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

Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall

Appendix J

Human Health Risk Assessment

Appendix J

Human Health Risk Assessment

Client: Bega Valley Shire Council

ABN: 26 987 935 332

Prepared by

AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com
ABN 20 093 846 925

May 2021

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Executive summary

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 on Arthur Kaine Drive, 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.

The aim of this technical report is to assess the potential risks to human health associated with the Project, and in doing so address the relevant Secretary's Environmental Assessment Requirements (SEARs) issued for the Project by the NSW Department of Planning, Industry and Environment. The assessment includes a qualitative Human Health Risk Assessment (HHRA) of the potential risk to human health associated with the discharge and beneficial re-use of treated wastewater under current (pre-upgrade) and post-upgrade conditions.

The assessment of potential human health risks associated with Project has been conducted in accordance with the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks* (NHMRC, 2006). This document outlines a qualitative HHRA approach and is considered appropriate as the framework for undertaking the HHRA for this Project. The assessment has also considered *Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards* (enHealth, 2012a), *Australian Exposure Factor Guide* (enHealth, 2012b) and *Health Impact Assessment: A Practical Guide* (NSW Health, 2007).

To facilitate preparation of the HHRA, a conceptual site model (CSM) was prepared based on the available information to identify the potential hazards, the potential migration pathways and the key receptors. Based on the pre and post-upgrade treated wastewater use, the receptors qualitatively assessed included recreational users of the Merimbula Beach / Bay, recreational users of the PMGC, landscape workers at the golf course involved in irrigation activities and agricultural workers of the Oaklands agricultural area who may directly or indirectly contact treated wastewater during irrigation activities.

Wastewater from the upgraded STP would be treated to a higher standard than the existing situation; with wastewater discharged via a new ocean outfall at a distance from the beach. The assessment of potential impacts of the pre- and post- STP upgrade scenarios indicate that the upgrades proposed as part of the Project are expected to result in improved wastewater quality. Hydrodynamic dispersion modelling demonstrates that the overall risk of impact to water quality is low when compared to the existing discharge at the beach-face outfall, and would improve the amenity of the beach with regards to water quality. Based on the available information, it is considered that the human health risk associated with the beneficial re-use of treated wastewater would be lower in post-upgrade conditions when compared with current (pre-upgrade) conditions.

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).

This Human Health Risk Assessment (HHRA) has been prepared to assess the risk to human health from the Project.

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 an ocean outfall offshore in Merimbula Bay.

The Project is described in further detail in **Section 2.0**, and an overview of the Project area is provided in **Figure 2-1**. A full Project description is provided in the EIS in **Chapter 2 Project description**.

1.2 Purpose of this technical report

This HHRA is one of a number of technical documents that forms part of the EIS. The aim of this technical report is to address the relevant Secretary's Environmental Assessment Requirements (SEARs) provided by the NSW Department of Planning Industry and Environment (DPIE) (Application number SS1 7614).

In order to address the relevant SEARs, a qualitative HHRA has been undertaken to assess potential risk to human health associated with re-use of treated wastewater under current (pre-upgrade) and post-upgrade conditions and to develop mitigation measures where necessary.

1.2.1 Secretary's environmental assessment requirements

Table 1-1 sets out the requirements as provided in the SEARs relevant to the HHRA.

Table 1-1 Secretary's Environmental Assessment Requirements - Health and safety

Secretary's Environmental Assessment Requirements	Where addressed in this report
3. Health and safety	
1. The Proponent must assess any change to the risk to human health and identify mitigation and management measures to ensure appropriate standards are met.	**Section 4.0** to **Section 9.0**.

1.2.2 Structure of this report

This report is structured as follows:

- **Section 1.0**: Introduction – provides an overview of the Project and this report.
- **Section 2.0**: Project description – provides a description of the Project.
- **Section 3.0**: Methodology – outlines the relevant guidelines, study area and methodology used for the assessment.

- **Section 4.0**: Stage 1 - Issue identification – outlines the process of planning and scoping the risk assessment and issue identification.
- **Section 5.0**: Site background and environmental setting – provides an overview of the site background and environmental setting.
- **Section 6.0**: Stage 2 - Data collection and evaluation – outlines the data collection and evaluation process, followed by a description of the conceptual site model (CSM) and identification of the chemicals of potential concern (CoPC).
- **Section 7.0**: Stage 3 - Exposure assessment – presents the exposure assessment, which is the process of estimating the magnitude, frequency, extent and duration of human exposure to the CoPC.
- **Section 8.0**: Stage 4 - Hazard assessment – provides the hazard assessment and describes the health effects associated with exposure to the CoPCs.
- **Section 9.0**: Stage 5 - Risk characterisation – provides a risk characterisation summary and includes risk mitigation recommendations.
- **Section 10.0**: Conclusion – provides a conclusion to 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 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**.

The 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

<table>
<tr><th>Project element</th><th>Summary</th></tr>
<tr><td></td><td>the pipeline would contain valves along its length for mitigating against air entrapment.</td></tr>
<tr><td>Existing exfiltration ponds</td><td>The existing exfiltration ponds within the adjacent sand dunes (east of the STP site) would cease to be used under the Project.</td></tr>
<tr><td>Existing beach-face outfall</td><td>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).</td></tr>
<tr><td>Water use</td><td>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.</td></tr>
<tr><th colspan="2">Construction</th></tr>
<tr><td>Construction footprint</td><td>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 47m^2 at the existing beach face outfall pipeline (to be decommissioned).</td></tr>
<tr><td>Construction timing, hours and workforce</td><td>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.</td></tr>
<tr><td>Traffic, construction vehicle types and</td><td>Construction traffic would indicatively comprise:
5 to 10 heavy vehicles per day (e.g. truck and dogs); and</td></tr>
</table>

Project element	Summary
workforce	• 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 from 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

Legend

Project area

Project area (temporary construction area)

