Appendix F Groundwater Specialist Study

Newcastle Power Station

Groundwater Specialist Study

AGL Energy Limited

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Bringing ideas to life

Document control record

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Executive summary

Aurecon Australia Pty Ltd (Aurecon) has been engaged by AGL Energy Limited (AGL) to undertake an Environmental Impact Statement (EIS) for the proposed Newcastle Power Station (NPS), located in Tomago, NSW. The Proposal would include the power station, associated infrastructure for access, gas supply, electrical connections, water supply, and wastewater disposal. This report provides a review of the current groundwater conditions and potential groundwater impacts that may arise during the construction and operational phases of the Proposal including impacts to groundwater quality, groundwater recharge, groundwater resource availability and groundwater dependent ecosystems.

The Proposal area includes the power station site as well as corridors for the gas pipelines linking the power station to the existing Newcastle Gas Storage Facility (NGSF) and the electrical transmission line.

The power station site is located on a topographic high point adjacent to the Hunter River and divided by a topographic ridge approximately central to the site. Current topographical conditions result in runoff from the north-eastern portion of the site flowing towards an off-site seep-away area, overlying the fringe of the Tomago Sandbeds. Whereas runoff from the south-western section also drains to an on-site collection and seep away low-lying area. The proposed surface water management plan would result in a portion of the northern runoff being diverted south and draining to the current low-lying area.

The water for the proposed power station would be sourced from the Port Stephens municipal water supply system. Most of the water would be evaporated and discharged to the atmosphere via the exhaust stack. Any excess process water would be tankered off site. Potable water drains and site sewage shall be collected and discharged to a site sewerage system. Septic tank(s) shall be used and will be pumped out by truck as required.

All runoff from roads, car-park and hardstand areas will be collected in a ‘pit and pipe’ stormwater system. This system will discharge after undergoing treatment through an oil and grease separator and a bioretention system. The expected discharge qualities would potentially be better than the current background local groundwater quality (receiving waterbody).

Previous groundwater investigations included the drilling of several bores within the study boundaries. The bores located within close proximity to the proposed power station indicated a range of depths to groundwater between 2 m and 4 m below ground level (m BGL). A groundwater mound was inferred with flow to the west-south-west and the north-east. This indicates that shallow groundwater at the proposed power station flows towards nearby drainages and the Hunter River and not to the south towards the Ramsar-listed wetlands within the Kooragang Nature Reserve. Monitoring bores located within close proximity to the proposed gas pipeline corridor indicated a range of depths to water level in this region from 0.08 m-3.15 m BGL.

Previous studies, targeted at the proposed power station site, detected several Chemicals of Potential Concern in groundwater samples in elevated concentrations, suggesting possible existing contamination. Available data for the proposed gas pipeline corridor indicates a significantly different water quality profile compared to that observed within the proposed power station area. This supports the system understanding that these areas are underlain by different aquifer systems.

Several potential impacts on the receiving environment’s groundwater systems have been identified for both the construction and operational phase. These impacts can mostly be mitigated by implementing several specified management plans and operational procedures. By implementing these plans a Neutral or Beneficial Effect (NorBE) on the receiving groundwater quality can be demonstrated.

It is expected, once the proposed mitigation measures are implemented, that there will be no measurable residual impact from the construction and operation of the Proposal on the:

- Groundwater Dependant Ecosystems in the immediate vicinity of the Proposal site
- The local or regional groundwater aquifers, with regards to quantities or qualities. This is in-line with the objectives of the current Water Sharing Plan for the area as well as the Water Management Act’s Aquifer Interference Policy.
- Ramsar-listed Hunter Estuary wetland

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1 Introduction

1.1 Purpose of this report

Aurecon Australasia Pty Ltd (Aurecon) has been engaged by AGL Energy Limited (AGL) to undertake an Environmental Impact Statement (EIS) for the proposed Newcastle Power Station (NPS), located in Tomago, NSW. The NPS, gas supply, electrical connections and associated infrastructure for access, water supply, and wastewater disposal constitute the Proposal. This report provides a review of the current groundwater conditions and potential groundwater impacts that may arise during the construction and operational phases of the power station. A separate Surface Water Specialist Study has been prepared to examine the current surface water conditions and potential hydrological / surface water quality impacts that may arise during the construction and operational phases of the Proposal.

The Proposal has been declared as Critical State Significant Infrastructure and Secretary's Environmental Assessment Requirements (SEARs) issued. Based on comment on the initial SEARs, supplemental SEARs were issued in September 2019. This report addresses SEARs and supplemental SEARs that pertain to groundwater.

To support the abating or elimination of potential adverse impacts on the receiving surface and groundwater systems caused by the Proposal, the report also incorporates proposed mitigation measures, including recommendations for the development of specific construction and operational environmental management plans.

1.2 Proposal summary

AGL propose to construct and operate a dual fuel (gas or diesel) fired fast-start peaking power station with a nominal operating capacity of 250MW (the NPS), and associated infrastructure including gas pipelines supplying gas to the facility, electricity transmission from the NPS, site access and ancillary facilities. The pipelines would supply the proposed NPS with gas from the eastern Australia gas transmission pipelines via the Jemena HPP network. A new electricity transmission line would transfer the electricity produced by the proposed NPS to the national electricity network via connection to the existing TransGrid Tomago 132kV switching station.

1.3 Study objectives

An objective of the EIS is to address potential groundwater impacts associated with the construction and operational phase of the Proposal. It also aims to provide guidance on ways of managing the potential sources of groundwater impacts to avoid any environmental degradation.

This assessment has been prepared to fulfil the requirements included in the SEARs, which are outlined in **Table 1-1** below. The assessment also addresses agency comments outlined in **Table 1-3**.

Table 1-1 SEARs Requirements for Groundwater

SEAR Element	Scope of assessment	Report Section
A description of the existing environment likely to be affected by the proposal using sufficient baseline data	Review of recent and historic reports relevant to groundwater assessment for the study area	Section 5
	Site inspection to obtain a valid understanding and conceptualisation of the groundwater conditions within and around the proposal space	Section 5

SEAR Element	Scope of assessment	Report Section
	Baseline desktop analysis of available information to characterise the groundwater environment within and around the proposal area	Section 5
An assessment of impacts of the proposal on the groundwater aquifers and groundwater dependent ecosystems having regard to the NSW Aquifer Interference Policy and relevant Water Sharing Plans	Identification and desktop assessment of the potential construction, operational and cumulative impacts on the local groundwater aquifers	Section 6
An assessment of the potential impacts of the proposal, including any cumulative impacts, and taking into consideration relevant guidelines, policies, plans and industry codes of practice	Identification and assessment of the potential construction, operational and cumulative impacts	Section 6
A description of how the proposal has been designed to avoid and minimise impacts (including selection of gas connection option)	Review of the neutral or beneficial effect on water quality (NorBE) assessment – an appropriate methodology to consider impacts to the Tomago sand beds and associated drinking water catchment land	Sections 6 and 8
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts during construction	Determination of constraints and opportunities for erosion and sediment control	Section 7
	Conclusions and recommendations for management or mitigation of potential impacts	Sections 7 and 10

Table 1-2 Supplemental SEARs Requirements for Groundwater

SEAR Element	Scope of assessment	Report Section
Assessment of all impacts that the action is likely to have on each matter protected by a provision of Part 3 of the EPBC	Update to impact assessment required for groundwater (with regards to potential impact on the Ramsar-listed Hunter Estuary wetlands)	6
Assessment of all protected matters in Ramsar wetlands including physico-chemical status and habitat or lifecycle of native species	Update to impact assessment required for groundwater.	6
Impacts must include an assessment of relevant impacts (likely to significantly impact on any matter under the EPBC) including a description and detailed assessment of the nature and extent of the likely direct, indirect and consequential impacts including short term and long term relevant impacts	Impact to groundwater to be updated:	6
Avoidance, mitigation and offsetting must include - for each of the relevant matters protected that are likely to be significantly impacted, mitigation measures must include a description, and assessment of the expected or predicted effectiveness of the mitigation measures	Mitigation measures for groundwater to be updated:	7
Strategic assessment, risk of groundwater contamination, groundwater connectivity to Ramsar, likely impact of the wetlands if ground contamination occurs	Mitigation measures for groundwater to be updated:	7

SEAR Element	Scope of assessment	Report Section
Description of controls to manage impacts of groundwater and surface water contamination, including analysis of how effective each of the controls will be to ensure the ecological character of Ramsar	Mitigation measures for groundwater to be updated:	7 and 8

Table 1-3 Agency Comments for Groundwater

Agency	Agency Comments	Report Section
OEH (Baseline Assessment)	The EIS must map the following features relevant to water and soils including: ▪ Groundwater ▪ Groundwater Dependent Ecosystems	Section 5.4.1, Section 5.4.2
EPA (Baseline Assessment)	Describe existing groundwater quality. An assessment needs to be undertaken for any water resource likely to be affected by the proposal. Issues to be discussed should include but are not limited to: ▪ a description of any impacts from existing industry or activities on water quality ▪ an outline of baseline groundwater information, including, for example, depth to water table, flow direction and gradient, groundwater quality, reliance on groundwater by surrounding users and by the environment	Section 5.4.6
Hunter Water (Impact Assessment)	▪ Aquifers and Groundwater Dependent Ecosystems (GDEs) ▪ An assessment of the impact of the project on the Tomago Sandbeds aquifer and GDEs should specifically address the extraction of groundwater for both construction and operation as well as discharge of stormwater and excess water from operational activities to the environment, if proposed. ▪ The NGSF is located within the groundwater draw zone for extraction wells at Station 20 in the Tomago aquifer. Where the proposed new gas pipeline would connect into the NGSF (either option) the construction and/or operation of the pipeline will potentially impact on the Hunter Water boreline and this should be addressed in the EIS.	Section 5.4.2, Section 6 Section 2.4, Section 6.2.2
NSW Department of Industry Lands and Water Division (Impact Assessment)	▪ Assessment of impacts on ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts. ▪ Consideration of relevant legislation, policies and guidelines, including the NSW Aquifer Interference Policy (2012), the Guidelines for Controlled Activities on Waterfront Land (2018) and the relevant Water Sharing Plans.	Section 6 Section 3.2, Section 5.4.3
EPA (Impact Assessment)	▪ Describe the nature and degree of impact that any proposed discharges will have on the receiving environment (groundwater). ▪ Assess impacts on groundwater and groundwater dependent ecosystems.	Section 6

2 Proposal description

2.1 Overview

The NPS would be a dual fuel (gas and diesel) fast-start peaking power station with a nominal operating capacity of 250MW at Tomago in NSW. The NPS would supply electricity to the grid at short notice during periods of high electricity demand, and/or low supply, particularly during periods where intermittent renewable energy supply is low or during supply outages. This operation is aligned with AGL's move to a renewable energy mix. While the primary role of the Newcastle Power Station would be to provide firming or peaking capacity to the National Electricity Market, to maximise operational flexibility each unit of the power station would be designed for continuous operation.

The Proposal would also involve the construction and operation of gas pipeline(s) and an electricity transmission line. The pipeline(s) would supply the proposed power station with gas from the eastern Australia gas transmission pipeline via the Jemena Gas Network (JGN) and from the Newcastle Gas Storage Facility (NGSF). A new electricity transmission line would transfer the electricity produced by the proposed power station to the national electricity network via connection to the existing 132kV Tomago switchyard.

The main elements of the Proposal are as follows:

- Power station comprising of either large reciprocating engine generators or gas turbine generators, necessary supporting ancillary equipment and supporting infrastructure. The power station would be capable of operating with diesel fuel, if necessary.
- 132kV electricity transmission line to the existing 132kV switching station, operated by TransGrid
- Gas transmission/storage pipelines and receiving station, compressor units, and ancillary infrastructure
- Storage tanks and laydown areas
- Water management infrastructure including pond(s), stormwater drainage and a connection to Hunter Water potable infrastructure in line with Hunter Water requirements
- Diesel storage and truck unloading facilities
- Site access road
- Office / administration, amenities, workshop / storage areas and carparking

2.2 Site Location and surrounds

The Proposal area is located beside the Pacific Highway in Tomago, NSW approximately 15 km north-west of Newcastle CBD, as indicated on Figure 2-1.

The NPS would be developed on Lot 3 DP 1043561 at 1940 Pacific Highway, Tomago. (see Figure 2-2). Lot 3 is owned by AGL. This land has been used previously for agricultural purposes, including grazing, and hosts a single storey residential dwelling which would be demolished if not repurposed during construction and operation. There are some isolated trees as well as stands of native vegetation generally confined to the lot boundaries.

Pipeline and electricity corridors would extend east into Lot 4 DP 1043561, Lot 202 DP 1173564 and part of Lots 1201, 1202 and 1203 DP1229590. These lots are owned by the Tomago Aluminium Company (TAC) and AGL (Figure 2-3). These lots are predominantly vegetated and contain existing cleared easements for gas pipelines, electrical infrastructure, and access roads. There are no dwellings in these lots.

The nearest major water body is the Hunter River, approximately 470 metres north-west of the Proposal area. Whilst there are scattered residences near the Proposal area, the nearest residentially zoned areas are more than two kilometres away. Land to the south (Tomago Aluminium smelter) and all land within the Proposal area is zoned General Industrial under the current Port Stephens Local Environmental Plan (LEP) as indicated on Figure 2-4.

