraction during construction of the project. The modelling approach uses a semi-analytic simulation of transient flow in groundwater systems. The Dupuit approximation is adopted for flow in aquifer layers and the storage in the aquifer layers is taken into account. The modelling is for confined aquifer systems and drawdown at any point at a given time is directly proportional to the pumping rate and inversely proportional to aquifer transmissivity and aquifer storativity. The model represents a simplification of the aquifer system and is considered suitable for this type of assessment.

1.2.1 Assumptions

The following assumptions have been used in this assessment:

1. groundwater extraction is simulated to occur with a varying pumping schedule based on annual construction demand as outlined in Table 1-2 during the four year construction period
2. surrounding basic landholder right (stock and domestic bores) extraction is not included in the assessment of cumulative drawdown
3. the groundwater bores are sealed from surface not less than 20 metres
4. the aquifer is confined
5. any rivers are disconnected (not included)
6. there is no groundwater gradient, i.e. the water table is flat
7. the aquifers are approximated as linear
8. the aquifer has infinite areal extent
9. the aquifer is homogeneous, isotropic and of uniform thickness
10. the water removed from storage discharges instantaneously with decline in hydraulic head
11. the pumping bore is fully penetrating; therefore, flow is horizontal
12. each of the existing private bores is fully penetrating
13. no rainfall recharge is considered.

1.3 Assessment criteria

The assessment criteria for acceptable level of impacts used for this assessment is for a confined aquifer in porous rock and fractured rock groundwater sources (DPI, 2018). The assessment criteria for confined aquifers are:

1. a cumulative drawdown of not more than 40% of the pre-development TAD at a distance of 200 metres from any water supply works including the pumping bores
2. an additional drawdown of not more than 3 metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties.

2 Elong Elong Energy Hub – Bore dealing assessment

2.1 Elong Elong Energy Hub location

The Elong Elong Energy Hub is located in the Gunnedah-Oxley Basin Murray Darling Basin Groundwater Source managed by the NSW Murray Darling Basin Porous Rock Groundwater Sources 2020. The property details and location are outlined in Table 1-1. The rules relating to water supply bore siting are described in Table 2-1.

The location of the proposed construction water supply bore at Elong Elong Energy Hub is outside these distance restrictions. The proposed bore location is shown in Figure 2-1.

Table 2-1 Water supply rules for the Gunnedah-Oxley Basin MDB Groundwater Source

Water Sharing Plan rule	Distance (m)
Distance restriction from an approved water supply work nominated by another access licence	400
Distance restriction from an approved water supply work for basic landholder rights only	100
Distance restriction from the property boundary	200
Distance restriction from an approved water supply work nominated by a local water utility or major utility access licence	500
Distance restriction from a DPE observation bore	200

2.2 Surrounding bore information

A registered bore search was conducted using data available from the NGIS database (BoM, 2022) and a search of the WaterNSW real-time water data website (WaterNSW, 2022). Groundwater bores within the 5 km of the Elong Elong Energy Hub are included in this assessment.

There are eight basic landholder rights bores, and one monitoring bore in the assessment area (i.e. within 5 km). Table 2-2 lists their location coordinate information, depth, standing water level, bore type and distance from the proposed bore site.

The area lithology comprises of a surficial unconsolidated material of clay to a depth of about 5–8 m (based on lithology logs from GW001142 and GW804456), overlying alternating siltstone, claystone, shale, coal and sandstone of the Black Jack Group. Lithology log for GW001142 and GW804456, are provided in Appendix A.

Available lithological logs from work summary reports (provided in Appendix A) in the area indicate that drilling depths of bores range from 5 mBGL to 99.9 mBGL. Water bearing yields range from 0.19 L/s to 2.4 L/s. Most water bearing zones occur in the consolidated sandstone, and shale of the Black Jack Group.

The proposed production bore would target the deep sandstone water bearing zones of the aquifer (i.e. greater than 50 m). Based on available drilling records it is reasonable to assume production pumping yields of 0.5–1 L/s would be achievable.

Monitoring bore GW804456 is located in the area, but has no ongoing water level monitoring.

Table 2-2 Elong Elong Energy Hub surrounding bores details

State bore ID	Easting	Northing	Bore type	Bore depth (m)	Standing water level (m)	Slot interval (mBGL)#	Water bearing zone (m) and yield (L/s)	Distance (m)
GW805273*	713195	6437853	stock, domestic	5	4	0–5	–	1,124
GW804456	713474	6435353	monitoring	38	–	36.5–38	–	1,416
GW001146*	711270	6438510	not known	18.8	6	0–17.2	17.6 m @ 0.53L/s	2,582
GW058583 (80WA711302)	710907	6438733	stock	53.3	4.6	(7.6–9.1), (45.7–48.7), (50.3–53.3)	7.6-7.9 m @1.14 L/s 46.3–46.6 m @ 2.4L/s	3,000
GW805034	709265	6435901	stock, domestic	99.9	–	45.7–99.9	85.3–99 m @ 1.26 L/s	3,963
GW001142	709000	6435198	stock	56.3	15.2	0.3–53.7	54.5 m @ 0.19 L/s	4,414
GW805274*	715435	6432821	stock, domestic	5	4	0–5	–	4,533
GW805275*	715441	6432822	stock, domestic	8.6	3.9	0–8.6	–	4,535

Note: * Information provided. These bores are assumed unconfined and not included in the assessment

mBGL = metres below ground level

2.3 Usage

All surrounding bores are used for stock and domestic purposes (i.e. basic rights) and there are no Water Access Licences (WAL's) associated with the bores in the assessment area.