N

0 500 1,000 m

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

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

Source: Nearmap, 2019

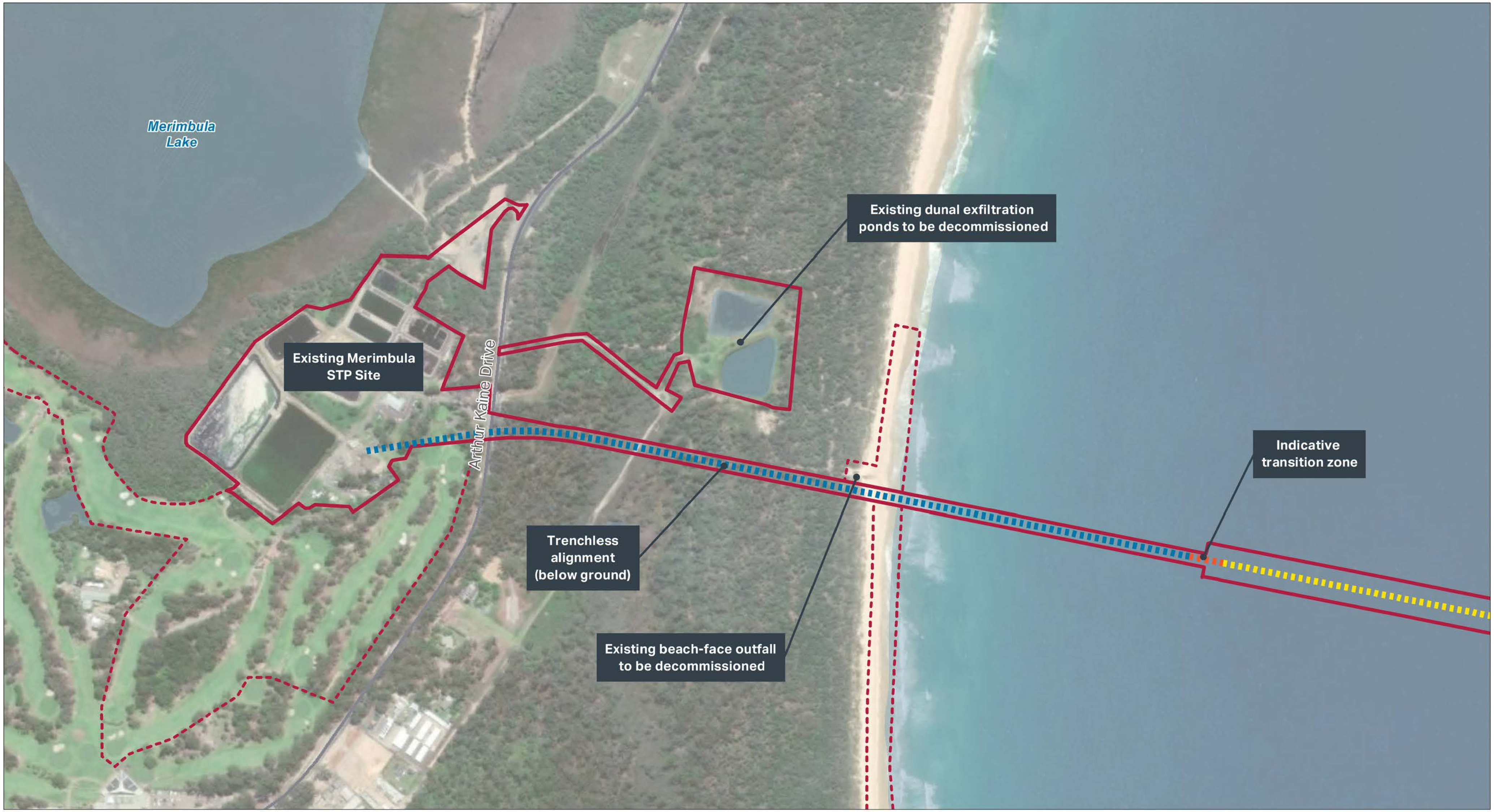

FIGURE 2-3: OCEAN OUTFALL PIPELINE - SECTION 1 (BELOW GROUND)

N
0 100 200 m

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

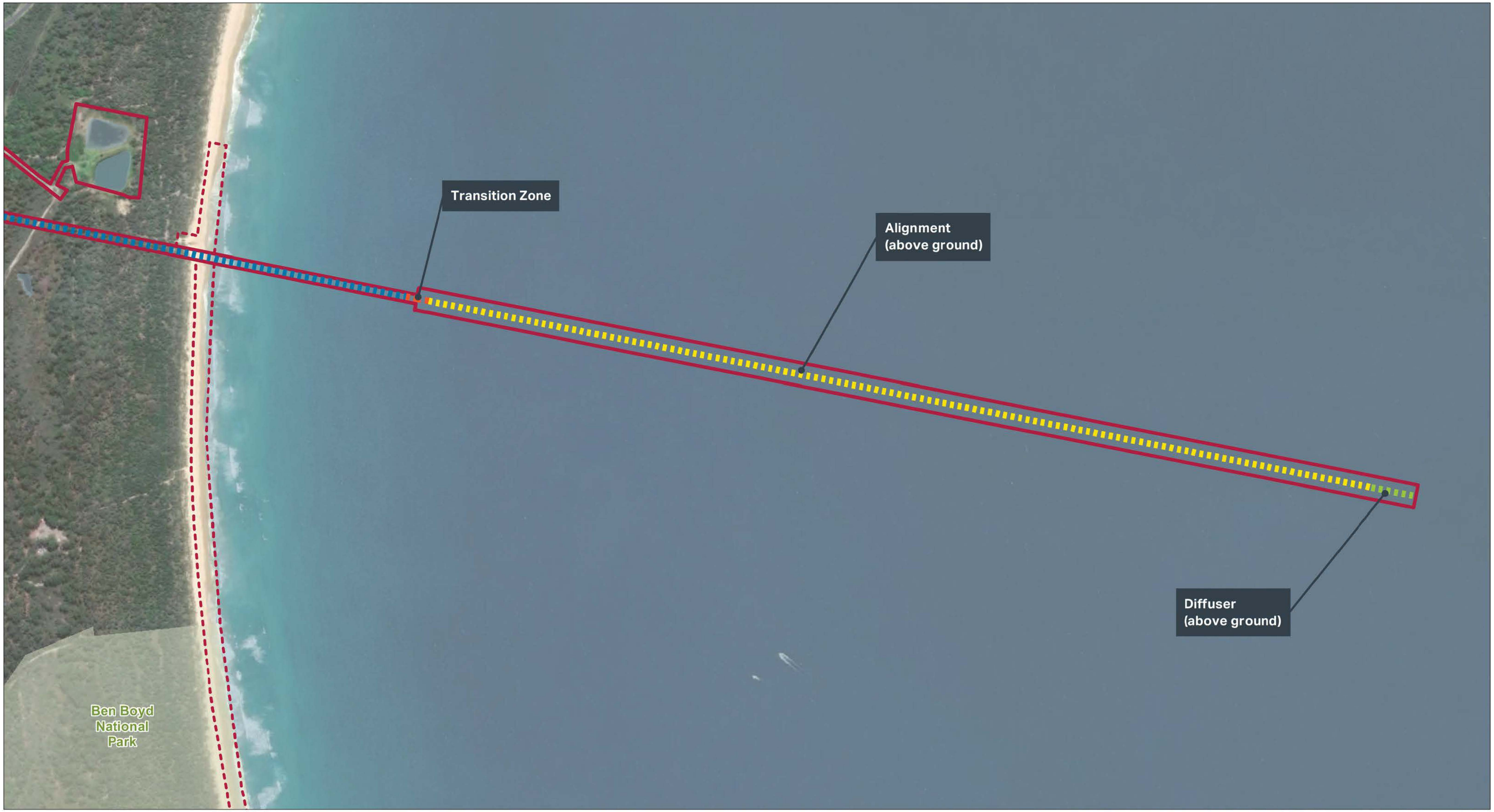

FIGURE 2-4 : OCEAN OUTFALL PIPELINE – SECTION 2 (ABOVE SEAFLOOR)

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

N
0 300 600 m

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

3.0 Methodology

3.1 Relevant guidelines

This HHRA was undertaken in general accordance with the following protocols and guidance:

- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks* (NHMRC, 2006): This document outlines a qualitative HHRA approach and is considered appropriate as the framework for undertaking the HHRA for this Project;
- *Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards* (enHealth, 2012a);
- *Australian Exposure Factor Guide* (enHealth, 2012b); and
- *Health Impact Assessment: A Practical Guide* (NSW Health, 2007).

In addition to the above guidelines, BVSC's Recycled Water Management System (RWMS) (2019) follows the qualitative risk assessment process outlined in NHMRC (2006) and provides a comprehensive basis for assessing risk to human health associated with re-use of treated wastewater under current (pre-upgrade) conditions. It is to be noted that the *Methodology for Valuing the Health Impacts of Changes in Particle Emissions* (EPA, 2013) referenced in the SEARs is not considered relevant to this HHRA as air quality impacts have not been assessed herein.

3.2 Study area

The study area for the assessment of human health impacts includes the Project Area, Merimbula Beach and Bay, the PMGC grounds and the Oaklands agricultural area, which are shown on **Figure 3-1**.