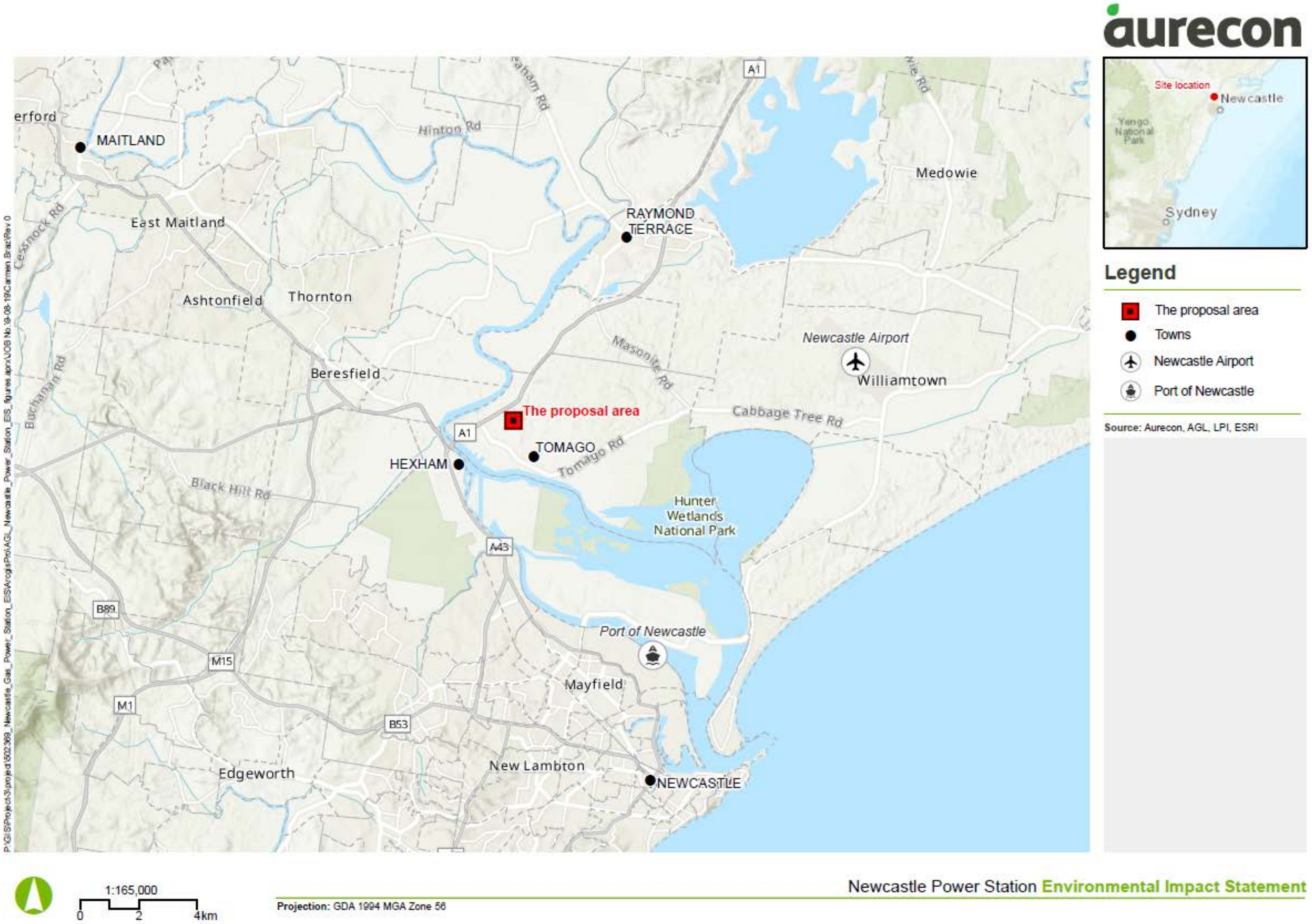


Figure 2-1 Proposal area location

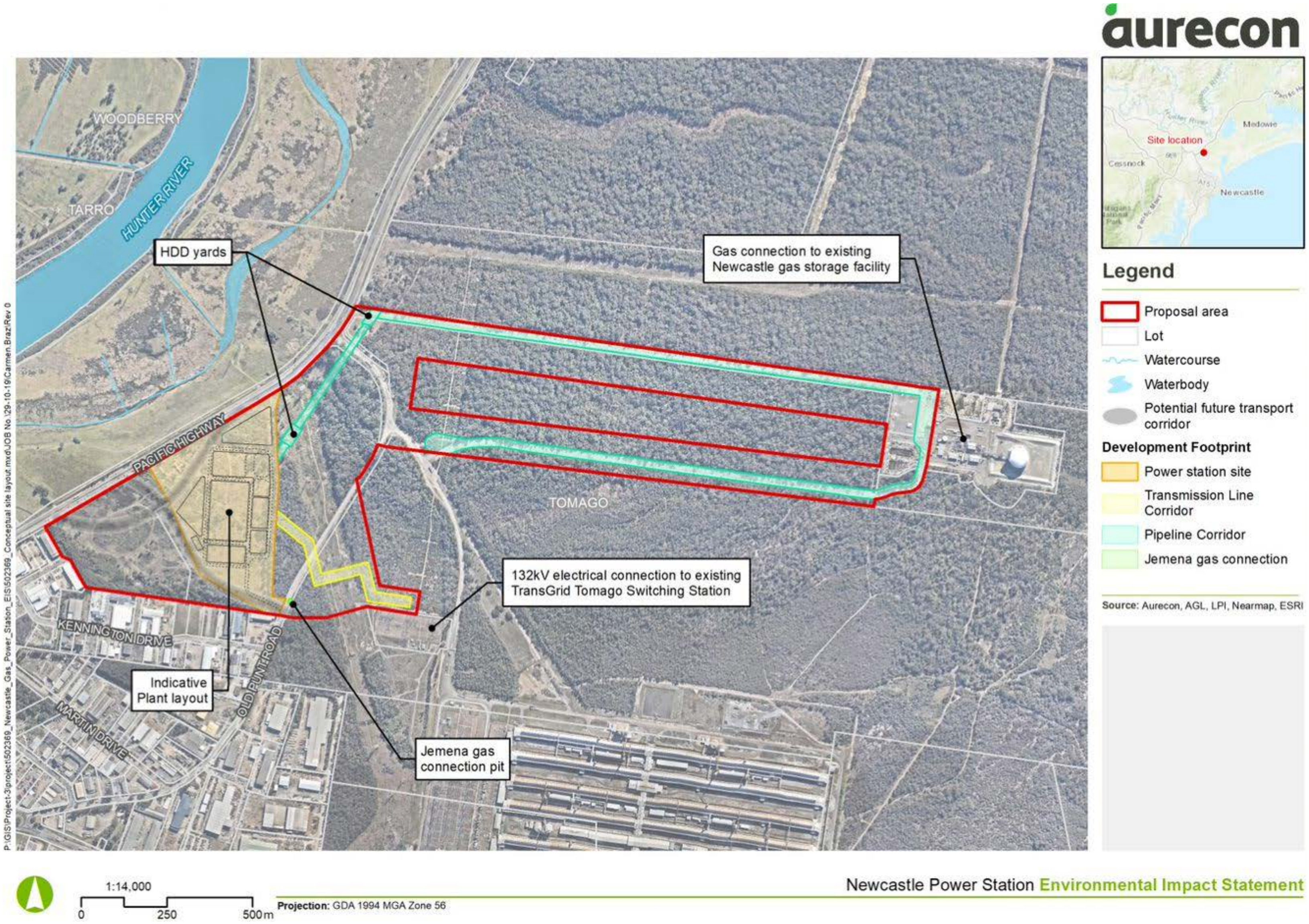


Figure 2-2 Conceptual site layout

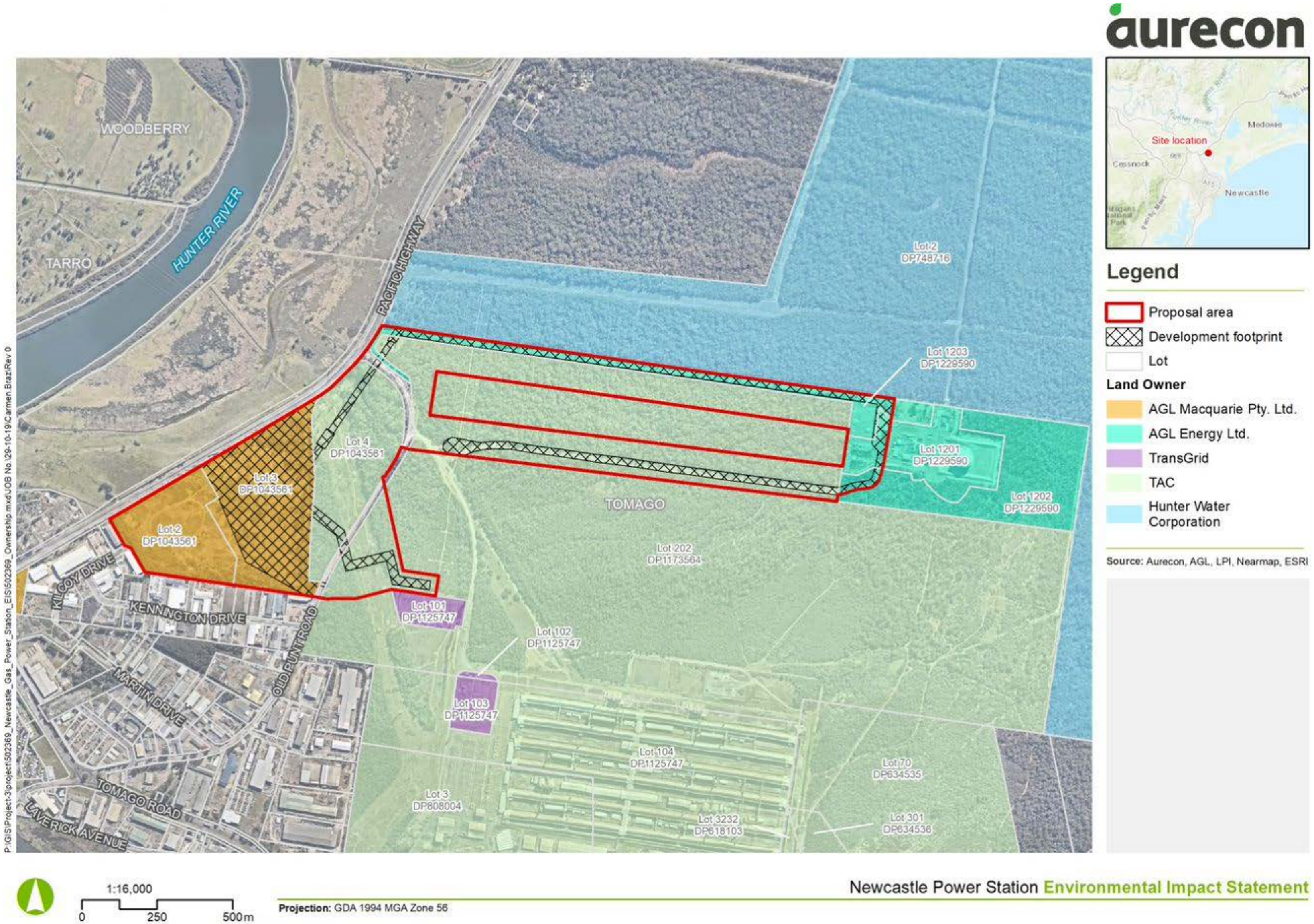


Figure 2-3 Land ownership

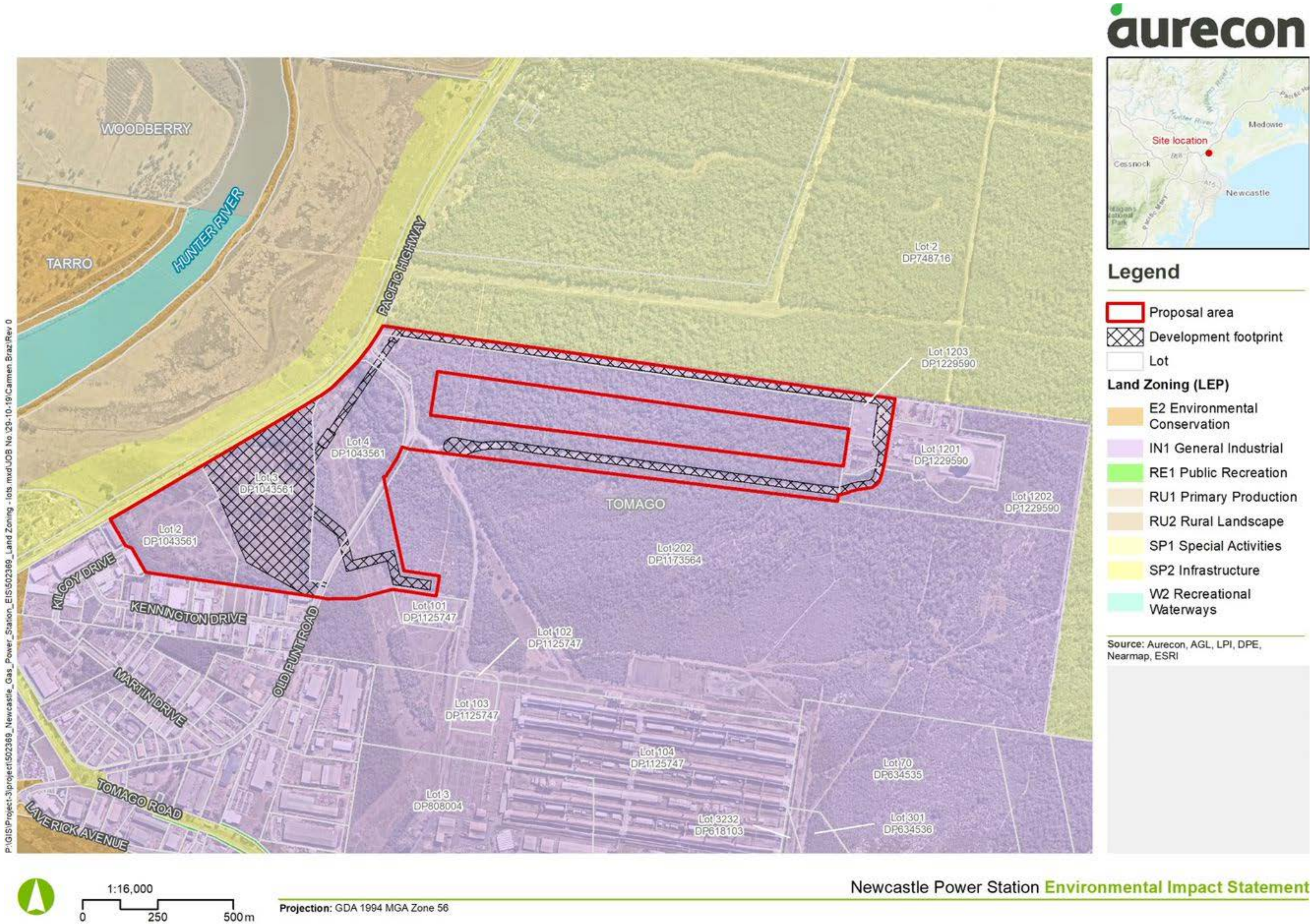


Figure 2-4 Land zoning

2.3 Power station

The proposed power station would be capable of generating approximately 250MW of electricity. The power station would either consist of large reciprocating engine generators or aero-derivate gas turbine generators. Generation units would be dual fuel capable, meaning they would be able to be supplied by natural gas and/or liquid fuel. A conceptual layout of the proposed power station is presented on Figure 2-5.

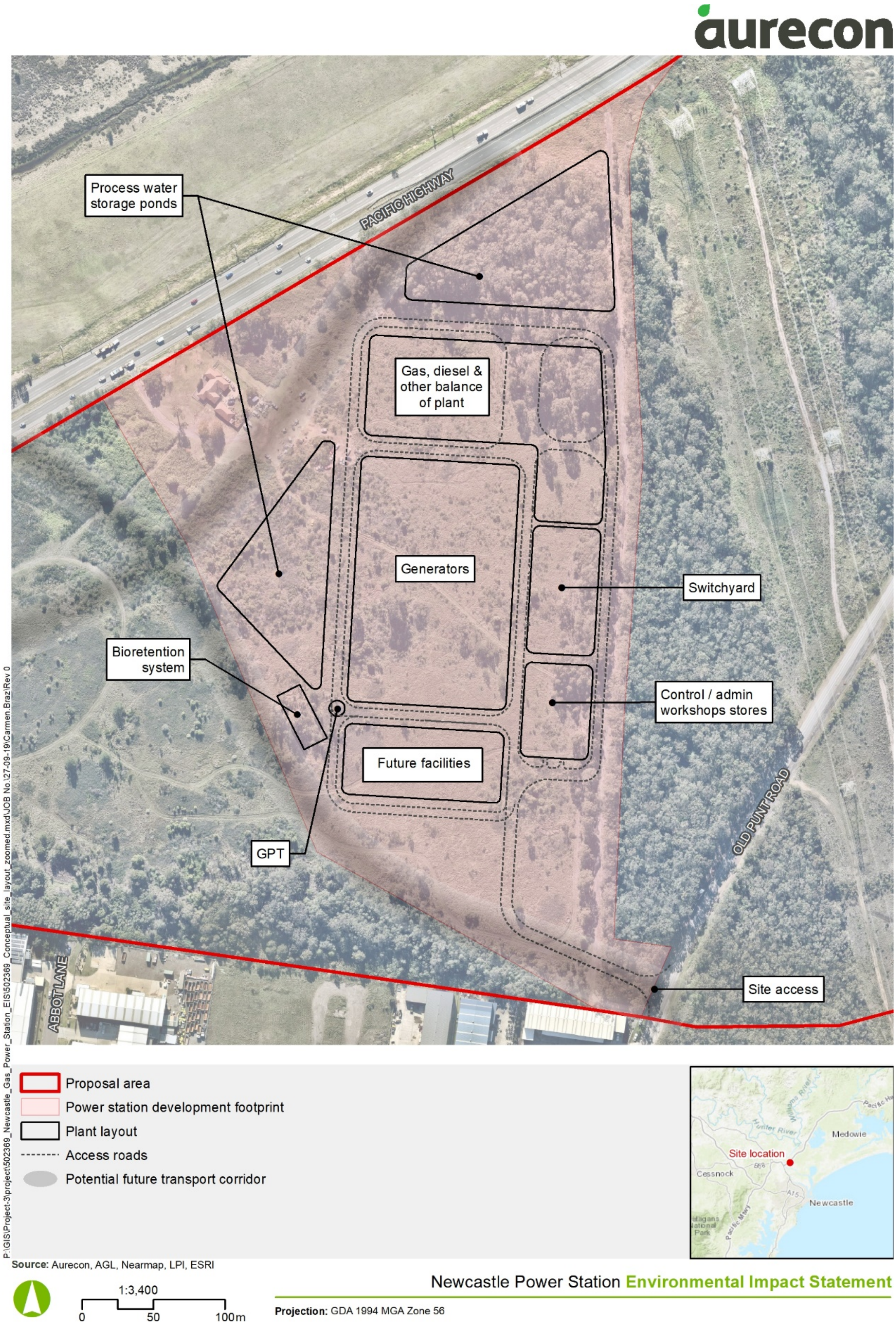


Figure 2-5 Power Station Conceptual Layout

The decision to install gas turbines or reciprocating technology would be made based on a range of environmental, social, engineering and economic factors that would be considered as part of the power station procurement process.

The power station, regardless of chosen technology, would require supporting ancillary facilities. These would include:

- Natural gas reception yard potentially including gas metering, pressure regulation, compression (if required), heating stations, pigging facilities (if required) and provision for flaring
- Generator circuit breakers, generator step-up transformers and switchyard including overhead line support gantry
- Water collection and treatment facilities
- Water storage tanks and pond(s)
- Truck loading/unloading facilities
- Liquid fuel storage tanks
- Emergency diesel generators with associated fuel storage
- Closed circuit cooling systems
- Control room
- Offices and messing facilities
- Electrical switch rooms
- Occupational health and safety systems including an emergency warning and evacuation system
- Workshop and warehouse
- Firefighting system
- Communication systems
- Security fence, security lighting, stack aviation warning lights (if required) and surveillance system
- Landscaped areas and staff parking areas
- Concrete foundations, bitumen roadways, concrete pads in liquid fuel unloading station and gas turbine or engine unit maintenance areas
- Concrete bunded areas with drains for liquid fuel tanks, liquid chemicals store, oil filled transformers (if installed) and other facilities where contaminated liquids could leak
- Level construction and laydown area
- Engineered batters to support and protect the power plant platform
- Sedimentation pond and associated diversion drain and earth bunding

2.4 Gas pipeline

Natural gas fuel would be supplied from the existing JGN and NGSF. The nearest supply point in JGN is at Hexam. An existing AGL owned pipeline runs from Hexham to the NGSF (the Tomago to Hexham HPP). The NGSF is located about 2 km north east of the proposed power station (see Figure 2-2).

A new gas pipeline connection to the Tomago to Hexham HPP would supply the power station. This connection would be made just east of Old Punt Road, east of the proposed power station site. The pipeline would be installed using traditional trenching and horizontal directional drilling (HDD) techniques. Assuming approximately 1 m of cover over the pipeline, anticipated trench depth will be approximately 2 m below ground level (m BGL).

To supplement the gas supply, AGL proposes to construct a gas storage pipeline(s) between the NGSF and the NPS to supplement gas supply which would be located along the northern and southern easements connecting the proposed power station with the NGSF (refer Figure 2-2). Gas would be drawn from the JGN or NGSF during periods of low gas demand, compressed, and stored in the pipeline for use by the NPS during periods of high power demand.

Gas compression, conditioning, heating and other facilities necessary to transport and store gas are also likely to be required and would be constructed at the proposed power station site.

2.5 Electricity transmission line

A new high voltage 132kV electricity transmission line would be required to connect the proposed power station to the TransGrid Tomago 132kV switching station, approximately 500 metres south east. The switching station would transfer the electricity produced at the power station to the regional electricity transmission system. The transmission line would require cleared easements over all land not owned by AGL or TransGrid. Where parallel to the TransGrid easements the power station connection line easement would be contiguous with the adjacent TransGrid easement.

2.6 Water and wastewater

Water would be required to operate the power station. Water would primarily be used for evaporative cooling and for nitrogen oxide (NOx) suppression, if necessary. When used for NOx suppression water would be injected into the combustion chamber where it would vaporise and discharge through the exhaust stack. Additionally, evaporative cooling would be used on hot dry days to reduce the temperature of the inlet air.

The water for the proposed power station would be sourced from the Port Stephens municipal water supply system via an extension of the existing water supply infrastructure on Old Punt Road.

Most of the water would be evaporated and discharged to the atmosphere via the exhaust stack. Any excess process water would be tankered off site.

Other uses for water at the site would include:

- Firefighting water
- Boosting the power of the power station
- Water for washing the gas turbine compressor (if installed)
- Potable water for staff amenities

Potable water drains and site sewage shall be collected and discharged to a site sewerage system. Septic tank(s) shall be used and will be pumped out by truck as required. The site sewerage system shall comply with the requirements of Government Agencies.

All runoff from roads, car-park and hardstand areas will be collected in a ‘pit-and-pipe’ stormwater system. The pit-and-pipe stormwater system would be provided along the roads within the power station site and would discharge to the natural depression at the south-west corner of the power station site, after undergoing treatment via a proposed oil and grease separator and a Bioretention Pond.

2.7 Vehicular access

The area around Tomago is serviced by a road network adequate to cater to heavy haulage vehicles due to the surrounding industrial land uses. Old Punt Road is a sealed single lane, two-way council owned road. Old Punt Road connects to the Pacific Highway approximately one kilometre to the north of the proposed power station access point (as seen on Figure 2-2).

During construction oversized or heavy items would be transported along the Pacific Highway and Old Punt Road.

During operation, vehicular access to the Proposal area would be provided via the newly formed access off Old Punt Road. This access would be used by operational staff. Parking for staff would be provided on site.

2.8 Construction activities

The power station is anticipated to be in operation in 2022. Key construction activities for the Proposal would include:

- Clearing of vegetation at the proposed power station site and as required along the electrical transmission and gas pipeline corridors
- Demolition of existing house if not repurposed during construction and operation
- Installation of gas pipeline(s) and electrical transmission line infrastructure
- Earthworks to prepare the power station site and construction areas
- Installation of foundations and underground services
- Installation of aboveground civil, mechanical and electrical plant and equipment
- Commissioning and testing

3 Legislation, policy and guidelines

3.1 Legislation and policy

This Proposal has been identified as a controlled action under Section 75 of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act provides for five different levels of required environmental assessment, the appropriate level is determined based on the potential and extent of impact as well as public interest. The primary areas of concern related to groundwater impacts are:

- Potential for a significant impact on a listed wetland of international importance (a Ramsar wetland)
- Potential for groundwater intersection

These impacts and the proposed mitigation measures are addressed in **Sections 6 and 7** of this report.

An overview of the relevant legislation and policy and their relevance to the Proposal is provided in **Table 3-1**.

Table 3-1 Overview of relevant groundwater legislation and policy

Legislation / Policy	Summary	Relevance
Water Management Act NSW (2000)	The overall objective of the Water Management Act 2000 (WM Act) is "sustainable and integrated management of the State's water" (DLWC, 2002). Water sharing plans are the main tool through which the WM Act achieves its objectives. The general and aquifer interference activities' water management principles set out in the WM Act are: ■ Generally: – water sources, floodplains and dependent ecosystems (including groundwater and wetlands) should be protected and restored and, where possible, land should not be degraded – habitats, animals and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored – the water quality of all water sources should be protected and, wherever possible, enhanced – the cumulative impacts of water management licences and approvals and other activities on water sources and their dependent ecosystems, should be considered and minimised – geographical and other features of Aboriginal significance should be protected – geographical and other features of major cultural, heritage or spiritual significance should be protected – the social and economic benefits to the community should be maximised – the principles of adaptive management should be applied, which should be responsive to monitoring and improvements in understanding of ecological water requirements ■ In relation to aquifer interference activities: – the carrying out of aquifer interference activities must avoid or minimise land degradation, including soil erosion, compaction, geomorphic instability, contamination, acidity, waterlogging, decline of native vegetation or, where	Elements of the Water Management Act 2000 relating to drainage management, aquifer interference activities and general principles that are relevant to this Proposal have been considered in this assessment to inform potential construction and operational phase risks of the power station. Dewatering is likely to be required during construction of the gas pipeline. Based on experience during construction of the pipeline for the NGSF it is not anticipated that adverse impact on the groundwater resource would occur because of the short-term duration of dewatering. As the Proposal was declared Critical State Significant Infrastructure (CSSI) by the NSW Minister for Planning in December 2018 under State Environmental Planning Policy (State and Regional Development) 2011, then water-take related approvals would be required from the NSW National Resources Access Regulator (NRAR). The Proposal does not intend to extract groundwater resource and will source potable water from municipal supply, hence there will not be significant on-going groundwater take as a result of the Proposal.

Legislation / Policy	Summary	Relevance
	appropriate, salinity and, where possible, land must be rehabilitated – the impacts of the carrying out of aquifer interference activities on other water users must be avoided or minimised.	
Coastal Management Act (2018)	State Environmental Planning Policy (Coastal Management) 2018 (the CM SEPP) updates and consolidates into one integrated policy the repealed State Environmental Planning Policies (SEPP): ■ SEPP 14 (Coastal Wetlands) ■ SEPP 26 (Littoral Rainforests) ■ SEPP 71 (Coastal Protection) The CM SEPP defines the coastal zone identifies development controls for consent authorities to apply to each coastal management area to achieve the objectives of the Coastal Management Act 2016. The Coastal Management SEPP specifies that development that requires consent on or near land mapped as coastal wetlands or littoral rainforest is declared to be designated development, including works that involve: ■ Destroying or removing native vegetation ■ Constructing a levee ■ Drainage works ■ Filling ■ Harm of marine vegetation ■ Any other development	Due to the location and nature of the Proposal, including the removal of vegetation within the Proposal area, elements of the Coastal Management Act 2018 have been considered as part of this assessment to inform potential construction and operational phase risks of the power station.
The NSW Aquifer Interference Policy (2012)	The NSW Aquifer Interference Policy (DPI, 2012) is the NSW Government's policy for the licensing and assessment of aquifer interference activities. Under the WM Act, an aquifer is defined as a geological structure or formation, or an artificial landfill that is permeated with water or is capable of being permeated with water. The WM Act defines aquifer interference as an activity that involves any of the following: ■ The penetration of an aquifer ■ The interference with water in an aquifer ■ The obstruction of the flow of water in an aquifer ■ The taking of water from an aquifer while carrying out mining or any other activity prescribed by the regulations ■ The disposal of water taken from an aquifer while carrying out mining or any other activity prescribed by the regulations	Elements of the NSW Aquifer Interference Policy (in particular interference of flow of water in an aquifer) have been considered in this assessment to inform potential construction and operational phase risks associated with the Proposal. Aquifer interference for the Proposal would include any extraction or disposal of groundwater from or to an aquifer during the operation of the plant. The provisions of the WM Act which relate to aquifer interference approvals have not commenced so far as they apply to the North Coast WSP, AGL does not require an aquifer interference approval. However, AGL may require a water access licence under the WM Act for dewatering from trenches and excavations for the construction of the pipelines.
The NSW Groundwater Protection Policy (1998)	The NSW Groundwater Quality Protection Policy (Department of Land & Water Conservation (DLWC), 1998) adopts the principles outlined in the NSW State Groundwater Policy Framework Document in relation to groundwater quality protection, and specifically the following management principles: ■ All groundwater systems should be managed so that the most sensitive identified beneficial use (or environmental value) is maintained	The policy identifies management tools to achieve groundwater protection, some of which would be relevant to the development of the project, including the use of groundwater management plans, groundwater vulnerability mapping and groundwater monitoring. The Proposal area also assesses potential groundwater dependent ecosystems which are afforded special protection

Legislation / Policy	Summary	Relevance
	■ Town water supplies should be afforded special protection against contamination ■ Groundwater pollution should be prevented so that future remediation is not required ■ For new developments, the scale and scope of work required to demonstrate adequate groundwater protection shall be commensurate with the risk the development poses to a groundwater system and the value of the resource ■ A groundwater pumper shall bear the responsibility for environmental damage or degradation caused by using groundwaters that are incompatible with soil, vegetation or receiving waters ■ Groundwater dependent ecosystems will be afforded protection ■ Groundwater quality protection should be integrated with the management of groundwater quantity ■ The cumulative impacts of developments on groundwater quality should be recognised by all those who manage, use, or impact on the resource ■ Where possible and practical, environmentally degraded areas should be rehabilitated, and their ecosystem support functions restored	under the NSW Groundwater Protection Policy.
Protection of the Environment Operations (POEO) Act (1997)	The POEO Act establishes the NSW environmental framework and includes provisions for regulating certain activities particularly relating to air emissions; contaminated sites; hazardous material; noise; pesticides; forestry activities; waste; water quality; and state of the environment reporting. The NSW Environmental Protection Authority (EPA) is the independent authority responsible for administering activities under the POEO Act. The EPA use Environment Protection Licences (EPLs) as a means to regulate the impacts of pollution in NSW.	The act identifies "scheduled activities", of which several will be undertaken as part of the Proposal. It further details the required licences for undertaking these activities as well as the potential penalties applicable if such licences are not obtained. It stipulates mandatory environmental audits as well as the frameworks guiding investigations and other proceedings. Sections 120 through 123 of the act address Water Pollution specifically.
The NSW Groundwater Dependent Ecosystem Policy (2002)	The Groundwater Dependent Ecosystems (GDEs) Policy (Department of Land & Water Conservation, 2002) provides a framework for the sustainable management of groundwater. It adopts the following principles for the management of GDEs in NSW: ■ The scientific, ecological, aesthetic and economic values of GDEs, and how threats to them may be avoided, should be identified and action taken to ensure that the most vulnerable and the most valuable ecosystems are protected. ■ Groundwater extraction should be managed within sustainable yield of aquifer systems, so that the ecological processes and biodiversity of their dependent ecosystems area maintained and/or restored. Management may involve establishment of threshold levels that are critical for ecosystem health, and controls on extraction in the proximity of groundwater dependent ecosystems. ■ Priority should be given to ensuring that sufficient groundwater of suitable quality is available at the time when it is needed, for: – Protecting ecosystems which are known to be, or are most likely to be, groundwater dependent.	The policy contains management principles and methods to protect GDEs that may be relevant if these ecosystems are encountered during the development and /or operation of the power station.

