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

bega valley shire council

Merimbula Sewage Treatment Plant Upgrade and Ocean Outfall

Appendix P

Climate Change Risk and Adaption Assessment Technical Report

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Climate Change Risk and Adaptation Assessment 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 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 purpose of this report is to present the findings of a climate change risk and adaptation assessment (CCRAA) completed as part of the Merimbula Sewage Treatment Plant (STP) upgrade and Ocean Outfall (the Project). This report and corresponding risk assessment serve to address the NSW Secretary's Environmental Assessment Requirements (SEARs) for the Project and align with the requirements outlined in version 1.2 (v.1.2) of the *Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Rating Scheme* for Cli-1 and Cli-2.

In line with the SEARs, this report assesses risks and vulnerability related to climate change relevant to the Project (and the broader STP site) in accordance with current guidelines, utilises the NSW Government's climate change projections, and identifies and recommends specific adaptation actions.

In addition to complying with the SEARs, and in consideration of the IS Rating Tool requirements for Cli-1 and Cli-2, this report identifies relevant climate effects and provides an assessment of the potential climate change risks to the Project. It further identifies appropriate risk management and adaptation measures to build the resilience of the Project (and broader STP site) to changing climate conditions.

For Cli-1 this is demonstrated by the following:

- the CCRAA has incorporated and utilised two different climate change projections for two different years (2030 and 2090), representing the commencement of operations and the projections closest to the end of the service life of the Project:
  - Representative Concentration Pathway (RCP) 8.5 from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM);
  - Special Report on Emissions Scenarios (SRES) A2 as per the NSW and ACT Regional Climate Modelling (NARCliM) results from AdaptNSW;
- the CCRAA has considered both direct and indirect risks posed to the Project; and
- the CCRAA has vetted and reviewed risks and adaptation measures with a multi-disciplinary internal workshop (with AECOM and Bega Valley Shire Council (BVSC) representatives) representing designers, environmental specialists, and the asset owner who would have responsibility for operations and maintenance of the Project.

For Cli-2 this is demonstrated by the following:

- adaptation options have been identified, assessed, and are in varying stages of implementation to treat the identified extreme (very high) and high risks for both the 2030 and 2090 time frames; and
- no residual very high or high risks exist based on the identified adaptation options.

Data sources

In order to assess the risk to the Project posed by climate change, the current climate science and model projections have been investigated for the following parameters based on available data sources. Reflecting the requirements of both the SEARs and the climate change credits in the IS rating scheme, this CCRAA has used two data sources for climate change projections:

- AdaptNSW and NARCliM developed by the Office of Environment and Heritage (OEH) (OEH, 2014; OEH, 2015) which provides projections at the 10 kilometre resolution; and
- CSIRO and BOM Climate Futures (CSIRO and BOM, 2015) which supplements the information available from the NARCliM projections for a number of key climate variables.

Projections are presented for emission scenarios or possible pathways, referred to as Representative Concentration Pathways (RCPs), each of which reflects a different concentration of global GHG emissions. While RCPs exist for low emissions (RCP 2.5) and medium emissions (RCP 4.5), the RCP reported here is for high emissions (RCP 8.5). The RCP 8.5 pathway, which arises from limited effort to reduce emissions and represents a failure to prevent warming by 2100, is similar to the highest SRES scenario and is used in this report. The RCP 8.5 pathway is also closest to the current emissions trajectory.

Construction risks

Risks for construction resulting from a changing climate were not identified as part of the risks assessment process understanding that construction would be complete within the next few years and that changes in the climate over this period would not be too dissimilar to current conditions.

Due to previous events experienced in and around the STP however, including observed trends, risks to construction could occur by way of physical damage, reduced capacity, and potential risks to human health and safety.

Based on these past events and trends, risks to the construction process could include:

- extreme rainfall and storm events resulting in the inundation or damage to the Project area, resulting in delays to the construction schedule and associated cost implications;
- uncertainty around extreme events impacting design conditions/requirements leading to a potential over or under design of infrastructure;
- increased intensity and frequency of extreme rainfall events increasing load on temporary water treatment devices, and erosion control devices, increasing flooding events and affecting water quality treatment levels achieved; and
- increased intensity and frequency of extreme events (bushfire, flooding, storms) resulting in road closures or other access constraints, congestion, and increased risk of road incidents during construction, affecting workers and/or equipment accessing sites resulting in delays in program and lost days.

Operational risks

Based on the CCRAA for the Project, increases to the intensity of extreme rainfall, flooding, storm events and sea level rise would present the highest risk in both the near term (2030) and long term (2090). Risks associated with these events include:

- inundation of the STP from rainfall and/or sea level rise resulting in damage or unregulated backflow/discharge into surrounding areas;
- decreased safety of personnel working on-site or trying to access the Project area due to an extreme event; and
- accelerated erosion/sand movement in the 'surf zone' due to increasing sea levels and extreme storm events potentially uncovering the outfall pipeline.

The preliminary climate risk assessment undertaken as part of this assessment identified a total of 39 climate change risk statements for the Project. During the course of the workshop subsequently undertaken, an additional four climate change risks were identified, bringing the total to 43 climate change risks for the Project (both direct and indirect risks). Additional risks were identified for bushfire, extreme rainfall and sea level rise. Based on this revised risk assessment, there would be six high risks to the Project by 2030, increasing to 22 high risks and one extreme (very high) risk by 2090, representing 53 per cent of the total assessment**. Table 1-1** provides a summary of the revised risk assessment.

Table 1-1 Summary of risk assessment

Risk rating	2030	Percentage	2090	Percentage
Low	7	16%	2	5%
Medium	30	70%	18	42%
High	6	14%	22	51%
Very High (Extreme)	0	0%	1	2%
Total Risks	43	100%	43	100%

Residual risk assessment

The ISCA IS Tool V1.2, Cli-2 Criteria require adaptation options to be identified for all high and extreme (very high when using BVSC's risk framework) risks. Adaptation options are proposed in **Section 7.0** to reduce risks to a tolerable threshold of medium (at minimum), where possible and practicable.

Furthermore, in accordance with best practice and current design standards, operations and maintenance practices, risk management and adaptation measures are typically incorporated into the pre-concept and concept designs for the Project. In addressing climate change adaptation, these measures include:

- undertaking additional modelling within the 'surf zone' around wave height, erosion and deposition to better understand the necessary trenching depth and underwater surfacing point of the ocean outfall pipeline;
- elevating critical equipment and systems above known flood levels; and
- providing further automation to the STP to minimise the personnel required to be on-site.

A residual risk assessment (post-application of adaptation measures) for the Project was undertaken to apply the relevant identified adaptation options for all 'very high' and 'high' risks. Based on the application of the adaptation measures, no residual 'very high' or 'high' risk ratings remain for the Project, which satisfies both SEARs and ISCA requirements.

As part of the residual risk assessment, individual, specific adaptation measures have been applied to multiple risks to help reduce the potential risks to the Project. It is anticipated that as the Project develops, this register would continue to be used to track compliance and progress against the adaptation measures to assist in reducing the risk exposure of the Project.

Considering v.1.2 of the ISCA IS Rating Scheme Cli-2 criteria, adaptation options for all high and extreme (very high using the BVSC risk framework) risks and a percentage of medium priority risks are identified with appropriate measures implemented.

Refer to **Appendix B** of this assessment for the residual risk table.

Next steps

It is recommended that risk management and adaptation measures identified for medium, high or very high risks in this report be incorporated into the Project to provide certainty that these risks are considered and mitigated, where possible and practicable. Furthermore, in anticipation of future operation, BVSC should begin to review and update existing operations and maintenance procedures to account for extreme events.

From an ISCA perspective, the CCRAA presented in this report has considered and addressed information that would be required for compliance with both the Cli-1 and Cli-2 credit categories, subject to approval and verification of adaptation measures. As part of the ISCA submission process however, evidence of initiatives and adaptation actions identified within this report must be provided including demonstration of how the adaptation actions have been and/or would be implemented. The ability to produce this information and address adaptation actions should be considered during subsequent phases of the Project for feasibility.

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 Climate Change Risk Assessment has been prepared to assess risks and vulnerability related to climate change relevant to the Project (and the broader STP site), in accordance with the Secretary's Environmental Assessment Requirements (SEARs). In addition to complying with the SEARs, and in consideration of the IS Rating Tool requirements for Cli-1 and Cli-2, this report also identifies relevant climate effects and provides an assessment of the potential climate change risks to the Project. It further identifies appropriate risk management and adaptation measures to build the resilience of the Project (and broader STP site) to changing climate conditions.

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 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 an overview of the Project area is provided 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

The purpose of this report is to present the findings of a climate change risk and adaptation assessment (CCRAA) completed as part of the Project. This report and corresponding risk assessment serve to address the NSW Secretary's Environmental Assessment Requirements (SEARs) for the Project and align with the requirements outlined in version 1.2 (v.1.2) of the Infrastructure Sustainability Council of Australia (ISCA) *Infrastructure Sustainability (IS) Rating Scheme* for Cli-1 and Cli-2. Cli-1: Climate Change Risk Assessment aims to reward the assessment of climate change risks, while Cli-2: Adaptation Measures aims to reward the assessment and implementation of climate change adaptation measures.

In line with the SEARs, this report assesses risks and vulnerability related to climate change relevant to the Project in accordance with current guidelines, utilises the NSW Government's climate change projections, and identifies and recommends specific adaptation actions.

With respect to the interdependencies and relationships between the Project (which proposes new elements to be incorporated into the existing Merimbula STP site) and the remainder of the Merimbula STP site however, this report has considered both in developing risk statements and adaptation actions to better embed resilience into the STP.

In addition to complying with the SEARs, and in considering of the IS Rating Tool requirements for Cli-1 and Cli-2, this report identifies relevant climate effects and provides an assessment of the potential climate change risks to the Project. It further identifies appropriate risk management and adaptation measures to build the resilience of the Project to changing climate conditions.

Climate adaptation – action taken to help cope with a changing climate that leads to a reduction in harm or risk of harm, or realisation of benefits.

Climate resilience – is the ability and capacity of a system to withstand, recover and adapt form stress. It is a measure of how much disturbance from a changing climate a system can handle without losing functionality.

1.2.1 Secretary's Environmental Assessment Requirements

The SEARs for the Project include a key issue and desired performance outcome around designing, constructing and operating the Project to be resilient to the future impacts of climate change. **Table 1-1** identifies the requirements and where within this report the requirement has been addressed.

Table 1-1 Secretary's Environmental Assessment Requirements – Climate change risk

Secretary's Environmental Assessment Requirements	Where it addressed in report
16. Climate Change Risk	
1. The Proponent must assess the risk and vulnerability of the Project to climate change in accordance with the current guidelines. *(The current guidelines are: Australian Government's Climate Change Impacts and Risk Management – A Guide for Business and Government (2006) AS/NZS 3100:2009 Risk Management – Principles and Guidelines).*	Assessment of the risks and vulnerability of the Project to climate change have been undertaken (refer **Section 6.0**) in accordance with the relevant guidelines, plans and policies as detailed in **Section 3.1**.
2. The Proponent must quantify specific climate change risks with reference to the NSW Government's climate projections at 10 km resolution (or lesser resolution if 10 km projections are not available) and incorporate specific adaptation actions in the design.	Specific climate change risks to the Project are quantified in **Section 6.0,** while **Section 5.0** provides a qualitative review of additional climate change risks during construction. Consideration of the NSW Government's climate projections is provided in **Section 3.3.1**. Adaptation actions for the design have been considered and incorporated as detailed in **Section 7.0**.
3. The Proponent must consider the capacity for ecosystem migration for mean sea levels of up to 0.9 m above 1990 levels, having regard to the existing and proposed topography of the land.	Specific projections for sea level rises have been identified and are detailed in **Table 4.2** and **Section 4.3.7** including consideration of 0.9 metre rise in sea levels. Risks to the STP and ocean outfall resulting from changes to mean sea levels and ecosystem migration have been identified, considered and addressed in **Section 4.3.7, Table 6-2** and in **Appendix B**.

1.2.2 Infrastructure Sustainability Council of Australia compliance

Table 1-2 provides an overview of the ISCA Rating Tool requirements for Cli-1: Climate Change Risk Assessment and Cli-2: Adaptation Measures. The Project aims to pursue both Cli-1 and Cli-2 subject to future consideration during the design and construct phases. Consideration and compliance with the criteria for each credit are summarised after each table.