2.4 Bore construction

Based on water bearing zone information available from surrounding bores, the Elong Elong production bore is proposed to have a depth of 100 m and target the water bearing zones greater than 50 mBGL. The construction water supply bore will be constructed to the *Minimum construction requirements for water bores in Australia* (NUDLC, 2020). The production bore will be constructed with a seal from surface to not less than 20 metres deep to seal off any shallow unconfined aquifers.

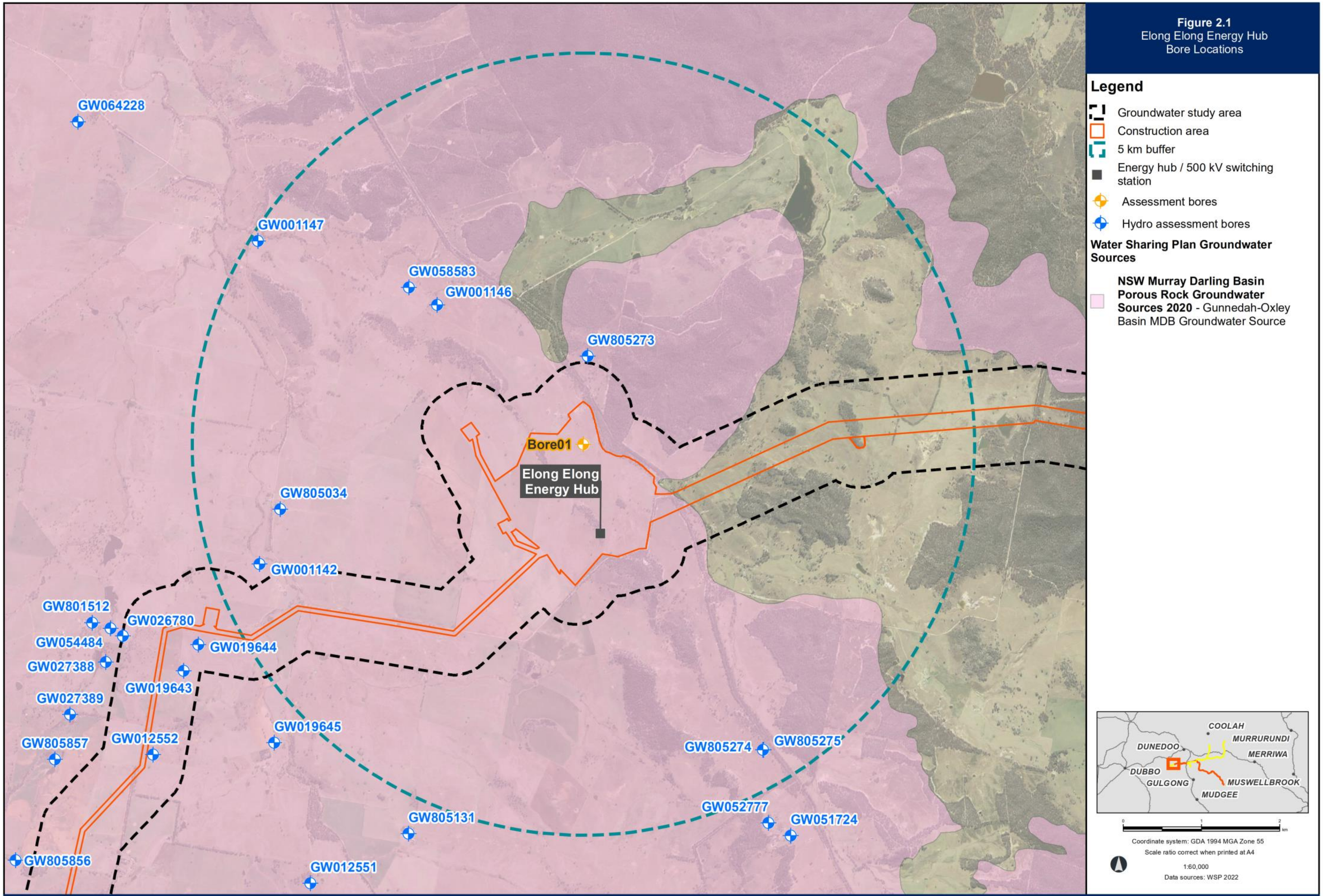

Figure 2.1
Elong Elong Energy Hub
Bore Locations

C:\Users\AUJB505996\WSP O365\AU-WKG - Geospatial - AIS - Projects\PS130593_EnergyCo_CWO_Substation\Mxd\08_Groundwater\PS130593_GEO_C-1_ElongElongEnergyHub_BoreLocations_r1v2.mxd

2.5 Assessment

2.5.1 Overview

The bore dealing assessment is required to assess that no more than minimal harm occurs because of extracting groundwater. The proposed use of the extracted groundwater is for non-potable uses such as dust suppression, landscaping and compaction of access roads and project areas. The adopted assessment method used an analytical groundwater model. The assessment of future groundwater drawdown due to the extraction of groundwater construction of the project used:

- a 5 km radius around the proposed bore location, as shown on Figure 2-1
- a single layer, confined aquifer type for the modelling
- publicly available information, such as bore depth and groundwater levels from surrounding bores with available information (see Table 2-2)
- hydraulic conductivity estimates based on literature values for porous and fractured rock sedimentary aquifers.

