

APPENDIX L

Climate Change and Greenhouse Gas

L-1 Climate Change Risk Assessment

L-2 Greenhouse Gas Assessment

NORTHERN
WATER PROJECT



Appendix L-1:

Climate Change Risk Assessment



NORTHERN WATER PROJECT

Department for Infrastructure and Transport

Climate Change Risk Assessment

Jacobs

Challenging today.
Reinventing tomorrow.



Northern Water Project Climate Change Risk Assessment

Client name: Department for Infrastructure and Transport, South Australia
Project name: Northern Water Project
Project no: IS449300
Document no: IS449300 - 1 - NS - RPT - 010
Version: 0
Date: 14/09/2026
Project manager: Rob Tokley
Prepared by: Zara Henderson
File name: Northern Water Project_Climate Change Risk Assessment_Rev 0

Document history and status

Version	Date	Description	Author	Checked	Reviewed	Approved
Rev 0	14/09/2026	Final	ZH	PW	JW	RT

Jacobs Group (Australia) Pty Ltd

Level 3, 121 King William Street
Adelaide, SA 5000
Australia

T +61 8 8113 5400
F +61 8 8113 5440
www.jacobs.com

© Copyright 2026 Jacobs Group (Australia) Pty Ltd. All rights reserved. The content and information contained in this document are the property of the Jacobs group of companies ("Jacobs Group"). Publication, distribution, or reproduction of this document in whole or in part without the written permission of Jacobs Group constitutes an infringement of copyright. Jacobs, the Jacobs logo, and all other Jacobs Group trademarks are the property of Jacobs Group.

NOTICE: This document has been prepared exclusively for the use and benefit of Jacobs Group client. Jacobs Group accepts no liability or responsibility for any use or reliance upon this document by any third party.

Executive summary

The Northern Water Project (the Project) aims to provide a secure climate resilient water source for industry in South Australia's Upper Spencer Gulf and Far North. Delivery of the Project will involve the construction and operation of a 51 gigalitre per year (GL/year) seawater reverse osmosis desalination plant located at Mullaquana Station on the Upper Spencer Gulf, and associated water transfer system (including pipelines, transfer pump stations, product water storages) and electricity infrastructure.

This report outlines the legislative and policy framework guiding climate change risk assessment and adaptation strategies and provides an evaluation of potential risks associated with climate change for the Project. The assessment identifies and analyses climate change risks that may impact Project receptors, utilising a risk rating system based on likelihood and consequence. The assessment considers existing risks, such as extreme heat, drought and extreme rainfall and flooding – which are projected to intensify, and new risks, including sea level rise attributed to climate change.

The first Climate Change Risk Workshop was held on Monday 16 October 2023 with the South Australia (SA) Government and the project team to identify the key risks associated with the Project based on the Cape Hardy design. The assessment considered risks across the varying asset typologies below:

- Utilities and Power Supply
- Intake and Outfall
- Water Storage and Distribution
- Desalination Plant Infrastructure
- Treatment and Process Systems.

In 2026, the Climate Change Risk Assessment was updated to reflect the current project alignment and design. The intent of this update is to confirm that the identified risks remain valid at a strategic level, with refinements made where design/location changes materially influence risk relevance or rating.

The workshop identified a total of 48 risks. No risks have been identified as 'extreme' nor 'high'.

Whilst most risks have some form of business-as-usual controls embedded within the design and operating procedures, for many of the medium risks, potential additional adaptation measures intended to further reduce the risk have been identified. Adaptation measures proposed should be reviewed and further refined during the detailed design stage to confirm their appropriateness and alignment with the project's risk acceptance thresholds.

The most critical mitigation measure is to incorporate projections for climate change into the detailed design process; to adapt designs to address risks from the future climate which the Project is expected to experience. This may include, but is not limited to, actions such as factoring in sea level rise, storm surge and extreme rainfall changes in flood assessments to inform alignment and design decisions, and incorporation of temperature changes into the design of cooling systems for the pump station and desalination plant.

Operational controls will also play an integral role in climate risk management for the Project. Given that there is inherent uncertainty associated with long-term climate projections, asset management must support adaptive management through continuous monitoring, informed prioritisation and regular climate risk reviews to ensure that infrastructure is maintained, upgraded, replaced and operated in ways that respond to a changing climate and enhance resilience.

A summary of the identified risk ratings before and after implementation of all adaptation measures is provided in **Table ES-1** below.

Table ES-1. Summary of the identified risk ratings

Rating	Number at inherent risk	Number at residual risk
Extreme	0	0
High	0	0
Medium	24	22
Low	24	26
Total	48	48

It is expected that the identified control measures are implemented to mitigate and manage inherent risks to an acceptable level. However, it is important to note that if these measures (or alternative effective measures) are not implemented, the risk profile may change. It is therefore recommended that all climate change risks, business-as-usual controls, and proposed adaptation measures are reviewed as the design progresses to ensure that no new high or extreme risks emerge due to design changes or a more up-to-date understanding of climate risks based on new climate change projections. Where any such risks are identified, they should be appropriately mitigated in subsequent design stages.

Contents

Executive summary	ii
1. Introduction.....	3
1.1 Key Project components.....	3
1.2 Purpose and scope of this report	3
2. Legislative and policy framework	4
2.1 National.....	4
2.2 South Australia	4
2.3 Other standards and guidelines	6
3. Assessment methodology.....	7
3.1 Study area	7
3.2 Methodology.....	9
3.3 Risk framework.....	10
3.4 Climate change risk identification	14
3.5 Assessment of potential construction impacts	15
4. Current climate and climate change projections	16
4.1 Overview of climate scenarios.....	16
4.2 Selection of future scenarios	18
4.3 Selection of representative sites.....	18
4.4 Existing climate conditions.....	19
4.5 Selection of projections and timeframes.....	21
4.6 Climate Change Projections for the Project area.....	24
5. Climate Change Risks.....	34
5.1 Increased ambient temperatures and heatwaves.....	34
5.2 Increased rainfall intensity and surface water flooding.....	35
5.3 Potential change in wind speed.....	36
5.4 Increase in frequency and intensity of bushfires	36
5.5 Changing Marine conditions.....	37
5.6 Decreases in average rainfall and increased drought conditions	39
6. Resilience Planning	40
6.1 Climate change adaptation	40
6.2 Potential adaptation measures.....	41
7. Conclusion	46
8. References	47
9. Glossary	49

Appendices

Appendix A. Adopted Climate Change Projections

Appendix B. Full Climate Change Risk Register

Tables

Table ES-1. Summary of the identified risk ratings	iii
Table 3-1. Likelihood rating criteria.....	10
Table 3-2. Consequence rating criteria	12
Table 3-3. Risk matrix.....	14
Table 4-1. BoM Stations used for historical data.....	18
Table 4-2. Project components and design life	23
Table 5-1: Risks and BAU controls associated with increased ambient temperatures and heatwaves (medium risks).....	34
Table 5-2. Risks and BAU controls associated with increased rainfall intensity and surface water flooding (medium risks).....	35
Table 5-3: Risks and BAU controls associated with increase in frequency and intensity of bushfires (medium risks).....	36
Table 5-4: Risks and BAU controls associated with changing marine conditions (medium risks).....	37
Table 5-5: Risks and BAU controls associated with decreases in average rainfall and increased drought conditions (medium risks)	39
Table 6-1. Mitigation measures reducing climate change risks to an acceptable level.....	41

Figures

Figure 1. Northern Water Project area (Southern)	7
Figure 2. Northern Water Project area (Northern)	8
Figure 3. Overview of the process for considering climate change risk and adaptation (AS 5334-2013).....	10
Figure 4. Surface air temperature change relative to 1850-1900 - comparison of RCPs and SSPs to illustrate scenario differences (single emulator; Figure 4.35b in IPCC, 2021)	17
Figure 5. Current Average Climate Conditions for the Project (Whyalla, SA).....	19
Figure 6. Current Average Climate Conditions for the Project (Port Augusta, SA).....	20
Figure 7. Current Average Climate Conditions for the Project (Woomera, SA)	21
Figure 8. Regional geographical divisions of SA as defined by the CSIRO and BoM CCIA project, with overlaid boundaries of the Landscape Regions of SA (DEW, 2022).....	23
Figure 9. Summary of maximum temperature projections for 2030-2090	26
Figure 10. Summary of minimum temperature projections for 2030-2090	27
Figure 11. Summary of temperature projections (Increase to days over 40 degrees C) for 2030-2090.....	27
Figure 12. Summary of rainfall projections for changes to average annual rainfall for 2030-2090.	29
Figure 13. Summary of rainfall projections (increase to 1% AEP extreme rainfall events < 1 hr duration) for 2030-2090.	29
Figure 14. Summary of rainfall projections (increase to 1% AEP extreme rainfall events > 24 hr duration) for 2030-2090	30
Figure 15. Summary of projected number of extreme fire danger days for 2030-2090.....	31
Figure 16. Summary of Sea Level Rise Projections for Whyalla and Port Augusta for the years 2030 - 2090 .	33

1. Introduction

The Northern Water Project (the Project) aims to provide a secure climate resilient water source for industry in South Australia's Upper Spencer Gulf and Far North. Delivery of the Project will involve the construction and operation of a 51 gigalitre per year (GL/year) seawater reverse osmosis desalination plant located at Mullaquana Station on the Upper Spencer Gulf, and associated water transfer system (including pipelines, transfer pump stations, product water storages) and electricity infrastructure.

1.1 Key Project components

The key Project components include:

- a 51 gigalitre (GL)/year seawater reverse osmosis desalination plant located at Mullaquana Station approximately 25 km south-west of Whyalla
- marine intake and outfall tunnels extending underneath the seabed and into Spencer Gulf
- diffuser structures for discharge of return water into Spencer Gulf
- a transfer system consisting of:
 - a ~360 km main transfer pipeline, largely constructed underground terminating at the delivery point at the Olympic Dam copper-gold mine
 - a ~46 km lateral branch to a delivery point at the Carrapateena copper-gold mine (which may be constructed above or below ground)
 - associated transfer pump stations and product water storage
- high voltage electricity supply including new transmission and distribution lines and new network substations and facility substations to provide power to the desalination plant and transfer pump stations
- associated temporary construction-related infrastructure (e.g. construction camps, site offices and amenities, yards, storages and laydown areas)
- access tracks including establishing new tracks and upgrading existing tracks
- enabling roadworks and road upgrades.

1.2 Purpose and scope of this report

This report is one of several reports that support the Environmental Impact Statement (EIS) for the Project. The purpose of this report is to assess the implications of climate change to the Project by identifying potential physical risks to operations. It also supports addressing the PlanSA Assessment Requirements Library Environmental Attribute 3: Climate Change and Resource Efficiency, specifically, Climate Change Adaptation.

The objectives of this investigation were to:

- Describe the existing environment with respect to regional climate
- Assess the risks from climate change for the project
- Recommend measures to mitigate the risks identified.

This assessment reflects the latest Project alignment (Revision 5, provided by JBS&G 6 November 2025).

2. Legislative and policy framework

This section outlines legislation and policy with a focus on climate change risk and adaptation relevant to this assessment. This section also lists the guidelines which have shaped the methodology for the assessment.

2.1 National

2.1.1 National Climate Risk Assessment and National Adaptation Plan 2025

The National Climate Risk Assessment is the first comprehensive assessment of climate change and its impacts in Australia. The assessment was developed by the Australian Climate Service, a partnership between the Bureau of Meteorology (BoM), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Bureau of Statistics and Geoscience Australia (Australian Climate Service, 2025).

The assessment identified 11 priority risks across seven key systems, including nationally significant risks for Aboriginal and Torres Strait Islander peoples. The assessment is coupled with the National Adaptation Plan, which outlines current and planned adaptation initiatives (Department of Climate Change, Energy, the Environment and Water, 2025).

2.1.2 National Disaster Risk Reduction Framework

The National Disaster Risk Reduction Framework (National Emergency Management Agency, 2018) outlines a strategic plan for disaster risk reduction in Australia. It emphasises the importance of improving public awareness and engagement on disaster risks and impacts, accountability in decision-making, and enhancing investment in disaster risk reduction.

The framework aligns with the Sendai Framework's¹ goal of substantially reducing disaster risk and losses. It emphasises the interconnected and interdependent nature of essential services, the increasing exposure and vulnerability of people and assets, and the long-term and complex impacts of disasters. The document also highlights the need for understanding disaster risk, integrating disaster risk information into planning across sectors, and identifying high priority mitigation opportunities.

The Second National Action Plan (NEMA, 2023) builds on the National Disaster Risk Reduction Framework to put the framework into practice. It is based on four priorities: understand disaster risk, accountable decisions, enhanced investment, and governance, ownership and responsibility. It is intended for all Australians, including individuals, communities, organisations, sectors and governments.

2.2 South Australia

2.2.1 PC 007 Climate Ready Government

The Premier and Cabinet Circular *PC007-Climate Ready Government* sets out requirements for public sector agencies to manage climate related risks and opportunities and reduce greenhouse gas emissions (emissions) in their operations (Government of South Australia, 2024). Under the Circular, South Australian Government public sector agencies are required to establish and maintain operational arrangements, deliver implementation actions and monitor the effectiveness of their approach to manage climate risks, opportunities and greenhouse gas (GHG) emissions. The Department for Environment and Water (DEW) is the agency responsible for coordinating and monitoring compliance with the PC-007 Circular.

¹ The Sendai Framework for Disaster Risk Reduction 2015 – 2030 (the Sendai Framework) was adopted by Australia and other members of the United Nations at the third UN World Conference on Disaster Risk Reduction. It aims to achieve substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.

2.2.2 State Planning Policies for South Australia

The State Planning Policies for South Australia (State Planning Commission, 2019) prioritises climate change adaptation and mitigation strategies to enhance resilience and reduce greenhouse gas emissions. South Australia is working towards creating a more resilient economy, community, and natural environment by promoting emerging technologies, energy efficient design and encouraging decision-making that considers climate change impacts. As a part of these measures, the policy identifies the need to safeguard the State's water supply and supporting infrastructure to enhance the state's resilience.

2.2.3 State Planning Commission Regional Plans

In January 2026, the SA State Planning Commission released six new country regional plans to guide future land use and infrastructure development to support sustainable growth for the next 15-to-30-years. The Eyre and Western Regional Plan (State Planning Commission, 2026a) and the Far North Regional Plan (State Planning Commission, 2026b) are relevant to this assessment, and both aim to support more climate resilient and sustainable outcomes for the region. Both plans emphasise the risks of climate change and acknowledge the need for careful planning and location of new development away from areas of high risk, with more vulnerable and sensitive uses located away from potentially hazardous areas.

2.2.4 Guide to Climate Projections for Risk Assessment and Planning in South Australia (2022)

The *Guide to Climate Projections for Risk Assessment and Planning in South Australia* (DEW 2022) provides a summary of the most up-to-date climate change projections for South Australia to assist in planning for the future. It summarises projected changes in key climate variables, including temperature, rainfall, fire weather, evapotranspiration, wind, sea level rise and marine conditions. These projections have been used as the primary source of climate projections in this assessment, as discussed in Section 4.

2.2.5 State Climate Change Resilience and Adaptation Actions

The South Australian Government's Climate Change Resilience and Adaptation Actions (2024) documents the plans and actions the SA Government is taking to address climate change and its potential impacts. Action 2.4 is to "provide a new climate independent water source for the Far North, Upper Spencer Gulf and Eastern Eyre Peninsula Regions of South Australia", to be enacted (pending investment decisions) by the Project. Action 3.10 requires assessment and addressing of climate change risk in government infrastructure decisions, which is to include use of climate change projections and scenarios to inform risk assessment, management and auditing.

In early 2026, the SA Government released its first Statewide Climate Change Risk and Opportunity Assessment. It identifies priority risks requiring near-term action and is intended to guide long-term adaptation planning, policy, and investment decisions. Risks to water resources and availability was determined as 'moderate' and 'extreme' for near-term and long-term future, respectively. It is recommended that future updates of the Project's climate change risk assessment align with its methodology and incorporate its findings.

2.2.6 SA Coast Protection Board Policy

The Coast Protection Board Policy (CPB, 2022) outlines responsibilities and strategies for protecting the coastal environment in South Australia. It acknowledges the impact of climate change on coastal areas and emphasises the importance of climate change adaptation strategies. These strategies include minimising the exposure of new and existing development to risks from coastal hazards, ensuring development avoids or minimises the impact on areas required for climate change adaptation (including blue carbon ecosystems), and minimising the impact of stormwater discharge to the coast and nearshore waters. The document emphasises the need for adequate buffer distances between development and the coast, and highlights the

importance of siting and designing coastal development to minimise its impact on the environment, heritage, and visual amenity of the coast.

The Coast Protection Board Policy document emphasises the importance of considering sea level rise in new coastal developments. It recommends adopting a mid-range sea level rise of 0.3 m by 2050 for most planning and design purposes and 1 m by 2100. Developments must be designed to be safe against coastal recession and storm erosion incorporating a 0.3 m sea level rise and be capable of being protected against the effects of an additional 0.7 m rise.

Major coastal developments should consider the full range of climate change and sea level rise effects, with designs that allow for later modifications to accommodate further sea level rise and sufficient setback for erosion. These guidelines aim to ensure that new developments are resilient to future sea level rise and coastal hazards, aligning with sustainable coastal management practices.

2.2.7 Regional climate change adaptation plan for the Eyre Peninsula

The Regional Climate Change Adaptation Plan for the Eyre Peninsula (EPICCA, 2014) identifies adaptation options and pathways for key sectors in the region. The plan aims to help the Eyre Peninsula adapt to the challenges posed by climate change.

The plan identifies water resources management as one of the key impacts to the region from climate change, with desalination forming part of their adaptation pathway.

2.2.8 Far North and Outback SA Climate Change Adaptation Plan

The Far North and Outback SA Climate Change Adaptation Plan (RDA Far North, 2016) outlines strategies to address the impacts of climate change in the region. It covers a wide range of topics, including the potential effects of climate change on infrastructure, ecosystems, and communities.

The plan emphasises the importance of incorporating traditional knowledge and engaging with local communities in the adaptation process. It provides case studies and examples of successful adaptation measures that have been implemented in the region. It identifies desalination as a potential action to support the maintenance of essential services in a changing climate.

2.3 Other standards and guidelines

The following standards have been used to guide the approach to this assessment:

- *AS 5334-2013 Climate change adaptation for settlements and infrastructure – a risk-based approach*
- *AS/NZS 31000:2018 Risk Management – Guidelines.*
- Ball et al. (2019) *Australian Rainfall & Runoff, Version 4.2*
- Key DIT technical guidelines and requirements, including the Sustainability Manual, Climate Adaptation Guidelines, Master Specification Part RD-DK-D1, Section 2.1.b NW PC-ST1-Sustainability in Design and Construction.

Note: the climate change chapter of Australian Rainfall and Runoff (Ball et al., 2019) was updated in 2024. The update drew on current peer-reviewed science, including the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report, to scale up the projected increase in extreme rainfall intensity with atmospheric warming. The previous iteration set an approximate 5% increase in rainfall intensity per degree of warming; whereas the current version 4.2 sets an 8-15% increase per degree of warming (for 24-hour and 1-hour events, respectively).

3. Assessment methodology

3.1 Study area

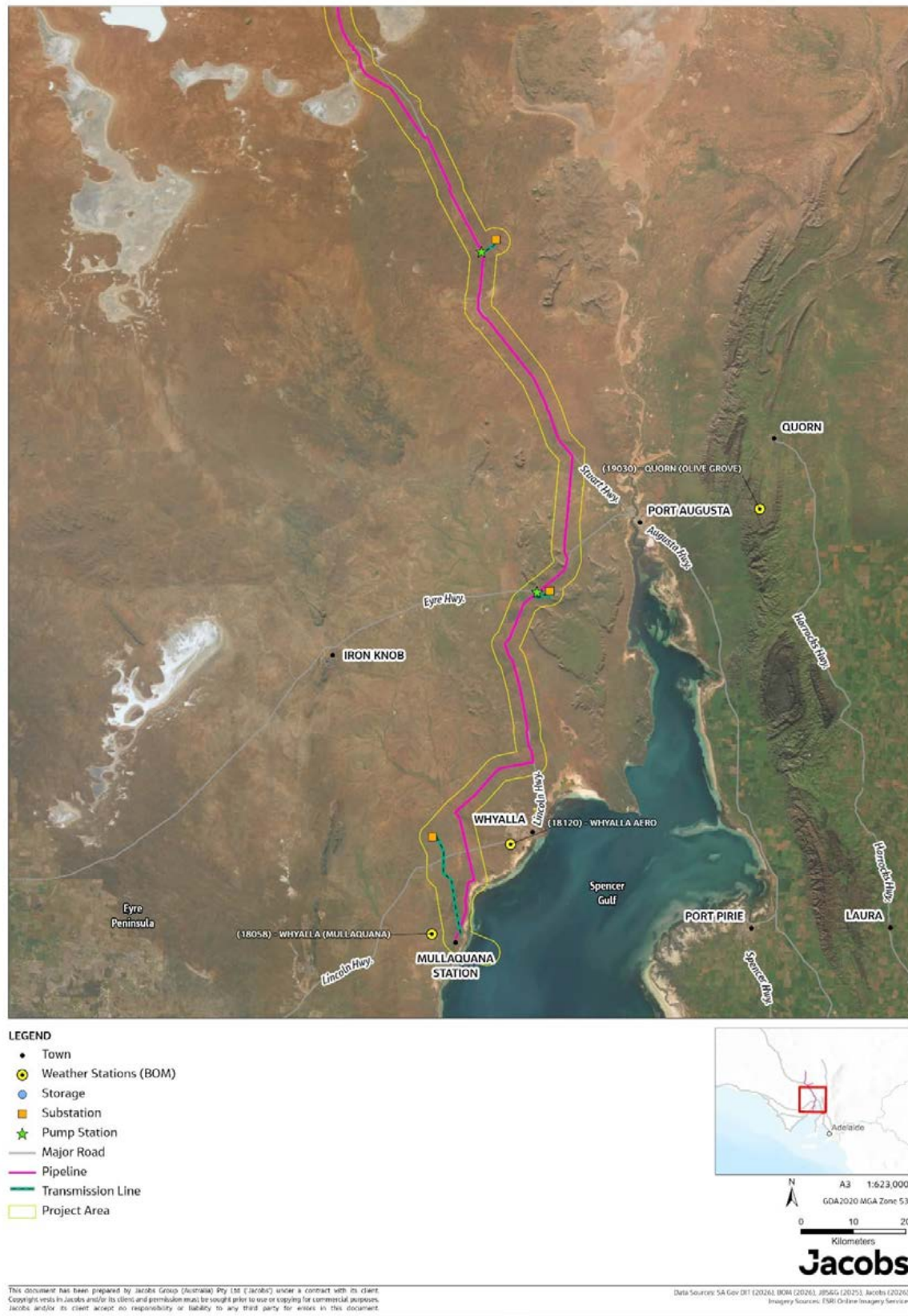


Figure 1. Northern Water Project area (Southern)

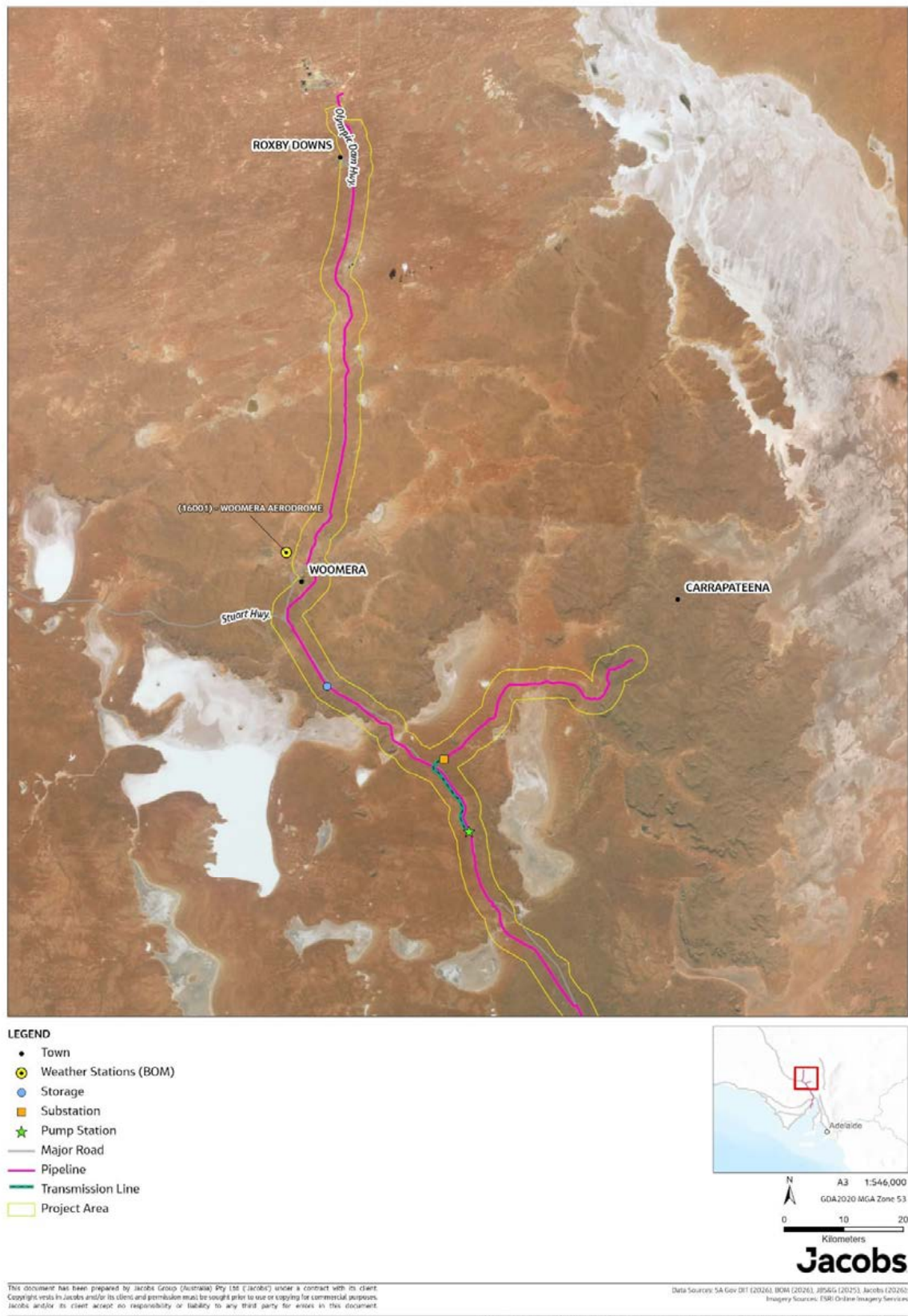


Figure 2. Northern Water Project area (Northern)

Figure 1 and **Figure 2** outline the Southern and Northern sections of the Project area, respectively, which includes the proposed desalination plant, the main transfer pipeline and lateral branch, pump stations, storage and transmission line infrastructure. For context, the Project area (which is used interchangeably with the term study area in this report) has been divided into two standard sections: southern and northern.