Table 1-2 ISCA compliance table

ISCA Credit	Aim	Level 1 Criteria	Level 2 Criteria	Level 3 Criteria
Cli-1: Climate Change Risk Assessment	To reward the assessment of climate change risks.	• A readily available climate change projection is identified and adopted for the asset region over the forecast useful life of the asset. • Direct climate change risks to the asset over the forecast useful life are identified and assessed.	• The requirements of Level 1 are achieved. • A number of readily available climate change projections are identified and adopted for the asset region over the forecast useful life of the asset. • The CCRAA also considered indirect climate change risks to the asset. • A multi-disciplinary team participated in identifying climate change risks and issues.	• The requirements of Level 2 are achieved. • Modelling is undertaken to characterise the likely impacts of the projected climate change for all High and Extreme priority climate change risks. • A comprehensive set of affected external stakeholders participated in identifying climate change risks and issues.
Cli-2: Adaptation Measures	To reward the assessment and implementation of climate change adaptation measures.	• Adaptation options to treat all extreme and high priority climate change risks are identified, assessed and appropriate measures implemented. • After treatment there are no extreme priority residual climate change risks.	• The requirements of Level 1 are achieved. • Adaptation options to treat 25 to 50 per cent of all medium priority climate change risks are identified, assessed and appropriate measures implemented.	• The requirements of Level 2 are achieved. • The optimal scale and timing of options is addressed (which may be triggered when a specific climate threshold is likely to be achieved). • Adaptation options to treat at least 50% of all medium priority climate change risks are identified, assessed and appropriate measures implemented. • After treatment there are no high priority residual

ISCA Credit	Aim	Level 1 Criteria	Level 2 Criteria	Level 3 Criteria
				climate change risks.

In accordance with the IS Rating Tool v.1.2, Cli-1 (climate change risk assessment) and Cli-2 (adaptation measures) credit requirements, this CCRAA demonstrates considerations of requirements within the respective categories. A decision around the pursued level within each credit category would be determined in consultation with the preferred contractor, however this CCRAA has considered the requirements to achieve Level 2 under the Cli-1 credit category and Level 1 under the Cli-2 credit category.

For Cli-1 this is demonstrated by the following:

- the CCRAA has incorporated and utilised two different climate change projections for two different years (2030 and 2090), representing a year relatively close to the commencement of operations (2030) and the projections closest to the end of the service life of the Project (2090):
  - Representative Concentration Pathway (RCP) 8.5 from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BoM); and
  - Special Report on Emissions Scenarios (SRES) A2 as per the NSW and ACT Regional Climate Modelling (NARCliM) results from AdaptNSW;
- the CCRAA has considered both direct and indirect risks posed to the Project; and
- the CCRAA has vetted and reviewed risks and adaptation measures with a multi-disciplinary internal (AECOM and BVSC) workshop representing designers, environmental specialists, and the asset owner who would have responsibility for operations and maintenance of the Project.

For Cli-2 this is demonstrated by the following:

- adaptation options have been identified, assessed, and are in varying stages of implementation to treat the identified extreme (very high) and high risks for both the near term (2030) and long term (2090) time frames; and
- no residual very high or high risks exist based on the identified adaptation options.

1.2.3 Structure of this report

This report is structured as follows:

- **Section 1.0** (this section) outlines how this report addresses the SEARs and ISCA requirements and provides an overview of the Project.
- **Section 2.0** provides a summary of the Project description.
- **Section 3.0** outlines the relevant guidelines and methodology used for the assessment.
- **Section 4.0** provides the local climate exposure, climate change projections and detailed climate variables.
- **Section 5.0** presents the climate change risk assessment during construction.
- **Section 6.0** presents the climate change risk assessment during operations including a summary of key findings.
- **Section 7.0** provides the mitigation and management measures (adaptation options) developed to address relevant climate change risks.
- **Section 8.0** provides a summary and includes recommendations and next steps.

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 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;
- 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, using chlorine gas, 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	*Phase four: Disposal and beneficial re-use* 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). Note that 0.28ha is a rounded up figure in accordance with the calculation of biodiversity offset credits contained in **Appendix H** (Biodiversity Assessment Report)).
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 would 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 tonne 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; • 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

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

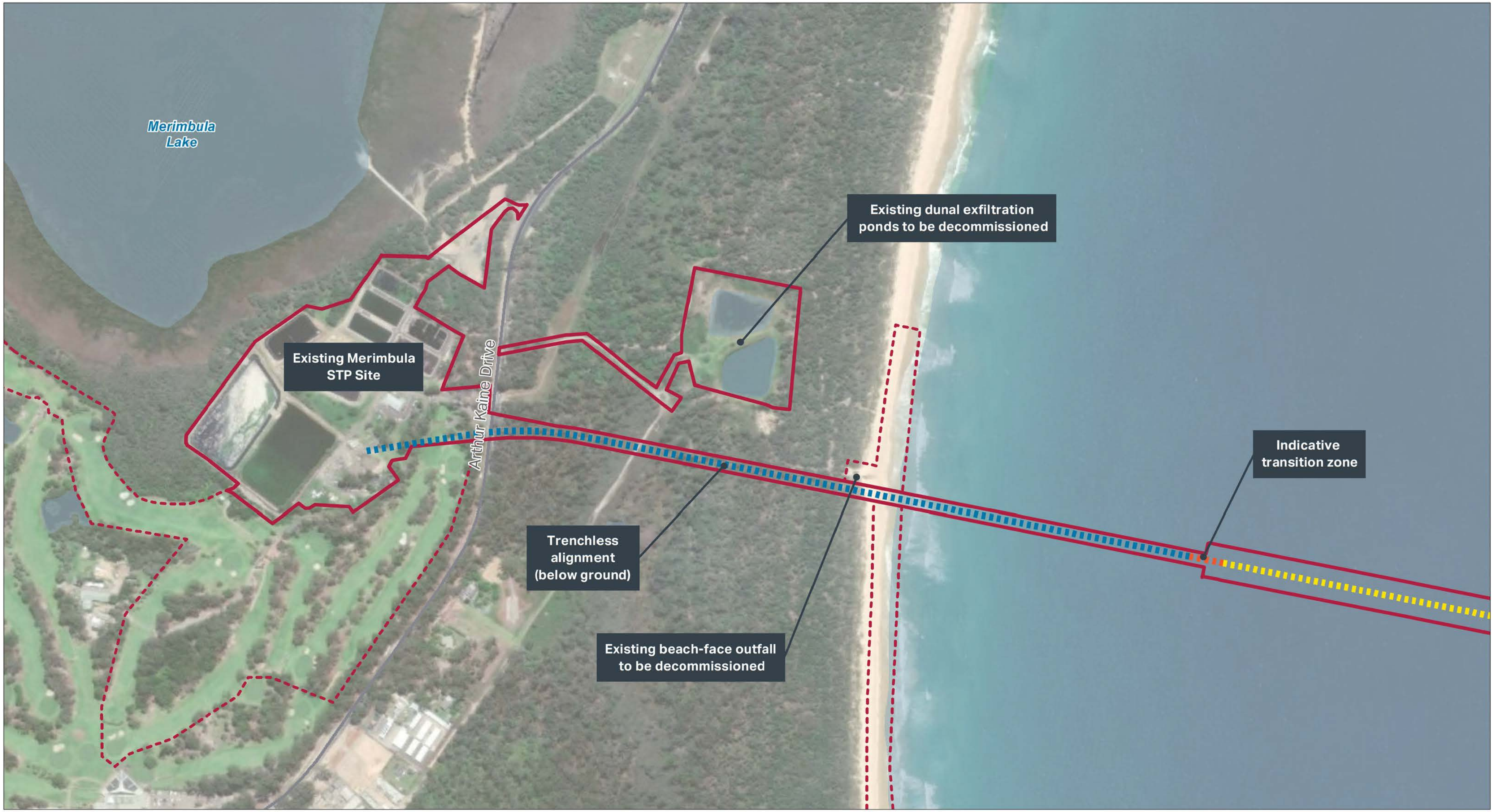

FIGURE 2-3: OCEAN OUTFALL PIPELINE - SECTION 1 (BELOW GROUND)

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

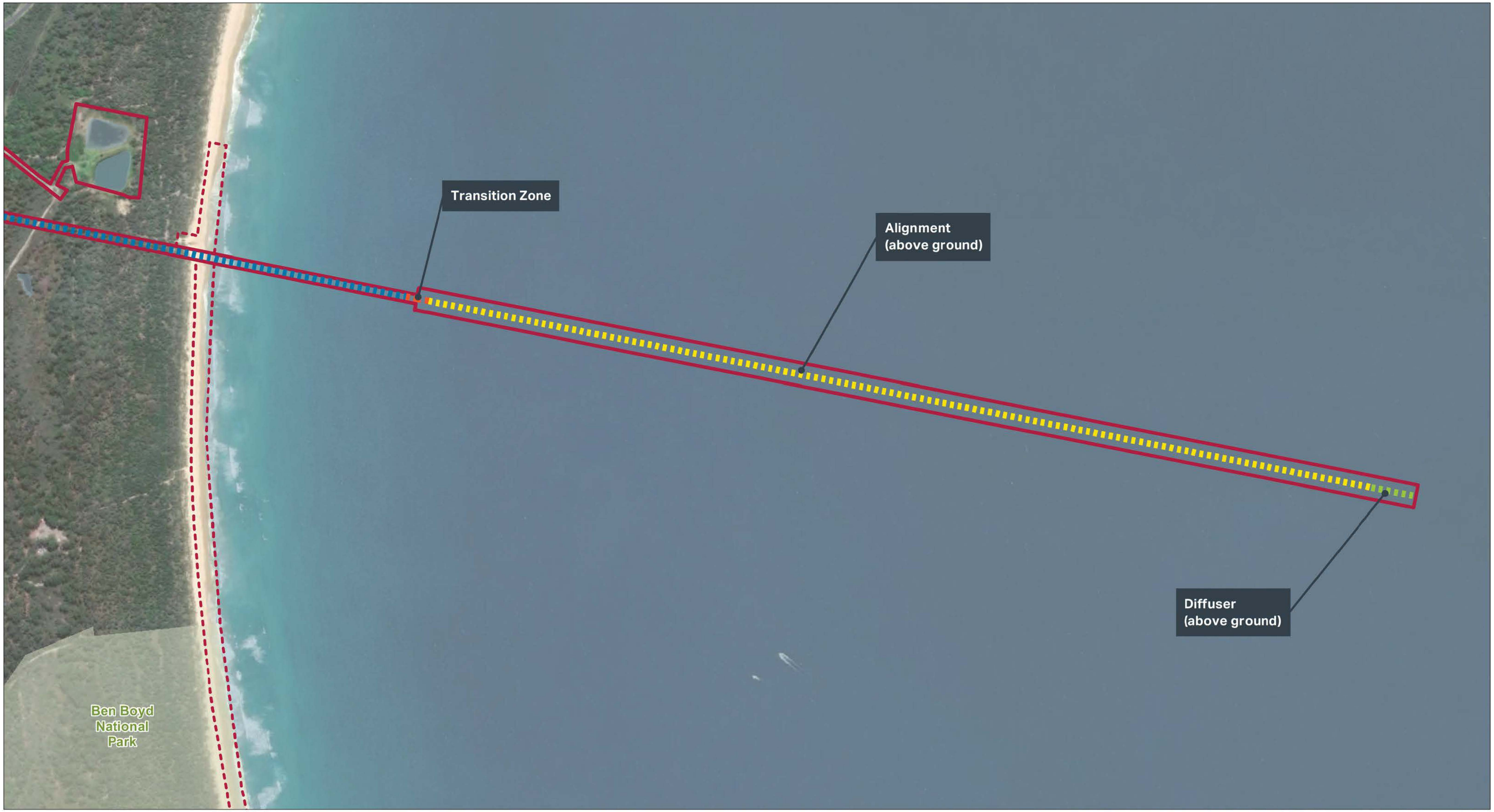

FIGURE 2-4 : OCEAN OUTFALL PIPELINE – SECTION 2 (ABOVE SEAFLOOR)

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

3.0 Methodology

3.1 Relevant guidelines and policies

The CCRAA undertaken for the Project follows the approach detailed within the draft *Technical Guide for Climate Change Adaptation for the State Road Network* (Roads and Maritime, 2015: unpublished), one of the current guidelines for assessing risk and vulnerability for infrastructure projects as the SEARs. While this guide was developed for use on motorway and road projects, the framework is applicable to all infrastructure projects (including STPs), as the guide is focused on risk management and is closely aligned with Australian Standard (AS)/New Zealand Standard (NZS) 3100:2009 *Risk Management – Principles and Guidelines*. The guide references the identification of relevant climate variables and impacts, undertaking a risk assessment, and the identification and evaluation of various risk treatments (adaptation options) to address each risk. By using this technical guide, the Project would allow for consistency with other agency's approach to climate change adaptation across NSW.

In addition to the technical guide, the CCRAA has been completed in line with the following relevant standards and current guidelines. These additional standards and guidelines serve to not only complement the technical guide, but also address various requirements outlined within the IS Rating Tool v1.2 Cli-1 and Cli-2 credits:

- the BVSC Enterprise Risk Management Framework (BVSC, 2019), developed in accordance with AS/NZS 3100:2018 *Risk Management – Principles and Guidelines*;
- AS 5334:2013 *Climate change adaptation for settlements and infrastructure – A risk based approach,* following ISO31000:2009 *Risk Management – Principles and Guidelines*;
- Australian Government's *Climate Change Impacts and Risk Management – A Guide for Business and Government* (Department of Environment and Heritage, 2006); and
- the *ISCA Climate Change Adaptation Guidelines* (Australian Green Infrastructure Council, 2011), which have been reviewed and used to guide, confirm and validate measures to mitigate and adapt to climate change risks.