Legislation / Policy	Summary	Relevance
	– For the GDEs which are under an immediate or high degree of threat from groundwater-related activities. ▪ Where scientific knowledge is lacking, the Precautionary Principle should be applied to protect GDEs. The development of adaptive management systems and research to improve understanding of these ecosystems is essential to their management. ▪ Planning, approval and management of development and land use activities should aim to minimise adverse impacts on GDEs by: – Maintaining, where possible, natural patterns of groundwater flow and not disruption groundwater levels that are critical for ecosystems. – Not polluting or causing adverse changes in groundwater quality. – Rehabilitating degraded groundwater systems where practical.	
Hunter Water Regulation, (HWC, 2015)	Hunter Water Regulation 2010 - Clause 15 … Tomago Sandbeds: ▪ A person must not engage in any extractive industry in the Tomago Sandbeds Catchment Area otherwise than in accordance with an approval given by the Secretary. Hunter Water Regulation 2010 - Clause 10 … Pollution of waters: ▪ A person must not pollute any waters in a special area. In this clause **pollute**, in relation to waters, has the same meaning as pollution of waters has in the Protection of the Environment Operations Act 1997, but extends to include disturbing geological or other matter (whether natural or artificial) in such a manner as to change, or to be likely to change, the physical, chemical or biological condition of the waters.	The Proposal area is partially located within the Tomago Sandbeds Catchment Area. Hunter Water Corporation (HWC) extracts groundwater from the Tomago Sandbeds to supplement the potable water supply for the Newcastle Region. The *Tomago Sandbeds Catchment Area* is declared a special areaunder the *Hunter Water Act 1991. The Hunter Water (Special Areas) Regulation 2003* and Hunter Water Regulation (*Public Exhibition Draft*) 2010 - makes provision for HWC to regulate activities within areas of declared special areas under the above act

3.2 Guidelines

This report has been prepared with reference to the state and federal guidelines listed in **Table 3-2**:

Table 3-2 Overview of relevant groundwater guidelines

Legislation / Policy	Summary	Relevance
National Water Quality Management Strategy (NWQMS)	The NWQMS was developed collectively by the states, territories and Commonwealth during the 1990s by the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ). The NWQMS (ANZECC and ARMCANZ 2000a) provides a nationally consistent approach to water quality management and the information and tools to help water resource managers, planning and management agencies, regulatory agencies and community groups manage and protect their water resources. The NWQMS comprises a description of policies, principles and guidelines for end users and water sources. The main policy objective of the NWQMS is to achieve	Construction and operational phases of the Newcastle Power Station have the potential to impact water quality within the adjacent Hunter River and Tomago Sandbeds. As such, construction and operational phases should integrate water quality management strategies (consistent with NWQMS) such that the environmental values of the sensitive receiving waterways are not adversely impacted. These should be included in the construction and operational EMPs.

Legislation / Policy	Summary	Relevance
	sustainable use of water resources, by protecting and enhancing their quality, while maintaining economic and social development. The NWQMS process involves development and implementation of a management plan for each catchment, aquifer, estuary, coastal water or other water body, by community and government. These plans focus on the reduction of pollution released into coastal pollution hotspots and other aquatic ecosystems around the country. Local government, community organisations and other agencies implement these plans using the NWQMS to protect agreed environmental values. The NWQMS consists of some 21 guideline documents which broadly cover ambient and drinking water quality, monitoring, groundwater, rural land uses and water quality, stormwater, sewerage systems and effluent management for specific industries. Two additional publications were released in 2001: ■ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) ■ Australian Guidelines for Water Quality Monitoring and Reporting (2000) These publications outline the current approach for deriving water quality guidelines, objectives and targets. They provide highly detailed and comprehensive information for water quality monitoring and management in Australia and New Zealand. Each publication is discussed in more detail in the following sections	
Guidelines for Development in the Drinking Water Catchments (Hunter Valley) (2017)	The Guidelines for development in the drinking water catchments aim to provide guidance for anyone proposing to undertake development activities within the drinking water catchment. The guidelines exist to ensure development and land use activities within the drinking water catchments are planned and undertaken so that they do not adversely affect drinking water quality. Hunter Water expects all developments in drinking water catchments to demonstrate a Neutral or Beneficial Effect (NorBE) on water quality. A development is considered to demonstrate NorBE if the development: ■ Has no identifiable potential impact on water quality. ■ Will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site. ■ Will transfer any water quality impact outside the site where it is treated and disposed of two standards approved by the consent authority	Due to the Proposal location in relation to the adjacent Tomago Sandbeds (although not within the sandbeds) and the potential impact to drinking water in the area, the guidelines should be considered during the construction and ongoing operation of the power station. This is addressed within the groundwater section of this EIS.
Guidelines for Controlled Activities on Waterfront Land (2018)	Waterfront land includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake or estuary.	The Proposal area is over 40m from the highest bank of the Hunter River and is therefore not considered to be waterfront land.

4 Methodology

4.1 Approach

Section 5 of this report presents a summary of the existing environmental conditions determined for the site from a combination of site walkover and desktop assessment. The culmination of these resources provided an in-depth understanding of the current environment and facilitated an assessment of potential environmental impacts and the mitigation measures associated with the construction and operation of the Proposal.

Details of the site walkover and desktop assessment approach are summarised below:

Table 4-1 Summary of site walkover and desktop assessment methodology

Component	Scope
Site Walkover	Inspection and survey of local terrain, topography, vegetative cover, potential drainage pathways, watercourses, wetlands and the surrounding environment in which the Proposal will interact with.
Desktop Assessment	Review of data available through the Bureau of Meteorology (BOM) to obtain localised rainfall, temperature and evaporation data for the lower Hunter River region.
	Review spatial mapping resources (Google Earth Pro and SIX Maps Digital Topographic Database) and the Port Stephens Local Environmental Plan (LEP) 2016 to enable conceptualisation of physical environmental conditions on-site and surrounding areas.
	Review of AGL management plans, monitoring data and construction reports from the adjacent NGSF
	Review of existing literature (detailed in Section 4.2 below) to amalgamate historic investigations and relevant information.
	Review of relevant legislation, policy and guidelines (detailed in Section 3.0) to address SEARs and agency requirements, and to inform potential construction, operational and cumulative impacts, in conjunction with possible mitigation controls for the Proposal.
	Review of Aurecon's Concept Design Report (2019) for the Proposal enabled the identification of construction and operational phase activities relevant to the Groundwater technical study. The potential impacts and associated mitigation measures were also assessed with consideration to the relevant components of the design. An interpolation of the groundwater level and proximity to the proposed power station development was undertaken in GIS using existing borehole and topographic data compared to the proposed reduced levels for the power station bench using cut/fill balance.

4.2 Previous investigations and reports

A review of previous investigations was undertaken to characterise the current groundwater conditions within or around the proposal area, assess the potential impacts and provide recommendations to avoid, mitigate or manage these impacts. Reports relevant to the Newcastle Power Station site are listed below:

Preliminary site investigation reports

- Environmental Strategies, 2017a. *Phase 1 Preliminary Environmental Site Assessment – Tomago Development Site.*
- Environmental Strategies, 2018. *Additional Pre-Existing Contamination Study – Tomago Development Site, NSW*

Environmental assessment reports

- Coffey 2011a, Environmental Assessment – Newcastle Gas Storage Facility Project, May 2011.
- Coffey 2011b, Groundwater and Surface Water Monitoring Program Factual Report Newcastle Gas Storage Facility Project, 26 October 2011.
- URS, 2002. Environmental Impact Statement - Tomago Gas Fired Power Station, Volume 1: Main Report

The key findings of the above listed reports are presented in the following sections.

Environmental Strategies (2017a): Phase 1 Preliminary Environmental Site Assessment – Tomago Development Site, NSW

Environmental Strategies (ES) was engaged to complete a Phase 1 Preliminary Environmental Site Assessment (PESA) of the Tomaga Development Site (TDS) property. The area covered in the PESA is the same as the proposed power station site covered in the current EIS (this report).

The assessment identified the potential historic and current contaminant sources on site, which included various domestic type contaminants (general rubbish, minor oil stains, 2 septic systems, storage and use of typical domestic chemicals) as well as several burnt out cars, car parts and mounded vegetation.

The following observations relating to the local groundwater systems were made:

- The topography indicates that surface water and groundwater between the site and the existing Tomago Aluminium facility (south of the site) is likely to flow south, away from the power station site.
- A search of the NSW National Resources Atlas revealed a total of four registered groundwater bores within a 500m radius of the power station site. No details were available regarding the construction or the purposes of the bores.
- Based on a previous geotechnical study, the groundwater in this area could be present at shallow depths and likely above the bedrock within 1.5mbgl, especially toward the southern section of the power station site.
- The investigation indicated that the following chemicals of potential concern may be present in soil, groundwater, and sediments on the site:
  - Total recoverable hydrocarbons (TRH)
  - Asbestos
  - Fluoride
  - Faecal and Total Coliforms
  - E Coli
  - Volatile Organic Compounds (VOCs)
  - BTEX (benzene, toluene, ethyl benzene, xylene)
  - 8 priority metals: (Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Mercury (Hg), Nickel (Ni), Zinc (Zn))
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Organochlorine pesticides (OCP)
  - Organophosphorus pesticides (OPP)
  - Polychlorinated biphenyls (PCBs)

Environmental Strategies (2018): Additional Pre-Existing Contamination Study – Tomago Development Site, NSW

Following on from the findings of the original Phase 1 ESA (ES, 2017a), a site-specific sampling program was undertaken, consisting of soil, sediment, surface water and groundwater sampling components. The assessment was undertaken over both Lots 2 and 3 of 1940 Pacific Highway Tomago.

Soil bores were extended to a maximum depth of 3 m below surface level or, at least 0.5 m into natural material or, to refusal, whichever was shallower. The locations of these groundwater monitoring wells, as indicated on Figure 4-1, were determined following review of the Phase 1 ESA. Soil bores which were to be converted into groundwater wells were extended to a maximum depth of 15 mbgl, or to a nominal depth of 2 m beyond the depth at which an aquifer was encountered, whichever occurred first.

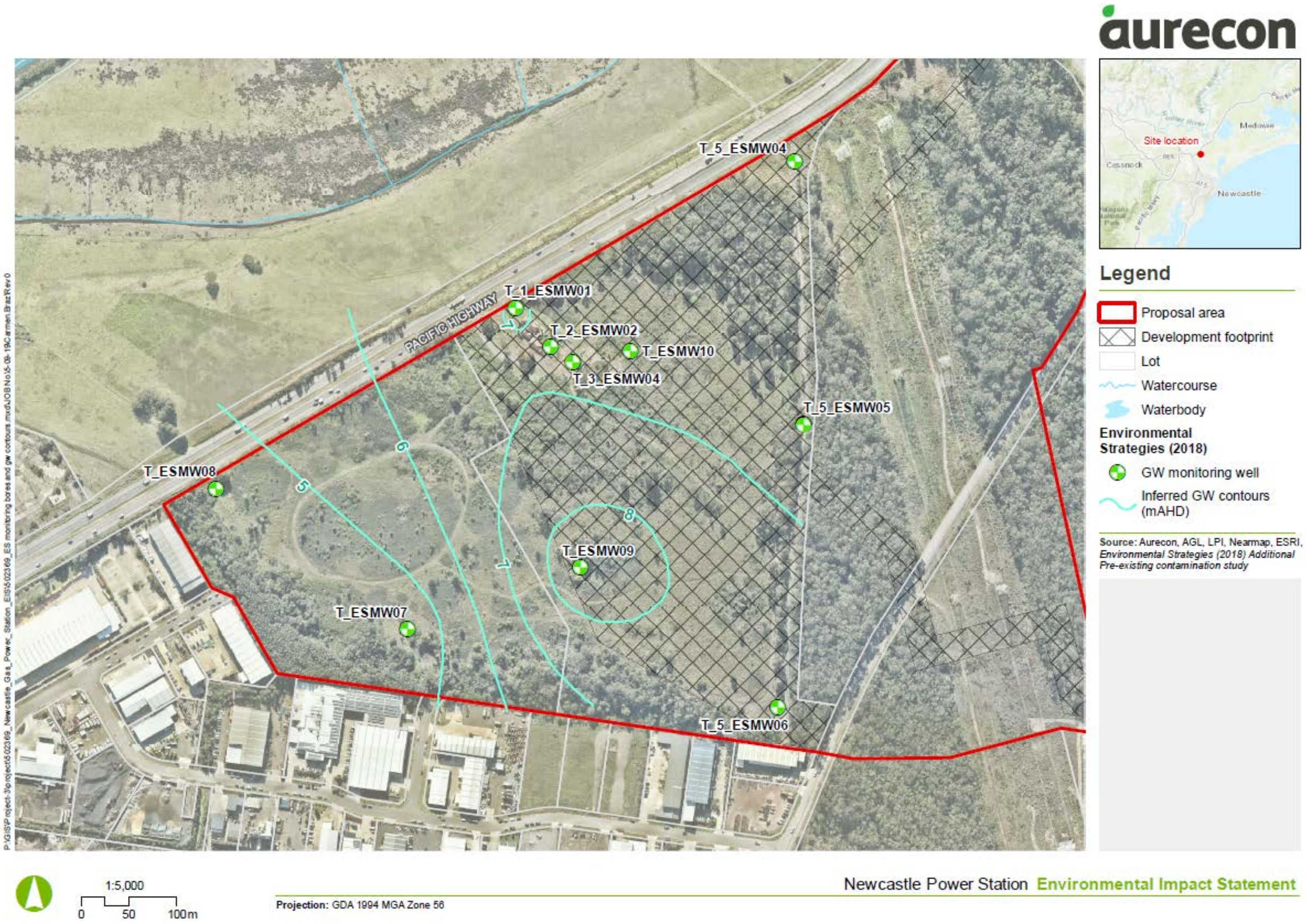


Figure 4-1 On-site monitoring bores and inferred groundwater elevation contours – Power Station (ES, 2018)

Several Chemicals of Potential Concern (CoPC) were detected in groundwater samples in elevated concentrations. ES considered the concentrations would constitute contamination and / or pollution. With respect to background groundwater quality, ES concluded that the well which is most likely to represent local background conditions T_ESMWO9, is located centrally on the site and is the well with the highest groundwater elevation, indicating that it is unlikely to be impacted by existing development. Apart from Nickel (Ni), all metals within T_ESMW09 were found to be below the GAC. As a result, ES adopted the result from T ESMW09 as the low reliability background screening level (LRBSL) for Ni only.

The high concentrations of copper detected in groundwater are similar across the eastern half of the site, both in background and areas of environmental concern. Based on the groundwater flow direction which can be interpolated from the groundwater elevation contours prepared by ES, it is unlikely that the concentrations of copper detected in the Background areas on the TDS are evidence of impact from the on-site areas of environmental concern. Rather it appears that concentrations in groundwater of copper are generally high in this section of the TDS. No potential source of copper was noted during the ES Phase 1 ESA (ES, 2017) or during the fieldworks, either on or off site, nor was copper detected in elevated concentrations in soil at any location sampled across the site. Based on the limitations of the scope of the completed, the source of elevated copper in background groundwater across the site remains undefined but may be indicative of local natural concentrations throughout the general area.

Coffey (2011a): Environmental Assessment – Newcastle Gas Storage Facility Project, Volume 1: Main Report

Coffey Geotechnics (Coffey) undertook an Environmental Assessment (EA) of the adjacent site (indicated on Figure 4-2) with the report finalised in May 2011. The EA report describes the proposed NGSF and provides an assessment of potential impacts that may occur if the NGSF is developed, and recommends measures to avoid, mitigate and / or manage those impacts.

Groundwater is addressed within the EA and a Groundwater assessment report in included as part of the EA main report appendices.

The key findings of this 2011 report, pertaining to the Newcastle Power Station, are outlined below:

- The gas pipeline corridors considered in the 2011 study (in close proximity to the current Proposal area) do not overlay any part of the Tomago, Tomaree and Stockton Groundwater Sources. Groundwater in these areas is generally believed to discharge to the adjoining Hunter River.
- Preventing surface water contamination is key to preventing impacts to groundwater.
- Mitigation and management measures for the protection of surface water (and groundwater) would be based on the following principles:
  - Minimise land disturbance.
  - Control stormwater runoff from construction sites.
  - Provide sedimentation treatment for all surface runoff from disturbed areas.
  - Separation of clean water (i.e., runoff from undisturbed areas), and potentially contaminated water at the construction sites.
  - Build temporary or permanent infrastructure to capture any spills or leaks of potentially contaminating chemicals before they enter the environment.
  - Collect and store wastewater before transporting offsite for treatment or disposal.
  - Undertake water quality monitoring to ensure that surface water management is meeting the objectives of the management plan and within criteria limits.

Figure 4-2 Groundwater and surface water monitoring locations (Coffey, 2011a)

Coffey (2011a): Environmental Assessment – Newcastle Gas Storage Facility Project, Volume 3: Appendix 6 – Groundwater Assessment

The Groundwater Assessment was undertaken by Coffey as part of the EA conducted and delivered in January 2011. A focus was placed on investigating the key groundwater management issues and to identify potential impacts and mitigation measures to reduce the potential for detrimental impacts.

The relevant key findings of the groundwater specialist study are outlined below:

- The sandy nature of the sediments of the Tomago Sandbeds suggest that rainfall recharge to the aquifer is rapid.
- The Tomago Sandbeds aquifer is assessed as having a high vulnerability rating because of the highly permeable sandy soils, the shallow water table and the value of the groundwater resource as a water supply source and a source of environmental water for groundwater dependent ecosystems (GDEs).
- The potential impacts and mitigation measures (in italics) to protect the groundwater system during the construction stage of the Project are:
  - Temporary dewatering during the pipeline trench construction program.

    Reinject water locally back into the sand aquifer approximately 50 m distant on the down gradient side of the trench.
  - Potential impacts to groundwater quality may result from an accidental spill or leak of fuel and oils from the construction vehicles and equipment.

    Surface water management controls, construction management plans, vehicle maintenance checks, hardstand and bunded areas for refuelling site machinery, boundary monitoring bore locations for water levels and water quality.
- The potential impacts and mitigation measures (in italics) to protect the groundwater system during the operation stage of the Project are:
  - Increased hardstand and buildings across the gas plant site will locally reduce rainfall recharge, although clearing will have the opposite effect and rainfall recharge will increase over the wider area.

    Minimal change (or slight increase) in overall recharge volumes is expected and the recommended monitoring bore network will assess actual changes.
- Groundwater monitoring during construction and operation will provide information on the response of the groundwater system to these changes and a comprehensive contingency plan should be developed to protect the potable water supply source.
- Pile design below six buildings including the LNG storage tank, fire water tank, MRL compressor building, gas liquefaction system and re-gasifiers (two buildings) was assessed as having negligible impact on the groundwater flow system in this area.
- The potential impacts to groundwater quality due to infiltration of stormwater potentially containing pollutants will be prevented by a range of controls. Surface water management including separation of low and high-quality stormwater runoff, appropriate storage and handling facilities and treatment controls will mitigate potential risks of groundwater contamination.
- Clean stormwater runoff (for example from roof areas) will not impact groundwater quality if directly discharged to the sand aquifer.
- Coffey anticipate that there will be no measurable groundwater impact from the construction and operation of the Project on Groundwater Dependent Ecosystems (GDEs) in the immediate vicinity of the gas plant site, along the proposed pipeline and access road or further away at the Hunter Estuary Wetlands Ramsar Site.
- Groundwater within the Proposal area is managed as part of the Water Sharing Plan (WSP) for the Tomago Tomaree Stockton Groundwater Sources. The Project will ensure that the development does

not affect the water quantities, water qualities or associated ecosystems that are recognised under this WSP.

Coffey concluded the Project meets the required NSW groundwater policies regarding protecting the water quality, water quantity and GDEs identified within the Proposal area.

URS (2002): Environmental Impact Statement - Tomago Gas Fired Power Station, Volume 1: Main Report

The Environmental Impact Statement (EIS) conducted by URS in 2002 (2002 EIS) on behalf of AGL Macquarie Generation proposed the development of a gas fired power station **within the same location as the current Proposal**. The 2002 EIS focused environmental document was utilised for information regarding the surface water and hydrological characteristics of the site, as well as informing on potential impacts and associated avoidance and / or mitigation measures.

The key elements relating to surface water and hydrology from the 2002 EIS are summarised below:

- The report entailed a desktop investigation of the existing environment inclusive of regional drainage, site drainage, flooding and existing surface water quality.
- Results of the preliminary laboratory testing to assess acid sulphate soil risk at the site indicated the presence of potential acid sulphate soils at depth (below 2m from ground level). Samples from within the upper 1 m were found to be free of potential acid sulphate soils (ASS). Additional laboratory analyses on several soil samples collected from between 0 to 1 m at several locations across the site revealed that the near surface soils down to a depth of 1.0 m BGL have negligible potential to generate ASS.
- Proposal mitigation measures during construction and operation phases were implemented to:
  - minimise hydrological impact (i.e. minimise flood risk)
  - minimise erosion at discharge points
  - minimise off-site discharge of suspended solids
  - minimise off-site discharge of potentially contaminated waters
  - ensure chemical, fuel and oil spills are contained and disposed of off-site by licensed waste contractor
- A SWMP would be developed for the construction phase and an ESCP developed for the operational phase with the primary aim of preventing sediment discharge offsite and to prevent erosion at discharge points.
- Once the power station was operational, approximately 30 per cent of the area would become impervious, resulting in an increase in stormwater run-off from the site. Given that construction of a detention pond would reduce the flow rate of surface water from the site and given the relative size of the site compared to the total catchment area of the Hunter River, there would likely be negligible impact on the hydraulic behaviour of the Hunter River.
- The design of the power station would incorporate a separate stormwater drainage system for clean and contaminated stormwater.
- Fuel, oil and chemical spills would be collected in sumps in bunded areas, pumped and disposed of off-site by a licensed waste contractor.
- Water to be released from the detention pond would be monitored and only released once it is determined that the water meets the relevant water quality criteria.

URS concluded that with the appropriate mitigation measures employed, the development is expected to have negligible impact on surface water quality.

5 Existing environment

5.1 Climate

5.1.1 Rainfall

Review of data available through the Bureau of Meteorology (BOM) - Monthly Statistics: Climate Data Online indicates that the nearest BOM weather station is located in Kinross, (Raymond Terrace (32.77° S, 151.74° E) NSW, and is positioned approximately 6 kilometres north of the site.

Utilising the BOM climate database, the mean total rainfall for each calendar month from 1970 to 2018 (48 years) was calculated and is summarised in Table 5-1 and presented on Figure 5-1.

Table 5-1 Average monthly rainfall data measured at the Raymond Terrace Station (1970-2018)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Avg. Rainfall (mm)	107	120	132	110	95	116	58	48	59	72	90	78	1067

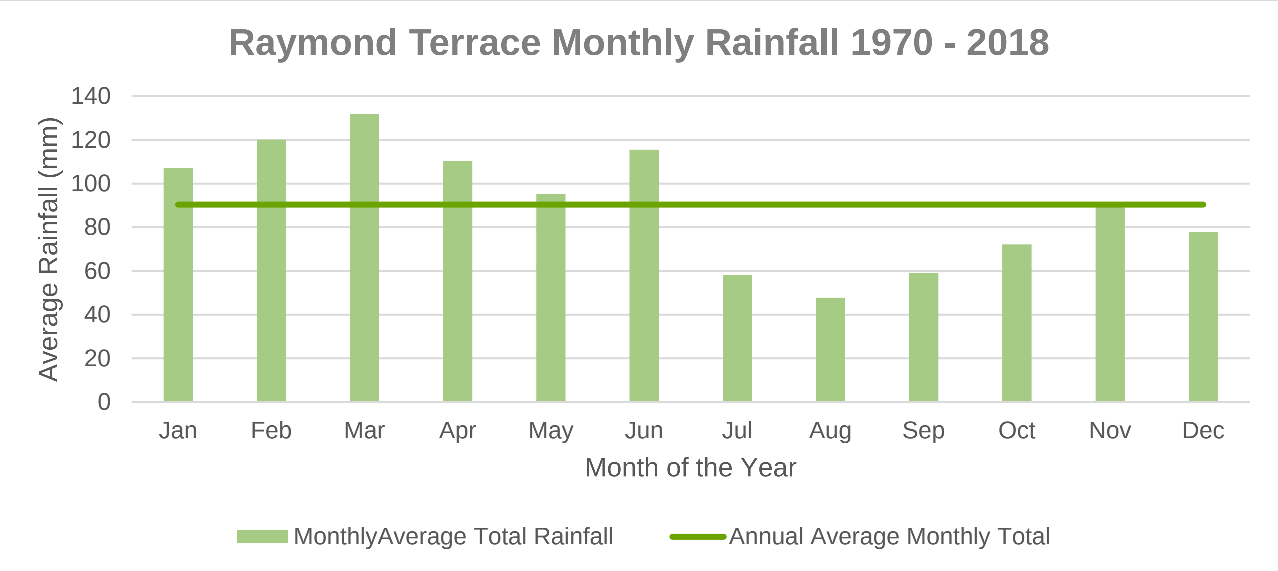


Figure 5-1 Average monthly rainfall data measured at the Raymond Terrace Station (1970-2018)

Analysis of the available rainfall data presented on Figure 5-1 is indicative of a seasonal cyclic variation in total monthly rainfall amounts. The data shows evidence of a prevalent 'wet' (January-June) and 'dry' (July-December) season with an average total monthly rainfall of 90.4 mm and an average total annual rainfall of 1066.9 mm.