This section summarises the assessment of the potential impacts and is structured as follows:

- Section 1.3 describes the assessment criteria used
- Section 1.2 describes the analytical model used to estimate future drawdown due to groundwater extraction
- Section 2.5.4 presents the model parameters used and the water supply extraction rates used during construction of the project
- Section 2.5.5 presents the analytical model results against the assessment criteria.

2.5.2 Total available drawdown

Total available drawdown (TAD) is used to determine the acceptable impact on the aquifer system as well as limit impact on the nearest sensitive receivers. The calculation of TAD is based on data from surrounding bores within 5 km of the proposed water supply bore with available bore depth information. Available data is provided in Table 2-3.

Four shallow basic landholder rights bores (GW805273, GW001146, GW805274, GW805275) had a recorded screen interval from 0 mBGL, and a maximum depth of 18 m (Table 2-2), are in the shallow, unconfined aquifer. These bores have been excluded from the TAD calculation as the alternating layers of shale, siltstone, claystone, and coal, are confining units present at the site (GW804456).

For the purposes of limiting any potential drawdown impacts at shallow bores, and due to the main water bearing zones being generally deeper than 45 m, as summarised in Table 2-2, a primary surface casing would be set into the competent formation to prevent washouts and erosion of the uppermost weathered rock during subsequent drilling. The casing and surface seal will be constructed to a minimum depth of 20 m depth to stabilise the weathered zone and to prevent the ingress of shallow groundwater. The top layers will be sealed off with cement-grout mixture, and therefore this assessment is for semi-confined conditions.

Water levels recorded at the time of drilling and available from work summary reports from bores within 5 km of the proposed water supply bore at Elong Elong Energy Hub were used to assess the average water level for the assessment.

Table 2-3 Elong Elong surrounding bores within 5 km used to calculate TAD

GW number	Easting	Northing	Bore depth (m)	Standing water level (m)	Distance (m)
GW058583	710907	6438733	53.3	4.6	3,000
GW805034	709265	6435901	99.9	–	3,963
GW001142	709000	6435198	56.3	15.2	4,414

The calculation of TAD is used to determine the acceptable level of impact and provided in Table 2-4.

Table 2-4 Calculation of TAD for Elong Elong Energy Hub

Parameter	Value	Unit	Comment
Aquifer depth	100 m	m	Proposed bore depth that is based on water bearing zones and yields from surrounding bores is used to calculate aquifer depth in the assessment area. (Table 2-3)
Standing water level	9.9	m	Average of water level from surrounding bores with information (Table 2-3)
TAD	91.1	m	Total available drawdown calculated from bore depth minus standing water level
40% TAD	36.4	m	40% of TAD in metres
40% TAD in mBGL	46.3	mBGL	40% of TAD in metres below ground level. Calculated by adding the standing water level to the 40% TAD (m).

2.5.3 Model calibration

Due to the limited bore usage data in the area and as there are no monitoring bores with ongoing monitoring in the assessment area, calibration was not possible for this assessment.

2.5.4 Model parameter values

Hydraulic properties assigned to the model are based on literature values for sandstone aquifers. Parameter values used in the analytical model are outlined in Table 2-5.

Table 2-5 Elong Elong model parameter values

Parameter	Value	Unit	Reference
Hydraulic conductivity	0.5	m/d	Sandstone (Domenico & Schwartz, 1990)
Storativity	0.0001	–	Sandstone (Domenico & Schwartz, 1990)
Aquifer thickness	91.1	m	TAD (Table 2-4)
Extraction rate	Varies due to project construction demands	ML/yr	Construction water demand varies over the four year period as outlined in Table 1-2. Required for non-potable use over four year construction period. Provided by EnergyCo.

2.5.5 Model results and discussion

The analytical groundwater flow model simulated the extraction of groundwater from the prosed water supply bore at Elong Elong Energy Hub at a varying rate as provided in Table 1-2 for the four year construction period.

2.5.6 Assessment criterion 1 – Cumulative drawdown

The cumulative simulated drawdown cannot exceed 40% of the pre-development TAD (mBGL) at a distance of 200 m from any water supply works including the applicant's bore within the assessment area.

There are no water supply bores with a linked WAL within the assessment area (5 km radius). Therefore, only the proposed water supply bore has been included in this assessment criterion.

Results of assessment for cumulative drawdown are provided in Table 2-6.

Table 2-6 Elong Elong cumulative drawdown results

Extraction point	Distance (m)	Cumulative drawdown at 200 m from water supply bore (mBGL) during construction period (4 years)			
Construction water supply bore	200	10.5	13.4	11.9	10.4

The results for cumulative drawdown do not exceed 40% of the pre-development TAD (mBGL) at a distance of 200 m from the proposed water supply bore. The assessment passes criterion 1.

2.5.7 Assessment criterion 2 – Additional drawdown

Additional drawdown cannot exceed three metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties. Results of assessment for additional drawdown at surrounding water supply works are provided in Table 2-7 and shown on Figure 2-2.