3.1.1 Risk assessment methodology

The following steps were undertaken to complete the CCRAA in line with both AS 5334:2013 and the Australia Government's *Climate Change Impacts and Risk Management – A Guide for Business and Government*:

1. Identification of key climate variables (e.g. temperature, rainfall and extreme events) and the climate variability that differentiates regional climate zones.
2. Development of potential climate change scenarios, based on the latest climate science, which describes how each variable may change over the design life of the Project.
3. Identification of broad climate-based risks that may impact on the Project.
4. Completion of a CCRAA, with risk ratings evaluated using the BVSC Enterprise Risk Management Framework, including likelihood and consequence criteria (refer **Section 3.4**). Consequence ratings have been selected based on the highest rating for the risk categories.
5. Identification of measures to mitigate and adapt to the identified climate change risks.
6. Assessment of residual risks (vulnerability) to the Project, considering specific adaptation measures to treat high and very high risks, which in turn would also help treat medium and low risks.

Figure 3-1 shows how risks to the Project have been developed from an assessment of climate variables and projected climate change.

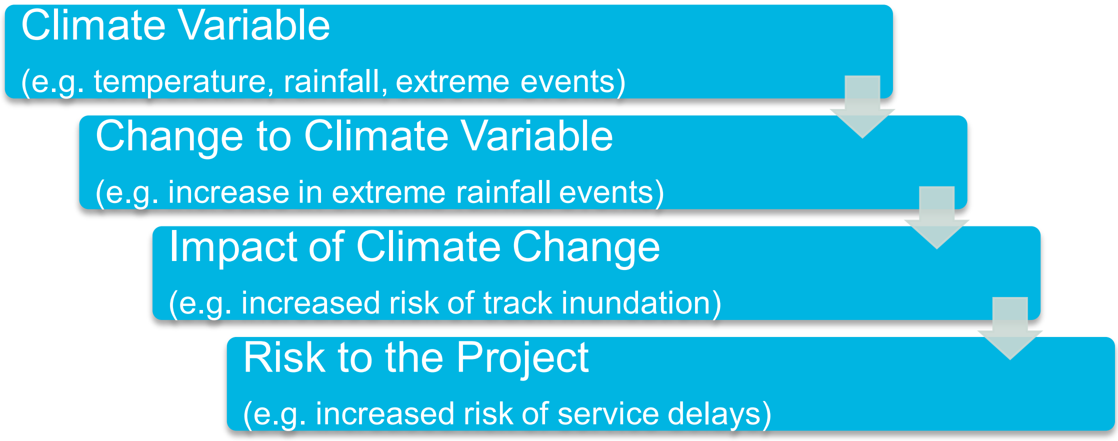

Figure 3-1 Climate change risk assessment process (Adapted from DEH, 2006)

3.2 Study area

The Project area encompasses the existing Merimbula STP site and the proposed outfall pipeline alignment. For the purposes of this assessment, the study area is considered to include the Project area, which encompasses the proposed construction footprint as well as the operational footprint.

3.3 Data sources

In order to assess the risk to the Project posed by climate change, the current climate science and model projections have been investigated for the following parameters based on available data sources. Reflecting the requirements of both the SEARs and the Climate Change credits in the IS rating scheme, this CCRAA has used two data sources for climate change projections:

- AdaptNSW and NARCliM developed by the Office of Environment and Heritage (OEH) (2014; 2015) which provides projections at the 10 km resolution; and
- CSIRO and BOM Climate Futures (CSIRO and BOM, 2015) which supplements the information available from the NARCliM projections for a number of key climate variables.

The NARCliM project, undertaken by the NSW and ACT Governments and presented through the OEH AdaptNSW web portal, presents regional downscaled climate projections (Climate Change Snapshots) for 12 regions within south-east Australia. Projections for the South East and Tablelands region have been used to inform this assessment, in accordance with both the SEARs (refer **Section1.2.1**) and ISCA credit requirements (refer **Section 1.2.2**).

The CSIRO and BOM present climate data through the Climate Futures Tool in the form of Cluster Reports, which are regional downscaled climate projects across eight regions in Australia. Based on the location of the Project, the Southern Slopes Cluster Report has been used to inform this assessment.

It is important to note the integrity of each climate data set as a whole, as the projections presented by each source represent a range of climate futures based on specific modelling parameters, scenarios and assumptions as described in the following sections. Care has been taken to consider each set of climate projections as a whole, to provide an 'internally consistent climate future' approach.

3.3.1 Climate projection scenarios

As stated, the greenhouse gas emissions scenarios used to inform this CCRAA are chosen based on the available climate projections from the following sources.

NARCliM

The SRES A2 scenario represents a high emissions pathway driven by economic growth and is projected to result in warming by approximately 3.4 degrees Celsius (ºC) by the year 2100. The SRES A2 emission scenario was selected for use in the NARCliM climate projections as a review of the global emissions trajectory suggests that we are tracking along the higher end of the A2 scenario (OEH, 2014 and OEH, 2015).

Climate futures

Projections are presented for emission scenarios or possible pathways, referred to as Representative Concentration Pathways (RCPs), each of which reflects a different concentration of global GHG emissions. Although RCPs exist for low emissions (RCP 2.5) and medium emissions (RCP 4.5), the RCP reported here is for high emissions (RCP 8.5). The RCP 8.5 pathway, which arises from a scenario of limited effort to reduce emissions and represents a failure to prevent warming by the year 2100, is similar to the highest SRES scenario and is used in this report. The RCP 8.5 pathway serves to assess a worst-case scenario (as consistent with best practice) with respect to the Project and is also closest to the current emissions trajectory.

3.3.2 Time scales

Sewage treatment plant infrastructure has a varied expected design life depending on the particular component and programmed schedule for renewal. For the purposes of this assessment, it has been assumed that the following design lives would be applied to the various STP components:

- electrical, pump and communications components – 20 years;
- buildings and concrete infrastructure (e.g. foundations) – 50 years; and
- outfall pipeline and other drainage infrastructure – 100 years.

Based on these design lives, construction of the Project being undertaken in the coming years (around 2020 to 2022) and the latest available climate data, the time periods selected for assessment are 2030 and 2090. 2030 was considered appropriate for short-term impacts on construction of the Project (assuming construction would be finished in the early-2020s with initial operation towards the middle of the 2020s). Climate change projections for 2090 are considered relevant to longer term operation and maintenance of the Project given the expected design life of critical parts of the infrastructure such as the ocean outfall pipeline. Projections, where available, for 2070 were included as a means of confirming long-term trends.

Climate projections for the selected time scales represent averages over a 20 year period:

- projections for 2030 represent the average for the 20 year period between 2020 and 2039 (near future, as defined by AdaptNSW);
- projections for 2070 represent the average for the 20 year period between 2060 and 2079 (far future, as defined by AdaptNSW); and
- projections for 2090 represent the average for the 20 year period between 2080 and 2099 (as projected by CSIRO and BoM).

3.4 Assessment criteria

Climate change risks identified for the Project have been assessed using the BVSC Enterprise Risk Management Framework, including the following likelihood and consequence tables (refer **Table 3-1**, **Table 3-2** and **Table 3-3**), to align with BVSC's overall programme risk register.

Table 3-1 Risk assessment matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	High	High	Very High	Very High
Likely	Medium	Medium	High	High	Very High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Source: Procedure 6.03.1 BVSC Enterprise Risk Management (August 2019)

Table 3-2 Likelihood criteria

Likelihood	Description	Probability of occurrence
Almost certain	Expected to occur in most circumstances	Within 1 year
Likely	Will probably occur in most circumstances	Within 2 years
Possible	Might occur at some time	Within 3-5 years
Unlikely	Could occur at some time	Within 10-20 years
Rare	May occur in exceptional circumstances	More than 20 years

Source: Procedure 6.03.1 BVSC Enterprise Risk Management (August 2019)

Table 3-3 Consequence criteria

Consequence Levels	Risk Categories Consequence Descriptors				
	Environmental	Financial	Legal	Reputational	Health/Safety
Catastrophic	Irreversible long-term	>$1million	Cessation of activities	Censure/ Inquiry	Death, severe permanent disablement or adverse health effect
Major	Wide long-term	$500k to $1million	Successful prosecution	High media	Hospitalisation, serious injuries resulting in long term absences and adverse health effect
Moderate	Wide short-term	$100k to $500k	Enforceable undertaking or fine	Moderate media	Medical treatment required and/or some lost time
Minor	Minor short-term	$20k to $100k	Compliance breach resulting in corrective action	Minor media	Medical treatment required, no lost time
Insignificant	Incident not requiring intervention	< $20k	Technical compliance breach with limited material impact	Incident that does not receive any coverage	First aid injury, No lost time

Source: Procedure 6.03.1 BVSC Enterprise Risk Management (August 2019)

3.5 Consultation

Considering the IS Rating Tool v.1.2. Cli-1 requirements, a CCRAA workshop was undertaken on 4 December 2019 with a multi-disciplinary internal team with representatives from AECOM and BVSC team providing design and environmental services as well as the asset owner who would have responsibility for operations and maintenance of the upgraded STP and ocean outfall pipeline. The workshop sought to review the:

- validation of preliminary climate change risks informed by a desktop assessment;
- identification of new climate change risks;
- allocation of preliminary risk ratings; and
- development of adaptation actions.

The following workshop participants were consulted in the development of climate change risk statements, risk ratings and adaptation options. **Appendix A** contains copies of the workshop presentation and materials.

Table 3-4 Workshop participants

Name	Role/Discipline	Organisation
Victor Chin	Design Manager	AECOM
Eric Lemont	Coastal Engineer	AECOM
Stuart Bettington	Coastal Engineering Lead	AECOM
Toby Browne	Operations	BVSC
Paul Ronan	Assets Manager	BVSC
Dylan Drysdale	Environmental Assessment	AECOM
Kimberly Skellern	Environmental Assessment	AECOM
Paul Himberger	Climate Change Specialist	AECOM

The key discussions points and outcomes from the workshop found:

- erosion and deposition due to the bathometry/morphology of Merimbula Bay is likely to impact on the ocean outfall pipeline and diffuser;
- loss of access to the surrounding road network (e.g. Princess Highway) may result in disruptions to both equipment/material delivery (e.g. chemicals) and inability of the workforce to access the STP; and
- increased groundwater levels from sea level rise may result in increased pipeline pressure and salinity, further resulting in seepage into the mains network.

4.0 Existing environment

In 2016, for the first time, global temperatures were confirmed to have risen by 1°C since pre-industrial levels. The *Paris Climate Change Accord* (effective 4 November 2016) seeks to limit climate change to under 2°C with a target of 1.5°C (UNFCC, 2016). Seeking to achieve these targets presents a significant challenge and even at 1°C we are already experiencing considerable changes with the earth's climate and weather systems.

The State of the Climate 2014 confirms the long term warming trend over Australia's land and oceans, showing that Australia's climate has warmed by 0.9°C since 1910 (Ekström et al., 2015). The Intergovernmental Panel on Climate Change *Fifth Assessment Report* (IPCC, 2013) states with high confidence that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. Other observed trends include an increase in record hot days, a decrease in record cold days and increases in global GHG concentrations.

4.1 Climate variables

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction (IPCC, 2007). Consequently, climate change and the associated impacts can be expected to vary from region to region. The CCRAA provided in this report is based on projections for the Southern Slopes and South East regions and where possible, is specific to the Merimbula region.

For the risk assessment, climate variables were selected based on the following factors related to the broader context and nature of the Project:

- the location of the Project in an area projected for a rise in sea levels;
- the location of the Project in an area subject to increased erosional and morphological impacts due to changing oceanic currents and extreme storm events; and
- the location of the Project in an area projected for an increase in extreme rainfall with subsequent flooding of surrounding areas.

As a result, the climate variables relevant to the Project are listed in **Table 4-1**.

Table 4-1 Primary and secondary climate effects

Primary climate[1] effect	Secondary climate[2] effect
Mean surface temperature	Extreme temperature and heatwaves
Average annual rainfall	Bushfire weather
Solar radiation	Flood and flash flood events
Extreme rainfall	Drought
Increased CO_2	Storm events
Sea level rise	-

Notes:

1 Primary effects – are those climate variables that are directly influenced or changed as a result of global warming/climate change. These include things such as air/sea surface temperature, precipitation, wind and solar radiation.

2 Secondary effects – are those variables that are derived from primary effects which are still influenced by a changing climate. These include things such as increased risk of bush fire weather and drought.

4.2 Observed local climate

The region surrounding the Project area is largely wet along the coast with milder conditions found throughout the year when compared to areas further inland. In summer, average temperatures range between 18ºC and 24ºC, with winter temperatures falling to between 8ºC and 12ºC. On average, the region experiences fewer than 10 hot (days above 35ºC) and cold (days below 2ºC) days per year.