5.1.2 Temperature

Review of data available through the BOM - Monthly Statistics: Climate Data Online indicates that the nearest BOM weather station with long term temperature data is located at Newcastle University, (32.89° S, 151.71°) NSW, and is positioned approximately 9 kilometres south of the site. Figure 5-2 presents the 17 years of temperature data.

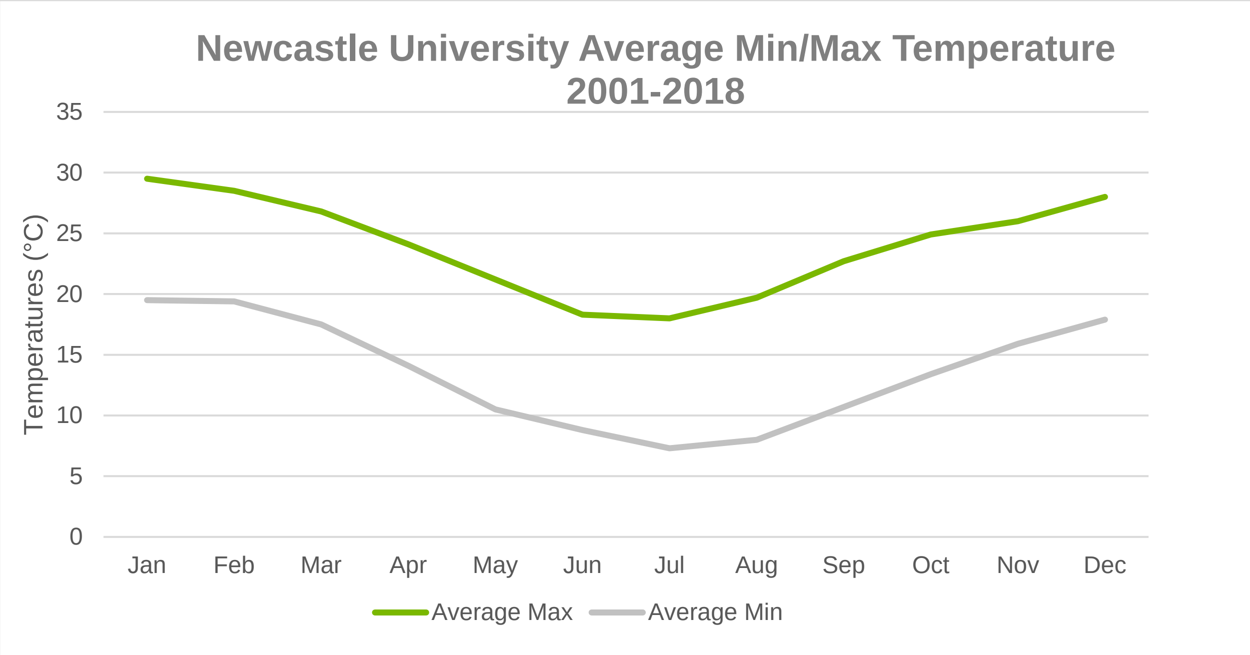


Figure 5-2 Monthly maximum and minimum temperature ranges measured at the Newcastle Station (2001-2018)

The analysis of available temperature data indicates that Tomago is positioned within a temperate climatic region characterised by mild to warm summers and moderately cool winters. Average minimum and maximum temperatures range from approximately 18-28°C (December-February) to 7-18°C (June-August) seasonally, with predominantly mild temperatures (~13-22°C) in the autumn and spring months.

5.1.3 Evaporation

Evaporation is the primary pathway in the water cycle whereby water moves from a liquid state to atmospheric water vapour. The BOM measures evaporation as the amount of water which evaporates from an open pan. The BOM generally use a Class A evaporation pan. The evaporation rate depends on elements such as cloud cover, air temperature and wind speed.

Review of data available through the BOM - Monthly Statistics: Climate Data Online indicates that the nearest BOM weather station with long term pan evaporation data is located at Williamtown RAAF, (32.79° S, 151.84° E) NSW, and is positioned approximately 12 kilometres north-east of the site.

The mean monthly rainfall for Raymond Terrace and pan evaporation rates for Williamtown RAAF have been calculated from the available data over a corresponding time period (2009 to 2015). This is illustrated and summarised on Figure 5-3.

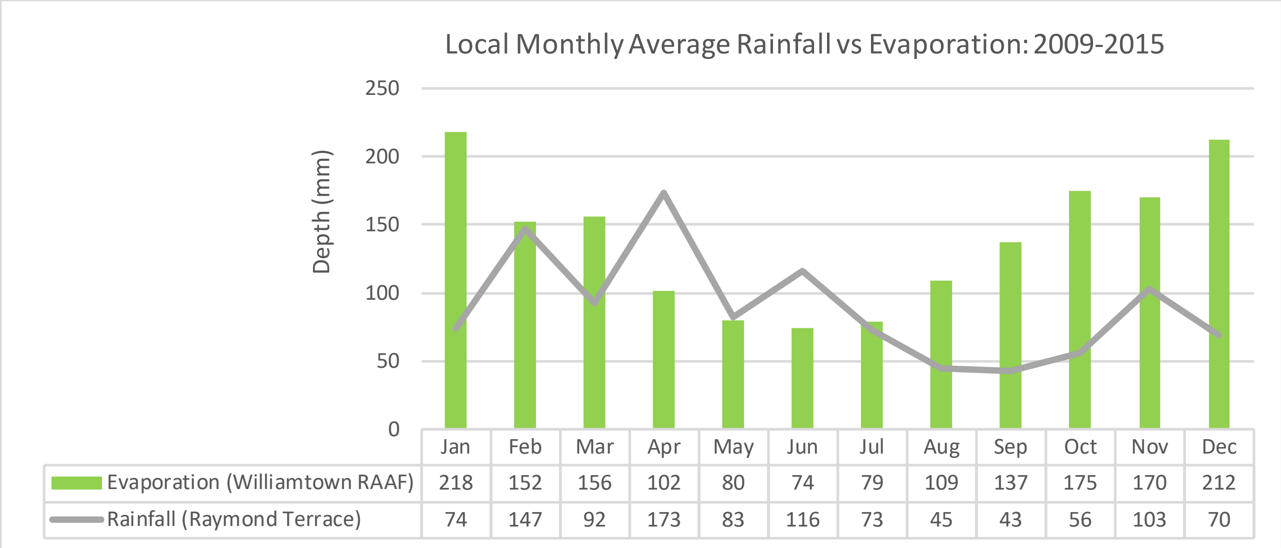


Figure 5-3 Monthly average local pan evaporation (Williamtown) and rainfall (Raymond Terrace)

Evaporation is an important factor to consider in the design phase of the Proposal as there is potential for natural evaporation ponds to be used in the removal and management of excess produced process water.

5.1.4 Water balance

Table 5-2 presents a summary of monthly rainfall and evaporation totals to describe net water balance for the local area.

Table 5-2 Summary of the water balance and climate conditions for the local area

Month	Rainfall Total	Evaporation Total	Net Water Balance	Climate Condition
January	74	218	-144	Drying
February	147	152	-5	Drying
March	92	156	-64	Drying
April	173	102	71	Wetting
May	83	80	3	Wetting
June	116	74	42	Wetting
July	73	79	-6	Drying
August	45	109	-64	Drying
September	43	137	-94	Drying
October	56	175	-119	Drying
November	103	170	-67	Drying
December	70	212	-142	Drying

The results show that long term averages for rainfall totals exceeding evaporation totals April and June, resulting in net wetting conditions. Long term averages for monthly evaporation exceed rainfall totals between July and March, resulting in net drying conditions.

The observed climate conditions will affect environmental (surface water flow and quality) conditions across the site and throughout the catchment.

5.1.5 Climate change

The NSW Climate Impact Profile report published by the Department of Environment, Climate Change and Water NSW (DECCW, 2010) indicated that within the Hunter Region, by 2050, the climate is virtually certain to become hotter year-round, with a likely decrease in rainfall in winter (5-20%), an increase in rainfall in spring (5-20%), summer (10-50%) and autumn (5-10%). Run-off and stream flow are likely to increase in summer and autumn and decrease in spring and winter.

Applying the expected local increases and decreases in rainfall and evaporation the following water balance changes could potentially occur in the catchment:

- Summer: Less dry, potentially moving into a wetting condition by February.
- Spring: The current drying condition is expected to be amplified.
- Winter: Limited expected change in water balance condition.
- Autumn: Dryer, potentially moving from wetting to drying condition by May.

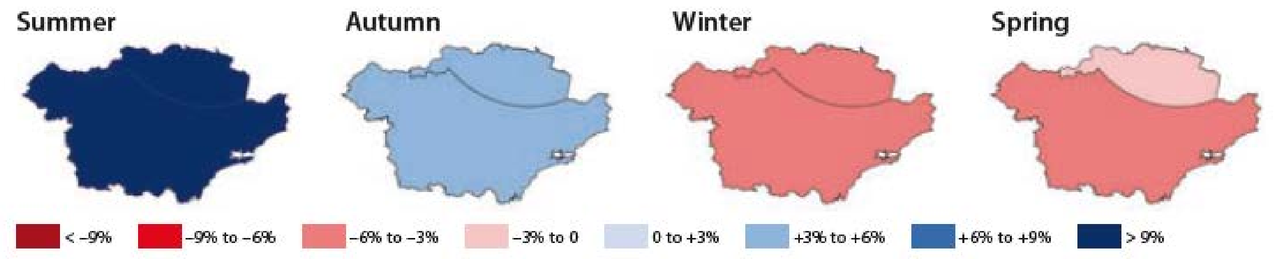


Figure 5-4 Estimated four-model mean percentage change in seasonal run-off for the Hunter region for projected 2030 climatic conditions (DECCW, 2010)

Substantial increases in runoff depths during summer could increase the potential for contaminant transfer to the environment. However, the receiving environment is likely to be wetter and off-site impacts could be minimised.

5.2 Topography and Surface Water

The proposed site for the power station is located on a topographic high point adjacent to the Hunter River and divided by a topographic ridge approximately central to the site, as shown on **Figure 5-5**. The average elevation along the ridge is 15 m AHD with a high point of 16 m AHD in the north west portion. A gentle slope occurs to the southern site boundaries, with elevations dropping to approximately 6-7 m. The gradient north of the central ridge is slightly steeper, dropping to 8 m AHD over nearly half the distance. One (1) drainage divide, two (2) drainage features, and two (2) ponds (dams) have been identified within the site boundary (**Figure 5-5)**. Along the proposed northern and southern pipeline easements the ground elevation ranges between approximately 2 mAHD and 4 mAHD.

Figure 5-6 shows the local and regional hydrology, including major watercourses, wetlands, waterbodies, protected zones, and the existing drainage pathways. Numerous important wetlands are located near the Proposal site. In particular, Ramsar-listed wetlands are located in the Kooragang Nature Reserve (within approximately 4 km southeast of the Proposal area) and in the Wetlands Centre Australia (approximately 5.5 km southwest of the Proposal site).

A baseline desktop analysis of spatial mapping resources and the Port Stephens Local Environmental Plan (LEP) 2016 provided detailed information on the Proposal area's topographic features. The proposed power station site is located next to a designated floodplain area east of the Hunter River. The proposed pipeline and transmission corridor is located within a designated floodplain (Figure 5-7).

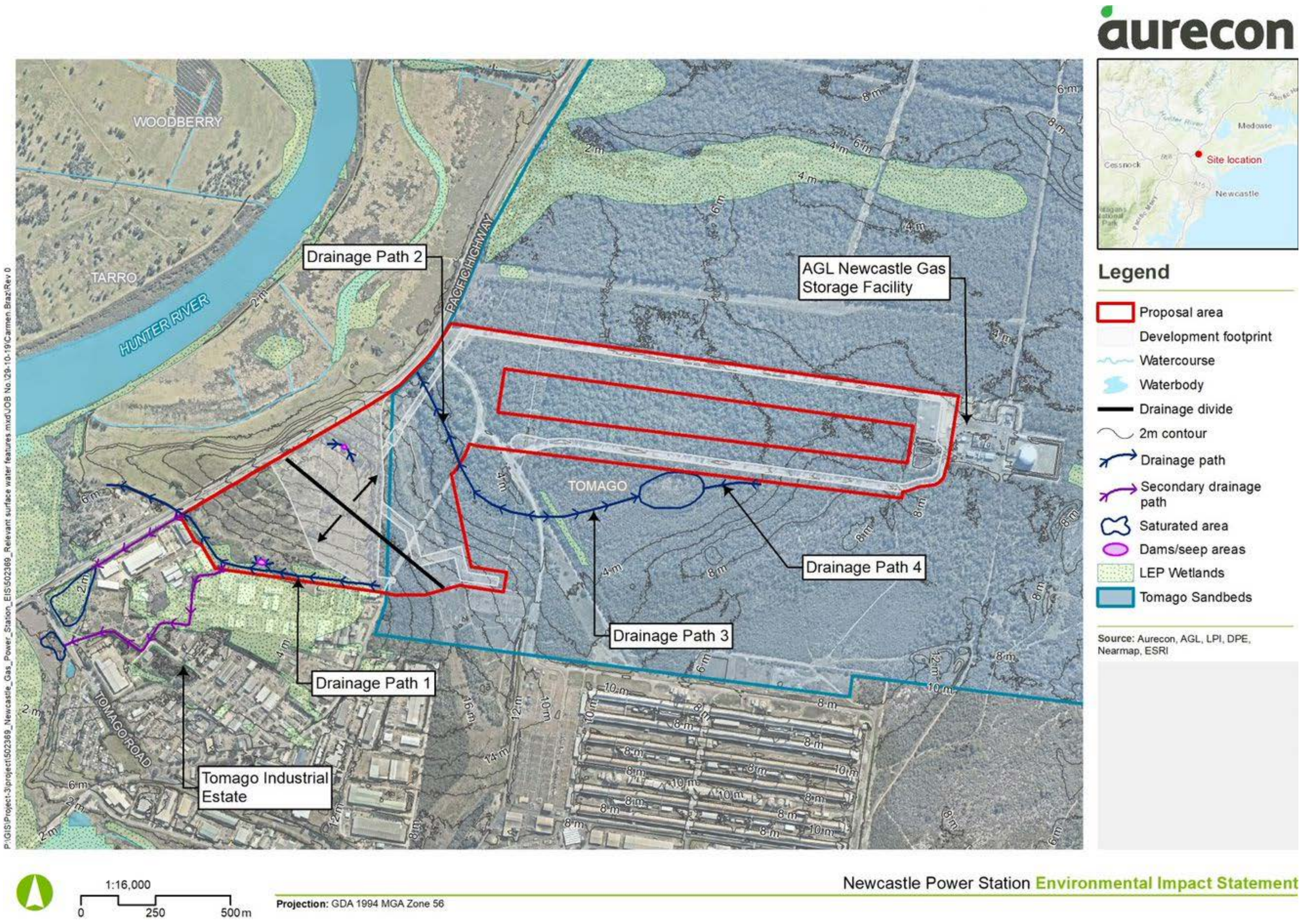


Figure 5-5 Proposal site and relevant surface water and hydrological features

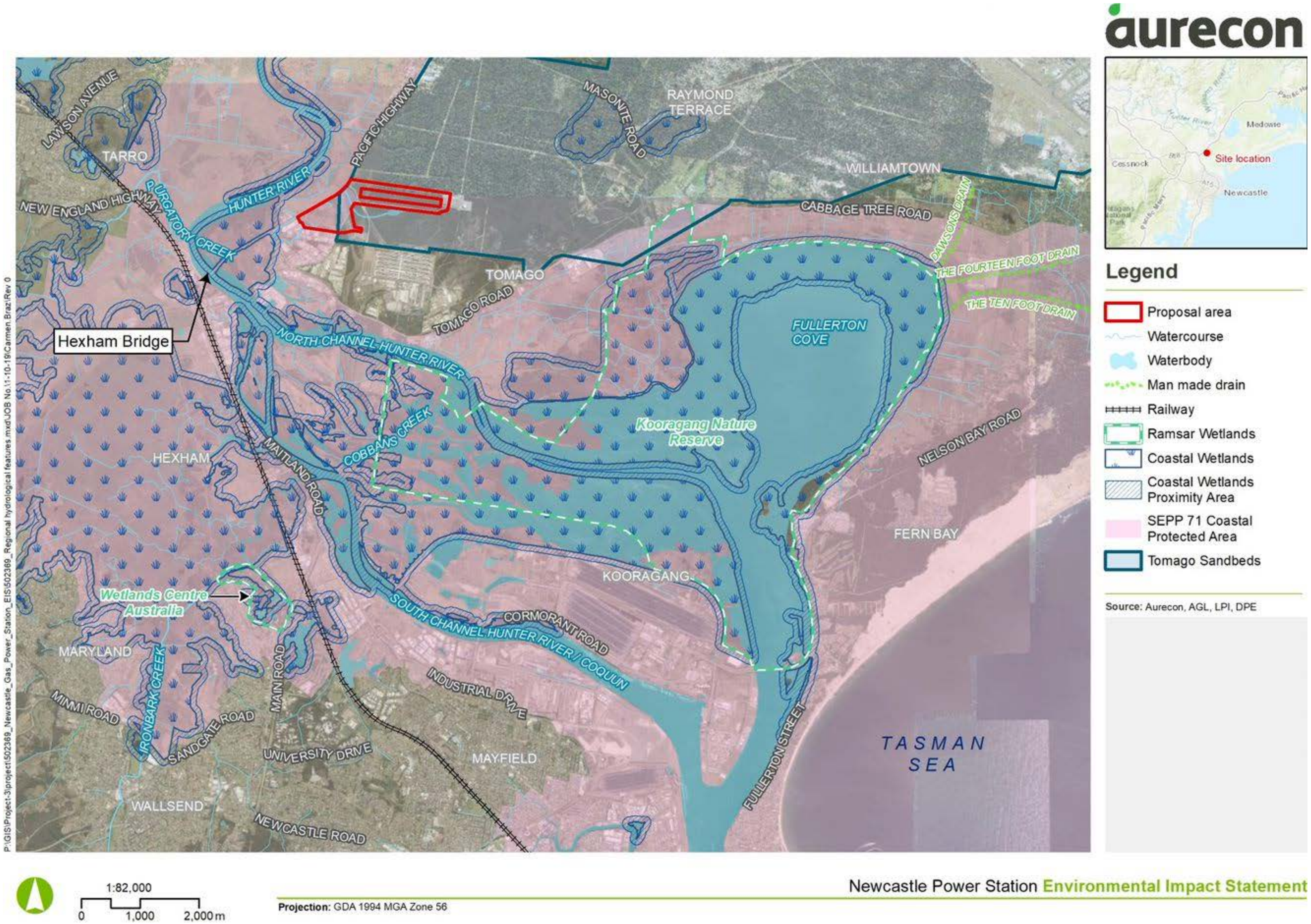


Figure 5-6 Regional surface water and hydrological features

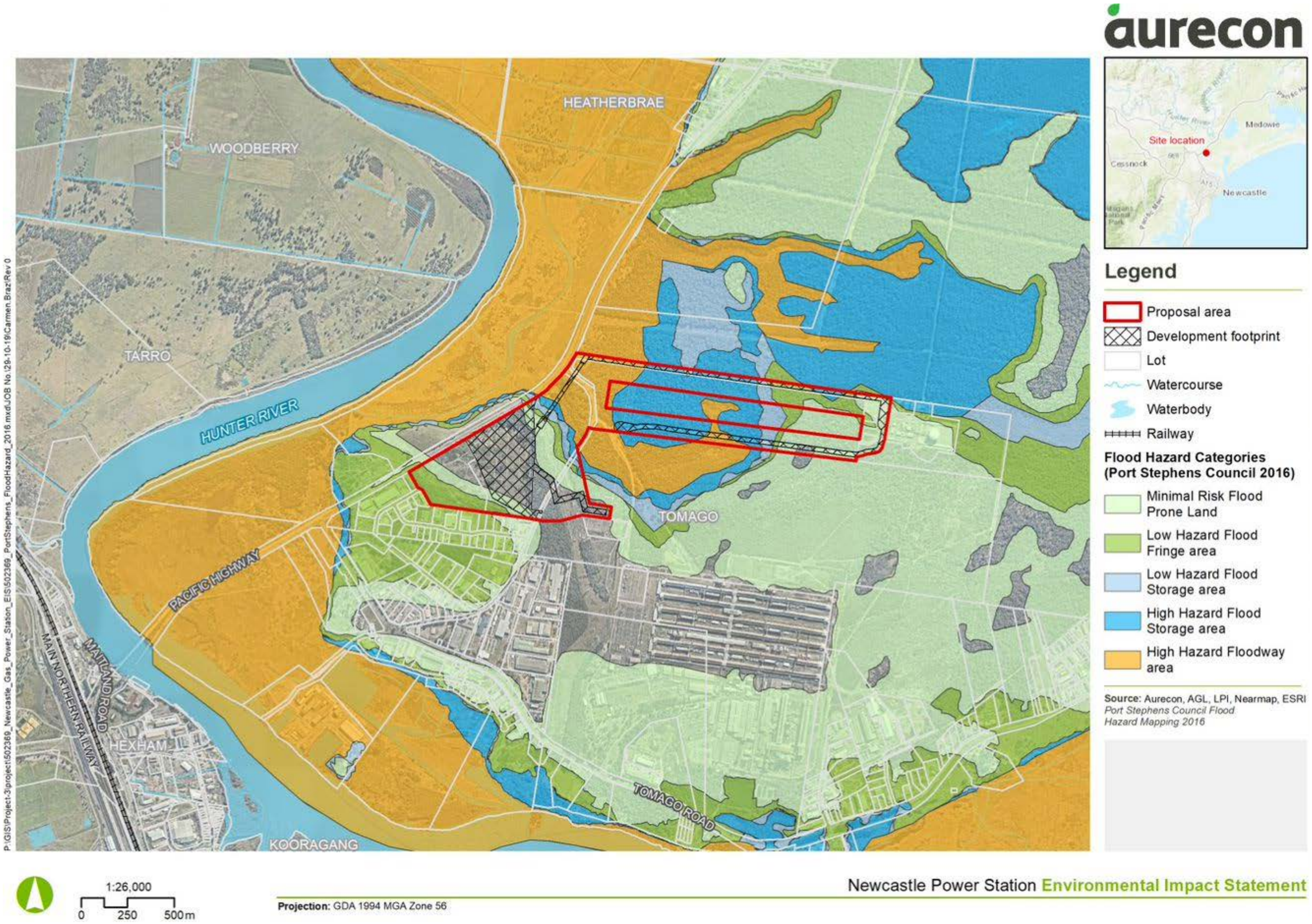


Figure 5-7 Flood Hazard Zones

5.3 Regional geology and soils

5.3.1 Geology

The Proposal area is in the northern part of the Sydney Basin, a major structural basin containing thick Permo-Triassic sedimentary sequences that extend from Batemans Bay to Port Stephens. The geology typically comprises sandstone and siltstone, with underlying coal seams.