Table 2-7 Additional drawdown results

GW number	Bore type	Distance (m)	Additional drawdown during construction period (m)			
			Year 1	Year 2	Year 3	Year 4
GW058583 (80WA711302)	Stock	3,000	0.1	1.5	1.1	0.4
GW805034	Stock, domestic	3,963	0.1	1.3	0.9	0.4
GW001142	Stock	4,414	0.1	1.2	0.9	0.4

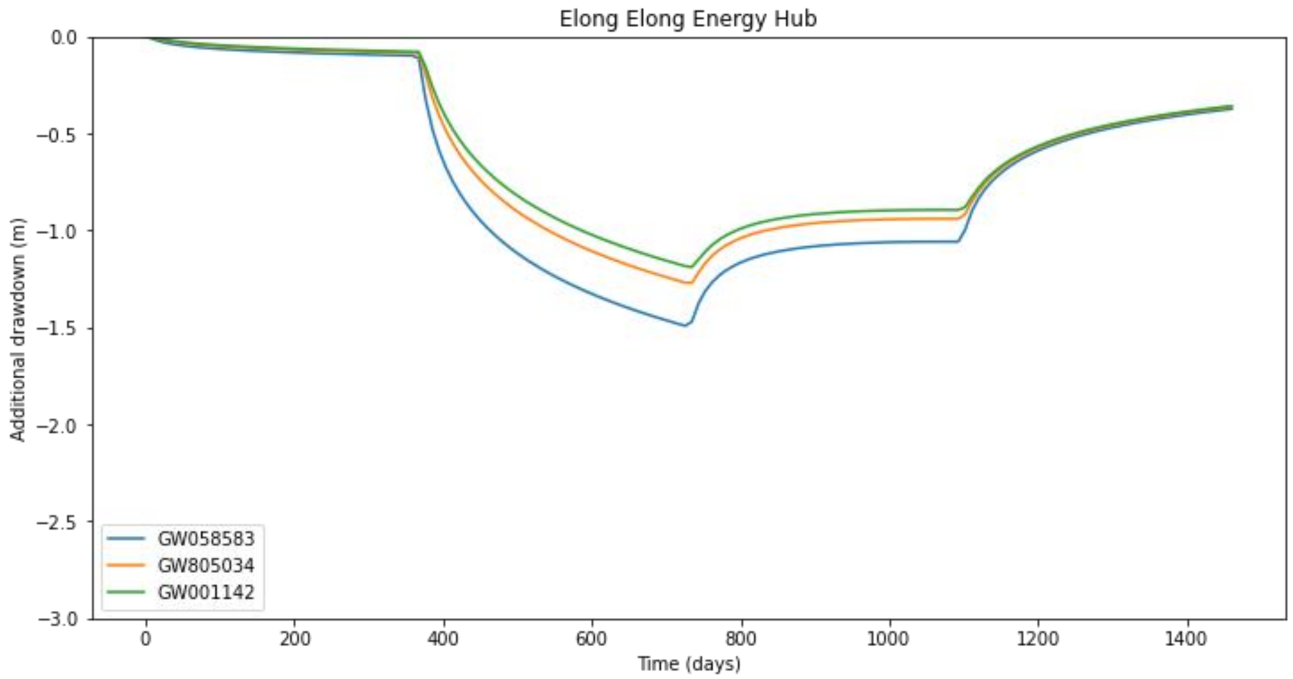

Figure 2-2 Additional drawdown for surrounding bores during the construction period

2.5.8 Discussion

The model developed for the bore dealing assessment for the Elong Elong Energy Hub construction water supply used publicly available information from surrounding bores. The proposed production bore will be screened into the deeper sandstone water bearing zones, that are (based on available information) typically greater than 50 m depth, with the top 20 m sealed to prevent inflow from any shallow water bearing zones. The assessment used the confined aquifer assessment criteria and showed that cumulative and additional drawdown is within the assessment criteria and that no more than minimal harm would occur due to extraction of groundwater during the four year construction period of the project.

3 Merotherie Energy Hub – Bore dealing assessment

3.1 Merotherie Energy Hub location

The Merotherie Energy Hub is located in the Lachlan Fold Belt MDB Groundwater Source managed by the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020. The property details and location are outlined in Table 1-1. The proposed bore for use at Merotherie Energy Hub is shown in Figure 3-1. The rules relating to water supply bore siting and design and are described in Table 3-1.

Table 3-1 Water supply rules for the Lachlan Fold Belt MDB Groundwater Source

Water Sharing Plan rule	Distance (m)
Distance restriction from an approved water supply work nominated by another access licence	400
Distance restriction from an approved water supply work for basic landholder rights only	200
Distance restriction from the property boundary	200
Distance restriction from an approved water supply work nominated by a local water utility or major utility access licence	500
Distance restriction from a DPE monitoring or observation bore	400

3.2 Surrounding bore information

A registered bore search was conducted using data available from the NGIS database (BoM, 2022) and a search of the WaterNSW real-time water data website (WaterNSW, 2022). Groundwater bores within the 5 km of the Merotherie Energy Hub are included in this assessment.

There are five basic landholder rights bores in the assessment area (i.e. within 5 km). Table 3-2 lists their location coordinate information, depth, standing water level, bore type and distance from the Merotherie Energy Hub's proposed bore site.

Available lithological logs from work summary reports in the area indicate that drilling depths of bores range from 42 mBGL to 88.2 mBGL. Table 3-2 provides a summary of yields for water bearing zones recorded on the driller's work summary reports. Yields range from 0.16 L/s to 1.1 L/s with most water bearing zones occurring in the fractured Gulgong granite.