FIGURE 3-1: STUDY AREA INCLUDING LOCATION OF EXISTING BENEFICIAL RE-USE SITES

N 0 500 1,000 m

AECOM

Legend

- Project area
- Project area (temporary construction area)
- Beneficial re-use site
- Existing treated wastewater pipeline

Source: Department of Customer Service, 2020; Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

3.3 Assessment methodology

This HHRA has been prepared in general accordance with the approach outlined in the guidelines listed in **Section 3.1** above. These guidelines specify a tiered approach to risk assessment in five stages as outlined below. The STP upgrade concept design and the BVSC RWMS (2019) document was used to inform Stages 1 to 4.

1. **Stage One Issue identification:** This stage included:
    - identification of the issue (or concern, problem or objective) to be assessed;
    - identification of relevant stakeholders and their objective (where relevant);
    - determination of the objective of the risk assessment; and
    - outline of the risk management decisions that need to be made.
2. **Stage Two Data collection:** evaluation and CSM. This step was informed by the current Environment Protection Licence (EPL) for the Merimbula STP (Ref. EPL 1741), and included:
    - identification of data that characterize potential hazards that warrant assessment in the HHRA;
    - identification of key data gaps and their potential significance to the HHRA outcomes;
    - development of a CSM. The CSM includes a description of the potentially complete linkages between:
        - the source of potential hazards to human health (i.e. treated wastewater);
        - potential migration pathways (i.e. discharge of treated wastewater at the beach face outfall or re-use for irrigation purposes at the PMGC grounds or Oaklands agricultural area); and
        - groups of people that may be exposed to treated wastewater, and the complete and potentially significant pathways via which this may occur (i.e. recreational users of the PMGC or Oaklands agricultural area who may directly or indirectly contact treated wastewater, workers involved in irrigation activities, beach users or recreational users of Merimbula Bay);
    - where potentially complete source-pathway-receptor linkages are not identified, there is considered to be no risk.
3. **Stage Three Exposure assessment:** This step included:
    - qualitative assessment of the expected frequency, extent and duration of exposure to treated wastewater by human receptors via identified exposure pathways; and
    - consideration of current and post-upgrade conditions. The likelihood of exposure under current conditions was informed by the BVSC RWMS (2019). The likelihood of exposure under post-upgrade conditions was informed by the STP upgrade concept design (AECOM, 2020).
4. **Stage Four Hazard assessment:** This step included:
    - identification of the hazards to human health that may be associated with discharge or re-use of treated wastewater;
    - qualitative assessment of the potential health consequence of the identified hazards; and
    - consideration of current and post-upgrade conditions. The potential consequence of exposure under current conditions was informed by the BVSC RWMS (2019). The potential consequence of exposure under post-upgrade conditions was informed by the STP upgrade concept design (AECOM, 2020).

5. **Stage Five Risk characterisation:**

- the final step in the HHRA is to combine the consequence and likelihood ranking for each hazard to characterise potential risk;
- this was based on the risk assessment matrix presented in the BVSC RWMS (2019) (which is consistent with the matrix presented in the NHMRC (2006), *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks*); and
- the change in risk profile for each health hazard identified in Stage 2 was then characterized based on comparison of current and post-upgrade risk estimates.

Key limitations on the HHRA:

- The assessment was limited to potential human exposure to treated wastewater and did not consider potential exposure of workers prior to treatment or any potential exposure to biosolids. It is considered that workers would be protected from exposure to chemical or biological hazards via the implementation of health and safety plans and safe work method statement (SWMS), which would implement a hazard control hierarchy of elimination, substitution, engineering controls, administrative controls or personal protective equipment (PPE), as required by Safework NSW (https://www.safework.nsw.gov.au/legal-obligations/employer-business-obligations/managing-hazards-and-risks).
- It is assumed that biological hazards would be treated to comply with the EPL criteria and therefore would not present an unacceptable risk following discharge via the outfall.
- It is assumed that all CoPC are captured by those listed in the EPL.

Potential human exposure to odours has been assessed separately in the air quality impact assessment (AQIA) and has not been included in the HHRA.

4.0 Stage 1 - Issue identification

4.1 Rationale for undertaking the HHRA

The ongoing use of the existing Merimbula STP and beach-face outfall does not meet community expectations and presents unacceptable risks to public health, the environment and the regional economy.

Previously, the NSW EPA updated the conditions of the EPL for the Merimbula STP requiring BVSC to obtain the necessary approvals to construct and commission an ocean outfall for the disposal of treated wastewater from the plant. The current EPL includes the following condition:

U1 Effluent management strategy for Merimbula STP

U1.1 The licensee must, by 31 March 2021:

a) Have completed than (sic) *Environmental Impact Statement (EIS) and Concept Design for a deep water ocean outfall and STP upgrade for the disposal of treated effluent from the premises.*

U1.2 The licensee must, by 31 March 2023:

a) Have obtained the necessary approvals, constructed and commissioned a deep water ocean outfall for the disposal of treated wastewater from the premises; and

b) Have obtained the necessary approvals, constructed and commissioned upgrades to the STP to ensure that the treated wastewater quality is commensurate with the standards required in condition 'a)' above.

The Project would address the above issue by improving the quality of treated wastewater being disposed of from the STP and address the issue of a beach-face outfall by introducing an ocean outfall pipeline with an offshore discharge point.

This qualitative HHRA has been undertaken to assess risk to human health associated with re-use of treated wastewater under current (pre-upgrade) and post-upgrade conditions and to develop mitigation measures where necessary.

4.2 Stakeholders

Key stakeholders identified for the HHRA are:

- BVSC;
- NSW EPA;
- recreational users of Merimbula Beach / Bay
- recreational users and landscape workers at the PMGC; and
- agricultural workers at the Oaklands agricultural area.

4.3 HHRA objectives

The overall objective of this HHRA is to undertake a qualitative assessment, based on the available data, of potential risks to the health of current and future receptors (namely recreational users, landscape workers and agricultural workers) associated with the presence of residual impacts identified in treated wastewater used for irrigation purposes. The HHRA addresses the SEARs and informs the EIS.

4.4 Risk management decisions

While risk management is a separate process to risk assessment, the following outcomes of the HHRA will be relevant to subsequent risk management decisions:

- Identification of the potential risks associated with the pre and post upgrade conditions will provide input to the decision as to whether risk management may be required, and if so, which potential exposure pathways need to be mitigated to reduce overall risks to acceptable levels.
- Assessment of the sensitivity of the risk assessment outcomes to the identified data gaps and uncertainties will provide input to the decision as to whether further investigation is required for specific hazards/ exposure pathways.

5.0 Site background and environmental setting

The existing Merimbula STP is located between Merimbula and Pambula on Arthur Kaine Drive, approximately 3.5 km south of the Merimbula town centre and 2.5 km north of Pambula village.

The Project area encompasses the existing Merimbula STP site, the proposed outfall pipeline alignment and the areas required for construction of the Project (e.g. temporary laydown areas on the PMGC grounds and on Merimbula Beach, and a temporary beach access from Pambula). The Project area is described below and shown in **Figure 2-1**. A description of the land parcels within the Project area is provided in **Table 5-1**.

Table 5-1 Project area land description

Project area component	Land description
Merimbula STP (including existing exfiltration ponds)	The Project area within the existing Merimbula STP site falls within the following parcels of land: • Lot 101 on DP1201186; • Lot 1 on DP853245; • Lot 2 on DP853245; • Lot 1 on DP861737; and • Lot 2 on DP861737.
Proposed ocean outfall pipeline alignment	**Section one** Section one of the outfall pipeline comprises primarily the onshore portion of the proposed pipeline. The pipeline would be located underground, and travel from the existing STP site to a point below the mean high water mark (MHWM) in Merimbula Bay, beyond the surf zone. Section one would traverse below the surface of the following parcels of land: • Lot 355 on DP 41837; • Lot 7308 on DP 1167035; • Lot 320 on DP 750227; • Lot 7307 on DP 1167035; • Road Reserve (Arthur Kaine Drive); and • Crown Land (i.e. land below the MHWM). **Section two** Section two of the outfall pipeline comprises the majority of the offshore portion of the proposed outfall pipeline. The pipeline would be laid on the seabed, from where it emerges from underground at a point below the MHWM to the diffuser location, approximately 2.7 km offshore. Sections of the pipeline would be located on Crown Land.
Construction areas (including beach access and areas not already described in land parcels above)	Beach access area (above MHWM) and site of decommissioning existing beach-face outfall pipeline: • Lot 7307 on DP1167035; • Lot 7917 on DP1187854; • Lot 7318 on DP1167151; and • Lot 7019 on DP1122193. Beach access area (below MHWM): • Crown Land (i.e. land below the MHWM). PMGC laydown area: • Lot 102 DP1201186; and • Lot 356 DP41837.