Long-term observations suggest that temperatures in the area of the Project have been increasing since around 1960 (OEH, 2014) with a noticeable acceleration in temperature over the past several decades. **Figure 4-1** displays the annual warming trend as shown over the period from 1910 to present, with nearly all of the previous 20 years showing warmer than average years and a general trend of increasing deviation away from the annual mean temperature.

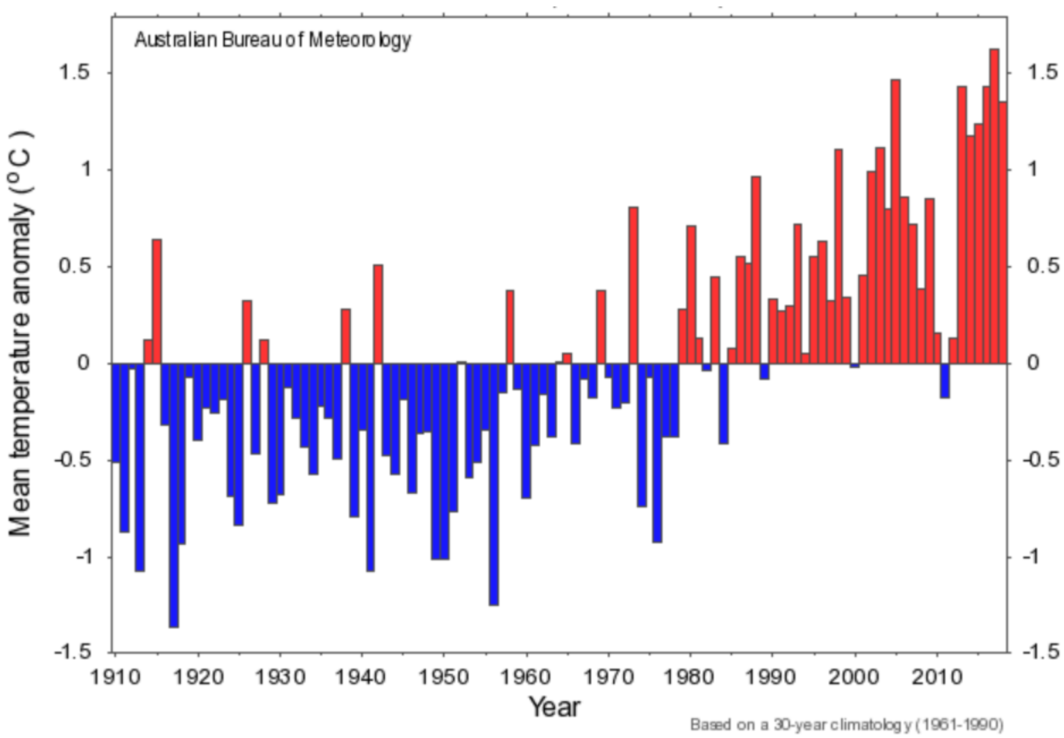

Figure 4-1 Annual mean temperature change (1910 to 2018)

Source: Bureau of Meteorology

Rainfall across the region varies based on the presence of topographical features such as the Snowy Mountains and Great Dividing Range, as well as the influence of ocean temperatures along the coastal fringes. Annual averages for the coastal areas are around 1,000 mm to 1,200 mm of rainfall. **Figure 4-2** shows coastal erosion and infrastructure damage at Pambula Beach resulting from a combination of extreme rainfall, high winds and king tide storm surge in 2016.

The Forest Fire Danger Index (FFDI) for the region suggests on average, the Project area experiences around 1.1 severe fire weather days per year (where the FFDI > 50), while the average annual FFDI is around 5.2, which indicates low to moderate fire weather.

To highlight these observed climate conditions, a number of key extreme weather events affected not only the existing STP, but also the surrounding region. These included:

- a flash flooding event in 2014 that resulted in local streets of Merimbula being inundated by up to 100 mm of flood waters[1];
- a severe to extreme heatwave event in 2018 impacting outdoor activities[2]; and

[1] Refer: https://www.abc.net.au/news/2014-09-19/more-storm/5754828
[2] Refer: https://www.merimbulanewsweekly.com.au/story/5175056/hello-hot-weather/

- an extreme rainfall event in 2018 which resulted in 24-hour rainfall totals exceeding 150 mm[3].

These events, among others demonstrate the magnitude and potential consequences of extreme events, the effects of which are expected to worsen in the future.

Figure 4-2 Damage to Pambula Beach (2016)

Source: Merimbula Weekly, 2016.

Figure 4-3 Flood waters in Merimbula

Source: ABC, 2014.

4.3 Detailed climate projections

The *IPCC Fifth Assessment Report* (AR5, 2013) states with high confidence, that Australia is already experiencing impacts from recent climate change, including a greater frequency and severity of extreme weather events. As a result, it is especially important to understand the 'most likely' and 'worst case' implications of climate change on high-value infrastructure, including the Project.

A summary of the current climate science available for the Southern Slopes Cluster Report (CSIRO and BOM, 2015) and the South East and Tablelands Climate Change Snapshot (OEH, 2014) are provided below in **Table 4.2**.

[3] Refer: https://www.begadistrictnews.com.au/story/5810294/severe-storm-warning-for-far-south-coast-flood-watch-issued/

Table 4.2 Detailed climate change projections[1]

Climate variable	Baseline data[2]	NARCliM AdaptNSW (OEH)		Climate Futures CSIRO and BOM	
		2030	2070	2030	2090
		SRES A2[3] (high emissions)	SRES A2 (high emissions)	RCP 8.5[4] (high emissions)	RCP 8.5 (high emissions)
Average daily annual temperature (°C)	18°C and 24°C Summer 8°C and 12°C Winter	+0.7°C (+0.5 – 0.8)	+2.0°C (+1.6 – 2.3)	+0.8°C (+0.5 – 1.1)	+3.1°C (2.5 – 4)
Average maximum temperature (°C)		+0.7°C (+0.5 – 1.0)	+2.1°C (+1.8 – 2.5)	+0.8°C (+0.6 – 1.2)	+3.5°C (2.5 – 4.3)
Average minimum temperature (°C)		+0.6°C (+0.4 – 0.7)	+2.0°C (+1.4 – 2.4)	+0.8°C (+0.5 – 1.1)	+2.9°C (+2.4 – 3.8)
Extreme heat days (above 35 °C)	< 10 days	+2.7 days (+0.7 – 4.5)	+8.2 days (+4.3 – 11.1)	13 days in total (12 – 15)*	24 days in total (19 to 32)
Average annual rainfall (% change)	1,000 to 1,200mm	-1.8% (-9.9% – +6.0%)	+1.4% (-6.4% – +9.9%)	-1% (-7% – +2%)	-5% (-19% – +5%)
Extreme rainfall (>125 mm in 24 hours)		Extreme rainfall events to increase in intensity and severity			
Fire weather (number of days/year FFDI[5] > 50)	1.1 days	+0.1 days (-0.2 – +0.4 range)	+0.5 days (-0.1 – +1.3 days)	1.2	2.1
Drought[6]		Both time spent in drought and occurrence of drought are anticipated to increase in intensity and severity.			
Solar radiation (% change)		N/A	N/A	+1.3% (+0.1% – 2.5%)	+3.1% (+0.3% – 6.8%)
Evapotranspiration (% change)		N/A	N/A	+4.3% (+2.2% – 6.1%)	+14.4% (+9.5% – 22.2%)
Sea level rise (m)[7]		N/A	N/A	0.1 m (0.1 – 0.27)	0.6 m (0.4 – 0.8)
Sea surface temperature (°C)[7]		N/A	N/A	+0.6 (0.3 – 0.9)	+2.3 (1.9 – 3.8)
Sea surface salinity[7]		N/A	N/A	-0.03 (-0.1 – +0.1)	+0.1 (-0.3 – +0.4)

Notes:

1 Quantitative results presented as model median (50th percentile) value, with 10 to 90 percentile range in brackets
2 NARCliM changes relative to 1990 to 2009 baseline, CSIRO and BoM changes relative to 1986 to 2005 baseline
3 The SRES A2 is the high emissions trajectory resulting from the Intergovernmental Panel on Climate Change Fourth Assessment Report
4 The RCP 8.5 is the high emissions scenario resulting from the Intergovernmental Panel on Climate Change Fifth Assessment Report
5 The Forest Fire Daily Index (FFDI) combines observations of temperature, humidity and wind speed. Fire weather is classified as severe when the FFDI is above 50. Data is for Nowra FFDI station – nearest to the Project area
6 As drought conditions are directly linked to corresponding rainfall projections, there is uncertainty regarding these projections. Rainfall is dependent on local climate drivers including topography with most models showing contrasting patterns and trajectories
7 Data for oceanic variables are taken from the Stony Point monitoring station – closest to the Project

4.3.1 Mean temperature

There is strong agreement on the direction and magnitude of temperature changes among global climate models and downscaling results and as a result, there is very high confidence in substantial warming for the annual and seasonal projections for daily mean, maximum and minimum surface air temperature for a range of emissions scenarios. On the whole, coastal regions including the Southern Slopes cluster, are projected to warm at a slightly lower rate when compared to inland regions.

Changes in mean temperature that can affect sewage treatment infrastructure largely occur at the extremes, for instance increasing the length of bushfire season, including increasing the likelihood of events occurring that could disrupt service or require additional treatment (e.g. ash accumulation) or resulting in increased evapotranspiration rates, reducing the quantity of stored treated wastewater in open air lagoons.

4.3.2 Extreme temperature

As with mean temperature, extreme heat days are projected to increase in both duration and intensity over time, including a noticeable increase in the number of warm spell days (days > 35°C). In addition to exacerbating impacts borne from changes in mean temperature (e.g. raising the FFDI), extreme heat days have the added effect of impacting on the STP operations through changes to aeration and digestion requirements and increasing the risk of heat exhaustion/stress for workers.

4.3.3 Mean rainfall and sea level pressure

Changes in rainfall pattern have generally indicated a decline in the amount of annual rainfall over the past 60 years with some seasonal variation and smaller periods of heavily wet years and dry years (e.g. Millennial Drought). Global projections show a continued reduction in annual rainfall in the future, however with some variability both seasonally and annually.

Of importance to mean rainfall are the position and intensity of sub-tropical ridges which create areas of high pressure that result in drier conditions across the region. Projections suggest that the intensity of these sub-tropical ridges are likely to continue to increase in the future, further resulting in reduced rainfall totals, particularly during the winter and spring.

Changes to mean rainfall that could influence STP operations include disruption of expected treatment volumes/flow and higher variability in expected storage requirements due to uncertainty.

4.3.4 Extreme rainfall and flooding

The frequency of heavy rainfall events and associated flooding is projected to increase in many regions of the Southern Slopes, even where projected changes to average rainfall are small or negative. In a warming climate, heavy rainfall events are expected to increase in magnitude mainly due to a warmer atmosphere being able to hold more moisture (Sherwood et al., 2010).

Increased intensities of rainfall can cause flash flooding across the Project area resulting in impacts such as overtopping of open-air lagoons and sludge ponds, loss of access to critical areas and inundation of intake pipes/screens resulting in disruption of treatment processes. **Figure 4-4** highlights the current exposure of the STP site to a probable maximum flood (PMF) event. As the Merimbula and Back Lake Flood Study (from which this figure was extracted; Cardno, 2017) did not take into consideration detailed climate change modelling including all sea level rise projections, entrance conditions and increased intensities of rainfall, conditions are expected to be worse in the future.

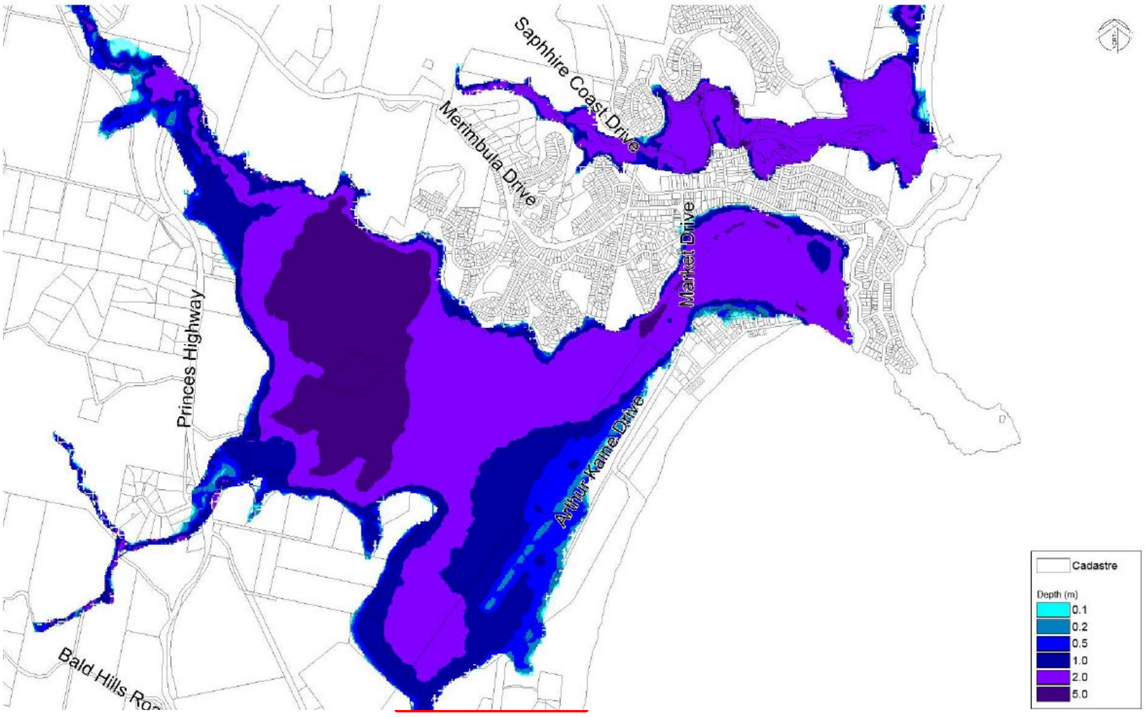

Figure 4-4 Probable Maximum depth (PMF), with Merimbula STP located within red boundary

Source: Merimbula and Back Lake Flood Studies, 2016.