The area lithology comprises of surficial unconsolidated material to about 7 m depth, overlying the fractured rock aquifer of the Gulgong granite. Some lithological logs indicate that sandstone, clay and sand is provided in Appendix A.

The proposed production bore would target the deep water bearing zones in the granite aquifer (i.e. greater than 40 m). Lithology log for bore GW061040 and GW800590, is provided in Appendix A. Based on the available drilling records it is reasonable to assume production pumping yields of 0.5–1 L/s would be achievable.

There are no monitoring bores located in the area with ongoing water level monitoring.

Table 3-2 Applicant's production bore and nearest neighbouring bores

State bore ID	Easting	Northing	Bore type	Bore depth (m)	Standing water level (m)	Slot interval (mBGL)#	Water bearing zone and yield (L/s)	Distance (m)
GW061040	741105	6443176	stock, domestic	42	–	–	–	0
GW800590	740413	6440934	stock, domestic	72	10.5	42–72	66–67 m @ 1.11 L/s	2,346
GW006099	737932	6442080	stock	53.3	–	30.4–53.3	42.6–42.6 m @ N/A, 45.7–45.7 m @ N/A	3,357
GW054481	737756	6441283	stock, domestic	68.6	–	–	–	3,847
GW052517	736516	6444301	stock, domestic	88.2	18.9	0.8–88	87.8–88.1 m @ 0.16 L/s	4,725

mBGL = metres below ground level

3.3 Usage

All surrounding bores are used for stock and domestic purposes (i.e. basic rights) and there are no WAL's associated with the bores in the assessment area.

3.4 Bore construction

Based on water bearing zone information available from surrounding bores, the Merotherie production bore is proposed to have a depth of 100 m and target the water bearing zones greater than 40 mBGL. The construction water supply bore would be constructed to the *Minimum construction requirements for water bores in Australia* (NUDLC, 2020). The production bore will be constructed with a seal from surface to not less than 20 metres deep to seal off any shallow unconfined aquifers.

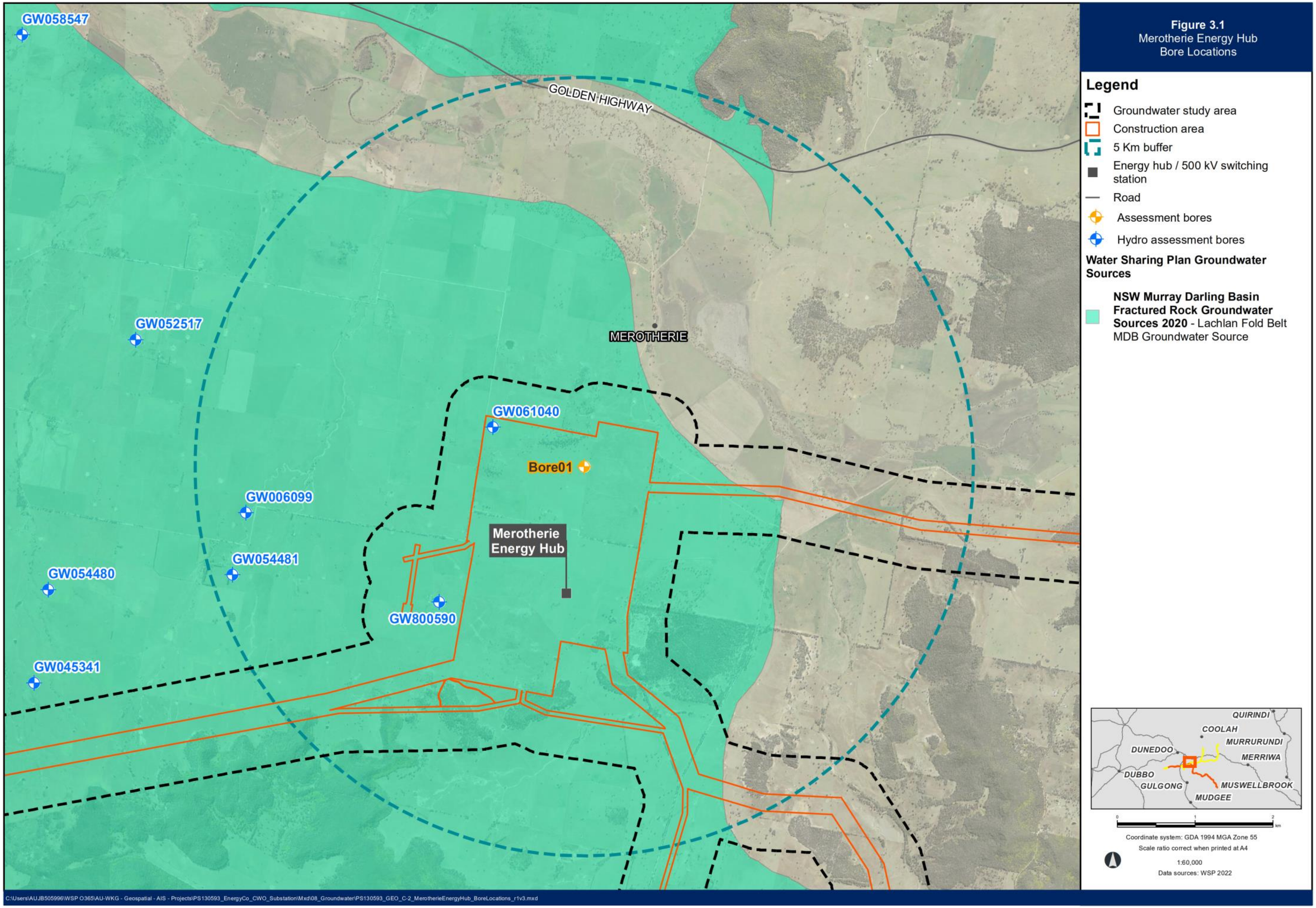
Figure 3.1
Merotherie Energy Hub
Bore Locations
Legend
Groundwater study area
Construction area
5 Km buffer
Energy hub / 500 kV switching station
Road
Assessment bores
Hydro assessment bores
Water Sharing Plan Groundwater Sources
NSW Murray Darling Basin Fractured Rock Groundwater Sources 2020 - Lachlan Fold Belt MDB Groundwater Source
GW058547
GOLDEN HIGHWAY
GW052517
MEROTHERIE
GW061040
Bore01
GW006099
Merotherie Energy Hub
GW054481
GW054480
GW800590
GW045341
QUIRINDI
COOLAH
MURRURUNDI
DUNEDOO
MERRIWA
DUBBO
GULGONG
MUSWELLBROOK
MUDGEE
Coordinate system: GDA 1994 MGA Zone 55
Scale ratio correct when printed at A4
1:60,000
Data sources: WSP 2022
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3.5 Assessment

