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Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall
Environmental Impact Statement
Bega Valley Shire Council
May 2021

bega valley shire council

Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall

Appendix D

Groundwater Technical Report

Appendix D

Groundwater Technical Report

Client: Bega Valley Shire Council

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Executive summary

Bega Valley Shire Council is proposing an upgrade to the Merimbula Sewage Treatment Plant (STP) including a new ocean outfall in Merimbula Bay (the Project). The Project would be located between Merimbula and Pambula, within the Bega Valley Shire local government area (LGA). The Merimbula STP is bounded by the Pambula Merimbula Golf Club (PMGC) to the south, Merimbula Lake to the west, Merimbula Airport to the north and Arthur Kaine Drive to the east. The Merimbula STP is accessed via Arthur Kaine Drive, which links to Princes Highway to the west and providing direct access to Merimbula Airport in the north.

The Project would involve an upgrade of sewage treatment at the Merimbula STP and replacement of the existing beach face outfall and dunal exfiltration ponds with an ocean outfall in Merimbula Bay. Specifically, the Project would involve:

- upgrade of the STP to improve the quality of treated wastewater (including for beneficial re-use);
- decommissioning of the beach-face outfall, as well as an STP effluent pond;
- discontinuing the use of the dunal exfiltration ponds;
- installation of a secondary disposal mechanism - an ocean outfall pipeline about 3.5 km in length to convey treated wastewater to a submerged diffuser;
- installation of upgraded pumps; and
- continuation of the beneficial re-use irrigation scheme at the PMGC grounds and the Oaklands agricultural area, with treated wastewater of improved quality.

The Project area comprises the existing Merimbula STP site and ocean outfall alignment, as well as areas required for construction, including laydown areas within the adjacent PMGC grounds and on Merimbula Beach (with access via Pambula Beach).

The Project is aimed at reducing the environmental and health impacts of current operations, by providing a higher level of treatment and a superior mode of discharge/ dispersion of the treated wastewater via an ocean outfall in Merimbula Bay. The upgraded STP would be operated with the additional treatment processes which would improve the quality of the treated wastewater.

This groundwater impact assessment has been developed to support the Environmental Impact Statement (EIS) for the Project. This assessment addresses the relevant Secretary's Environmental Assessment Requirements (SEARs), aiming to identify potential impacts of the Project and to outline performance outcomes and mitigation and management measures relating to groundwater during detailed design, construction and operation of the Project.

The Project

The Project is located between Merimbula and Pambula on Arthur Kaine Drive, approximately 3.5 kilometres (km) south of the Merimbula town centre and 2.5 km north of Pambula village. Landscape features within and near the Project area include Merimbula Lake, located immediately west and north of the STP site, Merimbula Airport is located about 280 m north and Pambula Merimbula Golf Club, located immediately south of the STP site. The proposed pipeline alignment would traverse across Merimbula Beach, and an area of coastal wetland, located approximately 300 metres west of Merimbula Beach.

The proposed pipeline would carry treated wastewater from the STP to an offshore ocean outfall within Merimbula Bay. The pipeline construction methodology would not require excavation of an open trench. The final design of the pipeline would be subject to detailed design and engineering, but it is expected the pipeline would comprise high density polyethylene (HDPE) or fused polyvinyl chloride (PVC). The pipeline would be installed with a casing (during or after drilling, depending on the drilling method used (e.g. horizontal directional drilling or direct drive tunnelling), and the drilling plan developed). Products to be installed would be inert and expected to be long-lasting. The final selection would be made during the detailed design phase of the Project.

The bored hole (and pipeline) would pass through the water table close to the local groundwater divide that separates groundwater flowing east to Merimbula Beach and west to Merimbula Lake. The proposed pipeline alignment would pass through Tertiary sandy and clayey materials near the launch pad and pass into Quaternary coastal sand deposits. It would initially pass through fresh groundwater before reaching a saltwater interface that is expected to underlie the coastal dunes behind Merimbula Beach. Fresh terrestrial groundwater is locally recharged by infiltrating rainwater, while saline groundwater near the beach is of marine origin.

Methodology

The methodology adopted for the groundwater impact assessment included a detailed review of hydrogeological information from previous site investigations, existing long-term monitoring results from the site and surrounds, and publicly available groundwater and climate databases. This assessment considered groundwater impacts within the terrestrial environment between the Merimbula STP and the coastlines to the east (Merimbula Bay) and west (Merimbula Lake).

Hydrogeological conditions were characterised by logging cores obtained from seven new drill holes located along the pipeline route. This was supported by an analysis of groundwater level and quality data from current monitoring bores located between the STP and Merimbula Beach. Hydraulic properties of the natural materials that make up the superficial aquifer were determined by reviewing the results of previous field testing which were tested within a site-wide groundwater assessment undertaken by Ian Grey Groundwater Consulting (IGGC) on behalf of Bega Valley Shire Council in 2013 (IGGC, 2013).

Because the proposed pipeline would intersect with groundwater, the assessment considered the following potential impacts:

- construction phase:
  - excessive loss of circulating fluids during directional drilling causes the superficial aquifer to become clogged leading to alterations in groundwater levels and flowpaths;
  - groundwater quality is adversely affected by drilling operations; and
  - construction activities could lead to adverse impacts on groundwater if not appropriately managed, including impacts resulting from mismanagement of drilling activities and associated drilling fluids.
- operational phase:
  - impacts to groundwater quality, groundwater levels or groundwater flows; and
  - adverse impacts on the local hydrogeological regime due to pipeline leakage.

Potential impacts of other excavation work associated with construction of the Project (e.g. STP upgrades) were also considered in the assessment.

Impacts to groundwater

The assessment of groundwater risks from the Project primarily concerned the proposed outfall pipeline, and concluded the following:

- Construction phase impacts:
  - The risk to aquifer, the groundwater it contains, its characteristics that define levels and flow, and existing users during the construction phase is low.
- Operational phase impacts:
  - Under reasonable worst-case conditions, the proposed pipeline is estimated to reduce groundwater flow by about 0.7%. This level of change is well within the range of natural climatic variability and therefore not significant. Within the context of seasonal variations of 0.5 m, this change is expected to be largely undetectable.
  - Under normal operating conditions, groundwater quality is not expected to be altered by the pipeline or the treated wastewater it would contain. Under a reasonable worst-case scenario involving a significant leak, groundwater is predicted to be locally altered and discharge at

the low tide mark across a narrow zone where it would disperse at the beach. Risks to off-site receptors such as the wetland and existing groundwater bore to the south and coastal groundwater discharges are low.

  - After the outfall pipeline is commissioned and the use of the exfiltration ponds has discontinued there would be an overall improvement of the quality of groundwater discharging at the beach. Previous discharges would begin to revert to natural quality but may take several years to flush residual seepage loadings from the flow system. The long-term quality of groundwater reaching the beach east of the exfiltration ponds would depend on the future use of the ponds site.

- Inter-Project cumulative impacts:
  - The available data indicate seepage from the exfiltration ponds results in water table fluctuations of about 1.5 m to 2.5 m near the ponds and smaller fluctuations of about 0.8 m to 1.0 m across the proposed ocean outfall pipeline route near the wetland area. This also indicates the natural water table gradient and seasonal fluctuations are flatter and about half the observed fluctuations from the exfiltration ponds. On this basis, it is possible the seepage-related fluctuations from the ponds are, for short periods of time, reversing the direction of groundwater flow, but, because of the high transmissivity of the coastal sand, return to normal rapidly after discharges to the ponds cease. The predicted changes to groundwater levels in the order of centimetres are unlikely to lead to a significant cumulative impact; and would be even smaller when the use of the exfiltration ponds are discontinued under the Project.
  - The impact on groundwater quality would depend on the severity of any leak from the ocean outfall pipeline. It is highly unlikely to alter the quality as much as the existing exfiltration ponds have done on groundwater as measured at the nearby bore PPK3. It is also unlikely to be worse than the existing beach-face outfall in terms of superficial groundwater quality.
  - Should there be a large leak from the ocean outfall pipeline beneath the wetland or upgradient to the west, the groundwater level beneath the wetland would rise more than it currently does. This could increase the availability of nutrients to local vegetation, and where groundwater is seasonally exposed, lead to more persistent ponding of surface water and possibly a deterioration of its quality.

Mitigation and management

The key risk during the construction phase relates to the design and management of drilling fluids. The fluids should use inert and non-contaminating additives, preferably National Sanitation Foundation (NSF) certified as suitable for potable aquifers, be selected based on local conditions and monitored by an appropriately trained and experienced mud engineer and driller. These requirements are commonly adopted in the drilling industry to minimise similar risks to those identified for this Project.

A Construction Environmental Management Plan (CEMP) would be developed and implemented for the Project. A groundwater management sub-plan would be developed for inclusion in the CEMP to manage impacts on groundwater and existing users. The sub-plan should include trigger levels that establish initial response actions as follows: confirmation, investigation, risk assessment and, if required, a construction method review and/or remediation. The trigger levels should be defined based on the results of baseline monitoring and be selected to identify potentially abnormal changes to groundwater levels and quality.

Groundwater in the superficial aquifer could be adversely affected by treated wastewater if a significant leak from the pipeline develops during the operation of the Project. While a significant leak from the pipeline is unlikely, the likelihood should be minimised by carefully considering the pipeline’s design, materials selection, installation and commissioning (e.g. including pressure testing before and after installation) and operational maintenance . The severity of the impact would be proportionate to the rate of leakage. Leakage should be monitored using dedicated equipment and inspections. Groundwater level measurements and quality testing in monitoring bores along the pipeline route should be undertaken to detect significant impacts to the natural environment.

Any operational constraints and compliance criteria would be developed in accordance with Australia New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018) and with consideration to the relevant NSW Water Quality Objectives.

Risks of groundwater contamination due to accidental spills and leaks during the construction phase are low if the Project adopts standard design and construction processes including:

- incorporating features into the final design that avoid disturbance of the aquifer and groundwater wherever practicable;
- avoiding the use of potentially harmful substances where practicable;
- placing barriers between the source(s) of contamination and the water table;
- handling potentially contaminating substances such as fuels, hydraulic oils and caustic (drilling mud additive) in accordance with relevant regulations; and
- developing and implementing a spill response plan that complies with relevant regulations.

The risks of significant changes to the water table elevation and quality of groundwater that supports the wetland and its ecosystem due to drilling are low.

Groundwater monitoring program

Groundwater monitoring during the construction phase should be undertaken in four existing bores and three new sites including:

- Bores A5, A6 and PPK4: which are located close to the proposed pipeline route near the wetland and recharge zone, and the groundwater discharge zone near the beach;
- Private bore GW047147: which although currently unlicensed should be protected for future use;
- AECOM1 (new site) – downgradient of the launch pit, drilling rig, fluid pit and cuttings storage sites to monitor changes to the groundwater quality;
- AECOM2 (new site): within the Tertiary deposits close to where the proposed pipeline borehole would pass through the water table to monitor changes to groundwater levels and quality; and
- AECOM3 (new site): within the Quaternary coastal sand deposits close to where the proposed pipeline borehole would pass under the wetland to monitor changes to groundwater levels and quality.

To supplement the monitoring bores installed and monitored for the construction phase, during the operational phase, two additional sites are recommended to monitor the quality of groundwater where under adverse conditions, it could discharge to the surface. This would provide a total of eight boreholes for the purpose of groundwater monitoring during the construction and operation of the Project.

The monitoring data should be collated and regularly reviewed to assess whether unplanned changes are occurring. The frequency of monitoring activities would vary from daily to weekly during construction, and from monthly to bi-annually during operation. These prescribed timings are dependent on the groundwater parameters to be measured.

The review of the groundwater monitoring results should be assessed against known existing trends to identify whether any changes are related to the pipeline or seasonal/event-based rainfall recharge.

1.0 Introduction

Bega Valley Shire Council (BVSC) is proposing an upgrade to the Merimbula Sewage Treatment Plant (STP) including a new ocean outfall in Merimbula Bay (the Project). The Project would be located between Merimbula and Pambula, within the Bega Valley Shire local government area (LGA) (refer **Figure 2-1**).

This Groundwater Technical Report has been prepared to assess the potential groundwater impacts of the Project, during construction and operation.

1.1 Project overview

The Project would involve an upgrade of sewage treatment processes at the Merimbula STP, decommissioning of an existing effluent storage pond, and replacement of the existing beach-face outfall and dunal exfiltration ponds with an ocean outfall pipeline in Merimbula Bay.

When operational, the Project would involve continuation of the beneficial re-use irrigation scheme at the Pambula Merimbula Golf Club (PMGC) grounds and the nearby Oaklands agricultural area, with improved treated wastewater quality from the upgraded STP.

The Project would reduce the environmental and health impacts of the current operations, by providing a higher level of treatment and a superior mode of discharge/dispersion of the treated wastewater via the ocean outfall offshore in Merimbula Bay.

The Project is described in further detail in **Section 2.0**, and the Project area is shown in **Figure 2-1**. A full Project description is provided in the EIS (refer **Chapter 2 Project description**).

1.2 Purpose of this technical report

This report has been prepared to address the SEARs in relation to groundwater. This report defines the hydrogeological conditions for the Project and has been prepared to support the EIS. The report is based on published information and from site investigation information gathered by the BVSC, its consultants and contractors.

The purpose of this groundwater impact assessment is to:

- meet the requirements of the SEARs and the *Aquifer Interference Policy 2012* (AIP) (DPI, 2012);
- establish baseline conditions to inform the EIS and to assist with the development of mitigation measures;
- establish baseline conditions for comparison with water quality and water level conditions during the construction and operational phases, including identification of areas of potential groundwater contamination;
- assess the potential groundwater impacts during construction and operational phases;
- assess the potential cumulative impacts on the hydrogeological regime due to the Project and other relevant projects; and
- develop mitigation and management measures to eliminate or manage the potential impacts of the Project on the hydrogeological regime during construction and operational phases.

To address the SEARs relevant to groundwater, the assessment considers potential impacts to groundwater levels and flow, groundwater quality and groundwater dependent wetlands. This chapter is concerned with activities during the construction phase that could interact with or otherwise disturb the aquifer and groundwater it contains including:

- permanent and temporary interruption of groundwater flow, including:
  - the extent of drawdown;
  - barriers to flows; and
- implications for groundwater dependent surface flows, ecosystems and species, groundwater users.

1.2.1 Secretary's environmental assessment requirements

The SEARs that are relevant to groundwater impacts and where they are addressed in this report are listed in **Table 1-1**.

Table 1-1 Secretary's environmental assessment requirements – Groundwater

Secretary's Environmental Assessment Requirements	Where addressed in report
1. Water Quality	
1. The proponent must: (k) identify proposed water quality monitoring locations, monitoring frequency and indicators of water quality, including groundwater quality.	**Section 5.4** and **Section 6.4**
7. Water and hydrology	
1. describe (and map) the existing hydrological regime for any groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project.	**Section 4.0**
3. assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on groundwater hydrology in accordance with the current guidelines, including: (b) impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement.	**Section 5.0** and **Section 6.0**. The potential for settlement is addressed in the EIS in **Chapter 13 Landform, geology and soils**
4. identify any requirements for baseline monitoring of hydrological attributes.	**Section 5.0** and **Section 6.0**

1.2.2 Structure of this report

This report is structured as follows:

- **Section 1.0** provides an introduction to the Project.
- **Section 2.0** provides a summary of the Project description.
- **Section 3.0** describes the assessment methodology.
- **Section 4.0** provides a description of the existing groundwater environment in the vicinity of the Project area.
- **Section 5.0** provides a construction impact assessment for the Project.
- **Section 6.0** provides an operational impact assessment for the Project.

- **Section 7.0** assesses potential cumulative impacts.
- **Section 8.0** describes the groundwater mitigation and management measures identified to address the potential impacts of the Project.
- **Section 9.0** provides the conclusions of the assessment.

2.0 Project description

This chapter outlines the existing operations at the Merimbula STP and provides a summary of the Project description. A full Project description is provided in **Chapter 2 Project description** of the EIS.

The Project would be located between Merimbula and Pambula on Arthur Kaine Drive, within the Bega Valley LGA approximately 3.5 kilometres (km) south of the Merimbula town centre and 2.5 km north of Pambula village, as shown on **Figure 2-1**. The Merimbula STP is bounded by the PMGC to the south, Merimbula Lake to the west, Merimbula Airport to the north and Arthur Kaine Drive to the east. The Merimbula STP is accessed via Arthur Kaine Drive, which links to Princes Highway to the west and provides direct access to Merimbula Airport in the north.

2.1 Existing operations

The existing operations at the Merimbula STP consist of:

- sewage treatment at the Merimbula STP; and
- disposal of treated wastewater via:
  - a beach-face outfall;
  - dunal exfiltration ponds; and
  - a beneficial re-use scheme at the adjacent Pambula Merimbula Golf Club (PMGC) grounds, and at Oaklands agricultural area.

The STP is an intermittently decanted extended aeration (IDEA) activated sludge plant designed to serve an equivalent population of 15,500. The STP has a capacity to accommodate an average dry weather flow of up to 3.72 megalitres per day (ML/day) and a peak wet weather flow of seven times the average dry weather flow, or 26 ML/day. It handles an average of 790 megalitres (ML) of treated wastewater per year .

The current strategy for managing treated wastewater from the Merimbula STP comprises a combination of:

- beneficial re-use (the preferred disposal option): use of treated wastewater to irrigate the adjacent PMGC grounds and 'Oaklands' agricultural area (approximately 25% of annual treated wastewater), located on the Pambula River flats at South Pambula; and
- disposal: discharge of excess treated wastewater to the environment, via dunal exfiltration ponds located within the sand dunes east of the STP between the ocean and Merimbula Lake (approximately 25% of annual treated wastewater), or via the existing beach-face outfall east of the STP at Merimbula Beach (approximately 50% of annual treated wastewater).

2.2 The Project

The Project would involve:

- upgrade of the STP to improve the quality of treated wastewater (including for beneficial re-use);
- decommissioning of the beach-face outfall, as well as an STP effluent storage pond;
- discontinuing the use of the dunal exfiltration ponds;
- installation of a secondary disposal mechanism - an ocean outfall pipeline about 3.5 km in length to convey treated wastewater to a submerged diffuser;
- installation of upgraded pumps; and
- continuation of the beneficial re-use irrigation scheme at the PMGC grounds and nearby Oaklands agricultural area with treated wastewater of improved quality.

Upgrades to the STP and the ocean outfall would reduce the environmental and health risks and impacts of the current operations, by providing a higher level of treatment and a superior mode of discharge/ dispersion of the treated wastewater via an ocean outfall offshore in Merimbula Bay.

A summary of the proposed Project elements is provided in **Table 2-1**.

The Project area comprises the existing Merimbula STP site and the proposed outfall pipeline alignment. The Project construction areas would include areas within the Merimbula STP, temporary laydown areas on the adjacent PMGC grounds and on Merimbula Beach (with associated access from Pambula), as shown in **Figure 2-1**.

This EIS is based on a concept design for the Project. It is noted that during subsequent design stages, and subsequent to a design and construction contractor(s) being engaged, details of the Project may change or be refined (e.g. specific locations of some elements or infrastructure within the existing STP site; materials to be used in plant construction and technology).

Table 2-1 Project elements

Project element	Summary
STP upgrade	The STP upgrade would involve additional treatment processes incorporated into the existing STP site, including two stage poly aluminium chloride (PAC) dosing, ultraviolet (UV) disinfection, chlorine dosing and tertiary filtration (if required). The indicative physical layout of the proposed STP upgrade is shown in **Figure 2-2**. The new treatment processes would be incorporated into the following existing STP phases (refer **Chapter 2 Project description** for further information): *Phase two: secondary treatment* Addition of: • two stage PAC dosing for phosphorous removal. *Phase three: disinfection* A change to the existing disinfection (chlorine dosing) treatment, involving: • addition of ultraviolet (UV) treatment; • chlorine dosing would continue to be applied to treated wastewater, however wastewater would be divided into two separate streams: - wastewater to be beneficially re-used would be dosed with chlorine; and - wastewater to be discharged via the ocean outfall would no longer be subject to chlorine dosing. • the chlorine dosing proposed would involve installation of a new chlorine dosing unit (including two 920 kg drum storage of chlorine, and a new pump system). The chlorine dosing unit would be stored at a dedicated storage facility within the STP (either the existing chlorine storage shed would be upgraded to house the increased volume of chlorine required for the Project, or a new shed would be built on or near to the site of the existing shed); and • tertiary filtration could also be installed (if required).

Project element	Summary
	The Project would also require the following within the existing STP site: • a new storage tank and new chlorine contact tank; • installation of up to four additional pump stations: - ocean outfall pump station – to pump treated wastewater through the outfall pipeline; - storage tank pump station – to pump treated wastewater to the new storage tank; - chemical sludge pump station (if tertiary filters required) – to pump sludge and treated wastewater; and - pump station – to pump from wet weather overflow back into the STP treatment train. • installation of ancillary infrastructure (including new sheds/structures to house new treatment processes, above-ground storage tanks, pipes, pits, power supply and additional low voltage (LV) connection (including transformer, cabling and distribution board), control kiosks, a retaining wall and internal access roads); and • relocation and upgrade of utilities to accommodate the additional features proposed.
Existing STP effluent storage pond	The existing 17 ML effluent storage pond within the STP site would be decommissioned, including dewatering and sediment/sludge removal.
New ocean outfall pipeline and effluent diffuser, and associated pump station	*<u>Phase four: Disposal and beneficial re-use</u>* New additions would involve: • installation of a 3.5 km outfall pipeline – the pipeline would travel from the STP in an east-south-easterly direction to a location approximately 2.7 km offshore in Merimbula Bay; • the pipeline would involve two construction methods for different sections of the pipeline as follows: - 'Section one' – STP to a location beyond surf zone: underground trenchless drilling method (refer **Figure 2-3**); and - 'Section two' – Location beyond surf zone to offshore pipeline termination point: laying of pipeline on sea floor and covering with rock or concrete mattresses (refer **Figure 2-4**). • Section one of the pipeline (the onshore component) would be about 0.8 km and below ground. installation of the underground section would be via a trenchless method (e.g. horizontal direction drilling or direct drive tunnelling), followed by pipeline insertion via pulling or pushing; • Section two (the above ground section of the pipeline) would be installed via direct placement on the sea floor in 600 m to 800 m pipe lengths. This would also involve progressive protection and stabilisation works for the pipeline (e.g. potentially using concrete or rock mattresses) held together with ropes/ slings/ cables; • the terrestrial component of the outfall pipeline would be laid between about -9.3 m and -19.5 m AHD, with greater depth largely depending on the nature of the overlying sand dunes; • a multi-port pipeline diffuser would be located at the end of the pipeline at a depth of approximately 30 m; the diffuser would be approximately 80 m in length; • the pipeline would have an outer diameter of up to 450 mm (366 mm internal diameter) and consist of pipeline lengths welded together; • a transition riser may be required to connect the underground pipeline with the above ground section of pipeline on the sea floor (if required, the riser would be located beyond the surf zone); and • the pipeline would contain valves along its length for mitigating against air entrapment.

Project element	Summary
Existing exfiltration ponds	The existing exfiltration ponds within the adjacent sand dunes (east of the STP site) would cease to be used under the Project.
Existing beach-face outfall	The existing public beach-face outfall pipeline would be decommissioned. The exposed end of the outfall pipeline would be removed, and the remainder of the pipeline would remain in-situ (i.e. would remain buried underground).
Water use	The STP would continue to use potable town water for kitchen and amenities on site. Apart from these water inputs, the Project would not require any other ongoing water source during operation.
Construction	
Construction footprint	The construction footprint includes temporary compound and laydown areas as shown in **Figure 2-5**. The location of laydown areas would be confirmed during detailed design and would depend on the method and location/s proposed to be used for directional drilling by the construction contractor. Temporary construction laydown areas would be located: • within the STP site; • within a portion of the adjacent PMGC grounds; and • on Merimbula Beach (if required, for pipe stringing and potentially an intermediate drill rig site for directional drilling). A total of approximately 2,800 square metres (m^2) (or 0.28 hectares) of vegetation removal / trimming would be required in the following locations: • approximately 217 m^2 at the Pambula Beach access track; and • approximately 2,464 m^2 of regrowth scrub within the existing STP site and for construction access from the construction laydown area within the PMGC grounds; and • approximately 47 m^2 at the existing beach face outfall pipeline (to be decommissioned).
Construction timing, hours and workforce	Pending Project approval, it is proposed to commence construction in 2022, with construction anticipated to be undertaken over a period of 24 months. Construction would be staged and there would be times when some construction stages overlap. Works would typically be limited to standard daytime hours, which include: • 7:00 am to 6:00 pm Monday to Friday; • 8:00 am to 1:00 pm Saturday; and • no work on Sundays, public holidays. Certain works may need to occur outside standard construction hours for the safety of workers, in accordance with transport licence requirements, or for constructability reasons. Activities to be carried out during out of hours periods may include oversized load deliveries and pipeline pulling as part of the directional drilling (which would need to be undertaken continuously until completed, which may take up to 48 hours). Construction works in Merimbula Bay could occur seven days a week to maximise works during favourable offshore weather conditions. Approval from BVSC would be required for any out of hours work and the affected community would be notified. Construction of the Project would require a workforce of around 20 workers, with peak construction periods requiring up to 30 workers.

Project element	Summary
Traffic, construction vehicle types and workforce	Construction traffic would indicatively comprise: • 5 to 10 heavy vehicles per day (e.g. truck and dogs); and • 10 to 20 light vehicles per day. Vehicles transporting machinery or oversized materials such as prefabricated units may be required from time to time, and oversized vehicles would require escort to and from site. The largest truck expected as part of construction is the directional drilling rig truck (the exact size would be confirmed by the construction contractor). The construction phase of the Project would require construction vehicles to transport materials and equipment along the existing road network to the construction compound/laydown areas at the Merimbula STP and PMGC grounds and, if required, at the Merimbula Beach laydown area via Pambula Beach. In facilitating these construction activities, various plant and equipment would be required, including: • small, medium and large excavators (3 to 25 tonne) (tracked and wheeled); • compaction plant (e.g. roller/s, plate compactor); • grader; • bulldozer; • directional drilling rig truck and associated infrastructure (i.e. drilling fluid recovery and recovery unit); • pumps for dewatering (if required); • vacuum truck; • bobcat; • concrete trucks and pumps; • mobile cranes (e.g. franna crane, scissor lift, forklift); • semi-trailers and tipper truck; • telehandlers; • micro-piling rig (on barge); • water carts; • hand tools and welding equipment; • barges (e.g. 55 m and 73 m barges, jack-up barge) and tugs; • small, self-propelled vessel; • demolition saw, jackhammer, grinder; • generator/s, lighting tower; • forklift; • light vehicles and light trucks; and • heavy vehicles. The size of vehicles used for haulage would be consistent with the access route constraints, safety and any worksite constraints. Some construction activities (such as the delivery of precast sections) may require truck and trailer combinations or semi-trailers.

Project element	Summary
Access	Construction vehicles would access/egress the STP site via the following accesses: • Arthur Kane Drive, via either the northern end of the STP site, and/or the existing main STP entrance. Construction of the outfall pipeline would also utilise the following accesses: • Coraki Drive, Pambula (construction vehicles would enter the temporary beach access track at the end of Coraki Drive, before traversing the beach access track to the laydown area on Merimbula Beach); and • Port of Eden, Twofold Bay (barge/s would transport materials and equipment northward to the location of the proposed outfall pipeline alignment). Construction site accesses at Arthur Kaine Drive and Pambula Beach are shown in **Figure 2-5**. Construction materials and equipment could also be delivered to the Port of Eden using shipping containers, with construction vehicles expected to haul these containers to the construction sites via the Princes Highway.

2.3 Operational stage

The Project would be operated with the additional treatment processes which would improve the quality of the treated wastewater. Levels of total phosphorus, total suspended solids, biological oxygen demand, virus, bacteria and other pathogens would be managed to be within discharge limits. Treated wastewater would be tested for quality prior to discharge via the ocean outfall pipeline or via beneficial re-use offsite (to existing land application areas at the Oaklands agricultural area or the adjacent PMGC grounds). Maintenance activities for the STP and ocean outfall would also be undertaken and would continue until the STP is decommissioned or further upgraded in the future.

FIGURE 2-1: PROJECT AREA

N
0 500 1,000 m

Legend

- Project area
- Project area (temporary construction area)

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

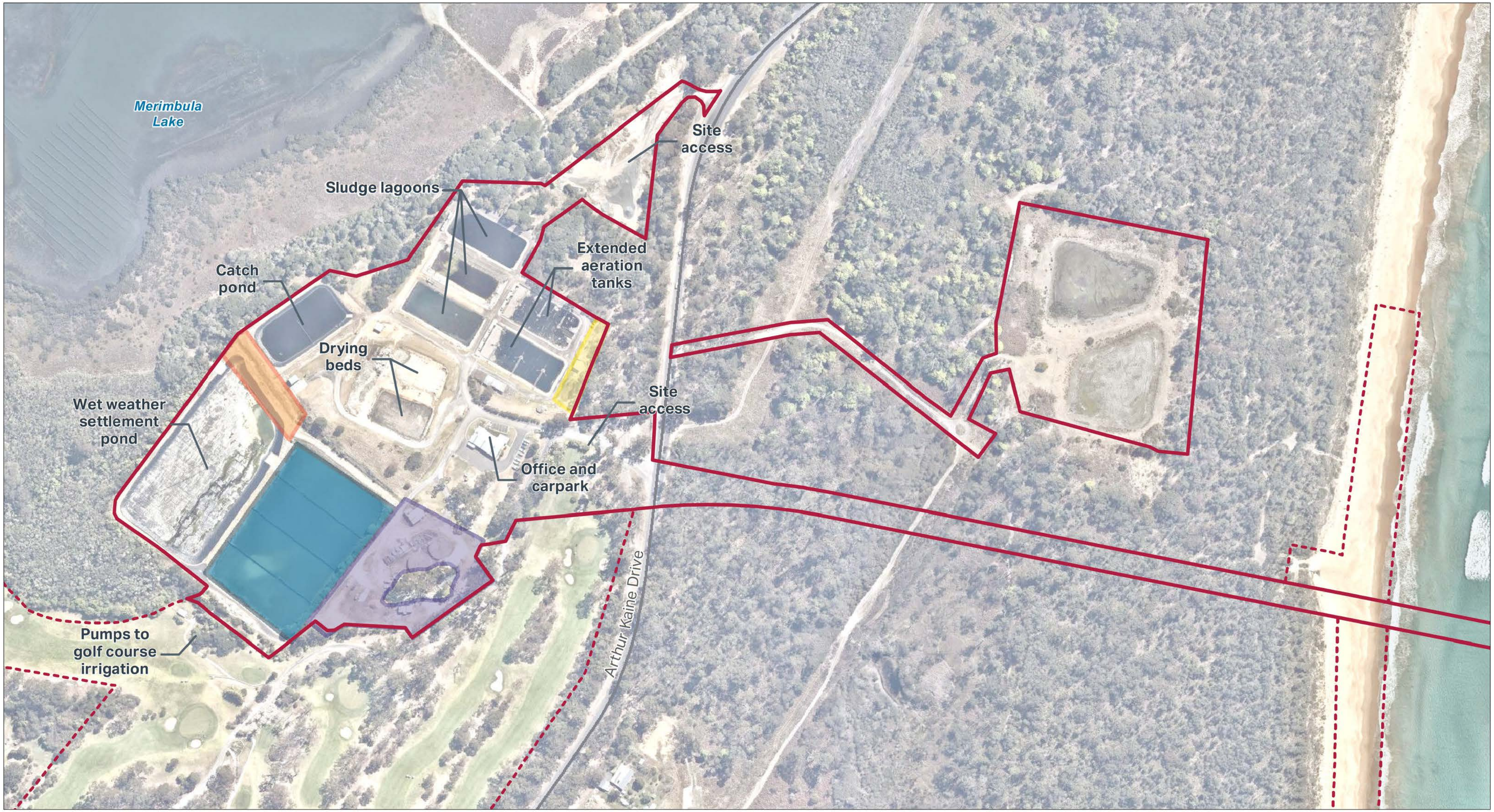

FIGURE 2-2: PROPOSED STP LAYOUT (INDICATIVE)

N
0 50 100 m

AECOM

Source: Nearmap, 2019

Legend

- Project area
- Project area (temporary construction area)

Proposed Project Upgrades

- PAC dosing, UV disinfection, tertiary treatment
- Pump stations, storage, chlorine disinfection
- PAC dosing (second unit)
- Effluent storage pond to be decommissioned

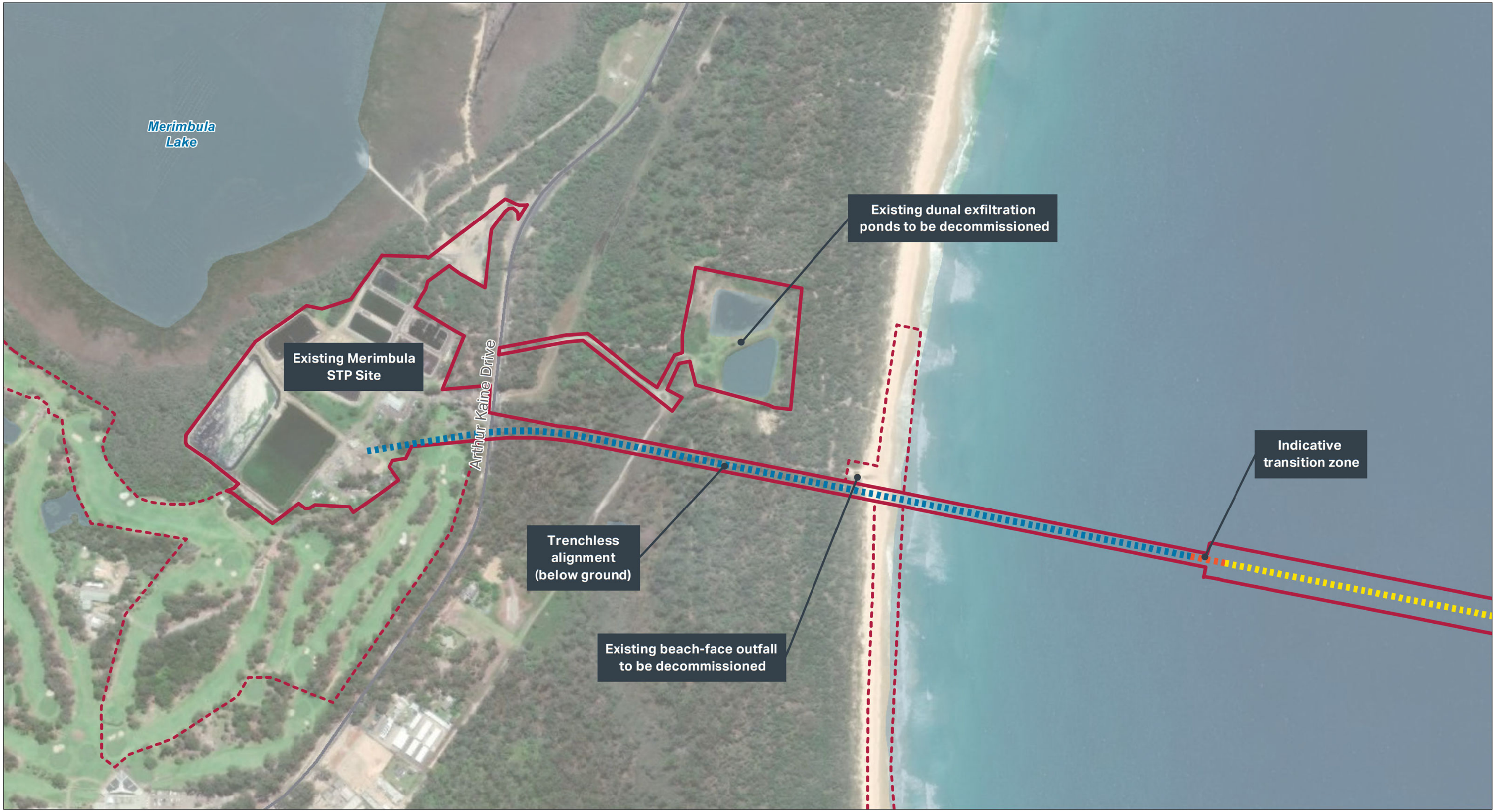

FIGURE 2-3: OCEAN OUTFALL PIPELINE - SECTION 1 (BELOW GROUND)

N
0 100 200 m

AECOM

Legend

- Project area
- Project area (temporary construction area)
- Outfall pipeline – Section 1 (below ground)
- Transition Zone
- Outfall pipeline – Section 2 (above seafloor)

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

FIGURE 2-4 : OCEAN OUTFALL PIPELINE – SECTION 2 (ABOVE SEAFLOOR)

Legend

- Project area
- Project area (temporary construction area)
- Outfall pipeline – Section 1 (below ground)
- Transition Zone
- Outfall pipeline – Section 2 (above seafloor)
- Diffuser (above seafloor)

N

0 200 400 m

AECOM

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

FIGURE 2-5: CONSTRUCTION COMPOUND/LAYDOWN AREAS

Legend

- Project area
- Temporary project area for construction
- Construction access
- Construction compound/laydown area
- Construction laydown area and potential intermediate drilling site
- Construction laydown area at Pambula-Merimbula Golf Club grounds

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

2.4 Ocean outfall pipeline construction methodology

Construction of the ocean outfall pipeline would generally involve the following (refer to **Chapter 2 Project description** for further information):

- establishment of site construction areas, including compound areas (including parking areas), laydown areas and access tracks;
- transport of pipeline lengths and construction materials to site and laydown;
- pipeline stringing and welding;
- establishment of drill rig pad and entry point, drill rig and recycling unit/tank to collect drilling fluids (where soil cuttings are separated from the fluid for removal offsite to a licensed facility, and re-use of the fluid for drilling (where appropriate). Excess fluid at the conclusion of drilling would also be removed offsite);
    - Note that the final location/s of the drill rig would be confirmed by the drilling contractor during detailed design and in the finalisation of the drilling plan. There are three possible locations for the drill rig to be set up, including a drill pad site at the STP site; a drill rig in the temporary laydown area on Merimbula Beach, or a drill rig located offshore on a barge (and drilling westward). The hole may be drilled in one length or require two lengths to be drilled and therefore require two drill rig locations. These scenarios have been accounted for in the EIS assessments where necessary;
- installation of underground section (Section one) via trenchless method (e.g. horizontal direction drilling (HDD) or direct drive tunnelling (DDT)), following by pipeline insertion via pulling or pushing;
- installation of a transition riser beyond the surf zone using micro-piling, if required;
- installation of a temporary barrier such as silt curtains to isolate the works from the rest of the marine environment and minimise mobilisation of sediment and pollutants into adjacent areas;
- installation of above ground section (Section two) via direct placement on seabed in 600 m to 800 m lengths. This would also involve progressive covering, protection and stabilisation works for the pipeline (e.g. using concrete or rock mattresses) held together with ropes / slings / cables;
- Installation of a temporary barrier such as silt curtains to minimise mobilisation of sediment and pollutants into adjacent areas;
- installation of fittings including access points and intermediate air valves. Access points may be required at the upstream end (e.g. at outfall pumping station) and the downstream end (e.g. at the diffuser) of the outfall pipeline for maintenance. Air valves would be required if a transition riser is incorporated;
- installation of multi-port diffuser (approximately 80 m in length) and risers (up to three) at the downstream end of the pipeline, including rock or concrete protection; and
- installation of multi-port diffuser (approximately 80 m in length) at the downstream end of the pipeline, including rock or concrete protection.