4.3.5 Drought

Both the duration and frequency of time spent in drought is projected to increase in the future. The duration and frequency are directly related to reductions in annual precipitation and increases in high pressure systems which further result in dry conditions. Coastal regions fare slightly better owing to the increased incidence of rainfall in the coastal areas which limit the impacts resulting from drought.

Drought is likely to impact on operation of the STP through changes to inflow resulting from water restrictions and reductions in groundwater infiltration (through lowering of the water table), as well as an increase in dust/particulate infiltration into the STP screens. From a positive perspective, increased incidence of drought would support the increased re-use of treated wastewater, minimising the need to use the diffuser and ocean outfall for discharge.

4.3.6 Bushfire weather

Given this strong dependency on the weather, climate change is likely have a significant impact on future fire weather (e.g. Hennessy et al., 2005; Lucas et al., 2007; Williams et al., 2009; Clarke et al., 2011; Grose et al., 2014). Results of previous studies and reviewing trends project that there is likely be a tendency towards increased and harsher fire conditions in the future. This is expected to be exacerbated by changing rainfall trends (reduction in average rainfall), increased drought conditions (bushfire fuel) and higher winds.

Bushfire could impact on STP operations due to smoke and ash infiltrating the treatment processes, severing access for delivery of chemicals and personnel access as well as a risk to personnel having to work during bushfire events.

4.3.7 Sea level rise

Observations of sea levels have shown an increase year on year since 1966 (an average of 2.1 mm/year) with an accelerated rise since 1993 (around 3.1 mm/year). This trend is projected to increase into the future with a high-end estimate of 0.2 m of global sea level rise by 2030 and nearly 0.9 m of global sea level rise by 2090. However, if key global processes are further disrupted (e.g. collapse of the Antarctic ice sheet), sea levels are likely to be several tenths of a metre higher.

Rising seas could impact on the STP and ocean outfall pipeline through increased erosion and elevation of the surf zone, potentially uncovering the buried portion of the outfall pipeline as well as permanent inundation of both the STP and surrounding road network. **Figure 4-5** shows the existing and relatively unimpacted STP in relation to a projected 0.9 m sea level rise, which is consistent with NSW Government climate change projections and based on CoastAdapt mapping (Coastal Risk Australia, 2019). A sea level rise of 0.9 m for the STP site is consistent with the globally projected rise of 0.9 m (and 0.8 m projected for the South East and Tablelands region) as the projections below account for local conditions (including projected rises, topography and bathymetric conditions of Merimbula Bay and Merimbula Lake) which may be slightly less than global projections.

Notwithstanding, consideration of a 0.9 m future increase in sea levels has also been accounted for in the *Merimbula Lake and Back Lake Flood Study* (Cardno, 2017). This study has shown that while erosional and depositional changes (which may facilitate ecosystem migration) are likely to occur as a result of sea level rise throughout Merimbula Bay and Merimbula Lake, these changes are unlikely to impact the STP site due to the existing elevation and vegetative buffers (mangroves) providing protection from tidal inundation. As detailed in the study, changes are likely to be located at the Merimbula Lake entrance (entrance berm experiencing higher deposition and difficulty in maintaining access) as a result of regular tidal flow and along the backside (western side) of Merimbula Lake itself where the topography is lower and has greater exposure to higher tides. Note that the *Bega Valley Shire Coastal Processes and Hazards Definition Study* (BMT WBM, 2015) also includes shoreline recession (including from sea-level rise) and lake entrance changes as a risk to the Merimbula Beach and Lake area, which is discussed further in **Chapter 10 Marine and Coastal Processes** of the EIS for further information).

As noted above, there is capacity for subsequent ecosystem migration as a result of sea level rise, as a result of associated erosion and depositional changes and also the higher sea levels; these changes include both marine and terrestrial ecosystem migrations (e.g. changes to lake, beach and dune morphology). A higher sea level would ultimately extend the marine ecosystem to the new limits of the ocean, and changes to the morphology of the lake, beach and dunal areas would bring about changes to current ecosystem habitation areas. Although these changes are unlikely to impact the STP site (as noted above), they may ultimately impact on the buried portion of the ocean outfall pipeline near the beach and surf zone. This risk is explored further in **Table 6-2**.

Note that the indirect impacts of climate change-related sea level rise on marine species is also discussed in the EIS in **Appendix G Marine ecology assessment report**.

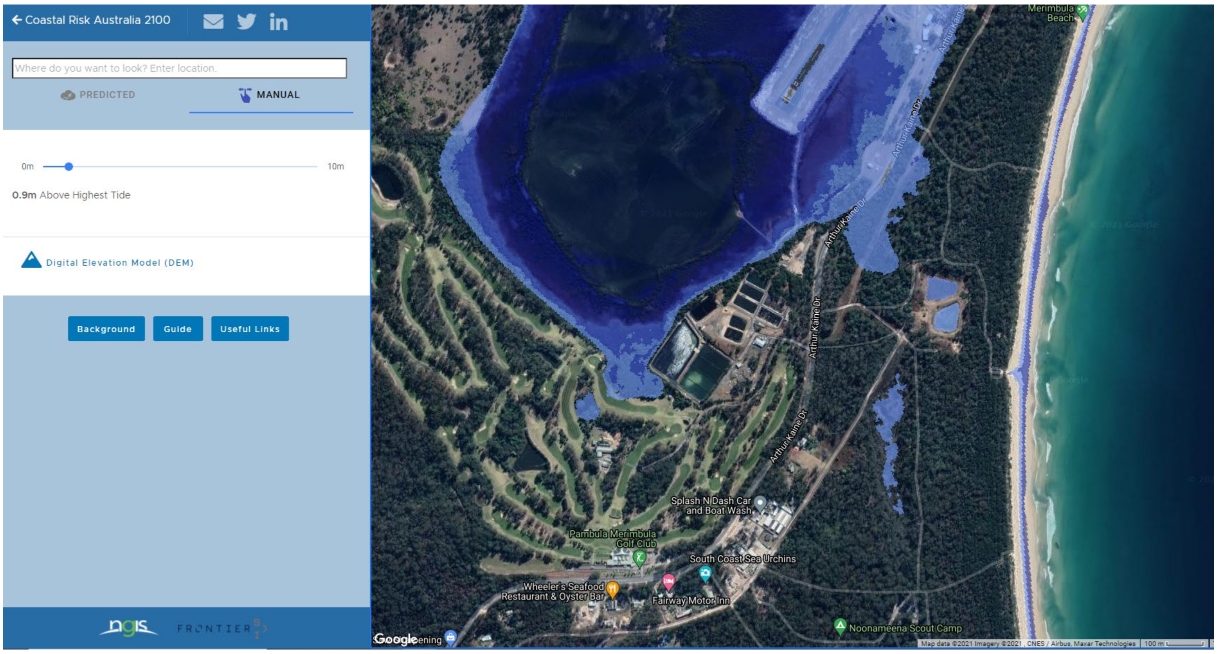

Figure 4-5 Sea level rise of 0.9m, with Merimbula STP located within red boundary (Source: Coastal Risk Australia, 2019).

4.3.8 Extreme storms

As with the majority of the east coast of Australia, East Coast low pressure systems and cut-off low pressure systems are expected to decrease in volume, however there is some indication that the average intensity of these storms may increase. This projected increase largely explains the projected increases in seasonal rainfall intensity changes.

The risk to Merimbula Beach from storm events and coastal inundation is also included in the *Bega Valley Shire Coastal Processes and Hazards Definition Study* (BMT WBM, 2015) (refer to **Chapter 10 Marine and Coastal Processes** of the EIS for further information).

Extreme storms can result in direct damage to the STP through falling debris, high winds and water seepage into critical infrastructure. Rainfall associated with these events are often heavy, resulting in increased volumes of flow into the STP (requiring treatment) and longer periods where the demand for reclaimed water remains low. More critically, given the location of the STP and ocean outfall pipeline along the shoreline, changes to erosion and deposition as a result of disruption of the current could result in erosion along the beach and surf zone (uncovering the pipeline) or deposition further offshore, burying critical ocean outfall infrastructure (e.g. diffuser heads).

4.3.9 Solar radiation and evapotranspiration

While there is likely only to be minimal changes to solar radiation and evapotranspiration rates in the near term, there is expected to be larger changes in the long term.

An increase in the amount of solar radiation and ultimately higher evapotranspiration rates could result in increased loss of water in storage tanks, increasing concentrations and ultimately requiring changes to the treatment process to account for these changes. Increasing solar radiation may also result in accelerated deterioration of components, including rubber fittings, facades and other site infrastructure. External to the STP, increased evapotranspiration is likely to result in increased demand from end users, putting additional pressure on the STP for treated wastewater.

5.0 Construction impact assessment

Risks for construction resulting from a changing climate were not identified as part of the risk assessment process, as construction would be complete within the next few years. However, changes in the climate over this period would not be too dissimilar to current conditions.

Given previous events experienced in and around the STP and with consideration to observed trends, risks to construction could occur by way of physical damage, reduced capacity, and potential risks to human health and safety. The increased frequency and intensity of extreme weather events such as extreme rainfall, bushfires and rising temperatures are already causing strain on existing infrastructure. More extreme weather events are likely to interrupt the construction process (Thom *et al*., 2010).

Based on these past events and trends, risks to the construction process could include:

- extreme rainfall and storm events resulting in the inundation or damage to the Project area, resulting in delays to the construction schedule and associated cost implications;
- uncertainty around extreme events impacting design conditions/requirements leading to a potential over or under design of infrastructure;
- increased intensity and frequency of extreme rainfall events increasing load on temporary water treatment devices, and erosion control devices, increasing flooding events and affecting water quality treatment levels achieved; and
- increased intensity and frequency of extreme events (bushfire, flooding, storms) resulting in road closures or other access constraints, congestion, and increased risk of road incidents during construction, affecting workers and/or equipment accessing sites resulting in delays in program and lost days.

As there is a high level of uncertainty to the timing and impact of any extreme events, it is recommended that BVSC incorporate contingency in both the schedule and budget to account for any potential delays in the program and/or construction.

6.0 Operational impact assessment

Based on the CCRAA for the Project, increases to the intensity of extreme rainfall, flooding, storm events and sea level rise would present the highest risk in both the near term and long term. Risks associated with these events include:

- inundation of the STP from rainfall and/or sea level rise resulting in damage or unregulated backflow/discharge into surrounding areas;
- decreased safety of personnel working on-site or trying to access the Project area due to an extreme event; and
- accelerated erosion in the surf zone due to increasing sea levels and extreme storm events potentially uncovering the outfall pipeline.

6.1 Summary of operational risk assessment

The preliminary climate risk assessment identified a total of 39 climate change risk statements for the Project. During the course of the workshop, an additional four climate change risks were identified, bringing the total to 43 climate change risks for the Project (both direct and indirect risks). Additional risks were identified for bushfire, extreme rainfall and sea level rise. Based on this revised risk assessment, there would be six high risks to the Project by 2030, increasing to 22 high risks and one extreme (very high) risk by 2090, representing 53 per cent of the total assessment. **Table 6-1** provides a summary of the revised risk assessment while **Table 6-2** details the revised risk assessment.

Risks have been grouped by the following climate variables:

- extreme rainfall/flood/storm events – 15 risks;
- extreme heat – seven risks;
- bushfire events – seven risks;
- sea level rise – six risks;
- increased CO2 emission – four risks; and
- mean rainfall change/drought – four risks.

Table 6-1 Summary of risk assessment

Risk rating	Year 2030	Percentage	Year 2090	Percentage
Low	7	16%	2	5%
Medium	30	70%	18	42%
High	6	14%	22	51%
Very High (Extreme)	0	0%	1	2%
Total Risks	43	100%	43	100%

Table 6-2 presents the CCRAA for the Project; with risk ratings evaluated first using the BVSC *Enterprise Risk Management Framework* and assessment criteria as well as in consultation with Project team members during the workshop. This combination allowed an appropriate determination of the consequence and likelihood of each risk.