- The southern section runs from north of the Munyaroo Conservation Park boundary to Lake Dutton / Pernatty Lagoon, covering Murninnie Beach, Colweds Landing, Whyalla and Port Augusta. Project elements include:
 - Desalination plant and marine infrastructure
 - Mullaquana transmission line (132 kV)
 - Mullaquana Station substation (new)
 - Southern section of main transfer pipeline
 - Pump Station (PS) 2 (Lincoln Gap pump station and storage)
 - Pandurra transmission line (275 kV)
 - Corraberra Hill substation (existing)
 - PS 3 (Kalaya pump station and storage)
 - Bookaloo transmission line (132kV)
 - Kootaberra substation line (new).
- The northern section runs from Lake Dutton / Pernatty Lagoon to Olympic Dam, covering the Carrapateena mine, Woomera, Pimba, Roxby Downs and Olympic Dam. Project elements include:
 - Northern section of main trunk pipeline
 - PS 4 (Mangata pump station and storage)
 - Oakden Hills transmission line
 - Mount Gunson substation (existing)
 - Carrapateena lateral branch pipeline
 - Bimba high point storage

Note that the pipeline construction footprint and Project Area terminate at the boundary of the BHP Special Mining Lease (SML).

This climate change risk assessment covers the full Project area listed above.

3.2 Methodology

The objective of the climate change risk assessment is to identify how the effects of a changing climate may present risks and vulnerabilities within the design, construction, and operation of the Project, and take reasonable measures to adapt to reduce these to a tolerable level.

The approach to the climate change risk assessment and adaptation planning process is aligned with the principles of *AS 5334:2013 Climate change adaptation for settlements and infrastructure – a risk-based approach* (Standards Australia, 2013; **Figure 3**) and *AS ISO31000:2018 Risk management – Guidelines* (Standards Australia, 2018). The main steps in the workflow are:

1. **Define climate change context:** as provided by relevant legislation and policy (see Section 2), the Project scope of works (Section 1.1); the geographic context for the Project (Section 3.1), historical climate conditions and climate change projections for the selected study areas (Section 4). Since the climatic conditions shift over the Project's extent, the projections have been prepared for the selected three key zones: Whyalla, Port Augusta and Woomera, which together cover the extent of the Project area.
2. **Climate change risk assessment:** risk narratives are developed for climate and climate-change exposed components of the Project system. These narratives identify risk causes and consequences and how these might be affected by climate change. Risks are assessed with "business-as-usual" (BAU) risk controls in place (i.e., those which are already developed and in place and would be delivered as part of the Project in the absence of particular attention to climate change). The BAU controls were identified as part of the Climate Change Risk Workshop and through additional engagement and review by sustainability and engineering advisors from DIT.

3. **Treat key climate risks:** climate resilience measures (or climate change adaptations) are proposed for the treatment of priority climate change risks. Residual risk, following treatment using these measures is also assessed.

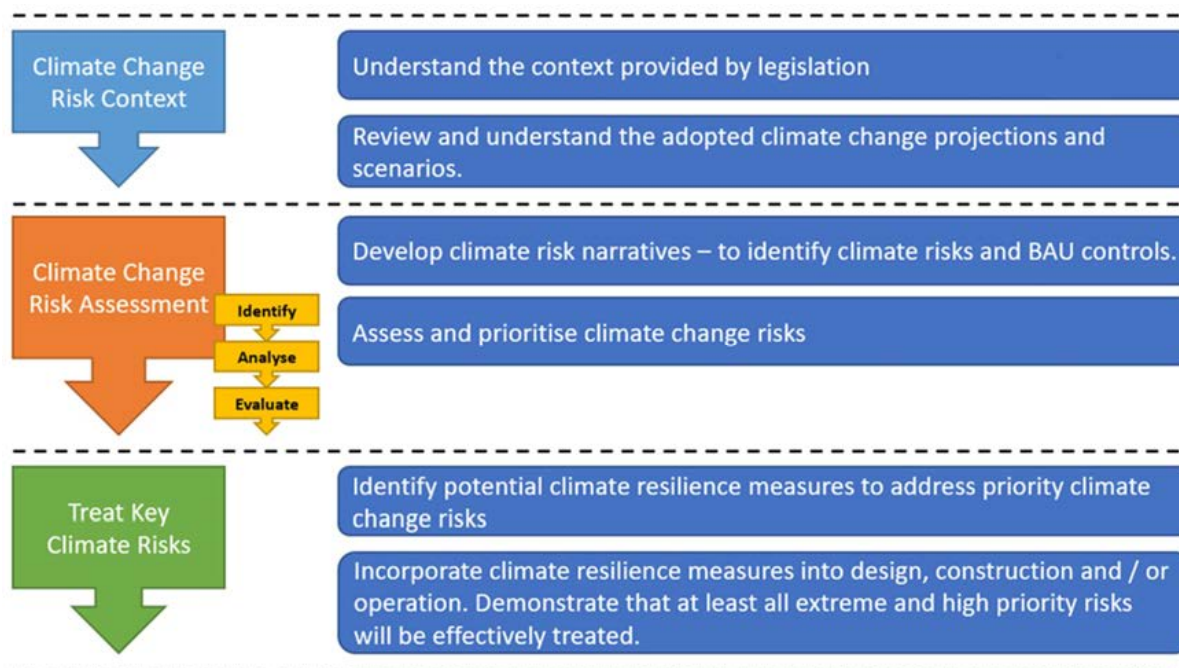


Figure 3. Overview of the process for considering climate change risk and adaptation (AS 5334-2013)

This report has assessed climate change risks for the full 100-year lifespan of the Project based on the Reference Design. In lieu of projections to 2130, those for 2090 are used to characterise the long-term conditions which may be experienced by long-lived or permanent components of the project.

It is expected that the approach outlined in this report is applied to future stages of the Project design. To achieve this, the risk register must be revisited at each stage to review the boundary and scope of the assessment, to determine the ongoing relevancy of the risks presented, and to provide a greater level of detail regarding the risks to the Project as they become available.

3.3 Risk framework

Risk evaluation considered their severity or consequences in relation to health and safety, environmental impact, operational reliability, reputational standing, legal and compliance implications, as well as financial ramifications. The definitions of likelihood and consequence have been derived from *AS5334-2013 Climate change adaptation for settlements and infrastructure – a risk-based approach*.

Risk likelihood was assessed cumulatively over the relevant asset lifespan, as opposed to estimating the probability of the hazard-consequence combination occurring in a specific year. The description of long-term risks is therefore the component of likelihood relevant to this assessment, and presented in **Table 3-1**.

Table 3-1. Likelihood rating criteria

Rating	Long term risk description
Almost certain	Has a greater than 90% chance of occurring in the identified period
Likely	Has a 60-90% chance of occurring in the identified period
Possible	Has a 40-60% chance of occurring in the identified period
Unlikely	Has a 10-30% chance of occurring in the identified period

Rare	May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period
------	--

A summary of the consequence framework used in the risk assessment follows in **Table 3-2**. The framework considers five tiers of consequence on seven aspects of the Project, with operational reliability and financial categories adapted to suit the Project context.

Table 3-2. Consequence rating criteria

Descriptor	Adaptive capacity	Infrastructure, service	Social/cultural	Governance	Financial	Environmental	Economy
Not significant	No change to the adaptive capacity.	No infrastructure damage, little change to service.	No adverse human health effects.	No changes to management required.	Little financial loss or increase in operating expenses.	No adverse effects on natural environment.	No effects on the broader economy.
Minor	Minor decrease to the adaptive capacity of the asset. Capacity easily restored.	Localised infrastructure service disruption. No permanent damage. Some minor restoration work required. Early renewal of infrastructure by 10-20%. Need for new/modified ancillary equipment.	Short-term disruption to employees, customers, or neighbours. Slight adverse human health effects or general amenity issues.	General concern raised by regulators required response action.	Additional operational costs. Financial loss small <10%.	Minimal effects on the natural environment.	Minor effect on the broader economy due to disruption of service provided by the asset.
Moderate	Some change in adaptive capacity. Renewal or repair may need new design to improve adaptive capacity.	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 20-50%.	Frequent disruptions to employees, customers or neighbours. Adverse human health effects.	Investigation by regulators. Changes to management actions required.	Moderate financial loss 10-50%.	Some damage to the environment, including local ecosystems. Some remedial action may be required.	High impact on the local economy, with some effect on the wider economy.
Major	Major loss in adaptive capacity. Renewal or repair would need new design to improve adaptive capacity.	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service. Early renewal of infrastructure by 50-90%.	Permanent physical injuries and fatalities may occur. Severe disruptions to employees, customers or neighbours.	Notices issued by regulator for corrective actions. Changes required in management. Senior management responsibility questionable.	Major financial loss 50-90%.	Significant effect on the environment and local ecosystems. Remedial action likely to be required.	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be required.

Descriptor	Adaptive capacity	Infrastructure, service	Social/cultural	Governance	Financial	Environmental	Economy
Catastrophic	Capacity destroyed, redesign required when repairing or renewing asset.	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service. Loss of infrastructure support and translocation of service to other sites. Early renewal infrastructure by >90%.	Severe adverse human health effects, leading to multiple events of total disability or fatalities. Total disruptions to employees, customers or neighbours. Emergency response at a major level.	Major policy shifts. Change to legislative requirements. Full change of management control.	Extreme financial loss > 90%	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be required.	Major effect on the local, regional and state economies.

The risk assessment matrix used to determine levels of risk from the likelihood and consequence ratings is shown in **Table 3-3**.

Table 3-3. Risk matrix

		Consequence				
		Not significant	Minor	Moderate	Major	Catastrophic
Likelihood	Almost certain	Low	Medium	High	Extreme	Extreme
	Likely	Low	Medium	Medium	High	Extreme
	Possible	Low	Low	Medium	High	Extreme
	Unlikely	Low	Low	Medium	Medium	High
	Rare	Low	Low	Low	Medium	Medium

3.4 Climate change risk identification

The context for the risk assessment for the Project is based on the key elements and the historical climate for the region in which it is to be constructed and operated.

Hazards used to identify and rate potential risks were based on the following climate variables:

- Extreme rainfall
- Mean rainfall
- Extreme temperature
- Mean temperature
- Bushfires
- Marine conditions.

A likelihood-consequence model has been applied to identify and analyse risks. This model is outlined below:

- **Hazard** – climate or climate-influenced attributes with potential to influence the operation and maintenance of the Project.
- **Receptor** – the component of the operation and/or maintenance of the Project that would be impacted by the hazard. This may also include users of the Project and affected elements of the surrounding environment. The main receptors identified for the Project are:
 - Utilities and power supply
 - Intake and outfall pipelines and associated infrastructure
 - Desalination plant infrastructure
 - Water storage and distribution infrastructure
 - Treatment and process systems.
- **Risk Rating** – utilising the likelihood (**Table 3-1**) and consequence (**Table 3-2**) rating system, an assessment of the way hazards influences the Project receptors is undertaken and a risk rating awarded (**Table 3-3**).

Risks and proposed controls were identified through a workshop process, held in 2023 with representatives from the SA Government and the Project team across engineering, environment and approvals as well as members from the Jacobs and JBS&G EIS project team. The workshop outcomes were documented in a risk

register. In 2026, the assessment outcomes were reviewed and updated to reflect the updated alignment and latest design. The updated risks are summarised in Sections 5 and 6, and presented in full in **Appendix B**.

3.5 Assessment of potential construction impacts

Given the timing of the construction period to occur later this decade, BAU risk controls for current average climatic conditions are assumed to generally be appropriate and hence a risk assessment for the Project construction phase has not been conducted.

4. Current climate and climate change projections

The context for assessing climate change risk is grounded in an understanding of the current climate the Project is subject to, and projections of how this climate will change into the future. The projections outlined in this report are generated by the analysis of historical climate data, the application of climate models, and the consideration of future climate under various emission scenarios. This section outlines this process in detail.

4.1 Overview of climate scenarios

The extent of changes in climate over the coming decades depends on the trajectory of greenhouse gas emissions, which are in turn subject to a range of variables related to population growth, technology change, political actions and ambition, and more. Potential climate futures are described through use of scenarios – a set of conditions and associated emissions that describe a hypothetical future. Scenarios are not predictions, but describe plausible conditions to allow decision-makers to plan for resilience.

At the time of writing, the primary publicly-available source of climate information for South Australia is from DEW (2022). It is based on high-resolution, dynamically-downscaled climate models developed through the NSW Government's NARcliM1.5 project.

These models were based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) suite of general circulation models, as underpinned the IPCC's Fifth Assessment Report (AR5, released 2013-2015). This generation of models described four potential climate futures under different GHG emissions scenarios, referred to as the Representative Concentration Pathways (RCPs). These have been widely adopted into Australian government policy and infrastructure planning, particularly RCP8.5 (high emissions future) and RCP4.5 (low-moderate emissions future). These RCPs have been set out as the relevant future climate scenarios to be assessed under the *Planning and Development Act 2016* (PDI Act) as specified in the project-specific Assessment Requirements for the Project EIS.

Climate science and risk management standards are always evolving, and in relation to this project it is important to note that the IPCC published its Sixth Assessment Report (AR6) over 2021-2023 (IPCC, 2021) which drew on an updated generation of general circulation models, developed under CMIP6. The new modelling illustrated potential future climates under five potential future development pathways, named the Shared Socio-economic Pathways (SSPs). Each SSP describes a set socio-economic trends and development drivers that is then paired with an appropriate greenhouse gas emissions scenario². Of the RCPs carried forward into the SSPs, the updated modelling indicates that climate futures may be more extreme than previously thought (**Figure 4**).

As mentioned in Section 2, it is recommended that future updates of the climate change risk assessment adopt the latest climate science and align with the current national and international standards, guidance, and dataset to ensure consistency with best practice and emerging regulatory expectations.

² Many more pathway-emissions scenario pairings were modelled, to include options such as overshoot pathways, low aerosols etc. However, five combined scenarios are the focus of much of the discussion in AR6 and the subsequent modelling effort, so are treated as 'core' or 'focus' scenarios.

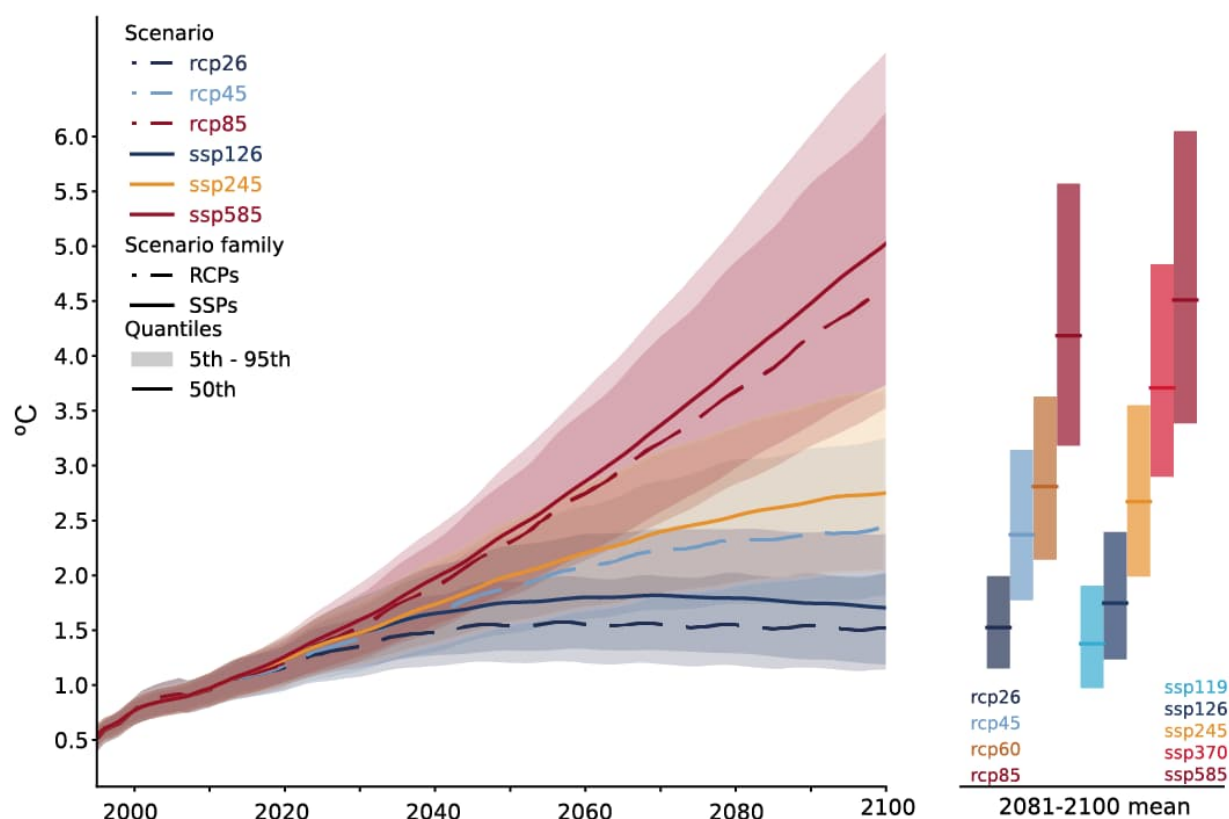


Figure 4. Surface air temperature change relative to 1850-1900 - comparison of RCPs and SSPs to illustrate scenario differences (single emulator; Figure 4.35b in IPCC, 2021)

Processing of the CMIP6 model suite for regional-scale projections is underway. At the time of writing this assessment, NARcliM2.0 has been released (see AdaptNSW, 2025). This provides climate projections for south-eastern Australia, including the Project area, on a 4 km grid. Further modelling in support of international downscaling effort is available for all of Australasia on a 10-18 km grid (see Queensland Government, 2024). However, projections outside of NSW, Queensland or Victoria are not currently in an easily accessible format.

At the time of writing, DEW (2022) has not incorporated the updated information, and the PlanSA Assessment Requirements still require the Project EIS to be based on RCP scenarios.

Australia is currently in a time of flux in policy relating to climate scenarios for risk assessment and design. For jurisdictions with regional CMIP6 modelling readily available (Queensland, NSW, Victoria), SSP3-7.0 is now the scenario recommended for use in describing a 'high' climate change future. This scenario has no comparable CMIP5 version, but as visible in the right-hand section of **Figure 4**, SSP3-7.0 is likely to sit close to but underneath RCP8.5. This means that infrastructure designed to future conditions described by RCP8.5 are almost certainly resilient to conditions described by SSP3-7.0, without dramatically over-estimating the risk.

This assessment continues to use the CMIP5 scenarios and modelling as provided by DEW (2022), with the updated ARR data integrated where appropriate. This approach uses the current best publicly-available information for the Project area, and a worst-case scenario of RCP8.5.

Updated ARR data has been used for extreme rainfall projections, which are accessible from the ARR Data Hub (Geoscience Australia, 2024). ARR recommends an increase of 15% per degree of warming for shorter-duration events (less than 1hr) whilst longer events (over 24h) are recommended to adopt an increase of 8% per degree of warming. This may be partially offset by increases in the rate of losses due to changes in moisture conditions prior to the rainfall event, with changes to initial and continuing losses of 4.5% per degree of warming respectively for the Port Augusta and Whyalla regions (DCCEEW, 2023). The latest data

from ARR utilises the SSP climate change scenarios instead of the RCPs. While the SSPs differ from the RCPs, ARR is considered to be the primary source for extreme rainfall projections. Extreme rainfall projections utilised in this report are based on SSP2-4.5 and SSP3-7.0. This approach is also considered to appropriately manage the climate change risk, given the reasonable alignment between RCP8.5 and SSP3-7.0 and RCP4.5 and SSP2-4.5.

4.2 Selection of future scenarios

Two scenarios have been adopted for this assessment:

- **RCP4.5:** This scenario represents a **low-moderate emissions pathway**. It assumes that global greenhouse gas emissions will peak around the year 2040 and then decline, leading to a stabilisation of radiative forcing after the year 2100. This scenario is associated with a global temperature increase of around 2°C by the end of the 21st century compared to pre-industrial levels.
- **RCP8.5:** This scenario represents a **high emissions pathway**. It assumes a continued increase in greenhouse gas emissions throughout the 21st century without any mitigation efforts. This scenario leads to a significant rise in global temperatures, with projections exceeding 4°C by the end of the century, causing dramatic shifts in the climate and significant challenges for adaptation.

As noted in Section 4.1, extreme rainfall projections are based on the latest data from ARR (Geoscience Australia, 2024), which uses SSPs instead of RCPs. Extreme rainfall projections are based on SSP2-4.5 and SSP3-7.0 to support broad alignment with RCP4.5 and RCP8.5, respectively.

Consideration of multiple climate change scenarios allows for a more thorough evaluation of potential climate risks and impacts, as well as risks, impacts and opportunities associated with the transition to a low-carbon future. By considering a range of scenarios, decision-makers can better understand the uncertainties and risks associated with climate change and socio-economic transitions, enabling them to develop robust adaptation and mitigation strategies for long-term sustainability.

4.3 Selection of representative sites

Given the variation in climate across the Project's ~360 km length, three locations have been used to characterise the climate for the Project, representing a cross section of the Project area described in Section 3.1.

Several BoM stations were utilised to establish a uniform reference period for temperature and rainfall observations. The specific stations employed for these observations are detailed in **Table 4-1** and shown in **Figure 4-2**.

Table 4-1. BoM Stations used for historical data

Climate Variables	Location of Climate Change Projections	BoM Station for Historical Data	BoM Station ID
Rainfall	Woomera	Woomera Aerodrome	016001
	Whyalla*	Whyalla (Mullaquana)	018058
	Port Augusta	Quorn (Olive Grove)	019030
Temperature	Woomera	Woomera Aerodrome	016001
	Whyalla	Whyalla Aero SA	018120
	Port Augusta	Whyalla Aero SA	018120
* It is noted that two BOM stations in Whyalla have been selected to capture changes in rainfall and temperature for the Mullaquana Station site			

4.4 Existing climate conditions

Setting the baseline historical climate data is necessary prior to overlaying projections to determine future climate statistics. This baseline climate data must be centred on 1995, consistent with the baseline used in the projection sets discussed in Section 4.6 which covers 1986–2005. Where available, Jacobs has expanded the baseline period to capture some of the hotter periods that occurred between 2005 and 2015 in the baseline (such that the projections build on this warmer baseline) i.e. a period from 1976 to 2015.

Note, in some cases extreme events have occurred since 2015 which are not reflected within the baseline conditions presented herein, as they incorporate some of the observed change in the climate covered by the projections discussed in Section 4.6.

4.4.1 Whyalla

Climate statistics for Mullaquana Station have been prepared using data sourced from two BOM stations based in Whyalla; Whyalla (Mullaquana) 018058 and Whyalla Aero (018120). Data ranges from 1986 to 2005 and reveals distinctive patterns in temperature and precipitation (**Figure 5**).

The mean maximum temperature fluctuates across the months, reaching its peak at 30°C in January and gradually decreasing to 17°C in July. The highest recorded temperature during this period peaked at 47.1°C in January 2003, while the lowest maximum temperature touched 9.4°C in June 1989. Mean minimum temperature ranges from 17.8°C in February to 5.2°C in July, with the lowest temperature recorded at -2.3°C in June 2002. The mean annual rainfall is 213mm, with the highest annual rainfall recorded at 384 mm in 1997 and the lowest at 128 mm in 2002. The highest daily rainfall reached 48mm on 14 March 1989.