As indicated on **Figure 4-10**, the proposed ocean outfall pipeline would intersect the water table about 120 m from the western extent of drilling. Available lithological logs indicate it would then pass through grey and brown quartz sand. Some organic material is present in the sand beneath the wetland and it is possible this may be intersected by the pipeline borehole. Although its position has not been precisely determined, the pipeline would pass through the saltwater interface beneath the coastal dunes, possibly about 100 m west of the beach.

Section one of the pipeline would extend between the STP and an offshore location past the surf zone. The direction of drilling is still to be finalised once detailed investigations have been completed, but is likely to commence from the STP in the west, drilling towards the beach in the east. To help keep the hole open, the hole would be directed to pass through denser sand deposits where possible. Drilling would start from a launching pit that is expected to remain above the water table (dewatering not required) and be continuously controlled to a high degree of accuracy. The initial length of the hole could have a collar installed (e.g. of about 50 m to 60 m in length) to stabilise the hole and minimise risks associated with break-out of the drilling fluids. These details would be confirmed during detailed design.

The cuttings from the drilling process would be flushed from the hole using drilling fluid. This fluid would contain bentonite clay, or similar, mixed to a thick slurry that would also form a layer on the walls of the hole. This layer and the pressure of the drilling fluid would stabilise the formation and minimise the exchange of drilling fluid and groundwater. Drilling fluids such as these are commonly used in the water well drilling industry using inert materials. Alternatively, if direct drive tunnelling is used, the pipeline would be inserted as the hole is drilled and is assembled on the surface as the hole progresses. Once in place, a smaller pipe would be inserted in one continuous run. At the temporary laydown area on the beach, a small (approximately 3 m x 5 m) recovery pit would be excavated to connect the pipeline to section two that passes beneath the surf zone.

Some water supply would be required to undertake the drilling program and for dust suppression during the construction phase. It has been assumed that this supply would be obtained from non-groundwater sources (such as reticulated system water) that do not pose a risk to groundwater quality. As such, this assessment does not consider environmental impacts associated with obtaining a water supply.

Cuttings and drilling fluid removed from the pipeline borehole during drilling would be separated at the drilling rig. The cuttings and drilling fluid would be managed in accordance with current NSW guidelines and not result in seepage or pose a risk to groundwater. This would normally be achieved by temporarily storing the cuttings and mud on site in an appropriately bunded area and disposing them at a licensed or approved facility. After the pipeline has been installed, the only water that would remain behind would be associated with the drilling mud. Unplanned seepage to the water table would be detected by dedicated groundwater monitoring bores. No further assessment of groundwater impacts from drill cuttings or drilling fluids are therefore required.

3.0 Methodology

3.1 Relevant legislation, guidelines and policies

3.1.1 Legislation

Groundwater aspects of this Project are subject to the legislation and statutory requirements described in **Table 3-1**.

Table 3-1 Legislative context

Requirement	Description	Context
Water Management Act 2000	Defines the allocation and provision of water for the environmental health of rivers and groundwater systems, while also providing licence holders with more secure access to water and greater opportunities to trade water through the separation of water licences from land, through the implementation of defined water management plans (groundwater and surface).	Legislative requirements for: • defining environmental water provisions; • the Towamba water sharing plan; and • the aquifer interference policy. Licenses for groundwater bores near the Project are issued by Water NSW in accordance with the requirements of this Act.
Water Management (General) Regulation 2018	Specifies important procedural and technical matters related to the administration of the *Water Management Act 2000*.	Regulatory requirements relating to the above aspects.
Water Sharing Plan for Towamba River Unregulated and Alluvial Water Sources	Specifies water sharing arrangements under Section 50 of the *Water Management Act 2000* for water contained within all alluvial sediments below the surface of the ground shown on the registered map referred to in the plan, held by the NSW Office of Water It does not include water contained in the coastal sands.	Relates to groundwater in alluvial sediments beneath the Project area but excludes groundwater in the coastal sand deposits.

3.1.2 Policies and guidelines

This report has been prepared with reference to the applicable policies as outlined in **Table 3-2** below.

Table 3-2 Applicable policy

Policy	Description and applicability to the Project
NSW Groundwater Quality Protection Policy and *NSW State Groundwater Policy Framework Document* (NSW Department of Land and Water Conservation (DLWC), 1998)	The *NSW Groundwater Quality Protection Policy* is one of three component policies which, in association with the Framework Document, make up the State Groundwater Policy. Relevant to this assessment, the *NSW Groundwater Quality Protection Policy* sets forth the expectations and provisions for the protection and management of groundwater quantity and quality, and groundwater dependant ecosystems. The *NSW State Groundwater Policy Framework Document* has been prepared to manage the State's groundwater resources such that they can sustain environmental, social and economic uses.

Policy	Description and applicability to the Project
Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) *National Water Quality Management Strategy Australian Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ 2000 as updated in ANZG 2018)	These guidelines aim to provide a framework for assessing and managing ambient water quality in natural and semi-natural water resources. As the Project would be located near a natural water resource (Merimbula Lake and Merimbula Beach) this assessment has been prepared in consideration of the water quality guidelines and guidelines for preparing and implementing water quality monitoring program that are described in this document.
Using the ANZECC Guidelines and Water Quality Objectives in NSW (NSW Department of Environment and Conservation (DEC, 2006)	Relevant to this groundwater impact assessment, the ANZECC 2000 guidelines provide: • a description of environmental values that can be used to categorise receiving water; • a framework to assess whether existing and predicted water quality in any identified receiving waters supports these environmental values; and • default guideline levels ('trigger values') which can be used to assess water quality. This groundwater impact assessment has adopted the environmental values provided by the ANZECC 2000 guidelines (as updated by the ANZG 2018 guidelines) to describe and categorise the existing groundwater conditions in the study area and has assessed the potential for groundwater impacts as a result of the Project using the framework and trigger values set forth in these guidelines.
NSW Water Extraction Monitoring Policy (NSW Department of Water and Energy (DWE, 2007)	This policy has been developed in accordance with the *Water Management Act 2000* and the *Water Act 1912* and applies to extraction from water sources in NSW. The purpose of the policy is to define the roles and responsibilities for DWE, State Water and holders of water extraction licences. While groundwater abstraction for the Project is not anticipated, the monitoring standards referred to in this document have nonetheless been considered in the development of the proposed groundwater monitoring program for the Project.
NSW Aquifer Interference Policy (DPI 2012) (AIP)	The AIP provides a framework for the regulation of groundwater to meet the requirements of the *Water Management Act 2000* (WM Act). According to definitions provided by the WM Act and AIP the Project would constitute an 'aquifer interference activity' as it: • would penetrate the aquifer; • would interact with groundwater in the aquifer (to some degree); and • may obstruct the flow of water in the aquifer. The WM Act includes the concept of ensuring "no more than minimal harm" for the granting of water access licences and the AIP identifies thresholds for key minimal impact considerations for various groundwater resources (alluvial, coastal sands, porous rock and fractured rock). These thresholds deal with water table and groundwater level

Policy	Description and applicability to the Project
	drawdown as well as groundwater and surface water quality changes. Unless identified as exempt under the AIP, aquifer interference activities must be assessed against the relevant minimal impact thresholds. The minimal impact considerations are outlined in Table 1 in Section 3.2.1 of the AIP where it is stated that *"if predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable"*. Under the AIP, trenches and pipelines that intersect the water table are listed as 'minimal impact activities' where a water access licence is not required. The Project meets these conditions, and as such does not require assessment under the AIP against the impact thresholds.
Approved Methods for Sampling and Analysis of Water Pollutants in NSW (DEC 2004)	This document provides guidance on sampling and analysis of groundwater that is applicable to the recommended monitoring program.
NSW Water Quality and River Flow Objectives, Towamba and Genoa River (DECC, 2006).	This policy is applicable to the Project as it identifies water quality objectives for lakes located within the Genoa and Towamba catchment, which include Merimbula Lake and Pambula Lake (Elgin Associates, 2020).
Managing Urban Stormwater; Soils and Construction (Landcom, 2004), also referred to as "the Blue Book".	This document provides guidance on stormwater management, with particular attention paid to the implementation of erosion and sediment controls during construction. The guidance provided in this document has been considered in the development of mitigation and management measures for the Project.

In consideration of the environmental values provided by the ANZG 2018 guidelines, the environmental values of the receiving waters of the Merimbula Lake, and Merimbula Bay are regarded as:

- aquatic ecosystems;
- aquatic foods;
- primary and secondary contact recreation; and
- visual amenity.

As groundwater from the Project area flows to or interacts with these receiving waters, the Project may have potential to impact the above environmental values. As such groundwater must be managed carefully during the construction and operation of the Project. The ANZG 2018 guideline specifies three levels of protection, from stringent to flexible, corresponding to whether the condition of the ecosystem is:

- of high conservation value;
- slightly to moderately disturbed; and
- highly disturbed.

This report assesses the Project against the influence that groundwater may have on the above environmental values and ANZG 2018 guidelines that are applicable to the surface water environment.

3.2 Study area

The general extent of the study area for this groundwater impact assessment includes the Project area and the nearby area. Selection of this study area was based on the results of previous groundwater investigations and the groundwater flow regime defined in these previous studies. The study area is shown on **Figure 3-1**. The study area also recognises the types and locations of potential groundwater receptors and encompasses pathways by which they may be impacted by the Project.

The study area extends to:

- the interface between terrestrial and aquatic environments along Merimbula Beach and the eastern shoreline of Merimbula Lake;
- the terrestrial groundwater environment:
  - upgradient to the south; and
  - downgradient to the east, north and west of the Project; and
- the groundwater flow system in a superficial aquifer comprising coastal dunes and alluvium.

Detailed explanations of the groundwater environment within this area are provided in **Section 4.0**.

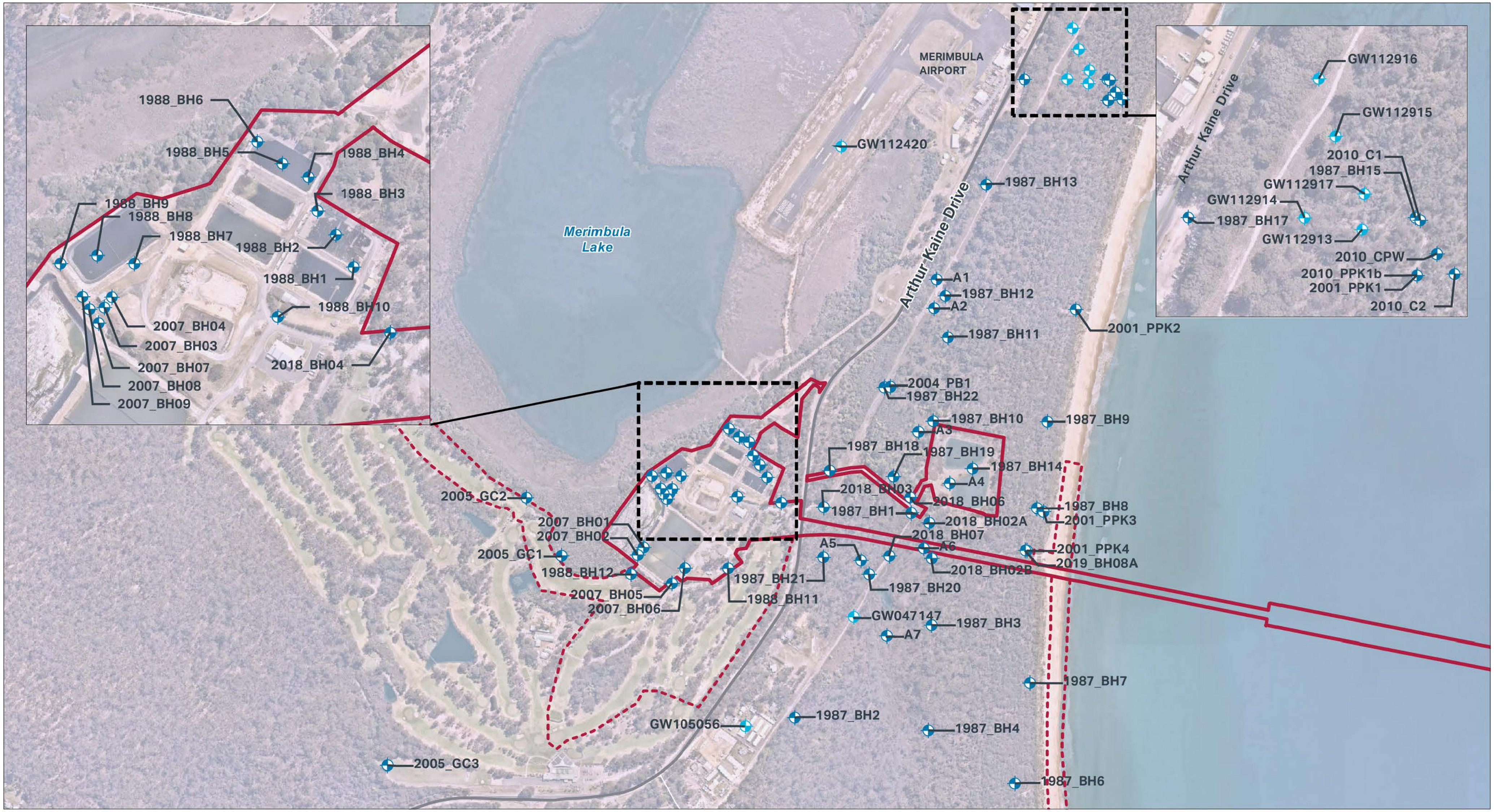

FIGURE 3-1: STUDY AREA - GROUNDWATER

Legend

- Project area
- Temporary project area for construction
- Groundwater monitoring bore
- Registered groundwater bore

0 200 400 m

Source: Nearmap, 2019

3.3 Methodology

This groundwater assessment adopted with the following methodology:

- review available groundwater quality data to define the existing environment;
- collate information on registered bores from the NSW Department of Planning, Industry and Environment – Water Division groundwater database;
- collate information on groundwater dependent ecosystems (GDE) from the National Atlas of Groundwater Dependant Ecosystems (Australian Bureau of Meteorology (BoM));
- define the area that influences the groundwater environment;
- review hydrogeological data collected during Project-specific subsurface investigations;
- identify potential impact of construction and operational activities and potential cumulative impact on water quality with reference to the ANZG (2018) water quality guidelines for protection of the relevant environmental values;
- nominate measures to manage potential cumulative impacts resulting from the Project; and
- provide a consolidated list of measures to be applied during construction and operational phase to mitigate potential impacts to groundwater.

3.4 Data sources

The sources of information used to define the existing groundwater environment, and to assess potential impacts of the Project on groundwater, are listed in **Table 3-3** .

Locations of geotechnical holes and groundwater bores referenced in **Table 3-3** are shown on **Figure 3-1**. These holes are generally numbered with a prefix denoting the year they were installed followed by a number or abbreviation of the originator. Details of bores near the Project area are provided in **Appendix A**. Groundwater level and quality data relevant to this Project are provided in **Appendix B** and **Appendix C**.

Table 3-3 Description of key data sources used to inform this Groundwater Impact Assessment

Information source	Purpose of report/ monitoring	Data available	Borehole identification number	Notes
Site specific hydrogeological information				
Mackie-Martin, 1987.	Appraisal of Sand Seepage Capacity and Conceptual Design of Infiltration Systems, Merimbula STW	22 geotechnical boreholes and groundwater sampling	1987_BH01. 1987_BH02, 1987_BH03, 1987_BH04, 1987_BH07, 1987_BH08, 1987_BH09, 1987_BH10, 1987_BH11, 1987_BH12, 1987_BH14, 1987_BH18, 1987_BH20, 1987_BH21, 1987_BH22, 1987_A1, 1987_A2, 1987_A3, 1987_A4, 1987_A6, 1897_A7	As described in PPK 2002 all the MMA bores have either been lost or destroyed. 1987_BH18, 1987_BH20 and 1987_BH21 were reported to terminate in weathered bedrock, however this is considered by PPK 2002 to be more likely to be Tertiary deposits. Logs of A-series bores unavailable.
Public Works Department,1988. Merimbula Wastewater Augmentation. Water Treatment Plan Stage 2 Geotechnical Investigation, (PWD, 1988)	To determine the geotechnical conditions and limitations for the construction of Stage 2 of the Merimbula wastewater treatment plant which included (but was not limited to) an aeration tank, sludge lagoon, effluent pump station, and amenities building.	12 shallow geotechnical boreholes, between 5 m to 10 m in depth.	1998_BH1, 1998_BH2, 1998_BH3, 1998_BH4, 1998_BH5, 1998_BH6. 1998_BH7, 1998_BH8, 1998_BH9, 1998_BH10, 1998_BH12.	Geotechnical information regarding underlying soils used to inform assessment of existing hydraulic conductivity hydraulic gradient.

Information source	Purpose of report/ monitoring	Data available	Borehole identification number	Notes
PPK, 2002. Assessment of Groundwater Conditions and Dune Disposal Options for Merimbula STP. EGIS/IDSM Joint Venture.	To investigate the groundwater conditions around the exfiltration ponds at Merimbula STP and to inform potential options for future effluent disposal methods.	Four monitoring wells including hydrochemistry and groundwater levels. Report provides groundwater information regarding the following at the Merimbula STP: groundwater level contours; hydro chemical properties; response to tidal influence and rainfall; production of groundwater hydrographs; and analysis of pump test and infiltration test data.	2001_PPK1, 2001_PPK2, 2001_PPK3, 2001_PPK4.	PPK1 and PPK2 are closest to the proposed outfall pipeline alignment. This report included monitoring data from seven wells monitored by BVSC between 1991 and 1992.
Parsons Brinkerhoff (PB), 2004 Investigation of the Deep Disposal Option for Reclaimed Water from Merimbula STP (draft report).	To investigate the option of deep disposal of effluent.	A pilot hole (62 m depth), environmental logging and a resistivity survey, including groundwater quality testing from the deep aquifer.	2004_PB1	
AECOM, 2020. Geotechnical Interpretive Report. Bega Valley Shire Council.	Provides a preliminary interpretation of the geotechnical conditions along the land portion of the proposed alignment of the proposed outfall pipeline.	Seven geotechnical holes and a geophysical survey for this Project	2018_BH002A, 2018_BH002B, 2018_BH003, 2018_BH004, 2018_BH006, 2018_BH007, 2019_BH08A	

Information source	Purpose of report/ monitoring	Data available	Borehole identification number	Notes
Groundwater level and quality monitoring data				
Bega Valley Shire Council groundwater monitoring database for the local government area (LGA), containing data from 2004 to 2019	Environmental monitoring associated with operating the STP	Groundwater level monitoring data collected between December 2005 and September 2019 and groundwater quality data between 1987 and September 2019.	1987_A1, **1987_A4, 1987_A5, 1987_A6, 1987_BH01,** 2001_PPK1, 2001_PPK2, **2001_PPK3, 2001_PPK4.**	Six of nine bores (**bolded**) have been used for this assessment based on availability of information and proximity to the Project.
Regional groundwater bore information				
NSW Water Register- A search of the register was conducted to identify any water licences, approvals, and environmental water within proximity to the Project (within 1,750 m)	The NSW Water Register amalgamates information from several public registers to provide information about water licences, approvals, water trading, water dealings, environmental water and other matters related to water entitlements in NSW	Water licences, approvals, and environmental water.	Bore numbers not known. Bores referred to by WaterNSW site reference numbers.	GW040592, GW040593, GW047147, GW105056, GW112913, GW112914, GW112915, GW112916, GW112917, GW112420.
Regional geology				
1:25,000, 1:100,000 and 1:250,000 scaled maps published by the NSW Geological Survey	Geological maps	Shows the geological units on a local and regional scale (respectively)	N/A	N/A
Climate information				
Applicable climate and rainfall data from the Bureau of Meteorology and Scientific Information for Land Owners (SILO) patched point dataset from the QLD Governments “Long Paddock” resource.	Long term national climate data collected by the Bureau of Meteorology and the Science and Technology Division of the Queensland Government's Department of Environment and Science.	Both resources provide datasets for a range of climate variables over a selectable time period, including rainfall, temperature, relative humidity, etc.	N/A	N/A

Information source	Purpose of report/ monitoring	Data available	Borehole identification number	Notes
Groundwater dependent ecosystem mapping				
Merimbula STP Upgrade and Ocean Outfall Pipeline Biodiversity Assessment Report (refer **Appendix H** of the EIS).	Prepared to inform the EIS for this Project	Vegetation and ecosystem mapping of the terrestrial component of the study site	N/A	N/A

3.5 Key assumptions

The following key assumptions were made in relation to this assessment:

- Pipeline construction as part of the Project would involve trenchless construction techniques using directional drilling and installation of pipeline casing (during or after drilling of the hole). This would:
  - minimise interference with groundwater, including the superficial aquifer (or unconfined aquifer, described in more detail in **Section 4.2.2**), by avoiding large surface excavations that could structurally damage the aquifer; and
  - avoid dewatering, and resultant impacts on existing groundwater users and the local ecology, by installing casing along the pipeline route.
- Components of this report rely on publicly available data being correct and up to date.

3.6 Assessment criteria

The NSW aquifer interference policy (DPI, 2012) refers to the definition of aquifer interference in the *Water Management Act 2000* as:

- 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; and
- the disposal of water taken from an aquifer while carrying out mining or any other activity prescribed by the regulations.

The subsurface pipeline to be installed as part of the Project would interact with the superficial aquifer and groundwater in the aquifer because it would extend into the aquifer below the water table, potentially interfere with groundwater in the aquifer and potentially obstruct the flow of groundwater. Due to the proposed construction technique and designs, dewatering of groundwater for the Project is not expected to be required (except in an intermediate drilling site is required, refer **Section 5.1**).

As described in **Table 3-2**, the AIP outlines the minimal impact considerations for aquifer interference activities as they relate to:

- groundwater regime including:
  - groundwater levels; and
  - groundwater quality.
- groundwater resource including:
  - existing users; and
  - ecological dependence.

The AIP provides the specific thresholds for minimal impact considerations for aquifers classified as highly productive and less productive groundwater sources. The superficial aquifer that is located below the Project is classified as a highly productive groundwater source as defined in the AIP as it meets the following criteria:

- has total dissolved solids of less than 1,500 mg/L; and
- underlying materials comprise coastal sands.

As such, this groundwater assessment has been undertaken in consideration of the thresholds for the minimal impact considerations for aquifer interference activities within highly productive groundwater sources as defined in Table 1, Section 2 “coastal sands water sources” of the AIP. As mentioned in

Table 3-2, the minimal impact considerations outlined in Table 1 of the AIP states that *"if predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable"*. Under the AIP, trenches and pipelines that intersect the water table are listed as 'minimal impact activities' where a water access licence is not required. The Project meets these conditions, and as such does not require assessment under the AIP against the impact thresholds.

Maintaining groundwater levels and protecting groundwater quality will, by and large, protect the resource. Groundwater levels in the existing environment are maintained by recharge from rainfall infiltration and are measured across the Project area via existing monitoring bores. Groundwater quality is the summation of the chemistry of rainfall recharge, sea salt, and aquifer geochemistry within a transient and mobile flow system. Protecting groundwater flow regime and quality was assessed by considering potential changes the Project may impose to the existing groundwater conditions (derived from existing monitoring data, as described in more detail in **Section 4.0**) during its construction and operational phases.

Protecting the groundwater resource and the existing users and the ecology that depend on it, was assessed based on whether there is a likely pathway from the Project that could lead to an impact. The assessment therefore considered the locations and type of user, mechanisms that could activate an impact pathway, and the expected severity of the change.

It is recognised that the STP site has been used to treat and discharge treated wastewater for 40 years. After treatment, the wastewater is currently piped to two exfiltration ponds and/or to an outfall on Merimbula Beach. As a result, groundwater quality near the exfiltration ponds is not regarded as the same as natural background quality.

4.0 Existing environment

4.1 Climate

The Project is in a region with a temperate climate. The closest Bureau of Meteorology (BoM) weather station is at the Merimbula Airport, site number 061397 (Latitude 36.91°S Longitude 149.90°E) located about 1 kilometre (km) north-east of the study area. The mean annual rainfall at this station is 727.7 millimetres (mm), based on a data series between 1998 and 2020, with monthly totals being higher in February, June and November (BoM 2020). **Table 4-1** and **Figure 4-1** illustrate the yearly seasonal variation in average monthly rainfall. It is also noted however that data from years that experienced high rainfall such as 2010, 2012 and 2014 shows that the total annual rainfall ranged from 983.4 mm to 1131.8 mm.

Temporal variability of rainfall or how much rainfall changes between seasons was examined in some detail by Ian Grey Groundwater Consulting Pty Ltd (IGGC, 2013). The analysis of rainfall residuals between 2001 and 2012 were considered to identify long-term variability and trends. Annual average rainfall residuals ranged from about -30mm to +40mm indicating the natural inter-seasonal variability is between 4.1% and 5.5% of the average annual rainfall. Merimbula has a warm mean maximum temperature in summer (24.9°C in January) and cool mean minimum temperature in winter (4.1°C in July).

Evaporation data is not measured at this meteorological station, however interpolated data from the SILO database (Long Paddock 2020) indicates that it normally ranges between 49.4 mm/month in June to 183.1 mm/month in January. The annual average evaporation is about 1,327.3 millimetres.

Table 4-1 Mean monthly rainfall totals at Merimbula Airport

	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
Mean monthly rainfall (mm)	61.0	84.7	79.2	63.2	45.9	73.7	43.7	43.2	42.4	51.4	79.4	59.7	727.7
Mean monthly evaporation (mm)	183.1	146.6	126.0	88.6	61.4	49.4	53.5	73.7	95.7	125.7	147.5	176.2	1,327.3

Note: Rainfall averages based on records from 1998 to 2020 (current on 22/6/2020) at BoM Station 069147
Evaporation averages based on interpolated data from the SILO database from 1889 to 2020.

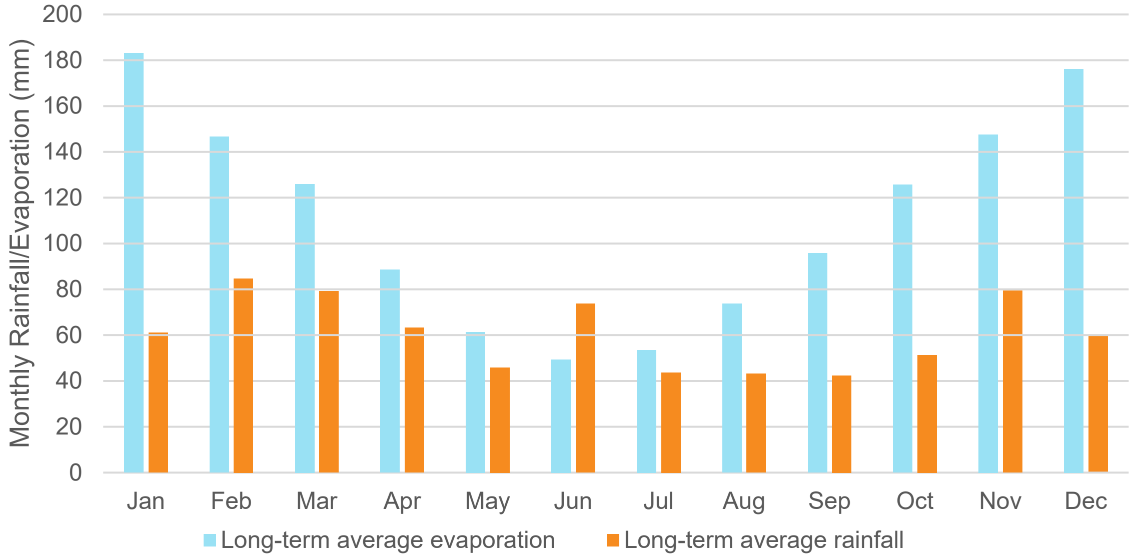

Figure 4-1 Long-term average monthly rainfall and evaporation

4.2 Geology and hydrogeology

A detailed account of regional geological mapping by the NSW Geological Survey and local investigations into the geology and hydrogeology of the site over the past 23 years was developed by IGGC (2013). Since then, sub-surface investigations were undertaken by AECOM in 2018 and 2019 to inform the Project assessment, as described in **Section 3.4**.

4.2.1 Regional geology

Regional and local geology interpreted from the published geology map: 1:250,000 scale Bega-Mallacoota Sheet (**Figure 4-2**) included the identification of:

- Quaternary (Holocene) deposits including coastal sand dunes, coastal beach sand, and estuarine deposits of sand, mud, gravel and shell;
- Tertiary sediments beneath a low ridgeline, west of the infiltration ponds; and
- bedrock comprising late Devonian metamorphosed sandstone, siltstone and mudstone of the Merimbula Group and middle Devonian volcanic rocks of the Boyd Volcanic Complex.