5.1 Land uses

Existing land uses within the Project area include the Merimbula STP site, beach-face outfall and exfiltration ponds. Construction areas also include a portion of the PMGC course, Pambula Beach, Jiguma Beach and Merimbula Beach. The Project, once operational, would be a continuation of the current land uses within the Project area, with the exception of ceasing the use of the exfiltration ponds and decommissioning the beach-face outfall pipeline. A description of the existing STP site and pipeline operations is provided in **Section 1.1**.

5.2 Treated wastewater irrigation system

Treated wastewater from the Merimbula STP is directed to a 17 ML effluent storage pond within the STP boundary. From here it is pumped to the beneficial re-use irrigation areas or discharged to the existing beach-face outfall, or exfiltration ponds located behind the foredune at Main Beach, Merimbula. Treated wastewater from the STP is used to irrigate:

- the grounds of the PMGC (EPL Point 2), comprising approximately 1.5 ha of greens and 20 ha of fairways; and
- approximately 40 ha of rye/clover/lucerne pastures for cattle feed at Oaklands agricultural area.

The approximate irrigation areas are shown in **Figure 3-1**.

5.2.1 Pambula Merimbula Golf Club

The PMGC is reliant on recycled water stored in the 17 Mega Litre (ML) recycled water pond at Merimbula STP. The PMGC has priority access to the supply of recycled water with some 10 ML of recycled water stored in the STP recycled water pond reserved for the PMGC.

The PMGC pumps water from the recycled water storage using three 37 Kilowatt (kW) variable speed Wilo Helix pumps plus a 10 kW Wilo Helix jockey pump, providing a maximum capacity of 58 Litres per second (L/s) at 1080 Kilopascals (kPa). A flowmeter measures the volume of recycled water used on the PMGC grounds.

The PMGC is responsible for the management of the recycled water irrigation on the PMGC grounds, in accordance with this RWMS and the Recycled Water Supply Agreement.

The golf course is irrigated according to the requirements of each playing surface, relying heavily on the experience of PMGC greenkeepers and close visual observation of condition and also direct measurement of soil moisture.

Irrigation of the PMGC grounds is programmed for between 6:00 pm and 4:00 am, with daily settings based on weather, season and the timing of high levels of golf course usage. The irrigation is programmed so that each surface receives one deep watering per week.

5.2.2 Oaklands agricultural area

The volume of recycled water above 10 ML in the recycled water pond at Merimbula STP is available for pumping to the Oaklands agricultural area, as well as being available for access by the PMGC.

Oaklands has a dedicated 20 ML recycled water storage located in the north western corner of the agricultural area. For the majority of the year, when the PMGC demand is below daily influent volumes, there is surplus recycled water available for pumping to the pond at Oaklands if it is below full capacity.

‘K-line pod systems’ are used to irrigate a paddock on the northern side of the and also a paddock situated on the south-western part of the property on the opposite side of the river (**Figure 3-1**).

The property manager at Oaklands is responsible for management of recycled water irrigation at Oaklands, in accordance with the RWMS and the Recycled Water Supply Agreement.

5.3 Sensitive receptors

The Study area (inclusive of the Project Area, the PMGC grounds and the Oaklands agricultural area) is surrounded by dunal areas, vegetated public spaces, beaches and lake Merimbula on the northern boundary. Further afield to the north of the Project area there is Merimbula Airport.

The closest built-up residential area is located approximately 1.5 km to the south west. In closer proximity are scattered rural residences to the south east of the Project area and Pambula Hospital and aged care facility to the south west. Surrounding sensitive receptors and their distance from the Project area are shown in **Table 5-2** and in **Figure 5-1**.

Table 5-2 List of surrounding sensitive receptors

Type	Approximate distance from Project area (m) / Direction[1]
Merimbula Beach	200 m E
Pambula Hospital	1300 m SW
Aged Care Facility	1300 m SW
Rural Residential	170 m SE
Rural Residential	230 m SE
Rural Residential	350 m SE

Notes:

1. Measured from Project area to property boundary of the sensitive receptor.

FIGURE 5-1: RESIDENTIAL AND SENSITVE RECEPTOR LOCATIONS

Legend

Project area

Project area (temporary construction area)

AECOM

Source: Nearmap, 2019

6.0 Stage 2 - Data collection and evaluation

6.1 Water quality monitoring

6.1.1 Monitoring at beach – face outfall

The data in this section relating to the operation of the beach-face outfall were provided from BVSC.

Treated wastewater quality at the beach-face outfall is monitored at EPA monitoring point 4 under EPL 1741. For the purpose of establishing treated wastewater concentrations for the various indicators in **Table 6-1**, historical monitoring data for EPA monitoring point 4 (EPL 1741) and treated wastewater discharge criteria stated within the design criteria for the Project (AECOM, 2019a), were used.

The assumed wastewater quality was established based on the following:

- where a wastewater discharge criterion has been set for the indicator, the maximum criteria (whether that be the 100th percentile or the 90th percentile criteria depending on indicator) was adopted; and
- where no discharge criteria were set, the 90th percentile historical wastewater quality was adopted for the purposes of this qualitative assessment.

Water quality monitoring conducted as part of the Project off the coast of Merimbula between April 2004 and April 2020 (as provided by BVSC) recorded the following water quality results against a range of indicators, as shown in **Table 6-1**. The adopted treated wastewater quality concentration (which include historical results) and assumptions are also provided in **Table 6-1**.

Table 6-1 Historical treated wastewater quality results (April 2004 to April 2020)

Indicator	Units	Treated wastewater quality concentration	Assumed wastewater quality
pH	pH units	6.5-8.5	Discharge criteria - 100th percentile limit (AECOM, 2018)
Suspended solids	mg/L	30	Discharge criteria - 100th percentile limit (AECOM, 2018)
Electrical conductivity	µS/cm	1210	90th percentile of historical monitoring data
Dissolved oxygen	mg/L	13	90th percentile of historical monitoring data
Total Nitrogen	mg/L	15	Discharge criteria - 100th percentile limit (AECOM, 2018)
Oxides of Nitrogen (NOx)	mg/L	7.2	90th percentile of historical monitoring data
Ammonia	mg/L	5	Discharge criteria - 100th percentile limit (AECOM, 2018)
Total Phosphorus	mg/L	13	Discharge criteria - 90th percentile limit (AECOM, 2018)
Orthophosphate	mg/L	11	90th percentile of historical monitoring data
Chlorophyll a	µg/L	68	90th percentile of historical monitoring data
Faecal coliforms	cfu/100 ml	200	Discharge criteria - 90th percentile limit (AECOM, 2018)
Enterococci	cfu/100 ml	204	90th percentile of historical monitoring data
E.Coli	cfu/100 ml	194	90th percentile of historical monitoring data