3.5.1 Overview

The bore dealing assessment is required to assess that no more than minimal harm occurs because of extracting groundwater The proposed use of the extracted groundwater is for non-potable uses such as dust suppression, landscaping and compaction of access roads and project areas. The adopted assessment method used an analytical groundwater model. The assessment of future groundwater drawdown due to the extraction of groundwater for dust suppression during construction of the project used:

- a 5 km radius around the proposed bore location, as shown Figure 3-1
- a single layer, confined aquifer type for the modelling
- publicly available information, such as bore depth and groundwater levels from surrounding bores with available information (Table 3-2)
- hydraulic conductivity estimates based on literature values for porous and fractured rock sedimentary aquifers.

This section summarises the assessment of the potential impacts and is structured as follows:

- Section 1.3 describes the assessment criteria used
- Section 1.2 describes the analytical model used to estimate future drawdown due to groundwater extraction
- Section 3.5.4 presents the model parameters used and the water supply extraction rates used during construction of the project
- Section 3.5.5 presents the analytical model results against the assessment criteria.

3.5.2 Total available drawdown

TAD is used to determine acceptable impact on the aquifer system as well as limit impact on the nearest sensitive receivers. The calculation of TAD is based on data from surrounding bores within 5 km of the proposed water supply bore with available bore depth information. Available data is provided in Table 3-3.

Water levels recorded at the time of drilling and available from work summary reports from bores within 5 km of the proposed water supply bore at Merotherie Energy Hub were used to determine the average water level for the assessment. The calculation of TAD is used to determine the acceptable level of impact and are provided in Table 3-4.

Table 3-3 Merotherie surrounding bores with 5 km with available information

GW number	Easting	Northing	Bore depth (m)	Standing water level (m)	Distance (m)
GW061040	741105	6443176	42	–	0
GW800590	740413	6440934	72	10.5	2,346
GW006099	737932	6442080	53.3	–	3,357
GW054481	737756	6441283	68.6	–	3,847
GW052517	736516	6444301	88.2	18.9	4,725

Table 3-4 Calculation of TAD for Merotherie Energy Hub

Parameter	Value	Unit	Comment
Aquifer depth	100	m	Proposed bore depth that is based on water bearing zones and yields from surrounding bores is used to calculate aquifer depth in the assessment area. (Table 3-2)
Standing water level	14.7	m	Average water level from surrounding bores with information
TAD	85.3	m	Total available drawdown calculated from bore depth minus standing water level
40% TAD	34.1	m	40% of TAD in metres
40% TAD in mBGL	48.8	mBGL	40% of TAD in metres below ground level. Calculated by adding the standing water level to the 40% TAD (m)

3.5.3 *Model calibration*

Due to the limited bore usage data in the area and as there are no monitoring bores in the assessment area, calibration was not possible for this assessment.

3.5.4 *Model parameter values*

Hydraulic properties assigned to the model are based on literature values for granite aquifers. Parameters values used in the analytical model are outlined in Table 3-5.

Table 3-5 Merotherie model parameter values

Parameter	Value	Unit	Reference
Hydraulic conductivity	0.5	m/d	Fractured rock granite (Domenico & Schwartz, 1990)
Storativity	0.0001	–	Fractured rock granite (Domenico & Schwartz, 1990)
Aquifer thickness	85.3	m	TAD (Table 3-4)
Extraction rate	Varies due to project construction demands	ML/yr	Construction water demand varies over the four year period as outlined in Table 1-2. Required for dust suppression over four years construction period. Provided by EnergyCo.

3.5.5 *Model results and discussion*

The analytical groundwater flow model simulated the extraction of groundwater from the prosed water supply bore at Merotherie Energy Hub at a varying rate as provided in Table A.3 for the four year construction period.

3.5.6 *Assessment criterion 1 – Cumulative drawdown*

The cumulative simulated drawdown cannot exceed 40% of the pre-development TAD (mBGL) at a distance of 200 m from any water supply works including the applicants bores within the assessment area. There are no water supply bores with a linked WAL within the assessment area (5 km radius). Therefore, only the proposed water supply bore has been included in this assessment criterion. Results of assessment for cumulative drawdown are provided in Table 3-6.