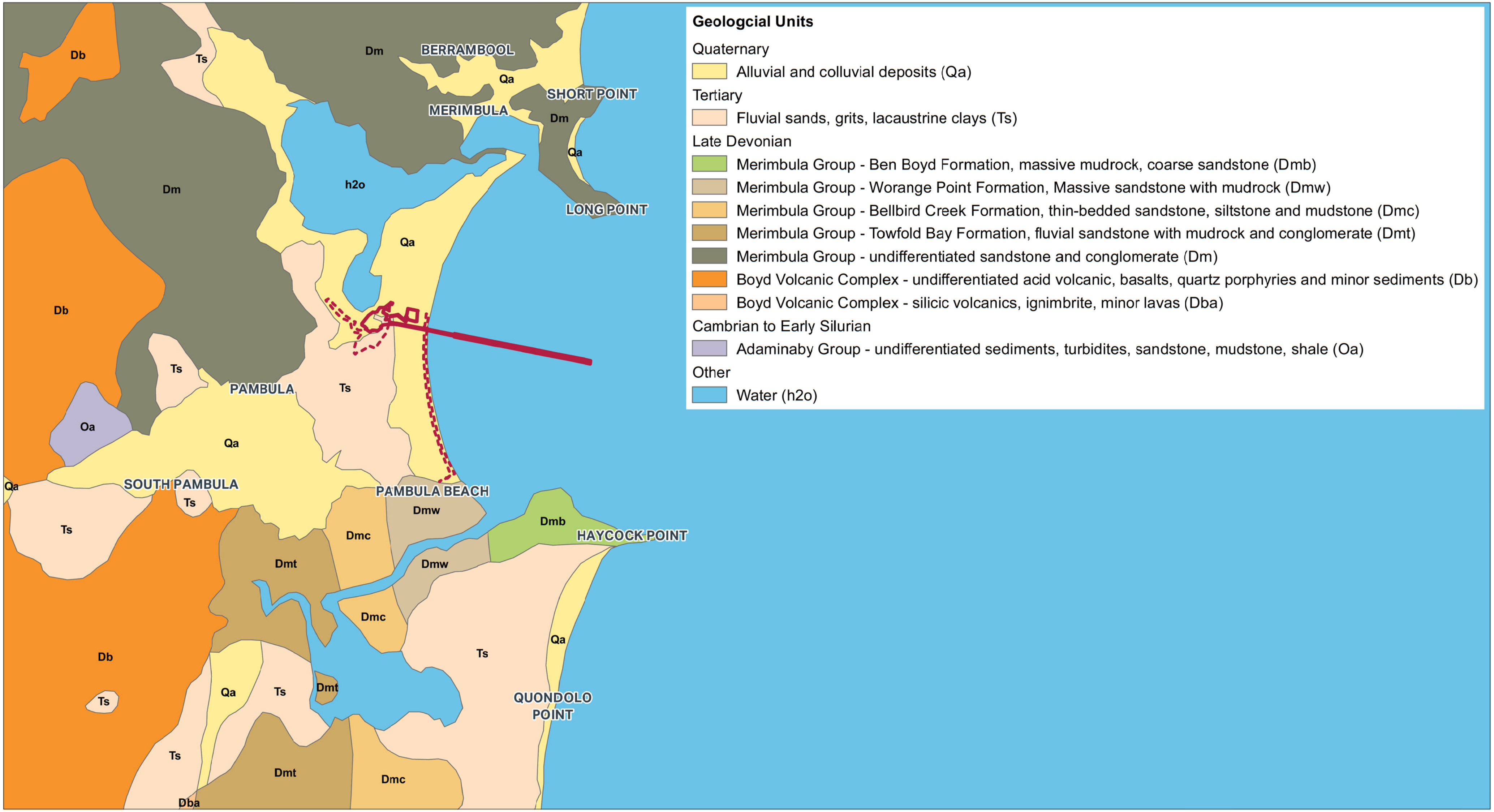

FIGURE 4-2: EXTRACT FROM BEGA-MALLACOOTA 1:250,000 GEOLOGICAL SHEET - GEOLOGICAL SURVEY OF NSW

N
0 1 2 km

Legend
Project area
Temporary Project area for construction

Source: Nearmap, 2019

Beneath the modern dune system are older sediments of fluvial (river/creek) and lacustrine (lake) origin. These deposits occupy a palaeo drainage network that was eroded by the ancestral Pambula River as shown on **Figure 4-2**. Whether the deposits are of fluvial or lacustrine origin was dependent on the relative sea level that has fluctuated during glacial and inter-glacial periods. The palaeovalley is understood to be in the order of at least 90 m depth and about 300 m wide.

At a local scale, the geology is dominated by sedimentary deposits of Quaternary age (**Figure 4-3**).

Detailed mapping is provided by the Geological Survey of NSW at 1:100,000 and 1:25,000 scales. This mapping identifies these deposits as follows:

- **Qheb**: Holocene estuarine in-channel bar and beach: marine sand, silt, clay, shell, gravel. West of the site;
- **Ts**: Tertiary Sediments. Forms a low ridge trending north south and underlies the alignment west of the exfiltration ponds;
- **Qhbf**: Holocene back-barrier flat: marine sand, silt, clay, gravel, shell: 10-20 m wide section, west of the exfiltration ponds;
- **Qhbd**: Holocene dunes: marine sand (exfiltration ponds to Merimbula Beach); and
- **Qhbb**: Holocene sandy beach: marine sand, shell, gravel (Merimbula Beach).

The geology and hydrogeology of the Project area is summarised in **Table 4-2**.

Table 4-2 Geology and hydrogeology of the Project area

Geological Era/Period	Geology	Hydrogeology
Quaternary	Alluvial, colluvial and dunal deposits (Qa, Qheb, Qhbf, Qhbd and Qhbb)	Unconfined aquifer (sand deposits) Aquitard (silt and clay deposits)
Cainozoic/Tertiary	Fluvial sand, grit and lacustrine clay (Ts)	Unconfined to confined aquifer (sand deposits) Aquitard (silty and clay deposits)
Geological unconformity (time gap in the geological strata)		
Late Devonian	Merimbula Group (Dm, Dmb, Dmc) sedimentary rocks - sandstone, siltstone and mudstone	Confined aquifer (fractured bedrock) Aquitard (fresh unfractured bedrock)
Middle Devonian	Boyd Volcanic Complex (Db) - volcanic rocks and minor sediment	

Note: Geological abbreviations derived from mapping by the Geological Survey of NSW.

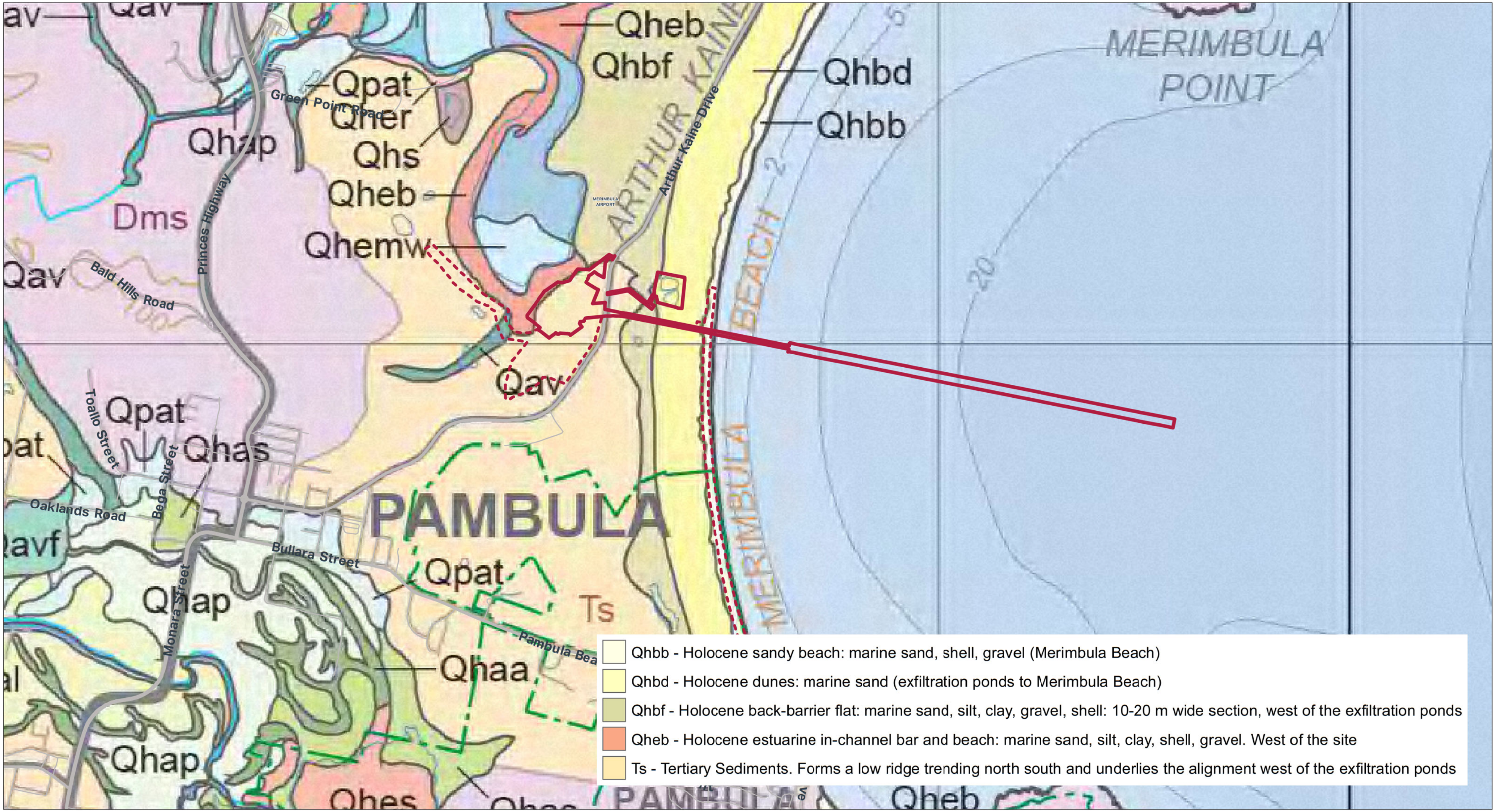

FIGURE 4-3: BEGA VALLEY COASTAL GEOLOGY MAP

AECOM

Legend

Project area

Temporary Project area for construction

Source: Bega Valley Coastal Quaternary Geology Maps 1:100,000 and 1:25,000 – Geological Survey of NSW,

4.2.2 Aquifer occurrence

Groundwater occurs below the water table, which is present within the sedimentary deposits that lie beneath the Project area. Following groundwater investigative work by Mackie Martin and Associates (MMA 1987), PPK (2002) and Parsons Brinkerhoff (PB 2004), a preliminary description of the hydrostratigraphy based on available drillhole and geophysical data indicated the presence of:

- an upper sand unit comprising medium to coarse sand, similar to dune sand;
- an underlying “middle” unit comprising clay with interbedded with coarse sand starting about 5m below the top of this unit;
- a lower unit comprising coarse sand with minor clayey interbeds; and
- inferred Pambula Palaeovalley deposits including the middle and lower units.

The upper unit was described as a shallow unconfined aquifer and underlying clay aquitards and (presumably) confined sand aquifers. Groundwater level data (from PB1) indicates upwards hydraulic gradients from deep layers of coarse sand giving rise to piezometric levels (confined aquifer groundwater levels) of about 2 metres above the Australian Height Datum (m AHD), which is slightly above the ground surface at some locations. Hydraulic testing by PB (2004) determined the deep sand strata had an average hydraulic conductivity (a measure of permeability) of about 4 m/d, compared to values of 12 m/d to 47 m/d determined by MMA (1987) for the superficial sand formations.

Results from the resistivity survey by PB (2004) identified three layers, from top-down: 1) unsaturated sand, 2) mixture of clay and sand and 3) bedrock. Bedrock depths were inferred to be between 25 m and 30 m below the surface increasing to more than 35 m north of the infiltration ponds that was interpreted to coincide with the palaeovalley.

In 2018, AECOM undertook an investigation that included:

- A gravity and Tromino survey by GBG Australia concluded the bedrock may be deeper than 140 metres below the ground surface (mbgs) and that it is increasing to the north. The depth of cover over the rock layer to the south of the investigation area. There were insufficient readings to inform inversion modelling and accurately define depths to bedrock in general.
- Borehole drilling that intersected (from top-down): 1) loose to dense dune sand from 8 m to 10 m+ in thickness, and 2) interbedded dense to very dense sand and very stiff to stiff clay.
- Estimated hydraulic conductivity of the dune sand ranging from 17 m/d to 52 m/d.

At a local scale the stratigraphy beneath the Project area comprises a thick succession of sand with discontinuous layers of clay and clayey sand as shown on **Figure 4-10**. The sand and clay under the STP are part of the Tertiary sedimentary succession, while the overlying sand formations to the east are Quaternary coastal dune and beach deposits (IGGC, 2013). A summary of aquifer test results by IGGC (2013) suggested the hydraulic conductivity of the superficial coastal sand deposits was 30 m/d to -50 m/d.

4.2.3 Groundwater recharge, levels and flow

Groundwater is recharged by rainfall that infiltrates to the water table. The rate of recharge depends on the prevailing land use and intensity and frequency of rainfall events. Based on investigative work by MMA (1987), PB (2004) and IGGC (2006) recharge has been estimated to range from 30% to 100%. Values higher than 40% are probably the result of concentrated runoff from paved roads and other hardstand surfaces and aquifer throughflow from upgradient areas. Groundwater levels are controlled by the rate of recharge and the hydraulic conductivity of the superficial strata below the water table. Groundwater level contours generated by IGGC (2013) shown in **Figure 4-4** are based on ‘typical’ conditions. These indicate:

- recharge accumulating at the water table has formed a north-south groundwater divide along the sand spit beneath Arthur Kaine Drive and Merimbula Airport;
- groundwater flows outward from a natural mound south of the Project; and
- groundwater discharges to Merimbula Beach (east) and Merimbula Lake (west).

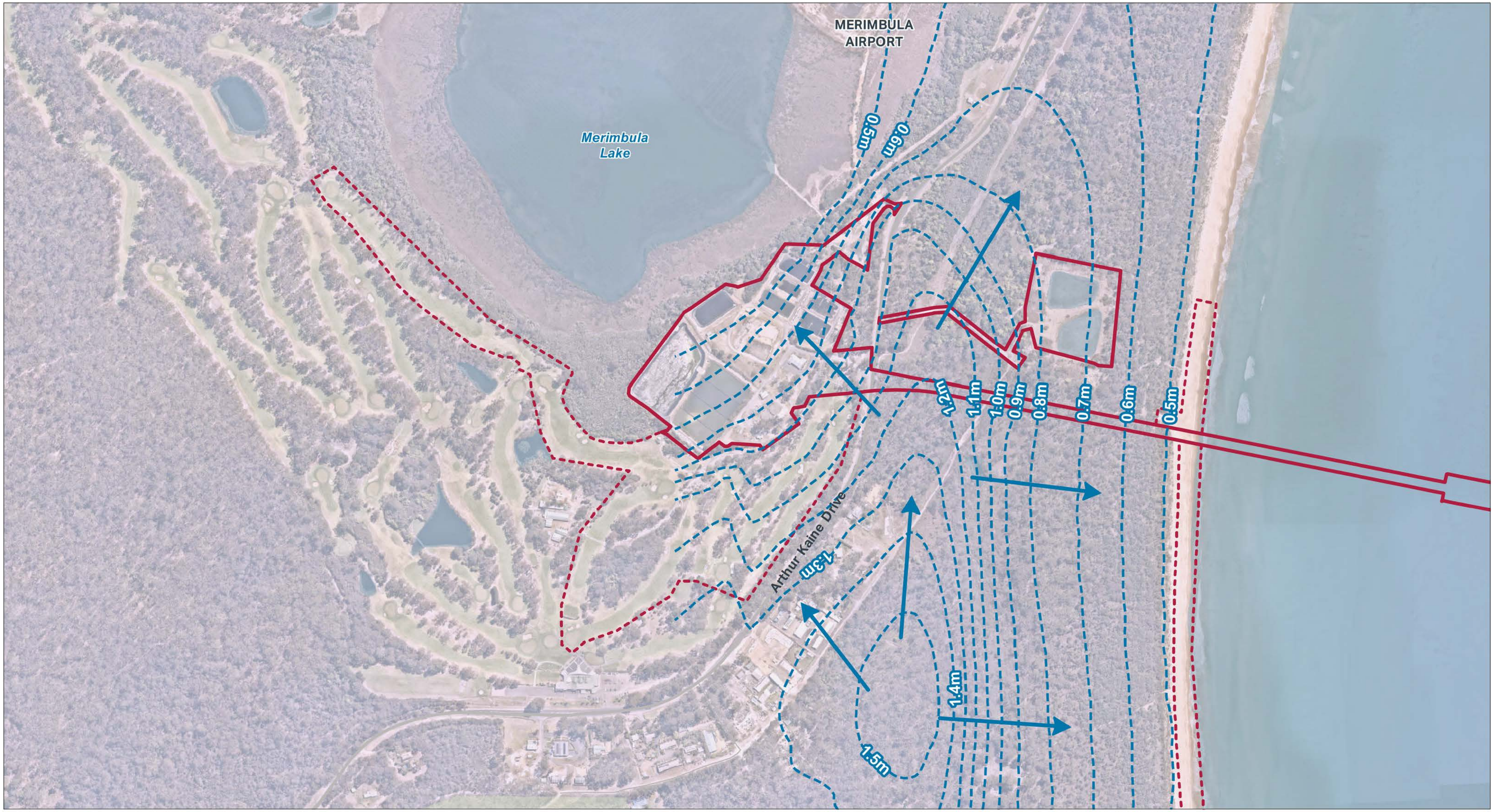

FIGURE 4-4: GROUNDWATER LEVEL CONTOURS AND INFERRED FLOW DIRECTIONS

Legend

- Project area
- Temporary Project area for construction
- Groundwater level contours under normal conditions (After IGGC, 2013)
- Inferred groundwater flow

N

0 200 400 m

AECOM

Source: Nearmap, 2019

The water table fluctuates in response to seasonal rainfall and near the coast, to tidal fluctuations and wave action (IGGC 2013). Hydrographs of four long-term monitoring bores, A5, A6, PPK3 and PPK4 have been developed and are shown on **Figure 4-5**). These boreholes are located near the Project, as shown on **Figure 3-1**. **Table 3-3** describes the relevant report for which each of these boreholes were originally established.

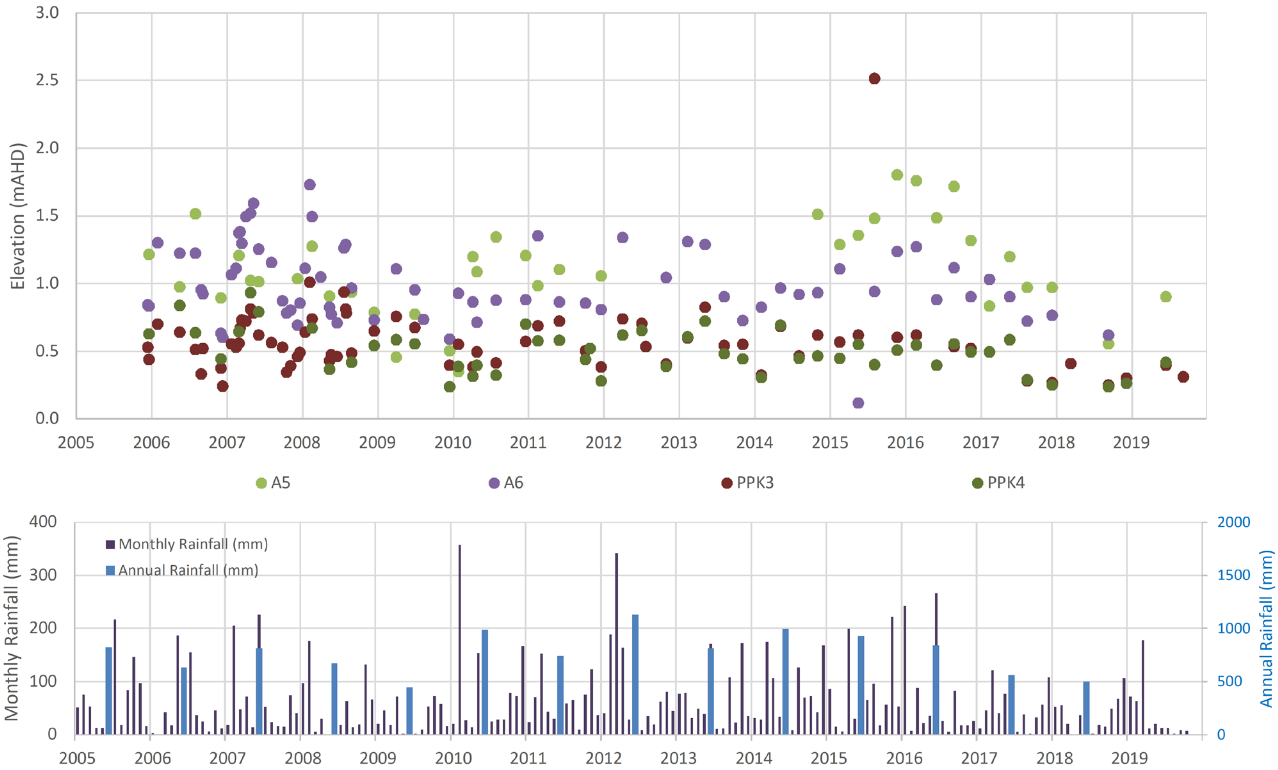

Figure 4-5 Hydrographs of selected groundwater monitoring bores

Groundwater levels close to the proposed pipeline fall from between 1.0 m AHD and 1.1 m AHD inland (bores A5 and A6) to between 0.5 m AHD and 0.6 m AHD close to Merimbula Beach (bores PPK3 and PPK4) as indicated in **Table 4-3**. The water table generally fluctuates by about 0.5 m inland (bores A5 and A6) and 0.3 m close to the beach (bores PPK3 and PPK4).

Table 4-3 Groundwater levels and fluctuation ranges

Groundwater Levels	Units	A5	A6	PPK3	PPK4
80th Percentile	(m AHD)	1.38	1.28	0.70	0.63
Mean		**1.10**	**1.00**	**0.58**	**0.50**
20th Percentile		0.88	0.78	0.39	0.37
Typical fluctuation range (m)	(m)	0.50	0.50	0.31	0.26

Detailed water level measurements undertaken by IGGC (2013) using automatic data loggers and manual readings concluded the water table in the Project area near Merimbula Beach is influenced by the levels in the two exfiltration ponds, rainfall and tidal levels. Short-term fluctuations in the order of 0.1 m were attributed to tidal influences at bore PPK3.

4.2.4 Groundwater quality

Groundwater quality has been monitored by the BVSC as part of the environmental monitoring program for the STP since November 2001. The bores are located to the east of the STP site near the exfiltration ponds, wetland area to the south and Merimbula Beach to the east. This monitoring generally includes:

- physicochemical properties (pH, EC, temperature, dissolved oxygen (DO), reducing-oxidising (a physicochemical hydrochemical property) (REDOX) potential, hardness, and alkalinity);
- major anions and cations (sodium, potassium, calcium, magnesium, chloride (free and total), sulphate, carbonate/bicarbonate, hydroxide;
- nutrients (ammonia, nitrogen and phosphate); and
- microbiological parameters (faecal coliform, *E. coli*, faecal streptococci and enterococci).

The chemistry of groundwater near the STP site based on averages from the long-term monitoring database are provided in **Table 4-4**.

Table 4-4 Groundwater average chemistry[1]

Site	Units	1987_BH10	A4	A6	PPK3	PPK4
pH		6.71	6.76	4.96	7.93	7.81
EC	µS/cm	735.5	979.2	206.1	906.7	829.3
Dissolved Oxygen	mg/L		0.99	1.03		1.19
Dissolved Oxygen	% Sat	2.18	3.54	3.19	2.46	1.69
Redox Potential	mV	-91.7	-98.8	76.5	26.2	-104.3
Temperature	ºC	17.0	19.2	16.7	17.9	17.5
Bicarbonate	mg/L	146.9	348.3	5.4	182.3	178.9
Carbonate	mg/L	2.0		1.7	2.0	2.0
Hydroxide	mg/L	2.0		1.7	2.0	2.0
Total Alkalinity	mg/L	146.9	317.8	5.1	182.3	179.0
Chloride	mg/L	127	119	51	145	131
Sulphate	mg/L	15.4	31.5	2.8	34.4	30.7
Dissolved Calcium	mg/L	23.4	100.5	2.7	45.9	41.6
Dissolved Mg	mg/L	12.8	11.7	4.6	10.3	9.3
Dissolved Na	mg/L	90	92	24	107	101
Dissolved K	mg/L	16.3	41.0	1.0	20.0	19.6
Ammonia (N)	mg/L	0.96	0.36	0.11	0.78	0.79
Nox (N)	mg/L	0.04		0.03	0.25	0.07
Nitrate (N)	mg/L	0.06		0.05	0.15	0.08
Nitrite (N)	mg/L	0.01	0.02	0.01	0.01	0.03
Total Nitrogen	mg/L	1.62	1.30	1.56	1.43	1.28
Phosphate	mg/L	0.48	0.06	0.02	5.02	1.48
Total Phosphorous as P	mg/L	0.56	0.71	0.17	5.35	1.52

[1] These results were derived by averaging the historical results in the BVSC groundwater quality database.

Site	Units	1987_BH10	A4	A6	PPK3	PPK4
Reactive Phosphorous	mg/L					0.1
Faecal Coliforms	CFU/100 mL	28		3	22	2
E. coli	CFU/100 mL	33		2	23	2
Faecal Streptococci	CFU/100 mL	15		5	112	2
Enterococci	CFU/100 mL	15	8	4	2,884	2

A comprehensive review of the local groundwater quality by IGGC (2013), and a summary of the groundwater quality results presented in the table above demonstrate:

- Groundwater in the Project area is typically fresh near the water table, becoming saline at depth. Higher salinity at depth is the result of natural processes whereby saline groundwater is more dense than fresh groundwater. Along the coastline saline groundwater of marine origin "wedges" underneath fresh groundwater that "floats" at the water table.
- Groundwater is otherwise slightly alkaline and predominantly composed of sodium and chloride ions.
- Nutrients are generally present at low concentrations with inorganic nitrogen, mostly as nitrate, of about 0.3 mg/L. Nutrient levels can fluctuate as a result of bush fires or controlled burns.
- Dissolved metal concentrations are generally low except for arsenic and zinc, and occasionally cobalt, copper and nickel, which can be elevated by local natural processes.
- Microbiological activity associated with pathogenic bacteria is generally low but elevated at bore PPK3, which is downgradient of the exfiltration ponds.

A recent review of surface water quality by Elgin (2020) determined Merimbula Lake is characterised by high water quality under normal tidal and baseflow conditions. Treated wastewater has been used to irrigate the PMGC grounds for many years. Evidently, any groundwater discharging as baseflow from the Golf Course to Merimbula Lake is not affecting the lake water quality.

The IGGC study considered the quality of effluent that was being discharged as irrigation to the PMGC grounds and Oaklands agricultural area or discharged to a beach-face ocean outfall of exfiltration ponds between the STP and the beach. The quality of the effluent water based on data from between 2004 and 2012 was characterised as being generally good and broadly similar to local fresh groundwater except for elevated phosphorous and the presence of faecal coliforms.

More recent work by AECOM (2020) characterised groundwater quality along the proposed pipeline alignment for the Project as follows:

- the salinity (based on electrical conductivity (EC)) ranges between fresh at the water table: 220 microsiemens per centimetre (μS/cm) to brackish at 10 m depth: 2,400 μS/cm at 2018_BH02B to saline (seawater) near the coast;
- the pH, sulphate and chloride concentrations, indicate that groundwater is stratified and acidic (pH 4.0 to 4.2), and fresh to brackish (and near neutral and fresh at the other two sites; and
- sulphate/chloride ratios that suggest the soils at BH02 have possibly been affected by acid-sulphate soil (ASS) instability.

Typical groundwater pH and EC across the Project area based on average values from the BVSC database (BVSC, 2019) are shown on **Figure 4-6**. These results indicate:

- the pH (pH 6.10 to 7.93) is within the normal circum-neutral range for groundwater (pH 6.0 to 8.5) but is lower near wetlands at bore A6 (pH 4.96); and
- the EC is lowest at bore A6 near the wetlands and higher downgradient near Merimbula Beach (PPK2, PPK3 and PPK4) and higher still near Merimbula Lake (bore GC2).

Acidic conditions relate to humic acids that accumulate in water-logged areas, while the increasing EC along the flowpath results from the natural accumulation of sea salt and proximity the beach and lake.

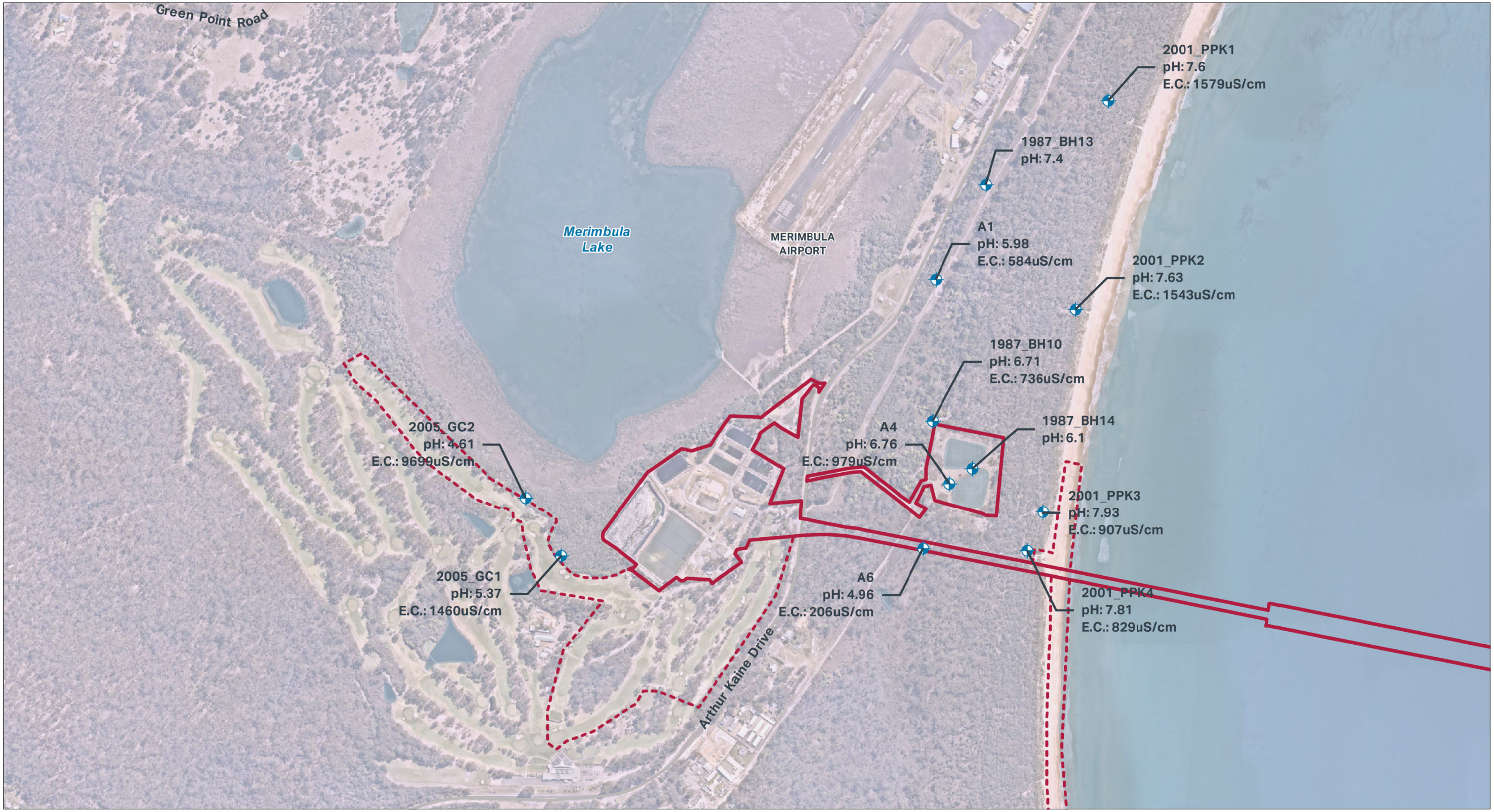

FIGURE 4-6: AVERAGE GROUNDWATER ELECTRICAL CONDUCTIVITY AND pH WITHIN THE STUDY AREA

Legend

Project area

Temporary Project area for construction

Groundwater monitoring bore

E.C. Electrical conductivity

Source: Nearmap, 2019

Changes to the quality of groundwater with time near the proposed pipeline based on data from bores 1987_BH10, A6, PPK3 and PPK4 are shown on **Figure 4-7**. These plots indicate:

- the pH fluctuates within a two-pH unit range at bore A6 near the wetland but within one pH unit near the discharge zone at Merimbula Beach;
- the pH fluctuates in-sync across the site from the recharge zone to discharge zone;
- the EC fluctuates seasonally in response to rainfall recharge;
- groundwater at the wetland site (bore A6) more acidic conditions occur when the EC is higher; and
- long-term trends are generally stable except the EC in the past two years that has increased due to below average rainfall.

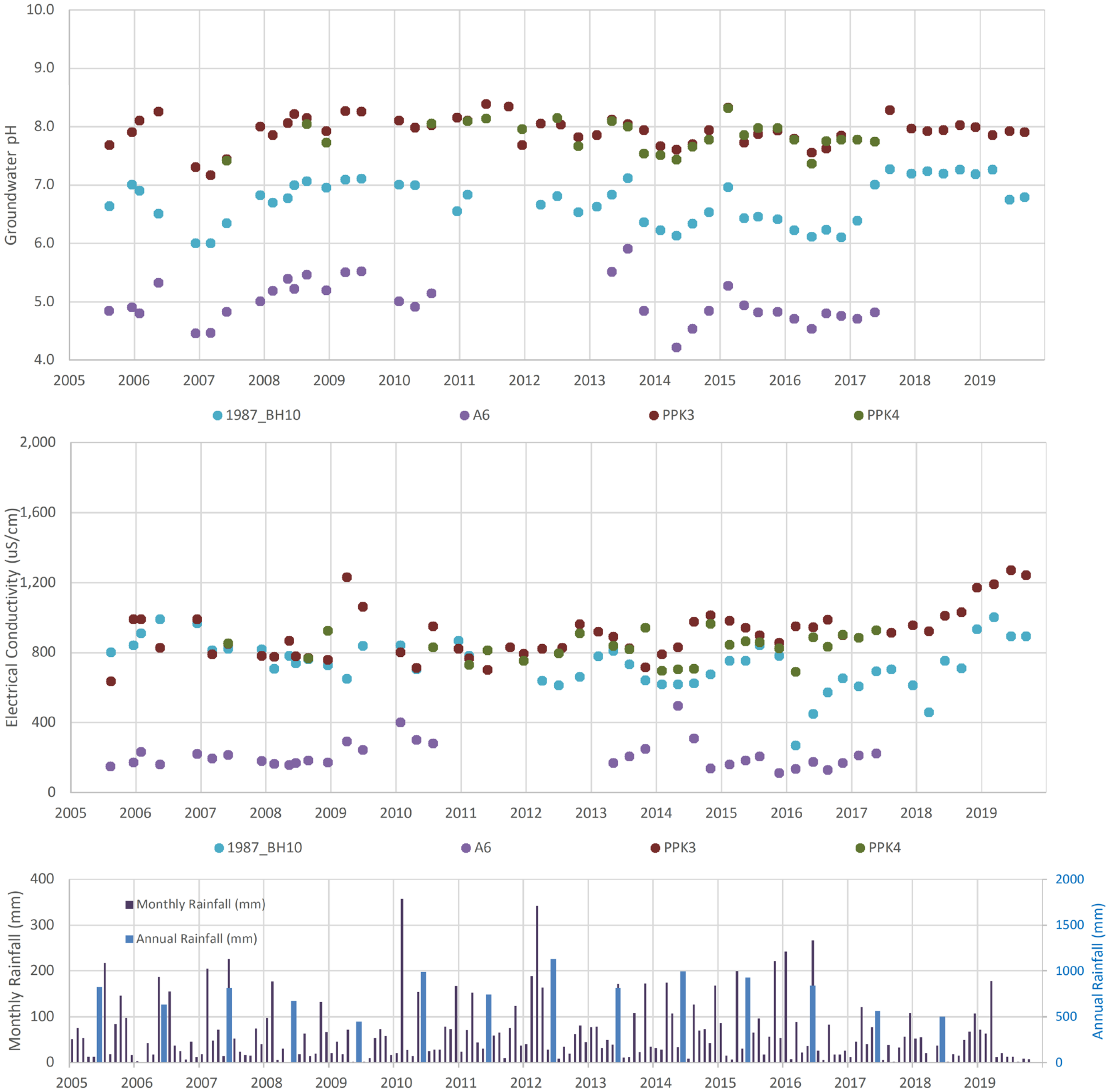

Figure 4-7 Time plots of quality from selected groundwater monitoring bores

4.3 Groundwater users

The Project area is relatively remote from other groundwater users. A search of registered groundwater bores from the NSW Office of Water (DPI, 2020) database indicates there are nine sites within 1.3 km of the Project as summarised in **Table 4-4** and shown on **Figure 4-8**. This distance was selected to identify nearby bores, and given the nature of the Project (**Section 1.1**) and hydrogeology (**Section 4.2**) any interference effects are expected to be well within this radius.