The Proposal site transverses two geological units (

Figure 5-8):

- Tomago Coal Measures (Pt) from the Newcastle Coalfield group, formed in the Permian period. Typical lithologies associated with the formation include shale, mudstone, sandstone, claystone, tuff and coal. This unit covers much of the power station site excluding a small portion along the northern boundary.
- Quaternary Alluvial Soils (Qpb) deposited during the late Pleistocene Quaternary period. Typical lithologies associated with the formation include sand, gravel, clay and silt. This geological unit covers a small area on the northern boundary of the power station site. As part of the Qpb the Tomago Sandbeds comprise the surface geology east of the power station site. The proposed pipeline and transmission corridor predominantly traverses the Tomago Sandbeds with some fine-grained soils associated with wetlands present at the western end of the pipeline corridor.

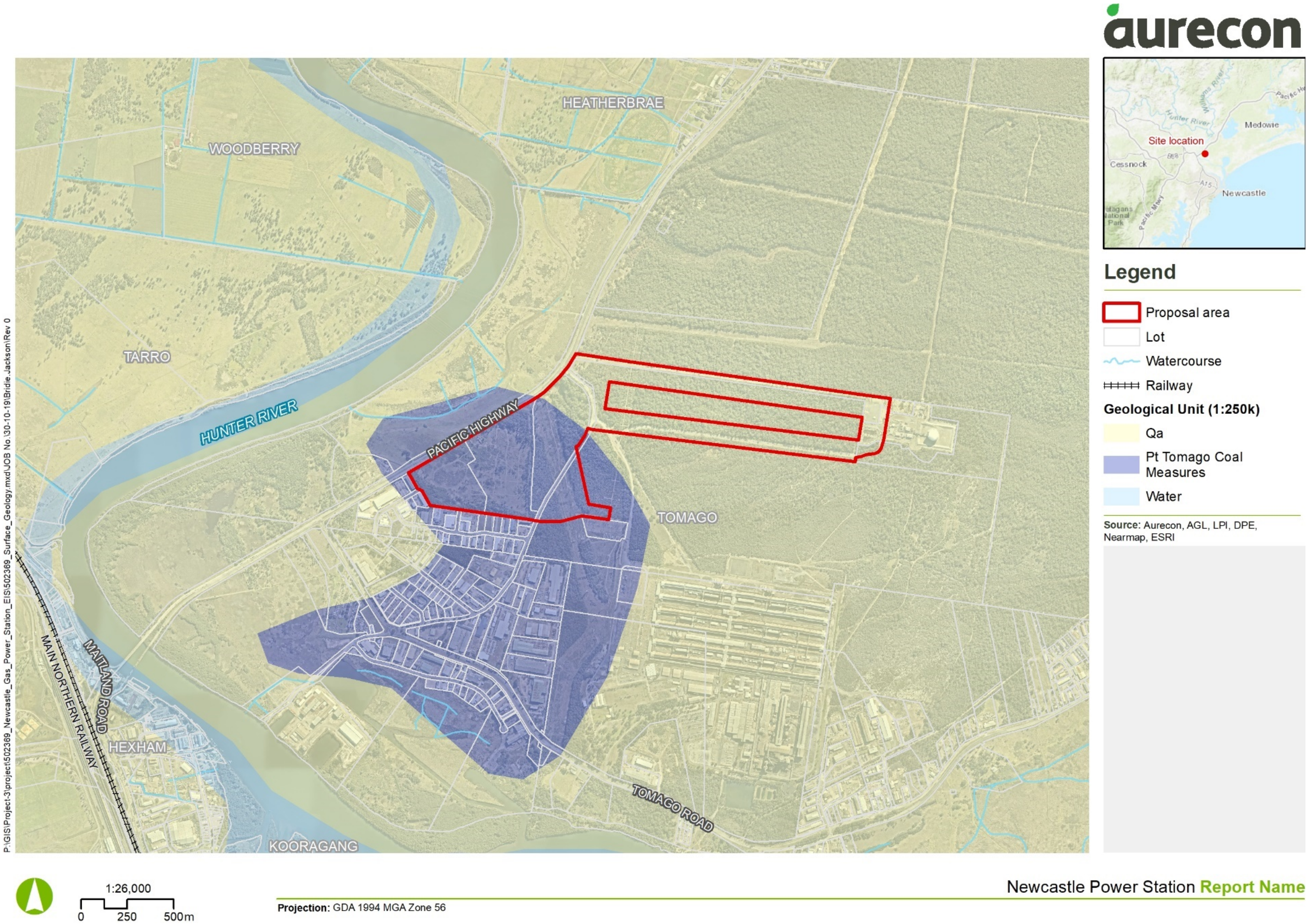


Figure 5-8 Surface Geology

5.3.2 Soils

Reference to the NSW Soil and Land Information (eSPADE) map indicates the Proposal area is predominantly situated across two soil landscape units, as shown on Figure 5-9:

- Beresfield – Residual Soil Landscape
- Tea Gardens– Aeolian Landscape

More information on the properties and potential risks associated with these two landscapes is provided below.

Beresfield

This landscape comprises undulating low hills and rises on Permian sediments. It covers most of the proposed power station site excluding a small portion in the northern corner of the site. Slope gradients of 3-15% and local reliefs to 50m are expected. The landscape comprises partially cleared tall open-forest at elevations from 20-50m.

Soils in this landscape are moderately deep (less than 120 cm) and moderately to imperfectly drained Yellow Podzolic.

Issues associated with this soil landscape unit include:

- High foundation hazard
- Water erosion hazard
- Mine Subsidence District
- Seasonal waterlogging and high run-on on localised lower slopes
- Highly acid soils of low fertility

Tea Gardens

This landscape comprises Pleistocene beach ridges on the Tomago Coastal Plain. This landscape is found in a small section in the northern corner of the power station site, and along the electrical transmission line and gas pipelines. Slope gradients are <5% and local reliefs are <1m within the unit. The landscape comprises uncleared dry and wet heath.

Soils in the Tea Gardens Landscape are deep (greater than 200 cm) and made up of well drained Humus Podzols on ridges with deep (greater than 200 cm), poorly drained Peaty/Humus Podzols in swales.

Issues associated with this soil landscape unit include:

- Permanently high water tables
- Seasonal waterlogging
- Ground water pollution hazard
- Strongly to extremely acid soils of low fertility

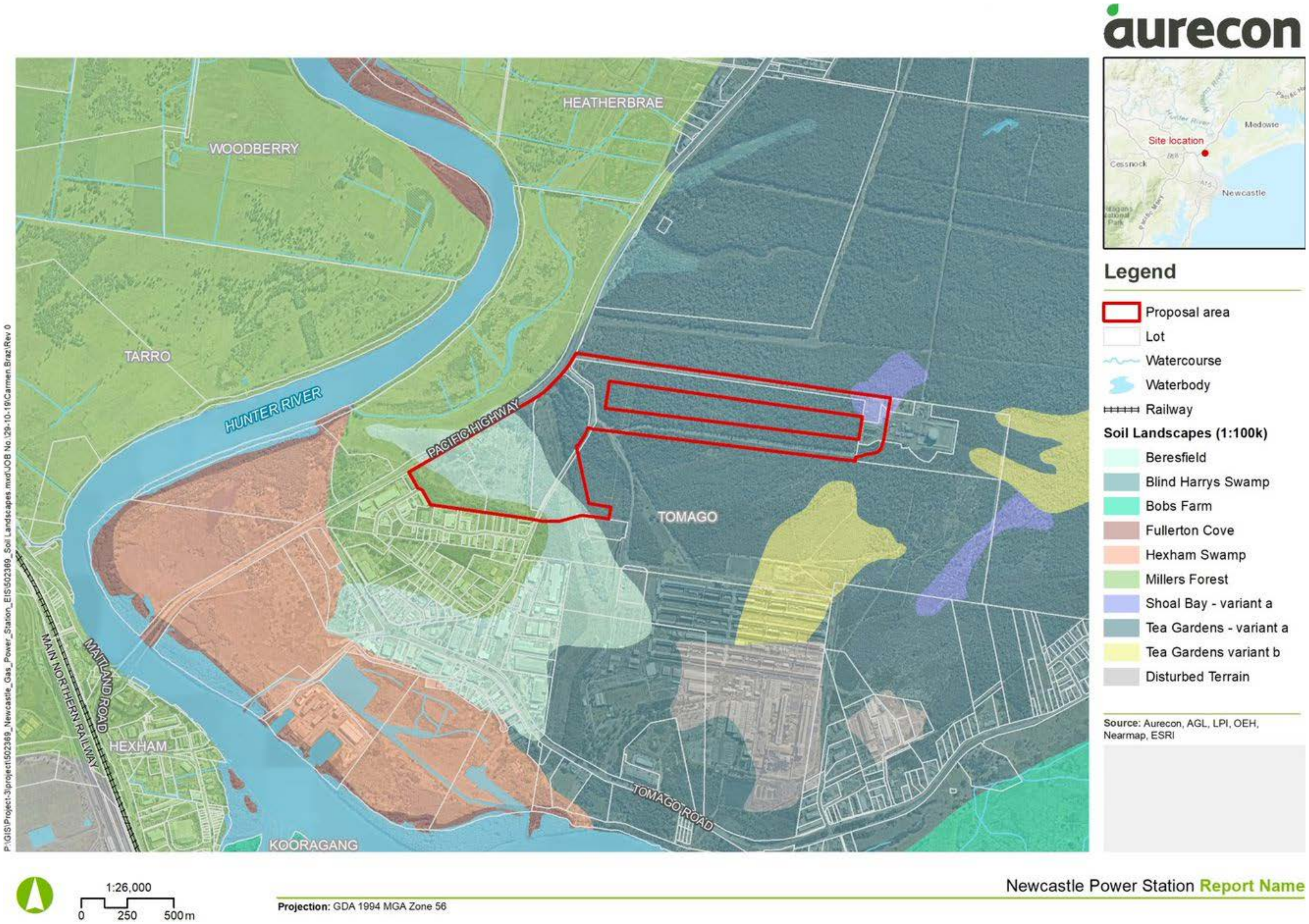


Figure 5-9 Soil Landscapes

5.3.3 Acid sulfate soils

There is a risk of encountering Potential Acid Sulfate Soils or Acid Sulfate Soils (collectively referred to as ASS) during excavations, ground disturbance and shallow dewatering for trenches. There is also a risk of encountering ASS in the event horizontal directional drilling (HDD) is implemented as part of HPP construction. The site has been classified as Class 3 (southern area) and Class 4 (central and eastern area) on the ASS Probability Map in the Port Stephens LEP (Figure 5-10) and is subject to the provision of Clause 7.1. It is also noted that the north-west boundary of the site is close to an area of Class 2 (closer to Hunter River). Clause 7.1 of the Port Stephens LEP details the restrictions to works within the appropriate Class on the land. Further description is provided below:

- **Class 2** encompasses land where development consent is required for works below the natural ground surface, and for works by which the water table is likely to be lowered.
- **Class 3** encompasses land where development consent is required for works more than 1 m below the natural ground surface, works by which the water table is likely to be lowered more than one metre below the natural ground surface.
- **Class 4** encompasses land where development consent is required for works more than 2 m below the natural ground surface, works by which the water table is likely to be lowered more than 2 m below the natural ground surface.

The potential for ASS to occur is also confirmed by the report prepared by URS in 2002 (refer to Section 4.2) which concluded that that ASS was present on the site.

Therefore, development of the site would be undertaken with reference to an Acid Sulfate Soil Management Plan and active mitigation would be required when ASS is disturbed.

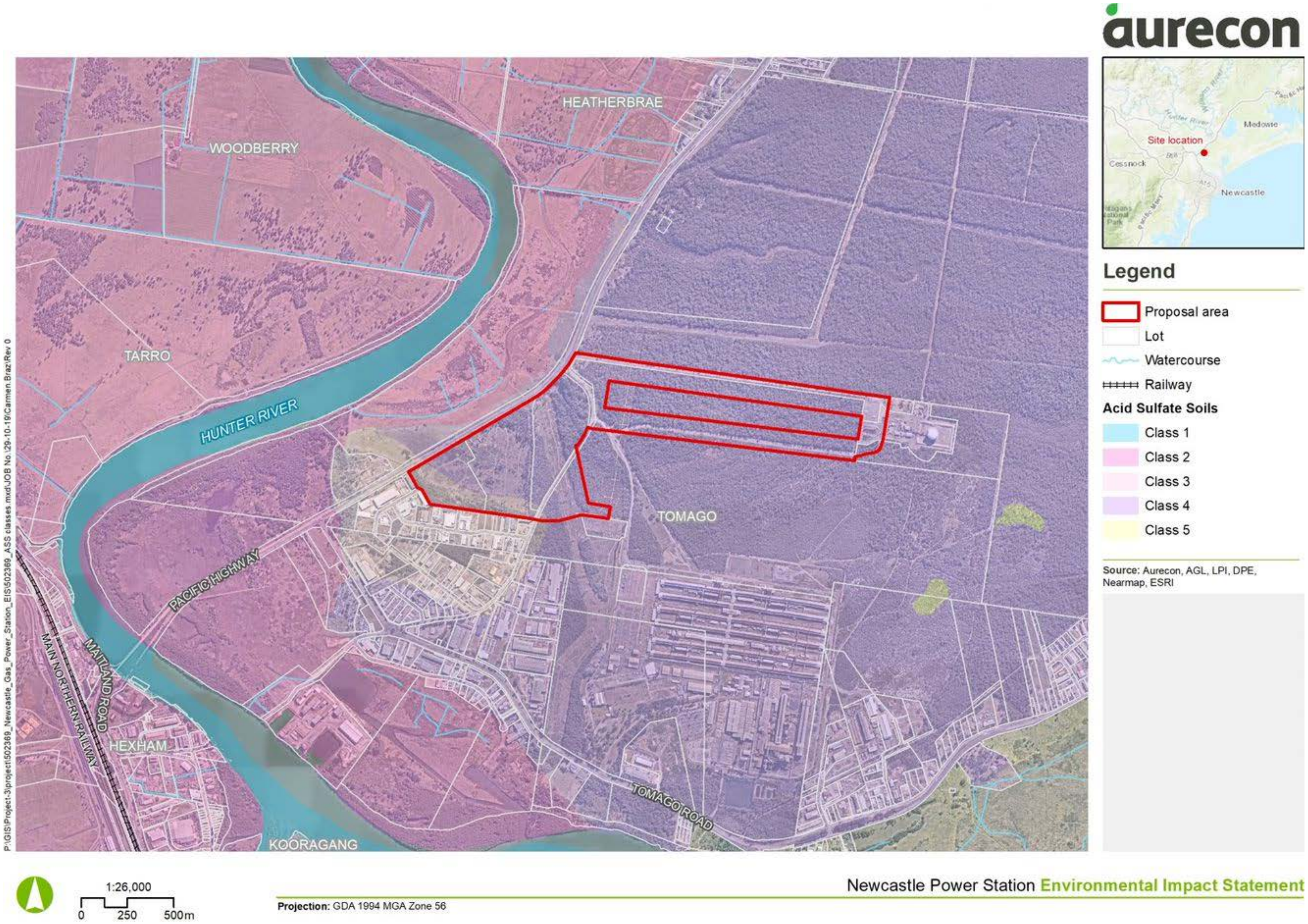


Figure 5-10 Acid Sulfate Soils

5.4 Hydrogeology

5.4.1 Aquifer characterisation

Shallow groundwater beneath the proposed power station site is located predominantly within the Tomago Coal Measures aquifer. Minor swamp deposits are present along the western and eastern edges of the site.

The Tomago Sandbeds aquifer comprises an extensive underground freshwater system running from Newcastle to Port Stephens. The aquifer acts as a back-up drinking water supply to the nearby Grahamstown Dam. Shallow groundwater associated with the proposed pipeline and transmission corridor occurs in the Tomago Sandbeds aquifer (part of the Hunter Valley alluvial aquifer) (refer

Figure 5-8).

The Tomago Sandbeds aquifer consists of highly permeable fine-grained sands underlain with impermeable clay and rock. On average the sand is 20 m thick, with some areas reaching a depth of 50 m. Highly permeable alluvial materials are often found in the base of the sandbeds.

Hydraulic conductivity within the alluvial deposits range between approximately 10 m/day and 240 m/day with the aquifer varying in thickness from 3 to 17 m (Williamson,1958). Coffey (2011a) reported interpreted values of hydraulic conductivity based on slug testing that ranged between 7 m/d and 11 m/d for the Tomago Sandbeds aquifer. Transmissivity of the Tomago Sandbeds aquifer is estimated to range between 400 m^2/day to 600 m^2/day (Crosbie, 2003). Specific yield (or effective porosity) of the sandbeds aquifer is typically between 30% and 40% (Woolley and others, 1995).

The sandbeds have the highest diffuse recharge rates in the region with between 25% and 40% of rainfall becoming diffuse net recharge (Woolley and others, 1995). Generally, the water table is shallow and highly responsive to rainfall and flooding.

5.4.2 Groundwater dependent ecosystems

Groundwater Dependent Ecosystems (GDEs) are defined as ecosystems that rely on groundwater for some or all of their water requirements. Six types of Groundwater Dependent Ecosystems have been identified in Australia:

- Terrestrial vegetation that relies on the availability of **shallow groundwater**.
- **Wetlands** such as paperbark swamp forests and mound springs.
- **River baseflow systems** where groundwater discharge, provides significant baseflow component to the river.
- **Subterranean** (aquifer and cave ecosystems) where life exists independent of sunlight.
- **Estuarine and near-shore marine systems**, such as coastal mangroves, salt marshes and seagrass beds, which rely on the submarine discharge of groundwater.

Whilst the majority of the proposed power station site does not have any GDEs mapped, the north-east corner of the site is identified as a moderate potential GDE featuring Woodlands on coastal sand vegetation that rely on the availability of shallow groundwater (refer Figure 5-11). The gas pipelines and electricity transmission lines would be developed across land identified as high, moderate and low potential terrestrial GDEs.

The Hunter River situated approximately 450 m to the east and 1.5 kms to the south-west of the site is also identified as an high potential aquatic GDE.

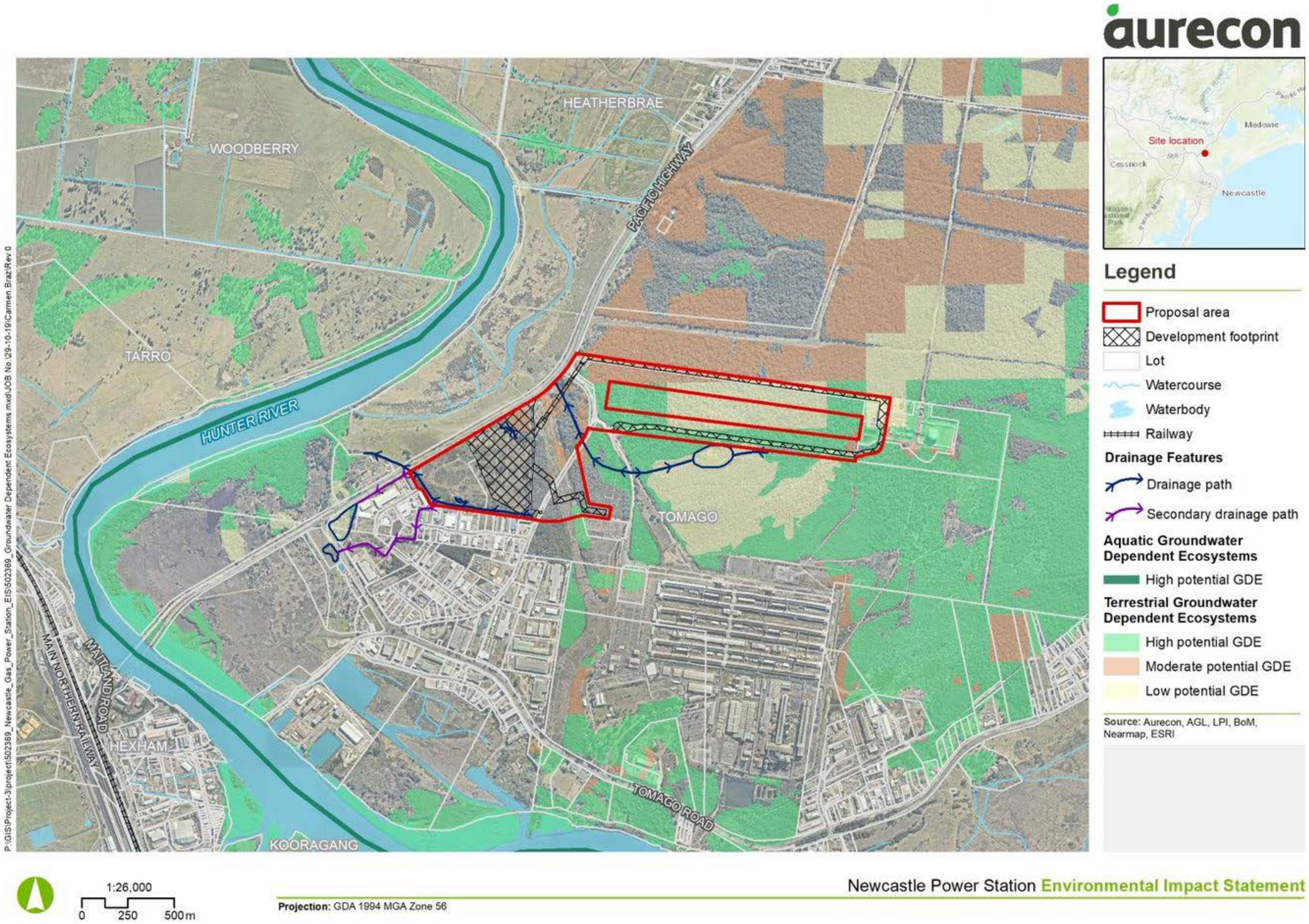


Figure 5-11 Groundwater Dependent Ecosystems (GDE)

5.4.3 Regional groundwater users and Water Sharing Plans

Information available through the NSW Water Quality and River Flow Objectives indicates the Proposal area is located within the Hunter River Catchment 'Estuary Zone'. Within this zone, the quality of groundwater needs to be protected, particularly in the Kooragang and Fullerton Cove areas. Groundwater levels should not be depleted in areas of acid sulfate soils, which underlie most of the estuary.