Indicator	Units	Treated wastewater quality concentration	Assumed wastewater quality
Aluminium	µg/L	96	90th percentile of historical monitoring data
Antimony	µg/L	1.5	90th percentile of historical monitoring data
Arsenic	µg/L	3	90th percentile of historical monitoring data
Barium	µg/L	10	90th percentile of historical monitoring data
Boron	µg/L	100	90th percentile of historical monitoring data
Cadmium	µg/L	0.025	90th percentile of historical monitoring data
Chromium (Total)	µg/L	1	90th percentile of historical monitoring data
Cobalt	µg/L	0.5	90th percentile of historical monitoring data
Copper	µg/L	227	90th percentile of historical monitoring data
Iron	µg/L	516	90th percentile of historical monitoring data
Lead	µg/L	4.6	90th percentile of historical monitoring data
Manganese	µg/L	53	90th percentile of historical monitoring data
Mercury	µg/L	0.05	90th percentile of historical monitoring data
Nickel	µg/L	3	90th percentile of historical monitoring data
Selenium	µg/L	9	90th percentile of historical monitoring data
Silver	µg/L	0.5	90th percentile of historical monitoring data
Zinc	µg/L	129	90th percentile of historical monitoring data

6.1.2 Licence discharge limits

The EPL discharge limits presented in **Table 6-2** for wastewater disposal at the beach-face outfall or dunal exfiltration ponds, are applicable to the parameters above.

Table 6-2 EPL discharge limits for the beach-face outfall or ex-dunal filtration ponds

Parameter	Units	90th percentile limit	100th percentile limit
Biological Oxygen Demand (BOD)	mg/L	10	15
Faecal coliforms	cfu/100 mL	-	200
Nitrogen (ammonia)	mg/L	2	5
Nitrogen (total)	mg/L	10	10
Oil and grease	mg/L	2	10
pH	pH units	-	6.5-8.5
Phosporous (total)	mg/L	13	-
Suspended solids	mg/L	20	30

6.2 Tier 1 Human health risk assessment

A Tier 1 (or screening level) HHRA comprises a comparison of representative site data with generic investigation levels and/or screening levels for protection of human health. Tier 1 screening levels are selected from values published by local regulatory authorities and relevant to the potential exposure pathways identified for the Project site. A Tier 1 HHRA provides an initial screening of the data to determine whether further quantitative risk assessment is required. The Tier 1 screening levels were sourced from relevant guidance as follows:

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia ANZG (2018);*
- *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (NHMRC, 2006); and*
- *Bega Valley Shire Council Recycled Water Management System (2019).*

6.2.1 Available water quality data

Data adopted for the Tier 1 HHRA comprised analytical results for treated wastewater samples collected between April 2004 and April 2020. The following chemicals were analysed in water samples:

- pH
- Suspended solids
- Electrical conductivity
- Dissolved oxygen
- Total Nitrogen
- Oxides of Nitrogen (NOx)
- Ammonia
- Total Phosphorus
- Orthophosphate
- Chlorophyll a
- Faecal coliforms
- *Enterococci*
- *E.Coli*
- Aluminium
- Antimony
- Arsenic
- Barium
- Boron
- Cadmium
- Chromium (Total)
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Silver
- Zinc.

6.2.2 Tier 1 Screening Levels current (pre-upgrade) conditions

For the Tier 1 human health assessment, Chemicals of Potential Concern (CoPC) were assessed by screening the pre-upgrade wastewater concentrations against the ANZG (2018) Marine Water Quality Objective for Primary and Secondary Contact Recreation presented in **Table 6-3**. Specific health-based water quality performance targets for recycled water irrigation of the PMGC grounds and Oaklands agricultural area (NHMRC, 2006) are also provided as additional screening levels.

Table 6-3 Preliminary water quality assessment for current (pre-upgrade) conditions

Indicator	Units	Treated wastewater quality 2004 2014	ANZG 2018 trigger level for primary and secondary recreation and visual amenity	NHMRC 2006 (Table 3.8): Municipal Use, with restricted access and application	NHMRC 2006 (Table A5.1) Irrigation LTV	Exceed guideline?
pH	pH units	6.5-8.5	5.0-9.0	-	-	No
Suspended solids	mg/L	30	-	-	-	-
Electrical Conductivity	µS/cm	1210	-	-	-	-
Dissolved Oxygen	mg/L	13	-	-	-	-
Total Nitrogen (TN)	mg/L	15	-	-	-	-
Oxides of Nitrogen (NOx)	mg/L	7.2	-	-	-	-
Ammonia	mg/L	5	0.01	-	-	Yes
Total Phosphorus	mg/L	13	-	-	-	-
Orthophosphate	mg/L	11	-	-	-	-
Chlorophyll a	µg/L	68	-	-	-	-
Faecal coliforms	cfu/100 ml	200	150	-	-	Yes
Enterococci	cfu/100 ml	204	35	-	-	Yes
E.Coli	cfu/100 ml	194	-	<100	-	Yes
Aluminium	µg/L	96	200	-	5000	No
Antimony	µg/L	1.5	-	-	-	-
Arsenic	µg/L	3	-	-	100	No
Barium	µg/L	10	1000	-	-	No
Boron	µg/L	100	1000	-	500	No
Cadmium	µg/L	0.025	5	-	10	No
Chromium	µg/L	1	50	-	100	No
Cobalt	µg/L	0.5	-	-	50	-
Copper	µg/L	227	1000	-	200	Yes

Indicator	Units	Treated wastewater quality 2004 2014	ANZG 2018 trigger level for primary and secondary recreation and visual amenity	NHMRC 2006 (Table 3.8): Municipal Use, with restricted access and application	NHMRC 2006 (Table A5.1) Irrigation LTV	Exceed guideline?
Iron	µg/L	516	300	-	200	Yes
Lead	µg/L	4.6	50	-	200	No
Manganese	µg/L	53	100	-	200	No
Mercury	µg/L	0.05	1	-	2	No
Nickel	µg/L	3	100	-	200	No
Selenium	µg/L	9	10	-	20	No
Silver	µg/L	0.5	50	-	-	No
Zinc	µg/L	129	5000	-	2000	No

Notes:
- no guideline available
Shaded cells indicate exceedance of adopted screening level.

6.2.3 Tier 1 Screening Levels - Post-upgrade conditions

It is noted that the post upgrade treated wastewater quality data is unavailable and as such, no Tier 1 screening assessment has been undertaken. The *STP upgrade 30% Concept Design Report* (AECOM, 2019c) and the *Merimbula STP Upgrade and Ocean Outfall Concept Design and Environmental Assessment* (Elgin, 2020) indicates that the post-upgrade design discharge limits are expected to achieve the following:

- reduction in the total phosphorus 90th percentile limit to 1.0 mg/L for re-use water, which is to be achieved by the proposed enhanced phosphorus removal in the STP upgrade by inclusion of the two-point PAC dosing in the treatment process;
- requirement for 4-log reduction of virus, bacteria and pathogens at the discharge point for re-use water, which is facilitated by the STP upgrade, final disinfection by UV radiation and chlorination;
- improved heavy metal removal from tertiary filtration (if required);
- potential to minimise impact of aluminium in final wastewater; and
- reduced load on downstream disinfection processes.

Hydrodynamic modelling of the study area (AECOM 2019b) demonstrated that discharge of treated wastewater at the ocean outfall location, situated 2.7 km offshore in 30 m depth provides significant improvement in dispersion over the existing beach-face outfall. Based on the information available at this time, it is considered that the possibility of direct contact with treated wastewater by recreational users of the beach /Merimbula Bay is low. Further, it is assumed that the biological hazards would be treated to comply with the EPL criteria and therefore would not present an unacceptable risk following discharge via the outfall.

6.2.4 Identification of chemicals of potential concern

The following CoPCs were identified based on comparison of reported wastewater concentrations for pre-upgrade conditions to identified Tier 1 screening levels:

- chemical stressors – ammonia;
- microbiological - faecal coliforms, *E.coli* and *Enterococci*; and
- metals – iron and copper.