Based on this information, the nearest bore (GW047147) at 350 m distance, is an unlicensed private water supply bore that was used for recreational purposes. It is a small diameter bore (<152 mm) at about 480 m distance, constructed in 1977. Another small diameter unlicensed bore (GW0105056) was installed in 2003 to test the supply and quality of groundwater for industrial purposes. The condition of these unlicensed bores is unknown. Near the Merimbula Airport are several monitoring bores, of which two (GW112420 and GW112913) are licensed for monitoring purposes.

Table 4-5 Registered groundwater users near the Project area

Bore number	Licensed?	Depth (mbgs)	Construction type	Use	Approx. distance (m)	Owner type
GW040592	No	3.0	Excavation	Unknown	1,300	Unknown
GW047147	No	14.0	Supply Bore	Recreational	350	Private
GW105056	No	79.2	Bore	Test bore for industrial purposes	480	Unknown
GW112420	Yes (10BL604910)	3.5	Bore	Monitoring	860	Private
GW112913	Yes (10BL604155)	16.0	Bore	Monitoring	1,240	Local Govt.
GW112914	No	16.1	Bore	Monitoring	1,220	Local Govt.
GW112915	No	20.5	Bore	Monitoring	1,280	Local Govt.
GW112916	No	11.5	Bore	Monitoring	1,300	Local Govt.
GW112917	No	5.0	Bore	Monitoring	1,260	Local Govt.

FIGURE 4-8: REGISTERED GROUNDWATER BORES NEAR THE PROJECT AREA

Legend
Project area
Temporary Project area for construction
Registered groundwater bore

N
0 200 400 m

AECOM

Source: Nearmap, 2019

4.4 Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are present in low-lying areas where the depth to the water table is small for most, if not all year-round. These areas include diverse communities of plants, animals and other organisms whose extent and life processes depend on groundwater. The assessment undertaken by EcoLogical Australia (refer **Appendix H** of the EIS) indicates wetlands that have some dependency on groundwater are present near the Project area as shown on **Figure 4-9**. The main terrestrial wetland is located along a back-dune area that extends across and south from the proposed pipeline route.

The water table in this area is close to the surface because it is topographically low and close to the contact between the Tertiary sand and clay deposits (low hydraulic conductivity) and Quaternary coastal sand deposits (high hydraulic conductivity). Semi-permanent water, present in a small area south of the Project area, is likely to be exposed groundwater. Groundwater levels in this area fluctuate by about 0.5 m in response to seasonal rainfall recharge (**Table 4-3**). The quality is fresh (**Table 4-4**) because it is within a recharge zone and tends to be acidic because of the fluctuating water table in an area where soils contain organic material.

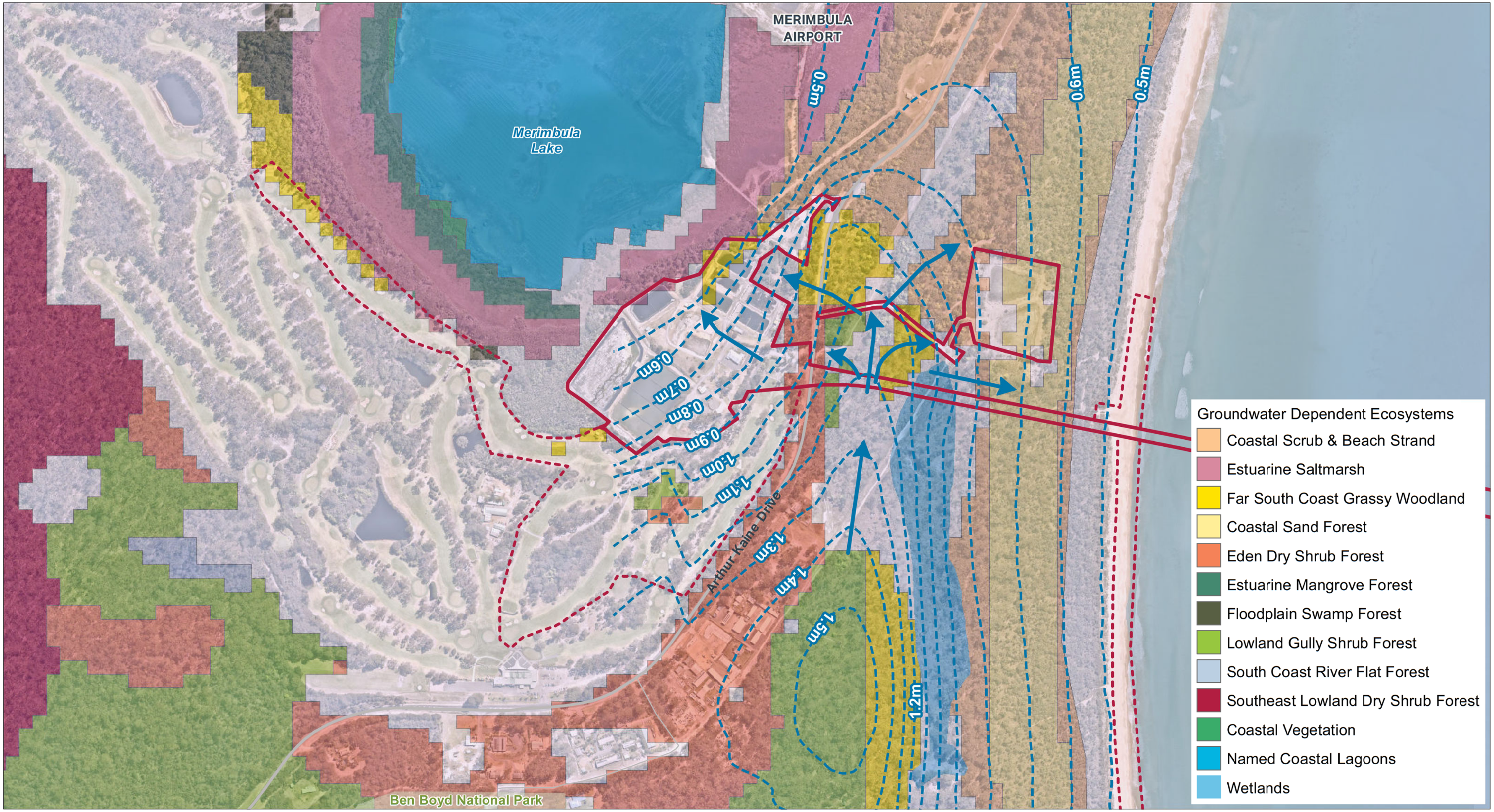

FIGURE 4-9: MAPPED GROUNDWATER DEPENDENT ECOSYSTEMS

Legend

Project area

Temporary Project area for construction

Groundwater level contours normal conditions (after IGGC, 2013)

Inferred groundwater flow

0 200 400 m

Source: Nearmap, 2019, Bureau of Meteorology GDE Atlas

4.5 Conceptual hydrogeological model

A conceptual hydrogeological model was developed for the Project area and is presented on **Figure 4-10**. The model is a qualitative representation of the hydrogeology and the way groundwater enters, flows through and discharges from the subsurface flow system. The conceptual model was used to identify source, pathway and receptor linkages that were assessed using analytical calculations to assess the severity of the impacts. The model is based on several key elements including:

- the proposed HDD ocean outfall pipeline (**Section 1.1**));
- the lithologies based on local drillhole logs (**Section4.2.2**);
- the water table based on the intersection of groundwater level data (**Section 4.2.3**); and
- groundwater flow directions inferred from local groundwater level data (**Section 4.2.3**).

The main hydrogeological attributes shown on **Figure 4-10** include:

- an unconfined aquifer that is hosted by deposits of quartz sand to the east and sand with discontinuous layers of clay and sandy clay;
- the sand and clay deposits in the west are Tertiary sediments that are generally of low hydraulic conductivity;
- the sand deposits in the east are Quaternary coastal formations that overlap the Tertiary deposits and have high hydraulic conductivity;
- organic material that is present in the Tertiary deposits and under the wetland that can affect the groundwater quality;
- the groundwater divide is close to the wetland between bores 2018_BH07 and A6 because it is low lying and adjacent to the clayey Tertiary deposits;
- the divide migrates to the east following a high rainfall event due to the higher rates of recharge through the Quaternary sand deposits;
- fresh groundwater accumulating beneath the dunes flows toward Merimbula Beach (east) and Merimbula Lake (west);
- the groundwater profile is stratified and becomes brackish, then saline at depth as observed at geotechnical hole 2018_BH02B;
- saltwater wedges are typically present in coastal settings where there is a density-driven interface between fresh (terrestrial) and saline (marine) groundwater;
- groundwater discharge at the beach after riding up the saltwater wedge at higher rates after seasonal wet periods and lower rates otherwise after the water table has flattened; and
- moderately acidic groundwater beneath the wetland disperses into the flow system and is neutralised by the natural groundwater alkalinity yielding near neutral to slightly alkaline conditions where it discharge to the marine environment.

Not shown on **Figure 4-10** is the upward hydraulic gradient between sand aquifers deep within the Pambula Palaeovalley and the superficial aquifer. Evidence from deep drilling in the area (PB 2004 in IGGC 2013) indicates the upward gradient may be strong, but due to the presence of thick clayey layers, restricts the overall rate that groundwater discharges to the unconfined aquifer beneath the Project. While the rate of upward flow has not been determined, any fresh water from the deep aquifer would either discharge at the beach or offshore where the sand aquifers may outcrop on the sea floor. These flowpaths are controlled by the extent of the coastal sand aquifer, and groundwater levels and gradients at the water table beneath the STP site.

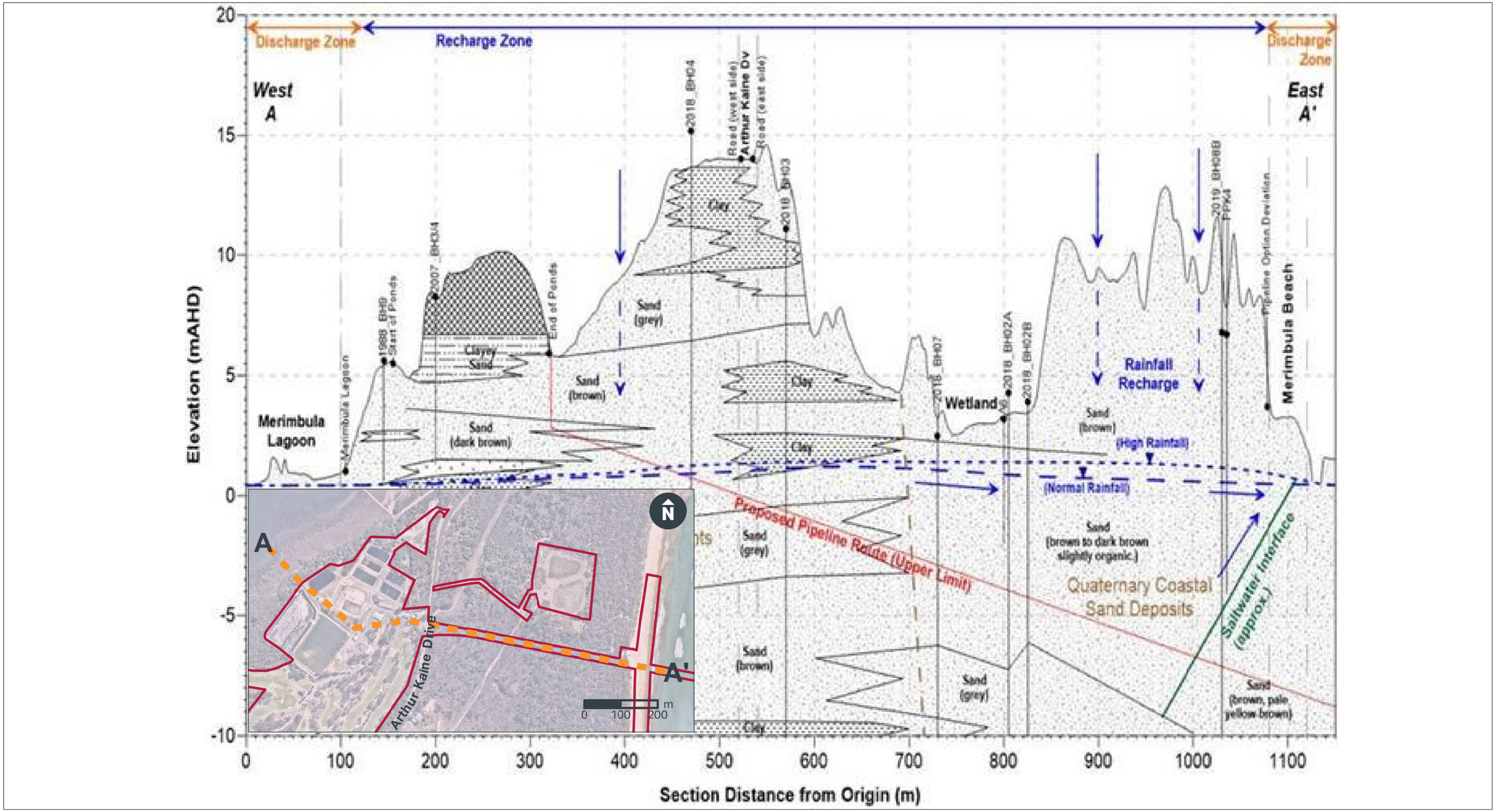

FIGURE 4-10: CONCEPTUAL HYDROGEOLOGICAL MODEL

AECOM

Legend

Project area

Alignment of conceptual model

5.0 Construction impact assessment

5.1 Groundwater levels and flow

Groundwater would be intersected while the proposed pipeline is being constructed. Even though groundwater would not be abstracted, the proposed activity is disturbance as defined by the *Water Management Act 2000* because it:

- would penetrate the aquifer;
- would interact with groundwater in the aquifer (to some degree); and
- may obstruct the flow of water in the aquifer.

Groundwater is not planned to be abstracted to supply water for the Project. Groundwater is also not expected in association with dewatering excavations associated with the ocean outfall pipeline or other subsurface works (e.g. excavations within the STP site for new infrastructure). Dewatering may be required however if an excavation is required at an intermediate drilling site at the construction laydown area on Merimbula Beach (to connect two sections of installed pipeline after the drilling process); however this would be seawater / marine (saline) groundwater, and therefore impacts to terrestrial (fresh or saline) groundwater are unlikely (as water pumping would occur from the seaward side of the salt-water wedge).

Drawdown-related impacts are not expected because the trenchless construction method would use drilling fluid that would maintain a positive pressure in the hole rather than a negative one if dewatering was to take place during the drilling process.

As depicted on **Figure 4-10**, the pipeline is expected to pass below the water table by at least 5 m to 10 m (8 mbgs to 20 mbgs) depending on the final design. While penetrating the aquifer is unavoidable, drilling into the aquifer has the potential to alter its hydraulic characteristics. As described in **Section 4.2.3**, groundwater flows through the superficial aquifer in response to the rate of recharge and hydraulic conductivity. The Project would not alter the rate that rainfall will recharge the aquifer since the pipeline does not require disturbance at the surface where it passes under the high recharge zone across the sand dunes.

The directional drilling would use a collar (e.g. along the first 50 m to 60 m of the hole) and drilling fluid to stabilise the hole and minimise interaction between the circulating fluid and groundwater in the aquifer. Should the physical characteristics of the mud (density, viscosity) or chemical characteristics (pH, salinity etc.) not be maintained, it is possible the drilling fluid could disperse into the aquifer. Normally, a thin wall cake created during these drilling activities forms quickly as new ground is exposed by the drilling bit. The fluids used for these types of holes is designed to penetrate the formation by less than a centimetre before it is sealed off by the wall caking agents such as bentonite, biopolymer or xanthan gum.

If the mud does not contain enough of the components required to form a wall cake, some drilling fluid could be lost to the formation where it can clog and reduce the hydraulic conductivity of the aquifer or alter the quality of groundwater (pH and possibly the salinity) nearby. The distance the fluid penetrates the formation would depend on its permeability and the time taken to introduce loss-circulation materials (cellulose/polymers) to the drilling fluid. These issues are normally minimised by the drilling fluid engineer who maintains the physical and chemical attributes of the fluid while the hole is being drilled in accordance with a drilling fluid management plan. As the fluid is recirculated from the drill bit to the surface (carrying cuttings with it) the mud engineer closely monitors the mud's properties and adds one or more products to maintain the volume (as more mud is required to replace the cuttings removed) and physical and chemical characteristics if the formation or groundwater cause it to be altered.

Drilling with fluid is a well-established process and has been used for many decades because it is engineered to local conditions and managed by experienced drillers and engineers. The drilling fluid and wall cake remain in place after the pipeline is installed. After the construction is complete, the small gap between the formation and pipeline including the residual wall cake closes around the pipeline adding a protective, low-permeability shroud around it. The total disturbance to the aquifer from the drilling mud is expected to be the pipeline diameter plus a few tens of centimetres around it.

The risk to aquifer, the groundwater it contains, its characteristics that define levels and flow, and existing users during the construction phase is therefore considered to be low.

5.2 Groundwater quality

While the details of the drilling mud are yet to be confirmed, products employed for this purpose are either inert e.g. bentonite clay or biodegradable e.g. biopolymers, xanthan gum. As with water-boring, these types of drilling operations are routinely undertaken using such products, many of which are certified for use in aquifers containing potable quality groundwater and are not harmful to the environment.

Impacts to the quality of groundwater intersected by the pipeline would be minimised by maintaining the physical and chemical properties of the drilling fluid throughout the construction phase of the pipeline. Risks to the quality of groundwater are therefore linked to the selection of drilling fluid additives and the successful implementation of the drilling program.

It would also be important to minimise interaction between groundwater and the drilling fluid and cuttings stored at the drill rig site near the launching pit. The fluid should be stored in a lined pit or tank to minimise seepage to the water table. Drill cuttings removed from the hole should be held in a lined pit or on a pad and protected from rain to minimise the potential for seepage to reach the water table. Depending on the quality of the drilling mud after the hole has progressed through the saltwater interface, the residual drilling mud may need to be disposed at an approved liquid waste facility to avoid local discharge and groundwater contamination.

Risks of groundwater contamination due to accidental spills and leaks during the construction phase are low if the Project adopts standard design and construction processes including:

- incorporating features into the final design that avoid disturbance of the aquifer and groundwater wherever practicable, including within the direction drilling methodology and drilling plan;
- avoiding the use of potentially harmful substances in the construction of the Project where practicable, including in the development of the drilling fluid components;
- placing barriers between the source(s) of contamination and the water table, including the use of a lined pit to store potentially contaminating materials such as drill cuttings;
- handling potentially contaminating substances such as fuels, hydraulic oils and caustic (drilling mud additive to regulate the pH of the fluid) in accordance with relevant regulations; and
- developing and implementing a spill response plan that complies with relevant regulations to manage the potential for accidental/ unplanned discharge.

5.3 Groundwater dependent ecosystems

As described in **Section 4.4**, groundwater dependent ecosystems occur in proximity to the Project. The proposed trenchless method of constructing the ocean outfall pipeline would avoid physical disturbance because it would be at least 5 m below the surface where it passes beneath this area.

Interaction between the construction activities and overlying wetlands is unlikely if the drilling fluid is maintained in accordance with good practice and the mud engineering program. As described in **Section 5.2**, the drilling fluid would create a low-permeability barrier between the fluid in the hole and the aquifer. Positive pressures in the uncased hole maintain the stability of the hole walls and mud-cake, which is only required until the continuous carrier pipe is inserted in the hole and the aquifer is sealed off.

While there may be a slight change in the hydraulic pressures (and small exchange of water until the mud cake is formed) near the open section of the hole, these would dissipate quickly in the sand aquifer, which is very transmissive (**Section 4.2.2**). This was demonstrated by groundwater modelling undertaken by IGGC (2013) where pumping water into the coastal sand aquifer at a rate of 840 m^3/day resulted in between about 0.5 m and 2 m of local mounding depending on rainfall patterns. That analysis assumed water was pumped into a 400 m trench for 3.3 years.

The risk of seepage and water table mounding are likely to be significantly smaller if the drilling technique used allows for the active drilling face (open hole ahead of the conveyor pipe) to be only several metres), and smaller again as a result of the wall-cake lining the open hole wall. Even with some uncertainty in the benefits of the short open hole section, and whether this particular method of having a short open hole is used or not, the changes to the water table from the fluid-drilling process are expected to be in the order of centimetres. Once it is sealed-off, the water table would return to background levels quickly (days to weeks) because of the permeable nature of the coastal sand aquifer. Groundwater mapping along the pipeline (**Figure 4-10**) indicates the depth to water during a high rainfall period (reasonable worst-case conditions) is about 1.1 m below ground surface (mbgs) and fluctuates by about 0.5 m seasonally (**Table 4-3**). Short-term changes in the order of centimetres from drilling is insignificant in this context.

The risks of significant changes to the water table elevation and quality of groundwater that supports the wetland and its ecosystem due to drilling are therefore considered to be low.

5.4 Construction monitoring program

To minimise construction-related impacts, it is recommended that local-scaled groundwater level and quality monitoring takes place. The objectives of a groundwater monitoring program during the construction phase are:

- ensuring the water table is not significantly mounded indicating drilling fluids are being released to the aquifer; and
- ensuring the drilling fluids are not affecting the quality of groundwater in a manner that could lead to a deterioration of ecological values.

To achieve this, groundwater monitoring should be undertaken at existing and new monitoring bores as listed on **Table 5-1** and shown on **Figure 5-1**.

Table 5-1 Recommended construction phase groundwater monitoring

Locations	Frequency Prior to Construction*	Frequency During Construction	Parameters
Existing monitoring bores: A5, A6, PPK4 *New monitoring bores:* AECOM1, AECOM2, AECOM3 (**Figure 5-1**)	Monthly	Daily	Field parameters: Static Water Level (SWL)
		Weekly	In-situ field profile**: pH, EC, temp, DO, REDOX Laboratory parameters: physicochemical: pH, TDS, alkalinity, hardness Major ions: Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 Nutrients: ammonia, oxidised nitrogen, total inorganic nitrogen, total phosphorous.
Existing private bores: GW047147		Weekly	Field parameters: SWL, In-situ profile: pH, EC, temp, REDOX

Note: * Baseline monitoring to occur for at least 12 months prior to construction
** In-situ profile to be taken only within the screened intervals (refer **Appendix A** for depth intervals – where known)

The proposed monitoring of existing bores includes:

- Bores A5, A6 and PPK4, which are located close to the proposed pipeline route near the wetland and recharge zone, and the groundwater discharge zone near the beach; and
- Private bore GW047147, which although currently unlicensed should be protected for future use.

The proposed monitoring program includes three new monitoring bores:

- AECOM1 – downgradient of the launch pit, drilling rig, fluid pit and cuttings storage sites to monitor changes to the groundwater quality;
- AECOM2 – within the Tertiary deposits close to where the proposed borehole would pass through the water table to monitor changes to groundwater levels and quality; and
- AECOM3 – within the Quaternary coastal sand deposits close to where the proposed borehole would pass under the wetland to monitor changes to groundwater levels and quality.

The monitoring data should be collated and regularly reviewed (at least monthly once construction starts) to assess whether unplanned changes are occurring, or likely to occur, and determine if or when contingency measures should be triggered. The review of the groundwater monitoring results should be assessed against the drilling progress and fluid monitoring data to identify whether any changes are related to drilling or seasonal/event-based rainfall recharge.

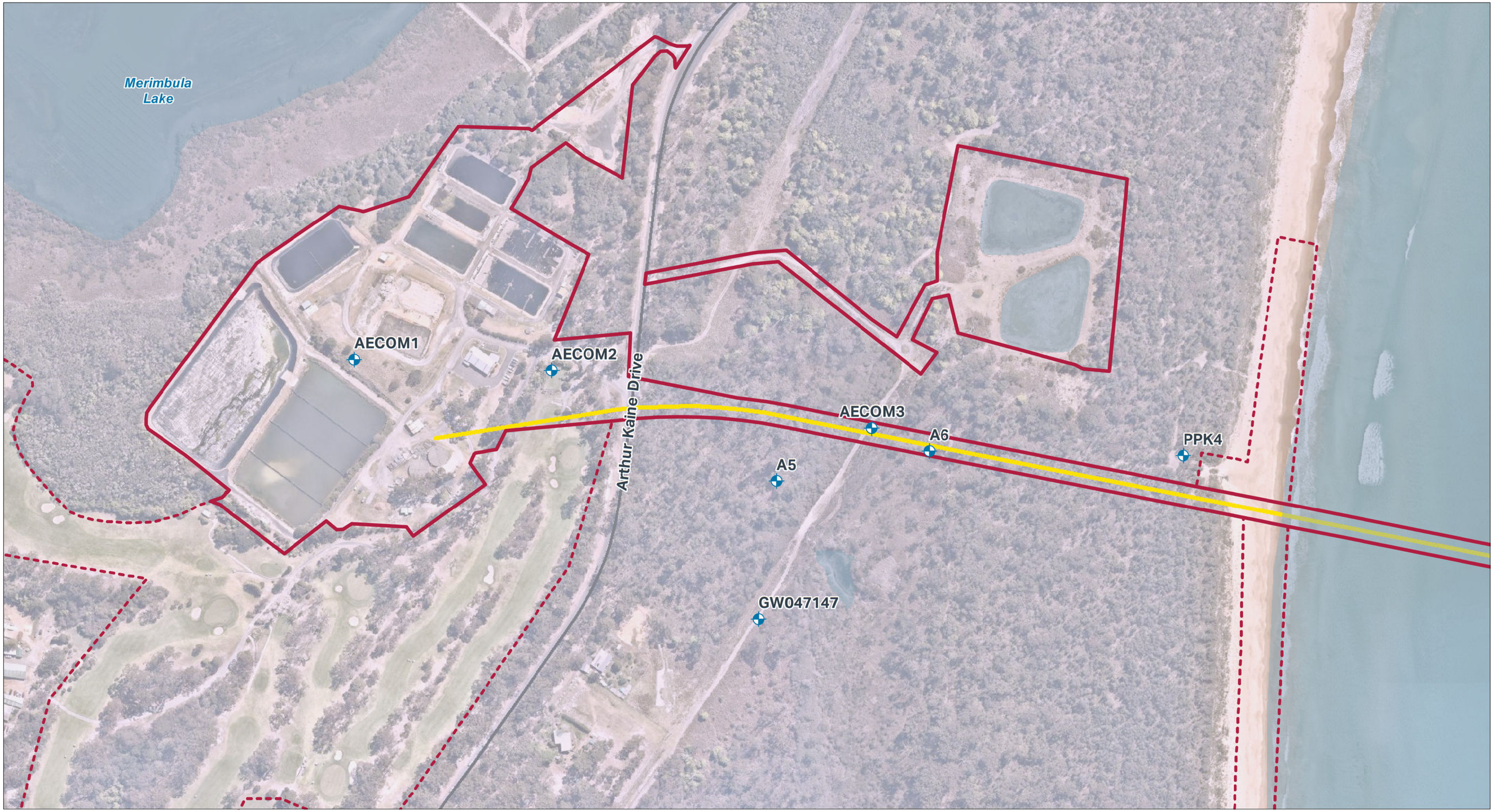

FIGURE 5-1: RECOMMENDED CONSTRUCTION PHASE GROUNDWATER MONITORING BORES

Legend

- Project area
- Temporary Project area for construction
- Proposed outfall pipeline
- Proposed groundwater monitoring location

Source: Nearmap, 2019

6.0 Operational impact assessment

As indicated on **Figure 4-10**, the proposed ocean outfall pipeline would intersect the water table for most of its length. Section one (the landward section) of the pipeline would pass through clayey Tertiary sediments for approximately the first 380 m and then Quaternary coastal sand deposits for the remaining 400 m.

To address the SEARs, the assessment considers potential impacts to groundwater levels and flow, groundwater quality and groundwater dependent wetlands. This chapter is concerned with the operational phase where groundwater could be impacted by:

- seasonal or perennial interruption of groundwater flow due to the presence of the pipeline within the groundwater flow system;
- changes to groundwater quality due to:
  - changes in the groundwater levels and flow;
  - leaks from the pipeline; and
- implications for groundwater dependent surface flows, ecosystems, groundwater users.

6.1 Groundwater levels and flow

As described in **Section 4.2.3**, groundwater levels are the result of the hydraulic gradient that is dependent on the transmissivity of the aquifer and the recharge rate. Given the rate of recharge is not expected to change as a result of the Project, any change from the Project can only arise if the transmissivity of the aquifer is significantly altered by the presence of the pipeline.

As indicated on **Figure 4-4**, the proposed pipeline would cross the groundwater divide, which runs roughly perpendicular to the pipeline along the peninsula. The cross-sectional area of the pipeline is small (assume for simplicity 1 m x 1 m = 1 m^2). Where the pipeline is aligned with the groundwater flow direction (either side of the divide), groundwater would not measurably change the aquifer hydraulics or direction of groundwater flow. The change in transmissivity (aquifer thickness x hydraulic conductivity) for a 1 m^2 area that is effectively zero is insignificant; groundwater would simply flow alongside the pipeline.

Where the pipeline passes across the divide, groundwater is inferred to flow across the pipeline route. In this orientation, the pipeline presents a partial barrier to groundwater flow along about 50 m of its length. The impact of this on groundwater flow is assessed by the change in transmissivity to the aquifer in relation to the hydraulic gradient in that area.

Geotechnical logs from holes drilled by AECOM (2020) indicate the base of the sand formation in this area ranges between -9.3 and -19.5 m AHD giving rise to an average aquifer transmissivity ranging from 416 m^2/d to 693 m^2/d using the range of hydraulic conductivities adopted by IGGC for this unit.

If we assume the pipeline is 1 m in diameter and is impermeable, then the change in transmissivity can be considered in terms of the proportion of the pipeline diameter to the aquifer thickness. Based on data from the recent geotechnical drilling program (AECOM, 2020) the saturated thickness of the aquifer the pipeline is passing through the divide area is between 10.5 m and 20.6 m (**Table 6-1**) or between 9.5% and 4.8% of the aquifer. As a reasonable worst-case scenario, the smaller aquifer thickness of 10.5 m was adopted for the analysis.

Conceptually, the above analysis is based on the arrangement shown on **Figure 6-1**. The position of the cross-section model is shown as the purple line on **Figure 6-2**.

Table 6-1 Superficial sand aquifer properties

Hole	Water Table Elevation (m AHD)*	Base of Sand (m AHD)	Submerged Thickness (m)	Estimated Transmissivity (m^2/d)**	
				K = 30	K = 50
2018_BH02A	0.9	-11.7	12.6	378	630
2018_BH02B	0.8	-13.6	14.4	432	720
2018_BH03	**1.2**	**-9.3**	**10.5**	**315**	525
2018_BH07	1.1	-19.5	20.6	618	1030
2019_BH08B	0.5	-10.7	11.2	336	560
Averages	0.9	-13.0	13.9	416	693

Notes:
* Water table interpolated from regional contours (**Figure 4-4**)
** Transmissivity calculated from submerged thickness x hydraulic conductivity (K = 30 m/d to 50 m/d – **Section 4.2.2**).

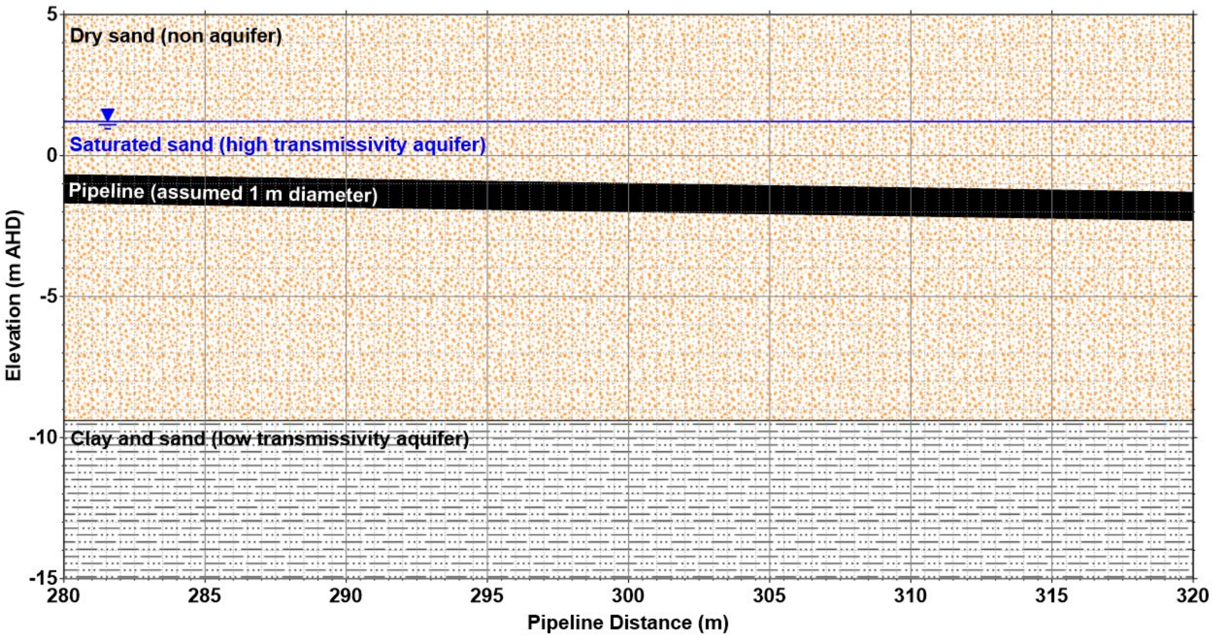

Figure 6-1 Conceptual model for pipeline flow-impedance analysis

Based on the groundwater contours (**Figure 4-4**) the gradient across the proposed pipeline route is 0.00067 (unitless). Under existing conditions, the rate of groundwater flow (Q) can be estimated from Darcy's formula (reference):

Q = KiA

where: K = hydraulic conductivity

i = hydraulic gradient, and

A = cross-sectional area.