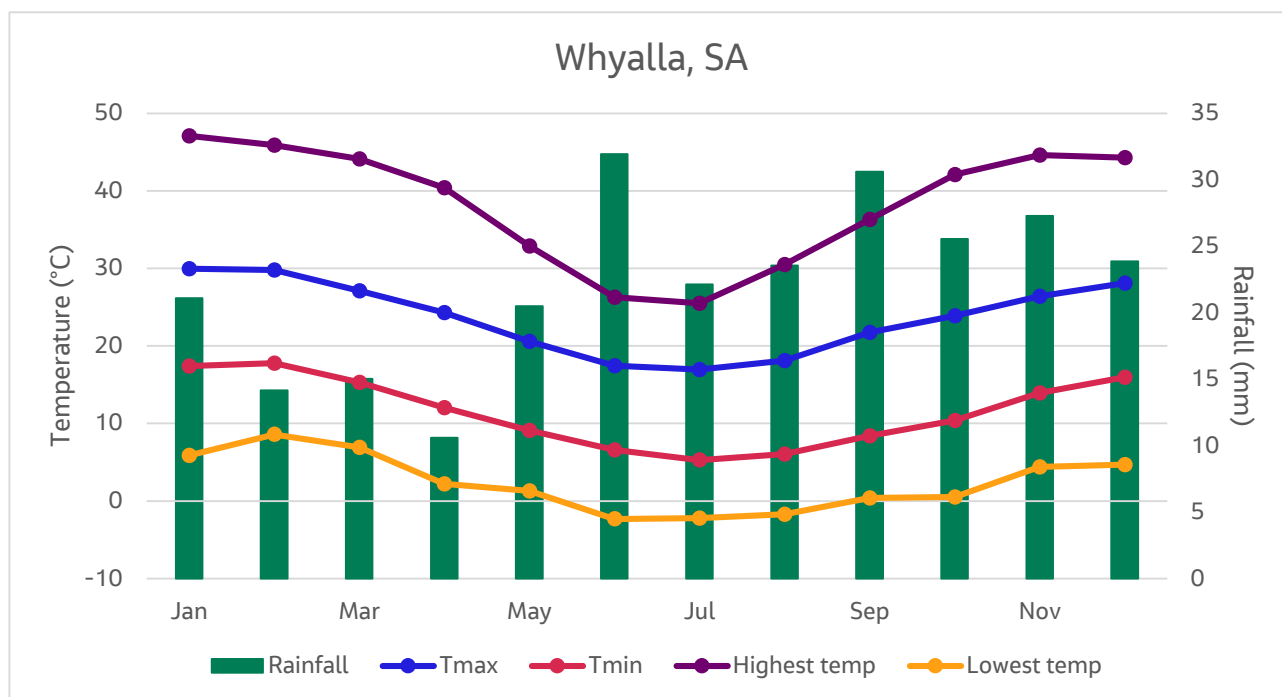


Figure 5. Current Average Climate Conditions for the Project (Whyalla, SA)

Within **Figure 5** records comprise: average monthly total rainfall (rainfall), monthly average maximum temperature (Tmax), highest recorded temperature in the month (Highest temperature), monthly average minimum temperature (Tmin) and lowest recorded temperature for the month (Lowest temperature).

The number of extreme heat days (temperatures over 35°C) for the baseline period is 19 days for Whyalla based on the climate statistics used above. Average humidity over the year varies from 38% (3pm) to 80% (9am).

4.4.2 Port Augusta

The climate statistics for Port Augusta Aero from 1986 to 2005 provide a comprehensive overview of the region's weather patterns (**Figure 6**).

The average maximum temperature ranged from 17°C in July to a peak of 30.06°C in January, with the highest recorded temperature reaching 47.1°C in January 2003. The mean minimum temperature fluctuates from 5.28°C in July to 17.79°C in February, while the lowest recorded temperature was -2.3°C in June 2002. The annual mean rainfall over the period was 436mm, with the highest annual rainfall of 778mm occurring in 1992 and the lowest of 182mm in 2002. The highest daily rainfall reached 79mm on 6 December 1992.

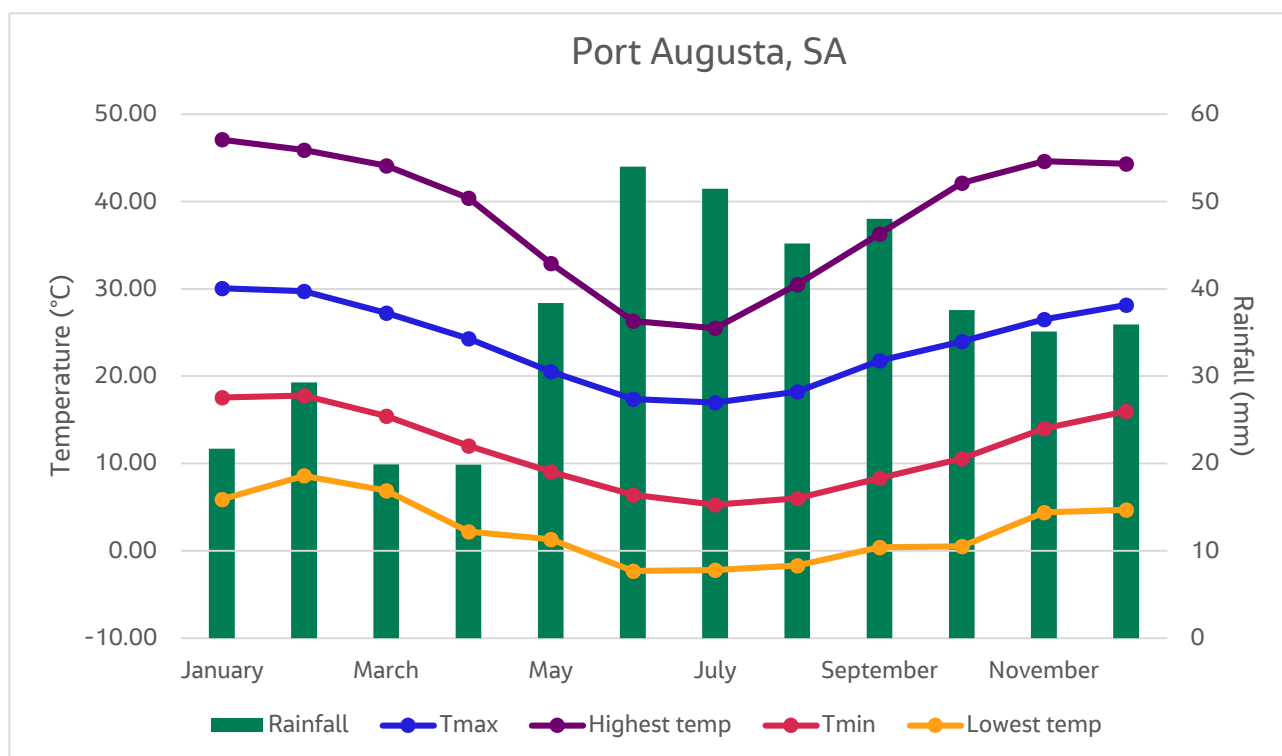


Figure 6. Current Average Climate Conditions for the Project (Port Augusta, SA)

Within **Figure 6** records comprise: average monthly total rainfall (rainfall), monthly average maximum temperature (Tmax), highest recorded temperature in the month (Highest temperature), monthly average minimum temperature (Tmin) and lowest recorded temperature for the month (Lowest temperature).

The number of extreme heat days (temperatures over 35°C) for the baseline period is 20.3 days for Port Augusta based on the climate statistics used above. Average humidity over the year varies from 44% (3pm) to 64% (9am).

4.4.3 Woomera

The climate statistics for Woomera provide a comprehensive overview of the weather patterns spanning from 1976 to 2015 (**Figure 7**).

The mean maximum temperature ranges from 12.81°C in July to 25.84°C in January, with the highest recorded temperature reaching 46.3°C in January 2003. The mean minimum temperature varies from 4.37°C in July to 14.84°C in February, while the lowest recorded temperature reached -0.9°C in July 1976. The region experiences limited rainfall, with mean annual rainfall at 130mm and the highest recorded rainfall of 363mm in 1992 and lowest recorded rainfall of 54mm in 2002. The highest daily rainfall reached 138mm on 14 March 1989.

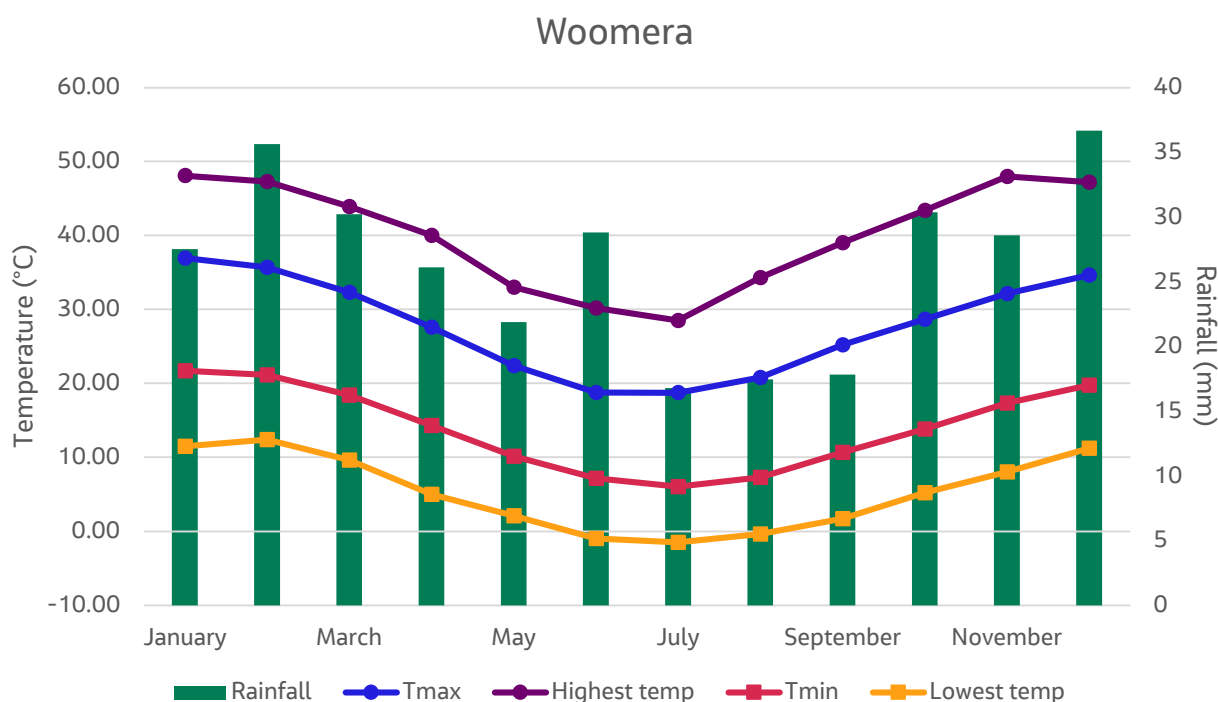


Figure 7. Current Average Climate Conditions for the Project (Woomera, SA)

Within **Figure 7** records comprise: average monthly total rainfall (rainfall), monthly average maximum temperature (Tmax), highest recorded temperature in the month (Highest temperature), monthly average minimum temperature (Tmin) and lowest recorded temperature for the month (Lowest temperature).

The number of extreme heat days (temperatures over 35°C) for the baseline period is 138.9 days for Woomera based on the climate statistics used above. Average humidity over the year varies from 30% (3pm) to 54% (9am).

4.4.4 Regional Fire Weather

The Forest Fire Danger Index (FFDI)³ takes measures of fuel dryness, temperature and wind speed to provide a measure of fire danger. Fire weather is considered 'extreme' when the FFDI exceeds 50, as bushfires have potentially greater human impacts at this level (DEW, 2022).

The baseline conditions for the number of extreme fire danger days for the relevant regional sub-clusters are as follows (DEW,2022):

- Whyalla and Port Augusta (Southern and South Western Flatlands): 4.2 extreme fire danger days per year
- Woomera (Rangelands): 12.7 extreme fire danger days per year

Further information on the local bushfire environment within the study area is available in the Northern Water Project Bushfire Risk Management Plan (JBS&G, 2026).

4.5 Selection of projections and timeframes

The climate change projections used for this assessment have been primarily sourced from DEW (2022).

³ Australia's fire danger rating framework has been revised, with current practice focusing on Fire Danger Ratings and Total Fire Ban days. FFDI projections are retained as they were the available and widely used metric at the time of analysis.

This includes dynamically downscaled projections for South Australia from the NARcliM 1.5 regional climate modelling project, which provides a more detailed appreciation of finer scale climate influences than is enabled by Global Climate Models (GCMs). It also includes projections from the Climate Change in Australia (CCIA) project from the CSIRO and BoM. DEW (2022) offers a portal to a range of climate projections from GCMs and downscaled results from Regional Climate Models (RCMs) using CMIP 5 models that informed the IPCC 5th Assessment Report.

The Guide includes information on climate change factors for temperature and annual rainfall variables for Woomera, Port Augusta and Whyalla. Climate change factors represent the magnitude of projected change compared to baseline period of 1986–2005. To develop climate change projections for the three sites, the climate change factors from DEW (2022) have been applied to historical climate data collected from BoM sites for the three locations over the same baseline period of 1986–2005. Where additional historical data is available, the baseline period has been extended to cover the period 1976–2015 to capture more recent climate change observations.

Projections for extreme rainfall variables based on the methodology within version 4.2 of Australian Rainfall and Runoff (ARR) (Ball et al, 2019) and have been sourced from the ARR Data Hub (Geoscience Australia, 2024). ARR recommends an increase of 15% per degree of warming for shorter-duration events (less than 1hr) whilst longer events (over 24h) are recommended to adopt an increase of 8% per degree of warming. This may be partially offset by increases in the rate of losses due to changes in moisture conditions prior to the rainfall event, with changes to initial and continuing losses of 4.5% per degree of warming respectively for the Port Augusta and Whyalla regions (DCCEEW, 2023). As noted in Section 4.1, the latest data from ARR utilises the SSP climate change scenarios instead of the RCPs. While the SSPs differ from the RCPs, ARR is considered to be the primary source for extreme rainfall projections. Extreme rainfall projections utilised in this report are based on SSP2-4.5 and SSP3-7.0, which are closest in comparison to RCP4.5 and RCP8.5, respectively.

Climate change projections relating to fire weather, relative humidity and wind speed have been sourced from the CCIA Cluster Reports, which communicate findings from climate change modelling outputs for eight regions of Australia based on former Natural Resource Management (NRM) regions (now Landscape Management Regions). This assessment has referred to the Cluster Reports for the Rangelands and Southern and Southwestern Flatlands clusters, which capture the Project areas, as seen in **Figure 8**. These have been overlaid on historical climate records for three locations along the Project extent to identify the future climate under which the Project will be required to operate.

Projections relating to sea level rise for Whyalla and Port Augusta have been sourced from CoastAdapt (2017), which is a national coastal climate risk management tool developed by the National Climate Change Adaptation Research Facility (NCCARF) and commissioned by the Australian Government through the (then) Department of Environment and Energy. Sea level rise projections have not been provided for Woomera on the basis that it is located around 160km northwest of the nearest coastline near Port Augusta and is unlikely to be directly impacted by sea level rise.

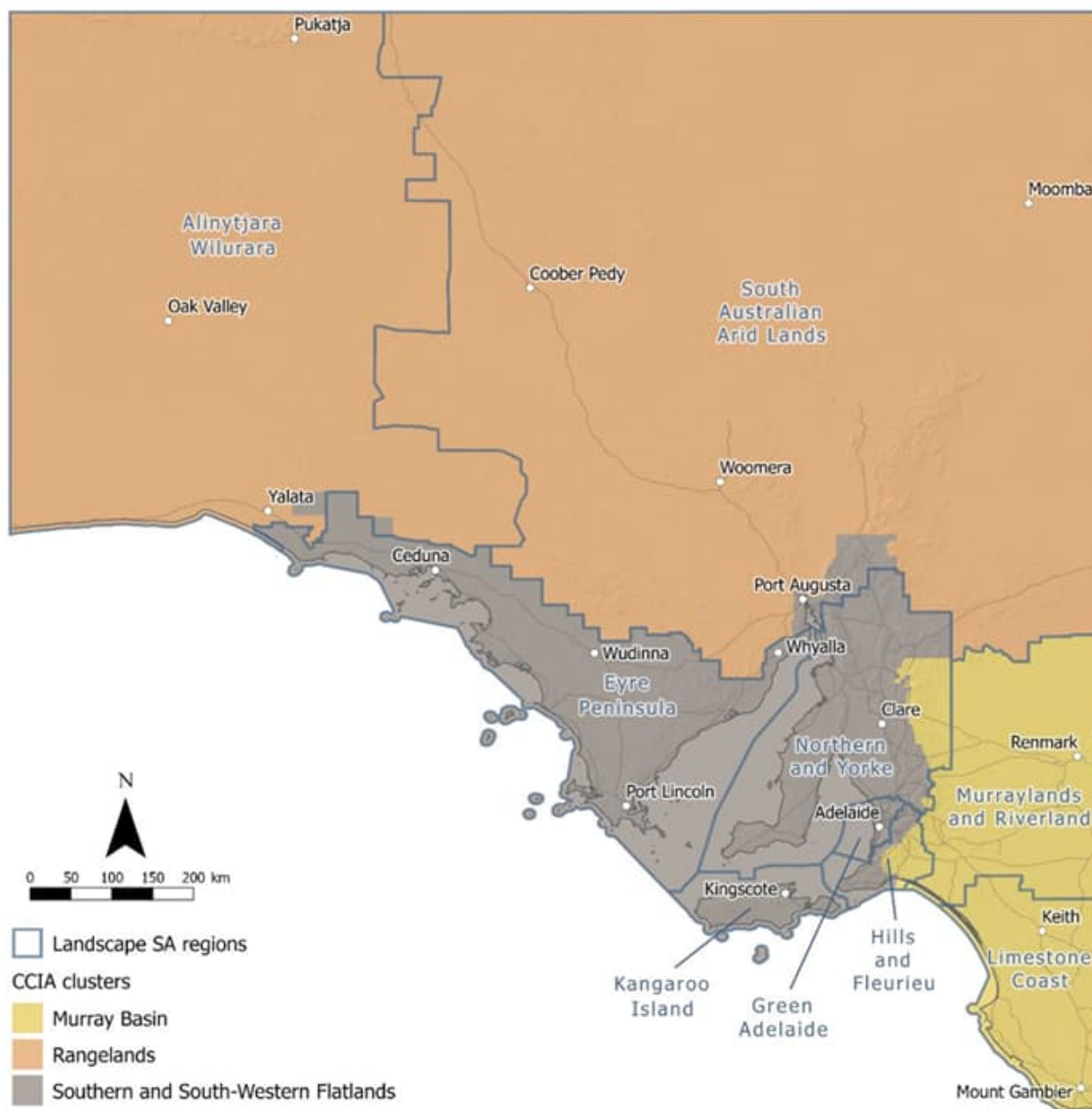


Figure 8. Regional geographical divisions of SA as defined by the CSIRO and BoM CCIA project, with overlaid boundaries of the Landscape Regions of SA (DEW, 2022)

The design life of the Project components determines the period for which climate change projections are used to assess the risk. This is because it is generally assumed that components with a shorter design life have the opportunity for longer term adaptations to be incorporated at the time of replacement and do not need to be designed beyond their initial life. For the Project, the assumed design life is presented in **Table 4-2**. Projections in 2050 are applied for shorter lived assets (0-40 years) whilst projections for 2090 can inform longer lived assets (>40 years). These projections are those from DEW (2022) introduced above and outlined in Section 4.6.

Table 4-2. Project components and design life

Project Component	Design Life (years)	Relevant Projection Year
RO membranes	5	2050
Instrumentation and control	15	2050

Cathodic protection	20	2050
Unsealed roads and access tracks	25	2050
Electrical / power supply assets (low voltage, high voltage)	25	2050
Mechanical assets (valves, drives, motors)	25	2050
Tanks – non-concrete and vessels	25	2050
Structures (platforms, walkways, etc)	50	2090
Above ground pipe – non-metals	25	2050
Above ground pipework – metallic	50	2090
Sealed roads and hardstands	50	2090
Tanks – concrete	50	2090
Concrete structures and sub-structures	50	2090
Terrestrial civil assets (shafts, buried pipelines, piles)	80	2090
Intake and outfall tunnels	100	2090
Marine structures, intake and outlet tunnels, concrete	100	2090
Marine pipework	100	2090
Marine replaceable components	50	2090
Water retaining or excluding structures	50	2090
Earth bank storages	50	2090
External slabs on ground / rigid pavement	50	2090
Buildings (warehouse, office, pump station)	50	2090
Controls / SCADA	15	2050
Ultrafiltration membranes	5	2050
Protective coatings on steelwork or concrete	25	2050

Projections in the section below are provided for the RCP8.5 scenario only for 2030 as the RCP4.5 scenario has a lack of divergence from RCP8.5 results by this time. Projections for both scenarios are provided for 2050 and 2090. Whilst projections are not available for the end of the Project's assumed 100-year lifespan (towards 2130), the trends out to 2090 have been used to inform increased risk beyond this period.

Information regarding the selection of a site to represent historical climate, and the projections adopted for the Project are presented in the following sections.

4.6 Climate Change Projections for the Project area

Climate change projections have been developed by adjusting historical climate records for the reference period with the climate change factors as set out in the section above. A full detailed set of climate change

projections which have been adopted for the assessment are presented in **Appendix A**, with key outcomes summarised below.

4.6.1 Mean and annual temperature

The annual mean daily maximum and minimum temperatures are expected to rise across all South Australian regions.

For Whyalla and Port Augusta, there is high confidence in the projection of more hot days and warm spells due to climate change. Extreme temperatures are anticipated to increase at a similar rate to the average temperature, leading to a significant rise in the temperature experienced on hot days and the frequency and duration of warm spells. These changes have notable implications for the region, suggesting an intensification of heat-related conditions.

By 2030, the projected increase in annual mean daily maximum temperatures in Woomera is up to 1.3°C. In the same timeframe, mean annual minimum temperatures are expected to increase by up to 1.1°C. Looking ahead to 2050, annual mean maximum temperatures may rise by up to 2.2°C, particularly impacting the north of the state. Mean annual minimum temperatures are projected to increase by up to 1.7°C.

4.6.1.1 Whyalla

Increase in temperatures

The maximum temperature in Whyalla is expected to rise over the forecasted years. This varies from an increase to 48.7 – 48.9°C in 2050, up to 49.1 – 50.8°C in 2090 under RCP4.5 and RCP8.5 respectively (**Figure 9**).

The minimum temperature, which was historically 2.3°C, is anticipated to increase between 0.6 – 0.9°C to circa 3.2°C by 2090 under RCP4.5 and RCP8.5 respectively (**Figure 10**).

Heat Extremes

Whyalla is projected to experience an increase in the average annual number of days with temperatures exceeding 40 degrees Celsius, from 5.7 days historically to 12.7 days in 2090 under RCP4.5 or 21.9 days under RCP8.5 (**Figure 11**).

4.6.1.2 Port Augusta

Increase in temperatures

In Port Augusta, the maximum temperature is projected to increase from 47.1°C historically to 48.8-48.9°C by 2050 and 49.4-51.3°C in 2090 under RCP4.5 and RCP8.5 respectively (**Figure 9**).

The minimum temperature is expected to rise from -2.3°C historically to -0.7 - 0.6°C in 2090 under RCP4.5 and RCP8.5 respectively (**Figure 10**).

Heat Extremes

Port Augusta is projected to experience an increase in the average annual number of days with temperatures exceeding 40 degrees Celsius, from 13.3 days historically to 26.3 days in 2090 under RCP4.5 or 40.3 days under RCP8.5 (**Figure 11**).

4.6.1.3 Woomera

Increase in temperatures

In Woomera, the maximum temperature is projected to increase from 46.3°C historically to 48.1-48.5°C by 2050 and 48.8-51°C in 2090 under RCP4.5 and RCP8.5 respectively (**Figure 9**).

The minimum temperature is expected to increase from -0.9°C historically to 1.1-2.8°C in 2090 under RCP4.5 and RCP8.5 respectively (**Figure 10**).

Heat Extremes

Woomera is projected to experience an increase in the average annual number of days with temperatures exceeding 40 degrees Celsius, from 10.2 days historically to 29.2 days in 2090 under RCP4.5 or 51.2 days under RCP8.5 (**Figure 11**).