6.3 Conceptual site model

A conceptual site model (CSM) is a description of the following:

- the source(s), nature and extent of site contamination;
- potential contaminant transport and/or migration pathways; and
- potential receptors that may be exposed to site contaminants, and the complete and potentially significant pathways via which they may be exposed.

6.3.1 Sources

Potential sources of contamination at the site and surrounds are associated with the STP operations, as discussed in **Section 5.2**.

6.3.2 Receptors

Based on the pre- and post-upgrade treated wastewater use, the following receptors have been identified:

- recreational users of the Merimbula Beach / Bay who may directly or indirectly contact treated wastewater;
- recreational and commercial fishers who may consume potentially contaminated aquatic biota;
- recreational users of the golf course who may directly or indirectly contact treated wastewater;
- landscape workers at the PMGC involved in irrigation activities who may directly or indirectly contact treated wastewater; and
- agricultural workers of the Oaklands agricultural area who may directly or indirectly contact treated wastewater during irrigation activities.

6.3.3 Potential human exposure pathways

Potentially complete exposure pathways associated with exposure to treated wastewater are listed in **Table 6-4**.

Table 6-4 Potential human exposure pathways

Exposure pathway	Recreational users of the PMGC	Landscape workers at the PMGC	Agricultural workers at the Oakland agricultural area	Recreational users of the beach	Recreational /commercial fishers (and seafood consumers)
Treated wastewater					
Incidental ingestion of treated wastewater	✓	✓	✓	✓	X
Dermal contact with treated wastewater	✓	✓	✓	✓	X

Exposure pathway	Recreational users of the PMGC	Landscape workers at the PMGC	Agricultural workers at the Oakland agricultural area	Recreational users of the beach	Recreational /commercial fishers (and seafood consumers)
Treated wastewater					
Ingestion of potentially contaminated aquatic biota	X	X	X	X	X [(a)]

Notes:
✓ - potentially complete pathway
X – incomplete pathway

a. *– Not considered a potentially complete pathway. Potential operational related impacts and risk level to marine ecological receptors was assessed to be low or minimal* (refer to **Chapter 11 Marine ecology** of the EIS *(AECOM 2020)). An ocean outfall would result in improved dispersion of wastewater and would reduce the risk of entrapment in the surf zone and a reduction in the risk of nutrients associated with the wastewater entering the Merimbula or Pambula estuaries. Dispersion modelling predicted that a 5 m to 25 m diameter mixing zone would result in the required dilution factor of 100 to achieve all metal default guidance values (DGVs) (under most conditions). The nearest rocky reef habitats for reef fish, abalone and other shellfish are located at least 1,400 m away (Hunter Reef), fish aggregation artificial habitat at 1,000 m distance (Merimbula Offshore Artificial Reef) and oyster aquaculture 2700 m to 3000 m away (Merimbula and Pambula Lakes). The small mixing zone required for metal attenuation and the relatively large distances to these habitats indicates that the risk of bio-accumulative metals to fish, abalone and other shellfish is low and that the water quality objective of "bioaccumulation of contaminants – no change from natural conditions" would not be precluded by the Project (AECOM 2020b).*

6.3.4 Potential data gap

Based on the information provided by BVSC and the above review, the following potential data gap which are considered relevant to the HHRA have been identified in **Table 6-5**.

Table 6-5 Data gap

Data gap	Discussion and relevance to HHRA
Adopted data in the Tier 1 assessment comprised analytical results from water samples collected between April 2004 to April 2020. No data are available from the more recent months.	The assessment has been undertaken adopting a conservative ('worst case') scenario approach by adopting the maximum wastewater concentrations over the 16 year period. As such it is considered that the absence of the more recent data is unlikely to have a material impact on the overall assessment.

7.0 Stage 3 – Exposure assessment

7.1 General

This section identifies the human populations (receptors) who may be exposed to the identified CoPC and outlines the mechanisms (exposure pathways) by which these populations may be exposed. The exposure assessment presented in the HHRA report provides a qualitative estimate of exposure and intake of the CoPC.

An exposure pathway is a mechanism by which an individual or group of individuals (receptors) may be exposed to the CoPC through mechanisms such as direct contact (incidental ingestion and dermal contact) and inhalation.

For an exposure pathway to be considered to be complete all of the following must be present:

- source of CoPC – how the chemical entered the environment (primary source) and/or is present in the environment (secondary source);
- transport media – how the chemical moves or migrates through the environment (soil, water or air);
- an exposure point – how people can come into contact with the chemicals (e.g., swimming, gardening, inhalation, direct contact or via the food web); and
- an exposure route – how the chemical could enter the body (i.e., inhalation, ingestion or dermal contact).

If any one of these steps (source, transport media, exposure point or route) is not present, then the exposure pathway is incomplete and further assessment of risks is not required.

In the cases where the exposure pathways are complete, or have the potential to be complete, then the pathways can be considered “significant” or “less significant”. The significance of the exposure pathway depends on the nature of the impact present and the evaluation of the likely exposure concentrations that may be associated with the pathway.

7.2 Potential human receptors

Potential human receptors considered in this assessment based on the current and potential future land uses at the study area are those discussed in **Section 6.3.2**.

7.3 Quantification of exposure

When estimating chemical intake or exposure, the risk assessment process focuses on exposure occurring over a prolonged period; that is, chronic exposure that occurs over years and possibly a lifetime. The following steps have been followed to estimate chemical intake:

- calculation of intake factors for each of the identified exposure pathways and receptors. An intake factor is a site-specific and receptor-specific value which, when multiplied by the concentration of each CoPC, provides an estimate of the daily chemical intake of the CoPC for each receptor and pathway. Some examples include inhalation rate, exposure frequency (i.e., hours per day or days per year) and exposure duration (e.g. number of years as a resident) and body weight; and
- estimation of the chemical concentration in each medium relevant to the receptor groups and exposure pathways. This involves the use of relevant data collected from the STP site and surrounds.

The assessment presented has addressed potential worst-case exposure to CoPC, and exposure has been estimated for a Reasonable Maximum Exposure (RME) scenario estimated by using the intake factors and chemical concentrations that define the highest exposure that is reasonably likely to occur in the area assessed. The RME is likely to provide a conservative estimate of total exposure and therefore health risk.

7.4 Human exposure parameters

Exposure parameters which are considered representative of RME have been selected for the receptor groups evaluated; off-site recreational users of the PMGC, beach users or recreational users of Merimbula Bay, landscape and agricultural workers. Where available, exposure parameters have been obtained from Australian sources (NHMRC 2013 and enHealth, 2012b). **Table 7-1** and **Table 7-2** presents an overview of the parameters selected for current (pre-upgrade) conditions.

Table 7-1 Adopted exposure parameters – Current recreational users of the Merimbula Bay and Pambula Merimbula Golf Club grounds

Parameter	Adopted value		Comment
	Adult	Child	
Body weight (kg)	70	15	NHMRC 2013.
Exposure duration (years)	29	6	NHMRC 2013.
Exposure frequency (days/year)	52	52	No frequency data were available, therefore assumed to occur on average once per week.
Incidental water ingestion rate (L/day) – Recreational users of the PMGC course	0.075	NA	No published data available. Adopted parameter is based on professional judgement, for a scenario where infrequent unintentional ingestion of water during sprinkler play. Assumed to be equal to half the rate of swimming as it is not an immersive activity.
Incidental water ingestion rate (L/day) – Recreational users of the Merimbula Beach / Bay	0.15	0.125	NHMRC 2013.
Skin surface area exposed to water contact (cm^2) – Recreational user of the PMGC course	7000	NA	Based on hands, forearms, lower legs and feet. enHealth (2012a) / professional judgement.
Skin surface area exposed to water contact (cm^2) – Recreational user of the Merimbula Beach / Bay	20000	6100	Entire body. enHealth (2012a) / professional judgement.
Activity duration (hours/day)	0.7	0.7	No published data available. Assumed to be equal to swimming and that the adult is playing with the children. Professional Judgement.
Events per day (event/day)	1	1	Activity duration is average time per day. Professional Judgement.