Information available through the Hunter Water Catchment Management Plan (2012) indicates that the power station site is not located within the gazetted Tomago Special Area (drinking-water catchment in the Tomago Sandbeds aquifer). However, the proposed gas pipelines and electricity transmission line would be located within the special area.

The Proposal area is located within the NSW Water Sharing Plan (WSP) for the North Coast Fractured and Porous Rock Groundwater Sources (DPI, 2016). The area was formally managed under the Tomago Tomaree and Stockton Groundwater Sources WSP, however the latter sharing plan was merged into the former plan when it was published in 2016.

The North Coast Fractured and Porous Rock Groundwater Sources WSP declares the amount of water available for abstraction on an annual basis, it also defines the sharing objectives and guidelines to ensure water is appropriately shared between the environment and licensees, and between the different categories of licences. Excluding basic landholder rights, all water extraction must be authorised under a water access license. The Tomago Sandbeds groundwater source is currently fully allocated, and no new licenses for this area are being issued at this stage. The Proposal does not intend to extract groundwater resources for construction or operation and will source potable water from municipal supply. The Proposal is not expected to impact on adjacent licensed water users or existing groundwater infrastructure.

Management plans should be put in place to ensure that the development does not affect the water quantities, water qualities or associated ecosystems that are recognised under this WSP.

5.4.4 Local groundwater resource and users

Review of access data available through the NSW Department of Primary Industries - Water NSW and Commonwealth of Australia (Bureau of Meteorology) for the project site indicate 35 registered groundwater bores within one (1) kilometre of the proposal area (see Figure 5-12). The metadata associated with these bores are presented in Table 5-3**.**

Table 5-3 Registered Groundwater Bores

ID	Depth (mbgl)	Purpose	Status	Reference Elevation (AHD)	Latitude	Longitude
GW079412	-	Unknown	Unknown	3.03	-32.806865	151.712897
GW079437	-	Unknown	Unknown	15.34	-32.820699	151.725911
GW079455	-	Water supply	Unknown	7.34	-32.818242	151.735346
GW079456	-	Water supply	Unknown	7.34	-32.817795	151.734808
GW079484	-	Unknown*	Unknown	6.89	-32.806365	151.725753
GW079507	-	Unknown	Unknown	8.22	-32.819772	151.728819
GW079509	-	Monitoring	Unknown	7.67	-32.818474	151.734179
GW079510	-	Unknown	Unknown	6.8	-32.815564	151.733633
GW079511	-	Unknown	Unknown	7.71	-32.816881	151.733635
GW079542	-	Unknown	Unknown	7.81	-32.821917	151.731299
GW079561	-	Unknown*	Unknown	9.76	-32.804864	151.726308
GW079591	-	Unknown	Unknown	3.01	-32.808194	151.7115
GW079605	-	Unknown	Unknown	3.06	-32.814853	151.697732
GW079722	-	Unknown	Unknown	13.03	-32.822882	151.712773

ID	Depth (mbgl)	Purpose	Status	Reference Elevation (AHD)	Latitude	Longitude
GW079723	-	Unknown	Unknown	13.55	-32.822334	151.714746
GW079724	-	Unknown	Unknown	19.9	-32.821631	151.719147
GW079725	-	Unknown	Unknown	10.18	-32.823786	151.712012
GW079726	-	Unknown	Unknown	9.61	-32.814028	151.724533
GW079730	-	Unknown	Unknown	10.61	-32.824133	151.715105
GW200102	-	Monitoring	Unknown	1.94	-32.800172	151.716275
GW200980	4.2	Monitoring	Functional	9.27	-32.810628	151.727031
GW200983	4.5	Monitoring	Functional	7.11	-32.811795	151.736156
GW200984	4.5	Monitoring	Functional	8.73	-32.813934	151.730999
GW201068	7.5	Monitoring	Functional	14.75	-32.820576	151.712766
GW201070	6	Monitoring	Functional	17.31	-32.823977	151.718913
GW201722	6.5	Monitoring	Functional	0	-32.814385	151.730982
GW201723	6.3	Monitoring	Functional	0	-32.81234	151.727657
GW201724	5.1	Monitoring	Functional	0	-32.810963	151.728862
GW201725	5	Monitoring	Functional	0	-32.811265	151.731069
GW201726	5.5	Monitoring	Functional	0	-32.811547	151.733031
GW201727	8.5	Monitoring	Functional	6.83	-32.812976	151.731696
GW201728	10.5	Monitoring	Functional	4.8	-32.811802	151.730634
GW201729	8.5	Monitoring	Functional	6.97	-32.811971	151.728581
GW201730	5.5	Monitoring	Functional	5.65	-32.812993	151.729795
GW202976	6.3	Monitoring	Functional	0	-32.812242	151.733095

* = Presumed to be one of the spearpoints for the Hunter Water pump station 20.

Information available regarding the registered bores indicate the status and purpose of the bores are largely unknown, with the exception of the new bores drilled to monitor the groundwater around the NGSF site in the east.

However, based the assessment for the NGSF (Coffey, 2011b) and on the groundwater draw zone for Hunter Water Pump Station 20 shown on Figure 5-14, 12 Hunter Water spearpoints are located along the roads where GW079561 and GW079484 (northwest of the NGSF) are located.

The closest functional bore to the proposed power station site is GW201068 (highlighted in blue in the table). The bore was drilled to 7.50 mbgl within the Quaternary alluvial formation approximately 500 m to the south-east of the site.

Review of geological information available from ‘GW201068’ indicates that the underlying geology is primarily characterised by a top layer of sand to a depth of 8 metres, below this clay extends down to 20 metres. Lithology of this nature is typical of the Tomago Sandbeds.

Private bore yields within the Sydney Basin-North Coast Groundwater Source are typically low (about 0.1 to 1L/s), but higher bore yields of up to 20 L/s can often be associated with fracture zones which allow for enhanced groundwater flow (DPI, 2016). The Sydney Basin-North Coast Groundwater Source is recharged primarily from rainfall. The valley floors with overlying Quaternary alluvium are areas for groundwater discharge with water levels within monitoring bores observed to be sub-artesian to artesian (DPI, 2016).

The Environmental Strategies (February 2018) assessment concluded that given the low hydraulic conductivity (0.1 m/day), a horizontal hydraulic gradient of approximately 0.01, and an effective porosity of approximately 20%, then a horizontal seepage velocity of about 2 m per annum is indicated. This indicates a low rate of migration of groundwater flow based on the assessments previously undertaken at the site.

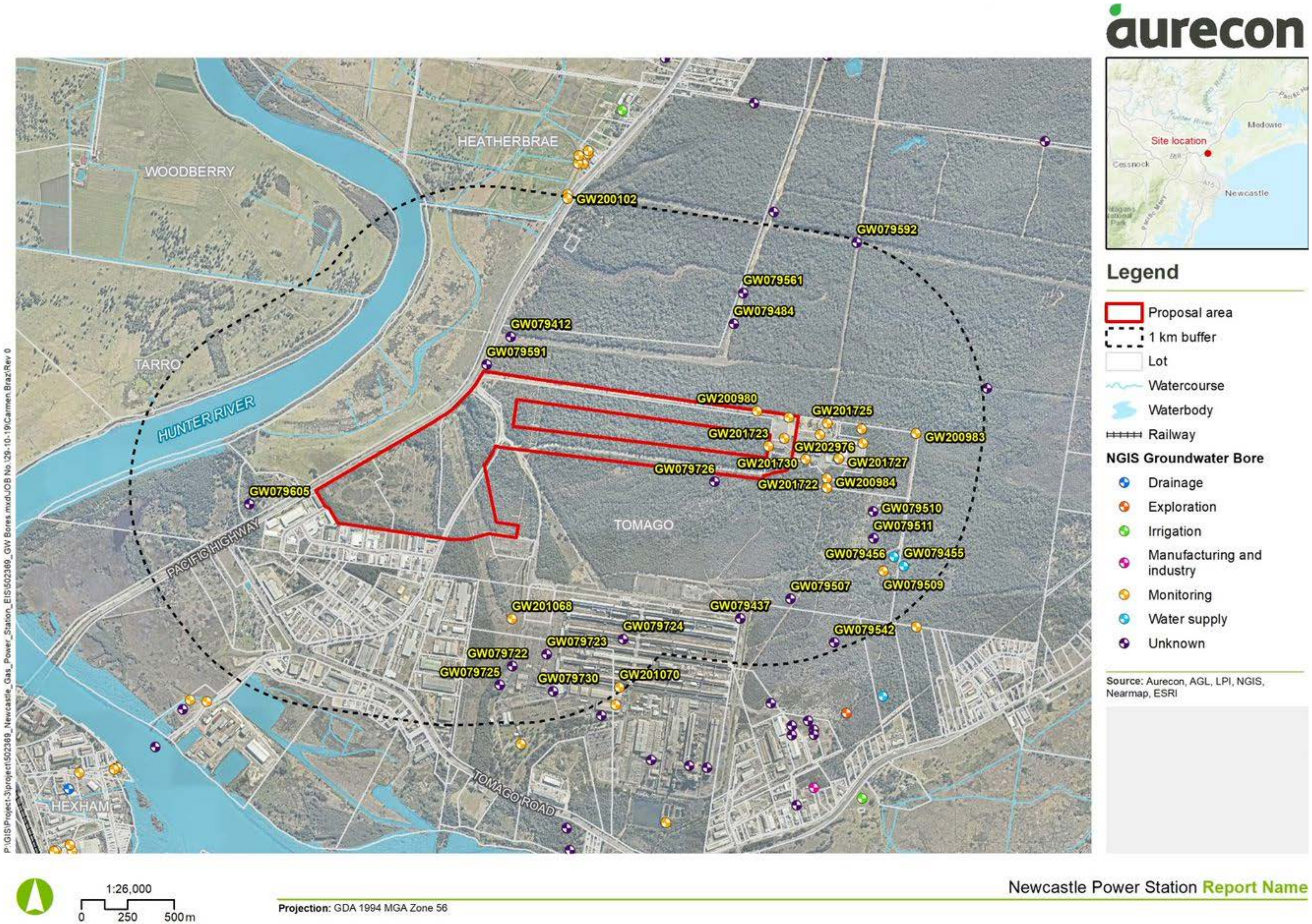


Figure 5-12 Registered Bores

5.4.5 Groundwater levels and flow

Woolley and others (1995) present a contour map of the regional groundwater levels measured predominantly in the Tomago Sandbeds aquifer (Figure 5-13). As shown on the inset on Figure 5-13, groundwater at the Project flows to the north to northwest towards the Hunter River. A northeast-southwest groundwater divide is present to the east of the Project. Hence, groundwater at the Project is not anticipated to flow towards the Ramsar-listed wetlands of the Kooragang Nature Reserve (including Fullerton Cove or the Hunter Estuary wetlands). For the NGSF environmental assessment (Coffey, 2011a) an set of inferred water-table contours using 2010 data was prepared. As with the 1995 contours, a groundwater divide was inferred in a location similar to the one shown on Figure 5-13.

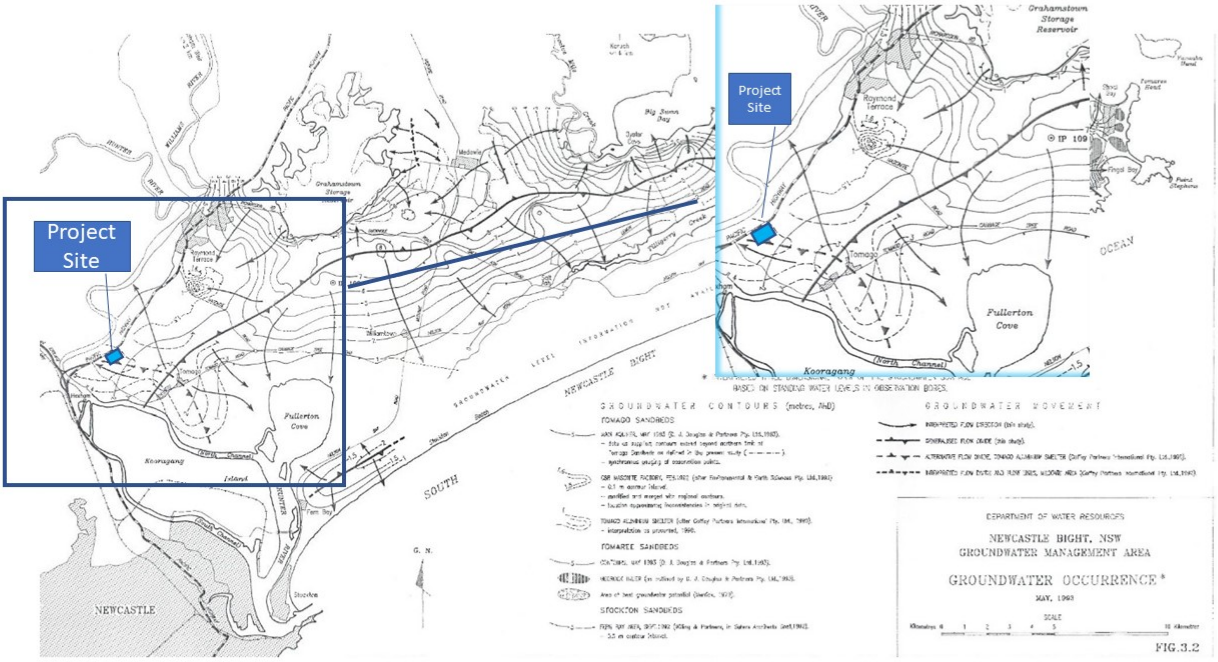


Figure 5-13 Inferred Regional Groundwater Contours (Woolley and others, 1995)

Proposed power station site

Investigations undertaken at the site by Environmental Strategies (February 2018) included the construction of 10 groundwater monitoring wells in the Proposal area as part of that study. The locations of these bores are shown on Figure 5-14. The bores indicated a range of depths to bedrock from 2 m and 15.6 m BGL. The geology is dominated by shallow bedrock, and the overlying Quaternary alluvium is dominated by clay fraction. The wells did not encounter water strikes during drilling indicating the alluvium to be a low effective permeability aquifer. A groundwater mound was interpreted with a differential flow path to the west-south-west and the north-east (Figure 5-15).

Figure 5-14 On-site monitoring bores (ES, 2018, Coffey 2011a and 2011b)

Figure 5-15 shows inferred groundwater contours for the proposed power station site based on 2018 groundwater levels measured by Environmental Strategies. Note that the groundwater levels reported for the northern cluster of wells (ESMW01, ESMW02, ESMW04, and ESMW10) may not have stabilised as these groundwater levels seem anomalously low compared to the level reported for ESMW09. The contours indicate that shallow groundwater flows radially from the proposed power station site towards Hunter River and the lowlands flanking the site, where the local flow merges with the regional flow of groundwater towards the Hunter River. This local flow of groundwater is consistent with the regional flow of groundwater shown on Figure 5-13.

An interpolation of the groundwater levels beneath the power station site was prepared using kriging in ESRI ArcMap using the inferred groundwater contours mapped and the groundwater depths recorded from the boreholes in the Environmental Strategies 2018 study. This data was compared with the existing topography and the reduced levels from a conceptual design of the proposed pad along two cross-sections oriented approximately southwest-northeast and north-south (Figure 5-16 and Figure 5-17, respectively) to determine the risk of intercepting the groundwater table when constructing the power station pad in the proposed cut-and-fill balance. Whilst the groundwater data used for the interpolation is restricted to a single point in time (December 2018) and therefore indicative only, the monitoring was undertaken at the end of the wet season and following a period of intense rainfall, which would have locally recharged the groundwater table, and can therefore be considered somewhat conservative.

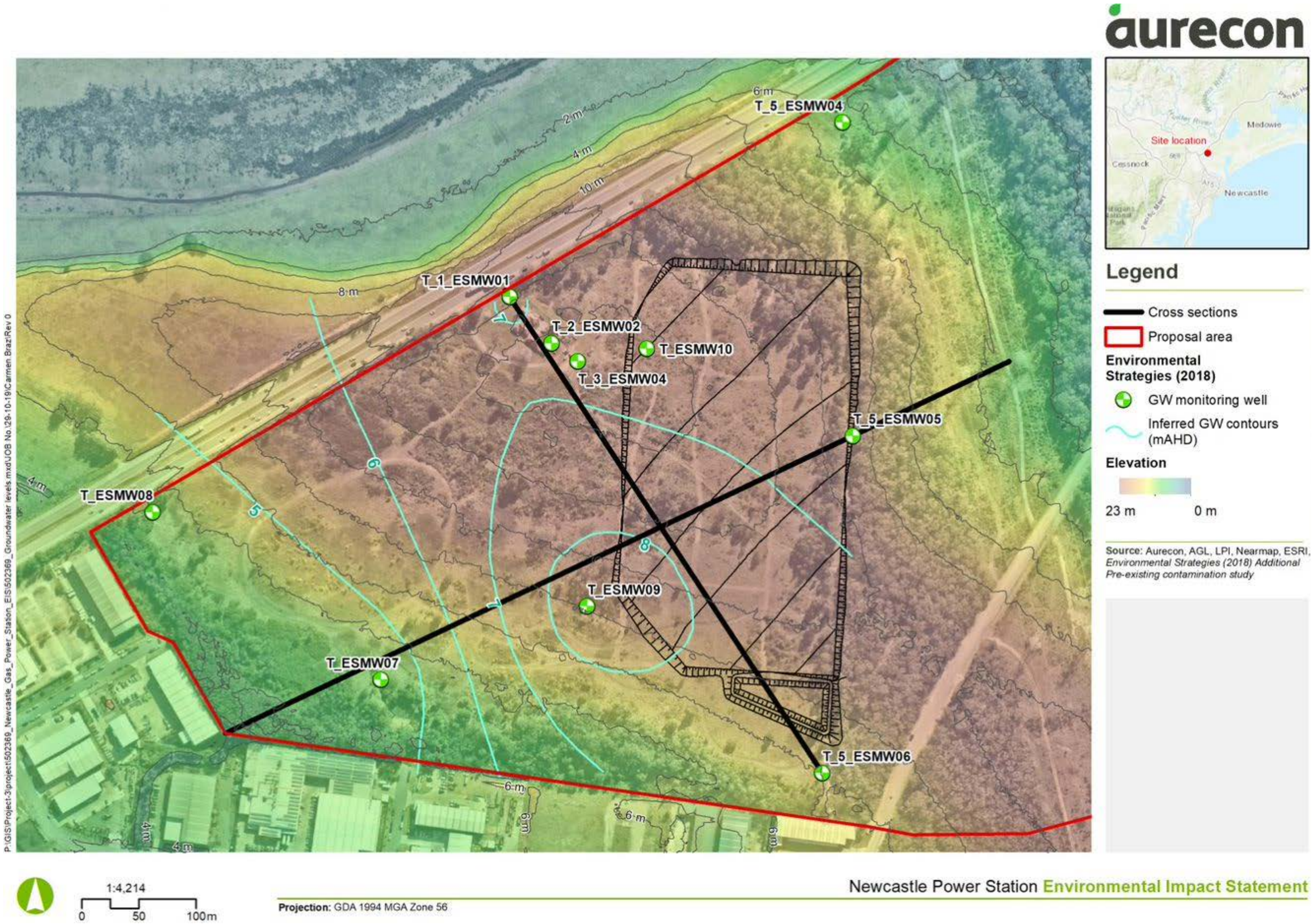


Figure 5-15 Proposed Power Plant Site - Inferred Groundwater Contours (Environmental Strategies, 2018)

The cross sections on Figure 5-16 and Figure 5-17 show that the proposed pad for the power station is not anticipated to intersect the water table (even with an increase in groundwater levels in the northern cluster of monitoring wells mentioned above). Based on the interpolation and the cross sections, in the vicinity of the proposed power station pad:

- The proposed power station pad straddles part of the interpreted groundwater mound
- The depth to the groundwater table ranges between approximately 4 and 8 m below the existing land surface (along the east- west cross section) and between approximately 3 and 7 m below the existing land surface (along the north-south cross section)
- The proposed cut/fill balance construction methodology should not intercept the groundwater table
- The depth to groundwater interpolated appears sufficient to enable the proposed construction activities (tree removal, grubbing, topsoil stripping, cut-and-fill earthworks, compaction, and installation of underground services) without intercepting the groundwater table (minimum clearance of approximately 2 m interpolated in the south-west)
- The construction of the proposed pad would not intercept or alter groundwater levels and therefore would not impact on GDE in this area during construction
- The power station bench would be predominantly constructed on fill where closest to the water table
- Following construction of the proposed pad, the groundwater table would be between approximately 5 and 6 m below the finished surface (east to west) and between approximately 2 and 8 m below the finished surface (north to south).

Figure 5-16 Proposed Power Plant Site – Southwest-Northeast Cross Section

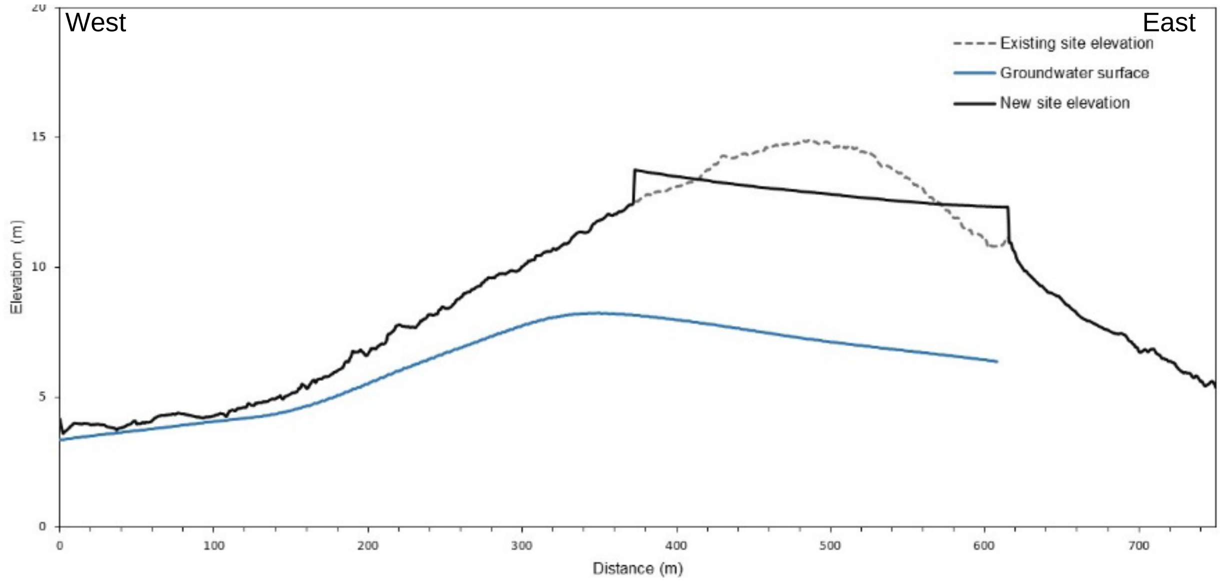
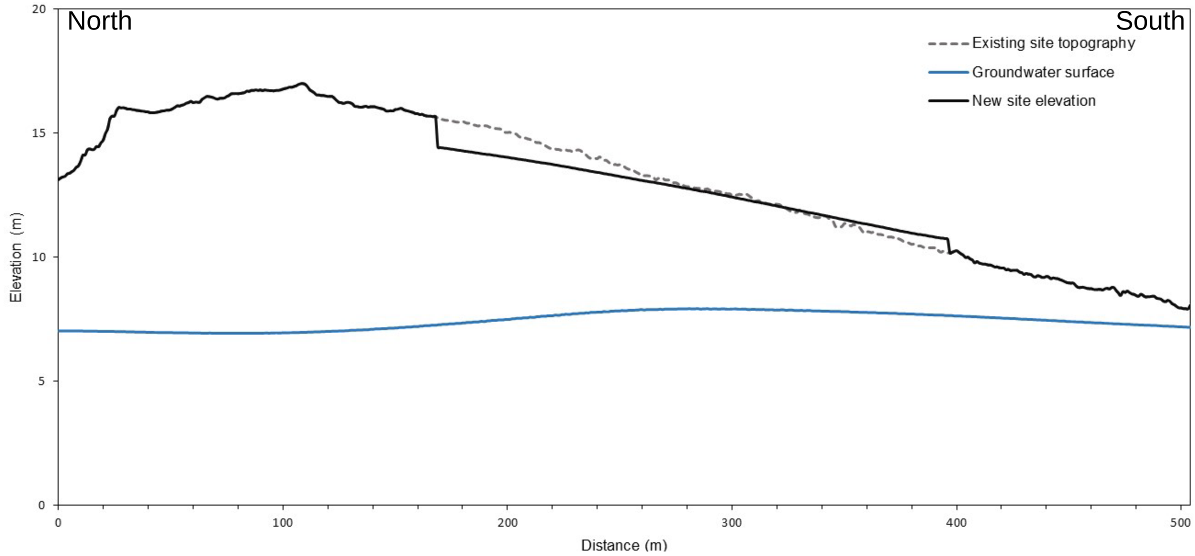


Figure 5-17 Proposed Power Plant Site – North-South Cross Section



Proposed pipeline and transmission corridor

For the NGSF investigation Coffey installed three wells screened in the Tomago Sandbeds aquifer (Figure 5-19). Measured water levels along with the slug test results are presented in Table 5-4 (Coffey, 2011a). MW1 is located at the eastern end of the northern pipeline easement. Note that the depths to water measured in MW1 are greater than 2 mbgl, which indicates that the pipe trench floor would be above the water table in this area.