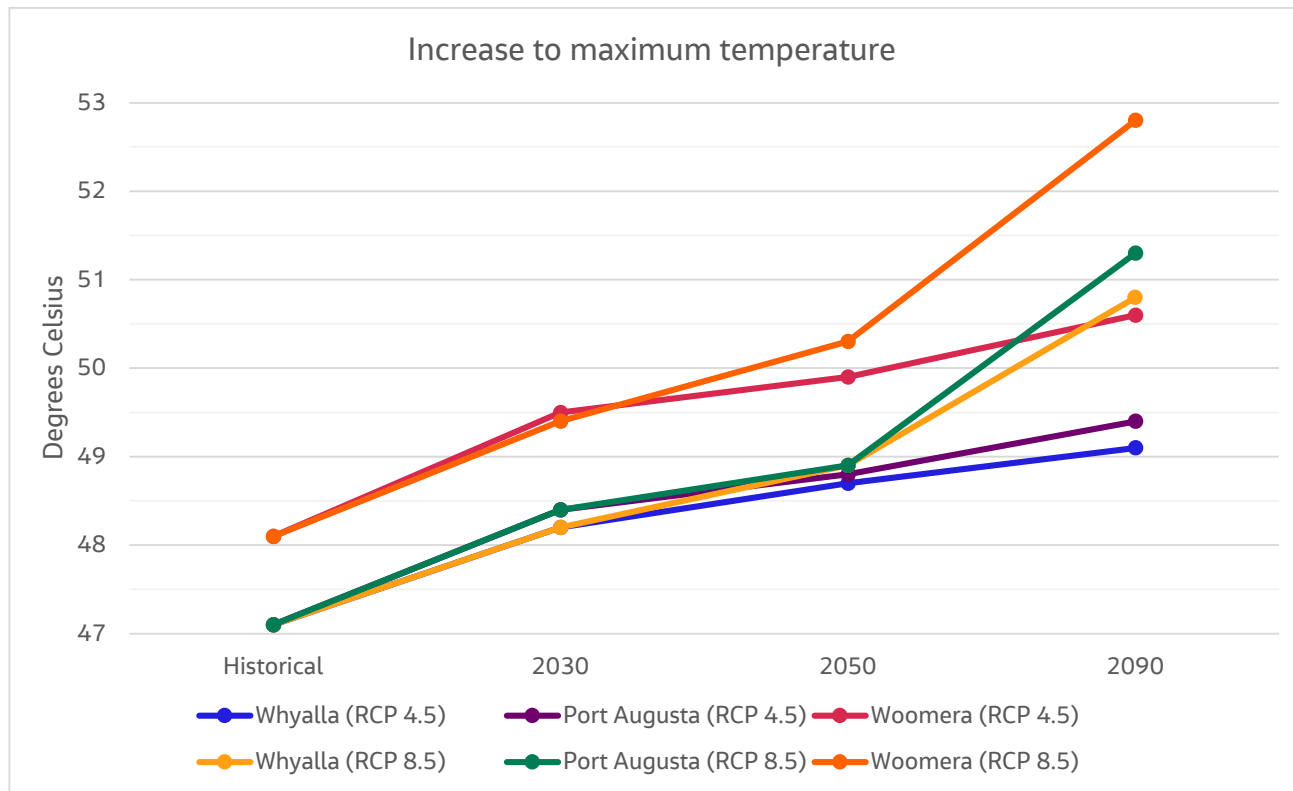


Figure 9. Summary of maximum temperature projections for 2030-2090

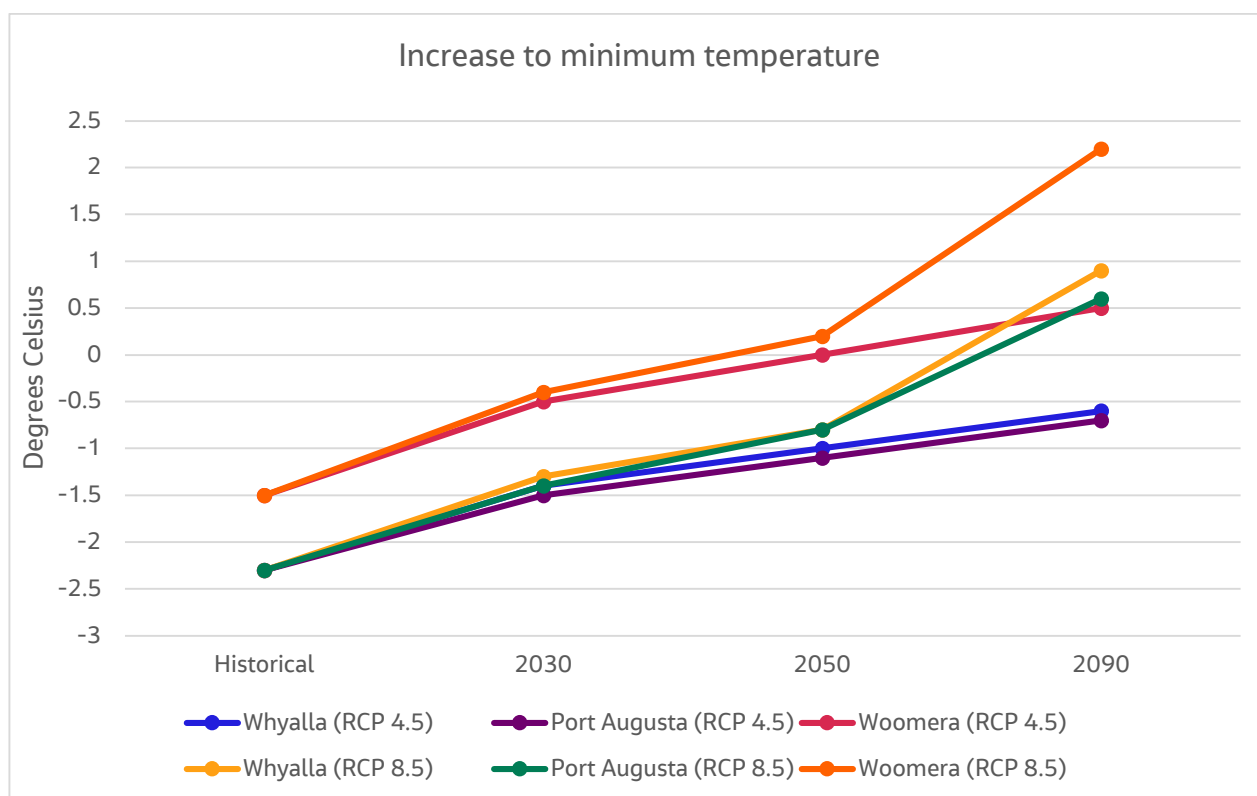


Figure 10. Summary of minimum temperature projections for 2030-2090

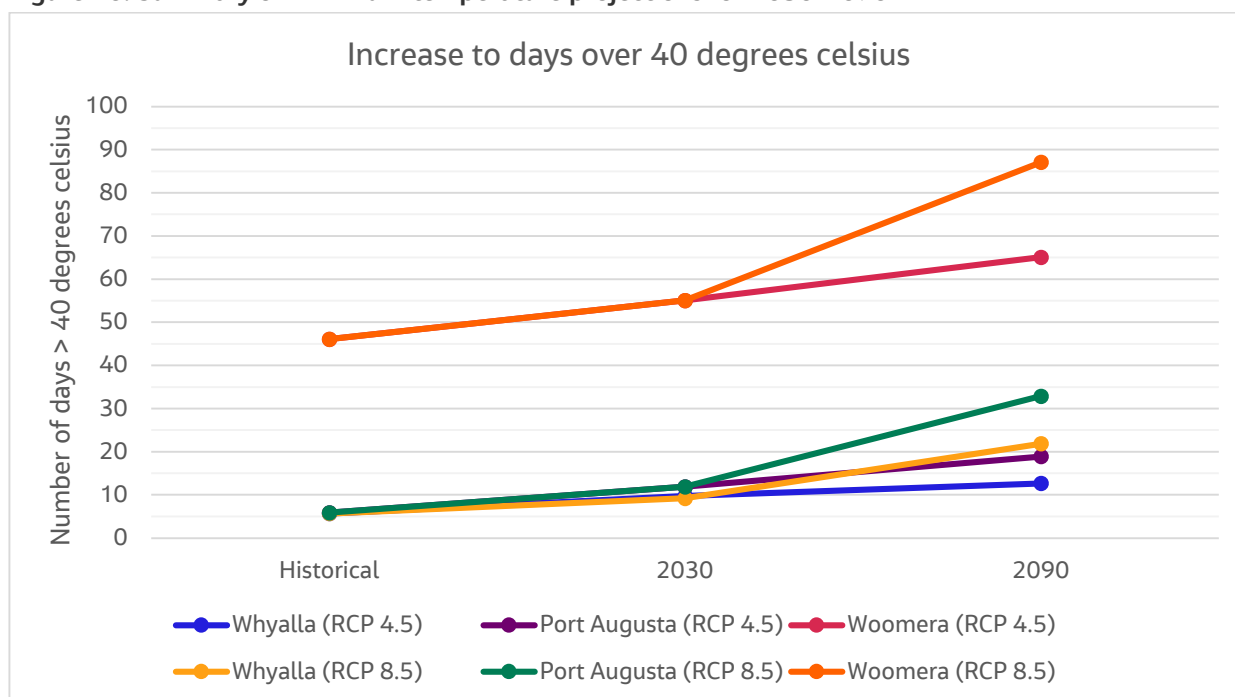


Figure 11. Summary of temperature projections (Increase to days over 40 degrees C) for 2030-2090

4.6.2 Average and extreme rainfall

Projections suggest that average annual rainfall will continue to decline throughout the century across all three locations. Under RCP 8.5, a 35% decrease in average annual rainfall is possible for Port Augusta and Woomera by 2090.

Shorter-duration extreme rainfall events (i.e. 1% AEP, <1hr events) are projected to increase in intensity for all sites across both emissions scenarios. While changes in extreme rainfall are relatively similar for both emissions scenarios for the 2030 and 2050 time horizons, by 2090 there is a much greater uplift in extreme rainfall intensity under a high emissions scenario. By 2090, under a moderate emissions scenario all three locations could see a 40% uplift in short-duration extreme rainfall events, which increases to a 59% uplift under a high emissions scenario.

Longer-duration extreme rainfall events (i.e. 1% AEP, >24hr events) are also projected to increase in intensity. There is little difference in extreme rainfall uplift between emissions scenarios for the 2030 and 2050 time horizons. By 2090, under a moderate emissions scenario all three locations could see a 20% uplift in longer-duration extreme rainfall events, which increases to a 29% uplift under a high emissions scenario.

4.6.2.1 Whyalla

The projections indicate a consistent decrease in average annual rainfall at Whyalla under RCP4.5 and RCP8.5 across the years 2030, 2050, and 2090. The average annual rainfall is projected to decrease by 16%-31% in 2090 under RCP4.5 and RCP8.5, respectively (**Figure 12**).

Shorter-duration extreme rainfall events are expected to increase in intensity, from 48mm historically to 67-76mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 13**).

Longer-duration extreme rainfall events are also projected to increase in intensity, from 124mm historically to 149-160mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 14**).

4.6.2.2 Port Augusta

The projections show a continual decline in average annual rainfall at Port Augusta under RCP4.5 and RCP8.5 for the years 2030, 2050, and 2090. Under RCP4.5, the average annual rainfall decreases by 17% in 2090 with a reduction of 35% projected under RCP8.5 (**Figure 12**).

Shorter-duration extreme rainfall events are expected to increase in intensity, from 52mm historically to 73-83mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 13**).

Longer-duration extreme rainfall events are also projected to increase in intensity, from 110mm historically to 132-142mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 14**).

4.6.2.3 Woomera

The projections indicate a consistent decrease in average annual rainfall at Woomera under RCP4.5 and RCP8.5 across the years 2030, 2050, and 2090. Under RCP4.5 the average annual rainfall is projected to decrease by 19% in 2090, and 35% under RCP8.5 (**Figure 12**).

Shorter-duration extreme rainfall events are expected to increase in intensity, from 49mm historically to 69-78mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 13**).

Longer-duration extreme rainfall events are also projected to increase in intensity, from 131mm historically to 157-169mm by 2090 under a moderate emissions scenario and a high emissions scenario, respectively (**Figure 14**).

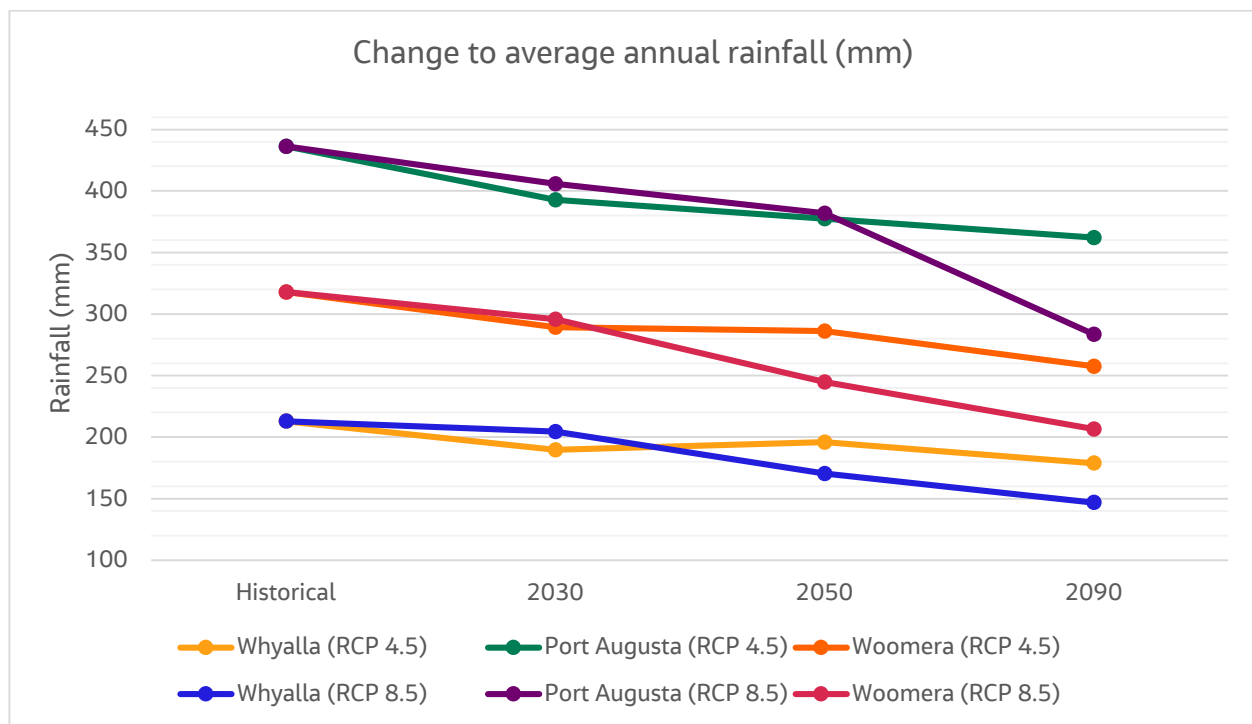


Figure 12. Summary of rainfall projections for changes to average annual rainfall for 2030-2090.

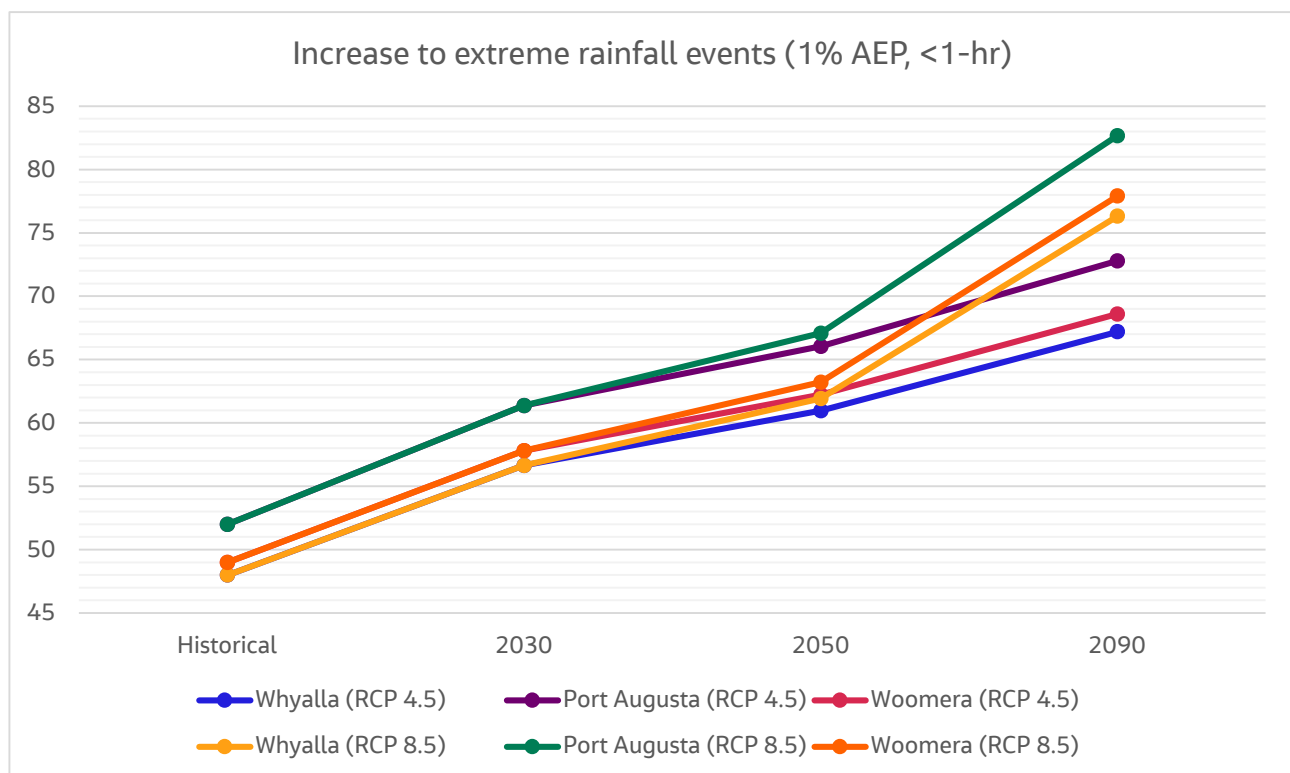


Figure 13. Summary of rainfall projections (increase to 1% AEP extreme rainfall events < 1 hr duration) for 2030-2090.

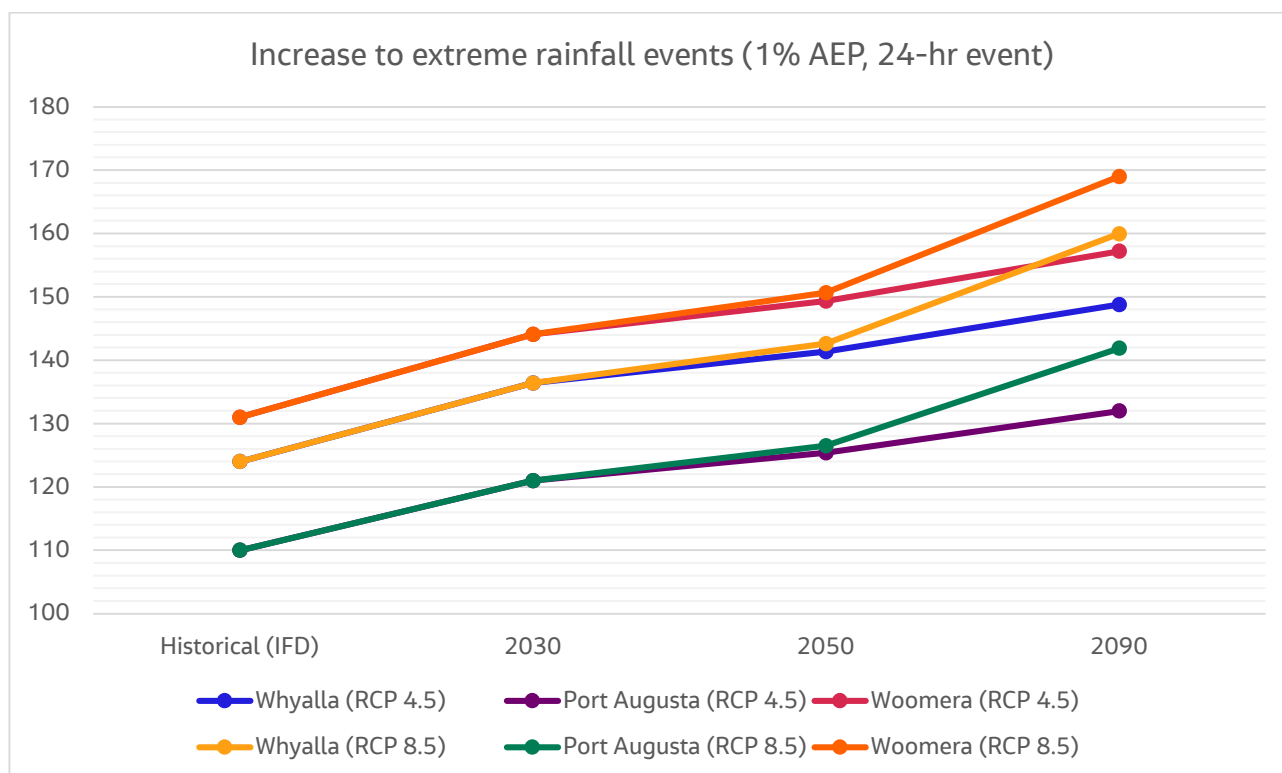


Figure 14. Summary of rainfall projections (increase to 1% AEP extreme rainfall events > 24 hr duration) for 2030-2090

4.6.3 Wind speed

Changes in wind speeds are expected to be small, and there is generally lower confidence in projections. Whilst more intense cyclonic conditions in the north of Australia may lead to the occurrence of increases in extreme wind, the study area is too far south to be exposed to these changes.

In the Rangelands and Southern and Southwestern Flatlands clusters, the range of projections is generally near zero, spanning small increases and decreases (broadly within 5% either side). Median values show the potential for small increases in seasonal winds in the Rangelands, and small decreases in the Southwestern Flatlands.

However, extra-tropical cyclones and tropical lows can move southward and bring heavy rainfall to the project region, particularly during summer months. Studies project that the frequency of tropical cyclones is expected to decrease over the century, however the proportion of the most intense storms may increase, further increasing the intensity of associated rainfall (Hope et al. 2015). This aligns with projections for extreme rainfall events presented in section 4.6.2.

4.6.4 Fire Weather

4.6.4.1 Whyalla and Port Augusta (Southern and Southwestern Flatlands East)

There is high confidence that climate change will lead to a harsher fire-weather climate in the Southern and Southwestern Flatlands East regions due to higher temperatures and lower rainfall (**Figure 15**). However, there is low confidence in predicting the magnitude of change in fire weather projections.

In the 2030 projections, it is anticipated that the Southern and Southwestern Flatlands East regions could experience an increase in extreme fire danger days from 4.2 to 5 days under RCP8.5, indicating a slight rise in extreme fire danger. By 2090, extreme fire danger days are projected to increase to 6 days (RCP4.5) and up to 7 (RCP8.5).

4.6.4.2 Woomera (Rangelands)

Bushfire activity in the Rangelands region depends on fuel availability, largely influenced by rainfall patterns. High confidence exists in the projection of a harsher fire weather climate due to higher temperatures and lower rainfall. Despite this, there is low confidence in the magnitude of fire weather projections.

In the 2030 projections (**Figure 15**), it is anticipated that the Woomera region could experience an increase in extreme fire danger days from 12.7 to 17.1 days under RCP8.5, indicating a notable rise in extreme fire danger. By 2090, these figures further intensify, reaching 18.8 days (RCP4.5) and up to 27.6 days (RCP8.5).

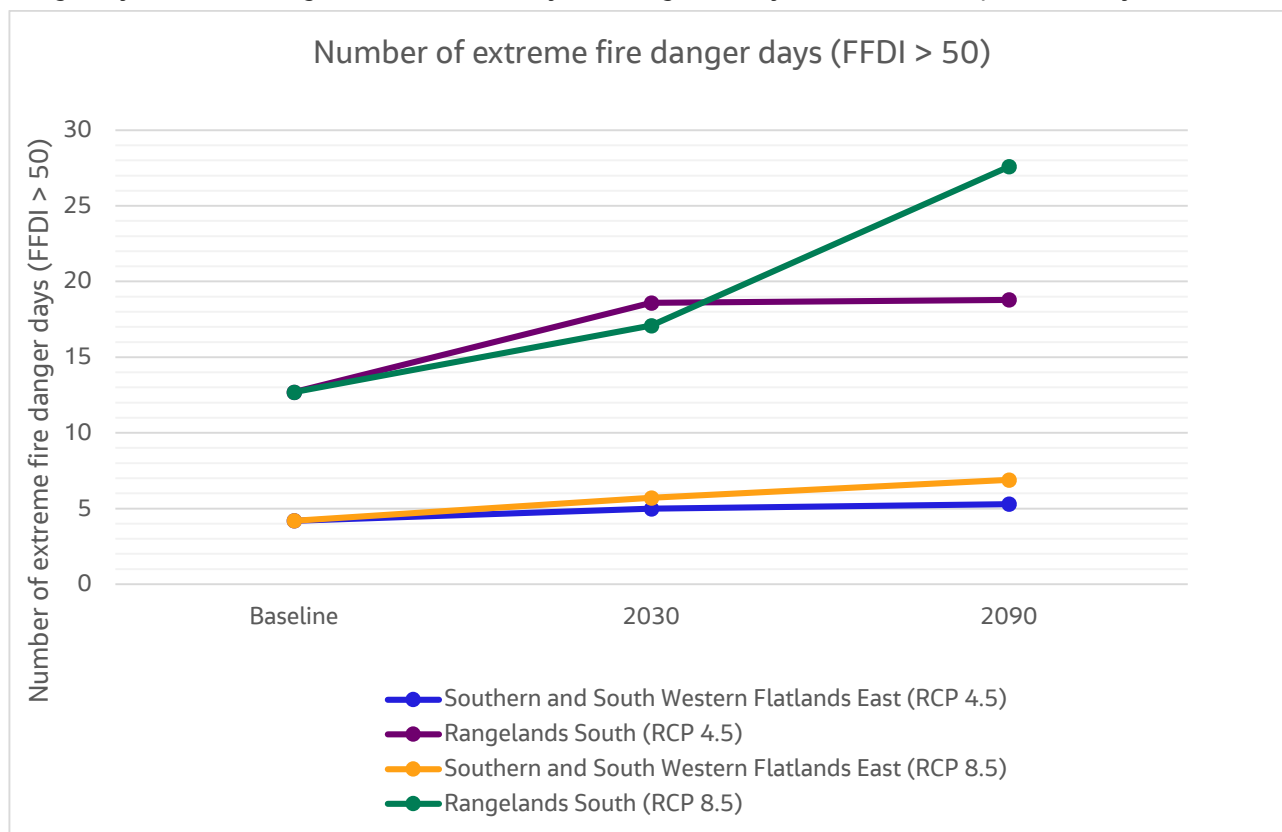


Figure 15. Summary of projected number of extreme fire danger days for 2030-2090.

4.6.5 Marine Conditions

DEW (2022) provides projections on climate-induced changing marine conditions in South Australia, focusing on acidity/alkalinity (pH) levels, ocean acidity, sea surface temperature, and salinity.

Additional marine projections specific to the Project for salinity and temperature have been prepared by the South Australian Research and Development Institute (SARDI) under the RCP8.5 scenario, though downscaling of a CMIP5 climate model. These projections were assessed for a future period (averaged across 2066 to 2095), relative to the historical reference period (averaged across 2006 to 2035). A validated one-kilometre resolution model of Spencer Gulf was completed, simulating present-day and future conditions with and without desalination plant return water discharge.

Findings presented in this section are based on climate modelling undertaken by SARDI for the Northern Water Project. Key results have been incorporated into this assessment.

4.6.5.1 pH Levels and Ocean Acidity

- There is very high confidence that the ocean around Australia will see a decrease in ocean pH making the ocean more acidic.
- The rate of ocean acidification is expected to be proportional to increases in carbon dioxide emissions.

4.6.5.2 Sea Surface Temperature

- Sea surface temperatures have been increasing significantly across the globe in recent decades.
- Projections, with very high confidence, suggest that this warming trend will continue. By 2030 and 2090, sea surface temperatures are expected to rise, with specific temperature increases projected for various locations in South Australia.

SARDI modelling outcomes close to the Project site show:

- Under the future climate scenario, mean water temperature across Spencer Gulf are projected to increase by approximately 1 to 2°C, while bottom water temperatures near the Mullaquana outfall are projected to increase by approximately 1.4 to 2.2°C, with the largest increases occurring during winter.
- Climate change and the desalination plant together are likely to hold temperature above 1.4°C relative to current conditions for much of the year.