Table 6-2 Climate change risks to Project operation

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
An increase in mean temperature and extreme heat (days over 35°C) resulting in:							
Direct Risks							
EH-1	Risks to health and safety of workforce working through heat stress or heat exhaustion	Possible	Major	**High**	Likely	Major	**High**
EH-2	An increase in the frequency of electrical system outages (including pump stations, communications equipment, treatment processes (e.g. UV), testing equipment and other critical systems) resulting from an increase in power demand/reduced efficiency of wiring	Possible	Minor	**Medium**	Likely	Minor	**Medium**
EH-3	Additional requirements for outdoor areas of respite (e.g. shade structures)	Likely	Minor	**Medium**	Almost Certain	Minor	**High**
EH-4	Accelerated degradation of infrastructure (predominately rubber fittings/casings/valves) leading to increased operational and maintenance costs (e.g. ongoing repairs)	Unlikely	Minor	**Low**	Possible	Minor	**Medium**
EH-5	Changes to conditions (e.g. higher water temperatures) for algae, bacteria and other organisms in the system which may have an adverse impact on treatment (e.g. additional chemical dosing requirements)	Possible	Minor	**Medium**	Likely	Minor	**Medium**
EH-6	Increased evaporation in sludge tanks and other storage/processing systems resulting in changes to operational requirements (e.g. increased concentrations of dissolved solids)	Possible	Insignificant	**Low**	Likely	Insignificant	**Medium**
Indirect Risks							
EH-7	Increased network power outages due to increased system demand (external sources) resulting in interruptions to operation and increased downtime of assets	Possible	Moderate	**Medium**	Likely	Moderate	**High**
An increase in the conditions for and incidence of bushfire resulting in:							
Direct Risks							
BF-1	Increased particulate matter (e.g. ash) in the intake and discharge water resulting in treatment method changes and nutrient loads	Possible	Minor	**Medium**	Possible	Minor	**Medium**
BF-2	Risk to health and safety of workforce through direct fire or indirect smoke during bushfire events (e.g. need to keep plant running)	Possible	Major	**High**	Possible	Major	**High**

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
BF-3	Damage to site infrastructure including both the main STP and ancillary infrastructure resulting in closure or lost processing time	Rare	Catastrophic	**Medium**	Possible	Major	**High**
BF-4	Loss of access to either primary (e.g. treatment) and ancillary functions (e.g. pump stations) of the Project area	Unlikely	Moderate	**Medium**	Possible	Moderate	**Medium**
Indirect Risks							
BF-5	Increased network power outages due to damage to substations resulting in interruptions to operation and increased downtime of assets	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
BF-6	Loss of surrounding road network due to bushfire event, resulting in loss of access to the STP (e.g. loss of chemical delivery)	Possible	Minor	**Medium**	Likely	Minor	**Medium**
BF-7	Loss of personnel due to surrounding bushfires (e.g. the need to take other actions or cannot physically reach the STP)	Possible	Minor	**Medium**	Likely	Minor	**Medium**
Changes to mean rainfall patterns and increased incidence and duration of drought resulting in:							
Direct Risks							
MRD-1	Erosion and movement resulting in the reduction in foundation integrity and potential structural failure	Rare	Catastrophic	**Medium**	Unlikely	Catastrophic	**High**
MRD-2	An increase in the amount of grit from dust and other particulates through the screens and into the STP	Possible	Minor	**Medium**	Likely	Minor	**Medium**
MRD-3	Water restrictions reducing the amount of flows through the sewerage system (e.g. outdoor watering infiltration) increasing septicity risk (e.g. odour, septic sewerage, corrosion)	Possible	Moderate	**Medium**	Likely	Moderate	**High**
MRD-4	A changing expected flow volume (either low flow or high flow periods) resulting in disruption to the treatment process	Possible	Moderate	**Medium**	Possible	Minor	**Medium**
Increased CO2 emissions/acidity (both oceanic and atmospheric) resulting in:							
CO-1	Accelerated corrosion and deterioration of intake and discharge concrete and steel infrastructure (through increased dissolved carbon in waste stream)	Rare	Major	**Medium**	Unlikely	Major	**Medium**
CO-2	An increase to dissolved carbon amounts in intake and discharge, resulting in changes to treatment methods (e.g. aeration requirements) and nutrient loads	Rare	Minor	**Low**	Unlikely	Minor	**Low**

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
CO-3	An increase to the acidity of rainfall leading to the accelerated deterioration of concrete structures (e.g. sludge lagoons, buildings)	Rare	Moderate	**Low**	Unlikely	Moderate	**Medium**
Indirect Risks							
CO-4	Changing oceanic conditions (e.g. increase acidity/decreased salinity) resulting in breaches of discharge limits into Merimbula Bay	Rare	Moderate	**Low**	Unlikely	Moderate	**Medium**
An increase in the severity and intensity of extreme rainfall, flooding and storm events resulting in:							
Direct Risks							
ERF-1	Malfunctioning of electrical equipment, including pump stations, dosing equipment, aerators, communications (e.g. telemetry systems) and associated circuitry due to submersion	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-2	Inundation of access roads causing potential isolation of assets	Possible	Minor	**Medium**	Likely	Minor	**Medium**
ERF-3	Increased risk of the STP not being able to handle more frequent and higher intensity peak flow, ultimately impacting treatment during peak wet weather flow periods	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-4	Inundation of the STP assets (e.g. from inadequate drainage, increased volumes of rainfall) and damage to the STP (civil structures), potentially requiring closure of the STP or backflow/unregulated discharge	Possible	Major	**High**	Likely	Major	**High**
ERF-5	Decreased safety of personnel working on-site during extreme events (e.g. workforce required on-site during a storm to address breaches or other infrastructure faults)	Likely	Major	**High**	Almost Certain	Major	**Extreme**
ERF-6	Overflow and unregulated discharge of lagoons, sludge storage areas, storm storage ponds or other plant processes, resulting in breach of EPA licence (e.g. Phosphate/Nitrate concentrations) for discharge and potential negative community concern	Possible	Major	**High**	Likely	Major	**High**
ERF-7	Increased potential for landslip/erosion due to increased overland wash and/or inundation of Merimbula Lake, resulting in reduced integrity of foundations and potential structural failure	Rare	Major	**Medium**	Unlikely	Major	**Medium**
ERF-8	Increased risk of mobilisation of fuels, oils, lubricants (chemical storage) and other contaminants (e.g. biosolids), resulting in contamination of surrounding areas	Possible	Moderate	**Medium**	Likely	Moderate	**High**

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
ERF-9	An increase and/or high grit volume/screening load to the STP	Likely	Minor	**Medium**	Almost Certain	Minor	**High**
ERF-10	Localised scour and erosion around drainage infrastructure due to increase flows	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-11	Accelerated degradation of materials and reduced life of buildings and structures such as the lagoons, above ground pipework and operational buildings	Rare	Minor	**Low**	Unlikely	Minor	**Low**
ERF-12	Accelerated erosion due to increased wave activity (storm tide) along the shoreline resulting in damage to site infrastructure	Unlikely	Major	**Medium**	Possible	Major	**High**
Indirect Risks							
ERF-13	Inundation or damage to the surrounding road network impeding access (e.g. personnel and/or deliveries) and potential isolation of assets	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-14	Faults and failures in the power network resulting in interruptions to power supply including increased down time of assets (e.g. pump stations, treatment equipment)	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-15	Increased stormwater runoff, increasing the turbidity and sediment load in Merimbula Bay, resulting in negative community perception	Possible	Moderate	**Medium**	Likely	Minor	**Medium**
An increase in sea levels resulting in:							
Direct Risks							
SLR-1	Permanent inundation of major site infrastructure (e.g. sludge lagoons, pump stations, access to site)	Rare	Catastrophic	**Medium**	Possible	Catastrophic	**High**
SLR-2	Accelerated erosion potentially uncovering the buried portion of the ocean outfall pipeline (within the surf zone)	Likely	Major	**High**	Likely	Major	**High**
SLR-3	Malfunctioning of electrical equipment, including dosing equipment, aerators, communications and associated circuitry due to submersion	Possible	Moderate	**Medium**	Likely	Moderate	**High**
SLR-4	Deposition from changing morphology resulting in the diffuser head being covered	Unlikely	Moderate	**Medium**	Likely	Moderate	**High**

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
Indirect Risks							
SLR-5	Inundation or damage to the surrounding road network impeding access and potential isolation of assets	Unlikely	Moderate	**Medium**	Likely	Moderate	**High**
SLR-6	Increased groundwater levels in the areas surrounding the STP resulting in increased pipeline pressure and salinity, resulting in seepage into the mains network	Unlikely	Minor	**Low**	Likely	Minor	**Medium**

7.0 Environmental management

7.1 Adaptation options

The ISCA IS Tool V1.2, Cli-2 Criteria require adaptation options to be identified for all high and extreme (very high when using BVSC's risk framework) risks. Adaptation options are proposed in this section to reduce risks to a tolerable threshold of medium (at minimum), where possible and practicable. Adaptation options may also reduce risks that were identified as being low (e.g. changes to treatment methods).

The following outlines mitigation and adaptation measures (mitigation and management measures) to reduce the impact of climate change risk to the Project. In some instances, a changing climate can result in beneficial outcomes, including improved conditions for aeration and treatment (from less cold nights). For the most part however, identified measures include a combined approach that addresses the avoidance of risk, designing out risk where possible and practicable, as well as procedures for the management of risks that may be unavoidable.

7.1.1 Current and planned actions

Table 7-1 outlines adaptation measures that have either been already considered as part of the design process, are currently underway, or would be undertaken prior to operation (planned). The nomination of these adaptation measures has resulted from discussions with design leads and technical specialists, review of Project information and documentation of existing BVSC operating practices.

In terms of timing, a "current" adaptation action is considered to be an action which has already been or will be integrated into the design process, while "planned" is considered to be an action that would be implemented during construction or operation specific to the Project or require an organisational operation change. The residual risk assessment would be updated periodically to account for any changes in the Project design or to reflect changes in BVSC operating procedure.

Furthermore, in accordance with best practice and current design standards, operations and maintenance practices, risk management and adaptation measures are typically incorporated into the pre-concept and concept designs. In addressing climate change adaptation, these measures include:

- undertaking additional modelling within the 'surf zone' around wave height, erosion and deposition to better understand the necessary trenching depth and underwater surfacing point of the ocean outfall pipeline;
- elevating critical equipment and systems above known flood levels; and
- providing further automation to the STP to minimise the personnel required to be on-site.

7.1.2 Potential actions

During the course of the workshop and in considering climate risks, a number of potential actions have been identified as adding value or reducing the exposure of the STP to a changing climate. These actions are briefly described below, however as they are not part of the Project, they have not been included in the residual risk assessment. Verification and feasibility of these measures should be undertaken in future by BVSC to determine their practicality. Potential actions include:

- adjusting operational procedures for processing to respond to changing conditions of intake wastewater – for example trigger points for when temperatures or concentrations exceed certain thresholds, or reseeding biomass requirements during periods of low flow;
- considering the addition of additional screens or increasing the capacity of sludge handling to account for increased potential of ash or other particulate matter (e.g. dust) entering the treatment process; and
- providing flexibility and adaptability in the design (including consideration of future replacement of components/equipment) to allow for future upgrades to respond to a changing climate/changing conditions.

7.2 Residual risk assessment

A residual risk assessment for the Project was undertaken to apply the relevant adaptation measures identified in the above section for all ‘very high’ and ‘high’ risks as shown in **Table 6-2**. Based on the application of the adaptation measures, no residual ‘very high’ or ‘high’ risk ratings remain for the Project, which satisfies both SEARs and ISCA requirements. There were no very high (extreme) risks identified for the Project.

As part of the residual risk assessment, individual, specific adaptation measures have been applied to multiple risks to help reduce the potential risks to the Project. It is anticipated that as the Project develops, this register would continue to be used to track compliance and progress against the adaptation measures to assist in reducing the risk exposure of the Project.

Considering v.1.2 of the ISCA IS Rating Scheme Cli-2 criteria, adaptation options for all high and extreme (very high using the BVSC Enterprise Risk Management Framework) risks and a percentage of medium priority risks are identified with appropriate measures implemented.

Refer to **Appendix B** of this assessment for the residual risk table. Note that risks rated as ‘low’ were excluded from the residual risk assessment as they do not require adaptation actions to be identified, nor the risk treated.