Table 3-6 Cumulative drawdown results

Extraction point	Distance (m)	Cumulative drawdown at 200 m from water supply bore (mBGL) during construction period (4 years)			
		Year 1	Year 2	Year 3	Year 4
Construction water supply bore	200	15.3	18.0	16.6	15.1

The results for cumulative drawdown do not exceed 40% of the pre-development TAD (mBGL), at a distance of 200 m from the proposed water supply bore and therefore pass assessment criterion 1.

3.5.7 Assessment criterion 2 – Additional drawdown

Additional drawdown cannot exceed 3 metres at any water supply works (excluding those on the same property) subject to negotiation with impacted parties. Results of assessment for additional drawdown at surrounding water supply works are provided in Table 3-7 and shown on Figure 3-2.

Table 3-7 Additional drawdown results

GW number	Bore type	Distance (m)	Additional drawdown during construction period (m)			
			Year 1	Year 2	Year 3	Year 4
GW061040	stock, domestic	1,278	0.1	2.1	1.4	0.4
GW800590	stock, domestic	2,547	0.1	1.6	1.1	0.4
GW006099	stock	4,386	0.1	1.2	0.9	0.3
GW054481	stock, domestic	4,730	0.1	1.1	0.8	0.3

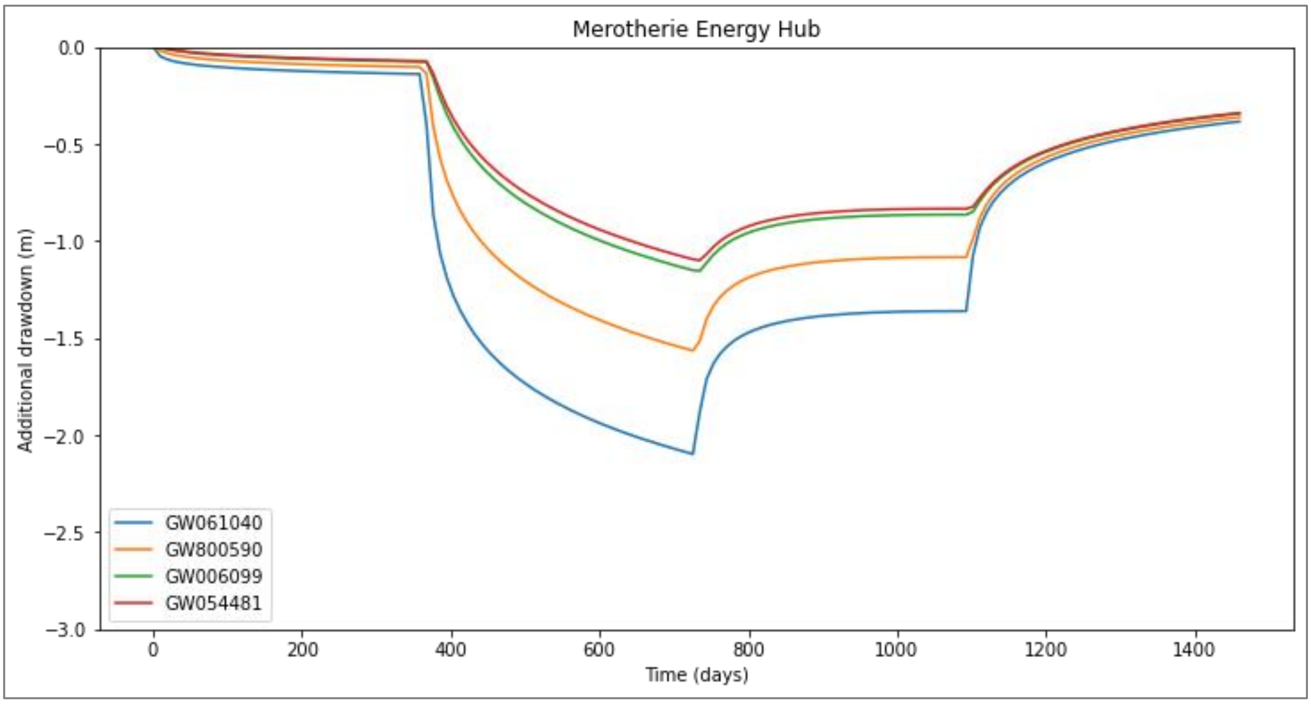

Figure 3-2 Additional drawdown for surrounding bores during construction period

3.5.8 Discussion

The model developed for the bore dealing assessment for the Merotherie construction water supply used publicly available information from surrounding bores. The proposed production bore will be screened into the deeper sandstone water bearing zones, that are (based on available information) typically greater than 40 m depth, with the top 20 m sealed to prevent inflow from any shallow water bearing zones. The assessment used the confined aquifer assessment criteria and showed that cumulative and additional drawdown is within the limits of the assessment criteria and that no more than minimal harm would occur due to extraction of groundwater during the four year construction period of the project.