Since transmissivity (T) = K x aquifer thickness, we can assume (for a one metre section width) that Q = T x i for each cross-sectional metre (width). Using the smallest transmissivity from 2018_BH03 and 2018_BH07 (315 m^2/d) from **Table 6-1**, the rate of groundwater flow under existing conditions is conservatively estimated to be 0.21 m^3/d per cross-sectional metre width or 10.5 m^3/d across the 50 m of pipeline. As indicated across the purple line on **Figure 6-2** a reduction of the transmissivity of up to 9.5% is therefore estimated, and under worst case conditions it may reduce the throughflow by 0.9 m^3/d to about 9.6 m^3/d.

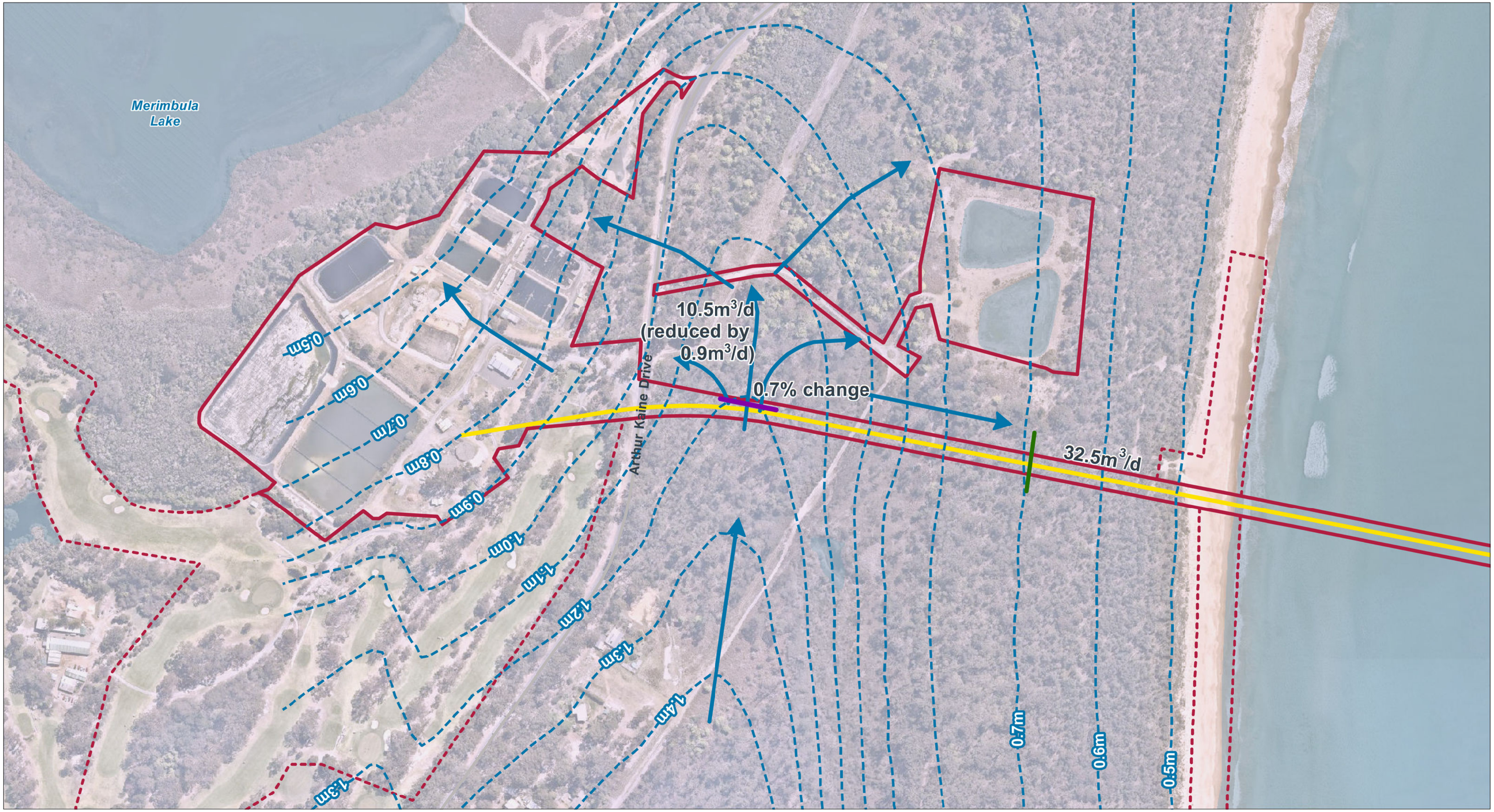

FIGURE 6-2: PREDICTED CHANGES TO GROUNDWATER FLOW DUE TO OCEAN OUTFALL PIPELINE

Legend
- Project area
- Temporary Project area for construction
- Proposed outfall pipeline
- Groundwater level contours normal conditions (After IGGC, 2013)
- Inferred change to groundwater flow

AECOM

Source: Nearmap, 2019

For context, the contours suggest the natural rate of flow along the pipeline and across the wetland towards Merimbula Beach is estimated to be three times higher at 32.5 m^3/d over a corresponding 50 m width (green line on **Figure 6-2**). This is based on a hydraulic gradient of 0.00160, transmissivity of 378 m^2/d (K = 30 m/d and cross-sectional thickness of 12.6 m at 2018_BH02A), which with Darcy's formula equates to a rate of 0.65 m^3/d per metre width. In this context, the reduction in throughflow (0.9 m^3/d) represents a change of about 2.8% assuming all the water from the divide flowed east. According to the contours and inferred flow net in this area **Figure 6-2**, only about 25% of the groundwater passing across this section of pipeline flows under the wetland, meaning the net change to the wetland north of the pipeline is estimated be about 0.7% (refer purple line on **Figure 6-2**).

Under reasonable worst-case conditions therefore, the proposed pipeline is estimated to reduce the flow that passes under the wetland by about 0.7%. This level of change is well within the range of natural climatic variability (**Section 4.1**) and therefore not significant. Within the context of seasonal variations of 0.5 m, this change is expected to be largely undetectable.

Given the small magnitude of the predicted change in groundwater flow rates and levels, risks from impacts to off-site receptors such as the wetland and existing groundwater bore to the south and coastal groundwater discharges are considered to be low.

6.2 Groundwater quality

The proposed pipeline is designed and constructed to minimise the risk of leaks of treated wastewater by employing highly resistant HDPE or fused PVC materials. While leaks are highly unlikely, should they occur, the wastewater would disperse into groundwater and migrate east to Merimbula Bay or west to Merimbula Lake depending on where the leak is located. Seepage migrating to the east would discharge along the beach close to where the pipeline passes under it. Seepage migrating to the west would be slower because of the higher clay content, but based on inferred flow directions, would pass under the existing facility and eventually discharge to the lake shoreline.

The impact on groundwater quality would depend on the severity of the leak. It is highly unlikely to alter the quality as much as the existing exfiltration ponds have done on groundwater as measured at bore PPK3. It is also unlikely to be worse that the existing beach-face outfall in terms of superficial groundwater quality.

Depending on the method of construction, if a carrier pipe was inserted into the pipeline casing installed during drilling, it is possible that the annular space between them would be affected by seawater if it was not sealed off at the beachside riser. This would only be a potential problem if the casing pipeline degraded and allowed seawater to pass into the coastal sand aquifer. The natural density balance between fresh and saline groundwater would, however, largely keep the seawater in place meaning significant intrusion of seawater is not expected to occur.

Ceasing the use of the exfiltration ponds would likely have a net benefit to the receiving environment over time as treated wastewater would cease to be released to land (and subsequently into groundwater) from this location. There would be a reduction in the nutrient and microbiological loadings to groundwater and discharging to the coastline, and this would also reduce the amount of temporary mounding at times as a result of their operation in the past.

6.3 Groundwater dependent ecosystems

As discussed in **Section 6.1**, the wetland that would overlie the pipeline receives groundwater from local recharge as well as throughflow from the groundwater divide that typically is located to the west. The importance of local recharge via the coastal sand dunes is reflected by the shift in the location of the divide following above-average seasonal rainfall (**Figure 4-10**).

Because the Project is proposing to adopt a trenchless construction method, it would not change the rate of aquifer recharge. The rate of throughflow to the wetland from the small area where the pipeline would cross the groundwater flow direction is predicted to change the rate north of the pipeline by only about 0.7%. This reduction would however, flow to the wetland south of the pipeline. Both are considered insignificant in terms of the natural seasonal variation and variability in rainfall between years. It is therefore predicted that the pipeline would not significantly change the water balance to the wetland.

Based on the above, risks to groundwater level and quality and dependent receptors from the operational pipeline are considered to be low.

6.4 Operational monitoring program

To manage operational impacts, it is recommended that groundwater level and quality monitoring near the pipeline takes place. The objectives of the operational groundwater monitoring program are:

- ensuring the water table is not significantly mounded indicating there is a significant leak; and
- ensuring the quality of groundwater is not significantly affected by leaks that could lead to a deterioration in the ecological value of the wetland.

To achieve this, groundwater monitoring should be undertaken at existing and new monitoring bores as listed on **Table 6-2** and shown on **Figure 6-3**.

In addition to the monitoring bores installed and monitored for the construction phase, two sites are recommended to monitor the quality of groundwater where it is expected to discharge to the surface. The sites, shown on **Figure 6-3**, would be accessed by excavating a shallow hole and recovering a groundwater sample during low tide. Should there be a significant leak, the quality at these sites would reflect what is currently detected down-gradient of the exfiltration ponds (2001_PPK3) rather than what is generally unaffected (2001_PPK4).

The monitoring data should be collated and regularly reviewed (at least biannually after the pipeline has been commissioned) to assess whether unplanned changes are occurring. The review of the groundwater monitoring results should be assessed against long-term trends to identify whether any changes are related to the pipeline or seasonal/event-based rainfall recharge.

Table 6-2 Recommended operational phase groundwater monitoring

Locations	Frequency shortly after construction*	Frequency during operations	Parameters
Existing monitoring bores: A5, A6, PPK4 *New monitoring bores:* AECOM1, AECOM2, AECOM3 (**Figure 5-1**)	Monthly	Monthly	Field parameters: SWL
		Biannually	In-situ field profile**: pH, EC, temp, DO, REDOX Laboratory parameters: physicochemical: pH, TDS, alkalinity, hardness Major ions: Na, K, Ca, Mg, Cl, SO_4, HCO_3/CO_3, NO_3 Nutrients: ammonia, oxidised nitrogen, total inorganic nitrogen, total phosphorous.
New monitoring sites: GWDZ1, GWDZ2			
Existing private bores: GW047147		Biannually	Field parameters: SWL, In-situ profile: pH, EC, temp, REDOX

Note: * Early operational phase monitoring to occur for at least 12 months after construction
** In-situ profile to be taken only within the screened intervals (refer **Appendix A** for depth intervals – where known)

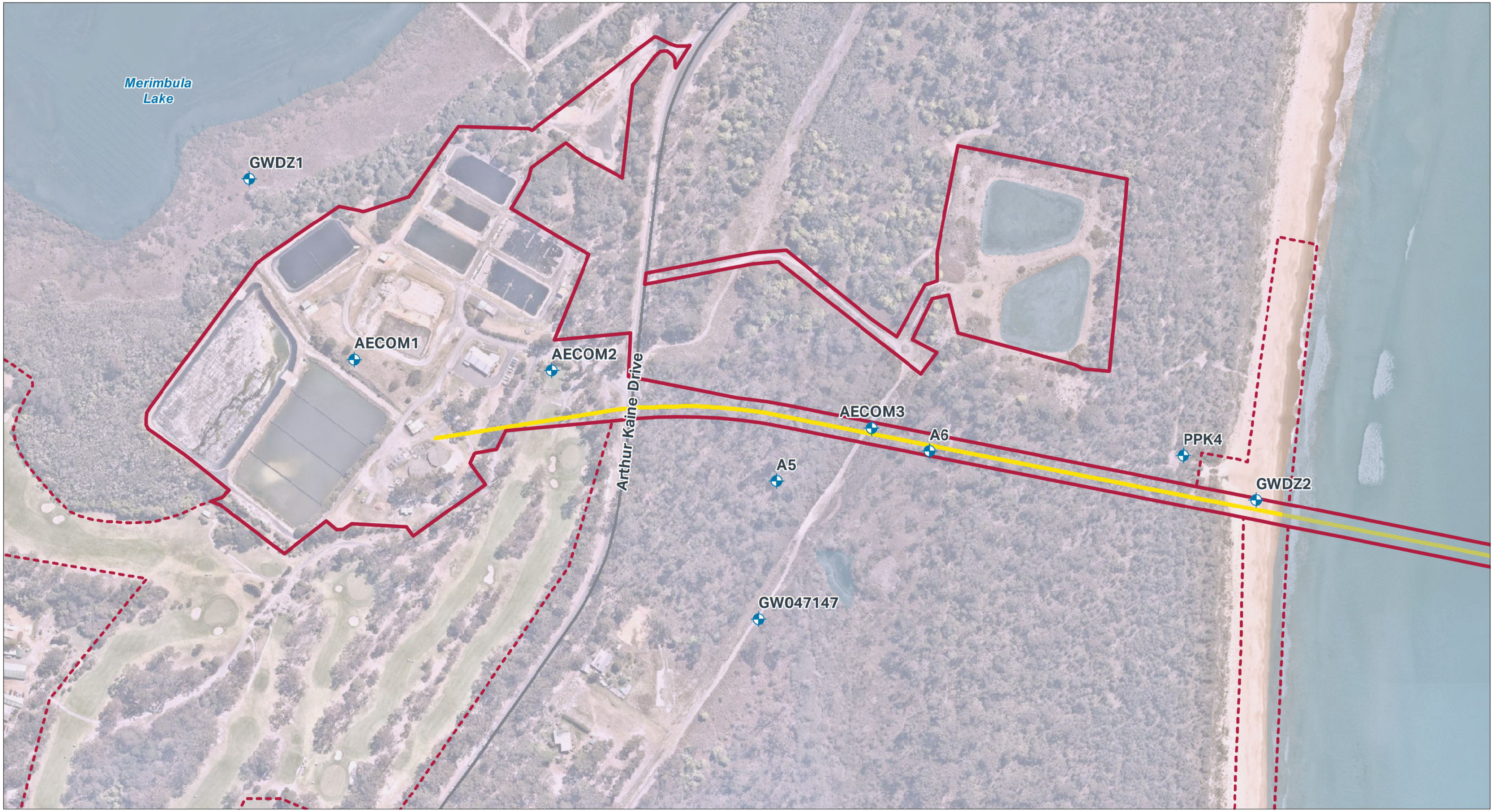

FIGURE 6-3: RECOMMENDED OPERATIONS PHASE GROUNDWATER MONITORING BORES

Legend
- Project area
- Temporary Project area for construction
- Proposed outfall pipeline
- Proposed groundwater monitoring location

0 100 200 m

AECOM

Source: Nearmap, 2019

7.0 Cumulative impacts

Several projects in the area were identified in the cumulative impact assessment undertaken for the EIS (refer **Chapter 27 Cumulative impacts**), however it was found that these are not expected to contribute to cumulative impacts with the Project, either due to their location, size or timing.

Although there are not expected to be cumulative impacts from other projects in the area, this section discusses the potential for general cumulative impacts in the context of the local hydrogeology (**Section 4.5**), existing conditions from over 40 years of STP operation and proximity to various groundwater receptors.

7.1 Groundwater levels and flow

As discussed in **Section 6.1** and **Section 7.1**, groundwater levels and flow are not expected to change significantly during construction or operation. The only other sources of change to groundwater that could interact with the proposed pipeline are the existing exfiltration ponds. The assessment of groundwater level impacts by IGGC (2013) concluded that seepage from the exfiltration ponds was causing localised short-term water table fluctuations as indicated in **Table 7-1**.

Table 7-1 Water table fluctuations near the exfiltration ponds

Bore	Pond related fluctuations (m)	Natural fluctuations (m)	Comment
1987_BH10	up to 1.47	0.68 to 0.77	Rapid rise and fall when the ponds are used
A1	N.D.	> 0.55	Strong response to rainfall recharge possibly masking response to pond seepage
A4	Up to 2.56	N.D.	Strongest response to the ponds
A5	0.75 to 1.00	0.35 to 1.73	Strong ponds response. Responds to rainfall evapotranspiration from wetland as well.
A6	Up to 1.04	> 0.23	Strong ponds response, subdues rainfall response
PPK3	0.57	> 0.1	Responds to pond seepage, rainfall recharge and tidal fluctuations
PPK4	0.17	0.60	Responds to pond seepage and rainfall recharge

Sourced from IGGC (2013).

The data in **Table 7-1** indicate seepage from the exfiltration ponds results in water table fluctuations of about 1.5 m to 2.5 m near the ponds and smaller fluctuations of about 0.8 m to 1.0 m across the proposed pipeline route near the wetland area. This also indicates the natural water table gradient and seasonal fluctuations are flatter and about half the observed fluctuations from the exfiltration ponds. On this basis, it is possible the seepage-related fluctuations from the ponds are, for short periods of time, reversing the direction of groundwater flow, but, because of the high transmissivity of the coastal sand, return to normal rapidly after discharges to the ponds cease.

In the above context, the predicted changes to groundwater levels in the order of centimetres described in **Section 5.1** and **Section 6.1** are unlikely to lead to a significant cumulative impact.

Further, once the use of the exfiltration ponds are ceased under the Project, seepage would only occur from the residual wastewater loadings in or under the ponds.

7.2 Groundwater quality

Groundwater quality would only be altered if there was a significant leak from the pipeline. Based on the above analysis of groundwater fluctuations and the zone of influence around the exfiltration ponds, it is likely the quality of groundwater beneath the pipeline east of the natural divide is already being influenced by treated wastewater.

After the pipeline is commissioned and once use of the exfiltration ponds has ceased there would be an overall improvement of the quality of groundwater discharging at the beach. Previous discharges would begin to revert to natural quality but may take several years to flush residual seepage loadings from the flow system. The long-term quality of groundwater reaching the beach east of the exfiltration ponds would depend on how the sites are rehabilitated.

If there is a leak from the pipeline, seepage-affected groundwater would still discharge to the beach as is currently occurring due to seepage from the exfiltration ponds. However, the affected section of the beach would, based on the groundwater level contours and flow directions, be smaller (tens of metres wide rather than hundreds of metres as is probably currently occurring).

Should a leak occur west of the groundwater divide, seepage is expected to migrate towards the eastern shoreline of Lake Merimbula. Should seepage occur, it is likely to lift the water table, possibly near the surface given the clayey nature of the Tertiary deposits in this area. The rate of migration of seepage-affected groundwater is expected to be slower than seepage to the east.

Under normal operating conditions, groundwater quality is not expected to be altered by the pipeline or the treated wastewater it would contain. Under a reasonable worst-case scenario involving a significant leak, groundwater is predicted to be locally altered but it would disperse within the coastal aquifer and discharge at the low tide mark across a narrow zone where it would further disperse at the beach. The affected groundwater would be flushed to the coast over the course of several years due to natural flow patterns associated with seasonal recharge.

7.3 Groundwater dependent ecosystems

Under current conditions, treated wastewater is discharged to the beach via a pipeline of the exfiltration ponds. The analysis by IGGC (2013) determined that the water table beneath the wetland area is fluctuating by up to 1 m for short periods of time due to seepage from the ponds. Based on the analysis in Section 5, the pipeline is not expected to alter the water table by a measurable amount. When the exfiltration ponds are ceased to be used under the Project, there is not expected to be any cumulative impacts between the normal operation of the pipeline and the exfiltration ponds.

Should there be a large leak from the pipeline beneath the wetland or upgradient to the west, the groundwater level beneath the wetland would rise more than it currently is. Accounting for any residual wastewater/contaminant loading beneath the exfiltration ponds, this could increase the availability of nutrients to local vegetation, and where groundwater is seasonally exposed, lead to more persistent ponding of surface water and a deterioration of its quality. With the discontinuation of use of the ponds however, this impact is expected to be minimal.

Long-term use of treated wastewater has not caused any significant impacts to the lake water quality (**Section 4.2.4**). The quality of the treated wastewater as a result of the proposed upgrade is expected to result in the removal of more phosphorous, aluminium and heavy metals. Ongoing use of treated wastewater from the STP to irrigate the PMGC grounds therefore presents a low risk to the quality of water in Merimbula Lake.

8.0 Mitigation and management measures

8.1 Overview

This chapter describes the management approach for groundwater during construction and operation of the Project, including performance outcomes. The mitigation and management measures described would be included in a Construction Environmental Management Plan (CEMP) for the Project. The CEMP should be a 'live' document with the capacity to be updated if conditions are different to those expected. A groundwater management sub-plan should be developed for inclusion in the CEMP. The groundwater management sub-plan would include a monitoring program as described in the management measures.

Mitigation and management measures would also be implemented during operation of the Project as relevant.

8.2 Performance outcomes

The groundwater performance outcome for the Project are as follows:

- potential impacts to groundwater are minimised and managed during drilling; and
- risk of groundwater contamination due to accidental spills and leaks during the construction are managed; and
- groundwater monitoring results during operation are within applicable criteria developed.

The Project would be designed, constructed and operated to achieve these performance outcomes.

8.3 Mitigation and management measures

Management and mitigation measures to minimise impacts to groundwater from the construction and operation of the pipeline are detailed in **Table 8-1**.

Table 8-1 Mitigation and management measures

ID	Mitigation and management measure	Applicable location(s)
Construction		
GW1	Potentially adverse impacts to groundwater levels would be minimised by the detailed design of the drill-path and implementation of a drilling fluid management plan which would consider the appropriate design, management and control of the physical and chemical characteristics of the drilling fluid, this plan would be incorporated in the groundwater management plan (discussed in more detail below). The make-up of the drilling fluid would be determined by an appropriately qualified drilling fluid engineer, based on local groundwater and soil geochemistry so that it forms a suitable wall cake thus minimising fluid loss and exchange with local groundwater. Inert or non-contaminating but effective additives for drilling fluids would be used. Any drilling fluid additives used e.g. bentonite clay, xanthan gum and/or biopolymer compounds would be certified for use in potable aquifers (certified to *American National standards Institute (ANSI)/NSF International (NSF) STD 60 Certified well Drilling Aids and well Sealants*). The drilling fluid additives would be closely monitored by the mud engineer and driller so that it remains chemically stable and volumetrically balanced with the progression of the hole and, if necessary, modified to maintain stability and minimise interaction with the groundwater. An appropriately experienced engineer would supervise the drilling operations and control the types, rates and volumes of additives should the fluid	Drill pad / drill rig compound location

ID	Mitigation and management measure	Applicable location(s)
	chemistry be unexpectedly altered by the formation. Drilling would be undertaken by a directional borehole driller who is appropriately trained and experienced with the selected drilling and casing installation technique.	
GW2	*Groundwater monitoring program - construction* A groundwater monitoring program will be developed and implemented for construction. The groundwater monitoring program would include appropriate investigations and baseline monitoring during the detailed design phase so that the drilling program can incorporate contingency measures to minimise impacts to groundwater levels and flow conditions. It will include but not be limited to infill test drilling to determine the physical characteristics (grain size analysis, permeability, organic content) of the materials and quality of groundwater in the aquifer through which the pipeline would pass. Ground water monitoring during construction would consider methods for checking: • that the water table is not significantly mounded indicating drilling fluids are being released to the aquifer; and • that the drilling fluids are not affecting the quality of groundwater in a manner that could lead to a deterioration in the ecological value. To achieve this, groundwater monitoring should be undertaken at existing and new monitoring bores as specified in **Section 5.4**.	Project area and surrounds (i.e. study area)
GW3	*Groundwater monitoring program - construction* The groundwater monitoring program would include groundwater quality trigger levels which if exceeded would initiate response actions as follows: confirmation, investigation, risk assessment and, if required, a construction method review and/or remediation. The trigger levels should be defined based on the results of baseline monitoring and be selected to identify potentially abnormal changes to groundwater levels and quality.	Project area and surrounds (i.e. study area)
GW4	*Groundwater monitoring program - operation* The groundwater monitoring program would monitor groundwater levels and groundwater quality in the superficial sand and clayey sand formations at the commencement of the operations phase. The monitoring should be a continuation of the construction groundwater monitoring program. The monitoring program should be developed in consultation with the NSW Environment Protection Authority, NSW Department of Planning Industry and Environment-Water and BVSC. The program should identify groundwater monitoring locations, performance criteria in relation to groundwater levels and groundwater quality and potential remedial actions that would manage or mitigate any non-compliances with performance criteria. The monitoring program should include the manual and automatic (using dataloggers) groundwater level monitoring and groundwater quality monitoring from selected monitoring wells intersecting groundwater in the superficial aquifer. The monitoring frequency should be six-monthly for three years or as stated in the conditions of Project approval.	Project area and surrounds (i.e. study area)
GW5	Any operational constraints and compliance criteria should be developed in accordance with ANZG 2018 and with consideration to the relevant NSW Water Quality Objectives. The operational water quality objectives should be set by the catchment manager of the receiving waters in consultation with the NSW EPA.	Project area

9.0 Conclusions

This groundwater impact assessment has been developed to support the EIS for the Project and was prepared in accordance with NSW water policies under the *Water Management Act 2000*. The objectives of the groundwater impact assessment are outlined in the SEARs issued for the Project which, in summary, included the following:

- the Proponent must describe (and map) the existing hydrological regime for any groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the Project;
- the Proponent must assess (and model if appropriate) the impact of the construction and operation of the Project and any ancillary facilities (both built elements and discharges) on groundwater hydrology in accordance with the current guidelines, including impacts from any permanent and temporary interruption of groundwater flow, including the extent of drawdown, barriers to flows, implications for groundwater dependent surface flows, ecosystems and species, groundwater users and the potential for settlement; and
- the Proponent must identify any requirements for baseline monitoring of hydrological attributes.

The methodology adopted for the groundwater impact assessment included a detailed review of hydrogeological information from previous site investigations, long-term monitoring and publicly available groundwater and climate databases. This assessment considered groundwater impacts within the terrestrial environment between the STP and the coastlines to the east and west.

Hydrogeological conditions were characterised by logging cores obtained from seven new drill holes located along the pipeline route. This was supported by an analysis of groundwater level and quality data from current monitoring bores located between the STP and Merimbula Beach. Hydraulic properties of the natural materials that make up the superficial aquifer were determined by field testing undertaken previously and tested within a site-wide groundwater model that was prepared by Ian Grey Consulting in 2013.

The proposed pipeline would carry treated wastewater from the STP to an offshore ocean outfall within Merimbula Bay. The pipeline construction methodology does not require excavation of an open trench. The final design of the pipeline would be subject to detailed design and engineering, but it is expected the pipeline would comprise HDPE or fused PVC. The pipeline would be installed with a casing (during or after drilling, depending on the drilling method used (e.g. horizontal directional drilling or direct drive tunnelling), and the drilling plan developed). Products to be installed would be inert and expected to be long-lasting. The final selection would be made during the detailed design phase of the Project.

The bored hole (and pipeline) would pass through the water table close to the local groundwater divide that separates groundwater flowing east to Merimbula Beach and west to Merimbula Lake. The directionally drilled hole would pass through Tertiary sandy and clayey materials near the launch pad and pass into Quaternary coastal sand deposits. It would initially pass through fresh groundwater before reaching a saltwater interface that is expected to underlie the coastal dunes behind Merimbula Beach. Fresh terrestrial groundwater is locally recharged by infiltrating rainwater, while saline groundwater near the beach is of marine origin.

Because the pipeline would intersect with groundwater, the assessment considered potential impacts from the following:

- construction phase:
  - excessive loss of circulating fluids during drilling causes the superficial aquifer to become clogged leading to alterations in groundwater levels and flowpaths;
  - groundwater quality is adversely affected by drilling operations; and
  - poor water management could lead to adverse impacts on the environment.
- operational phase:
  - impacts to groundwater quality, groundwater levels or groundwater flows; and

- adverse impacts on the local hydrogeological regime due to pipeline leakage.

Potential impacts of other works associated with the Project (e. STP upgrades) were also considered in the assessment.

The assessment of groundwater risks from the Project primarily concerned the proposed pipeline and concluded the following.

Construction phase impacts

- The risk to aquifer, the groundwater it contains, its characteristics that define levels and flow, and existing users during the construction phase is considered to be low.
- Risks of groundwater contamination due to accidental spills and leaks during the construction phase are low if the Project adopts standard design and construction processes including:
  - incorporating features into the final design that avoid disturbance of the aquifer and groundwater wherever practicable;
  - avoiding the use of potentially harmful substances where practicable;
  - placing barriers between the source(s) of contamination and the water table;
  - handling potentially contaminating substances such as fuels, hydraulic oils and caustic (drilling mud additive) in accordance with relevant regulations; and
  - developing and implementing a spill response plan that complies with relevant regulations.
- The risks of significant changes to the water table elevation and quality of groundwater that supports the wetland and its ecosystem due to drilling are considered to be low.

Operational phase impacts

- Under reasonable worst-case conditions, the proposed pipeline is estimated to reduce the flow that passes under the wetland by about 0.7%. This level of change is well within the range of natural climatic variability and therefore not significant. Within the context of seasonal variations of 0.5 m, this change is expected to be largely undetectable.
- Under normal operating conditions, groundwater quality is not expected to be altered by the pipeline or the treated wastewater it would contain. Under a reasonable worst-case scenario involving a significant leak, groundwater is predicted to be locally altered and discharge at the low tide mark across a narrow zone where it would disperse at the beach. Risks to off-site receptors such as the wetland and existing groundwater bore to the south and coastal groundwater discharges are low.
- After the ocean outfall pipeline is commissioned and the use of the exfiltration ponds has discontinued there would be an overall improvement of the quality of groundwater discharging at the beach. Previous discharges would begin to revert to natural quality but may take several years to flush residual seepage loadings from the flow system. The long-term quality of groundwater reaching the beach east of the exfiltration ponds would depend on the future use of the ponds site.

Cumulative impacts

- No cumulative impacts are expected from other projects proposed in the area, however cumulative impacts have been assessed in the context of the local hydrogeology, existing conditions from over 40 years of STP operation and proximity to various groundwater receptors.
- The available data indicate seepage from the exfiltration ponds results in water table fluctuations of about 1.5 m to 2.5 m near the ponds and smaller fluctuations of about 0.8 m to 1.0 m across the proposed pipeline route near the wetland area. This also indicates the natural water table gradient and seasonal fluctuations are flatter and about half the observed fluctuations from the exfiltration ponds. On this basis, it is possible the seepage-related fluctuations from the ponds are, for short periods of time, reversing the direction of groundwater flow, but, because of the high transmissivity of the coastal sand, return to normal rapidly after discharges to the ponds cease. The predicted changes to groundwater levels in the order of centimetres are unlikely to lead to a

significant cumulative impact; and would be even smaller when the use of the exfiltration ponds are discontinued under the Project.

- The impact on groundwater quality would depend on the severity of any leak from the pipeline. It is highly unlikely to alter the quality as much as the existing exfiltration ponds have done on groundwater as measured at bore PPK3. It is also unlikely to be worse that the existing outfall in terms of superficial groundwater quality.
- Should there be a large leak from the pipeline beneath the wetland or upgradient to the west, the groundwater level beneath the wetland would rise more than it currently is. This could increase the availability of nutrients to local vegetation, and where groundwater is seasonally exposed, lead to more persistent ponding of surface water and possibly a deterioration of its quality.

Mitigation and management

The key risk during the construction phase relates to the design and management of drilling fluids. The fluids should use inert and non-contaminating additives, preferably NSF certified as suitable for potable aquifers, be selected based on local conditions and monitored by an appropriately trained and experienced mud engineer and driller. These requirements are commonly adopted in the drilling industry to minimise similar risks to those identified for this Project.

A groundwater management sub-plan should be developed for inclusion in the CEMP. The sub-plan should be developed and implemented to manage impacts on groundwater and existing users and include trigger levels that establish initial 3response actions as follows: confirmation, investigation, risk assessment and, if required, a construction method review and/or remediation. The trigger levels should be defined based on the results of baseline monitoring and be selected to identify potentially abnormal changes to groundwater levels and quality.

Groundwater in the superficial aquifer could be adversely affected by treated wastewater if a significant leak from the pipeline develops.

While a significant leak from the pipeline is unlikely, the likelihood should be minimised by carefully considering the pipeline's design, materials selection and maintenance. The severity of the impact would be proportionate to the rate of leakage. Leakage should be monitored using dedicated equipment and inspections. Groundwater level measurements and quality testing in monitoring bores along the pipeline route should be undertaken to detect significant impacts to the natural environment.

Any operational constraints and compliance criteria should be developed in accordance with ANZG (2018) and with consideration to the relevant NSW Water Quality Objectives. Ultimately the water quality objectives should be set by the catchment manager of the receiving waters in consultation with the EPA.

Groundwater monitoring program

Groundwater monitoring during the construction phase should be undertaken in four existing bores and three new sites including:

- Bores A5, A6 and PPK4, which are located close to the proposed pipeline route near the wetland and recharge zone, and the groundwater discharge zone near the beach;
- Private bore GW047147, which although currently unlicensed should be protected for future use;
- AECOM1 (new site) – downgradient of the launch pit, drilling rig, fluid pit and cuttings storage sites to monitor changes to the groundwater quality;
- AECOM2 (new site) – within the Tertiary deposits close to where the proposed borehole would pass through the water table to monitor changes to groundwater levels and quality; and
- AECOM3 (new site) – within the Quaternary coastal sand deposits close to where the proposed borehole would pass under the wetland to monitor changes to groundwater levels and quality.