4.6.5.3 Salinity

- Ocean salinity in coastal waters is expected to be affected by changes in rainfall and evaporation.
- Salinity changes can impact stratification, mixing, and nutrient supply in coastal waters.
- Projections for salinity changes in South Australian waters, including Spencer Gulf, vary, including possible increases and decreases, particularly under higher emission scenarios.

SARDI modelling outcomes close to the Project site show:

- Changes in salinity are more pronounced in bottom waters than at the surface. Current salinity conditions in Spencer Gulf vary spatially, with offshore waters near the shelf boundary typically exhibiting salinity values below 36 Practical Salinity Units (PSS-78), while salinities in Upper Spencer Gulf commonly exceed 38.5 due to the Gulf's naturally inverse-estuarine and hypersaline characteristics.
- Under the future climate scenario alone, mean bottom salinity increases by about 0.3 in the southern Gulf to more than 0.8 in the upper Gulf. At the outfall site, bottom salinity is projected to increase by 0.4 to 0.6 relative to current conditions, with the largest increases occurring in summer.
- The discharge of return water raises bottom water salinity by less than 0.5 at Mullaquana, confined mostly within 2 - 8 kilometres of the outfall, diluting to less than 0.03 beyond the site, and behaving much as under present-day conditions, though extending further north-east towards Whyalla and closer to the coast.
- The modelling also indicates that the existing inverse-estuarine circulation of Spencer Gulf is likely to persist and strengthen under future climate conditions, influencing the distribution of salinity changes throughout the Gulf.
- In summary, at Mullaquana, the projected climate signal is the dominant control on future salinity, and the discharge of return water, a secondary, localised contribution. If emissions continue at current levels, the regional salinity increase will substantially exceed that from the desalination plant alone.

4.6.5.4 Sea Level Rise

The rate of sea level rise has been accelerating since the 19th century. In the near term, projections are almost independent of the emissions scenario, but separate from around 2050. For the more intense RCP8.5, the rate of rise continues to increase and is projected to result in a sea level rise approximately 30 per cent higher than RCP4.5 by 2090 (Dowdy, A. et al, 2015).

Sea level rise projections from CoastAdapt (2017) project that both Whyalla and Port Augusta may experience sea level rises, ranging from 0.23 metres in 2050 to 0.59 metres by 2090 under RCP8.5 (**Figure 16**). CPB (2022) identifies the need to adapt to a minimum of 0.3m by 2050 with sufficient allowance to cater to 1m by 2100.

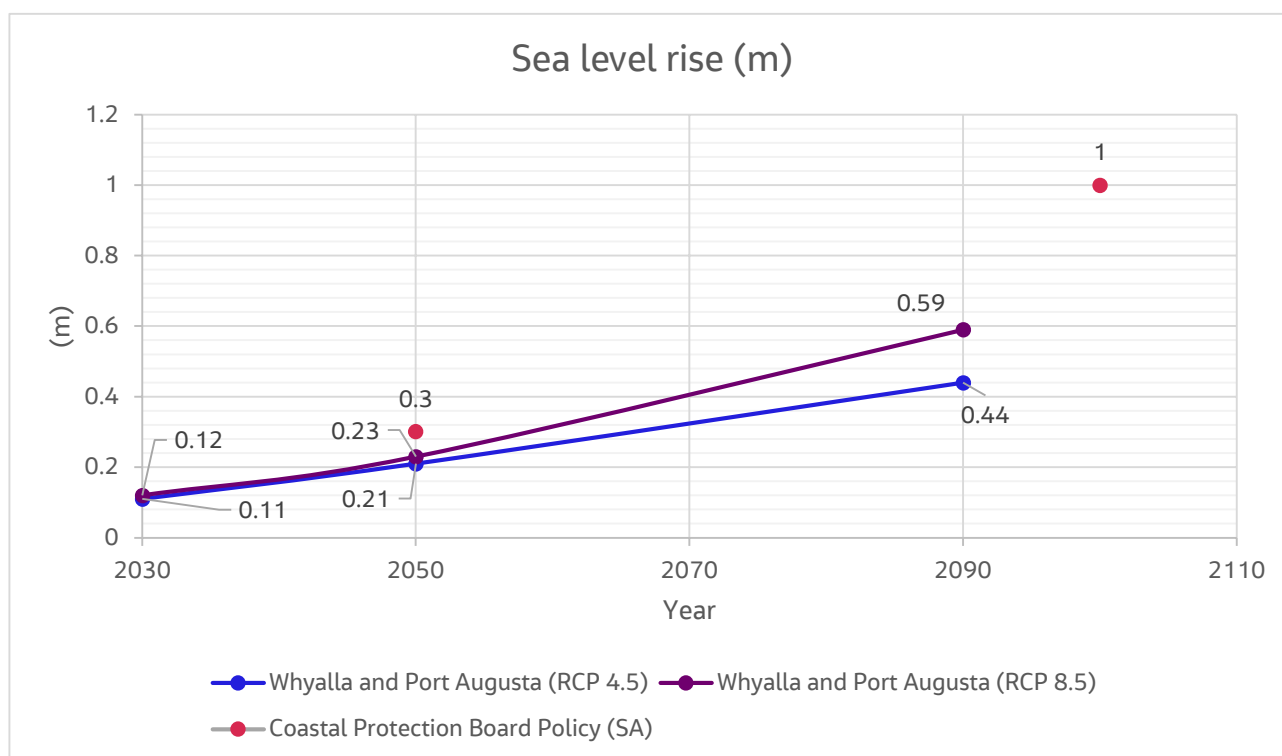


Figure 16. Summary of Sea Level Rise Projections for Whyalla and Port Augusta for the years 2030 - 2090

4.6.6 Humidity

Changes in humidity patterns are expected due to climate change. Specifically, as the atmosphere warms, the capacity to hold moisture increases. Consequently, relative humidity is projected to rise over ocean areas, however, the increased warming of land temperatures compared to sea temperatures leads to humidity generally decreasing over continents, particularly away from the coasts.

4.6.6.1 South and Southwestern Flatlands East (Port Augusta and Whyalla)

Minor changes in relative humidity are projected for 2030 with high confidence. Under RCP4.5, by 2090 there is projected to be a substantial decrease of up to 1.5% in relative humidity during spring (high confidence).

Under RCP8.5, by 2090 there is projected to be a 1.6% annual reduction in relative humidity, with reductions ranging between 0.3% in autumn to 2.8% in spring.

4.6.6.2 Rangelands (Woomera)

By 2090, there is medium confidence in a decrease in humidity in the Rangelands region for summer and autumn, and a high confidence in winter and spring. The degree of change varies with each season, with a 2.4% annual reduction projected and between 1.1% in summer to 3.7% in winter under RCP8.5 by 2090.

5. Climate Change Risks

The Project infrastructure faces numerous climate risks of varying levels of likelihood and consequence resulting from forecast changing climate patterns.

This section addresses the identified climate change-related risks and their potential implications on the Project. Risks and controls were identified through a workshop process, held with representatives from the SA Government and the project team across engineering, environment and approvals as well as members from the Jacobs and JBS&G EIS project team. Risks have been reviewed and updated to account for design changes.

No extreme or high risks have been identified. A summary of the key narratives relating to the causes and consequences of the medium risks, is provided. All risks and controls, likelihood and consequence are identified in **Appendix B**.

5.1 Increased ambient temperatures and heatwaves

As discussed in Section 4.6.1, minimum, average and maximum temperatures are expected to increase across the Project extent, which raises potential risks for the Project, presented in this section.

All of the risks assessed against increased ambient temperatures and heatwaves shown in **Table 5-1** resulted in a medium inherent risk rating.

Table 5-1: Risks and BAU controls associated with increased ambient temperatures and heatwaves (medium risks)

Assets / Operations Impacted	Climate Risk	Business as usual controls
Utilities & Power Supply	More hot days and increased power demand could lead to brown-outs / black-outs potentially leading to the plant and pump stations being taken offline. There would be an inability to provide water treatment during the outage period, stopping the transfer of water to transfer system, but no damage to equipment.	Incorporate water storage and back-up power to meet required water production and reliability requirements.
	An increase in hot days leads to overheating of power supply. Consequences could lead to thermal runaway and fires from overheating of equipment.	Equipment designed with temperature triggers and appropriate protection from over energisation from network. Fire detection and prevention systems installed within all buildings.
All asset components	Higher temperatures and proximity to the ocean may have a combined effect of increased humidity and cause accelerated damage to exposed components, reducing the design life and requiring more frequent or expensive repairs.	Durability and minimum standards for corrosion control and material selection will be built into the tender documentation.
	Increased ambient temperatures and frequency of heatwaves could lead to	Pump stations feature ventilation fans to assist in maintaining the internal temperatures close to

	higher internal temperatures in the pump stations, leading to equipment outages. There would be an inability to provide services during the outage period but no damage to equipment.	the outside temperature, with a maximum difference of 5°C. The need for reverse cycle air conditioning for the pump room should also be considered during detailed design in consultation with the operator.
	Increased ambient temperatures and frequency of heatwaves could cause potential for uncovered Project storages to have increased evaporation. Potential for inadequate sizing of storage.	Design of the Project storages are to be covered, according to a design requirement.
	Combined effects of increased temperatures and decreased rainfall may result in potential future offtakers / demands beyond the capacity of the Project.	Project capacity and infrastructure sizing has been informed by negotiations with potential future offtakers and includes consideration of capacity for growth.

5.2 Increased rainfall intensity and surface water flooding

As discussed in Section 4.6.2, the intensity of extreme rainfall events is expected to increase across the project extent, which raises potential risks for the Project, presented in this section.

All risks assessed against increased rainfall intensity and surface water flooding shown in **Table 5-2** resulted in a medium inherent risk rating.

Table 5-2. Risks and BAU controls associated with increased rainfall intensity and surface water flooding (medium risks)

Asset/s Impacted	Climate Risk	Business as usual controls
Desalination Plant Infrastructure	A reduction in rainwater infiltration on the site combined with potential future increases in extreme rainfall could result in the drainage systems becoming inadequate and causing flash flooding and pooling which could damage ground level assets and equipment.	Landscape design to encourage natural rainwater infiltration and implement appropriate stormwater management measures to a suitable standard that accounts for future climate change. This may include features such as retention ponds or bioswales to manage increased stormwater runoff.
Water Storage and Distribution	Increase of rainfall intensity and surface water flooding events creating greater local erosion causing a risk to water delivery pipeline infrastructure due to exposure to impact and/or degradation of footings around waterway crossings.	Appropriate engineering of pipeline structures to resist erosion, backfilling and recontouring disturbed areas to approximately match pre-construction levels to ensure stabilised soils and to reinforce natural environments and mitigate erosion around waterway crossings.
	Cumulative effect of storm surge and high rainfall and/or flooding	Appropriate engineering solutions to prevent displacement during storm surge and flooding

	damaging distribution infrastructure through debris impact and accelerated corrosion causing temporary loss of service.	events through optimised pipeline burial depths and additional engineering solutions to anchor pipelines securely if required. Durability and minimum standards for corrosion control and material selection will be built into the tender documentation.
	An increase in surface flooding events causes a greater risk of overland flows entering pipes through air valves, resulting in contamination of product water.	Air valve design to assume overland flow. Design to ensure prevention of flooding of air valves to avoid water quality risk. Emergency discharges may be required if pipeline water quality is unsuitable and will require flushing via the scour valves, although modern management methods seek to minimise the amount of flushing carried out on a pipeline to reduce water losses.
	Combined impacts of increased rainfall intensity with impacts of heat and drought cause damage to water delivery infrastructure due to increased corrosion potential.	Water delivery pipeline design to mitigate combined impacts through selection of erosion-resistant backfill materials and corrosion-resistant pipeline materials.

5.3 Potential change in wind speed

Whilst there is generally expected to be small change to wind speeds within the study area (medium confidence), there is low confidence in whether the change is likely to be a small increase or decrease for the Woomera region (DEW, 2022).

As such, there are only low risks associated with potential changes in wind speed, further covered in **Appendix B**.

5.4 Increase in frequency and intensity of bushfires

All risks assessed against an increase in the frequency and intensity of bushfires shown in **Table 5-3** resulted in a medium inherent risk rating. For water storage and distribution infrastructure, bushfire risks become more significant by 2050, however, for utilities and power supply, bushfire risks are expected to increase later in the century by 2090.

Further information on recommended mitigation and management measures for bushfires is available in the Northern Water Project Bushfire Risk Management Plan (JBS&G, 2026).

Table 5-3: Risks and BAU controls associated with increase in frequency and intensity of bushfires (medium risks)

Asset/s Impacted	Climate Risk	Business as usual controls
Utilities & Power Supply	More frequent and more extreme bushfires cause risks to power distribution infrastructure at a regional scale which could disrupt power supply over longer time scales.	Storages in place at desalination plant sites and along the pipeline to meet water reliability requirements.
Water Storage	Increase in frequency and intensity of bushfires causes damage to the Lincoln Gap, Kalaya, Mangata, and Bimba water storage.	Design is to meet BAL ratings. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan, including

Desalination Plant and Pump Stations	Increase in frequency and intensity of bushfires causes damage to the Mullaquana desalination plant and pump station, Lincoln Gap pump station, Kalaya pump station, and Mangata pump station.	vegetation management in proximity to the desalination plant, pumping station and water storage tanks, asset protection zone management, regular asset inspections and maintenance, investigations into network events, bushfire season controls, security measures, as well as Preparedness, Response and Recovery measures.
---	--	---

5.5 Changing Marine conditions

As discussed in Section 4.6.5, marine conditions are expected to change under climate change, with sea levels projected to rise, potential increases in acidity and differences in salinity, which raises risks for the Project, presented in this section.

All risks assessed against changing marine conditions as a result of climate change shown in **Table 5-4** resulted in a medium inherent risk rating.

Table 5-4: Risks and BAU controls associated with changing marine conditions (medium risks)

Asset/s Impacted	Climate Risk	Business as usual controls
Intake and Outfall	Increase in sea surface temperatures as a result of climate change could promote additional sea life growth which could result in higher growth rates of fouling organisms or higher rates of other intake organisms such as jellyfish. This could increase the roughness and decrease the effective diameter of the intake tunnel or block intake screens, reducing the available water intake rates.	Control measures include chlorine dosing in the intake tunnel to prevent fouling, maintenance and design to include screening in the intake systems.
	Change in Spencer Gulf pH and salinity as a result of climate change causing corrosion and associated damage of riser and intake marine structures causing increased level of repair and maintenance.	The following control measures aim to mitigate the risk of degradation in riser and intake pump infrastructure due to changes in Spencer Gulf pH and salinity: ▪ designing infrastructure with corrosion-resistant coatings and redundancy, ▪ selecting durable materials, and ▪ adhering to stringent design standards to ensure resilience and reduce the need for increased repair and maintenance.
	Compounding effect of storm surge and high rainfall/flooding causing potential impacts to intake / outfall pump station.	Bunds upgradient have been designed to convey 1% AEP for 2100 under SSP3-7.0.

		Finished floor level is an additional 0.25m above minimum site level (≥ 4.15 m AHD to 2150). Note that 1% AEP sea level rise to 2150 is 3.90 m AHD.
Desalination Plant Infrastructure	Higher sea surface temperatures and acidification as a result of climate change may reduce the facility life due to failure of irreplaceable components (tunnel linings etc).	Develop a corrosion control and material selection specification for a high-level framework for durability.
Treatment / process systems	Increased frequency and intensity of marine heatwaves and / or more frequent and intense extreme rainfall and catchment flooding result in reduced quality of intake water supply. This can lead to additional pretreatment requirements, chemical and energy usage, which may accelerate degradation of membranes and require more frequent replacements. The increase in chemical and / or reagent demand may also exceed site storage requirements, leading to the facility being unable to meet the desired treatment capacity.	- Design to consider range of intake water qualities and selecting appropriate and flexible pre-treatment, - Chemical treatment inputs, - Designing facilities with the ability to retrofit additional treatment options, - Selecting adaptable treatment technologies capable of being online or offline, or scaling up or down as needed, such as a dissolved air flotation (DAF) or dissolved air flotation and filtration (DAFF) system to remove organic matter, and - Implementing ongoing water quality monitoring to proactively identify deviations in water quality, thereby mitigating the impact by enabling implementation of treatment measures.

It is acknowledged that concerns have been raised regarding the potential cumulative impacts of the desalination plant's outfall return water and modelled changes in gulf salinity, temperature or pH levels (as a result of climate change) causing effects on the environment and receptors.

Future projections for changes to salinity (and temperature and other relevant factors) resulting from climate change (based on the RCP 8.5 climate scenario) have been incorporated into far-field hydrodynamic modelling (see separate EIS report) for the Project to enable assessment of cumulative impacts.

Notwithstanding this being assessed elsewhere in the EIS, this is not considered to be a risk as any changes to background conditions will have proportional effects on the return water and are not expected to result in any cumulative escalations. This is already controlled through:

- implementing site specific and fit for purpose plant design that will ensure effective management of return water concentrations, and
- opportunities to reduce potential impacts to the surrounding environment via optimising diffuser design to ensure the release of water to regulatory standards.

5.6 Decreases in average rainfall and increased drought conditions

As discussed in Section 4.6.2, average rainfall is expected to decrease across the study area, which raises potential risks for the Project, presented in this section.

All risks assessed against decreases in average rainfall and increased drought conditions shown in **Table 5-5** resulted in a medium inherent risk rating. All risks were not reached until 2090.

Table 5-5: Risks and BAU controls associated with decreases in average rainfall and increased drought conditions (medium risks)

Asset/s Impacted	Climate Risk	Business as usual controls
Utilities and Power Supply	Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.	Design standards typically consider a range of moisture contents and ground conditions based on geotechnical testing to consider shrink/swell impacts.
Desalination Plant Infrastructure		
Water Storage and Distribution		

6. Resilience Planning

The Department of Infrastructure and Transport (DIT) (the EIS Proponent) have introduced specific technical requirements for Sustainability in Design and Construction. for the purpose of potential contractors to adhere to as part of the tender process for the Design, Build, Operate and Maintain request for tender process. This includes requirements for contractor design documentation for each design package to include relevant climate change risks and adaptation measures, which will apply to the Project in future design and construction phases. Requirements include the following:

- The contractor must undertake a Climate Change Risk Assessment (in addition to this assessment which forms part of the EIS) that includes meeting any requirements of the primary Project approvals.
- The Climate Change Risk Assessment must be undertaken using a multi-disciplinary team and be undertaken prior to the submission of, and documented within, preliminary design documentation to confirm final risk ratings and update with additional risks identified. The Climate Change Risk Assessment must involve DIT, include relevant natural hazards, and ensure alignment with DIT's Climate Change Adaptation Guideline.
- Climate change risks classified as high and extreme in the Climate Change Risk Assessment must be managed and treated in accordance with DIT Technical Requirements related to Risk Management.
- Adaptation and mitigation measures for climate change risks must be included in relevant design documentation with evidence of implementation clearly documented, and residual risks entered into the Project's Risk Register in accordance with DIT Technical Requirements related to Risk Management.
- The contractor must ensure and provide evidence that appropriate risk treatments have been implemented for any high and extreme climate change risks, and residual risks (and recommended treatments) incorporated into the relevant documentation provided at project handover with management responsibility identified.
- The Climate Change Risk Assessment must be reviewed and revised to account for potential updates to projection and hazard data, and material changes to design, construction and operations.

This section of the report outlines potential climate change adaptation measures that have been identified for further consideration during design and construction phases to respond to these requirements.

6.1 Climate change adaptation

Climate change adaptations involve adjusting natural or human systems in response to current or projected climate conditions and their potential impacts, whether beneficial or adverse (Smit et al., 2001). The purpose of adaptation is to enhance resilience to climatic and other changing factors that may affect the performance, operating life, and usage of an infrastructure system. These adaptations can occur independently or because of planned actions, with the latter involving additional controls introduced to address climate risks that remain at unacceptable levels despite the application of BAU risk controls.

The process of identifying 'adaptations' or 'resilience measures', as outlined by Smit et al. (2000), involves addressing four key questions:

Adaptation to what? This pertains to understanding the specific climatic or other change factors to which resilience needs to be built, considering timeframes and spatial scales.

Who or what adapts? This question focuses on determining which aspects of the infrastructure and/or its operation require modification to ensure resilience over its operating life.

How does adaptation occur? This involves considering the changes needed in infrastructure design, construction, and/or operation to incorporate the necessary resilience, and determining whether adaptive

measures should be implemented at the outset, or incrementally, as climate change progresses and the asset is managed.

How effective is the adaptation? This addresses whether the adaptation measures effectively mitigate the identified risks and if the benefits of risk reduction justify the associated costs.

These were discussed as part of the climate risk workshop held between the SA Government and the project team and members from Jacobs and JBS&G, and reassessed following a review of inherent risks, as well as residual risks following their implementation. This section presents a summary of the adaptation measures which were deemed appropriate for exploration beyond BAU controls, to further reduce the high and medium risks.

While risk treatment options have been initiated for some of the more significant identified risks, further exploration and detailed investigation will be conducted during the detailed design phase. This stage will involve further modelling and decisions regarding design components to refine the adaptation strategies and ensure their effectiveness.

6.2 Potential adaptation measures

It is noted that there are no extreme or high risks identified. Adaptation measures proposed should be further assessed at the detailed design stage to determine appropriateness against risk acceptance. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required. The adaption measures proposed for potential implementation are those identified to manage the 'medium' risks as discussed in Section 5. These are presented in **Table 6-1**.

Table 6-1. Mitigation measures reducing climate change risks to an acceptable level.

Risk	Potential adaptation measures	Residual risk rating
Compounding effect of storm surge and high rainfall/flooding causing potential impacts to intake / outfall pump station.	Design to provide resilience to cumulative impacts of sea level rise, storm surge changes and increases in extreme rainfall under SSP3-7.0 over the design life in final alignment and detailed design of intake pump station infrastructure. Adaptive operational procedures to allow for additional measures to be implemented as needed.	Medium
An increase in hot days leads to overheating of power supply. Consequences could lead to thermal runaway and fires from overheating of equipment.	The detailed design stage should consider climate change scenarios expected at end of life and design to maintain level of service under the expected increase in ambient temperatures and frequency / intensity of heatwaves.	Medium
More hot days and increased power demand could lead to brown-outs / black-outs potentially leading to the plant and pump stations being taken offline. There would be an inability to provide water treatment during the outage period, stopping the transfer of water to transfer system, but no damage to equipment.		Low

Risk	Potential adaptation measures	Residual risk rating
Higher temperatures and proximity to the ocean may have a combined effect of increased humidity and cause accelerated damage to exposed components, reducing the design life and requiring more frequent or expensive repairs.		Medium
Increased ambient temperatures and frequency of heatwaves could lead to higher internal temperatures in the pump stations, leading to equipment outages. There would be an inability to provide services during the outage period but no damage to equipment.	The detailed design stage should investigate the adequacy of air conditioning within pump stations based on asset performance under increased ambient temperatures to maintain ideal operating temperatures.	Medium
Increased ambient temperatures and frequency of heatwaves could cause potential for uncovered Project storages to have increased evaporation. Potential for inadequate sizing of storage.	The detailed design stage should consider the climate change scenarios expected at end of life and design to maintain level of service under the projected increase in ambient temperatures and frequency / intensity of heatwaves.	Medium
Combined effects of increased temperatures and decreased rainfall may result in additional potential future offtakers / demands beyond the capacity of the Project.	The detailed design stage should consider demands and potential future offtakers to be monitored by the project proponent post operations and maintenance commencement. Investigations can be commissioned to increase scheme production capacity or storage capacity well in advance of when NW is expected to reach capacity limits.	Medium
A reduction in rainwater infiltration on the site combined with potential future increases in extreme rainfall could result in the drainage systems becoming inadequate and causing flash flooding and pooling which could damage ground level assets and equipment.	Design of detention basins for longer term climate conditions. Ongoing monitoring of asset performance under climate change and adaptive operational procedures to allow for additional measures to be implemented as needed.	Low
Increase of rainfall intensity and surface water flooding events create greater local erosion causing a risk to water delivery pipeline infrastructure due to exposure to impact and/or degradation of footings around waterway crossings.	Vegetation selection to keep in mind erosion risk (alongside other climate hazards). Vegetate with ground covers, particularly in bare patches of land within tank and pump station compounds, to prevent erosion and improve aesthetics.	Medium

Risk	Potential adaptation measures	Residual risk rating
Cumulative effect of storm surge and high rainfall and/or flooding damaging distribution infrastructure through debris impact and accelerated corrosion causing temporary loss of service.	The detailed design stage should consider climate change scenarios expected at end of life and design to maintain level of services under the projected increase in rainfall intensity.	Medium
An increase in surface flooding events causes a greater risk of overland flows entering pipes through air valves, resulting in contamination of product water.		Medium
Combined impacts of increased rainfall intensity with impacts of heat and drought cause damage to water delivery infrastructure due to increased corrosion potential.		Medium
Increase in sea surface temperatures as a result of climate change could promote additional sea life growth which could result in higher growth rates of fouling organisms or higher rates of other intake organisms such as jellyfish. This could increase the roughness and decrease the effective diameter of the intake tunnel or block intake screens, reducing the available water intake rates.	The detailed design stage should consider the climate change scenarios expected at end of life and design to maintain level of services under the projected changing marine conditions.	Medium
Change in Spencer Gulf pH and salinity as a result of climate change causing corrosion and associated damage of riser and intake pump infrastructure causing increased level of repair and maintenance.		Medium
Higher sea surface temperature and acidification may reduce the facility life due to failure of irreplaceable components (tunnel linings etc).		Medium
Higher sea surface temperatures and acidification as a result of climate change may reduce the facility life due to failure of irreplaceable components (tunnel linings etc).		Medium

Risk	Potential adaptation measures	Residual risk rating
Increased frequency and intensity of marine heatwaves and / or more frequent and intense extreme rainfall and catchment flooding result in reduced quality of intake water supply. This can lead to additional pretreatment requirements, chemical and energy usage, which may accelerate degradation of membranes and require more frequent replacements. The increase in chemical and / or reagent demand may also exceed site storage requirements, leading to the facility being unable to meet the desired treatment capacity.		Medium
More frequent and more extreme bushfires cause risks to power distribution infrastructure at a regional scale which could disrupt power supply over longer time scales.		Medium
Increase in frequency and intensity of bushfires causes damage to the Lincoln Gap, Kalaya, Mangata, and Bimba water storage.	The detailed design stage should consider the climate change scenarios and design to maintain level of service under the projected increase in frequency and intensity of bushfires.	Medium
Increase in frequency and intensity of bushfires causes damage to the Mullaquana desalination plant and pump station, Lincoln Gap pump station, Kalaya pump station, and Mangata pump station.		Medium
Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.	The detailed design stage should consider the climate change scenarios expected at end of life and design to maintain level of service under the projected long-term change in average rainfall and drought conditions.	Medium
Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.		Medium

Risk	Potential adaptation measures	Residual risk rating
Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.		Medium

A full risk register with possible adaption measures for all risks is presented in **Appendix B**.