Notes: NA – Not Applicable.

Table 7-2 Adopted exposure parameters – Current landscape and agricultural workers

Parameter	Adopted value Adult	Comment
Body weight (kg)	70	NHMRC 2013.
Exposure duration (years)	29	NHMRC 2013.
Exposure frequency (days/year)	240	NHMRC 2013.
Incidental water ingestion rate (L/day)	0.005	Incidental ingestion during irrigation; based on professional judgement.
Skin surface area exposed to water contact (cm^2)	7000	Based on hands, forearms, lower legs and feet. enHealth (2012a) / professional judgement.
Activity duration (hours/day)	1.1	Based on average time per day on grounds (for landscape workers) and animal care (for agricultural workers of the Oakland agricultural area) (enHealth (2012a).
Events per day (event/day)	1	Activity duration is average time per day. Professional Judgement.

It is considered that the post-upgrade exposure parameters would remain generally unchanged for the recreational users of the PMGC, and the landscape and agricultural workers. The Project would include moving the outfall from beach-face to an ocean outfall located approximately 2.7 km off-shore which would increase dispersion and reduce the risk of entrapment in the surf zone (AECOM, 2019b). As such the potential exposure of treated wastewater to recreational users of Merimbula Beach and Bay is expected to be significantly reduced as a result of the Project.

8.0 Stage 4 – Hazard assessment

8.1 Hazard identification

The hazard identification stage is a qualitative description of the capacity of a contaminant or agent to cause harm. The hazard identification process requires a review of existing toxicological information from a variety of appropriate sources to describe the capacity of a specific agent to produce adverse health effects.

Toxicological summaries for the specific CoPC quantitatively assessed in this HHRA are provided below.

8.1.1 Ammonia

Ammonia occurs naturally as a product of decomposing organic material and volcanic eruptions and has a number of commercial applications including the manufacture of fertilizers, plastics, synthetic fibres and resins and explosives.

No health effects have been found in humans exposed to typical environmental concentrations of ammonia. Exposure to high levels of ammonia in air may be irritating to skin, eyes, throat, and lungs and cause coughing and burns. Lung damage and death may occur after exposure to very high concentrations of ammonia. Some people with asthma may be more sensitive to breathing ammonia than others.

Swallowing concentrated solutions of ammonia can cause burns in the mouth, throat, and stomach. Splashing ammonia into your eyes can cause burns and even blindness.

The available animal and human data indicate that ammonia and ammonium ions may have clastogenic and mutagenic properties, however the majority of studies that indicated positive genotoxicity results were associated with ammonium compounds and were tested on animals. Human studies are inconclusive.

8.1.2 Microbiological organisms

E.Coli and *Enterococci* are used as relatively inexpensive and straightforward indicators of potential faecal contamination. Although they are not generally harmful, they indicate the possible presence of pathogenic (disease causing) bacteria, viruses and protozoans. They are not exclusively of human origin.

E.Coli is a species of faecal coliform bacteria that is specific to faecal material from humans and other warm-blooded animals. US EPA recommends *E.Coli* as the best indicator of health risk from water contact in recreational waters; however WHO (2003) note that *E.Coli* show generally poor correlation with disease outcomes and *Enterococci* are more able to survive in marine water and thereby may be more representative of pathogens. Therefore, WHO (2003) advocates the use of *Enterococci* as the preferred faecal indicator.

Water contaminated by human excreta may contain a range of pathogenic microorganisms, such as viruses, bacteria and protozoa. These pathogens may pose a health hazard, especially when the water is used for recreational activities that involve whole-body contact, due to the fact that there is reasonable risk that during these activities' pathogens would enter the body. Gastroenteritis and respiratory illness are the main health effects likely to arise from microbially contaminated recreational water (Corbett et al 1993, WHO 2003). Contaminated water can cause more serious diseases, such as hepatitis, giardiasis, cryptosporidiosis, campylobacteriosis and salmonellosis (Philipp, 1991), particularly in children, the elderly and the severely immunocompromised.

8.1.3 Iron

Iron is an essential element in human nutrition with minimum daily requirements varying between 10 to 50mg/day depending on age, sex, physiological status and iron bioavailability.

Gastrointestinal absorption of iron varies from 1% to 20%, according to individual requirements and the source of iron. It is used in the production of haemoglobin, myoglobin and a number of enzymes, and is stored in the spleen, liver, bone marrow and muscle.

There is no evidence that iron induces cancer in humans or laboratory animals. Mutagenicity tests involving iron salts did not induce chromosome aberrations in human cells. Iron and iron compounds are not considered to be genotoxic (NHMRC, 2004).

8.1.4 Copper

Copper is an essential nutrient that is incorporated into a number of metalloenzymes involved in hemoglobin formation, drug/xenobiotic metabolism, carbohydrate metabolism, catecholamine biosynthesis, the cross-linking of collagen, elastin, and hair keratin, and the antioxidant defence mechanism. Copper-dependent enzymes, such as cytochrome c oxidase, superoxide dismutase, ferroxidases, monoamine oxidase, and dopamine β-monooxygenase, function to reduce activated oxygen species or molecular oxygen.

Copper is readily absorbed from the stomach and small intestine. Excess copper, not required form nutritional needs, is absorbed into gastrointestinal mucosal cells where it binds to the metal binding protein metallothionein or is stored in the liver. In both cases it is eventually lost from the body in feces (sloughed intestinal cells or with bile).

While the body can adapt to some level of copper excess, higher levels are associated with copper toxicity which can result in liver and kidney damage, anemia, immunotoxicity, and developmental toxicity. Gastrointestinal effects are the most commonly reported and include nausea, vomiting, abdominal pain usually as a result of drinking copper sulfate or beverages stored in copper or brass containers. Copper is a respiratory tract irritant and causes coughing, sneezing, runny nose, pulmonary fibrosis, and increased vascularity of the nasal mucosa. Effects on the liver are marked with the development of necrosis, fibrosis and abnormal biomarkers. Inflammation, necrosis, and altered serum markers of liver damage have been observed in rats fed diets with copper sulfate levels that are at least 100 times higher than the nutritional requirement. There is some evidence from animal studies to suggest that exposure to airborne copper or high levels of copper in drinking water can damage the immune system.

The carcinogenicity of copper has not been adequately studied. The IARC has classified copper in Group 4 in relation to its potential carcinogenicity. In-vivo and in-vitro studies do not indicate copper has genotoxic properties.

9.0 Stage Five - Risk characterisation

An overall risk ranking for each of the hazards was qualitatively selected after review of all the relevant data obtained. Based on the approach recommended in NHMRC (2006) the following was conducted:

- identification of all potential health and environmental hazards for each of the CoPCs;
- identifying the hazardous events that may lead to the presence of the identified hazards; and
- assessing the level of risk based on the likelihood of these hazards causing harm and the severity of the consequences in exposed populations or receiving environments.

Risks were assessed at two levels in accordance with the NHMRC (2006):

- maximum risk (Pre-upgrade Scenario); and
- residual risk after consideration of post-upgrade preventative measures (Post-upgrade Scenario)

The level of risk was estimated by identifying the likelihood of occurrence and evaluating the severity of consequences if the hazardous event were to occur. The risk category summary table is presented in **Table 9-1**. The hazards associated with use of treated wastewater, the hazardous events that may lead to the presence of these hazards, the maximum levels of risk for these hazardous events and the preventative measures to reduce the risk to residual levels are described in **Table 9-2**.