Table 5-4 Groundwater Levels and Slug Test Results for Monitoring Bores (Coffey, 2011a)

Bore ID	Total Depth (mbgl)	Groundwater Depth (September 2010) (mbgl)	Groundwater Elevation (September 2010) (m AHD)	Groundwater Depth (June 2011) (mbgl)	Horizontal Hydraulic Conductivity (September 2010) (m/d)
MW1	4.2	2.43	1.57	2.10	7.4
MW2	3.5	0.32	3.03	0.08	9.6
MW3	4.5	3.15	3.15	3.07	11.3

At the western end of the southern pipeline easement groundwater has been reported at a depth of approximately 0.85 mbgl (WorleyParsons, 2013). This suggests that the trench floor would be below the water table and dewatering may be required to construct the pipeline in the western portion of both easements.

More recent monitoring of groundwater levels at the NGSF (GHD, 2019) show that at the NGSF the groundwater levels within the Tomago Sandbeds aquifer range between approximately 1 mAHD (MW1) and 5 mAHD (MW3A). Groundwater levels fluctuate consistently driven by recharge and discharge events associated with periods of high and low rainfall. The levels are expected to be lowest at the end of the dry season before the summer rains recharge the system. Note that these groundwater elevations are lower than levels reported for the shallow groundwater at the proposed power station site.

Figure 5-18 NGSF – Groundwater Elevations and Cumulative Rainfall Departure (CRD) (after GHD, 2019)

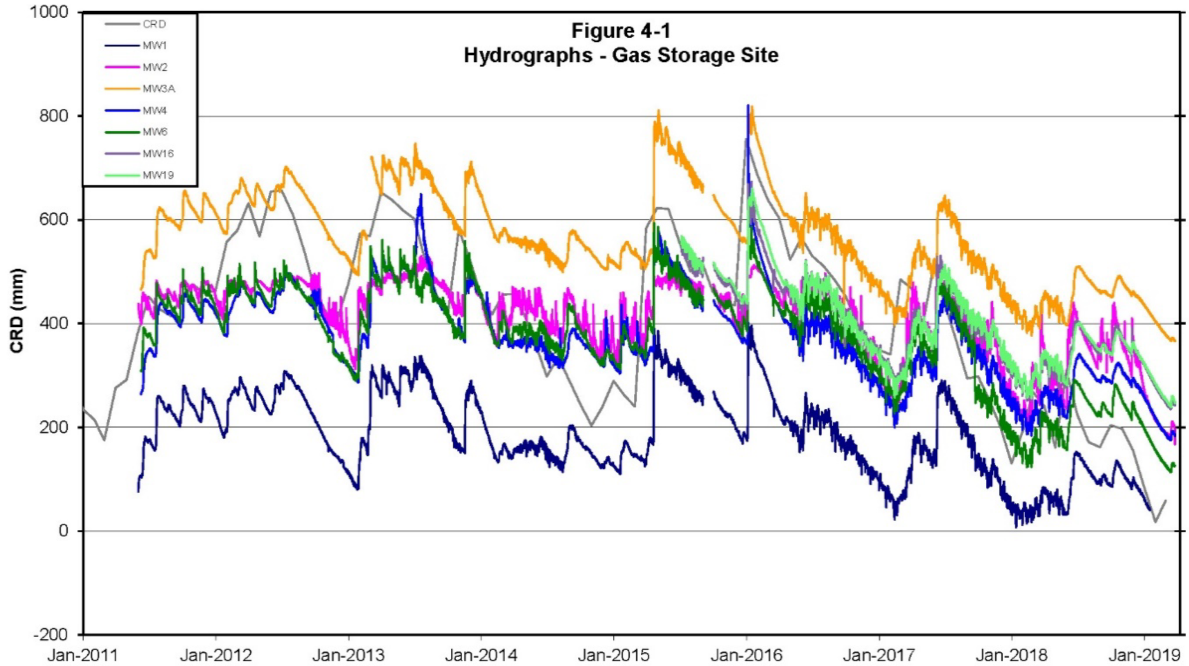
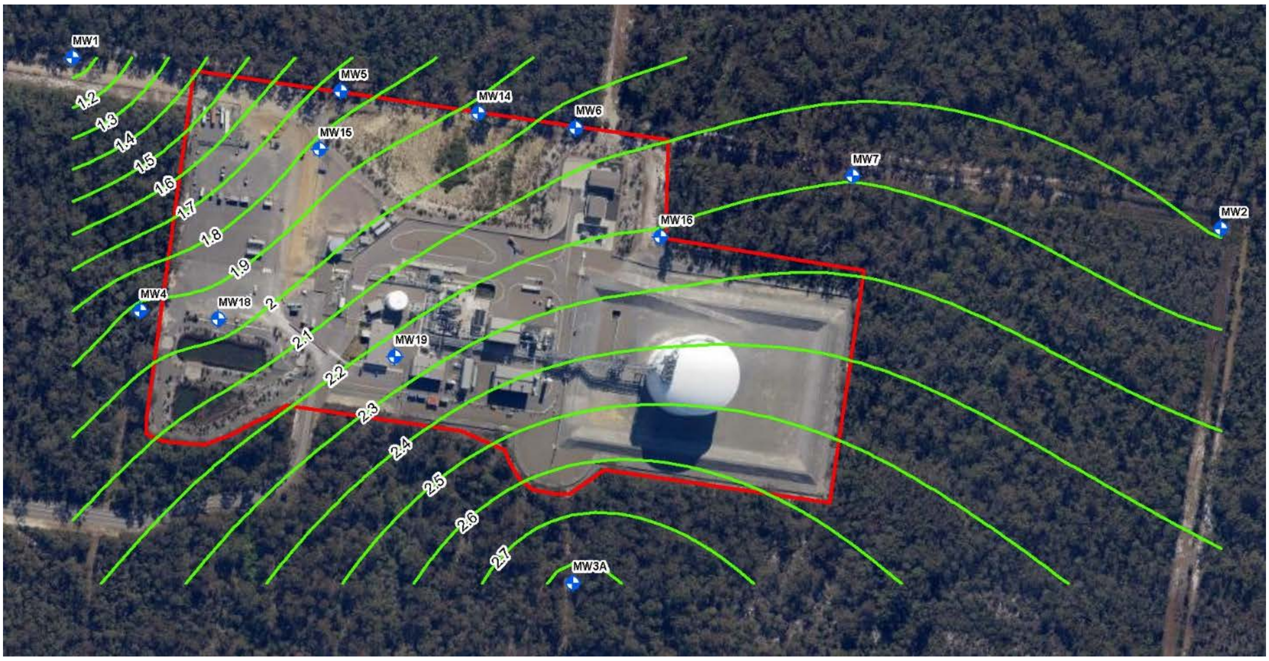


Figure 5-19 shows that at the NGSF shallow groundwater in the Tomago Sandbeds aquifer generally flows to the northwest towards the Hunter River. This flow direction is consistent with the regional flow system shown on Figure 5-13.

Figure 5-19 NGSF – Inferred Groundwater Elevations – March 2019 Measurements (GHD, 2019)



5.4.6 Groundwater quality

The 2018 Environmental Strategies (February 2018) sampling program, which targeted the proposed power station site, included field measurements of temperature, reduction-oxidation potential (redox), dissolved oxygen, electrical conductivity (EC), and pH. Ranges of measurements for these parameters are presented in Table 5-5. Note that the EC measurements indicate that groundwater is fresh to brackish at the proposed power station site. In contrast, as shown in Table 5-6, field measurements taken during purging of the NGSF monitoring wells (Environmental Strategies, 2018), which would be representative of groundwater quality along the Proposal pipeline alignments, indicated that groundwater was fresh, which is typical for groundwater in the Tomago Sandbeds aquifer (Woolley and others, 1995).

Table 5-5 Proposed Power Station Site: Summary of Field Parameters (ES, 2018)

Parameter Range	Temperature (C°)	Redox (mV)	Dissolved Oxygen (mg/L)	EC (µS/cm)	pH
Minimum	17.4	85.6	0.36	293	3.87
Maximum	20.3	414.2	5.97	16,768	5.22

Table 5-6 NGSF Summary of Field Parameters (Coffey, 2011b)

Parameter Range	Temperature (C°)	Redox (mV)	Dissolved Oxygen (mg/L)	EC (µS/cm)	pH
Minimum	15.2	-72.0	0.6	99.0	3.4
Maximum	19.6	138.0	3.8	178.0	5.3

Results from the sampling program detected several chemicals of potential concern (CoPCs) with elevated concentrations in groundwater samples. A summary of the water quality results is provided in Table 5-7 below.

Table 5-7 Water Sampling Results (ES, 2018)

Units: µg/L	Arsenic	Cadmium	Cadmium (Filtered)	Chromium (III+VI)	Chromium (III+VI) (Filtered)	Copper	Copper (Filtered)	Lead	Lead (Filtered)	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)
NEPM 2013 B1 Table 1C GILs, Fresh Waters (A)	**13**	**0.2**	**0.2**	**1**	**1**	**1.4**	**1.4**	**3.4**	**3.4**	**0.06**	**0.06**	**11**	**11**	**8**	**8**
NEPM 2013 B1 Table 1C GILs, Marine Waters (A)		**0.7**	**0.7**	**4.4**	**4.4**	**1.3**	**1.3**	**4.4**	**4.4**	**0.1**	**0.1**	**7**	**7**	**15**	**15**
Median Concentration	3	0.1	0.075	**3.5**	0.5	8	4	11	4.5	0.025	0.025	38	36	99	115
Maximum Concentration (Location: T_5_ESMW***XX***)	13 (06)	2.2 (06)	2.1 (06)	11 (10)	6 (10)	50 (05)	42 (05)	45 (06)	33 (06)	0.11 (02)	0.07 (02)	150 (06)	140 (06)	870 (06)	780 (06))

*Red text: Exceeds both criteria
**Purple Text: Exceeds only the Fresh Water Criteria

The following concentrations were detected above the relevant Groundwater Assessment criteria (GAC) as summarised below:

- National Environment Protection Measure (NEPM) 2013 (NEPC, 2013) B1 Table 1C GILs Fresh Waters (A) Guideline. (Groundwater Investigation Level – GIL)
  - Arsenic: 1 times the Site Assessment Criteria (SAC).
  - Cadmium: 1 times the SAC.
  - Chromium: 8-9 times the SAC.
  - Copper: 12 - 36 times the SAC.
  - Mercury: 1.5 times the SAC.
  - Nickel: 3 - 13.6 times the SAC.
- NEPM 2013 B1 Table lC GILs Marine Waters(A) Guideline.
  - Cadmium: 1.4-3.1 times the SAC.
  - Chromium:1.8-2.0 times the SAC.
  - Lead: 4.1-10.2 times the SAC.
  - Zinc: 8.7-58 times the SAC.
- NEPM 2013 B1 Table lC GILs Drinking Water (B) Guideline.
  - Arsenic: 1.2-1.3 times the SAC.
  - Cadmium: 1.1 times the SAC.
  - Lead: 1.8-4.5 times the SAC.
  - Nickel: 1.7-7.5 times the SAC.
  - Benzo(a)pyrene: 14 times the SAC.

ES considered the above concentrations would constitute contamination and / or pollution. With respect to background groundwater quality, ES have concluded that the well that is most likely to represent local background conditions is T_ESMW09. This well is located centrally on the site and is the well with the highest groundwater elevation, indicating that it is unlikely to be impacted by surrounding existing development. Apart from nickel, all metals within T_ESMW09 were found to be below the GAC. ES adopted the result from T ESMW09 as the low reliability background screening level (LRBSL) for nickel only.

Several CoPCs were detected in concentrations exceeding the adopted GAC in the Background areas of the site. The exceedances are provided below:

- NEPM 2013 Bl Table 1C GILs Fresh Waters (A) Guideline for groundwater.
  - Cadmium: 2 times the SAC.
  - Copper: 10-165 times the SAC.
  - Chromium: 2-11 times the SAC.
  - Zinc: 1.4 times the SAC.
- NEPM 2013 Bl Table lC GILs Marine Waters(A) Guideline.
  - Lead: 1.6-7.3 times the SAC.
  - Chromium: 2.5 times the SAC.
  - Zinc: 1-18 times the SAC.
- NEPM 2013 Bl Table lC Glls Drinking Water (B) Guideline.
  - Lead: 1.1-2.2 times the SAC.
- Tomago Development Site LRBSL (Ni).
  - Nickel: 1- 3.4 times the SAC.

The high concentrations of copper detected in sampled groundwater are similar across the eastern half of the site, both in background and areas of environmental concern. Based on the inferred northwest groundwater flow direction (refer Figure 5-19), it is unlikely that the concentrations of copper detected in the background areas on the Tomago Development Site are evidence of impact from the on-site areas of environmental concern. No potential source of copper was noted during the ES Phase 1 ESA (ES, 2017) or during the fieldworks, either on or off site, nor was copper detected in elevated concentrations in soil at any location sampled across the site. Therefore, copper is inferred to be naturally elevated in site groundwater.

The investigation area associated with the proposed gas pipelines was not accessed during the 2018 field campaign. However, data is available from the 2011 NGSF Assessment (Coffey, 2011a) for this area. The data for the three monitoring boreholes (refer Figure 5-19) is shown in Table 5-8 and Table 5-9.

Table 5-8 Groundwater Quality Data (Coffey, 2011)

Units: µg/L	Arsenic	Cadmium	Chromium (III+VI)	Copper	Lead	Nickel	Zinc
NEPM 2013 B1 Table 1C GILs, Fresh Waters (A)	**13**	**0.2**	**1**	**1.4**	**3.4**	**11**	**8**
NEPM 2013 B1 Table 1C GILs, Marine Waters (A)		**0.7**	**4.4**	**1.3**	**4.4**	**7**	**15**
Detection Limit	***1***	***0.1***	***1***	***1***	***1***	***1***	***1***
MW1	1	BTL	**1**	<1	BTL	1	66
MW2	<1	BTL	**2**	<1	BTL	<1	55
MW3	<1	BTL	**2**	1	BTL	<1	51

*BTL: Below Detection Limit; **Red text: Exceeds both criteria; ***Purple Text: Exceeds only the Fresh Water Criteria

Table 5-9 Groundwater Quality Data – General Indicators and non-metallic inorganics (Coffey, 2011)

	pH	Electrical Conductivity	Calcium	Magnesium	Sodium	Chloride	Fluoride	Sulfate
Units		***µS/cm***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***	***mg/L***
MW1	5.4	160	1.9	4.6	30	25	0.04	22
MW2	5.4	190	2.7	3.3	43	41	0.02	7
MW3	5.0	130	3.1	4.4	21	22	0.03	19

These results indicate a significantly different water quality profile within the proposed pipeline area compared to that observed within the proposed power station area. This supports the current system understanding that these areas are underlain by different aquifer systems. The results indicate a relatively pristine environment, increasing the potential for adversely affecting it without appropriate mitigation measures and management plans in place.

6 Impact assessment

6.1 Construction impacts

This section identifies and assesses the potential impacts and management options associated with the construction phase activities of the Proposal.

6.1.1 Construction phase activities

The power station is anticipated to be in operation in 2022. Key construction activities for the Proposal include:

- Clearing of limited vegetation at the proposed power station site and as required along the electrical transmission and gas pipeline corridors
- Demolition of existing house if not repurposed during construction and operation
- Installation of gas pipelines and electrical transmission line infrastructure
- Earthworks to prepare the power station site and construction areas
- Installation of foundations and underground services
- Installation of aboveground civil, mechanical and electrical plant and equipment
- Commissioning and testing

6.1.2 Potential impacts

Impacts to groundwater during construction may arise from excavation, earthworks or environmental management activities at the site. The groundwater system underlying the site is reliant on rainfall as its primary recharge method. Therefore, altered surface water runoff due to vegetation removal may potentially affect the local groundwater level. However, extensive additional clearing of vegetation is not anticipated for construction of the pipelines as the proposed alignment is within the area that had been cleared previously for construction of the NGSF pipeline.

Additional impacts may arise from contaminant spills and leaks throughout the construction phase. These may occur via the temporary storage and handling of fuels, oils and chemicals or the leaking of oil or fuel from construction equipment. By developing a detailed Construction Environment Management Plan (CEMP) and an accompanying Soil and Water Management Plan (SWMP) prior to beginning works, and ensuring all relevant staff are trained in the requirements of these plans, potential impacts can be suitably managed. By implementing these plans, a Neutral or Beneficial Effect (NorBE) on the receiving groundwater quality can be demonstrated.

The groundwater evaluation described in Section 5.4.5 indicates that construction of the power station pad using the proposed cut/fill balance methodology would not intercept the regional groundwater table. The potential for encountering excessive groundwater during construction activities is significantly higher in the area where the proposed gas pipelines will be installed along the northern and southern easements, compared to the actual power station site which is located on a topographic high-point.

As discussed on Figure 5-18, groundwater elevations reported for MW1 (located at the eastern end of the northern pipeline easement) has ranged between approximately 1 mAHD and 3 mAHD. Ground elevation in this area is between approximately 4 mAHD and 6 mAHD

The Environmental Assessment (EA) undertaken for the NGSF (Coffey, 2011a) indicated that groundwater in the area generally discharges to the adjoining Hunter River and preventing surface-water contamination was the key to preventing impacts to groundwater. The groundwater study that informed the EA assessed the Tomago Sandbeds aquifer as having a having a high vulnerability rating because of the highly permeable sandy soils, the shallow water table and the value of the groundwater resource as a water supply source for the region as well as a source of environmental water for GDEs. The EA concluded that there would be no measurable groundwater impact from construction and operation of the NGSF on GDEs in the immediate vicinity of the gas plant site, along the proposed pipeline and access road or further away at the Hunter Estuary Wetlands Ramsar Site. The EA also found that development of the NGSF would meet the required groundwater policies regarding protecting water quality and quantity. In particular, although the eastern portion of the NGSF is located within the draw zone of the Hunter Water pump station 20, construction and operation of the NGSF would not adversely impact on the operation of the Hunter Water bore field.

Experience from construction of the NGSF can inform regarding potential groundwater issues that might occur during construction of the gas pipeline for this project. Trench depth for the Proposal pipelines will be similar to the adjacent DN400 NGSF pipeline (approximately 1.5 m BGL). Extracted groundwater is understood to have been re-injected at least 50 m away from the excavation. Results for samples of groundwater collected from the NGSF monitoring network has not identified any adverse impacts (although naturally elevated concentrations of some metals were reported). It is therefore expected that construction of the Proposal pipeline and transmission corridor would not adversely impact on groundwater.

Some segments of the gas pipeline for this Proposal are anticipated to be installed below the water table, which is between approximately 0.08 m and 3 m BGL. Hence, dewatering is likely to be required during pipeline construction. Therefore, installation of the pipeline below the water table could potentially impact on groundwater flows and GDEs within the area. Project plans indicate works to be conducted approximately 2 m to 3 m below the land surface with the pipeline constructed of DN1050 (42") ASME Class 900 pipe. The installation of the pipeline will require boring pits (and associated tunnelling or HDD) where it crosses existing services or roads, all other portions along the pipeline route will be trenched with an estimated depth of cover between 900 mm and 1,200 mm from the top of pipe to the surface. Where the buried pipeline is oriented across the flow direction of groundwater damming of shallow groundwater could occur. However, the soil surrounding the pipeline will typically be coarse-grained material (sand or gravel assigned to the Tomago Sandbeds) that would facilitate the flow of groundwater around the pipe and mitigate adverse impact on the flow of shallow groundwater by the pipeline. This design would also mitigate potential adverse impacts on GDEs near the proposed alignment by reducing the disturbance of the flow of shallow groundwater along the proposed pipeline alignment.

Although ASS was not detected in soil samples collected along the NGSF pipeline alignment, due to the depth of the Proposal pipeline, there is the potential to encounter ASS during trenching and tunnelling works for the pipeline, which could release acidic leachate into adjacent drains and wetlands if not contained. Excavation and tunnelling activities will need to implement ASS testing and management procedures (including containment and treatment requirements). These procedures and requirements will be set out in the ASS management plan, which will be prepared during detailed design.

At the proposed power station site it is not anticipated that regional groundwater would be encountered during earthworks for the power station. Localised perched water may be encountered during excavation, but it is not anticipated that shallow excavations for construction of the power station would encounter significant in-flow or create enduring impact on regional groundwater level.

The SWMP would include measures to minimise soils and erosion, capture and management of stormwater and groundwater during excavation and the options for management of water encountered (such as use in dust suppression, landscaping and release as stormwater or reinjection into the water table, dependent on water quality).