7. Conclusion

This report outlines the legislative and policy framework guiding climate change risk assessment and adaptation strategies and provides an evaluation of potential risks associated with climate change for the Project. The assessment identifies and analyses climate change risks that may impact Project receptors, utilising a risk rating system based on likelihood and consequence. The assessment considers existing risks, such as extreme heat, drought or extreme rainfall and flooding – which are projected to intensify, and new risks, including sea level rise attributed to climate change.

The climate risk assessment identified a total of 48 risks. No risks have been identified as 'extreme' nor 'high'.

Whilst most risks have some form of BAU controls embedded within the design and operating procedures, for many of the medium risks, potential additional adaptation measures intended to further reduce the risk have been identified.

The most critical mitigation measure is to incorporate projections for climate change into the detailed design process; to adapt design standards suitable to the future climate the Project is expected to experience. This may include, but is not limited to, actions such as factoring in sea level rise, storm surge and extreme rainfall changes in flood assessments to inform alignment and design decisions, and incorporation of temperature changes into the design of cooling systems.

A summary of the identified risk ratings before and after the provided BAU controls and additional adaptation measures are provided in **Table 7-1** below.

Table 7-1: Risk rating summary

Rating	Number at inherent risk	Number at residual risk
Extreme	0	0
High	0	0
Medium	24	22
Low	24	26

The assessment has determined that with appropriate mitigations in place there are not expected to be any residual extreme or high risks for the Project. It is recommended that the climate change risks, BAU controls and adaptation measures are reviewed and incorporated as the design progresses.

8. References

AdaptNSW (2025) NSW Climate Projections, <https://www.climatechange.environment.nsw.gov.au/narclim>, accessed 29/7/2025.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2019) Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia (Geoscience Australia), Version 4.2.

CoastAdapt (2017). Sea-level rise and future climate information for coastal councils. National Climate Change Adaptation Research Facility (NCCARF), Gold Coast. <https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils>

Coast Protection Board (2022). Coast Protection Board Policy. Government of South Australia. Retrieved from <https://cdn.environment.sa.gov.au/environment/docs/CPB-Policy-October-2022.pdf>.

Department for Environment and Water (2022). Guide to Climate Projections for Risk Assessment and Planning in South Australia 2022. Government of South Australia, through the Department for Environment and Water, Adelaide. Retrieved from <https://data.environment.sa.gov.au/Content/Publications/Guide%20to%20>.

Department of Agriculture, Water and Environment (2021). 'National Climate Resilience and Adaptation Strategy 2021-2025. Australian Government. Retrieved from <https://www.dcceew.gov.au/climate-change/policy/adaptation/strategy/ncras-2021-25>.

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2023), Draft update to the Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation, available at https://storage.googleapis.com/files-au-climate/climate-au/p/prj2aec7b7ec59ab390bffc6/public_assets/Draft%20update%20to%20the%20Climate%20Change%20Considerations%20chapter.pdf

Dowdy, A. et al. (2015). Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, Dowdy, A. et al., eds. Ekström, M. et al., CSIRO and Bureau of Meteorology, Australia.

Geoscience Australia (2024). Australian Rainfall and Runoff (ARR) Data Hub. <https://data.arr-software.org/>

Government of South Australia (2024) Climate Change Resilience and Adaptation Actions, Government of South Australia, <https://cdn.environment.sa.gov.au/environment/docs/South-Australian-Government-Resilience-and-Adaptation-Actions.pdf>, accessed 29/7/2025.

Hope, P., Abbs, D., Bhend, J., Chiew, F., Church, J., Ekstrom, M., Kirono, D., Lenton, A., Lucas, C., McInnes, K., Moise, A., Didier, M., Mpelasoka, F., Timbal, B., Webb, L. and Whetton, P., 2015, Southern and South-Western Flatlands Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, M. Ekström, et al. (eds), CSIRO and Bureau of Meteorology, Australia, https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/172/SSWFLATLANDS_CLUSTER_REPORT.pdf.

Intergovernmental Panel on Climate Change (IPCC) (2013). Summary for Policymakers. Working Group, I contribution to the IPCC Fifth Assessment Report. Climate Change 2013: The Physical Science Basis. Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2021) *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896.

Jacobs Group (Australia) Pty Ltd and GHD Group Pty Ltd. (2023). Northern Water Supply – Business Case Engineering Services. Document No. PREM051415-CH-00-T-G-RPT-00-001 Revision B issued 18 August 2023.

JBS&G (2026), Northern Water Project Bushfire Risk Management Plan

National Emergency Management Agency (NEMA) (2018). National Disaster Risk Reduction Framework. National Emergency Management Agency. Canberra. <https://nema.gov.au/sites/default/files/national-disaster-risk-reduction-framework.pdf>

National Emergency Management Agency (NEMA) (2023). Second National Action Plan to implement the National Disaster Risk Reduction Framework. https://nema.gov.au/sites/default/files/inline-files/28605%20NEMA%20Second%20Action%20Plan_V10_A_1.pdf

PlanSA. (2022) Assessment Requirements Library Impact Assessed Development Version 1.0. Government of South Australia.

Queensland Government (2024) *Queensland Future Climate: High Resolution Projections Data – CMIP6*, available at <https://www.longpaddock.qld.gov.au/qld-future-climate/data-info/tern-cmip6/>, accessed 29/7/2025.

RDA Far North SA. (2016). Far North and Outback SA Climate Change Adaptation Plan. A plan prepared for the RDA Far North SA, Outback Communities Authority and the South Australian Arid Lands Natural Resource Management Board by Seed Consulting Services and URPS.

Sieberttritt, M., Halsey, N. and Stafford-Smith, M. (2014). Regional Climate Change Adaptation Plan for the Eyre Peninsula. Prepared for the Eyre Peninsula Integrated Climate Change Agreement Committee.

Smit, B., Burton, I., Klein, R.J. et al. (2000). An Anatomy of Adaptation to Climate Change and Variability. *Climatic Change* 45, 223–251. Retrieved from <https://doi.org/10.1023/A:1005661622966>

Smit, B & Pilifosova, O. (2003). Adaptation to Climate Change in the Context of Sustainable Development and Equity. *Climate Change, Adaptive Capacity and Development*. 8. 879-906.

Standards Australia. (2009). AS/NZS ISO31000-2009 Risk management – principles and guidelines

Standards Australia. (2013). AS5334-2013 Climate change adaptation for settlements and infrastructure – a risk-based approach.

State Planning Commission (2019) State Planning Policies for South Australia. Issued by the Minister for Planning on 23 May 2019. Version 1.1. Gazetted 23 May 2019. Department of Planning, Transport, and Infrastructure. ISBN: 978-0-7590-0287-6 (Print), ISBN: 978-0-7590-0286-9 (Online)

State Planning Commission. (2026a). Eyre and Western Regional Plan. Department for Housing and Urban Development. South Australia. <https://regional.plan.sa.gov.au/regional-plans/eyre-and-western>

State Planning Commission. (2026b). Far North Regional Plan. Department for Housing and Urban Development. South Australia. <https://regional.plan.sa.gov.au/regional-plans/far-north>

United Nations Office for Disaster Risk Reduction. (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations. Retrieved from <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030>

9. Glossary

Adaptation	Adjustment in natural or human systems that are taken in response to actual or expected climatic [and other] stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation is concerned with managing the unavoidable impacts of climate change (and variability) and considers what needs to be done differently – both more and better – to cope with the change
BAU	Business-as-usual. BAU risk controls in this report are those which would apply to the reference design or the project's operation in the absence of any consideration of climate change.
BoM	Australian Bureau of Meteorology.
CCIA	Climate Change in Australia web site and technical report; see www.climatechangeinaustralia.gov.au .
Climate	A statistical description of "average" weather in terms of the mean and variability of relevant quantities over time scales ranging from months to millennia. It is influenced by factors that operate at various time and spatial scales, including: atmospheric energy balance, atmospheric composition and ocean and atmospheric circulation patterns.
Climate change	Refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may occur because of: internal changes within the climate system; interaction between its components; or because of changes in external forcings either for natural reasons or because of human activities. It is generally not possible to clearly attribute causation between these causes. Projections of future climate change generally consider only the influence on climate of anthropogenic increases in greenhouse gases and other human-related factors.
Climate change factors	The percentage or absolute change in rainfall, temperature or other climate variable that results from climate change under a particular scenario. Climate change factors describe the change from averages during the reference period.
GCM	General Circulation Model or Global Climate Model. Computer model that runs mathematical representations of the global climate system. They are used to project the influence of emissions or other global change scenarios on climate. Climate change projections are typically based on an ensemble or group of models rather than the results of an individual GCM.
IPCC	Intergovernmental Panel on Climate Change.
PS	Pump Station
RCP	Representative concentration pathway. A future trajectory for radiative forcing, reflecting changes in atmospheric greenhouse gas concentrations. Four RCP scenarios are commonly presented, ranging from RCP2.6 to RCP8.5. The numeric factor represents the 2100 radiative forcing value of the scenario (or in the case of RCP2.6, the peak value).
Resilience	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.
Risk	The potential for realisation of unwanted, adverse consequences; usually based on the consequence and likelihood of an event. Risk is the effect of uncertainty on objectives.

Scenario	A coherent, plausible but often simplified description of a possible future state. Scenarios capture a range of future possibilities and allow decision makers to consider changes that might otherwise be ignored.
Tmax/Tmin/Tav	Maximum/minimum/average temperature.

Appendix A. Adopted Climate Change Projections

Increase to average daily maximum temperature						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Whyalla	1.1	1.1	1.6	1.8	2	3.7
Port Augusta	1.3	1.3	1.7	1.8	2.3	4.2
Woomera	1.4	1.3	1.8	2.2	2.5	4.7
Increase to average daily minimum temperature						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Whyalla	0.9	1	1.3	1.5	1.7	3.2
Port Augusta	0.8	0.9	1.2	1.5	1.6	2.9
Woomera	1	1.1	1.5	1.7	2	3.7
Increase to average annual rainfall						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Whyalla	-11.0%	-4%	-8.0%	-20.0%	-16.0%	-31.0%
Port Augusta	-10.0%	-7.0%	-13.5%	-12.5%	-17.0%	-35.0%
Woomera	-9.0%	-7.0%	-10.0%	-23.0%	-19.0%	-35.0%
Increase to average annual number of days of 40 degrees or above						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Whyalla	4.0	3.5	6.0	6.6	7.0	16.2
Port Augusta	6.0	6.0	10.0	11.0	13.0	27.0
Woomera	9.0	9.0	14.0	17.0	19.0	41.0
Days per year rainfall above historic 99.9th percentile						
Whyalla	0.5	0.6	0.6	0.5	0.6	0.6
Port Augusta	0.5	0.5	0.6	0.5	0.5	0.6
Woomera	0.4	0.5	0.5	0.4	0.5	0.5
Change in annual potential evapotranspiration						
Year	2030		2050		2090	
Region	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Eyre Peninsula (Whyalla and Port Augusta)	2.5	2.7	3.5	4.1	4.2	8.4
SA Arid Lands (Woomera)	2.7	3.2	3.8	5.2	5.2	10.2
Extreme rainfall (1% AEP, <1hr)						
Year	2030		2050		2090	

Region	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Whyalla	1.2	1.2	1.3	1.3	1.4	1.6
Port Augusta	1.2	1.2	1.3	1.3	1.4	1.6
Woomera	1.2	1.2	1.3	1.3	1.4	1.6
Extreme rainfall (1% AEP, >24hr)						
Year	2030		2050		2090	
Region	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0	SSP2-4.5	SSP3-7.0
Whyalla	1.1	1.1	1.1	1.2	1.2	1.3
Port Augusta	1.1	1.1	1.1	1.2	1.2	1.3
Woomera	1.1	1.1	1.1	1.2	1.2	1.3
Extreme Heat						
Sub Cluster	Extreme Heat					Confidence
Southern and South Western Flatlands East	More hot days and warm spells are projected with very high confidence. Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days, the frequency of hot days, and the duration of warm spells (very high confidence).					Very High
Rangelands South						
Relative humidity						
Sub Cluster	Relative humidity					Confidence
Southern and South Western Flatlands East	Minor change in relative humidity for 2030 is projected with high confidence. By 2090, a substantial decrease of up to 1.5% during spring is projected with high confidence under RCP 4.5. By 2090, under RCP8.5 a 1.6% annual reduction is projected, with values ranging between a 0.3% reduction in autumn to a 2.8% reduction in spring.					High
Rangelands South	Little change in relative humidity is projected for 2030 under both scenarios. By 2090, under RCP4.5 a 1.6% reduction is projected with medium confidence, while a 2.6% reduction is projected under RCP8.5, with high confidence in reductions in winter and spring months.					Medium Medium - High
Wind speed						
Sub Cluster	Wind speed					Confidence
Southern and South Western Flatlands East	By 2030, minor reductions of 0.9% are projected with medium confidence under RCP4.5. Under RCP8.5, there is little change projected with high confidence. By 2090, there is medium confidence in further decreases in wind speed. A 1.4% reduction is projected under RCP4.5, while a 1.8% reduction is projected under RCP8.5. There is high confidence in a 2.5% reduction in wind speed during autumn months.					Medium – High Medium
Rangelands South	By 2030, little change is projected under both scenarios. By 2090, under RCP4.5 there is projected to be little change with high confidence. Under RCP8.5, there is medium confidence in a small increase of 0.7% in wind speed.					Medium - High
Fire weather						
Sub Cluster	Fire weather					Confidence

Southern and South Western Flatlands East	There is high confidence that climate change will results in a harsher fire-weather climate in the future. However, there is low confidence in the magnitude of the change as this is strongly dependent on the summer rainfall projection.					High (but low confidence in magnitude)
Rangelands South	Bushfire in the Rangeland depends highly on fuel availability, which mainly depends on rainfall. For most of this cluster, extensive bushfire activity occurs after extended wet periods. These lead to vegetation growth that burns after the wet period ends. There is high confidence that climate change will result in a harsher fire weather climate in the future, due to higher temperature and lower rainfall. But there is low confidence in the magnitude of fire weather projections. When bushfires occur, more extreme fire behaviour can be expected.					
Sea level rise (m)						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Whyalla	0.1	0.1	0.2	0.2	0.4	0.6
Port Augusta	0.1	0.1	0.2	0.2	0.4	0.6
Sea surface temperature (degC)						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Port Augusta	N/A	N/A	N/A	N/A	N/A	0.9
Salinity (Practical Salinity Scale (PSS)-78)						
Location			RCP8.5			
Offshore Spencer Gulf			Increase of approximately 0.3			
Upper Spencer Gulf			Increase of approximately 0.6 to >0.8			
Mullaquana outfall			Increase of approximately 0.4-0.6			
Ocean pH						
Year	2030		2050		2090	
Location	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Port Augusta	-0.1	-0.1	N/A	N/A	-0.2	-0.3

Appendix B. Full Climate Change Risk Register

The register presents the climate change risks identified relevant to the project, with the 'inherent' risk rating (ie incorporating business as usual controls, when assumed to be applied), the recommended adaptation measures or matters requiring further investigation during detailed design, and the resulting 'residual' risk rating.

Risk	Climate Variable	Asset/s Impacted	Climate Risk	Business as Usual Controls	Inherent Risk Rating						Proposed Adaptation Actions	Residual Risk Rating						Risk owner
					2050			2090				2050			2090			
					C	L	Rating	C	L	Rating		C	L	Rating	C	L	Rating	
1	Increased ambient temperatures and frequency / intensity of heatwaves	All	An increase in hot days and higher ambient temperatures may lead to health and safety related issues for personnel and ongoing operational and maintenance activities.	Design to ensure: - Regularly occupied spaces are conditioned to maintain thermal comfort within best practice specified boundaries. - Health and safety procedures for full-time and maintenance staff are in place regarding operation during sustained heatwaves and higher ambient temperatures.	Minor	Rare	Low	Minor	Rare	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Rare	Low	Minor	Rare	Low	Owner / Operator, Mechanical, ESD
2		Utilities & Power Supply	More hot days and increased power demand could lead to brown-outs / black-outs potentially leading to the plant being taken offline. There would be an inability to provide water treatment during the outage period, stopping the transfer of water to transfer system components, but no damage to equipment.	Incorporate water storage and back up power to meet required water production and reliability requirements.	Minor	Possible	Low	Minor	Likely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design, including storage capacity, to accommodate potential increase in power outages / inability to maintain water treatment processes. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Owner / Operator, Electrical
3			An increase in hot days leads to overheating of power supply. Consequences could lead to thermal runaway and fires from overheating of equipment.	Equipment designed to include overtemperature shutdowns and appropriate protection from over energisation from network. Fire detection and prevention systems installed within all buildings.	Moderate	Rare	Low	Moderate	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in ambient temperatures and frequency / intensity of heatwaves. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Unlikely	Medium	Owner / Operator, Electrical, Architecture, Fire
4		Desalination Plant Infrastructure	Increased frequency of extreme temperatures could lead to Workplace Health and Safety risks associated with extreme temperatures of exposed metal surfaces causing injury of staff.	Any high temperature pipework that is exposed to workers will have appropriate coatings to prevent extreme temperatures. PPE provided as additional protection.	Minor	Rare	Low	Minor	Rare	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Rare	Low	Minor	Rare	Low	Owner / Operator
5			An increase of extreme temperatures may exceed allowances for mechanical cooling and	The main process building will be naturally ventilated and equipment is inherently cooled	Minor	Rare	Low	Minor	Unlikely	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while	Minor	Rare	Low	Minor	Unlikely	Low	Mechanical

			ventilation systems. This could cause an inability to cool adequately, potentially exceeding the maximum operating temperature of critical equipment causing failure and temporary plant shutdown.	by the seawater flowing through the process equipment.						operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
6			Higher temperatures and proximity to the ocean may have a combined effect of increased humidity and change in marine conditions to cause accelerated damage to exposed components, reducing the design life and requiring more frequent or expensive repairs.	Durability and minimum standards for corrosion control and material selection will be built into the tender documentation.	Major	Rare	Medium	Major	Rare	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in ambient temperatures and frequency / intensity of heatwaves. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Rare	Medium	Major	Rare	Medium	Civil, Structural, Architecture, Electrical, Mechanical
7			Increasing ambient temperatures could cause conditions of above ground tanks (reinforced concrete tanks with steel roof in reference design) to become much warmer. This would in turn warm contents (water) leading to degradation of chlorine content and require a higher dosing of chlorine.	BAU measures to include: - Tank design including passive natural ventilation. - Water quality monitoring. - Tank dosing.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Civil, Hydraulics, Owner / Operator
8		Water Storage and Distribution	Increased ambient temperatures and frequency of heatwaves could lead to higher internal temperatures in the pump stations, leading to equipment outages. There would be an inability to provide treatment during the outage period but no damage to equipment.	Pump stations feature ventilation fans to assist in maintaining appropriate internal temperatures to within 5°C of ambient temperature. The need for reverse cycle air conditioning for the pump room should also be considered during detailed design in consultation with the operator.	Moderate	Possible	Medium	Moderate	Likely	Medium	Investigating the adequacy of ventilation and mechanical conditioning within pump buildings based on increased ambient temperatures. Ability to vegetate Pump Station surroundings to assist with passive cooling. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Unlikely	Medium	Mechanical, Electrical
9			Extreme temperatures could cause potential for lower work hours and/or increased night	Work safety to be included within D&C Contractor and O&M Contractor safety management plans.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should	Minor	Unlikely	Low	Minor	Possible	Low	Owner / Operator, Management

			work due to health and safety concerns.							prioritise adaptability and flexibility to enable additional measures to be implemented as required								
10			Increased ambient temperatures and frequency of heatwaves could cause potential for uncovered Project storages to have increased evaporation. Potential for inadequate sizing of storage.	Control measures include: - Design of Northern Water storages are covered.	Moderate	Unlikely	Medium	Moderate	Possible	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in ambient temperatures and frequency / intensity of heatwaves. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Mechanical, Hydraulics, Chemical, Process
11			Combined effects of increased temperatures and decreased rainfall may result in additional potential future offtakers / demands beyond the capacity of the Northern Water Project.	Project capacity and infrastructure sizing has been informed by negotiations with potential future offtakers and includes consideration of capacity for growth	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Demands and potential offtakers to be monitored post O&M commencement by Northern Water. Investigations can be commissioned to increase scheme production capacity or storage capacity well in advance of when NW is expected to reach capacity limits. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Mechanical, Hydraulics, Chemical, Process
12		Treatment / process systems	An increase in ambient temperatures could spoil or reduce the storage life of treatment chemicals.	Mitigate through design with measurement of residual ammonia and control systems to adjust for varying active concentrations. Ensure chemicals are appropriately stored in line with manufactures instructions.	Minor	Possible	Low	Minor	Possible	Low	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in ambient temperatures and frequency / intensity of heatwaves. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Possible	Low	Minor	Possible	Low	Mechanical, Hydraulics, Chemical, Process
13	Increased rainfall intensity and surface water flooding	Utilities & Power Supply	Increased rainfall intensity and surface flooding could create potential flooding at the desalination plant substation site leading to failure of the power	Pump stations and water storage pads are to be designed to be higher than surrounding ground levels, expected to be no less than 300mm, and stormwater flows from surrounding areas are to be	Minor	Unlikely	Low	Minor	Unlikely	Low	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the drainage design to accommodate the expected increased rainfall intensity and	Minor	Unlikely	Low	Minor	Unlikely	Low	Civil, Electrical

			supply to the facility. There would be an inability to provide treatment and pumping during the outage period.	diverted away from the pads via berms or similar.						surface water flooding. Drainage design and implementation of erosion and sediment controls to address stormwater runoff to be clarified further as part of detailed design. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
14			Increased potential in surface flooding, and in turn, access track erosion could create site access issues during required maintenance resulting in delayed maintenance times.	Measures to reduce potential risk include appropriate: - O&M Vehicle selection; - O&M of vehicle access tracks; - Design of vehicle access tracks.	Minor	Possible	Low	Minor	Possible	Low	Drainage design and implementation of erosion and sediment controls to address stormwater runoff to be clarified further as part of detailed design. The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increased rainfall intensity and surface water flooding. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Possible	Low	Minor	Possible	Low	Environmental, Civil
15		Intake and Outfall	Increased intensity of storm flows into the gulf may cause changes in sediment concentrations in intake water resulting in potential reduced capacity of treatment.	Online raw water quality monitoring to be used at intake points to enable adjustments to the treatment processes if required to ensure consistent water quality.	Minor	Rare	Low	Minor	Rare	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Rare	Low	Minor	Rare	Low	Mechanical, Process
16		Desalination Plant Infrastructure	A reduction in rainwater infiltration on the site combined with potential future increases in extreme rainfall could result in the drainage systems becoming inadequate and causing flash flooding and pooling which could damage ground level assets and equipment.	Landscape design to encourage natural rainwater infiltration and implement appropriate stormwater management measures to a suitable standard that accounts for future climate change. This may include features such as retention ponds or bioswales to manage increased stormwater runoff.	Moderate	Possible	Medium	Moderate	Possible	Medium	Design of detention basins for longer term climate conditions OR provision for future expansion. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Rare	Low	Civil, Hydraulics
17			Long term access road exposure to flooding has the potential for	Appropriate access road design such as elevating primary access roads, incorporating proper	Minor	Unlikely	Low	Minor	Unlikely	Low	Monitoring programs should continue to track asset performance under evolving	Minor	Unlikely	Low	Minor	Unlikely	Low	Environmental, Civil

		plant process disruptions due to supply chain access restrictions (chemical supply or waste disposal, etc).	draining and establishing a secondary access route to the plant to minimise potential disruptions.						climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
18		An increase in flooding events to cause increased degradation of access roads causing increased maintenance requirements.	Appropriate access road design such as elevating primary access roads and incorporating proper draining to reduce ongoing maintenance requirements.	Minor	Possible	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Possible	Low	Minor	Possible	Low	Environmental, Civil
19		Increased potential in surface flooding, and in turn, access track erosion could create site access issues during required maintenance resulting in delayed maintenance times.	Landscaping and stormwater management control measures such as appropriate vegetation with deep root systems and engineered drainage systems to prevent erosion and redirect stormwater runoff.	Not Significant	Possible	Low	Not Significant	Likely	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Not Significant	Possible	Low	Not Significant	Likely	Low	Environmental, Civil
20		Increase of rainfall intensity and surface water flooding events creating greater local erosion causing a risk to pipeline infrastructure due to exposure of pipeline to impact and/or degradation of footings around waterway crossings.	Appropriate engineering of pipeline structures to resist erosion, strategically planning vegetation to stabilise soil and redirect floodwaters, and implementing revegetation and remediation efforts post-construction to reinforce natural environments and mitigate erosion around waterway crossings.	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Vegetation selection to keep in mind erosion risk (alongside other climate hazards). Vegetate with ground covers, particularly in bare patches of land within tank and pump station compounds, to prevent erosion and improve aesthetics. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Environmental, Civil, Hydraulics
21	Water Storage and Distribution	Increased potential in surface flooding, and in turn, access track erosion could create site access issues during required maintenance resulting in delayed maintenance times.	Appropriate access road design such as elevating primary access roads and incorporating proper draining to reduce ongoing maintenance requirements.	Not Significant	Possible	Low	Not Significant	Likely	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Not Significant	Possible	Low	Not Significant	Likely	Low	Environmental, Civil
22		Cumulative effect of storm surge and high rainfall and/or flooding damaging distribution infrastructure through debris impact and accelerated corrosion causing temporary loss of service.	Appropriate engineering solutions to prevent displacement during storms urge and flooding events through optimised burial depths and additional engineering solutions to anchor pipelines securely if required. Durability and minimum standards for corrosion control and material selection will be	Major	Rare	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increased rainfall intensity and surface water flooding. Monitoring programs should continue to track asset performance under evolving climate conditions, while	Major	Rare	Medium	Major	Unlikely	Medium	Civil, Hydraulics