Table 7-1 Current and planned risk mitigation and climate adaptation options

Adaptation option	Applicable risk(s)	Associated Risk ID	Current or planned	Responsibility
Design the outfall pipe (both size and operational timing) to respond to increased rainfall intensities and volumes to facilitate high flow events and avoid disruptions in processing.	Extreme rainfall and floods	ERF-3, ERF_4, ERF-6, MRD-4	Current	Design team
Provide upgrades to the STP (e.g. UV disinfection) to allow for further automation and remote operation to reduce the number of personnel required on-site.	All	EH-1, BF-2, BF-3, ERF-5, ERF-13, SLR-5	Current	Design team
Update operational procedures to provide for a weekly flush, pigging or physical removal of marine organisms along the ocean outfall pipeline to prevent odours, septicity risk and degradation.	Mean rainfall/drought	MRD-3	Current	Design team/BVSC
Construct the ocean outfall pipeline out of high-density polyethylene (as opposed to concrete) to minimise the risk of accelerated degradation and structural failure.	Mean rainfall/drought	MRD-1	Current	Design team
Provide for the use of remote operated vehicles and regular diver maintenance to allow for the diffuser head of the ocean outfall pipeline to remain open.	Extreme storms and sea level rise	SLR-4	Current	BVSC
Underground pumps and pipeline network where feasible to prevent exposure and direct damage.	Bushfire	BF-3	Current	Design team, BVSC
Design to consider connections, if possible, to multiple substations to reduce the reliance on only one substation in the event of a power outage.	All	EH-7, BF-5, ERF-14	Current	Design team, BVSC
Undertake additional modelling of potential changes (including future changes) to surf zone morphology and wave impacts to determine the appropriate ocean outfall pipeline depth (for the buried portion of the pipeline).	Extreme storms and sea level rise	ERF-12, SLR-2, SLR-4	Planned	Design team
Update operational procedures to increase the frequency of erosion monitoring to protect against buried assets being uncovered.	Extreme storms and sea level rise	ERF-12, SLR-2, SLR-4	Planned	BVSC
Provide additional shade through the use of covered dosing sheds for incidental respite from extreme heat/solar exposure.	Extreme heat	EH-1, EH-3	Planned	Design team
Undertake a review of current BVSC standard operational procedures and policies to incorporate extreme weather events (e.g. heat waves, bushfire events, etc.). This includes event notification, use of appropriate PPE and changes to operations during extreme events.	All	EH-1, BF-2, ERF-5	Planned	BVSC
Elevating critical equipment and systems above known flood levels.	Extreme rainfall and floods	ERF-1, ERF-8, SLR-1, SLR-3	Planned	Design team

Adaptation option	Applicable risk(s)	Associated Risk ID	Current or planned	Responsibility
Engage experienced contractors to advise on key constructability concerns and challenges including shifting soils and foundational integrity of site infrastructure and the pipeline network.	Mean rainfall/drought, extreme rainfall	MRD-1	Planned	Design team, BVSC
Incorporate the use of solar PV, battery storage and/or backup generators where possible on-site for critical systems to minimise the impact of power disruption.	All	EH-7, ERF-14	Planned	Design team
Undertake community outreach to educate the community around potential concerns (e.g. odour, water restrictions, discolouration, etc.).	Mean rainfall/drought	MRD-3	Planned	BVSC
Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow.	Extreme rainfall/flooding	ERF-5, ERF-6, ERF-7, ERF-10	Planned	Design team

8.0 Conclusion

8.1 Summary

With the implementation of adaptation measures, the residual risk assessment has resulted in no remaining extreme (very high) or high risks.

Based on the CCRAA for the Project (and considering the STP site as a whole), increases to the intensity of extreme rainfall, flooding, storm events and sea level rise would present the highest risk in both the near term and long term. Risks associated with these events include:

- inundation of the STP from rainfall and/or sea level rise resulting in damage or unregulated backflow/discharge into surrounding areas;
- decreased safety of personnel working on-site or trying to access the Project area due to an extreme event; and
- accelerated erosion in the surf zone due to increasing sea levels and extreme storm events potentially uncovering the buried portion of the ocean outfall pipeline.

A residual risk assessment was conducted based on the adaptation measures identified in **Table 7-1** with an appropriate responsibility and timing taken into consideration. Adaptation measures were identified for all 'very high' and 'high' risk.

It is anticipated that all high risks identified for the works can be reduced to a residual risk rating of at least medium through the implementation of the recommended risk management and adaptation measures through the Project's design, construction and operation. As shown in **Appendix B**, several of the risk management and adaptation measures can be applied to more than one projected climate impact.

Risk management and adaptation measures identified in this report have been previously considered as part of design and construction, planned for future phases (detailed design, operational procedures) or have been recommended as a potential action to provide certainty that risks to the works are considered and mitigated, where possible and practicable.

While uncertainty regarding future climate projections exists, particularly to 2090, the adaptation measures identified as part of this CCRAA would result in a lowering of residual risks to the STP and ocean outfall pipeline across future scenarios.

8.2 Recommendations

It is recommended that risk management and adaptation measures identified for medium, high or very high risks in this report be carried forward into the next stages of design and construction to provide certainty that these risks are considered and mitigated, where possible and practicable. Furthermore, in anticipation of future operation, BVSC should begin to review and update existing operations and maintenance procedures to account for extreme events.

From an ISCA perspective, the CCRA presented in this report has considered and addressed information that would be required for compliance with both the Cli-1 and Cli-2 credit categories, subject to approval and verification of adaptation measures. As part of the ISCA submission process however, evidence of initiatives and adaptation actions identified within this report must be provided including demonstration of how the adaptation actions have been and/or would be implemented. The ability to produce this information and address adaptation actions should be considered during subsequent phases of the proposed works for feasibility.

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10.0 Glossary and abbreviations

Term	Description
AS	Australian Standard
BoM	Bureau of Meteorology
BVSC	Bega Valley Shire Council
CCRAA	Climate change risk and adaptation assessment
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FFDI	Forest Fire Danger Index
IS	Infrastructure Sustainability
ISCA	Infrastructure Sustainability Council of Australia
ML	Megalitre
NARCliM	New South Wales and Australian Capital Territory Regional Climate Modelling
NSW	New South Wales
NZS	New Zealand Standard
PMF	Probable Maximum Flood
RCP	Representative Concentration Pathway
SEARs	Secretary’s Environmental Assessment Requirements
SRES	Special Report on Emissions Scenarios
STP	Sewage Treatment Plant

Appendix A

Workshop Materials

AECOM

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Agenda of Meeting

Bega Valley Shire Council – Sewage Treatment Plant & Ocean Outfall

Subject	Climate Risk Assessment Workshop	Page	1
Venue	Level 8, 420 George Street and by teleconference	Time	10:00 am to 12:30 pm
Participants	As per calendar invite		
Apologies	None		
		Date	04-December-2019
Distribution	As above		

No	Item	Time
1	Welcome and Purpose of Workshop	5 mins
2	Overview, context and introductions	10 mins
3	Observed and projected changes to the climate	10 mins
4	Potential climate impacts	10 mins
5	Group Activity 1: Validation of climate risk (Group)	50 mins
7	Adaptation planning	10 mins
8	Group Activity 2: Identification of adaptation options (Group)	50 mins
9	Wrap up and next steps	5 mins

Total duration 2.5 hours

Risk assessment matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Medium	High	High	Very High	Very High
Likely	Medium	Medium	High	High	Very High
Possible	Low	Medium	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

Likelihood criteria

Likelihood	Description	Probability of occurrence
Almost Certain	Expected to occur in most circumstances	Within 1 year
Likely	Will probably occur in most circumstances	Within 2 years
Possible	Might occur at some time	Within 3-5 years
Unlikely	Could occur at some time	Within 10-20 years
Rare	May occur in exceptional circumstances	More than 20 years

Consequence criteria

Consequence Levels	Risk Categories Consequence Descriptors				
	Environmental	Financial	Legal	Reputational	Health / Safety
Catastrophic	Irreversible long-term	>$1m	Cessation of Activities	Censure / Inquiry	Death, severe permanent disablement or adverse health effect
Major	Wide long-term	$500k - $1m	Successful Prosecution	High media	Hospitalisation, serious injuries resulting in long term absences and adverse health effect
Moderate	Wide short-term	$100k - $500k	Enforceable undertaking or fine	Moderate media	Medical treatment required and/or some lost time
Minor	Minor short-term	$20k - $100k	Compliance breach resulting in corrective action	Minor media	Medical treatment required, No lost time
Insignificant	Incident not requiring intervention	< $20k	Technical compliance breach with limited material impact	Incident that does not receive any coverage	First Aid injury, No lost time

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
An increase in mean temperature and extreme heat (days over 35°C) resulting in:							
EH-1	Risks to health and safety of staff working through heat stress or heat exhaustion	Possible	Major	**High**	Likely	Major	**High**
EH-2	An increase in the frequency of electrical system outages (including pumping stations, communications equipment, testing equipment and other critical systems) resulting from an increase in power demand / reduced efficiency of wiring	Possible	Minor	**Medium**	Likely	Minor	**Medium**
EH-3	Additional requirements for cooling in buildings (e.g. HVAC) and outdoor areas of respite (e.g. shade structures)	Likely	Minor	**Medium**	Almost Certain	Minor	**High**
EH-4	Accelerated degradation of infrastructure (predominately rubber fittings / casings / valves) leading to increased operational and maintenance costs (e.g. ongoing repairs)	Unlikely	Minor	**Low**	Possible	Minor	**Medium**
EH-5	Changes to conditions (e.g. higher water temperatures) for algae, bacteria and other organisms in the system which may have an adverse impact on treatment (e.g. additional chemical dosing requirements)	Possible	Minor	**Medium**	Likely	Minor	**Medium**
EH-6	Increased evaporation in sludge tanks and other open-air systems resulting in changes to operational requirements (e.g. increased concentrations of dissolved solids)	Possible	Minor	**Medium**	Likely	Minor	**Medium**
EH-7	Increased network power outages due to increased system demand (external sources) resulting in interruptions to operation and increased downtime of assets	Possible	Moderate	**Medium**	Likely	Moderate	**High**
An increase in the conditions for and incidence of bushfire resulting in:							
BF-1	Increased particulate matter (e.g. ash) in the intake and discharge water resulting in treatment method changes and nutrient loads	Possible	Minor	**Medium**	Possible	Minor	**Medium**
BF-2	Risk to health and safety of staff through direct fire or indirect smoke during bushfire events (e.g. need to keep plant running / fix issue)	Possible	Major	**High**	Possible	Major	**High**
BF-3	Damage to site infrastructure including both the main plant and ancillary infrastructure resulting in closure or lost processing time	Unlikely	Major	**Medium**	Possible	Major	**High**
BF-4	Loss of access to either primary (e.g. treatment) and ancillary functions (e.g. pumping) of the site	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
BF-5	Increased network power outages due to damage to substations resulting in interruptions to operation and increased downtime of assets	Possible	Moderate	**Medium**	Possible	Moderate	**Medium**
Changes to mean rainfall patterns and increased incidence and duration of drought resulting in:							
MRD-1	Soil subsidence, erosion and cracking resulting in the reduction in foundation integrity and potential structural failure, particularly the outfall pipe	Rare	Catastrophic	**Medium**	Unlikely	Catastrophic	**High**
MRD-2	An increase in the amount of grit from dust and other particulates through the screens and into the STP	Possible	Minor	**Medium**	Likely	Minor	**Medium**
MRD-3	Water restrictions reducing the amount of flows through the sewer (e.g. outdoor watering infiltration) increasing septicity risk (e.g. odour, septic sewerage, corrosion)	Possible	Moderate	**Medium**	Likely	Moderate	**High**
MRD-4	A changing expected flow volume (either low flow or high flow periods) resulting in disruption to the treatment process	Unlikely	Minor	**Low**	Possible	Minor	**Medium**
Increased CO2 emissions / acidity (both oceanic and atmospheric) resulting in:							
CO-1	Accelerated corrosion and deterioration of intake and discharge concrete piping (through increased dissolved carbon in waste stream)	Rare	Major	**Medium**	Unlikely	Major	**Medium**
CO-2	An increase to dissolved carbon amounts in intake and discharge, resulting in changes to treatment methods (e.g. aeration requirements) and nutrient loads	Rare	Minor	**Low**	Unlikely	Minor	**Low**
CO-3	An increase to the acidity of rainfall leading to the accelerated deterioration of concrete structures (e.g. sludge lagoons, buildings)	Rare	Moderate	**Low**	Unlikely	Moderate	**Medium**
CO-4	Changing oceanic conditions (e.g. increase acidity / decreased salinity) resulting in breaches of discharge limits into Merimbula Bay	Rare	Moderate	**Low**	Unlikely	Moderate	**Medium**