In addition to the monitoring bores installed and monitored for the construction phase, two sites are recommended to monitor the quality of groundwater where it is expected to discharge to the surface.

The monitoring data should be collated and regularly reviewed (at least six-monthly during construction and annually after the pipeline has been commissioned) to assess whether unplanned changes are occurring. The review of the groundwater monitoring results should be assessed against long-term trends to identify whether any changes are related to the pipeline or seasonal/event-based rainfall recharge.

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11.0 Glossary and abbreviations

Term	Description
A	cross-sectional area (expressed as square metres)
AECOM	AECOM Australia Pty Ltd
AHD	Australian height datum
AIP	Aquifer Interference Policy, 2012. Published by the NSW Department of Primary Industries (now the NSW Office of Water).
ANZECC	Australian and New Zealand Environmental Conservation Council (ANZECC)
ANZG	Australia New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018)
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
BoM	Bureau of Meteorology
BVSC	Bega Valley Shire Council
C	Celsius
CEMP	construction environmental management plan
CFU/100 mL	colony forming units per 100 ml (a unit of measure for bacteria)
DDT	Direct drive tunnelling (drilling method)
DLWC	Department of Land and Water Conservation
DEC	Department of Environment and Conservation
DO	dissolved oxygen (expressed as percent saturation (% Sat) or mg/L)
DPI	Department of Primary Industries
DPIE	Department of Primary Industries and Environment
DWE	Department of Water and Energy
E. coli	*Escherichia coli* (a species of bacteria)
EC	electrical conductivity
EIS	Environmental impact statement
ESCP	erosion and sediment control plan
GDE	groundwater dependent ecosystem
HDD	horizontal directional drilling (drilling method)
HDPE	high density polyethylene
i	hydraulic gradient (a unitless expression of the slope of the water table)
K	hydraulic conductivity (a measure of aquifer permeability expressed as m/d)
m	metres
m AHD	meters above the Australian height datum
mbgs	metres below ground surface
mg/L	milligrams per litre
mm	millimetres
m/d	metres per day (hydraulic conductivity unit)

Term	Description
mV	millivolt
m^2	square metres
m^2/d	square metres per day (the unit of aquifer transmissivity)
m^3/d	cubic metres per day (the unit of groundwater flow)
NSF	National Sanitation Foundation
pH	a unit of measure of water acidity/alkalinity
PVC	polyvinyl chloride
Q	Flow rate (a unit of groundwater flow expressed as m^3/d)
REDOX	reducing-oxidising (a physicochemical hydrochemical property)
SEAR	Secretary's environmental assessment requirements
STP	sewage treatment plant
SWL	static water level (groundwater level expressed as mbgs or m AHD)
T	transmissivity (a unit of measure of the bulk permeability of an aquifer in m^2/d)
TDS	total dissolved solids (a measure of salinity)
µS/cm	microsiemens per centimetre (a unit of electrical conductivity)

Appendix A

Groundwater Bore Details

Groundwater and Geotechnical Borehole Details at the Merimbula Sewage Treatment Plant

Borehole	Easting	Northing	Elevation	Drilled Depth (mbgl)	Construct Date	Cased Depth (mbgl)	Casing Type	Stickup Height (magl)	Screened Depth (mbgl)	SWL Date	SWL (mbgl)	SWL (mAHD)	Salinity (mg/L TDS)	Airlift Yield (L/s)	Aquifer Description	K (m/d)	Lithology Log?	Quality Data?	Status	Bore Type	Driller	Consultant	Source Reference
A1	758400.8	5910729.3	1.62	N.D.	~1991	5.2	84mm ID PVC	0.41	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.5	No	Yes	Unknown	Monitoring	N.D.	N.D.	Bega Shire Council monitoring bores 1991 to 1993 (referred to in PPK, 2002)
A2	758395.7	5910665.0	N.D.	N.D.	~1991	N.D.	84mm ID PVC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Destroyed	Monitoring	N.D.	N.D.	
A3	758360.7	5910387.9	N.D.	N.D.	~1991	N.D.	84mm ID PVC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Lost	Monitoring	N.D.	N.D.	
A4	758431.8	5910272.3	3.87	N.D.	~1991	4.6	84mm ID PVC	0.45	-0.15 to ?	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.58	No	Yes	Damaged	Monitoring	N.D.	N.D.	
A5	758231.7	5910098.8	2.38	N.D.	~1991	4.4	84mm ID PVC	0.54	0.54 to ?	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.5	No	No	Unknown	Monitoring	N.D.	N.D.	
A6	758372.0	5910126.3	3.16	N.D.	~1991	5.2	84mm ID PVC	0.46	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.53	No	Yes	Unknown	Monitoring	N.D.	N.D.	
A7	758289.5	5909929.1	N.D.	N.D.	~1991	N.D.	84mm ID PVC	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Lost	Monitoring	N.D.	N.D.	
1987_BH1	758345.5	5910206.8	2.41	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	1.12	1.29	N.D.	N.D.	N/A	12	No	No	Unknown	Monitoring	N.D.	Mackie Martin	Mackie Martins groundwater data in PWD report: *Merimbula Sewage Augmentation Effluent Disposal Report* dated September 1987.
1987_BH2	758083.8	5909747.0	25.43	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH3	758390.0	5909954.7	3.73	0.9	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH4	758383.4	5909718.6	3.67	0.9	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH5	N.D.	N.D.	3.12	1.2	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	26	No	Yes	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH6	758577.0	5909600.0	9.09	0.6	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.2 to 28	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH7	758611.9	5909824.8	7.23	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH8	758628.0	5910216.3	5.49	0.7	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH9	758650.8	5910411.6	6.57	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.6 to 50	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH10	758393.8	5910412.6	2.40	0.8	1987	7.9	40mm ID PVC	0.39	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	4.3	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH11	758427.9	5910600.6	1.88	0.5	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	8	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH12	758421.1	5910693.8	1.87	0.5	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH13	758513.0	5910943.0	2.21	0.5	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	11	No	Yes	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH14	758482.9	5910306.4	2.70	0.9	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	26 to 45	No	Yes	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH15	758786.0	5911179.0	7.39	0.5	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH16	N.D.	N.D.	6.83	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.7 to 26	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH17	758599.0	5911179.0	2.65	0.5	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	19	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH18	758162.4	5910301.3	9.51	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH19	758305.7	5910288.4	3.93	0.7	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH20	758250.7	5910068.4	2.57	1.1	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH21	758147.3	5910107.3	12.44	N.D.	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1987_BH22	758284.8	5910488.4	1.35	0.6	1987	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Mackie Martin	
1988_BH1	758021.0	5910286.0	7.2	10.0	3/11/1988	N/A	N/A	N.D.	N/A	3/11/1988	4.5	2.66	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	*Merimbula Wastewater Augmentation, Wastewater Treatment Plant Stage 2 Geotechnical Investigation*, Report 88187 dated Dec 1988
1988_BH2	758005.0	5910314.0	7.5	5.0	4/11/1988	N/A	N/A	N.D.	N/A	4/11/1988	4.5	2.97	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH3	757989.0	5910335.0	7.4	10.0	3/11/1988	N/A	N/A	N.D.	N/A	5/11/1988	4	3.39	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH4	757981.0	5910365.0	8.2	10.0	4/11/1988	N/A	N/A	N.D.	N/A	4/11/1988	5.25	2.94	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH5	757958.0	5910377.0	8.2	5.0	4/11/1988	N/A	N/A	N.D.	N/A	N.D.	N.D.	N.D.	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH6	757936.0	5910396.0	8.2	5.0	4/11/1988	N/A	N/A	N.D.	N/A	N.D.	N.D.	N.D.	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH7	757828.0	5910289.0	6.6	10.0	2/11/1988	N/A	N/A	N.D.	N/A	2/11/1988	5.5	1.08	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH8	757795.0	5910296.0	5.6	9.8	3/11/1988	N/A	N/A	N.D.	N/A	3/11/1988	6.75	-1.20	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH9	757763.0	5910289.0	5.6	5.0	3/11/1988	N/A	N/A	N.D.	N/A	3/11/1988	4	1.56	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH10	757954.0	5910242.0	11.2	4.7	2/11/1988	N/A	N/A	N.D.	N/A	N.D.	N.D.	N.D.	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH11	757934.0	5910082.0	9.9	4.7	5/11/1988	N/A	N/A	N.D.	N/A	N.D.	N.D.	N.D.	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
1988_BH12	757716.0	5910069.0	3.1	9.8	4/11/1988	N/A	N/A	N.D.	N/A	4/11/1988	2.15	0.99	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Saxon Drilling Co.	PWD	
2010_PPK1b	758787.4	5911131.5	7.7	11.5	28/07/2010	11.2	PVC	0.73	5.3 - 11.2	14/10/2010	7.16	0.50	N.D.	N.D.	Medium grained Sand	47.6	Yes	No	Unknown	Monitoring	Terratest	IGGC	Composite logs published by IGGC for the BVSC
2001_PPK1	758787.4	5911131.5	6.7	10.0	9/10/2001	10.0	Cl 18 uPVC	0.69	7.0 - 10.0	N.D.	N.D.	N.D.	N.D.	N.D.	Fine to medium sand	13.1	No	Yes	Unknown	Monitoring	Terratest	PPK	Assessment of Groundwater Conditions and Dune Disposal Options for Merimbula STP, Report No. 57P039A dated April 2002. (Note: the bore numbers adopted in this assessment were reversed by IGGC in 2010 i.e. PPK1 became PPK4 etc.)
2001_PPK2	758714.0	5910663.0	5.9	9.0	9/10/2001	9.0	Cl 18 uPVC	0.47	6.0 - 9.0	N.D.	N.D.	N.D.	N.D.	N.D.	Fine to medium sand	24	No	No	Unknown	Monitoring	Terratest	PPK	
2001_PPK3	758642.0	5910209.0	5.6	8.0	10/10/2001	7.7	Cl 18 uPVC	0.56	5.0 - 8.0	N.D.	N.D.	N.D.	N.D.	N.D.	Fine to medium sand	22.3	No	No	Unknown	Monitoring	Terratest	PPK	
2001_PPK4	758605.0	5910122.0	6.8	9.5	10/10/2001	9.4	Cl 18 uPVC	0.6	6.5 - 9.5	N.D.	N.D.	N.D.	N.D.	N.D.	Fine to medium sand	14	No	Yes	Unknown	Monitoring	Terratest	PPK	
2004_PB1	758298.0	5910489.0	1.62	61.6	Jul-04	N.D.	N.D.	N.D.	N.D.	Jul-04	N.D.	~+2.00	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	Unknown	Test hole	N.D.	Parsons Brinkerhoff	*Investigation of the Deep Disposal Option for Reclaimed Water from Merimbula STP*. Parsons Brinckerhoff, July 2004
2005_GC1	757560.0	5910110.0	N.D.	4.0	10/08/2005	4.0	Cl 18 50mm PVC	0.00	1.0 - 4.0	14/08/2005	0	N.D.	934	N.D.	N.D.	N.D.	No	Yes	Unknown	Monitoring	Terratest	IGGC	*Merimbula/Pambula Reuse Scheme – Monitoring Bore Installation and Baseline Monitoring Program*. Letter report BJ001\LT039_draft, dated 20 Sep 2005
2005_GC2	757480.0	5910240.0	N.D.	5.7	10/08/2005	5.7	Cl 18 50mm PVC	0.02	2.7 - 5.7	14/08/2005	1.95	N.D.	6207	N.D.	Sandy clay, plastic	N.D.	Yes	Yes	Unknown	Monitoring	Terratest	IGGC	
2005_GC3	757170.0	5909640.0	N.D.	6.0	10/08/2005	6.0	Cl 18 50mm PVC	N.D.	3.0 - 6.0	14/08/2005	Dry	N.D.		N.D.	Bedded Sand, Clay and Silt/Sand	N.D.	Yes	No	Unknown	Monitoring	Terratest	IGGC	
2007_BH01	757744.4	5910128.8	N.D.	7.1	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	*Geotechnical Investigation BVSP, Proposed Merimbula STP Upgrade*. Report GF8636AA-01, dated 22 August 2007
2007_BH02	757730.7	5910111.4	N.D.	7.1	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH03	757801.5	5910250.5	N.D.	7.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH04	757808.2	5910259.5	N.D.	6.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH05	757807.0	5910047.8	N.D.	6.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH06	757836.5	5910081.7	N.D.	4.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH07	757796.5	5910236.6	N.D.	6.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH08	757788.3	5910248.9	N.D.	5.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	
2007_BH09	757782.4	5910259.9	N.D.	5.0	22/03/2007	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Yes	N/A	Abandoned	Geotech	N.D.	Coffey	

Groundwater and Geotechnical Borehole Details at the Merimbula Sewage Treatment Plant

Borehole	Easting	Northing	Elevation	Drilled Depth (mbgl)	Construct Date	Cased Depth (mbgl)	Casing Type	Stickup Height (magl)	Screened Depth (mbgl)	SWL Date	SWL (mbgl)	SWL (mAHD)	Salinity (mg/L TDS)	Airlift Yield (L/s)	Aquifer Description	K (m/d)	Lithology Log?	Quality Data?	Status	Bore Type	Driller	Consultant	Source Reference
2010_C1	758790.0	5911176.8	7.8	16.0	27/07/2010	11.5	PVC	0.73	6.5 - 15.5	14/10/2010	7.26	0.51	N.D.	N.D.	Medium to coarse Sand, some shells	52.1	Yes	Yes	Unknown	Monitoring	Terratest	IGGC	
2010_C2	758818.3	5911132.6	7.2	16.0	27/07/2010	16.0	PVC	0.68	7.0 - 16.0	14/10/2010	6.69	0.50	N.D.	N.D.	Medium to coarse Sand, some shells	43.8	Yes	Yes	Unknown	Monitoring	Terratest	IGGC	Composite logs published by IGGC for the BVSC
2010_CPW	758803.7	5911149.0	8.0	21.0	11/08/2010	18.8	PVC Casing, Stainless Screens	0.78	9.8 - 18.8	14/10/2010	7.5	0.50	N.D.	N.D.	Medium to fine Sand	59.7	Yes	Yes	Unknown	Monitoring	Terratest	IGGC	
2018_BH02A	758385.0	5910184.0	4.25	20.0	6/11/2018	N/A	N/A	N.D.	N/A	6/11/2018	1.30	2.95	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
2018_BH02B	758390.0	5910104.0	3.87	30.0	8/11/2018	N/A	N/A	N.D.	N/A	7/11/2018	1.30	2.57	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
2018_BH03	758148.0	5910218.0	11.11	30.0	2/11/2018	N/A	N/A	N.D.	N/A	8/11/2019	5.00	6.11	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
2018_BH04	758053.0	5910228.0	15.18	15.0	9/11/2018	N/A	N/A	N.D.	N/A	N.D.	N.D.	N.D.	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	Merimbula Ocean Outfall Site Investigation, AECOM, 60541653
2018_BH06	758343.0	5910241.0	3.47	20.0	6/11/2018	N/A	N/A	N.D.	N/A	5/11/2018	1.20	2.27	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
2018_BH07	758295.0	5910109.0	2.45	40.2	31/10/2018	N/A	N/A	N.D.	N/A	31/10/2018	1.20	1.25	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
2019_BH08A	758601.0	5910122.0	6.80	20.0	28/11/2019	N/A	N/A	N.D.	N/A	28/11/2019	6.05	0.75	N.D.	N.D.	N/A	N.D.	Yes	No	Abandoned	Geotech	Terratest	AECOM	
GW040592	758311.9	5911496.2	N.D.	3.0	N.D.	3.0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Excavation	N.D.	Unknown	
GW040593	758497.3	5911891.7	N.D.	3.0	N.D.	3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Bore	N.D.	Unknown	
GW047147	758215.0	5909972.0	N.D.	14.0	1/07/1977	8.5	152mm casing	N.D.	7.9 - 8.5	1/07/1977	1.20	N.D.	"Corrosive"	1.52	Sand, Small gravel (water supply)	N.D.	Yes	No	Unknown	Supply Bore	Roy M Barrett	N/A	
GW105056	757972.0	5909727.0	N.D.	79.2	1/10/2003	79.2	80mm Cl 12 uPVC, slotted	N.D.	70.0 - 79.2	1/10/2003	29.3	N.D.	203	N.D.	Medium sand	N.D.	Yes	No	Unknown	Test Bore	Glenn J Gricks	N/A	
GW112420	758187.0	5911028.2	N.D.	3.5	16/08/2011	3.5	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	WaterNSW online bore register (22/10/2019)
GW112913	758742.2	5911169.0	N.D.	16.0	27/07/2010	16.0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	
GW112914	758694.6	5911178.7	N.D.	16.1	27/07/2010	16.1	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	
GW112915	758720.1	5911246.0	N.D.	20.5	11/08/2010	20.5	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	
GW112916	758706.4	5911293.3	N.D.	11.5	28/07/2010	11.5	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	
GW112917	758744.2	5911198.3	N.D.	5.0	10/08/2010	5.0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No	No	Unknown	Monitoring	N.D.	Unknown	

Appendix B

Groundwater Level Data

Appendix B. Groundwater Level Data

Bore	A1		A4		A5		A6		1987_BH10		2001_PPK1		2001_PPK2		2001_PPK3		2001_PPK4	
Datum Height (magl)	1.624	mAHD	3.871	mAHD	2.383	mAHD	3.161	mAHD	2.514	mAHD	7.377	mAHD	6.181	mAHD	6.418	mAHD	7.404	mAHD
Revised Datum Height (magl)									2.785	2.785	7.66				6.371			
1/12/2005																		
14/12/2005							2.32	0.841	1.86	0.654					5.89	0.528		
21/12/2005	1.15	0.47	3.15	0.72	1.17	1.21	2.33	0.831	1.88	0.634	6.9	0.48	5.68	0.50	5.98	0.438	6.78	0.62
1/02/2006							1.86	1.301	1.43	1.084					5.72	0.698		
1/03/2006																		
1/05/2006																		
18/05/2006	1.04	0.58	2.46	1.41	1.41	0.97	1.94	1.221	1.3	1.214	6.84	0.54	5.6	0.58	5.78	0.638	6.57	0.83
1/08/2006	0.5	1.12	2.81	1.06	0.87	1.51	1.94	1.221	1.47	1.044	6.72	0.66	5.54	0.64	5.91	0.508	6.77	0.63
30/08/2006							2.21	0.951	1.655	0.859					6.09	0.328		
8/09/2006							2.24	0.921	1.71	0.804					5.90	0.518		
5/12/2006	1.41	0.21	3.36	0.51	1.49	0.89	2.53	0.631	2.11	0.404	7.08	0.30	5.78	0.40	6.05	0.373	6.965	0.44
13/12/2006							2.56	0.601	2.14	0.374					6.18	0.238		
25/01/2007							2.1	1.061	1.648	0.866					5.867	0.551		
16/02/2007							2.05	1.111	1.59	0.924					5.89	0.528		
28/02/2007	0.81	0.81	1.22	2.65	1.18	1.20	1.79	1.371	1.08	1.434	7.14	0.24	5.85	0.33	5.86	0.558	6.76	0.64
7/03/2007							1.78	1.381	0.82	1.694	7.035	0.34			5.75	0.668		
15/03/2007							1.865	1.296	0.81	1.704	7.02	0.36			5.69	0.728		
4/04/2007							1.67	1.491	0.97	1.544	6.99	0.39			5.7	0.718		
26/04/2007	0.61	1.01	1.48	2.39	1.365	1.02	1.645	1.516	0.68	1.834	7.015	0.36	5.695	0.49	5.61	0.808	6.475	0.93
11/05/2007							1.57	1.591	0.695	1.819	6.99	0.39			5.64	0.778		
6/06/2007			2.46	1.41	1.37	1.01	1.91	1.251	1.255	1.259	7.01	0.37	5.67	0.51	5.8	0.618	6.615	0.79
6/08/2007							2.01	1.151	1.48	1.034	6.72	0.66			5.855	0.563		
28/09/2007							2.29	0.871	1.81	0.704	6.93	0.45			5.89	0.528		
19/10/2007							2.38	0.781	1.945	0.569	7.025	0.35			6.075	0.343		
8/11/2007							2.36	0.801	1.86	0.654	6.955	0.42			6.03	0.388		
10/12/2007			3.31	0.56	1.35	1.03	2.47	0.691	2.17	0.344	7.03	0.35	5.72	0.46	5.96	0.458		
21/12/2007							2.31	0.851	1.9	0.614	7.00	0.38			5.93	0.488		
16/01/2008							2.05	1.111	1.64	0.874	6.97	0.41			5.778	0.64		
7/02/2008							1.435	1.726	0.688	1.826	6.90	0.48			5.41	1.008		
20/02/2008			1.66	2.21	1.11	1.27	1.67	1.491	0.897	1.617	6.95	0.43	5.62	0.56	5.68	0.738	6.735	0.67
5/03/2008									1	1.514	7.00	0.38						
20/03/2008									1.3	1.214	7.02	0.36						
1/04/2008							2.115	1.046	1.52	0.994	7.05	0.33						
13/05/2008			3.13	0.74	1.48	0.90	2.34	0.821	1.87	0.644	6.94	0.44	5.7	0.48	5.99	0.428	7.04	0.36
21/05/2008							2.39	0.771	1.92	0.594	6.96	0.42			5.945	0.473		
19/06/2008							2.455	0.706	1.985	0.529	6.96	0.42			5.96	0.458		
23/07/2008							1.9	1.261	1.07	1.444	6.90	0.48			5.485	0.933		
31/07/2008							1.875	1.286	1.065	1.449	6.86	0.52			5.61	0.808		
4/08/2008									1.17	1.344					5.637	0.781		
28/08/2008			2.828	1.04	1.45	0.93	2.195	0.966	1.55	0.964	6.93	0.44	5.7	0.48	5.932	0.486	6.99	0.41
16/12/2008			3.22	0.65	1.6	0.78	2.432	0.729	1.945	0.569	6.86	0.52	5.5	0.68	5.77	0.648	6.865	0.54
8/01/2009									1.585	0.929	6.98	0.40						
22/01/2009									1.6	0.914	7.00	0.38						
17/02/2009									1.67	0.844	7.06	0.32						
20/03/2009									1.6	0.914	7.08	0.30						
23/03/2009									1.565	0.949	7.08	0.30						
2/04/2009			2.113	1.76	1.927	0.46	2.055	1.106	1.54	0.974	6.95	0.42	5.63	0.55	5.665	0.753	6.822	0.58
23/04/2009									1.17	1.344	7.02	0.36						
29/04/2009									1.142	1.372								
20/05/2009									1.16	1.354	6.94	0.44						
2/07/2009			2.91	0.96	1.611	0.77	2.21	0.951	1.632	0.882	6.86	0.52	5.492	0.69	5.744	0.674	6.851	0.55
12/08/2009							2.43	0.731	1.915	0.599	7.00	0.38						
17/08/2009									1.943	0.571	7.01	0.37						
1/10/2009									1.505	1.009	6.94	0.44						
19/11/2009			3.249	0.62					1.96	0.554								
17/12/2009			3.365	0.51	1.884	0.50	2.575	0.586	2.1	0.414			5.78	0.40	6.025	0.393	7.17	0.23
28/01/2010			2.49	1.38	2.035	0.35	2.235	0.926	1.763	0.751			5.808	0.37	5.87	0.548	7.018	0.39
9/02/2010									1.411	1.103								
10/03/2010									1.405	1.109								
9/04/2010			3.08	0.79	1.185	1.20	2.3	0.861	1.75	0.764			5.72	0.46	6.035	0.383	7.09	0.31
29/04/2010			3.22	0.65	1.3	1.08	2.45	0.711	1.905	0.609			5.665	0.52	5.925	0.493	7.012	0.39
11/06/2010									1.181	1.333								
15/06/2010									1.244	1.27								
29/07/2010			3.039	0.83	1.04	1.34	2.287	0.874			7.12	0.54	5.711	0.47	6.005	0.413	7.083	0.32
20/08/2010									1.985	0.8								
11/10/2010									1.605	1.18								
21/12/2010			3.065	0.806	1.18	1.203	2.284	0.877	1.898	0.887	7.005	0.655	5.561	0.620	5.847	0.571	6.704	0.700
11/02/2011									1.446	1.339								
17/02/2011			1.782	2.089	1.4	0.983	1.812	1.349	1.188	1.597	7.125	0.535	5.731	0.450	5.733	0.685	6.832	0.572
25/05/2011									1.976	0.809								
2/06/2011			3.07	0.801	1.283	1.100	2.3	0.861	1.996	0.789			5.454	0.727	5.7	0.718	6.825	0.579
16/06/2011									1.9	0.885								
21/07/2011									1.47	1.315								
10/08/2011									1.48	1.305								
5/10/2011			3.088	0.783			2.309	0.852	1.989	0.796	6.975	0.685	6.132	0.049	5.915	0.503	6.969	0.435
28/10/2011									1.729	1.056	7.085						6.887	0.517
30/11/2011									1.75	1.035								
21/12/2011			3.143	0.728	1.33	1.053	2.357	0.804	2.014	0.771	7.13	0.530	5.771	0.410	6.037	0.381	7.124	0.280
22/12/2011									2.014									
5/01/2012									1.974	0.811								
7/02/2012									1.692	1.093								
15/02/2012									1.455	1.33								
4/04/2012							1.825	1.336	1.556	1.229	6.79	0.870	5.401	0.780	5.68	0.738	6.788	0.616
24/05/2012									1.64	1.145								
5/07/2012			2.81	1.061					1.695	1.09	6.743	0.917			5.717	0.701	6.752	0.652
18/07/2012									1.745	1.04								
25/07/2012															5.885	0.533		
4/09/2012									1.945	0.84								
18/09/2012									1.95	0.835								
25/09/2012									1.83	0.955								
3/10/2012									1.74	1.045								
8/10/2012									1.669	1.116								
12/10/2012									1.595	1.19								
16/10/2012									1.612	1.173								
23/10/2012									1.72	1.065								
31/10/2012			2.865	1.006			2.12	1.041	1.826	0.959	7.13	0.530	5.785	0.396	6.014	0.404	7.018	0.386
16/11/2012									1.964	0.821								
20/12/2012									2.162	0.623								
4/01/2013									1.959	0.826								
16/01/2013									1.942	0.843								
23/01/2013									1.872	0.913								
6/02/2013									1.635	1.15								
13/02/2013							1.855	1.306	1.594	1.191	7.074	0.586	5.723	0.458	5.822	0.596	6.8	0.604
22/02/2013									1.667	1.118								

Appendix B. Groundwater Level Data

Bore	A1		A4		A5		A6		1987_BH10		2001_PPK1		2001_PPK2		2001_PPK3		2001_PPK4	
Datum Height (magl)	1.624	mAHD	3.871	mAHD	2.383	mAHD	3.161	mAHD	2.514	mAHD	7.377	mAHD	6.181	mAHD	6.418	mAHD	7.404	mAHD
Revised Datum Height (magl)									2.785	2.785	7.66				6.371			
25/02/2013									1.668	1.117								
28/03/2013									1.972	0.813								
12/04/2013									2.118	0.667								
24/04/2013									1.963	0.822								
3/05/2013									1.756	1.029								
8/05/2013							1.873	1.288	1.683	1.102	6.945	0.715	5.552	0.629	5.594	0.824	6.683	0.721
13/05/2013									1.6	1.185								
16/05/2013									1.565	1.22								
24/05/2013									1.59	1.195								
31/05/2013									1.71	1.075								
18/06/2013									1.643	1.142								
26/07/2013									1.85	0.935								
7/08/2013							2.26	0.901	1.938	0.847	6.925	0.735	5.565	0.616	5.88	0.538	6.925	0.479
3/09/2013									2.084	0.701								
25/09/2013									1.886	0.899								
10/10/2013									1.874	0.911								
17/10/2013									1.865	0.92								
24/10/2013									1.918	0.867								
5/11/2013							2.435	0.726	2.055	0.73	7.05	0.610	5.592	0.589	5.87	0.548	6.965	0.439
28/11/2013									1.89	0.895								
6/12/2013									1.967	0.818								
16/12/2013																		
5/02/2014							2.34	0.821	2.04	0.745	7.19	0.470	5.835	0.346	6.096	0.322	7.1	0.304
20/03/2014																		
7/05/2014							2.196	0.965	1.898	0.887	6.7	0.960	5.386	0.795	5.737	0.681	6.715	0.689
14/07/2014									1.886	0.899								
29/07/2014									1.924	0.861								
5/08/2014					1.029		2.244	0.917	1.964	0.821	6.947	0.713	5.718	0.463	5.954	0.464	6.959	0.445
4/09/2014									1.777	1.008								
29/09/2014									1.842	0.943								
8/10/2014									1.908	0.877								
15/10/2014									1.743	1.042								
31/10/2014									1.931	0.854								
5/11/2014	1.005	0.62			0.874	1.509	2.23	0.931	1.966	0.819	6.969	0.691	5.53	0.651	5.799	0.619	6.941	0.463
26/11/2014									2.071	0.714								
5/12/2014									2.048	0.737								
12/12/2014									1.742	1.043								
17/12/2014									1.834	0.951								
23/12/2014									1.872	0.913								
9/01/2015									1.625	1.16								
19/01/2015									1.425	1.36								
21/01/2015																		
27/01/2015									1.326	1.459								
19/02/2015	1.183	0.44			1.099	1.284	2.054	1.107	1.68	1.105	7.094	0.566	5.72	0.461	5.853	0.565	6.957	0.447
27/02/2015									1.803	0.982								
19/03/2015									2.08	0.705								
25/03/2015									2.127	0.658								
27/03/2015																		
1/04/2015									2.175	0.61								
7/04/2015									2.175	0.61								
9/04/2015									1.872	0.913								
13/04/2015									1.779	1.006								
16/04/2015									1.708	1.077								
21/04/2015									1.561	1.224								
24/04/2015									1.333	1.452								
30/04/2015									1.405	1.38								
5/05/2015									1.463	1.322								
14/05/2015									1.611	1.174								
21/05/2015	0.99	0.63			1.028	1.355	3.048	0.113	1.68	1.105	6.885	0.775	5.524	0.657	5.8	0.618	6.855	0.549
6/08/2015	0.94	0.68			0.905	1.478	2.221	0.94	1.876	0.909	6.946	0.714	5.579	0.602	3.903	2.515	7.005	0.399
25/09/2015									1.958	0.827								
28/09/2015																		
13/10/2015									1.785	1								
21/10/2015																		
9/11/2015									1.588	1.197								
26/11/2015	0.775	0.85			0.581	1.802	1.928	1.233	1.635	1.15	6.867	0.793	5.555	0.626	5.819	0.599	6.897	0.507
15/12/2015									1.813	0.972								
22/12/2015																		
6/01/2016									1.478	1.307								
12/01/2016									0.84	1.945								
29/01/2016									1.28	1.505								
10/02/2016									1.4	1.385								
25/02/2016	0.93	0.69			0.626	1.757	1.89	1.271	1.615	1.17	6.965	0.695	5.52	0.661	5.8	0.618	6.862	0.542
1/04/2016									1.759	1.026								
8/04/2016									1.884	0.901								
2/06/2016					0.901	1.482	2.284	0.877	2.063	0.722	7.018	0.642	6.684	-0.503			7.009	0.395
24/06/2016									1.533	1.252								
15/07/2016									1.631	1.154								
12/08/2016									1.755	1.03								
25/08/2016	0.956	0.67			0.669	1.714	2.045	1.116	1.836	0.949	6.99	0.670	5.592	0.589	5.886	0.532	6.851	0.553
22/09/2016									1.864	0.921								
10/11/2016									2.084	0.701								
16/11/2016	1.268	0.36			1.069	1.314	2.26	0.901	2.112	0.673			5.528	0.653	5.9	0.518	6.911	0.493
18/11/2016									2.121	0.664							6.916	
8/12/2016									2.169	0.616								
19/12/2016									2.221	0.564								
6/02/2017									2.285	0.5								
15/02/2017	1.341	0.28			1.553	0.83	2.131	1.03	2.044	0.741			5.635	0.546			6.913	0.491
2/03/2017									1.85	0.935								
10/03/2017									1.678	1.107								
24/04/2017									2.076	0.709							7.04	
24/05/2017	0.956	0.67			1.188	1.195	2.263	0.898	1.933	0.852	6.960	0.700	5.519	0.662			6.821	0.583
16/08/2017	1.194	0.43			1.415	0.968	2.441	0.72	2.184	0.601			6.738	-0.557	6.141	0.277	7.116	0.288
27/09/2017																		
20/10/2017									2.122	0.663								
27/10/2017									2.093	0.692								
7/11/2017									2.006	0.779								
14/12/2017	1.111	0.51			1.416	0.967	2.398	0.763	2.068	0.717	7.086	0.574	5.759	0.422	6.155	0.263	7.154	0.250
15/01/2018									1.68	1.105								
29/01/2018									1.53	1.255								
31/01/2018									1.535	1.25								
13/02/2018									1.685	1.1								
19/02/2018									1.776	1.009								
14/03/2018									1.828	0.957	7.199	0.461			6.010	0.408		

Appendix B. Groundwater Level Data

Bore	A1		A4		A5		A6		1987_BH10		2001_PPK1		2001_PPK2		2001_PPK3		2001_PPK4	
Datum Height (magl)	1.624	mAHD	3.871	mAHD	2.383	mAHD	3.161	mAHD	2.514	mAHD	7.377	mAHD	6.181	mAHD	6.418	mAHD	7.404	mAHD
Revised Datum Height (magl)									2.785	2.785	7.66				6.371			
28/03/2018									1.875	0.91								
3/04/2018									1.775	1.01								
10/04/2018									1.700	1.085								
16/04/2018									1.680	1.105								
23/04/2018									1.731	1.054								
26/04/2018									1.750	1.035								
4/05/2018									1.775	1.01								
11/05/2018																		
14/06/2018									1.99	0.795								
10/08/2018									2.203	0.582								
13/09/2018	1.333	0.29			1.831	0.552	2.546	0.615	2.276	0.509	7.710	-0.050	5.745	0.436	6.168	0.25	7.168	0.236
27/09/2018									2.310	0.475								
10/10/2018									2.07	0.715								
17/10/2018									1.921	0.864								
22/10/2018									1.805	0.98								
30/10/2018									1.71	1.075								
15/11/2018									1.9	0.885								
11/12/2018									2.163	0.622	7.161	0.499			6.119	0.299	7.145	0.259
17/12/2018									1.95	0.835								
4/01/2019									1.675	1.11								
8/01/2019									1.625	1.16								
11/01/2019									1.59	1.195								
18/01/2019									1.51	1.275								
21/01/2019									1.515	1.27								
25/01/2019									1.51	1.275								
30/01/2019									1.465	1.32								
31/01/2019									1.42	1.365								
8/04/2019									1.853	0.932								
30/04/2019									1.547	1.238								
20/06/2019					1.485	0.898			2.008	0.777	6.985	0.675			6.025	0.393	6.990	0.414
11/09/2019									2.325	0.46	7.070	0.590			6.110	0.308		
25/09/2019																		
20th %	0.8	0.36	2.3	0.65	1.0	0.88	1.9	0.78	1.5	0.73	6.9	0.37	5.5	0.41	5.7	0.39	6.8	0.37
Average	1.0	0.60	2.8	1.12	1.3	1.10	2.2	1.00	1.7	0.99	7.0	0.50	5.7	0.49	5.8	0.58	6.9	0.50
80th %	1.3	0.81	3.2	1.55	1.5	1.38	2.4	1.28	2.0	1.21	7.1	0.67	5.8	0.65	6.0	0.70	7.0	0.63