				built into the tender documentation.						operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
23			An increase in surface flooding events causes a greater risk of overland flows entering pipes through air valves, resulting in contamination of pipeline water.	Air valve design to assume overland flow. Must prevent flooding of air valves to avoid WQ risk. Emergency discharges may be required if pipeline water quality is unsuitable and will require flushing via the scour valves, although modern management methods seek to minimise the amount of flushing carried out on a pipeline to reduce water losses	Moderate	Rare	Low	Moderate	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increased rainfall intensity and surface water flooding. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Unlikely	Medium	Hydraulics, Mechanical
24			Combined impacts of increased rainfall intensity with impacts of heat and drought cause damage to water delivery infrastructure due to increased corrosion potential	Pipeline design to mitigate combined impacts through selection of erosion-resistant backfill materials and corrosion-resistant pipeline materials.	Minor	Rare	Low	Moderate	Possible	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increased rainfall intensity and surface water flooding. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Rare	Low	Moderate	Possible	Medium	Environmental, Civil, Hydraulics, Mechanical, Process
25	Changing marine conditions	Utilities & Power Supply	Rising sea levels could cause flooding at the desalination plant substation, leading to failure of the power supply to the facility. There would be an inability to provide treatment during the outage period.	Substation site selection mitigates potential flooding due to sea level rise.	Moderate	Rare	Low	Moderate	Rare	Low	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected rising sea levels. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Rare	Low	Environmental, Civil, Hydraulics, Electrical
26			Increase in sea surface temperatures as a result of climate change could promote additional sea life growth which could result in higher growth rates of fouling organisms or higher rates of other intake	Control measures include chlorine dosing in the intake tunnel to prevent fouling, maintenance and design to include screening	Major	Rare	Medium	Major	Rare	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving	Major	Rare	Medium	Major	Rare	Medium	Process, Mechanical, Hydraulics

			organisms such as jellyfish. This could increase the roughness and decrease the effective diameter of the intake tunnel or block intake screens, reducing the available water intake rates.							climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
27			Change in Spencer Gulf pH and salinity as a result of climate change causing corrosion and associated damage of riser and intake marine structures causing increased level of repair and maintenance.	The following control measures aim to mitigate the risk of degradation in riser and intake pumps infrastructure due to changes in Gulf pH and salinity through designing infrastructure with corrosion-resistant coatings and redundancy, selecting durable materials, and adhering to stringent design standards to ensure resilience and reduce the need for increased repair and maintenance.	Major	Rare	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Rare	Medium	Major	Unlikely	Medium	Civil, Process, Mechanical
28			Increased sea level rise and higher pressures at the outfall head could create potential for increased pressure required for outfall flow and diffusion, reducing the capacity of the current design.	Control measures include optimising: - Diffuser design to accommodate higher pressures and maintain effective dispersion; - Outfall design parameters such as pipe diameter and discharge velocity to ensure efficient flow.	Moderate	Rare	Low	Minor	Rare	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Minor	Rare	Low	Civil, Process, Mechanical, Hydraulics
29			Compounding effect of storm surge and high rainfall/flooding causing potential damage to intake / outfall pump station.	Diversion bunds upgradient have been designed to convey 1% AEP for 2100 SSP3-7.0. Finished Floor level for the pump station is an additional 0.25m above minimum site level (>= 4.15 m AHD to 2150). Note that 1% AEP sea level rise to 2150 is 3.90 m AHD. Note that desalination plant water storage is sited on higher ground and is unlikely to be at risk of flooding or coastal inundation.	Moderate	Unlikely	Medium	Moderate	Possible	Medium	Design to provide resilience to cumulative impacts of sea level rise, storm surge changes and increases in extreme rainfall under SSP3-7.0 over the design life in final alignment and detailed design of intake pump station infrastructure Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Unlikely	Medium	Major	Unlikely	Medium	Civil, Mechanical, Hydraulics
30		Desalination Plant Infrastructure	Higher sea surface temperature and acidification may reduce the facility life due to failure of irreplaceable components (tunnel linings etc).	Develop a corrosion control and material selection memo for a high-level framework for durability.	Major	Rare	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should	Major	Rare	Medium	Major	Unlikely	Medium	Civil, Mechanical, Electrical

										prioritise adaptability and flexibility to enable additional measures to be implemented as required							
31		Changing marine conditions resulting in reduced quality of intake water supply leading to inability to meet potential future offtaker water product specifications.	Control measures include selecting adaptable treatment technologies capable of scaling up or down as needed, designing facilities with the ability to retrofit additional treatment options, and implementing ongoing water quality monitoring and modelling to proactively identify and address deviations in water quality, thereby mitigating the risk of reduced water quality.	Major	Unlikely	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Unlikely	Medium	Major	Unlikely	Medium	Process, Mechanical, Owner / Operator
32		Increased frequency and intensity of marine heatwaves and / or more frequent and intense extreme rainfall and catchment flooding result in reduced quality of intake water supply. This can lead to additional pretreatment requirements, chemical and energy usage, which may accelerate degradation of membranes and require more frequent replacements. The increase in chemical and / or reagent demand may also exceed site storage requirements, leading to the facility being unable to meet the desired treatment capacity.	Design to consider range of intake water qualities and selecting appropriate and flexible pre-treatment, Chemical treatment inputs, Designing facilities with the ability to retrofit additional treatment options, Selecting adaptable treatment technologies capable of being online or offline, or scaling up or down as needed, such as a dissolved air flotation (DAF) or dissolved air flotation and filtration (DAFF) system to remove organic matter, and Implementing ongoing water quality monitoring and modelling to proactively identify deviations in water quality, thereby mitigating the impact by enabling implementation of treatment measures.	Major	Unlikely	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Unlikely	Medium	Major	Unlikely	Medium	
33		Changing marine conditions resulting in reduced quality of intake water supply leading to additional pretreatment requirements, chemical and energy usage, which may accelerate degradation of membranes and require more frequent replacements. The increase in chemical and / or reagent demand may also exceed site storage requirements, leading	Design to consider range of intake water qualities and selecting appropriate and flexible pre-treatment, Designing facilities with the ability to retrofit additional treatment options, and Implementing ongoing water quality monitoring and modelling to proactively identify deviations in water quality, thereby mitigating the impact by enabling implementation of treatment measures.	Major	Unlikely	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected changing marine conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Unlikely	Medium	Major	Unlikely	Medium	Process, Mechanical, Owner / Operator

			to the facility being unable to meet the desired treatment capacity.															
34	Little change in wind speed but potential increase in hail intensity	Utilities and Power Supply	An increase in the size of hailstones may exceed the impact resistance of the PV system causing damage requiring repair or replacement of PV systems and loss of generation capacity during outage period.	Solar panels are impact rated for hailstones up to 25cm.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Electrical
35			An increase in the size of hailstones may exceed the impact resistance of external electrical infrastructure leading to temporary blackouts or brownouts.	Dedicated switch rooms provided for most major electrical equipment and pit/conduit systems used for cable routes.	Moderate	Rare	Low	Moderate	Rare	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Rare	Low	Electrical
36		Desalination Plant Infrastructure	An increase in wind speeds could exceed the designed capacity of the building structural system causing extensive damage and/or injury.	The building structural system will be designed to the minimum standards Northern Water infrastructure must adhere to withstand.	Minor	Rare	Low	Minor	Rare	Low	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in wind speeds. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Rare	Low	Minor	Rare	Low	Structural, Mechanical
37	Increase in frequency and intensity of bushfires	Utilities and Power Supply	More frequent and more extreme bushfires cause risks to larger power lines at a more regional scale which could disrupt power supply over longer time scales.	Storages in place at delivery point sites to manage temporary outage periods in supply. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.	Moderate	Possible	Medium	Moderate	Likely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in frequency and intensity of bushfires. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Possible	Medium	Moderate	Likely	Medium	Environmental, Electrical
38			Increase in frequency and intensity of bushfires may lead to lack of workforce availability if workers stay home to protect properties during bushfire days.	The control measures involve establishing minimum performance requirements in O&M contracts to ensure continuity of essential services during bushfire events and integrating bushfire response protocols into emergency plans.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional	Minor	Unlikely	Low	Minor	Possible	Low	Owner / Operator, Management

				Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required						measures to be implemented as required								
39		Intake and Outfall	Increase in frequency and intensity of bushfires may increase potential for particulate (ash) deposition in intake water impacting desalination plant performance. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.	The control measures include implementing robust water quality monitoring to detect changes in intake water quality and establishing clear operation and maintenance (O&M) shutdown procedures triggered by predefined thresholds for water quality parameters	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Environmental, Mechanical, Process
40		Desalination Plant Infrastructure	Increase in frequency and intensity of bushfires may lead to potential for restricted access due to farmers imposing limitations during high grassfire risk periods.	Consultation to develop operational procedures for continued access. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Environmental
41			Increase in frequency and intensity of bushfires in the Project area causes damage to the Mullaquana desalination plant and pump station, Lincoln Gap pump station, Kalaya pump station, and Mangata pump station.	Design is to meet BAL ratings. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan, including vegetation management in proximity to the desalination plant, pumping station and water storage tanks, asset protection zone management, regular asset inspections and maintenance, investigations into network events, bushfire season controls, security measures, as well as Preparedness, Response and Recovery measures.	Moderate	Possible	Medium	Moderate	Likely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in frequency and intensity of bushfires. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Possible	Medium	Moderate	Likely	Medium	Environmental, Civil, Hydraulics
42				Increase in frequency and intensity of	Generators and backup power to continue cooling of critical	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset	Minor	Unlikely	Low	Minor	Possible	Low

			bushfires increases potential for power outages due to indirect network exposure leading to reduced cooling at pump stations and plant.	systems in outage. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.						performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required								
43		Water Storage and Distribution	Increase in frequency and intensity of bushfires in the Project area causes damage to the Lincoln Gap, Kalaya, Mangata, and Bimba water storage.	Design is to meet BAL ratings. Provision of vegetation clearance zones and buffers at aboveground sites e.g. creek crossings. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.	Major	Unlikely	Medium	Major	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected increase in frequency and intensity of bushfires. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Major	Unlikely	Medium	Major	Unlikely	Medium	Environmental, Civil, Hydraulics
44			Increase in frequency and intensity of bushfires increases potential for power outages due to indirect network exposure leading to reduced cooling at pump stations and plant.	Generators and backup power to continue cooling of critical systems in outage. Adoption of recommended Bushfire Risk Mitigation and Management measures identified in the Bushfire Risk Management Plan.	Minor	Unlikely	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Unlikely	Low	Minor	Possible	Low	Electrical, Mechanical
45	Decreases in average rainfall and relative humidity, increased time in drought	Utilities and Power Supply	Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.	Design standards typically consider a range of moisture contents and ground conditions based on geotechnical testing to consider shrink/swell impacts.	Moderate	Rare	Low	Moderate	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected long term change in average rainfall and drought conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Unlikely	Medium	Civil, Structural
46		Desalination Plant Infrastructure	Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.	Design standards typically consider a range of moisture contents and ground conditions based on geotechnical testing to consider shrink/swell impacts.	Moderate	Rare	Low	Moderate	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected long term change in average rainfall and drought conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should	Moderate	Rare	Low	Moderate	Unlikely	Medium	Civil, Structural

										prioritise adaptability and flexibility to enable additional measures to be implemented as required								
47		Water Storage and Distribution	Long term change in average rainfall and drought conditions leading to a change in geotechnical properties of the infrastructure foundations leading to potential lack of asset / structural integrity.	Design standards typically consider a range of moisture contents and ground conditions based on geotechnical testing to consider shrink/swell impacts.	Moderate	Rare	Low	Moderate	Unlikely	Medium	The detailed design stage should consider the relevant changing climate conditions and evaluate the appropriateness of changes to the design to accommodate the expected long term change in average rainfall and drought conditions. Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Moderate	Rare	Low	Moderate	Unlikely	Medium	Civil, Structural
48			Long term change in average rainfall and drought conditions leading to re-vegetation from construction impact not establishing mitigating attempts of reinstated affected land.	The control measures involve specifying performance requirements for re-vegetation in Design and Construction (D&C) contracts and carefully selecting suitable vegetation (drought tolerant) species to mitigate the risk of inadequate reinstatement.	Minor	Possible	Low	Minor	Possible	Low	Monitoring programs should continue to track asset performance under evolving climate conditions, while operational procedures should prioritise adaptability and flexibility to enable additional measures to be implemented as required	Minor	Possible	Low	Minor	Possible	Low	Environmental

Appendix L-2:

Greenhouse Gas Assessment



NORTHERN WATER PROJECT

Department for Infrastructure and Transport

Greenhouse Gas Assessment

Jacobs

Challenging today.
Reinventing tomorrow.

Northern Water Project – Greenhouse Gas Assessment

Client name: Department for Infrastructure and Transport
Project name: Northern Water Project
Project no: IS449300
Document no: IS449300 - 1 - NP - RPT - 014
Version: Rev 0
Date: 28 May 2026
Project manager: Rob Tokley
Prepared by: Nadya Serje
File name: Northern Water Project_Greenhouse Gas Assessment_Rev 0

Document history and status

Version	Date	Description	Author	Checked	Reviewed	Approved
Rev 0	28/05/2026	Final	NS	JW	JW	RT

Jacobs Group (Australia) Pty Ltd

Level 3, 121 King William Street
Adelaide, SA 5000
Australia

T +61 8 8113 5400
F +61 8 8113 5440
www.jacobs.com

© Copyright 2026 Jacobs Group (Australia) Pty Ltd. All rights reserved. The content and information contained in this document are the property of the Jacobs group of companies ("Jacobs Group"). Publication, distribution, or reproduction of this document in whole or in part without the written permission of Jacobs Group constitutes an infringement of copyright. Jacobs, the Jacobs logo, and all other Jacobs Group trademarks are the property of Jacobs Group.

NOTICE: This document has been prepared exclusively for the use and benefit of Jacobs Group client. Jacobs Group accepts no liability or responsibility for any use or reliance upon this document by any third party.

Executive summary

The Northern Water Project (the Project) aims to provide a secure climate resilient water source for industry in South Australia's Upper Spencer Gulf and Far North. Delivery of the Project will involve the construction and operation of a 51 gigalitre per year (GL/year) seawater reverse osmosis (RO) desalination plant located at Mullaquana Station on the Upper Spencer Gulf, and associated water transfer system (including pipelines, transfer pump stations, and product water storages) and electricity infrastructure.

The South Australian government has set goals to achieve at least a 60% emissions reduction below 2005 levels by 2030 and zero net emissions by 2050, as well as 100% net renewable electricity generation by 2027. The Plan SA Assessment Requirements have established the objective to minimise greenhouse gas emissions through the design, construction and operation of the Project to align with these goals.

The purpose of this report is to identify and quantify the main sources of greenhouse gas emissions from the Project and recommend mitigation measures in support of the above goals and objectives.

A greenhouse gas (GHG) inventory has been prepared for all materially significant sources of emissions across upfront carbon and in-use phases of the Project. This has been completed by combining estimates of activity data (quantitative information about the Project's emission sources, such as kilolitres (kL) of diesel or tonnes of concrete) with published emissions factors which are a proxy measure of the GHG emissions associated with each unit of activity (such as t CO₂e / kL of diesel).

During construction of the Project, the greatest upfront carbon emissions are associated with manufacturing of construction products and materials, vegetation clearing and fuel consumption. The Project's remote location and significant length of pipeline contribute to the scale of each of these sources of GHG emissions.

During the in-use phase of the Project, the most significant emissions are associated with embodied emissions from chemical usage, and the operational electricity use for water treatment and distribution under the location-based accounting method. Other contributions arise from operational waste treatment.

Over the life of the Project (construction and 100 years of operation), the total GHG impact is expected to be approximately 4.8 mega tonnes of carbon dioxide equivalents (MtCO₂e) when using a location-based approach for estimating emissions from electricity.

Under a location-based approach, Scope 3 emissions account for 66% of total emissions, primarily from operational chemical use and materials. Scope 2 emissions contribute 25%, associated with electricity consumption, while Scope 1 emissions account for 10%, primarily from vegetation clearance and diesel use.

Annual emissions are expected to peak during the construction phase. During operations, Scope 2 and Scope 3 emissions are projected to fluctuate with changes in grid emissions intensity and asset replacement cycles.

The project has committed to procuring 100% renewable electricity for operations. This is recognised through a market-based approach for emissions accounting, under which total GHG emissions are estimated to be approximately 3.2 MtCO₂e.

The commitment to source 100% renewable electricity is consistent with the State of South Australia's targets of 100% net renewable energy by 2027. However, as the Project is creating a large additional electricity demand, to the extent reasonably practicable, the sourcing of renewable electricity for the Project should seek supply that is additional to the existing supply.

Whilst the Project will result in an increase in the State's GHG emissions overall, it will enable the continued operation, growth and/or be a catalyst of industries critical for broader decarbonisation, including copper extraction.

The Project proponent, the South Australian Department for Infrastructure and Transport (DIT), has nominated sustainability priority topics and objectives for the Project (DIT, 2025). This includes the following committed objectives and requirements for the emissions reduction and resource efficiency topic:

- Minimise the generation of greenhouse gases across the asset lifecycle.
- Contribute to circular economy outcomes by optimising the use of resources and materials, avoiding and reducing waste and using recycled materials where feasible.
- Optimise energy use across the asset lifecycle.
- Maximise efficient water use and water reuse.

It is recommended the Project consider carbon emissions in significant decisions and investigate and assess mitigation opportunities aligned with the carbon reduction hierarchy —prioritising avoidance, adoption of alternative solutions, and improved resource efficiency to reduce whole-of-life emissions, while applying best available techniques that are economically achievable.

Additional opportunities to meet DIT technical requirements, while minimising the Project's emissions impact and better aligning with the South Australian government's emissions reduction commitments, have been recommended to be further investigated and implemented in subsequent stages of the Project.

During design and construction, opportunities include:

- Incorporation of energy efficiency and recovery measures into the design, including:
 - optimising desalination plant layout to support hydraulic performance and maximise gravity flows
 - optimising pipe sizing for transfer system to minimise energy losses
 - optimising intake and outfall tunnel diameters and lengths for flow velocities and energy use whilst meeting environmental performance requirements
 - using energy recovery devices to optimise recovery of energy within the RO process
 - selecting energy efficient desalination and membrane technology
 - selecting high efficiency pumps, fans, and motor systems while ensuring appropriate sizing, and
 - using variable speed drives.
- Adopting, where reasonably practicable, of electrified or alternative fuel vehicles, plant and equipment.
- Investigating the potential for on-site renewable energy and storage systems, where reasonably practicable, to reduce diesel use in on-site generators.
- Optimising pipeline alignment during design to minimise vegetation clearance, where reasonably practicable.
- Maximising the reuse of excavated material as backfill to minimise haulage and use of new aggregates.
- Integrating criteria for local and/or low-carbon sourcing in construction materials procurement arrangements.
- Identifying, and where practicable, optimising freight logistics to integrate lower emission options for transporting material to site
- Maximising efficient water use and water reuse, where reasonably practicable.

During operations, opportunities include:

- Monitoring plant performance indicators to ensure operational efficiency.
- Implementing a regular inspection, maintenance, and audit regime for high energy use systems (e.g., pump efficiency testing) to reduce the risk of inefficiencies associated with deterioration.

- Monitoring trends in specific energy use per kL of water produced to identify and support efficiency improvements
- Maximising plant utilisation to reduce inefficiencies associated with start-up, stopping, or ramping of the desalination plant.
- Integrating criteria for local and/or low-carbon sourcing in chemical procurement arrangements.
- Using power factor correction measures, where appropriate.

The assessment of greenhouse gas emissions and evaluation of opportunities should be revisited throughout the design and delivery of the Project to continue to identify the most effective means of reducing GHG emissions.

Contents

Executive summary	i
Important notes about this report.....	6
1. Introduction.....	7
1.1 Key Project components.....	7
1.2 Purpose of this report.....	9
1.3 Assessment Requirements	9
2. Legislative and policy framework	10
2.1 International.....	10
2.2 National.....	10
2.3 State	11
2.4 Other standards and guidelines	11
3. Assessment methodology.....	13
3.1 Lifecycle stages and system boundary	13
3.2 Scope and Boundary	15
3.3 Calculation approach.....	18
3.4 Upfront carbon.....	19
3.5 In-use phase embodied carbon	29
3.6 In-use phase operational carbon	33
4. Estimated GHG emissions	35
4.1 Upfront carbon emissions.....	35
4.2 In-use phase embodied emissions	36
4.3 In-use phase operational emissions	37
4.4 Total emissions	38
4.5 Total and annual emissions per scope.....	39
4.6 Uncertainty assessment.....	40
4.7 Benchmarking.....	41
5. Mitigation measures.....	43
6. Conclusion	45
7. References	47

Appendices

Appendix A. Detailed Greenhouse Gas Inventory

Tables

Table 3-1 System boundary: Sources of GHG emissions – upfront carbon	16
Table 3-2 System boundary: Sources of GHG emissions – in-use embodied.....	17
Table 3-3 System boundary: Sources of GHG emissions – in-use operational.....	18
Table 3-4 Estimated material quantities required for construction of the Project	19
Table 3-5 Emissions factors for construction materials	20
Table 3-6 Estimated transport distance and mode	22
Table 3-7 Emissions factors for transport	23
Table 3-8 Fuel and energy consumption by activity type.....	24
Table 3-9 NGA (2025) Emissions Factors for Fuel Combustion.....	25
Table 3-10 Construction emissions intensity factors for transmission line infrastructure	25
Table 3-11 Spoil disposal quantity and distance	26
Table 3-12. Construction wastage rates and quantities	26
Table 3-13. Waste emission factors for recycling	27
Table 3-14 Construction water quantities and haulage	28
Table 3-15. TAGG Workbook Emissions Factors for Vegetation Clearing	29
Table 3-16. Chemical Use during in-use phase	29
Table 3-17. In-use phase waste.....	30
Table 3-18. Design lives of project components.....	32
Table 3-19 Estimated material replacement quantities for each asset class (total for all replacements).....	33
Table 3-20. Operational Energy Use	33
Table 3-21 Emissions Factor Projections for Electricity Consumption in South Australia.....	34
Table 4-1. Upfront carbon emissions breakdown by life cycle module	35
Table 4-2. In-use embodied carbon emissions breakdown by life cycle module.....	36
Table 4-3. In-use operational emissions by electricity accounting method.....	37
Table 4-4. Percentage of Estimated Emissions by life cycle stage and electricity accounting method	38
Table 4-5. Breakdown of total emissions per scope over the life of the development.....	39
Table 4-6. Average annual emissions per scope over the life of the development.....	40
Table 4-7. SEC Values for Other Australian SWRO Plant (Kim et al, 2019)	41

Figures

Figure 1-1. Northern Water Project overview	8
Figure 3-1. Overview of sources of whole life carbon emissions (ITMM, 2024).....	13
Figure 3-2. Overview of scopes and emission sources (WBCSD and WRI, 2004)	15
Figure 4-1. Upfront carbon emissions source contributions.....	35
Figure 4-2. In-use embodied carbon emissions source contributions	37
Figure 4-3. Estimated Emissions by Emission Source and Electricity Accounting Method.....	39

Important notes about this report

The sole purpose of this report and the associated services performed by Jacobs is to provide greenhouse gas emission assessment services in accordance with the scope of services set out in the contract between Jacobs and the Client, JBS&G, and head client, Department for Infrastructure and Transport (DIT).

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the head Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report using various information sourced from DIT and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of DIT and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and JBS&G. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

The Northern Water Project (the Project) aims to provide a secure climate resilient water source for industry in South Australia's Upper Spencer Gulf and Far North. Delivery of the Project will involve the construction and operation of a 51 gigalitre per year (GL/year) seawater reverse osmosis desalination plant located at Mullaquana Station on the Upper Spencer Gulf, and associated water transfer system (including pipelines, transfer pump stations, and product water storages) and electricity infrastructure.

1.1 Key Project components

The Project comprises the following key elements:

- a 51 GL/year seawater reverse osmosis desalination plant located at Mullaquana Station approximately 25 km south-west of Whyalla
- marine intake and outfall tunnels extending underneath the seabed and into Spencer Gulf
- diffuser structures for discharge of return water into Spencer Gulf
- a transfer system consisting of:
 - a ~360 km main transfer pipeline, largely constructed underground terminating at the delivery point at the Olympic Dam copper-gold mine
 - a ~46 km lateral branch to a delivery point at the Carrapateena copper-gold mine (which may be constructed above or below ground)
 - associated transfer pump stations and product water storage
- high voltage electricity supply including new transmission and distribution lines and new network and facility substations to provide power to the desalination plant and transfer pump stations
- associated temporary construction-related infrastructure (e.g. construction camps, site offices and amenities, yards, storages and laydown areas)
- access tracks including establishing new tracks and upgrading existing tracks
- enabling roadworks and road upgrades.

Figure 1-1 outlines the entire Project area, which includes the proposed desalination plant, the main transfer pipeline and lateral branch, pump stations, storage and transmission line infrastructure.