Appendix A

Lithological logs

WaterNSW
Work Summary

GW001142

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/02/1923

Final Depth: 56.30 m
Drilled Depth: 56.40 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:

Standing Water Level (m):
Salinity Description: Fresh
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	LINCOLN	DAPPER	24
Licensed:			

Region: 80 - Macquarie-Western
River Basin: 421 - MACQUARIE RIVER
Area/District:

CMA Map: 8733-N
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6435198.000
Easting: 709000.000

Latitude: 32°12'01.4"S
Longitude: 149°13'02.2"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.28	53.70	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
54.50	54.50	0.00	Consolidated	15.20		0.19			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.65	3.65	Clay	Clay	
3.65	39.62	35.97	Shale	Shale	
39.62	56.38	16.76	Sandstone Water Supply	Sandstone	

*** End of GW001142 ***

WaterNSW
Work Summary

GW061040

Licence: 80WA711416

Licence Status: CURRENT

Authorised Purpose(s): STOCK,DOMESTIC
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/12/1985

Final Depth: 42.00 m
Drilled Depth: 42.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: N/A NSW

GWMA: -
GW Zone: -

Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	BLIGH	MERUTHERA	14
Licensed:	BLIGH	MEROTHERIE	Whole Lot //

Region: 80 - Macquarie-Western

CMA Map: 8833-4N

River Basin: 421 - MACQUARIE RIVER
Area/District:

Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)

Northing: 6443176.000
Easting: 741105.000

Latitude: 32°07'19.4"S
Longitude: 149°33'20.2"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	5.00	5.00	Loam Soil	Loam	
5.00	7.00	2.00	Sandstone	Sandstone	
7.00	42.00	35.00	Clay Dark	Clay	
7.00	42.00	35.00	Sand Heavy Mixture	Sand	

***** End of GW061040 *****

WaterNSW
Work Summary

GW800590

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): STOCK, DOMESTIC

Work Type: Bore
Work Status: Test Hole
Construct.Method: Rotary
Owner Type: Private

Commenced Date:
Completion Date: 24/04/1998

Final Depth: 72.00 m
Drilled Depth: 72.00 m

Contractor Name: Competitive Drilling Services
Driller: Phillip William Brown
Assistant Driller:

Property:

GWMA:
GW Zone:

Standing Water Level (m): 10.500
Salinity Description: Good
Yield (L/s): 1.110

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	BLIGH	MERUTHERA	LOT 15
Licensed:			

Region: 80 - Macquarie-Western
River Basin: 210 - HUNTER RIVER
Area/District:

CMA Map: 8833-N
Grid Zone:

Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6440934.000
Easting: 740413.000

Latitude: 32°08'32.7"S
Longitude: 149°32'55.8"E

GS Map: -

MGA Zone: 55

Coordinate Source: Map Interpre

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	42.00	200			Rotary
1		Hole	Hole	42.00	72.00	150			Rotary
1	1	Casing	Pvc Class 9	0.00	42.00	150			Driven into Hole, Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
66.00	67.00	1.00	Unknown	10.50		1.11	72.00	02:00:00	

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.00	1.00	Topsoil	Topsoil	
1.00	3.00	2.00	Clay	Clay	
3.00	6.00	3.00	Shale, soft	Shale	
6.00	60.00	54.00	Shale, hard grey	Shale	
60.00	72.00	12.00	Granite	Granite	

***** End of GW800590 *****

WaterNSW
Work Summary

GW804456

Licence:

Licence Status:

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore
Work Status: Equipped
Construct.Method: Down Hole Hammer
Owner Type: Mines

Commenced Date:
Completion Date: 01/10/2009

Final Depth: 38.00 m
Drilled Depth: 38.00 m

Contractor Name: HIGHLAND DRILLING PTY LTD
Driller: Brett Delamont
Assistant Driller:

Property:

Standing Water Level (m):

GWMA:
GW Zone:

Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	LINCOLN	DAPPER	1//754305
Licensed:			

Region: 80 - Macquarie-Western
CMA Map: 8733-N

River Basin: 421 - MACQUARIE RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown
Northing: 6435353.000
Easting: 713474.000
Latitude: 32°11'53.3"S
Longitude: 149°15'52.8"E

GS Map: -
MGA Zone: 55
Coordinate Source: GPS - Global

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	6.00	200			Down Hole Hammer
1		Hole	Hole	6.00	38.00	140			Down Hole Hammer
1		Annulus	Concrete	0.00	6.00	200	168		
1		Annulus	Waterworn/Rounded	6.00	38.00	140	60		Graded
1	1	Casing	Pvc Class 18	0.00	32.00	60			Seated on Bottom, Screwed
1	1	Casing	Steel	0.00	6.00	168			Driven into Hole, Welded
1	1	Opening	Screen	36.50	38.00	60		0	PVC Class 18, Screwed, A: 0.50mm

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	8.00	8.00	Clay	Clay	
8.00	9.00	1.00	Sandstone	Sandstone	
9.00	11.00	2.00	Siltstone	Siltstone	
11.00	12.00	1.00	Claystone	Claystone	
12.00	14.00	2.00	Siltstone	Siltstone	
14.00	14.50	0.50	Claystone	Claystone	
14.50	19.50	5.00	Siltstone	Siltstone	

19.50	20.00	0.50	Coal	Coal	
20.00	23.50	3.50	Sandstone	Sandstone	
23.50	25.00	1.50	Claystone	Claystone	
25.00	30.00	5.00	Siltstone	Siltstone	
30.00	34.50	4.50	Coal	Coal	
34.50	38.00	3.50	Sandstone	Sandstone	

Remarks

01/10/2009: Form A Remarks:
Nat Carling, 4-Nov-2010: GPS provided by consultant.

***** End of GW804456 *****

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