Table 9-1 Risk category summary (RWMS, 2019)

Consequence Likelihood	**1. Insignificant** Insignificant impact or not detectable	**2. Minor** Minor impact for small population	**3. Moderate** Minor impact for large population	**4. Major** Major impact for small population; predominantly local, but potential for off-site impacts	**5. Catastrophic** Major impact for large population; widespread on-site and off-site impacts
1. Rare Insignificant impact or not detectable	Low	Low	Low	High	High
2. Unlikely Insignificant impact or not detectable	Low	Low	Moderate	High	Very High
3. Possible Insignificant impact or not detectable	Low	Moderate	High	Very High	Very High
4. Likely Insignificant impact or not detectable	Low	Moderate	High	Very High	Very High
5. Almost Certain Insignificant impact or not detectable	Low	Moderate	High	Very High	Very High

Table 9-2 Hazard identification and risk assessment for the Use of treated wastewater

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
Ammonia, iron, copper, faecal coliforms, *E.coli* and *Enterococci*	Irrigation with recycled water, spray drift beyond irrigation area, dermal contact and incidental ingestion by humans in adjoining properties or public access areas. Spray drift and/or surface runoff reaching water courses, then: Incidental ingestion by humans during primary or secondary contact recreation.	2	3	**M**	STP upgrades would result in improved wastewater quality that includes: Improved heavy metal removal from tertiary filtration (if required) 4-log reduction in virus, bacteria and pathogens at the discharge point. <u>Routine Management:</u> Maintain buffer distances between irrigation areas and water courses of 40 m – 50 m. Observe and track current and imminent weather conditions (wind) for pre-warning of cessation or commencement of irrigation <u>Incident Response:</u> Cease irrigation if surface runoff is observed	At all times At all times As soon as reported or noticed. As soon as	Recycled Water User Recycled Water User Recycled Water User; BVSC Water Resources Coordinator, WaSS;	2	2	**L**

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
					Cease irrigation during strong winds that result in spray drift outside irrigation areas If a human infection or public health incident has occurred and a link with recycled water irrigation is suspected, assist with investigations and provide all required information to NSW Health and other relevant organisations	reported or noticed. Immediately	BVSC Environmental Science Officer, WaSS. BVSC Manager, WaSS; BVSC Water Resources Coordinator, WaSS; BVSC Environmental Science Officer, WaSS; BVSC Manager, BVSC Environment and Sustainability Coordinator, Planning and Sustainability			
Ammonia, iron, copper, Faecal coliforms, *E.coli* and *Enterococci*	STP process failure due to power outage, equipment failure, operator error, toxic shock loading. Recycled water leaving the outfall with levels of CoPC above the EPL then: Ingestion of pathogens by recreational users of the beach during primary or secondary contact recreation. Human infection. Ingestion of	3	3	**High**	STP upgrades would result in improved wastewater quality that includes: Construction of ocean outfall for disposal of treated wastewater Decommissioning of beach-face outfall Decommissioning of dunal ex-filtration ponds			1	1	**Low**

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
	contaminated aquatic biota by recreational/commercial fishers.				Ongoing beneficial re-use of treated wastewater Improved heavy metal removal from tertiary filtration (if required) 4-log reduction in virus, bacteria and pathogens at the discharge point. <u>Routine Management:</u> Scheduled operation and maintenance of STP system components in accordance with relevant STP Site Operations and Maintenance Plan, Job Safety and Environmental Analysis forms and Standard Operating Procedures. Implement routine environmental mitigation and management measures in accordance with relevant	As specified in plans, forms and procedures As specified in register	BVSC Treatment Plant Operations Superintendent; BVSC Treatment Plant Operations Team BVSC Treatment Plant Operations Superintendent;			

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
					STP Aspect/Impact and Hazard/Risk Register.		BVSC Treatment Plant Operations Team			
					Undertake routine STP operational monitoring and inspections	As specified in procedures	BVSC Treatment Plant Operations Team			
					Generators and backup equipment on-site and properly maintained	As specified in procedures	BVSC Treatment Plant Operations Team			
					<u>Incident Response:</u>					
					Implement incident environmental control measures in accordance with the relevant STP Aspect/Impact and Hazard/Risk Register, Standard Operating Procedures and Emergency Response Plan	Immediately	BVSC Treatment Plant Operations Superintendent; BVSC Treatment Plant Operations Team			
					Where/if incident response to STP process failure is not documented, key response measures to include:	Immediately				

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
					Seek to eliminate and mitigate against further environmental harm Investigate cause of STP process failure Seek advice from STP Process Engineers about restoring process control Notify and discuss with BVSC Operations Engineer, Water and Sewerage Services Restart/restore STP process control Reseed bioreactor tanks from another STP (if necessary, e.g., due to biomass depletion/kill) Advise EPA of STP process failure and seek advice.		BVSC Treatment Plant Operations Superintendent; BVSC Treatment Plant Operations Team			

Hazard	Hazardous event	Maximum Risk Pre upgrade Scenario			Upgrades and preventative measures	When	Who	Residual Risk Post upgrade Scenario		
		Likelihood	Consequence	Maximum risk				Likelihood	Consequence	Residual risk
					Notify public if recycled water disposal is likely to pose an elevated public health risk, or STP odours are likely to be objectionable and persistent. Undertake regular monitoring in the aeration tanks and recycled water storage.					

10.0 Conclusion

A qualitative HHRA has been undertaken to assess risk to human health associated with re-use of treated wastewater under current (pre-upgrade) and post-upgrade conditions. A summary of the key findings is provided below:

- Comparison of the current wastewater concentrations with Tier 1 human health screening guidelines indicate exceedances in ammonia, faecal coliforms, *E.coli, Enterococci*, iron and coper.
- The proposed STP upgrades are expected to result in improved wastewater quality that includes:
  - reduction in the total phosphorus 90th percentile limit to 1.0 mg/L for re-use water, which is to be achieved by the inclusion of the two-point PAC dosing in the treatment process;
  - requirement for 4-log reduction of virus, bacteria and pathogens at the discharge point for re-use water, which is facilitated by final disinfection by UV radiation and chlorination;
  - improved heavy metal removal from tertiary filtration (if required);
  - potential to minimise impact of aluminium in final wastewater; and
  - reduced load on downstream disinfection processes.
- Hydrodynamic modelling of Merimbula Bay in the study area (AECOM, 2019b) demonstrated that discharge of treated wastewater at the preferred ocean outfall location situated 2.7 km offshore in 30 m depth provides significant improvement in dispersion over the existing beach-face outfall. Based on the information available at this time, it is considered that the possibility of direct contact with treated wastewater by recreational users of the beach is low. Further, it is assumed that the biological hazards would be treated to comply with the EPL criteria and therefore would not present an unacceptable risk following discharge via the proposed ocean outfall.
- The assessment of potential impacts of the pre- and post- upgrade scenarios indicate that the proposed upgrades under the Project are expected to result in improved wastewater quality. Hydrodynamic dispersion modelling demonstrates that the overall risk of impact to water quality is low when compared to the existing discharge at the beach-face outfall. Based on the available information, it is considered that the human health risk associated with re-use of treated wastewater would be lower in post-upgrade conditions when compared with current (pre-upgrade) conditions.

11.0 References

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12.0 Abbreviations

Term	Description
CoPC	Contaminants of potential concern
CSM	Conceptual site model
EPC	Exposure point concentration
HHRA	Human health risk assessment
km	kilometre(s)
mg/L	milligrams per litre
µg/L	micrograms per litre
NHMRC	National Health and Medical Research Council
RME	Reasonable maximum exposure