Appendix C

Groundwater Quality Data

Appendix C. Groundwater Quality Data

Site	Date	pH	EC	DO (mg/L)	DO (% Sat)	Redox Potential	Temp	Bicarb	Carb	Hydrox	Total Alk	Chloride	Sulphate	Diss Calcium	Diss Mg	Dis Na	Dis K	Free Cl	Total Cl	Ammonia (N)	Nox (N)	Nitrate (N)	Nitrite (N)	Nitrate (NO3)	Organic N as N	Total Nitrogen	Phosphate	Total Phosphorous as P	Reactive Phosphorous	Orthophosphate as P	Faecal Coliforms	E. coli	Faecal Streptococci	Enterococci
Units			uS/cm	mg/L	%	mV	ºC	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	CFU/100mL
1987_BH5	1987	5.6						23					2.7	3.5	8.2	12	2.9							1			0.22							
1987_BH10	16/12/2004	6.81	743		18.6	-67	15.7	149	2	2	149	150	5.4	25	6.1	110	15			0.79	0.01					1.4	0.07	0.24			<2	<2	<2	<2
1987_BH10	15/08/2005	6.63	799		30.9	-33	14.8	159	2	2	159	150	9.1	30	8.3	100	17			1.1	0.01					1.6	0.16	0.33			<2	<2	<2	<2
1987_BH10	21/12/2005	7	840		n/a	n/a	n/a	160	2	2	160	160	14	25	8.7	95	14			1	0.01					1.6	0.08	0.33			<2	<2	<2	<2
1987_BH10	1/02/2006	6.9	910		n/a	n/a	n/a	92	2	2	92	230	12	19	7.8	130	11			0.66	0.01					1.1	0.01	0.12			<2	<2	<2	<2
1987_BH10	18/05/2006	6.5	990		0.43	-94	17	100	2	2	100	220	16	27	11	130	19			1.6	0.02					2.1	0.05	0.17			<2	<2	<2	<2
1987_BH10	13/12/2006	6	965		0.71	-12	16.9	130	2	2	130	210	13	27	11	130	20			1.4	0.02					1.5	0.06	0.34			<2	<2	<2	<2
1987_BH10	7/03/2007	6	811		1.04	-21	18.8	120	2	2	120	160	31	24	9.7	100	17			1.5	0.01					1.7	0.04	0.16			<2	<2	<2	<2
1987_BH10	6/06/2007	6.34	819		1.24	-53	17.8	120	2	2	120	130	26	24	7.4	93	14			1.1	0.01					1.6	0.24	0.43			32	32	2	2
1987_BH10	10/12/2007	6.82	817		0.95	-79	15.9	150	2	2	150	130	21	26	7.6	92	13			1	0.01					1.4	0.15	0.25			<2	<2	<2	<2
1987_BH10	20/02/2008	6.69	706		0.87	-86	17.5	110	2	2	110	130	28	18	5.6	81	11			1.1	0.01					1.5	0.1	0.19			2	2	2	2
1987_BH10	13/05/2008	6.77	780		0.82	-4	17.5	130	2	2	130	130	34	23	6.6	96	16			1	0.01					1.5	0.32	0.4			<2	<2	<2	<2
1987_BH10	19/06/2008	6.99	736		1.05	-20	17.1	130	2	2	130	130	30	23	6.9	99	15			1.1	0.01					1.5	0.23	0.31			<2	<2	<2	<2
1987_BH10	28/08/2008	7.06	760		1.11	22	16.4	130	2	2	130	140	27	23	5.6	98	16			0.92	0.01					1.4	0.35	0.44			<2	<2	<2	<2
1987_BH10	16/12/2008	6.95	725		0.77	-16	16.7	140	2	2	140	120	13	22	5.3	91	16			0.84	0.01					1.7		0.48			<2	<2	<2	<2
1987_BH10	2/04/2009	7.09	649		1.17	-22	18.1	110	2	2	110	100	23	13	4.7	84	18			1.2	0.01					1.8	0.07	0.08			<2	<2	<2	<2
1987_BH10	2/07/2009	7.1	838		1.05	70	16.5	140	2	2	140	150	33	23	6.9	110	23			1.1	0.01					1.8	0.26	0.44			<2	<2	<2	<2
1987_BH10	28/01/2010	7	840		1.68	66	18.6	116	<0.1	<0.1	116	140	34	20	6	100	21			1.1	0.01					1.7	0.08	0.1			6	6	41	41
1987_BH10	29/04/2010	6.99	703		1.08	-42	19.7	130	<0.1	<0.1	130	100	40	32	10	100	21			0.89	0.02					1.5	0.46	0.56			<2	<2	<2	<2
1987_BH10	21/12/2010	6.55	867		0.78	-169	17.6	137			137	170	52	10	9.4	150	34			1.4	0.01					2	0.88	0.97			<2	<2	<2	<2
1987_BH10	17/02/2011	6.83	779		0.85	-84.4	19.4	152	<0.1	<0.1	152	130	35	10	9.9	120	28			1.9	0.01					2.5	1	1.1			<2	<2	<2	<2
1987_BH10	4/04/2012	6.66	638		0.86	-194.1	18.8	143	<0.1	<0.1	143	110	3.2	12	12	89	25			1.2	0.003					2	0.89	0.97			<2	<2	<2	<2
1987_BH10	5/07/2012	6.8	611		1.01	-256.4	15	141	<0.1	<0.1	141	97	10	13	12	80	23			1	0.05					1.8	0.82	0.9			<2			<2
1987_BH10	31/10/2012	6.53	660		1	-111.6	17	170	<0.1	<0.1	170	100	19	17	16	92	22			0.9	0.05					1.6	0.64	0.75			<2			<2
1987_BH10	13/02/2013	6.62	776		1.43	-141.7	18.6	188	<0.1	<0.1	188	130	21	21	19	110	25			1.2	0.05					1.8	0.87	0.89			<2			<2
1987_BH10	8/05/2013	6.83	810		1.58	-94.2	18.4	225	<0.1	<0.1	225	120	12	27	21	95	23			1.2	0.05					1.9	0.88	1			<2			<2
1987_BH10	7/08/2013	7.11	731		1.06	-56.8	14.3	208	<0.1	<0.1	208	99	6.3	26	20	78	20			0.9	0.05					1.7	0.68	0.78			<2			<2
1987_BH10	5/11/2013	6.36	640		1.71	-52.6	16.5	203	<0.1	<0.1	203	79	5.9	26	19	74	19			0.8	0.05					1.6	0.6	0.72			<2			<2
1987_BH10	5/02/2014	6.22	616		1.03	-178.5	17.7	183	<0.1	<0.1	183	79.6	7.2	24.3	16.2	66	15.7			0.8	0.05					1.76	0.71	0.81			<2			<2
1987_BH10	7/05/2014	6.13	616		1.36	-142.4	17.6	170	<0.1	<0.1	170	82	7.6	23.9	16.8	68.8	15.9			0.9	0.05					1.71	0.69	0.76			<2	<1	<2	<2
1987_BH10	5/08/2014	6.33	624		1.26	-142.3	14.7	155	<0.1	<0.1	155	90.6	8.8	23.1	16.3	64.1	14.8			1	0.05					1.69	0.65	0.69			<1			<1
1987_BH10	5/11/2014	6.53	675		1.29	-142.2	15.4	150	<0.1	<0.1	150	113	7	20.7	17.2	76.3	14.2			0.9	0.05	0.05	0.01			1.86	0.53	0.64			<1			<1
1987_BH10	19/02/2015	6.96	751		0.88	-132.3	19.4	177	<0.1	<0.1	177	124	9.4	23.3	19.4	83	15.5			1.2	0.05	0.05	0.01			1.83	0.59	0.62			<1			<1
1987_BH10	21/05/2015	6.43	751		1.26	-149.5	16.7	169	<0.1	<0.1	169	121	11	24.1	18.8	87.4	15.1	<0.03	<0.03	1	0.05	0.05	0.01			1.75	0.62	0.72			<2			<2
1987_BH10	6/08/2015	6.45	839		1.78	-144.8	13.7	155	<0.1	<0.1	155	159	18.4	24.8	21.4	85.3	15.7		<0.03	1	0.05	0.05	0.01			1.74	0.49	0.505			<2			<2
1987_BH10	26/11/2015	6.41	780		1.14	-199	17.9	150	<0.1	<0.1	150	147	13.8	23	18.2	95.8	13.4	<0.03	<0.03	0.9	0.05	0.05	0.01			1.7	0.5	0.52			<2			<2
1987_BH10	25/02/2016	6.22	267		1.2	143.2	20.5	85.2	<0.1	<0.1	85	26	2.4	11.4	10.2	23.9	6.9	<0.03	<0.03	0.4	0.05	0.05	0.01			1.91	0.57	0.64			12			<2
1987_BH10	2/06/2016	6.11	448		1.57	2.6	16.8	109	<0.1	<0.1	109	63.6	3.6	17.7	13.7	37.2	8.6	<0.03	<0.03	0.5	0.05	0.05	0.01			1.42	0.57	0.61			<2			<2
1987_BH10	25/08/2016	6.23	572		1.06	-124.6	14.9	120	<0.1	<0.1	120	94	2.3	19	15.4	53	9	<0.03	<0.03	0.6	0.05	0.05	0.01			1.54	0.48	0.53			<2			<2
1987_BH10	16/11/2016	6.1	651		1.5	-97.3	15.8	128	<0.1	<0.1	128	124	3	22.2	16.1	71.5	11.4	<0.03	<0.03	0.8	0.05	0.05	0.01			1.66	0.5	0.54			<2			<2
1987_BH10	15/02/2017	6.38	605		1.07	-114	19.2	169	<0.1	<0.1	169	96.3	1.4	25.3	14.6	84.3	13	<0.03	<0.03	0.7	0.05	0.05	0.01			1.55	0.68	0.72			<2			<2
1987_BH10	24/05/2017	7	692		1.25	-95.8	16.4	174	<0.1	<0.1	174	120	1.1	26.6	16.5	80.8	13.5	<0.03	<0.03	0.7	0.05	0.05	0.01			1.41	0.61	0.62			<2	<2		<2
1987_BH10	16/08/2017	7.27	702		2.08	-88.9	14.8	166	<0.1	<0.1	166	132	2.4	27.1	17.9	83.2	11.8	<0.03	<0.03	0.7	0.05	0.05	0.01			1.4	0.54	0.55			<2	<2		<2
1987_BH10	14/12/2017	7.19	611		1.01	-185.1	16.5	154	<0.1	<0.1	154	104	4	22.3	15.5	74.5	11.2	<0.03	<0.03	0.6	0.05	0.05	0.01			1.36	0.59	0.59			90	90		<2
1987_BH10	14/03/2018	7.23	458		0.19	-220	18.6	160	<0.1	<0.1	160	14.6	1.3	26.6	11	53.9	12.8	<0.03	<0.03	0.6	0.05	0.05	0.01			1.23	0.8	0.85			<2	<2		<2
1987_BH10	14/06/2018	7.19	751		1.54	-130.5	15.9	147	<0.1	<0.1	147	146	20.1	42.2	16	74.6	12.8	<0.03	<0.03	0.7	0.05	0.05	0.01			1.36	0.67	0.7			<2	<2		<2
1987_BH10	13/09/2018	7.26	708		1.16	-153.3	14.6	144	<0.1	<0.1	144	130	12.4	37.9	14.7	62.8	11.6	<0.03	<0.03	1	0.05	0.05	0.01			1.25	0.58	0.68			<2	<2		<2
1987_BH10	11/12/2018	7.18	932		0.9	-200.2	17	135	<0.1	<0.1	135	175	21.6	37.7	21.8	107	11.9	<0.03	<0.03	0.8	0.05	0.05	0.01			1.35	0.59	0.61			<2	<2		<2
1987_BH10	15/03/2019	7.26	1,000		2.81	-60	18.9	135	<0.1	<0.1	135	219	4.7	31.7	13.7	145	12.6			0.9	0.05	0.05	0.01			1.56	0.56	0.64			<2	<1		<2
1987_BH10	20/06/2019	6.74	893		2.16	-96	15.4	166	<0.1	<0.1	166									0.7	0.25	0.25	0.01			1.32	0.56	0.61			<1	<1		<1
1987_BH10	11/09/2019	6.79	891		1.48	-198.5	14.9	162	<0.1	<0.1	162									0.6	0.05	0.05	0.01			1.21	0.59	0.59			<1	<1		<1
1987_BH13	1987	7.4						100					20	64	14	76	5.7							1			0.1							
1987_BH14	1987	6.1						140					16	46	15	130	12							2			0.2							
A1	28/11/2001	5.45	736	0.87	9.4	22	20.9				58	186	6	18	13	100	5					nd	0.03						0.03					
A1	19/02/2015	6.55	885		1.07	-14.3	22.6	66.8	<0.1	<0.1	67	33.4	0.9	17.1	12.1	125	6.6			0.6	0.05	0.05	0.01			2.16	0.04	0.08			<2			<2
A1	21/05/2015	5.9	876		1.19	-71.8	16	52.7	<0.1	<0.1	53	233	7	13.8	11	138	5.8	<0.03	<0.03	0.5	0.05	0.05	0.01			2.63	0.02	0.09			4			6
A1	6/08/2015	6.03	482		1.41	-64.7	11.2	42.5	<0.1	<0.1	42	117	2.1	8.59	7.47	67	4		<0.03	0.5	0.05	0.05	0.02			2.78	0.02	0.071			<2			<2
A1	26/11/2015	5.98	350		0.8	-82.4	20.6	46.2	<0.1	<0.1	46	59.2	0.4	9.8	6.14	49.4	4.3	<0.03	<0.03	0.5	0.05	0.05	0.02			2.87	0.04	0.1			2			22
A1	25/02/2016	5.77	358		1.12	-19	22.7	53.2	<0.1	<0.1	53	59.5	0.4	9.38	5.73	46.9	4.2	<0.03	<0.03	0.4	0.05	0.05	0.02			3.24	0.04	0.12			10			<2
A1	2/06/2016	6	703		1.63	22.3	15.8	80	<0.1	<0.1	80	158	1.1	14.7	9.1	84.5	5.5	<0.03	<0.03	0.6	0.05	0.05	0.01			2.41	0.04	0.1			<2			<2
A1	25/08/2016	5.77	394		1.14	-16.7	12.3	52.1	<0.1	<0.1	52	75.9	0.4	8.23	5.55	47.8	4.1	<0.03	<0.03	0.3	0.05	0.05	0.02			2.68	0.02	0.1			2			<2
A1	16/11/2016	5.91	472		1.41	-2.7	17.9	55.2	<0.1	<0.1	55	96.8	0.4	8.48	5.68	63.6	4.6	<0.03	<0.03	0.5	0.05	0.05	0.02			2.56	0.04	0.14			<2			18
A1	15/02/2017	6.18	610		2.37	-14.4	20.9	89.2	<0.1	<0.1	89	127	0.4	17.7	7.28	107	5.7	<0.03	<0.03	0.4	0.05	0.05	0.02			2.38	0.05	0.13			<2			24
A1	24/05/2017	6.29	560		1.5	-7.5	16.1	98.9	<0.1	<0.1	99	95.5	1.3	16.5	6.86	88.2	4.8	0.03	0.07	0.3	0.05	0.05	0.02			2.26	0.05	0.13			70	70		<2
A4	28/11/2001	6.41	881	0.99	10.3	-79	22.9				226	138	13	63	15	84	19					nd	0.02						nd					
A4	29/07/2010	6.89	1,050		1.2	-153.3	18.2	342	<0.1	<0.1	342	120	49	110	11	110	110			0.28	<0.01					0.9	0.04	0.65			<2	<2	<2	<2
A4	5/10/2011	7.26	888		1.02	-89.4	16.5	271	<0.1	<0.1	271	130	41	99	7.9	93	15			0.3	<0.05					1.5	0.1	0.89			<10	<10	<10	<10
A4	31/10/2012	6.46	1,098		1.64	-73.6	19.3	432	<0.1	<0.1	432	87	23	130	13	79	20			0.5	<0.05					1.5	0.04	0.59			<2			8
A6	28/11/2001	4.88	109	1.03	10.6	194	24				4	24	4	2	2	12	nd					nd	0.03						0.02					
A6	16/12/2004	4.69	190		26.6	142	18.3	4	0	0	4	45	5.5	3.1	5.1	26	0			0.04	0.04					1.7	0.02	0.06			0	0	0	0
A6	14/08/2005	4.84	147		36.2	223	13.1	1	0	0	1	34	4	2.1	3.5	19	0.5			0.02	0.03					1.4	0.02	0.07			8	8	6	0
A6	21/12/2005	4.9	170		na	na	na	2	2	2	2	36	14	1.9	3.2	22	0.2			0.05	0.01					2.4	0.03	0.5			2	2	na	1
A6	1/02/2006	4.8	230		na	na	na	2	2	2	2	56	2	2.1	4.1	26	0.6			0.1	0.01					2.2	0.02	0.51			2	2	2	2
A6	18/05/2006	5.32	160		0	-113	16.6	2	2	2	2	35	1	1.9	3.4	18	0.8			0.07	0.01					1.9	0.03	0.39			2	2	2	2
A6	13/12/2006	4.45	220		0.83	-13	16.8	2	2	2	2	46	4	2.7	5.4	27	0.3			0.07	0.02					2	0.03	0.37			2	2	18	18
A6	7/03/2007	4.46	194		0.46	-9	18.7	3	2	2	3	40	1.5	1.8	3.2	25	0.9			0.15	0.01					2.2	0.02	0.61			2	2	2	2
A6	6/06/2007	4.82	213		0.35	-11	16.6	1	1	1	1	39	1.1	2.6	4.8	18	0.9			0.68	0.01					0.99	0.02	0.24			2	2	2	2
A6	10/12/2007	5	181		1.84	148	16.1	3	2	2	3	33	3.7	1.9	3.4	18	0.2			0.06	0.01					2.3	0.03	0.53			2	2	8	8
A6	20/02/2008	5.18	163		0.61	-54	18.6	5	2	2	5	35	1.5	1.7	2.6	17	0.9			0.01	0.01					1.2	0.02	0.19			2	2	2	2
A6	13/05/2008	5.39	157		0.67	77	17.3	5	2	2	5	27	1.1	2	3.4	17	0.5			0.06	0.01					1.9	0.03	0.33			<2	<2	<2	<2
A6	19/06/2008	5.22	167		0.94	93	16.3	3	2	2	3	29	3.5	1.9	3.5	19	0.5			0.07	0.01					1.6	0.03	0.17			<2	<2	<2	<2
A6	28/08/2008	5.46	183		0.7	48	14.6	6	2	2	6	39	2.4	1.9	3.2	20	1			0.07	0.01					1.3	0.04	0.11			<2	<2	<2	<2
A6	16/12/2008	5.19	170		1.07	130	17.5	2	2	2	2	33	8	2.1	3.8	19	0.7			0.01	0.01					1.9		0.39			<2	<2	<2	<2
A6	2/04/2009	5.5	290		0.21	20	18.3	3	2	2	3	68	0.7	2.8	4.8	30	2.4			0.34	0.02					1.8	0.04	0.18			<2	<2	<2	<2
A6	2/07/2009	5.52	242		0.2	60	15.2	2	2	2	2	57	0.9	2.8	5.6	25	0.8			0.08	0.01					1.8	0.02	0.2			<2	<2	<2	<2
A6	28/01/2010	5	399		0.46	66	18.6	1.8	<0.1	<0.1	<1	99	1.1	3.8	8.6	40	2.3			0.29	0.01					1.3	0.04	0.1			<2	<2	<2	<2
A6	29/04/2010	4.91	300		0.76	175.8	18.2	3.2	<0.1	<0.1	1	84	4	4.5	10	38	0.6			0.05	0.01					1.6	0.04	0.13			<2	<2	<2	<2
A6	29/07/2010	5.14	280		0.81	-28.9	15.1	17.7	<0.1	<0.1	17	76	2.6	4.7	8.8	36	0.7			0.01	0.01					1.4	0.02	0.19			<2	<2	<2	<2

(Source: Bega Valley Shire Council)

Appendix C. Groundwater Quality Data

Site	Date	pH	EC	DO (mg/L)	DO (% Sat)	Redox Potential	Temp	Bicarb	Carb	Hydrox	Total Alk	Chloride	Sulphate	Diss Calcium	Diss Mg	Dis Na	Dis K	Free Cl	Total Cl	Ammonia (N)	Nox (N)	Nitrate (N)	Nitrite (N)	Nitrate (NO3)	Organic N as N	Total Nitrogen	Phosphate	Total Phosphorous as P	Reactive Phosphorous	Orthophosphate as P	Faecal Coliforms	E. coli	Faecal Streptococci	Enterococci
Units			uS/cm	mg/L	%	mV	ºC	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	CFU/100mL
A6	8/05/2013	5.51	167		1.33	4.2	17.2	10.7	<0.1	<0.1	7	38	0.4	2.1	2.9	22	1.1			0.1	0.05					1.2	0.02	0.04			<2			<2
A6	7/08/2013	5.9	206		1.28	46.9	13.7	4.6	<0.1	<0.1	4	46	3.7	2.2	4.3	24	0.6			0.1	0.05					1.4	0.02	0.07			<2			<2
A6	5/11/2013	4.84	247		1.69	70.8	15.9	7.5	<0.1	<0.1	5	61	3.4	4	5.9	30	0.7			0.1	0.05					1.2	0.02	0.05			<2			<2
A6	7/05/2014	4.21	493		0.89	148.7	17.5	<0.1	<0.1	<0.1	<1	130	5.6	8.04	14	48.9	0.8			0.1	0.05					1.04	0.02	0.04			<2	<1	<2	<2
A6	5/08/2014	4.53	308		1.05	83	15.2	7.2	<0.1	<0.1	7	72.2	5.2	3.85	5.71	37.9	0.8			0.1	0.05					1.76	0.02	0.06			<2			<2
A6	5/11/2014	4.84	137		0.93	50.7	15.8	6	<0.1	<0.1	6	25.8	1.6	1.43	2.2	20	0.4			0.1	0.05	0.05	0.02			1.89	0.03	0.06			<2			<2
A6	19/02/2015	5.27	159		1.09	-13.8	19.4	6.1	<0.1	<0.1	6	224	0.4	1.85	2.96	22.4	0.6			0.1	0.05	0.05	0.01			1.29	0.02	0.04			<2			<2
A6	21/05/2015	4.93	183		1.89	-10.8	15.8	4.9	<0.1	<0.1	5	32.6	3	2	3.14	22.1	0.5	<0.03	<0.03	0.1	0.05	0.05	0.01			1.19	0.02	0.04			<2			<2
A6	6/08/2015	4.81	204		1.31	12.9	13.3	7.4	<0.1	<0.1	7	48.6	1	2.36	4.47	24.8	0.4		<0.03	0.1	0.05	0.05	0.01			1.16	0.02	0.022			<2			<2
A6	26/11/2015	4.82	112		1.36	130.3	17.3	8.9	<0.1	<0.1	9	17.4	1.4	2.68	2.92	14	0.5	<0.03	0.03	0.1	0.05	0.05	0.01			1.58	0.02	0.04			6			<2
A6	25/02/2016	4.7	135		1.19	228.5	18.3	8	<0.1	<0.1	8	27.2	0.8	2.12	2.96	16.9	0.8	<0.03	<0.03	0.1	0.05	0.05	0.01			1.47	0.02	0.05			6			6
A6	2/06/2016	4.53	175		1.6	182.9	15.6	7.3	<0.1	<0.1	7	34.1	0.7	2.69	3.92	21.3	1.3	<0.03	<0.03	0.1	0.05	0.05	0.01			1.71	0.02	0.07			<2			<2
A6	25/08/2016	4.8	129		1.35	223.8	13.5	9.1	<0.1	<0.1	9	23.1	0.6	1.88	2.67	14.2	2.4	<0.03	<0.03	0.1	0.05	0.05	0.02			1.54	0.02	0.07			2			<2
A6	16/11/2016	4.75	167		1	130.5	15.6	8.9	<0.1	<0.1	9	36.4	0.7	2.71	4.14	19.7	2.8	<0.03	<0.03	0.1	0.05	0.05	0.01			1.25	0.02	0.05			<2			<2
A6	15/02/2017	4.7	212		5.38	80.9	18	6.7	<0.1	<0.1	7	49.7	1	3.1	4.21	28	2.9	<0.03	<0.03	0.2	0.05	0.05	0.01			1.14	0.02	0.03			<2			<2
A6	24/05/2017	4.81	222		1.74	83	15.9	11	<0.1	<0.1	11	46.1	5.1	2.99	5.46	25.5	3	<0.03	<0.03	0.1	0.05	0.05	0.01			0.87	0.02	0.04			<2	<2		<2
CPW	12/10/2010	7.44	19,900			69	17.1					6700	870	220	450	3700	200					0.33	<0.05		0.2	0.57	0.05		23	0.03	<2			<2
GC1	14/08/2005	5.37	1,460		57	134	13.2	10			10	390	38	3.2	19	210	4.6			0.07	<0.01					1.3		1.1		0.01	<2	na	6	0
GC2	14/08/2005	4.61	9,699		76.1	188	15.5	3			3	3400	110	36	220	1600	3			0.23	<0.01					0.51		0.46		0.01	<2	na	6	0
MERIC1	2/06/2011	7.92	5,050		0.85	37.9	16.5	216	<0.1	<0.1	216	1400	170	130	93	850	40			<0.01	0.04					0.22	0.07	0.08			<2	<2	<2	<2
MERIC1	5/10/2011	8.08	4,820		0.75	103.1	16.8	207	<0.1	<0.1	207	1400	160	120	77	550	36			<0.1	<0.05					0.21	0.05	0.07			<2	<2	<2	<2
MERIC1	21/12/2011	7.69	4,580		0.98	0.1	16.5	214	<0.1	<0.1	214	1400	160	120	81	710	36			<0.1	<0.05					0.18	0.06	0.07			<2	<2	<2	<2
MERIC1	4/04/2012	7.74	3,497		1.27	9.2	17.4	221	<0.1	<0.1	221	950	110	110	54	460	25			0.015	0.028					0.21	0.043	0.073			<2	<2	<2	<2
MERIC2	21/12/2010	7.62	12,260		0.67	54	16.2	220	<0.1	<0.1	220	3600	500	170	230	2100	81			0.02	0.25					0.46	0.08	0.1			<2	<2	<2	<2
MERIC2	17/02/2011	7.74	11,190		1.05	23.4	16.9	222	<0.1	<0.1	222	3300	450	160	210	1900	100			0.04	0.31					0.51	0.07	0.07			<2	<2	<2	<2
MERIC2	2/06/2011	7.66	11,220		0.98	48.4	16.5	232	<0.1	<0.1	232	3400	430	170	230	2100	100			<0.01	0.23					0.43	0.06	0.07			<2	<2	<2	<2
MERIC2	5/10/2011	7.97	10,230		1.08	66.6	16.9	225	<0.1	<0.1	225	3100	390	160	190	1300	84			<0.1	0.16					0.6	0.03	0.06			<2	<2	<2	<2
MERICBCH	17/02/2011																			0.04	<0.01					0.19	0.02	<0.01						
MERICBCH	2/06/2011	8.39	56,200		10.98	34.2														0.01	0.02					0.5	0.01	0.03						
MERICBCH	5/10/2011																			0.1	0.05					0.14	0.02	0.01						
MERICBCH	22/12/2011																			0.031	0.076					0.24	0.012	0.02						
MERICBCH	5/07/2012																			0.1	0.05					0.31	0.02	0.01						
MERICBCH	31/10/2012																			0.019	0.002					0.46	0.003	0.017						
MERICBCH	13/02/2013																			0.011	0.002					0.15	0.002	0.011						
MERICBCH	8/05/2013																			0.1	0.05					0.13	0.02	0.01						
MERICBCH	7/08/2013																			0.1	0.05					0.41	0.02	0.01						
MERICBCH	5/11/2013																			0.1	0.05					0.18	0.02	0.01						
MERICBCH	5/02/2014																			0.1	0.05					0.32	0.02	0.02						
MERICBCH	7/05/2014																			0.1	0.05					0.22	0.02	0.01						
MERICBCH	5/08/2014																			0.1	0.05					0.16	0.02	0.01						
MERICBCH	5/11/2014																			0.008	0.016	0.016	0.002			0.25	0.003	0.026						
MERICBCH	19/02/2015																			0.008	0.036					0.15	0.002	0.004						
MERICBCH	21/05/2015																			0.01	0.028					0.13	0.007	0.011						
MERICBCH	6/08/2015																			0.012	0.014					0.3	0.004	0.017						
MERICBCH	26/11/2015																			0.009	0.003					0.18	0.004	0.012						
MERICBCH	25/02/2016																			0.019	0.035					0.31	0.008	0.01						
MERICBCH	2/06/2016																			0.018	0.039					0.15	0.009	0.008						
MERICBCH	25/08/2016																			0.011	0.01					0.09	0.008	0.011						
MERICBCH	16/11/2016																			0.012	0.004					0.12	0.004	0.007						
MERICBCH	15/02/2017																			0.011	0.002					0.1	0.004	0.004						
MERICBCH	24/05/2017																			0.018	0.048					0.18	0.008	0.011						
MERICBCH	16/08/2017																			0.008	0.016					0.16	0.008	0.008						
MERICBCH	14/12/2017																			0.017	0.002					0.12	0.002	0.003						
MERIEXN	6/06/2007	8.17	773		11.13	79	14.1	100	2	2	110	92	41	19	7.5	88	20			0.04	1.1					2.3	9	9.6			32	32	38	38
MERIEXN	20/02/2008	7.89	1,270		6.17	89	26.1	120	2	2	120	230	50	22	15	190	21			0.01	0.01					1.1	8.5	8.8			62	62	4	4
MERIEXN	28/08/2008	10.56	721		19.11	36	17.2	11	52	2	63	120	51	8.5	6.2	91	20			0.04	7					8.4	1.5	2.2			<2	<2	<2	<2
MERIEXN	2/07/2009	7.77	757		5.44	212	12.7	150	2	2	150	110	28	20	8.5	95	24			1.5	0.01					3	7	7.5			230	230	20	20
MERIEXN	28/01/2010	6.08	907		12.52	140	28.4	143	<0.1	<0.1	143	140	32	22	8.7	110	28			0.06	<0.01					1.7	8.5	9.1			94	94	41	41
MERIEXN	17/02/2011	8.33	745		4.79	49.9	23.9	117	<0.1	<0.1	117	130	29	19	8.7	110	24			0.27	0.03					2.1	8.8	10			84	84	70	70
MERIEXS	2/04/2009	8.18	774		8.06	45	22.7	140	2	2	140	110	34	20	7.4	92	23			0.77	0.35					2.3	10	12			6000	6000	560	560
MERIN1	21/12/2010	7.53	3,860		0.86	25.8	18.2	259	<0.1	<0.1	259	1100	120	150	60	580	29			0.03	0.06					0.34	0.06	0.06			<2	<2	<2	<2
MERIN1	17/02/2011	7.51	3,900		0.85	14.4	18.5	322	<0.1	<0.1	322	1100	110	150	62	570	25			0.04	0.05					0.54	0.08	0.08			<2	<2	<2	<2
MERIN1	5/10/2011	7.85	4,280		0.71	-162.1	17	298	<0.1	<0.1	298	1100	120	140	63	410	26			0.1	0.11					0.47	0.05	0.09			<2	<2	<2	<2
MERIN1	22/12/2011	7.49	3,770		1.17	-87.5	16.9	308	<0.1	<0.1	308	990	110	140	63	500	25			0.1	0.08					0.47	0.04	0.08			<2			<2
MERIN1	5/07/2012	7.55	3,180		1.04	-233.4	16.6	292	<0.1	<0.1	292	790	70	130	41	430	16			0.1	0.05					0.47	0.05	0.1			<2			<2
MERIN1	31/10/2012	7.57	1,998		1.67	-171.7	19.6	347	<0.1	<0.1	347	460	36	150	28	260	7.6			0.2	0.05					0.63	0.05	0.12			<2			<2
MERIN1	13/02/2013	7.45	2,925		1.18	-207.6	18.3	334	<0.1	<0.1	334	750	64	140	40	450	15			0.1	0.05					0.48	0.07	0.12			<2			<2
MERIN1	8/05/2013	7.56	2,975		1.07	-165.1	17.4	335	<0.1	<0.1	335	750	57	150	39	380	14			0.1	0.05					0.52	0.08	0.12			<2			<2
MERIN1	7/08/2013	7.54	2,960		0.8	-146.8	16.9	279	<0.1	<0.1	279	780	64	130	36	390	14			0.1	0.05					0.45	0.03	0.09			<2			<2
MERIN1	5/11/2013	7.47	2,579		1.14	-127.4	18.5	278	<0.1	<0.1	278	700	55	130	32	360	14			0.1	0.05					0.41	0.09	0.09			<2			<2
MERIN1	7/05/2014	7.03	2,252		1.21	-170	17.1	287	<0.1	<0.1	287	622	42.3	125	29.7	311	12.5			0.1	0.05					0.42	0.05	0.1			<2	<2	<2	<2
MERIN1	5/08/2014	7.43	1,942		1.19	-147.9	16.9	284	<0.1	<0.1	284	463	31.2	124	22.8	219	7.9			0.1	0.05					0.37	0.06	0.08			<1			<1
MERIN3	21/12/2010	7.47	13,800		1.78	120.5	17.1	255	<0.1	<0.1	255	4200	610	200	270	2500	97			0.01	0.71					1.1	0.09	0.09			<2	<2	<2	<2
MERIN3	17/02/2011	7.6	13,300		1.44	90.2	17.8	254	<0.1	<0.1	254	4200	600	180	280	2400	98			0.05	0.77					1.2	0.08	0.08			<2	<2	<2	<2
MERIN3	2/06/2011	7.64	12,070		1.31	76	17.2	259	<0.1	<0.1	259	3700	490	200	250	2200	92			<0.01	0.62					1	0.07	0.08			<2	<2	<2	<2
MERIN3	5/10/2011	7.78	11,030		1.54	71.4	17	267	<0.1	<0.1	267	3400	450	160	200	1500	98			<0.1	0.29					1.1	0.03	0.07			<2	<2	<2	<2
MERINBCH	17/02/2011																			0.05	0.01					0.21	0.01	0.01						
MERINBCH	2/06/2011	8.43	56,900		11.29	101.8	17.3													0.01	0.02					0.34	0.02	0.02						
MERINBCH	5/10/2011																			0.1	0.05					0.3	0.02	0.02						
MERINBCH	22/12/2011																			0.018	0.015					0.25	0.006	0.017						
MERINBCH	4/04/2012																			0.083	0.004					0.39	0.002	0.011						
MERINBCH	5/07/2012																			0.1	0.05					0.12	0.02	0.01						
MERINBCH	25/07/2012																																	
MERINBCH	31/10/2012																			0.018	0.002					0.24	0.003	0.009						
MERINBCH	13/02/2013																			0.011	0.002					0.21	0.002	0.01						
MERINBCH	8/05/2013																			0.1	0.05					0.25	0.02	0.01						
MERINBCH	7/08/2013																			0.1	0.05					0.22	0.03	0.03						
MERINBCH	5/11/2013																			0.1	0.05					0.32	0.02	0.01						