		2030			2090		
Risk ID	**Risk Source**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
An increase in the severity and intensity of extreme rainfall, flooding and storm events resulting in:							
ERF-1	Malfunctioning of electrical equipment, including pump stations, dosing equipment, aerators, communications (e.g. telemetry systems) and associated circuitry due to submersion	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-2	Inundation of access roads causing potential isolation of assets	Possible	Minor	**Medium**	Likely	Minor	**Medium**
ERF-3	Increased risk of the STP not being able to handle more frequent and higher intensity peak flow, ultimately impacting treatment during peak wet weather flow periods	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-4	Inundation of the STP assets (e.g. from inadequate drainage, increased volumes of rainfall) and damage to the treatment plant (civil structures), potentially requiring plant closure or backflow / unregulated discharge	Possible	Major	**High**	Likely	Major	**High**
ERF-5	Decreased safety of personnel working onsite during extreme events (e.g. staff required onsite during a storm to address breaches or other infrastructure faults)	Likely	Major	**High**	Almost Certain	Major	**Extreme**
ERF-6	Overflow and unregulated discharge of lagoons, sludge storage areas, storm storage ponds or other plant processes, resulting in breach of EPA licencing (e.g. Phosphate / Nitrate concentrations) for discharge and potential negative community concern	Possible	Major	**High**	Likely	Major	**High**
ERF-7	Increased potential for landslip / erosion due to increased overland wash and/or inundation of the lake, resulting in reduced integrity of foundations and potential structural failure (e.g. maturation ponds / lagoons)	Rare	Catastrophic	**Medium**	Unlikely	Catastrophic	**High**
ERF-8	Increased risk of mobilisation of fuels, oils, lubricants (chemical storage) and other contaminants (e.g. biosolids), resulting in contamination of surrounding areas	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-9	An increase and/or high grit volume / screening load to the STP	Likely	Minor	**Medium**	Almost Certain	Minor	**High**
ERF-10	Localised scour and erosion around drainage infrastructure due to increase flows	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-11	Accelerated degradation of materials and reduced life of buildings and structures such as the lagoons, above ground pipework and operational buildings	Rare	Minor	**Low**	Unlikely	Minor	**Low**
ERF-12	Inundation or damage to the surrounding road network impeding access and potential isolation of assets	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-13	Faults and failures in the power network resulting in interruptions to power supply including increased down time of assets (e.g. pumping stations, treatment equipment)	Possible	Moderate	**Medium**	Likely	Moderate	**High**
ERF-14	Increased stormwater runoff, increasing the turbidity and sediment load in Merimbula Bay, resulting in increased dosing or reduction of outfall flows	Possible	Minor	**Medium**	Likely	Minor	**Medium**
An increase in sea levels resulting in:							
SLR-1	Permanent inundation of major site infrastructure (e.g. sludge lagoons, pumping stations)	Unlikely	Catastrophic	**High**	Likely	Catastrophic	**Extreme**
SLR-2	Accelerated erosion and inundation of the beach and dune system potentially uncovering the outfall pipe	Unlikely	Major	**Medium**	Likely	Major	**High**
SLR-3	Malfunctioning of electrical equipment, including dosing equipment, aerators, communications and associated circuitry due to submersion	Unlikely	Moderate	**Medium**	Likely	Moderate	**High**
SLR-4	Inundation or damage to the surrounding road network impeding access and potential isolation of assets	Unlikely	Moderate	**Medium**	Likely	Moderate	**High**

Risk ID	Risk Statement	Climate Variable	Likelihood (2030)	Consequence (2030)	Risk Rating (2030)

Adaptation Measure	Climate Variable	Current / Planned / Potential	Trigger	Timing	Responsibility

Appendix B

Residual Risk Assessment

		2030	2090							
Risk ID	**Risk Source**	**Risk Rating**	**Risk Rating**	**Adaptation Action**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
An increase in mean temperature and extreme heat (days over 35^{O}C) resulting in:										
Direct Risks										
EH-1	Risks to health and safety of workforce working through heat stress or heat exhaustion	**High**	**High**	Undertake a review of current BVSC standard operational procedures and policies to incorporate extreme weather events (e.g. heat waves, bushfire events, etc.). This includes event notification, use of appropriate PPE and changes to operations during extreme events. Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site. Provide additional shade through the use of covered dosing sheds for incidental respite from extreme heat/solar exposure.	Rare	Major	Medium	Unlikely	Major	Medium
EH-3	Additional requirements for outdoor areas of respite (e.g. shade structures)	**Medium**	**High**	Provide additional shade through the use of covered dosing sheds for incidental respite from extreme heat/solar exposure.	Likely	Insignificant	Medium	Almost Certain	Insignificant	Medium
Indirect Risks										
EH-7	Increased network power outages due to increased system demand (external sources) resulting in interruptions to operation and increased downtime of assets	**Medium**	**High**	Incorporate the use of solar PV, battery storage and/or backup generators where possible on-site for critical systems to minimise the impact of power disruption.. Design to consider connections, if possible, to multiple substations to reduce the reliance on only one substation in the event of a power outage.	Possible	Minor	Medium	Likely	Minor	Medium
An increase in the conditions for and incidence of bushfire resulting in:										
Direct Risks										
BF-2	Risk to health and safety of workforce through direct fire or indirect smoke during bushfire events (e.g. need to keep plant running)	**High**	**High**	Undertake a review of current BVSC standard operational procedures and policies to incorporate extreme weather events (e.g. heat waves, bushfire events, etc.). This includes event notification, use of appropriate PPE and changes to operations during extreme events. Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site.	Rare	Major	Medium	Unlikely	Major	Medium
BF-3	Damage to infrastructure including both the main STP and ancillary infrastructure resulting in closure or lost processing time	**Medium**	**High**	Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site. Underground pumps and pipeline network where feasible to prevent exposure and direct damage.	Rare	Major	Medium	Unlikely	Major	Medium
Changes to mean rainfall patterns and increased incidence and duration of drought resulting in:										
Direct Risks										
MRD-1	Erosion and movement resulting in the reduction in foundation integrity and potential structural failure	**Medium**	**High**	Construct the ocean outfall pipeline out of high density polyethylene (as opposed to concrete) to minimise the risk of accelerated degradation. Engage experienced contractors to advise on key constructability concerns and challenges including shifting soils and foundational integrity of site infrastructure and the pipeline network.	Rare	Major	Medium	Unlikely	Major	Medium

		2030	2090							
Risk ID	**Risk Source**	**Risk Rating**	**Risk Rating**	**Adaptation Action**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
MRD-3	Water restrictions reducing the amount of flows through the sewerage system (e.g. outdoor watering infiltration) increasing septicity risk (e.g. odour, septic sewerage, corrosion)	**Medium**	**High**	Update operational procedures to provide for a weekly flush, pigging or physical removal of marine organisms along of the ocean outfall pipeline to prevent odours, septicity risk and degradation. Undertake community outreach to educate the community around potential concerns (odour, water restrictions, discolouration, etc.).	Possible	Minor	Medium	Likely	Minor	Medium
An increase in the severity and intensity of extreme rainfall, flooding and storm events resulting in:										
Direct Risks										
ERF-1	Malfunctioning of electrical equipment, including pump stations, dosing equipment, aerators, communications (e.g. telemetry systems) and associated circuitry due to submersion	**Medium**	**High**	Elevate critical equipment and systems above known flood levels.	Unlikely	Moderate	Medium	Possible	Moderate	Medium
ERF-3	Increased risk of the STP not being able to handle more frequent and higher intensity peak flow, ultimately impacting treatment during peak wet weather flow periods	**Medium**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow. Design the outfall pipe (both size and operational timing) to respond to increased rainfall intensities and volumes to facilitate high flow events and avoid disruptions in processing.	Possible	Minor	Medium	Likely	Minor	Medium
ERF-4	Inundation of the STP assets (e.g. from inadequate drainage, increased volumes of rainfall) and damage to the STP (civil structures), potentially requiring closure of the STP or backflow/unregulated discharge	**High**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow. Design the outfall pipe (both size and operational timing) to respond to increased rainfall intensities and volumes to facilitate high flow events and avoid disruptions in processing.	Unlikely	Moderate	Medium	Possible	Moderate	Medium
ERF-5	Decreased safety of personnel working on-site during extreme events (e.g. workforce required on-site during a storm to address breaches or other infrastructure faults)	**High**	**Extreme**	Undertake a review of current BVSC standard operational procedures and policies to incorporate extreme weather events (e.g. heat waves, bushfire events, etc.). This includes event notification, use of appropriate PPE and changes to operations during extreme events. Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site.	Rare	Major	Medium	Unlikely	Major	Medium
ERF-6	Overflow and unregulated discharge of lagoons, sludge storage areas, storm storage ponds or other plant processes, resulting in breach of EPA licence (e.g. Phosphate/Nitrate concentrations) for discharge and potential negative community concern	**High**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow. Design the outfall pipe (both size and operational timing) to respond to increased rainfall intensities and volumes to facilitate high flow events and avoid disruptions in processing.	Unlikely	Moderate	Medium	Possible	Moderate	Medium
ERF-7	Increased potential for landslip due to increased overland wash and/or inundation of Merimbula Lake, resulting in reduced integrity of foundations and potential structural failure	**Medium**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow. Engage experienced contractors to advise on key constructability concerns and challenges including shifting soils and foundational integrity of site infrastructure and the pipeline network.	Rare	Major	Medium	Unlikely	Major	Medium
ERF-8	Increased risk of mobilisation of fuels, oils, lubricants (chemical storage) and other contaminants (e.g. biosolids), resulting in contamination of surrounding areas	**Medium**	**High**	Elevate critical equipment (including storage of chemicals) and systems above known flood levels.	Possible	Minor	Medium	Likely	Minor	Medium

		2030	2090							
Risk ID	**Risk Source**	**Risk Rating**	**Risk Rating**	**Adaptation Action**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
ERF-9	An increase and/or high grit volume/screening load to the STP	**Medium**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow. Design the outfall pipe (both size and operational timing) to respond to increased rainfall intensities and volumes to facilitate high flow events and avoid disruptions in processing.	Likely	Insignificant	Medium	Almost Certain	Insignificant	Medium
ERF-10	Localised scour and erosion around drainage infrastructure due to increase flows	**Medium**	**High**	Model for potential increases in rainfall (e.g. 10%) and design site drainage to account for additional flow.	Possible	Minor	Medium	Likely	Minor	Medium
ERF-12	Accelerated erosion due to increased wave activity (storm tide) along the shoreline resulting in damage to infrastructure	**Medium**	**High**	Undertake additional modelling of potential changes to surf zone morphology and wave impacts to determine the appropriate ocean outfall pipeline depth (for the buried portion of the pipeline). Update operational procedures to increase the frequency of erosion monitoring to protect against buried assets being uncovered.	Rare	Major	Medium	Unlikely	Major	Medium
Indirect Risks										
ERF-13	Inundation or damage to the surrounding road network impeding access (e.g. personnel and/or deliveries) and potential isolation of assets	**Medium**	**High**	Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site.	Possible	Minor	Medium	Likely	Minor	Medium
ERF-14	Faults and failures in the power network resulting in interruptions to power supply including increased down time of assets (e.g. pump stations, treatment equipment)	**Medium**	**High**	Incorporate the use of solar PV, battery storage and/or backup generators where possible on-site for critical systems to minimise the impact of power disruption. Design to consider connections, if possible, to multiple substations to reduce the reliance on only one substation in the event of a power outage.	Possible	Minor	Medium	Likely	Minor	Medium
An increase in sea levels resulting in:										
Direct Risks										
SLR-1	Permanent inundation of major site infrastructure (e.g. storage tanks, pump stations, access to site)	**Medium**	**High**	Elevate critical equipment and systems above known flood levels (including accounting for increases in sea level.	Rare	Major	Medium	Unlikely	Major	Medium
SLR-2	Accelerated erosion potentially uncovering the buried portion of the outfall pipeline (within the surf zone)	**High**	**High**	Undertake additional modelling of potential changes to surf zone morphology and wave impacts to determine the appropriate ocean outfall pipeline depth (for the buried portion of the pipeline). Update operational procedures to increase the frequency of erosion monitoring to protect against buried assets being uncovered.	Rare	Major	Medium	Unlikely	Major	Medium
SLR-3	Malfunctioning of electrical equipment, including dosing equipment, aerators, communications and associated circuitry due to submersion	**Medium**	**High**	Elevate critical equipment and systems above known flood levels (including accounting for increases in sea level).	Unlikely	Moderate	Medium	Possible	Moderate	Medium

		2030	2090							
Risk ID	**Risk Source**	**Risk Rating**	**Risk Rating**	**Adaptation Action**	**Likelihood**	**Consequence**	**Risk Rating**	**Likelihood**	**Consequence**	**Risk Rating**
SLR-4	Deposition from changing morphology resulting in the diffuser head being covered	**Medium**	**High**	Undertake additional modelling of potential changes to surf zone morphology and wave impacts to determine the appropriate ocean outfall pipeline depth (for the buried portion of the pipeline). Provide for the use of remote operated vehicles and regular diver maintenance to allow for the diffuser head of the ocean outfall pipeline to remain open. Update operational procedures to increase the frequency of deposition monitoring to allow diffuser head to remain free to operate.	Rare	Moderate	Low	Unlikely	Moderate	Medium
Indirect Risks										
SLR-5	Inundation or damage to the surrounding road network impeding access and potential isolation of assets	**Medium**	**High**	Provide upgrades to the STP (e.g. UV disinfection plant) to allow for further automation and remote operation to reduce the number of personnel required on-site.	Unlikely	Minor	Low	Likely	Minor	Medium