Table 6-1 Potential Construction Phase Issues and Proposed Controls

Source of potential impact	Impact	Proposed Control
Earthworks including stockpiling	Earthworks will involve the removal of topsoil and vegetation, destabilising the soil and generating dust Sediment erosion and potential for pollutants to move off site and impact groundwater and surface water	Mitigation should be outlined within the CEMP Erosion and Sediment Control Plan (ESCP) provided as an appendix to the CEMP Dust suppression would be implemented throughout the construction phase of the project Geofabric would be used on stockpiles throughout the course of construction Appropriate sediment basins would to be constructed
Heavy vehicle movement	Heavy vehicle movement across the soil has the potential to destabilise the soil	Heavy vehicles and machinery would only use allocated tracks to minimise soil erosion
Increase in impervious surfaces	Reduction in recharge to groundwater aquifers	Limit the amount of impervious surface development. Post construction, rehabilitate compacted areas not needed for operational activities by loosening the soil, adding organic matter and revegetating the area.
Removal of vegetation	Land clearing has the potential of destabilising the soil, promoting erosion of the area	Vegetation removal would be limited as far as practicable. Only vegetation approved by ecologist or arborist would be removed Relocate the removed native plants to other areas on site where possible (based on advice provided by ecologist or arborist)
Aquifer Interference	Requirement for increased dewatering during construction and higher risk of contaminating groundwater system.	Any water encountered and abstracted from the Tomago Sandbeds aquifer should be re-injected locally back into the aquifer approximately 50 m distant on the hydraulically down-gradient side of the construction works. Prior to re-injection the abstracted groundwater must be inspected for any signs of contamination (high turbidity, oily sheen or odour of hydrocarbons) and tested for water quality parameters (temperature, dissolved oxygen, redox, EC, and pH), which would be compared to measurements from nearby monitoring wells. If greater than 10% difference with the groundwater measurements treatment would be required prior to re-injection. If collected groundwater does not meet criteria for re-injection, then the collected groundwater must be disposed to either sanitary sewer (as permitted trade waste) or to a facility licenced to accept and treat contaminated water. When working near the aquifer boundary, additional precautions should be made when using or transporting fuels and chemicals, and any spills should be immediately contained, and the impacted material removed from the site to a facility licenced to accept the impacted material.

Source of potential impact	Impact	Proposed Control
Working in groundwater / Intercepting the groundwater table	Increased risk of contaminating groundwater exposed in the excavation. Safety issue with regards to ground stability. Temporary lowering of the water table that could adversely impact nearby GDEs.	Controls and mitigation measures will be outlined within the CEMP; chemical containment plan and reporting of any spills; extracted groundwater will be stored pending characterisation for either re-injection or disposal after treatment (as needed to comply with discharge requirements). Use appropriate materials, such as trench shields or sheet piles, to maintain the stability of excavation walls. Dewater to lower water table beneath the floor of the excavation to provide a safe and dry working surface. Consider undertaking trenching and HDD outside likely wet periods to reduce the volumes of groundwater extracted; HDD techniques will be used to avoid excavating across drainage paths.
Pollution associated with construction	Oil and fuel and chemical spills associated with machinery Waste from construction	Controls and mitigation measures will be outlined within the CEMP Chemical containment plan and reporting of any spills Provide adequate waste disposal bins on site
Acid sulfate soil	There is potential of encountering acid sulfate soils that may generate acid and further contamination to the area	Mitigation would be outlined within an Acid Sulfate Soil Management Plan The plan would include information relating to minimising groundwater dewatering (potentially oxidising potential acid sulfate soils)
Water degradation	Construction related works have the potential to degrade surface and ground water. The rapid infiltration rates associated with the sandbeds make the Tomago aquifer susceptible to contamination. GDEs may be adversely affected	Mitigation measures, including sealed pavement for refuelling and chemical storage, would need to be outlined within the CEMP. Specific attention should be given to addressing any spills or other mechanisms for contamination of the groundwater during construction of the pipelines. Spill kits and staff training would reduce the risk of adverse impact from leaks and spills. Where the trench extends below the water table, excavating the trench over short lengths will reduce the volume of groundwater extracted during construction. This would reduce the change in recharge and discharge volumes and qualities. Therefore, using this approach there is not expected to be any measurable groundwater impact on the GDEs in the immediate vicinity of the Proposal area.
Disturbance of contaminated soils and / or groundwater	Impact to the health of construction workers or nearby members of community. Impact to ecological health (e.g. nearby aquatic ecosystems in local creek or river)	Mitigation would be outlined within the CEMP and would include characterisation of the impacted materials and disposal to a facility licenced to accept this type of waste. This includes the use of Personal Protective Equipment (PPE) by construction workers, dust mitigation and sediment / stormwater migration prevention.
Hazardous Materials within the Residential Property	Based on the age of the residential property on site, there is a strong potential of the building containing hazardous materials such as asbestos, lead containing paint and PCBs	Completion of a pre-demolition hazardous materials survey, and based on the findings, implementation of any required controls for removing any identified materials (including licensed asbestos removalists)

6.2 Operational impacts

6.2.1 Operational phase activities

The power station is intended to be operated as a peaking plant capable of achieving a 5-minute start up period to full capacity. The station would be able to run off both gas and liquid fuel and be capable of running completely unmanned for operations. During operations, up to 14 personnel on shifts would be required, and an expected additional 15 personnel would be required for routine maintenance, based on a major overhaul. The control room would be available for local operation. However, it will generally be unmanned.

6.2.2 Potential impacts

Potential groundwater pathways between the power station site and the Tomago Sandbeds are unlikely to occur due to inferred flow of shallow groundwater towards the Hunter River rather than towards the Tomago Sandbeds. In the northern and southern pipeline easements a portion of the pipelines may be up to 1 m below the water table in the Tomago Sandbeds aquifer. However, it is not anticipated that the pipelines would significantly dam up groundwater. Hence, the pipelines are not anticipated to interfere with operation of the Hunter Water borefield associated with pump station number 20. Therefore, the Proposal is thus not expected to impact the Tomago aquifer or the Hunter Water boreline during the operational phase.

With regards to a complete groundwater pathway between the Proposal site and the Hunter River Estuary wetlands, the presence of a groundwater divide located to the south to southeast of the Proposal site prevents potentially impacted groundwater from reaching the wetlands.

There is the potential for altered local groundwater recharge on and surrounding the Proposal site. Conceptual plans of the Proposal development footprint indicate the development of impervious surfaces across approximately 30% of the site of the proposed power station, which would decrease the amount of local recharge. Due to the clayey nature of the underlying geology at the proposed site for the power station, this may cause local groundwater levels in the Tomago Coal Measures aquifer to drop. However, this is not anticipated to adversely reduce recharge of the Tomago Sandbeds aquifer, which is predominantly recharged directly by rainfall rather than lateral flow from surrounding aquifers.

Throughout operation of the power station there is the potential for fuel and contaminant spills. In addition, gas could leak from the pipeline(s) such that shallow groundwater could be impacted. While appropriate design of fuel storage infrastructure would render this unlikely, these may occur within storage and unloading areas or direct leaking from power station infrastructure and can be mitigated by a chemical storage containment plan and separate stormwater and chemical drains.

Table 6-2 Potential Operational Phase Issues and Proposed Controls

Source of potential impact	Impact	Proposed Controls
Accidental oil, fuel or chemical spill	Groundwater contamination may occur through accidental spills of oil, fuel and chemicals associated with the power station.	Mitigation should be outlined within the Operational Environmental Management Plan (OEMP) A leak-detection system f would alert station staff that gas is leaking from the pipeline(s) A chemical drains system would be provided for collection and treatment of chemical spills and storm water falling into bunded chemical storage areas (if outdoors) Chemical drains would be collected in a drains sump for testing and treatment before being piped to the process waste water system A Spill Containment Plan is required as well as reporting of any spills on the Spill Register A register of all hazardous chemicals kept on site is to be maintained and updated regularly Appropriate sediment basins to be constructed

Source of potential impact	Impact	Proposed Controls
Heavy vehicle movement	Heavy vehicle movement across the soil has the potential to destabilise the soil	Mitigation would be outlined within the OEMP Heavy vehicles and machinery would only use allocated tracks A Soil and Water Management Plan (SWMP) would be implemented during the operation phase Erosion and Sediment Control Plan (ESCP)
Increase in impervious surfaces	Reduction in recharge to groundwater aquifers and subsequent lowering of local groundwater table	Limit the amount of impervious surface development. Post construction, rehabilitate compacted areas not needed for operational activities by loosening the soil, adding organic matter and revegetating the area.
Water degradation	Operation related works have the potential to impact groundwater flow Groundwater Dependant Ecosystems (GDEs) may be adversely affected	Mitigation would be outlined within the OEMP Stormwater should be captured and treated and the discharge from the treatment process monitored to confirm ongoing effectiveness of the proposed system By ensuring minimal change in recharge and discharge volumes and qualities, there is not expected to be any measurable groundwater impact on the GDEs in the immediate vicinity of the proposal area.
Effluent discharge	Effluent discharged locally may adversely affect the water quality of the receiving environment	Process water is not to be discharged to the environment. Construction of appropriate sewage systems would accommodate increased human occupancy to the area (if any)
Storm water system	As the natural landscape will change, there is a potential risk of altering the natural drainage system Impacted stormwater discharged locally may adversely affect the water quality of the receiving environment. As the treated stormwater discharge is expected to flow to a depression from where it will evaporate and seep away, there is a potential for groundwater contamination via this pathway.	Stormwater plan including appropriate run-off water diversion. The proposed stormwater collection and treatment system (as detailed in the Surface Water and Hydrology specialist report) will treat the runoff generated to the required council standards prior to any discharge to the environment. The effluent from the system should be monitored to confirm ongoing efficiency.
Disturbance of contaminated soils and / or groundwater	Impact to the health of construction workers or nearby members of community Impact to ecological health (e.g. nearby aquatic ecosystems in local creek or river)	Mitigation would be outlined within the OEMP This includes PPE, dust mitigation and sediment / stormwater migration prevention

6.3 Cumulative impacts

The Proposal is situated in an area that is zoned for industrial purposes, it is adjacent to areas currently used for industrial purposes and is more than 2 km from the nearest residential zoning. Any minimal disturbance of groundwater flow as a result of the proposed construction and operation is unlikely to adversely impact on the ecological character of nearby waterways.

As the Proposal is located at a groundwater mound and the alluvial materials in the vicinity of the power station have been investigated as being of low effective permeability, it is considered that there is low potential for impact that may have any cumulative effect.

The proposed pipelines would be constructed along alignments that had been previously disturbed during construction of the NGSF. Therefore, it is not anticipated that construction of the gas pipeline would significantly increase the cumulative impact on the Tomago Sandbeds aquifer.

7 Mitigation

The following measures are recommended to manage groundwater impacts:

- Continue monitoring water level and quality at the established boreholes on the power station site and compare to background values
- Prepare a Groundwater Management Plan for the construction and operation stages of the Proposal as part of detailed design of the facility
- Include a leak-detection system to monitor for gas leaks from the pipelines
- Develop a detailed contingency plan to respond to groundwater contamination impacts
- Prepare a Spill Containment Plan
- Consult with NSW Office of Water to assess regulatory requirements for short-term dewatering and sourcing local groundwater for tank and pipeline testing
- Re-inject or infiltrate extracted groundwater of acceptable quality to reduce adverse impact on GDEs located near areas requiring dewatering during construction
- Revise groundwater dewatering requirements during construction activities as necessary
- Determine the final water management strategy for the infiltration and disposal of the pipeline hydrotesting water
- For areas planned as infiltration basins as part of the on-site stormwater detention and surface water management plan, conduct infiltration tests in test trenches to assess local infiltration rates
- To support design of a construction dewatering system conduct a groundwater assessment (including short-term aquifer testing) near any pipelines that will be trenched below the water table

Management plans to be generated for the Proposal are detailed in **Table 7-1**.

Table 7-1 Management plans to be implemented throughout the construction and operational phases

Management Plan	Description
Construction and Operation Environmental Management Plans (CEMP and OEMP)	These plans would outline the environmental risks, mitigation proposed (including PPE and engineering measures), monitoring requirements, contingency planning and responsibilities.
Soil and Water Management Plan	This document will incorporate the plans detailed below.
Surface Water Management Plan	The plan would describe best practice surface water control measures to reduce the risk of contamination of surface water or the alteration of surface water flows.
Groundwater Management Plan	As there is potential for groundwater flow and quality to be impacted, a groundwater management plan would be prepared. As the water table may be lowered (due to dewatering to construct the portions of the pipeline located below the water table), the management plan would need to cover this aspect of the work and mitigation to be in place to minimise oxidation of PASS and limit impacts to GDEs and groundwater flows (including groundwater extracted by Hunter Water).
Acid Sulfate Soil Management Plan	The Acid Sulfate Soil Management Plan focuses on environmental risks associated with acid sulfate soil and appropriate management of these risks. The guidance provided should be based on the Acid Sulfate Soil Manual published by the Acid Sulfate Soil Management Advisory Committee in 1998 (ASSM, 1998).

Management Plan	Description
Spill Containment Plan	This Spill Containment Plan describes planning, prevention and control measures to minimize impacts resulting from spills of fuels, petroleum products, or other chemicals. All spills would be recorded in a Spill Register
Erosion and Sediment Control Plan	An Erosion and Sediment Control Plan (ESCP) would need to be prepared in accordance with the Landcom: Managing Urban Stormwater Volume 1 (2004, Blue Book)
Construction Waste Management Plan	A Construction Waste Management Plan would be implemented throughout the construction phase of the project and would be done in accordance with the EPA guidelines.

Potential mitigation measures (environmental safeguards) are presented in Table 7-2.

Table 7-2 Environmental safeguards related to direct/prescribed and indirect impacts

Impact	Environmental Safeguard	Timing
Groundwater – general	A Groundwater Management Plan would be prepared and implemented as part of the CEMP and OEMP. The plan would describe best practice control measures to reduce the risk of contamination of shallow groundwater, or the substantial alteration of groundwater flows due to drawdown effects. The plan would detail: ▪ Baseline data of groundwater levels and quality ▪ Groundwater quality monitoring requirements Parameters Criteria Locations Frequency ▪ Water treatment methods including flocculation and pH adjustment prior to discharge of construction water ▪ Discharge process and location/s including avoiding erosion or scour ▪ Permits and records required ▪ Investigation and notification process ▪ Spill response plan ▪ Contamination response plan ▪ Drawdown contingency plan	Baseline, Construction, and Operation

Impact	Environmental Safeguard	Timing
Aquifer interference requiring dewatering	Any water encountered and abstracted from the Tomago Sandbeds aquifer should be re-injected locally back into the aquifer approximately 50 m distant on the hydraulically down-gradient side of the construction works. Prior to re-injection the abstracted groundwater must be inspected for any signs of contamination (high turbidity, oily sheen or odour of hydrocarbons) and tested for water quality parameters (temperature, dissolved oxygen, redox, EC, and pH), which would be compared to measurements from nearby monitoring wells. If greater than 10% difference with the groundwater measurements treatment would be required prior to re-injection. If collected groundwater does not meet criteria for re-injection, then the collected groundwater must be disposed to either sanitary sewer (as permitted trade waste) or to a facility licenced to accept and treat contaminated water. When working near the aquifer boundary, additional precautions should be made when using or transporting fuels and chemicals, and any spills should be immediately contained, and the impacted material removed from the site to a facility licenced to accept the impacted material.	Construction
	▪ Test and treat water generated by dewatering of trenches or excavations as required ▪ Infiltrate back into the groundwater table at designated infiltration areas or alternatively transport offsite to a licensed disposal facility ▪ Dewatering permit	Construction
Changes to groundwater flows	Replace material excavated from trenches to minimise changes to groundwater flows. Where possible, pipelines will be bedded on sand in the base of the trench.	Construction
Reduction in recharge to aquifers	Limit the amount of impervious surfaces Rehabilitate compacted areas which are not needed for operational activities by loosening the soil, adding organic matter and revegetating the area	Design and Post-construction / Pre-operation
Changes to groundwater levels	Minimise disturbance of groundwater levels by shoring trenches that encounter groundwater to stabilise the trench wall and reduce lateral inflow of groundwater. Dewater in short sections (nominally 50 m intervals) to reduce the volume of groundwater that needs to be extracted. If of acceptable groundwater quality, recharge the aquifer away from the trench to reduce drawdown of the water table. Monitor groundwater levels within and at the boundaries of the Proposal area. Compare to baseline (pre-construction) levels and rainfall to evaluate whether changes in groundwater levels is due to construction or operation of the facility.	Construction and operation
GDE	Restrict disturbance of pre-construction groundwater flows by using designs that limit restriction of groundwater flow, such as incorporating permeable zones that allow groundwater to bypass the buried gas pipeline.	Design/construction
Exceedance of groundwater criteria	Protocol would be developed for the investigation, notification and mitigation of any identified exceedances of the groundwater quality criteria	
	Prepare a remediation action plan for major spills or other incidents that may cause impact to groundwater quality. This may include hydraulic containment using downgradient berms and pumps	
	A program to monitor the effects of any change in groundwater levels or quality on groundwater dependent ecosystems	

8 Residual impact

Several potential impacts on the receiving environment's groundwater systems have been identified for both the construction and operational phase. These impacts can mostly be mitigated by implementing several specified management plans and operational procedures. By implementing these plans, a Neutral or Beneficial Effect (NorBE) on the receiving groundwater quality can be demonstrated.

Based on a review of environmental information available for the site (including reported contaminant concentrations), the following relates to potential residual impacts (with mitigation in place) relating to the SEARs and Supplementary SEARs environmental requirements outlined in **Table 1-1** and **Table 1-2** (Section 1.3):

- In relation to the construction phase, with adequate mitigation in place (including adhering to the documents specified in the plans outlined in **Table 6-1**), there is a low risk of residual impacts.
- In relation to the operation phase, with adequate mitigation in place (including adhering to the documents specified in the plans outlined in **Table 6-2**), there is also a low risk of residual impacts.

All plans outlined in **Table 7-1** would include contingency approaches, in the unlikely event of an incident with proposed mitigation in place.

It is expected that by implementing the controls set out in Section 6 there will be no measurable residual impact from the construction and operation of the Proposal on the:

- GDEs in the immediate vicinity of the Proposal site
- The local or regional groundwater aquifers, with regards to quantities or qualities. This aligns with the objectives of the current Water Sharing Plan (WSP) for the area as well as the Water Management Act's aquifer interference policy.

Hunter River Estuary wetlands (particularly the Ramsar-listed area) because the site groundwater flows away from these wetlands; hence, there is not a complete pathway between the potential contaminant sources at the Proposal site and the Hunter River Estuary wetlands.

9 Monitoring requirements

A recommended groundwater monitoring and reporting program is provided for the pre-construction, construction and operation stages of the Proposal.

The 10 existing monitoring bores on the power station site (ES, 2018) as well as the available boreholes at the NGSF site (in close proximity to the proposed pipeline corridor) should be monitored on a monthly basis leading up to construction, on a weekly basis during construction, and on a monthly basis once operation of the power station commences.

Risks associated with groundwater contamination from exposure of gas would need to be considered for pipeline excavations. Groundwater drawdown is assessed as being minimal due to the depth to the water table, however, monitoring bores in these areas would be important to confirm this and to monitor potential changes in groundwater levels that may lead to oxidation of potential ASS. It is proposed to install four monitoring bores near the directional drilling entry and exit pits. Monitoring requirements would be reviewed once the details of the construction are finalised.

Groundwater monitoring within the site of the Proposal would target potential changes in groundwater quality and levels as a result of construction and continued operation of the Proposal.

10 Conclusion

This Groundwater Specialist Study report outlines the potential environmental impacts for groundwater conditions at the Proposal area during construction, operations, or environmental management phases based on the previous survey results and desktop assessment. The impacts addressed include earthworks (stockpiling); heavy vehicle movement; increase in impervious surfaces; removal of vegetation; aquifer interference; pollution associated with construction; acid sulfate soil; spills; water degradation; effluent discharge; storm water system; disturbance of contaminated soils and / or groundwater; and hazardous materials within the residential property.

To address these issues, Construction and Operational Environmental Management Plans (CEMP and OEMP) will be developed to outline the environmental risks, mitigations proposed (including avoidance, management and engineering measures), monitoring requirements, contingency planning and responsibility allocation. Also, a comprehensive Soil and Water Management Plan will be developed. This overarching document will need to include the following plans addressing mitigation for focus areas:

- Groundwater Management Plan
- Construction Waste Management Plan
- Acid Sulfate Soil Management Plan
- Spill Containment Plan
- Erosion and Sediment Control Plan

With adequate mitigation in place, and by adhering to the requirements of the management plans specified, there is a low risk of residual impacts on groundwater during construction and operation phases of the Proposal. The likelihood of an impact on the Ramsar wetland is negligible given the distance, provided that the avoidance, mitigation, and management measures recommended in this report are implemented.

11 References

- AGL, 2013, Groundwater Monitoring Program – Newcastle Gas Storage Facility, November 2013.
- Coffey, 2011a, Groundwater and Surface Water Monitoring Program Factual Report Newcastle Gas Storage Facility Project, 26 October 2011.
- Coffey, 2011b, Environmental Assessment – Newcastle Gas Storage Facility Project, Volume 1: Main Report.
- Coffey, 2011c, Environmental Assessment – Newcastle Gas Storage Facility Project, Volume 2: Appendix 3 – Surface Water Assessment (Conducted by WorleyParsons).
- Crosbie, R., 2003, *Regional scaling of groundwater recharge*. The University of Newcastle, Newcastle, Australia.
- Department of Environment, Climate Change and Water (DECCW) NSW, 2010, NSW Climate Impact Profile. Accessed 14 March 2019 at **https://climatechange.environment.nsw.gov.au/Impacts-of-climate-change/2010-NSW-climate-impact-reporting**.
- Department of Primary Industries (DPI), 2016, *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources: Background Document*. Accessed 14 March 2019 at **https://www.industry.nsw.gov.au/__data/assets/pdf_file/0010/166870/northcoast-coastal-sands-groundawter.pdf.**
- Department of Land & Water Conservation (DLWC), 1998, *NSW Groundwater Protection Policy: A component of the NSW State Groundwater Policy.*
- Department of Land & Water Conservation (DLWC), 2002, *The NSW State Groundwater Dependent Ecosystem Policy.*
- Environmental Strategies (ES), 2017, *Tomago Development Site, NSW – Phase 1 Preliminary Environmental Site Assessment.*
- Environmental Strategies (ES), 2018, *Tomago Development Site, NSW – Additional Pre-existing Contamination Study.*
- GHD, 2019, Newcastle Gas Storage Facility, Groundwater and Surface Water Monitoring Program, March 2019, prepared for AGL Energy, dated May 2019.
- Hunter Water, 2011, *Catchment Management Plan, Hunter Water's eight element plan for our catchments*. Accessed 14 March 2019, **https://www.hunterwater.com.au/Resources/Documents/Plans--Strategies/CatchmentMangementPlan_FINAL_Mar2011_lowres.pdf**.
- Kellett JR, Williams BG and Ward JK, 1989, *Hydrogeochemistry of the upper Hunter River valley, New South Wales*. Bureau of Mineral Resources, Sydney. Accessed 19 March 2019, **http://www.ga.gov.au/corporate_data/25/Bull_221.pdf**.
- National Environment Protection Council (NEPC), 2013, *National Environment Protection (Assessment of Site Contamination) Measure*, Amended April 2013.
- URS, 2002, *Environmental Impact Statement - Tomago Gas Fired Power Station, Volume 1: Main Report.*
- Williamson WH, 1958, *Groundwater resources of the Upper Hunter Valley New South Wale*s. In: Water Conservation and Irrigation Commission (ed.). New South Wales Government, Sydney.
- Woolley, D., Mount, T., and Gill, J., 1995, Tomago Tomaree Stockton Groundwater Technical Review, NSW Department of Water Resources, February 1995, 245 pgs.
- WorleyParsons, 2013, Newcastle Gas Storage Facility, Additional Geotechnical Investigation HP Gas, Alignment and Power Transmission, 9 January 2013.

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