Appendix C. Groundwater Quality Data

Site	Date	pH	EC	DO (mg/L)	DO (% Sat)	Redox Potential	Temp	Bicarb	Carb	Hydrox	Total Alk	Chloride	Sulphate	Diss Calcium	Diss Mg	Dis Na	Dis K	Free Cl	Total Cl	Ammonia (N)	Nox (N)	Nitrate (N)	Nitrite (N)	Nitrate (NO3)	Organic N as N	Total Nitrogen	Phosphate	Total Phosphorous as P	Reactive Phosphorous	Orthophosphate as P	Faecal Coliforms	E. coli	Faecal Streptococci	Enterococci
Units			uS/cm	mg/L	%	mV	ºC	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	CFU/100mL
MERINBCH	5/02/2014																			0.1	0.05					0.17	0.03	0.03						
MERINBCH	7/05/2014																			0.1	0.05					0.33	0.02	0.01						
MERINBCH	5/08/2014																			0.1	0.05					0.31	0.02	0.01						
MERINBCH	5/11/2014																			0.04	0.284	0.284	0.002			0.59	0.005	0.013						
MERINBCH	19/02/2015																			0.031	0.155					0.58	0.003	0.007						
MERINBCH	21/05/2015																			0.011	0.06					0.13	0.004	0.005						
MERINBCH	6/08/2015																			0.021	0.064					0.18	0.003	0.012						
MERINBCH	26/11/2015																			0.008	0.007					0.15	0.004	0.01						
MERINBCH	25/02/2016																			0.012	0.012					0.17	0.005	0.006						
MERINBCH	2/06/2016																			0.016	0.034					0.16	0.012	0.012						
MERINBCH	25/08/2016																			0.009	0.009					0.09	0.008	0.011						
MERINBCH	16/11/2016																			0.016	0.002					0.11	0.004	0.007						
MERINBCH	15/02/2017																			0.01	0.002					0.1	0.003	0.005						
MERINBCH	24/05/2017																			0.021	0.041					0.15	0.007	0.01						
MERINBCH	16/08/2017																			0.005	0.025					0.17	0.008	0.006						
MERINBCH	14/12/2017																			0.018	0.002					0.12	0.002	0.003						
MERISBCH	17/02/2011																			0.06	0.01					0.15	0.01	0.01						
MWC1	14/10/2010	7.71	11,840			63	17.2					3800	530	160	250	2100	90					0.2	<0.05		0.3	0.42	0.07		13	0.05	<10			<2
MWC2	14/10/2010	7.61	18,980			67	17.3					6300	880	220	420	3500	160					0.25	<0.05		<0.1	0.47	0.08		21	0.07	<1			<1
MWN1	12/10/2010	7.48	6,410			73	17.8					1900	220	160	110	1100	61					0.15	<0.05		0.3	0.49	0.01		6	0.05	<2			48
MWN3	12/10/2010	7.31	26,710			96	17.4					8600	1300	270	610	5300	280					1.2	<0.05		<0.1	1.4	<0.01		31	0.09	<2			<2
NPW	14/10/2010	7.64	37,430			73	17.2					13000	1800	330	910	7800	430					0.95	-		<0.1	1	0.13		46	0.04	<1			<1
PF1	14/08/2005	6.4	570		34	-16	16.8	127			127	88	2.3	21	18	38	3.1			8.1	<0.01					8		0.17		0.01	1	1	2	0
PF2	14/08/2005	6.6	472		21.4	-68	16.7	94			94	90	<1.0	15	16	45	3.4			1.1	<0.01					1.5		0.52		0.01	5	5	15	15
PF3	14/08/2005	6.06	375		31	20	16.6	61			61	74	3.5	15	13	32	1.4			1	<0.01					1.8		0.29		<0.01	<5	na	20	5
PF4	14/08/2005	6.13	241		55	51	16.7	69			69	29	17	11	8.5	26	0.8			0.03	<0.01					0.78		0.73		0.01	19000	19000	80	80
PPK1	28/11/2001	7.35	866	1.19	12.1	-51	19.3				180	151	32	45	10	107	27					nd	0.2						0.1					
PPK1	20/02/2008	7.5	1,190		1.9	40	17.2	250	2	2	250	190	19	82	11	90	2.6			0.01	0.32					0.5	0.08	0.08			<2	<2	<2	<2
PPK1	13/05/2008	7.78	1,270		4.41	138	17.2	260	2	2	260	120	39	46	9.5	95	23			0.05	0.59					0.65	0.04	0.06			<2	<2	<2	<2
PPK1	19/06/2008	7.85	1,290		4.08	180	16.5	269	2	2	260	220	21	100	14	110	3.4			0.02	0.64					0.9	0.04	0.08			<2	<2	<2	<2
PPK1	28/08/2008	7.81	1,290		4.23	158	16.2	260	2	2	260	250	29	100	15	120	2.8			0.01	0.61					0.89	0.05	0.06			<2	<2	<2	<2
PPK1	16/12/2008	7.51	1,210		1.79	135	17.2	260	2	2	260	230	25	96	13	110	2.8			0.01	0.37					0.75		0.06			<2	<2	<2	<2
PPK1	2/04/2009	7.91	1,200		1.01	126	17	250	2	2	250	210	20	100	13	100	2.1			0.01	0.36					0.6	0.08	0.06			<2	<2	<2	<2
PPK1	2/07/2009	7.79	1,170		0.62	195	16.3	250	2	2	250	180	18	95	14	92	2.7			0.01	0.26					0.5	0.05	0.06			<2	<2	<2	<2
PPK1	28/01/2010																																	
PPK1	29/04/2010																																	
PPK1	29/07/2010	7.87	1,450		9.62	98.8	16.7	257	<0.1	<0.1	257	330	27	110	18	190	7.2			0.09	0.26					0.58	0.23	0.37			<2	<2	<2	<2
PPK1	21/12/2010	7.46	1,598		1.85	148.6	16.4	266	<0.1	<0.1	266	370	28	110	17	200	8.2			0.02	0.26					0.47	0.05	0.08			<2	<2	<2	<2
PPK1	17/02/2011	7.77	1,561		1.86	82.3	18.3	238	<0.1	<0.1	238	350	26	100	17	190	7.4			0.04	0.35					0.59	0.05	0.06			<2	<2	<2	<2
PPK1	2/06/2011																																	
PPK1	5/10/2011																																	
PPK1	21/12/2011																																	
PPK1	4/04/2012	7.71	1,580		2.53	56.2	18.4	247	<0.1	<0.1	247	350	26	110	17	200	7.6			0.019	0.35					0.57	0.037	0.061			<2	<2	<2	<2
PPK1	5/07/2012	7.74	1,574		3.3	56.6	16.3	244	<0.1	<0.1	244	340	27	100	16	180	6.8			0.1	0.45					0.69	0.04	0.06			<2			<2
PPK1	25/07/2012																																	
PPK1	31/10/2012	7.55	1,305		4.11	62.3	20	244	<0.1	<0.1	244	300	24	110	15	170	5.2			0.1	0.56					0.8	0.06	0.05			<2			<2
PPK1	13/02/2013	7.44	1,527		2.18	46	21.3	247	<0.1	<0.1	247	340	26	100	17	190	6.3			0.1	0.29					0.47	0.04	0.05			<2			<2
PPK1	8/05/2013	7.65	1,743		1.65	-12.9	17.2	243	<0.1	<0.1	243	400	32	100	18	210	8.1			0.1	0.16					0.38	0.04	0.05			<2			<2
PPK1	7/08/2013	7.79	1,815		1.92	-67.2	17.5	251	<0.1	<0.1	251	420	31	110	19	210	7.7			0.1	0.38					0.63	0.03	0.05			<2			<2
PPK1	5/11/2013	7.53	1,681		1.95	8.6	20.5	240	<0.1	<0.1	240	420	30	110	19	210	8.5			0.1	0.35					0.49	0.09	0.05			<2			<2
PPK1	5/02/2014	7.4	1,629		1.79	57.6	17.2	241	<0.1	<0.1	241	399	29.4	101	17.3	197	7.2			0.1	0.28					0.52	0.05	0.05			<2			<2
PPK1	7/05/2014	7.21	2,022		2.23	-51.5	17.4	246	<0.1	<0.1	246	494	38.1	106	21.5	257	9.4			0.1	0.09					0.33	0.05	0.05			<5	<5	<2	<2
PPK1	5/08/2014	7.56	1,852		1.3	-92.3	16.5	250	<0.1	<0.1	250	442	31.4	104	19.9	216	7.9			0.1	0.08					0.3	0.06	0.05			<1			<1
PPK1	5/11/2014	7.51	1,654		1.77	-47.5	16.9	244	<0.1	<0.1	244	373	28.6	97.4	17.2	194	6.8			0.1	0.16	0.13	0.04			0.38	0.09	0.04			<1			<1
PPK1	19/02/2015	7.92	1,551		1.81	0.9	19.4	253	<0.1	<0.1	253	363	27.6	102	17.4	190	6.9			0.1	0.19	0.19	0.01			0.45	0.06	0.05			<1			<1
PPK1	21/05/2015	7.36	1,753		2	-85.7	16.7	259	<0.1	<0.1	259	412	29.7	106	18	218	7.7	<0.03	<0.03	0.1	0.14	0.14	0.01			0.36	0.04	0.05			<2			<2
PPK1	6/08/2015	7.48	1,541		6.1	-82.6	15.6	280	<0.1	<0.1	280	340	26.3	105	16.5	166	5.9		<0.03	0.1	0.18	0.18	0.01			0.46	0.02	0.104			<2			<2
PPK1	26/11/2015	7.45	1,492		2.74	-35.5	18.1	260	<0.1	<0.1	260	307	25.5	103	15.2	176	5.7	<0.03	<0.03	0.1	0.31	0.29	0.02			0.59	0.04	0.04			<2			<2
PPK1	25/02/2016	7.33	1,342		3.31	-9.8	21	265	<0.1	<0.1	265	297	26.2	96.6	14.4	157	5.8	<0.03	<0.03	0.1	0.23	0.23	0.01			0.48	0.08	0.06			<2			<2
PPK1	2/06/2016	7.17	1,469		2.67	21.4	16.5	264	<0.1	<0.1	264	284	23.2	101	14.3	153	6.1	<0.03	<0.03	0.1	0.24	0.23	0.01			0.48	0.04	0.05			<2			<2
PPK1	25/08/2016	7.27	1,312		2.72	-3.6	15.8	268	<0.1	<0.1	268	234	22.4	94.6	13.2	122	4.7	<0.03	<0.03	0.1	0.23	0.21	0.02			0.45	0.03	0.05			<2			<2
PPK1	16/11/2016	7.36	1,286		2.17	24.5	17.5	287	<0.1	<0.1	287	265	24.1	99.4	13.8	142	5.2	<0.03	<0.03	0.1	0.15	0.13	0.02			0.37	0.05	0.05			<2			<2
PPK1	15/02/2017	7.24	1,375		2.55	57	18.8	287	<0.1	<0.1	287	292	24.9	106	15.6	188	5.3	<0.03	<0.03	0.1	0.32	0.3	0.01			0.57	0.05	0.04			<2			<2
PPK1	14/03/2017	7.82	1,610		0.29	-122	16.6	328	<0.1	<0.1	328	189	15.6	121	19.6	206	5.6	<0.03	<0.03	0.1	0.05	0.05	0.01			0.29	0.03	0.07			<2	<2		<2
PPK1	24/05/2017	7.5	1,525		1.56	-52.5	16.4	306	<0.1	<0.1	306	244	17.3	105	16.3	177	5	<0.03	<0.03	0.1	0.05	0.05	0.01			0.31	0.04	0.07			<2	<2		<2
PPK1	16/08/2017	8.01	1,543		1.96	-40.5	16.6	333	<0.1	<0.1	333	318	22.2	121	17.3	183	4.5	<0.03	<0.03	0.1	0.05	0.05	0.01			0.31	0.05	0.08			<2	<2		<2
PPK1	14/12/2017	7.86	1,580		1.03	-82.9	16.8	325	<0.1	<0.1	325	350	31.2	115	17.4	190	4.6	<0.03	<0.03	0.1	0.05	0.05	0.01			0.33	0.04	0.08			40	40		6
PPK1	14/06/2018	7.86	1,810		1.3	-83.8	16.3	277	<0.1	<0.1	277	415	29	120	21.7	223	8	<0.03	<0.03	0.1	0.05	0.05	0.01			0.29	0.05	0.07			<2	<2		<2
PPK1	13/09/2018	7.9	1,950		1.05	-112.4	17.3	309	<0.1	<0.1	309	449	32.3	116	21.4	234	8.6	<0.03	<0.03	0.2	0.05	0.05	0.01			0.26	0.06	0.06			<2	<2		<2
PPK1	11/12/2018	7.87	2,090		1.07	-143.9	17.1	331	<0.1	<0.1	331	455	35	129	24.8	290	7.6	<0.03	<0.03	0.3	0.05	0.05	0.01			0.31	0.04	0.05			<2	<2		<2
PPK1	15/03/2019	7.63	2,100		2.85	-42.9	16.9	247	<0.1	<0.1	247	471	36.4	116	20.3	279	7.4			0.1	0.05	0.05	0.01			0.24	0.02	0.04			<2	<1		<2
PPK1	20/06/2019	7.59	2,320		5.01	-24.8	16.2	283	<0.1	<0.1	283									0.1	0.05	0.05	0.01			0.25	0.02	0.04			<1	<1		<1
PPK1	11/09/2019	7.64	2,580		1.75	-52.8	17	259	<0.1	<0.1	259									0.1	0.09	0.09	0.01			0.34	0.02	0.04			<1	<1		<1
PPK2	29/04/2010	7.46	2,580		3.93	295.1	17	284	<0.1	<0.1	284	670	96	95	38	410	25			0.02	0.84					1.7	0.07	0.09			<2	<2	<2	<2
PPK2	29/07/2010	7.56	1,180		1.58	-48.2	16.8	253	<0.1	<0.1	253	220	32	84	19	150	6.1			<0.01	0.21					0.58	0.05	0.07			<2	<2	<2	<2
PPK2	2/06/2011	7.88	1,131		0.78	66.2	16.7	242	<0.1	<0.1	242	200	30	91	15	140	6.4			<0.01	0.09					0.5	0.06	0.07			<2	<2	<2	<2
PPK2	5/10/2011	7.99	1,360		2.39	65.5	16.3	250	<0.1	<0.1	250	260	41	96	17	160	6.5			<0.1	1.7					2.1	0.08	0.07			<2	<2	<2	<2
PPK2	21/12/2011	7.66	1,166		1.19	51.9	16.7	241	<0.1	<0.1	241	210	36	84	15	150	6.2			<0.1	0.13					0.58	0.05	0.07			<2	<2	<2	<2
PPK2	7/05/2014	7.22	1,839		4.62	71.4	16.5	279	<0.1	<0.1	279	402	61	94.4	26.3	234	9.2			0.1	1.29					1.69	0.06	0.07			<2	<1	<2	<2
PPK3	16/12/2004	7.74	994		21.9	77	16.1	204			204	180	27	61	15	120	16			0.21	0.28					1.1	0.53	0.67			0	0	0	0
PPK3	15/08/2005	7.68	634		38	64	15.8	163	2	2	163	120	28	44	12	71	15			0.67	0.13					1.2	0.91	1.2			2	2	2	2
PPK3	21/12/2005	7.9	990		na	na	na	190	2	2	190	180	35	56	13	81	11			0.7	0.63					1.5	0.82	0.92			4	4	na	42000
PPK3	1/02/2006	8.1	990		na	na	na	190	2	2	190	120	33	49	11	92	12			0.78	0.38					1.6	0.97	1.1			2	2	2	2
PPK3	18/05/2006	8.25	825		0.41	20	17.4	160	2	2	160	120	38	42	9.2	94	12			0.57	1.1					2.2	1.5	1.5			2	2	2	2
PPK3	13/12/2006	7.3	990		2.56	125	16.9	190	2	2	190	150	41	60	11	110	19			0.3	0.71					1.4	1.2	1.4			2	2	2	2
PPK3	7/03/2007	7.16	788		0.37	72	18.3	170	2	2	170	120	36	39	7.7	95	17			0.3	0.17					0.9	1.7	1.8			2	2	1200	1200
PPK3	6/06/2007	7.44	848		0.68	98	17.4	150	2	2	150	96	52	34	7.1	92	19			0.4	0.9					1.8	3.6	4			2	2	0	0
PPK3	10/12/2007	8	779		0.9	67	17.4	150	2	2	150	95	52	25	6.8	80	19			0.66	0.06					0.99	2.6	2.8			2	2	2	2

Appendix C. Groundwater Quality Data

Site	Date	pH	EC	DO (mg/L)	DO (% Sat)	Redox Potential	Temp	Bicarb	Carb	Hydrox	Total Alk	Chloride	Sulphate	Diss Calcium	Diss Mg	Dis Na	Dis K	Free Cl	Total Cl	Ammonia (N)	Nox (N)	Nitrate (N)	Nitrite (N)	Nitrate (NO3)	Organic N as N	Total Nitrogen	Phosphate	Total Phosphorous as P	Reactive Phosphorous	Orthophosphate as P	Faecal Coliforms	E. coli	Faecal Streptococci	Enterococci
Units			uS/cm	mg/L	%	mV	°C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	CFU/100mL	CFU/100mL	CFU/100mL	CFU/100mL
PPK3	20/02/2008	7.85	774		0.72	42	18.3	190	2	2	190	110	37	35	7.3	84	21			0.52	0.04					0.75	3.8	3.9			2	2	2	2
PPK3	13/05/2008	8.06	867		1	-10	18.2	190	2	2	190	230	20	110	15	100	3.5			0.32	0.08					0.67	4.2	4.4			<2	<2	<2	<2
PPK3	19/06/2008	8.21	778		0.84	89	17.5	180	2	2	180	100	36	38	8.9	93	21			0.42	0.05					0.75	3.8	4			<2	<2	<2	<2
PPK3	28/08/2008	8.14	769		0.99	175	18	170	2	2	170	110	47	38	8.1	89	19			0.42	0.02					0.72	4.8	4.8			<2	<2	<2	<2
PPK3	16/12/2008	7.92	756		0.76	193	17.9	170	2	2	170	100	46	39	8.7	86	21			0.5	0.06					1		4.2			<2	<2	<2	<2
PPK3	2/04/2009	8.26	1,230		0.38	125	18.7	150	2	2	150	250	43	46	14	140	27			0.92	0.03					1.4	3.4	3.7			<2	<2	<2	<2
PPK3	2/07/2009	8.25	1,060		0.47	216	17.7	170	2	2	170	180	51	37	12	130	23			0.8	0.19					1.5	5.1	5.4			<2	<2	<2	<2
PPK3	28/01/2010	8.1	799		0.66	-81	18.9	176	<0.1	<0.1	176	110	35	30	8.3	99	20			0.97	<0.01					1.5	6.4	6.3			<2	<2	12	12
PPK3	29/04/2010	7.98	712		0.63	47.1	19.1	168	<0.1	<0.1	168	130	21	25	5.4	120	21			1.2	0.04					1.8	5.8	5.9			<2	<2	<2	<2
PPK3	29/07/2010	8.02	950		1.18	-82.1	17.6	172	<0.1	<0.1	172	160	49	44	12	140	19			0.5	0.25					1.2	5.3	5.4			2	2	<2	<2
PPK3	21/12/2010	8.15	820		0.65	26.2	17.9	173	<0.1	<0.1	173	130	41	33	9.3	110	26			0.81	0.02					1.3	5.6	6			<2	<2	6	6
PPK3	17/02/2011	8.1	767		0.64	13.9	19.2	149	<0.1	<0.1	149	110	33	33	8.9	97	22			0.35	2.4					3.3	6	6.4			<2	<2	<2	<2
PPK3	2/06/2011	8.38	701		0.39	-14.8	18.5	138	<0.1	<0.1	138	110	29	32	8.9	100	23			0.18	0.64					1.4	5.8	5.9			<2	<2	<2	<2
PPK3	5/10/2011	8.34	828		1	54.3	18.4	158	<0.1	<0.1	158	140	31	37	9.3	110	21			0.2	0.2					0.72	5.7	6.1			<2	<2	<2	<2
PPK3	21/12/2011	7.68	791		0.8	-0.8	18.6	179	<0.1	<0.1	179	120	28	40	10	100	26			0.2	0.1					0.81	5.8	6.1			<2	<2	<2	<2
PPK3	4/04/2012	8.05	820		0.92	21.9	19.1	173	<0.1	<0.1	173	120	39	38	11	110	23			0.69	0.34					1.4	4.3	6			<2	<2	<2	<2
PPK3	25/07/2012	8.03	827		1.33	64.5	18.8	158	<0.1	<0.1	158	140	33	39	9.6	100	22			0.7	0.45					1.6	6.4	6.8			<2	<2	<2	<2
PPK3	31/10/2012	7.82	959		1.16	-52.3	21	187	<0.1	<0.1	187	180	35	49	12	130	23			0.9	0.11					1.5	6	6.2			<2			<2
PPK3	13/02/2013	7.85	918		1.07	-49.3	18.8	189	<0.1	<0.1	189	170	34	49	11	130	20			0.6	0.05					1	5.9	6.1			<2			<2
PPK3	8/05/2013	8.12	890		1.42	-75.6	18.1	184	<0.1	<0.1	184	150	32	40	9.5	120	21			1.2	0.07					1.8	6.4	6.8			<2			<2
PPK3	7/08/2013	8.04	824		1.25	-56.4	16.7	192	<0.1	<0.1	192	120	26	41	10	94	19			0.7	0.05					1.2	5.9	6.4			<2			<2
PPK3	5/11/2013	7.94	714		1.01	-29	19.6	163	<0.1	<0.1	163	110	26	32	9.3	98	22			0.7	0.05					1.3	6.4	6.6			<2			<2
PPK3	5/02/2014	7.66	790		2.34	64.9	18.3	179	<0.1	<0.1	179	126	26.3	37.4	9.09	98.5	19.2			0.8	0.11					1.4	7.29	7.77			<2			<2
PPK3	7/05/2014	7.6	830		2.24	9.2	17.5	173	<0.1	<0.1	173	129	31.2	39.7	9.71	103	21.4			0.9	0.1					1.42	6.34	7.07			<2	<2	<2	<2
PPK3	5/08/2014	7.7	976		2.09	13.3	16.5	216	<0.1	<0.1	216	151	33.7	58.3	11.5	105	18.4			0.9	0.26					1.49	6.04	6.3			<1			<1
PPK3	5/11/2014	7.94	1,012		1.08	-46	17.2	250	<0.1	<0.1	250	150	31.7	56.3	16	110	20.5			1	0.05	0.05	0.01			1.54	5.61	6.01			<1			<1
PPK3	19/02/2015	8.32	979		1.74	5.2	18.4	208	<0.1	<0.1	208	156	36.2	53.3	10.9	110	22			0.8	0.08	0.08	0.01			1.25	6.56	6.91			<1			2
PPK3	21/05/2015	7.72	940		1.49	-28.9	17.4	195	<0.1	<0.1	195	150	33.3	46.3	9.41	120	21.8	<0.03	<0.03	0.8	0.1	0.1	0.01			1.29	7.07	7.75			<2			<2
PPK3	6/08/2015	7.87	898		2.16	-31.2	16.2	193	<0.1	<0.1	193	140	29.6	43.8	9.07	98.2	21.3		<0.03	1	0.05	0.05	0.01			1.48	6.3	7.92			<2			<2
PPK3	26/11/2015	7.93	855		2.51	-11.7	19.3	196	<0.1	<0.1	196	124	26.5	51	10.4	96.1	18.9	<0.03	<0.03	0.9	0.46	0.46	0.01			1.75	6.69	6.89			2			28
PPK3	25/02/2016	7.79	950		3.52	105.9	19	193	<0.1	<0.1	193	152	34.5	49.8	10.6	112	20.8	<0.03	<0.03	0.5	0.68	0.68	0.01			1.73	6.28	7.45			<2			<2
PPK3	2/06/2016	7.55	943		3.93	78.3	17.4	171	<0.1	<0.1	171	133	33.1	44.6	10	89.6	21.6	<0.03	<0.03	0.5	0.07	0.07	0.01			1.22	6.93	6.74			<2			2
PPK3	25/08/2016	7.62	986		2.94	67.1	16.7	218	<0.1	<0.1	218	144	30.4	58.5	11	92	21.5	<0.03	<0.03	0.7	0.35	0.35	0.01			1.44	5.89	6.08			<2			<2
PPK3	16/11/2016	7.84	898		2.33	34.1	18.6	203	<0.1	<0.1	203	137	31.6	56.3	11.9	92.4	24.7	0.03	0.04	1	0.14	0.14	0.01			1.59	5.69	5.9			<2			<2
PPK3	16/08/2017	8.28	912		1.38	-23.5	17.3	222	<0.1	<0.1	222	142	31.3	59.5	9.73	112	17.8	<0.03	<0.03	1.5	0.05	0.05	0.01			1.94	5.18	5.23			<2	<2		<2
PPK3	14/12/2017	7.96	954		1.15	-66.9	17.6	239	<0.1	<0.1	239	164	24.6	60	10.8	119	21.1	<0.03	<0.03	2.4	0.05	0.05	0.01			2.8	5.38	5.43			259	259		<2
PPK3	14/03/2018	7.92	921		0.99	5.2	17.9	244	<0.1	<0.1	244	127	17.4	58.4	11.8	119	19.1	<0.03	<0.03	1.8	0.05	0.05	0.01			2.21	5.67	6.03			<2	<2		<2
PPK3	14/06/2018	7.94	1,010		0.78	-17.9	17.4	178	<0.1	<0.1	178	205	31.9	53.2	10.4	124	19.8	<0.03	<0.03	0.8	0.05	0.05	0.01			1.39	5.67	5.77			<2	<2		<2
PPK3	13/09/2018	8.02	1,030		0.93	-17.3	17.5	189	<0.1	<0.1	189	199	34.2	46.4	10	124	20.5	<0.03	<0.03	1.5	0.05	0.05	0.01			1.52	5.27	5.93			<2	<2		<2
PPK3	11/12/2018	7.99	1,170		1.04	-4.1	17.8	201	<0.1	<0.1	201	198	39.9	56.3	10.6	160	22.7	<0.03	<0.03	1.1	0.11	0.11	<0.01			1.49	5.43	6.37			<2	<2		<2
PPK3	15/03/2019	7.85	1,190		1.34	0	18.1	150	<0.1	<0.1	150	242	48.9	49.8	10.2	173	21.7			1.4	0.05	0.05	0.01			1.32	7.2	7.36			<2	<1		<2
PPK3	20/06/2019	7.92	1,270		1.5	10.4	17.2	163	<0.1	<0.1	163									0.9	<0.05	<0.05	<0.01			1.4	6.18	7.11			<1	<1		<1
PPK3	11/09/2019	7.9	1,240		1.32	26	17.7	151	<0.1	<0.1	151									0.9	<0.05	<0.05	<0.01			1.33	6.96	7.18			<1	<1		<1
PPK4	28/11/2001	7.12	909	2.63	27.8	1	18.7				242	147	16	100	15	70	5					0.34	rid						0.04					
PPK4	6/06/2007	7.41	852		0.31	-62	16.8	170	2	2	170	110	29	37	8.3	94	14			0.52	0.02					0.97	0.16	0.21			2	2	2	2
PPK4	28/08/2008	8.04	766		0.73	12	16.7	180	2	2	180	110	39	43	7.3	87	17			0.41	0.08					0.86	0.14	0.14			<2	<2	<2	<2
PPK4	16/12/2008	7.72	924		0.85	1	17	210	2	2	210	150	36	62	8.9	96	16			0.19	0.11					0.76		0.15			<2	<2	<2	<2
PPK4	29/07/2010	8.05	830		1.11	-228.1	17.4	206	<0.1	<0.1	206	120	26	41	8	120	22			2	0.03					2.5	0.22	0.26			2	2	<2	<2
PPK4	17/02/2011	8.09	729		0.57	-154.9	18.5	169	<0.1	<0.1	169	110	34	32	7.8	99	19			2.1	<0.01					2.6	0.64	0.69			<2	<2	<2	<2
PPK4	2/06/2011	8.13	813		0.51	-155.7	18.2	177	<0.1	<0.1	177	120	40	44	8.5	110	21			1.7	0.1					2.4	0.41	0.44			<2	<2	<2	<2
PPK4	21/12/2011	7.95	751		0.82	-154.9	18	160	<0.1	<0.1	160	110	35	35	8.1	98	22			1.3	0.13					1.9	0.89	0.95			<2	<2	<2	<2
PPK4	5/07/2012	8.14	794		0.81	-179.8	17.3	164	<0.1	<0.1	164	130	26	32	8.5	100	21			1	<0.05					1.5	0.96	1.1			<2			<2
PPK4	31/10/2012	7.66	908		1.44	-145.9	19.2	192	<0.1	<0.1	192	160	28	49	10	120	21			0.5	0.06					1	1.3	1.4			<2			<2
PPK4	8/05/2013	8.09	838		1.13	-172.2	17.9	162	<0.1	<0.1	162	150	35	36	9.8	110	24			0.4	0.05					0.94	1.8	1.9			<2			<2
PPK4	7/08/2013	8	818		1.37	-121.3	16.6	153	<0.1	<0.1	153	140	33	33	9.1	100	21			0.5	0.05					0.97	1.5	1.6			<2			<2
PPK4	5/11/2013	7.53	940		2.1	-114.9	20.1	178	<0.1	<0.1	178	170	34	49	11	120	23			0.4	0.05					0.86	1.3	1.5			<2			<2
PPK4	5/02/2014	7.51	694		0.99	-113.3	17.5	156	<0.1	<0.1	156	104	24.4	28.2	7.31	87.8	17.5			0.4	0.05					0.93	2.02	2.17			<2			<2
PPK4	7/05/2014	7.43	702		1.28	-102.1	17.5	162	<0.1	<0.1	162	101	24	35.1	7.76	87.3	17.8			0.4	0.05					0.85	1.76	1.94			<2	<2	<2	<2
PPK4	5/08/2014	7.65	705		1.22	-122.7	16.6	172	<0.1	<0.1	172	101	22.7	38.8	8.14	77.7	15.7			0.4	0.05					0.72	1.48	1.64			<1			<1
PPK4	5/11/2014	7.77	962		1.44	-119.6	17	194	<0.1	<0.1	194	166	29.9	52.7	11.9	112	14.9			0.3	0.05	0.05	0.01			0.66	1.23	1.26			<1			<1
PPK4	19/02/2015	8.31	842		0.74	-111.7	17.9	197	<0.1	<0.1	197	121	32.9	43.1	10.8	97.3	19.4			1	0.06	0.06	0.01			1.47	2.13	2.24			<1			<1
PPK4	21/05/2015	7.85	863		1.68	-153.6	17.1	177	<0.1	<0.1	177	139	32.2	41.2	10.2	107	20.9	<0.03	<0.03	0.8	0.05	0.05	0.01			1.36	2.1	2.23			<2			<2
PPK4	6/08/2015	7.97	856		3.75	-112.4	16	172	<0.1	<0.1	172	147	34.2	38.1	9.87	96.7	19.6		<0.03	0.7	0.05	0.05	0.01			1.33	1.79	2.07			<2			<2
PPK4	26/11/2015	7.97	823		0.88	-163.2	17.6	174	<0.1	<0.1	174	141	34	39.6	9.39	99	17.9	<0.03	<0.03	0.7	0.06	0.06	0.01			1.1	2.28	2.28			<2			<2
PPK4	25/02/2016	7.77	688		1.02	-94.6	18.1	157	<0.1	<0.1	157	103	25.5	32.4	7.91	83	19	<0.03	<0.03	0.8	0.2	0.18	0.02			1.38	2.84	2.88			<2			<2
PPK4	2/06/2016	7.36	885		1.61	-24.3	17.1	182	<0.1	<0.1	182	137	29.6	55.9	9.68	83.5	16.5	<0.03	<0.03	0.4	0.23	0.21	0.02			1.02	1.53	1.55			<2			<2
PPK4	25/08/2016	7.75	832		1.9	-38.4	16.2	175	<0.1	<0.1	175	121	27.1	37.6	9.2	88	20	<0.03	<0.03	0.9	0.09	0.09	0.01			1.41	2.36	2.46			<2			<2
PPK4	16/11/2016	7.77	900		2.11	-9.4	17	190	<0.1	<0.1	190	148	30.4	43.4	10.6	106	22	<0.03	<0.03	0.9	0.05	0.05	0.01			1.26	1.79	1.83			<2			<2
PPK4	15/02/2017	7.77	883		1.28	-70.9	18.2	203	<0.1	<0.1	203	154	31.1	50	11	125	19.1	<0.03	<0.03	0.8	0.05	0.05	0.01			1.23	2.19	2.28			<2			<2
PPK4	24/05/2017	7.74	926		1.89	-51.6	16.5	220	<0.1	<0.1	220	117	23.4	50.4	11.3	115	21.1	<0.03	<0.03	0.9	0.05	0.05	0.01			1.24	2.16	2.27			<2	<2		<2
SW3	28/11/2001	6.22	221	3.31	36.4	96	21.7				3	62	3	3	5	26	4					nd	0.02						nd					
SW4	28/11/2001	6.54	274	0.74	9.4	85	15.9				27	64	2	7	5	20	25					nd	0.06						nd					