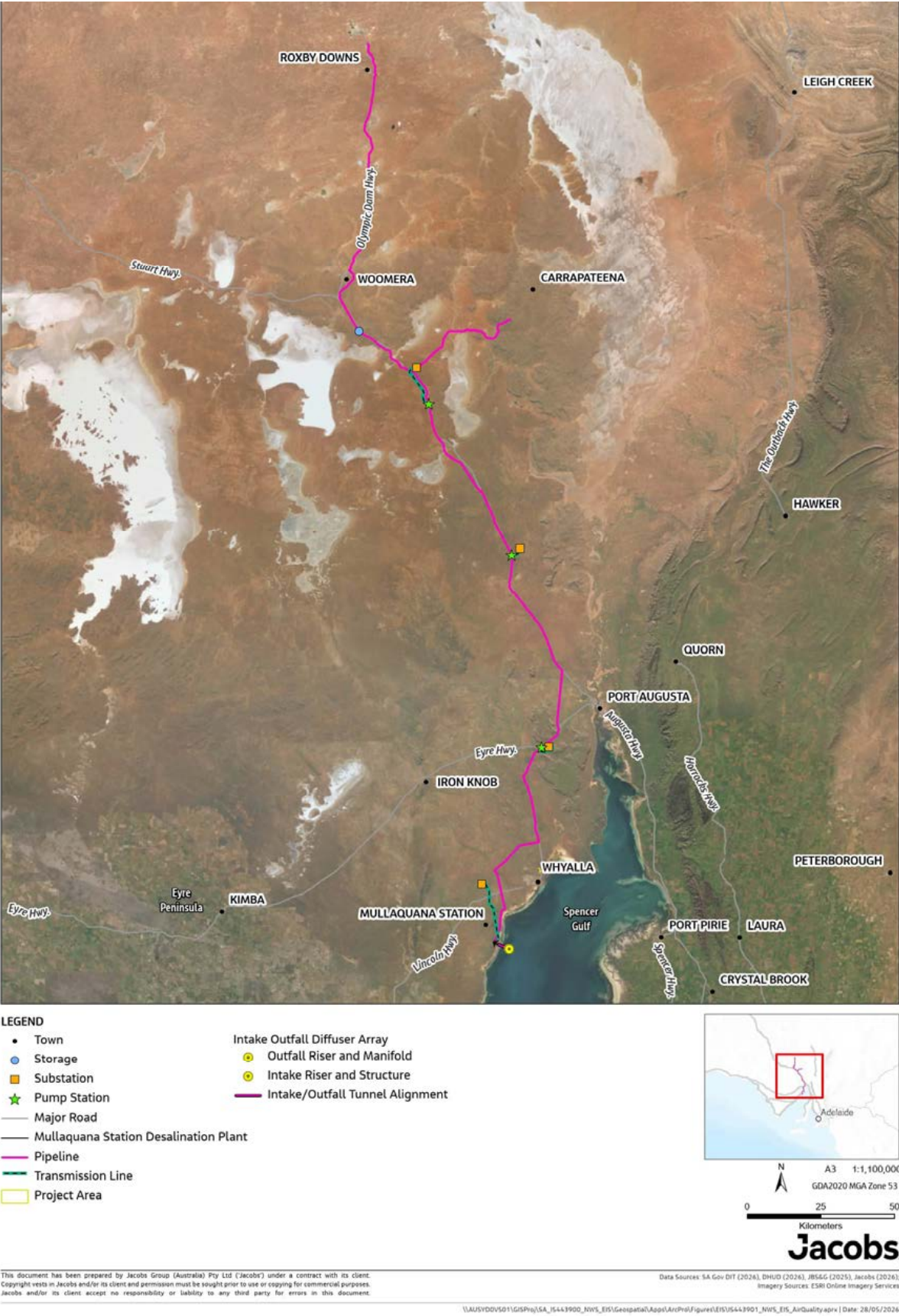


Figure 1-1. Northern Water Project overview

1.2 Purpose of this report

This report is one of several reports that support the Environmental Impact Statement (EIS). The purpose of this report is to identify and quantify the main sources of greenhouse gas (GHG) emissions from the Project and recommend mitigation measures. In doing so, it responds directly to the PlanSA Assessment Requirements Library Environmental Attribute 3: Climate Change and Resource Efficiency, specifically, Greenhouse Gas (see Section 1.3).

The objectives of this investigation were to:

- Identify and quantify GHG emissions during construction and operation.
- Propose mitigation and management measures to reduce potential emissions.

1.3 Assessment Requirements

The final Assessment Requirements are yet to be confirmed, with this assessment based on the PlanSA (2022) Assessment Requirements Library, Environmental Attribute 3: Climate Change and Resource Efficiency (CCRE2: Greenhouse gas emissions).

It has been assumed at this stage of assessment that the Standard level of assessment will apply, as *"The project is unlikely to result in significant impacts on the environmental attribute if managed through conventional management and mitigation measures, including cumulative impacts."*

These Standard Impact Assessment Requirements include the need to:

- 1) *Undertake a greenhouse gas assessment that:*
 - (a) *identifies all sources GHG emissions that would be generated.*
 - (b) *provides the estimated annual GHG emissions from each source.*
 - (c) *provides an estimate of yearly net GHG emissions and emissions intensity, including an uncertainty assessment.*
 - (d) *provide an inventory of projected annual Scope 1 and Scope 2 emissions for each GHG over the life of the development. Provide an estimate of annual Scope 3 GHG emissions for the life of the development.*
- 2) *Describe how the project will contribute to South Australia's emissions targets i.e. 100% renewable energy target by 2030, 50% emissions reduction below 2005 level by 2030 and zero net emissions by 2050.*
- 3) *Describe measures that have been incorporated in the design to minimise, reduce, and ameliorate greenhouse gas emissions, particularly the use of alternative or renewable energy sources and off-sets, energy efficiency and energy conservation measures, and if it incorporates integrated passive design principles and climate-responsive techniques and features and identify barriers to implementation.*

2. Legislative and policy framework

This section outlines relevant legislation and policy which has a focus on greenhouse gas emissions management and mitigation, and which has a bearing on this assessment. It also identifies the guidelines which have shaped the methodology for the assessment.

2.1 International

2.1.1 The Paris Agreement

As part of the United Nations Framework Convention on Climate Change (UNFCCC), global government members regularly meet for Conference of the Parties (COPs) on a typically annual basis. As part of the 21st COP (COP21) in 2015, an international agreement, known as the Paris Agreement was made for signatories to:

- Keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius
- Submit revised emission reduction targets every five years (from 2018), with the first being effective from 2020, and goals set to 2050
- Define a pathway to improve transparency and disclosure of emissions
- Make provisions for financing the commitments beyond 2020.

In response to this challenge, Australia is required to submit Nationally Determined Contributions (NDCs), outlining its emission reduction targets. Australia's most recent NDC outlines a commitment to reduce emissions by 43 per cent below 2005 levels by 2030, by 62-70% by 2035 and transitioning to a low-emission economy and achieving net zero emissions by 2050.

2.2 National

2.2.1 Climate Change Act 2022

The *Climate Change Act 2022* emphasises the importance of aligning Australia's climate actions with global goals, particularly those outlined in the Paris Agreement that aims to limit global warming and its impacts by keeping the increase in global average temperature well below 2°C above pre-industrial levels and pursuing efforts to limit it to 1.5°C.

This Act also establishes GHG emissions reduction targets for Australia to combat climate change. By 2030, Australia is targeting a 43% reduction in net GHG emissions compared to 2005 levels, with this target structured as a point target and an emissions budget spanning 2021 to 2030. Additionally, Australia aims to reach net zero GHG emissions by 2050.

Australia's 2035 target is a 62-70% reduction in net national GHG emissions below 2005 emissions levels, covering all sectors of the economy and all GHGs. This will be implemented as an emission budget over 2031 and 2035. This target aligns with Australia's Net Zero Plan, which charts out Australia's path to achieving net zero by 2050.

2.2.2 National Greenhouse and Energy Reporting Act 2007

The Federal Government uses the *National Greenhouse Gas and Energy Reporting Act 2007* (NGER Act) legislation to measure, report and verify Australian GHG emissions. This legislation is used for a range of purposes, including being used for international GHG reporting. Corporations which meet the thresholds for reporting under NGER must register and report their GHG emissions.

Under the NGER Act, constitutional corporations in Australia which exceed thresholds for GHG emissions or energy production, or consumption, are required to measure and report data to the Clean Energy Regulator on an annual basis. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (made under the NGER Act) identifies several methodologies to account for GHGs from specific sources relevant to a project. This includes emissions of GHGs from direct fuel combustion (fuels for transport energy purposes), emissions associated with consumption of power from direct combustion of fuel (e.g., diesel generators used during construction), and from consumption of electricity from the grid.

2.2.3 Australian Carbon Credit Unit Scheme and the Safeguard Mechanism

The Australian Government's Direct Action Plan was introduced on 1 July 2014 and aims to focus on sourcing low cost emission reductions. The Direct Action Plan included an Emissions Reduction Fund (ERF), now known as the Australian Carbon Credit Unit (ACCU) scheme. Legislation to implement the ERF came into effect on 13 December 2014, and the ACCU scheme is now considered to be a key part of the Australian Government's policy suite to reduce emissions.

The Safeguard Mechanism requires Australia's largest emitting facilities to reduce their emissions in line with Australia's emission reduction targets of 43% below 2005 levels by 2030 and net zero by 2050. A default baseline of 100,000 tonnes of carbon dioxide equivalent emissions (tCO₂e) per year applies to all facilities covered by the Safeguard Mechanism unless another type of baseline is relevant. Whilst baselines adjust with annual production for standard facilities, overall emissions limits for standard and landfill facilities decline each year in line with Australia's climate targets. The sectoral baseline for grid-connected electricity generators is set to 198 million tCO₂e emissions per year.

High-emitting facilities which exceed or expect to exceed their baselines must manage their excess emissions, including by trading Safeguard Mechanism credit units (SMCs) with companies who have fallen under their threshold, or by surrendering ACCUs.

2.3 State

2.3.1 South Australia Climate Change and Greenhouse Emissions Reduction Act 2007

The *Climate Change and Greenhouse Emissions Reduction Act 2007* in South Australia aims to address climate change issues and promote sustainable development by setting targets to reduce GHG emissions. The principal target is to achieve a zero net GHG emissions within the State by 2050.

The Act integrates the following related targets:

- to reduce net GHG emissions in the State to an amount that is at least 60% below 2005 levels by 2030
- to achieve 100% net renewable electricity generation in the State by 2027.

To provide a clear pathway to net zero emissions, interim emissions targets will be set under this Act every five years to 2050, with a 2035 target to be set before the end of 2030.

In 2022-23, South Australia's GHG emissions were already 55% below the 2005 financial year amounts.

2.4 Other standards and guidelines

The following standards have been used to guide the approach to this assessment:

- The Greenhouse Gas Protocol (GHG Protocol) (2004, 2011 & 2015) by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI).

- PAS2080:2023 Carbon management in buildings and infrastructure, a global standard, which specifies requirements for the management of whole life carbon in buildings and infrastructure.
- EN 17472:2022 Sustainability of construction works. Sustainability assessment of civil engineering works. Calculation method for definition of life cycle stages and the system boundary for Civil (or economic) infrastructure projects.
- Infrastructure and Transport Ministers Meeting (ITTM), 2024, Embodied Carbon Measurement for Infrastructure Technical Guidance.

3. Assessment methodology

A GHG inventory (sometimes referred to as a carbon footprint) is an assessment of the lifecycle GHG emissions associated with a product, service, or event. All GHGs (such as methane and nitrous oxide, as well as carbon dioxide) are aggregated and reported as a single number of 'carbon dioxide equivalents', hence when talking about carbon footprinting, this is referring to an aggregated calculation of all GHGs.

Increasing concentrations of GHGs in the atmosphere are known to contribute to climate change; hence being able to reduce these emissions across the lifecycle of the Project would reduce the potential for the Project to contribute to climate change.

3.1 Lifecycle stages and system boundary

The objective of this report is to provide an assessment of GHG emissions associated with the construction and operation of the Project.

The system boundary determines the asset lifecycle stages that will be included in the carbon assessment. This report provides the GHG assessment calculations and results based on ITMM (2024), which aligns with PAS2080:2023 *Carbon management in buildings and infrastructure*.

The GHG inventories for this assessment have been calculated in accordance with the principles of the internationally accepted *Greenhouse Gas Protocol (WBCSD and WRI, 2004 and 2011)* and *EN 17472:2022 Sustainability of construction works - Sustainability assessment of civil engineering works - Calculation methods*.

The different periods of an asset's life are known as its lifecycle stages. Lifecycle modules provide standardised designations for each lifecycle stage. They are referred to as upfront carbon (A1-A5), in-use embodied (B1-B5), end-of-life (C1-C4), in-use operational carbon (B6-B7), user carbon (B8), and benefits beyond the asset lifecycle (D). These are shown in **Figure 3-1**.

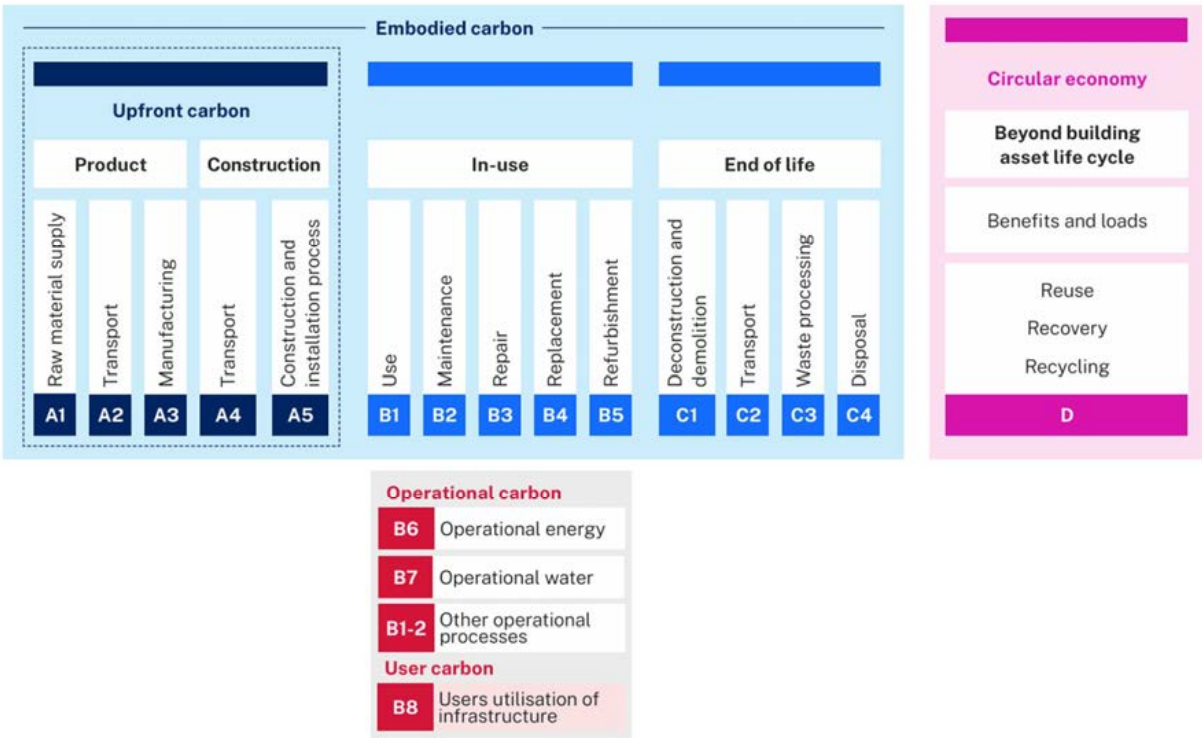


Figure 3-1. Overview of sources of whole life carbon emissions (ITMM, 2024)

3.1.1 Emissions Scopes

To satisfy the Assessment Requirements, the GHG inventories for this assessment have been allocated based on the emissions 'Scopes' of the Greenhouse Gas Protocol (WBCSD and WRI, 2004 and 2011) (GHG Protocol). According to the GHG Protocol, GHG emissions are split into three categories, known as 'Scopes'. Scopes 1, 2 and 3 are defined by the GHG Protocol and can be summarised as:

- **Scope 1** – Direct emissions of GHGs from sources that are owned or operated by a reporting organisation (examples include combustion of diesel in company owned vehicles or used in on-site generators)
- **Scope 2** – Indirect Emissions associated with the import of energy from another source (examples include the import of electricity from the grid)
- **Scope 3** – Other indirect emissions – other than energy imports (above) which are a direct result of the operations of the organisation, but from sources not owned or operated by them (examples include manufacture of construction materials and extraction, production and transport of fuel prior to combustion).

The Scope 1, 2 and 3 emissions can be best illustrated using

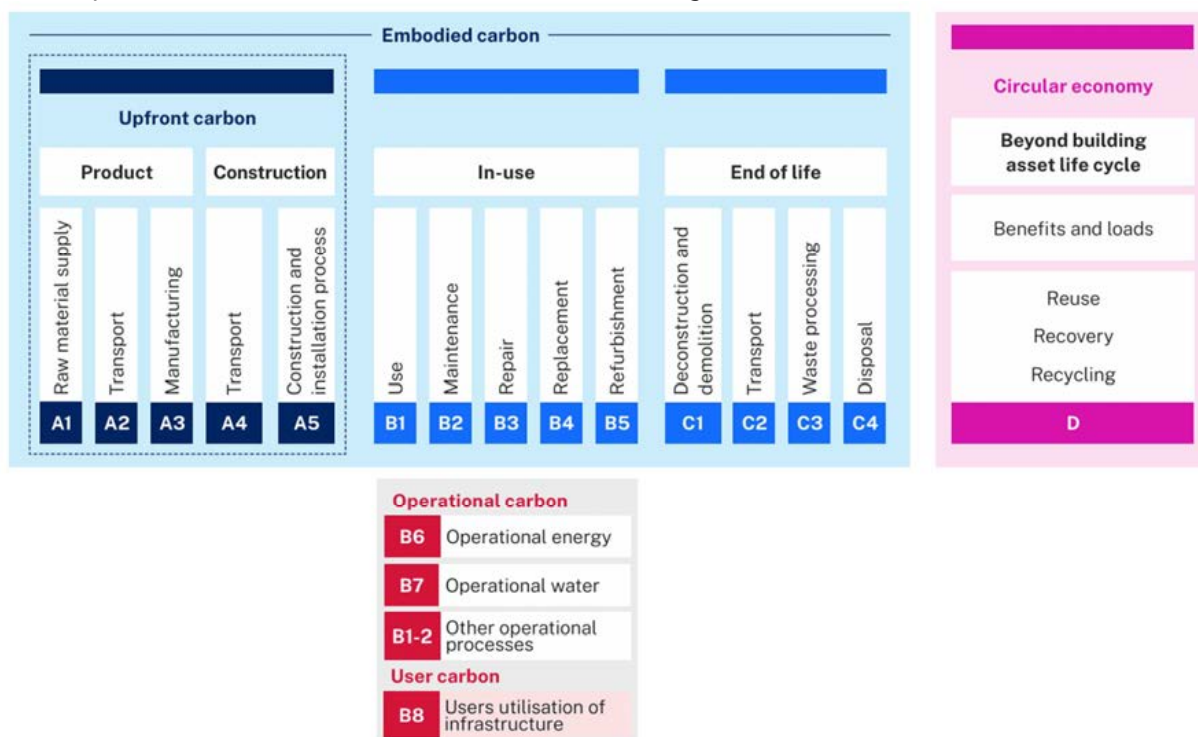


Figure 3-1.

It's noted the GHG Protocol was established for application to organisations, and therefore emissions Scopes are typically defined from an organisational perspective. As is typical for the application of the GHG Protocol to project carbon footprints, emissions scopes for the construction stage have been defined from the perspective of the Principal Contractor, whilst emissions scopes for the operational stage have been defined from the perspective of the operator.

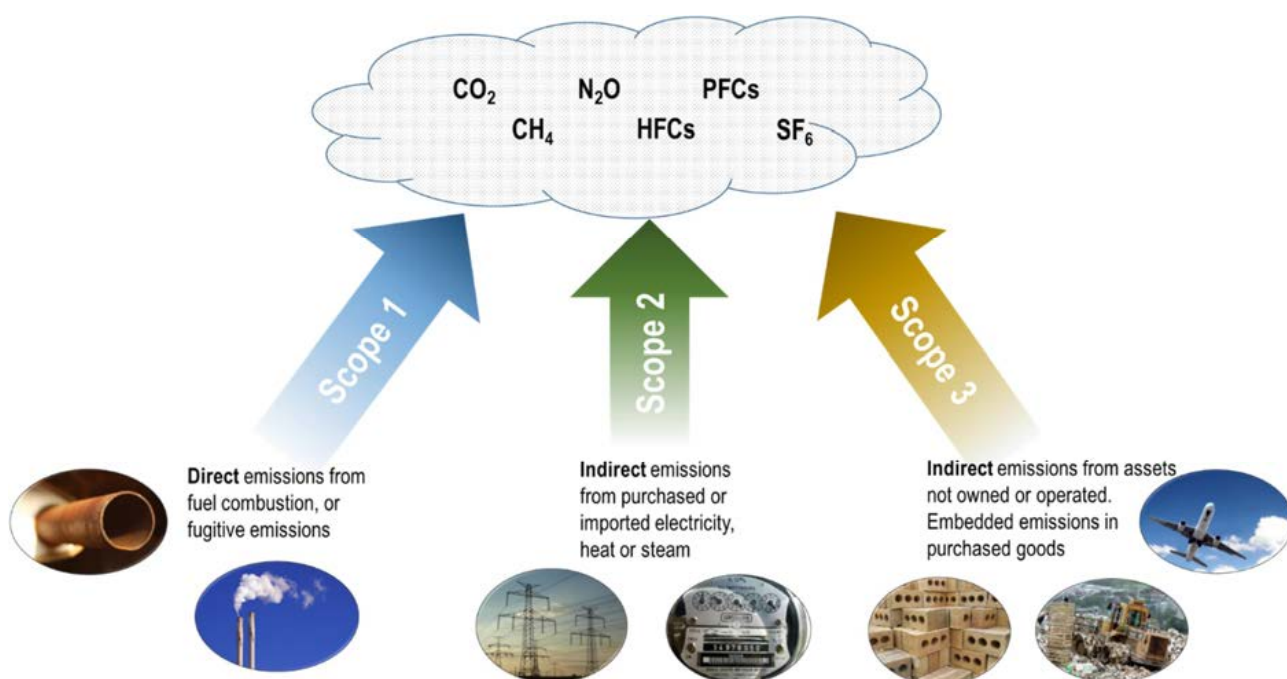


Figure 3-2. Overview of scopes and emission sources (WBCSD and WRI, 2004)

3.2 Scope and Boundary

The scope and boundary definition are important steps in the preparation of a GHG inventory, as they define:

- The reasons for the assessment and the extent to which emissions will be modelled; and
- The emissions that are included and excluded from the assessment (with reasons why).

The scope of the assessment includes all material emissions sources associated with upfront carbon, in-use embodied carbon, and in-use operational carbon of the Project.

This assessment excludes any emissions associated with user carbon, end-of-life and circular economy, as they are considered outside of the scope and immaterial.

3.2.1 Upfront carbon assessment boundary

The upfront carbon inventory includes an assessment of all material GHG/energy sources associated with the manufacturing of products and materials used in the infrastructure asset (A1-A3), their transport to site (A4), and construction activities (A5) both within the Project site boundary, and upstream and downstream enabling activities within the Project's value chain. These are provided in **Table 3-1**.

Where a source group or activity has been excluded from the GHG inventory, this determination is based on a high-level estimate of materiality generally using approximate assumptions and/or information scaled from previous experience of similar projects. The materiality threshold adopted for this assessment is consistent

with ITMM (2024), which applies an upscaling factor to cover emissions that are not quantified due to time or information constraints described in **Section 3.3**.

Table 3-1 System boundary: Sources of GHG emissions – upfront carbon

Source of GHG emission	Activity	Included in inventory?	Life cycle stage	GHG Protocol Scope
Construction materials	Embodied emissions of materials used in construction.	✓	A1-A3	3
Transport fuel	Fuel consumed for construction materials transport to site.	✓	A4	3
Stationary Fuel	Fuel consumed by construction plant / equipment.	✓	A5	1 & 3
Transport fuel	Fuel consumed for use in site management vehicles (utility vehicles).	✓	A5	1 & 3
Stationary Fuel	Fuel consumed for the operation of temporary site offices and workforce accommodation.	✓	A5	1 & 3
Purchased electricity	Electricity consumed in construction plant / equipment.	✓	A5	2 & 3
Construction waste	Manufacture, transport, and end-of-life treatment of material that becomes construction waste, including spoil.	✓	A5	3
Transport fuel	Workforce air travel.	✓	A5	3
Carbon sinks	Land clearing / soil disturbance.	✓	A5	1

The following exclusions are noted:

- No emissions were estimated for emission sources during the design phase (e.g. consumption of electricity in offices, fuel consumption of plant / equipment used in investigative work such as the geotechnical program and baseline environmental studies). The exclusion of these emissions would not materially impact on the assessment as they are likely to represent less than one per cent of the total emissions for the Project. Yu et. al. (2017) found that 'Services' (which includes professional services) contributed only 0.02% of the total footprint of the construction sector.

3.2.2 In-use phase embodied carbon assessment boundary

Emissions associated with in-use embodied carbon emissions of the Project are largely associated with the production and transport of chemicals, and includes other sources of emissions, such as treatment and disposal of waste, replacement of major materials, and fuel consumption for maintenance activities, during the project design life.

The boundary of emissions sources considered for the in-use embodied of the project is presented in **Table 3-2**.

Table 3-2 System boundary: Sources of GHG emissions – in-use embodied

Source of GHG emission	Activity	Included in inventory?	Life cycle stages	GHG Protocol Scope
Fugitive emissions	Emissions associated with leakage of gases or vapours	✗	B1	1
Embodied emissions	Emissions associated with production of chemicals used in the water filtration and treatment activities	✓	B1	3
Waste emissions	Emissions associated with the disposal of lime sludge from the facility operations	✓	B1	3
Transport fuel	Fuel consumed for the transportation of operational waste and chemicals	✓	B1	3
Transport fuel	Travel of staff for operations and maintenance	✓	B2	1 & 3
Stationary fuel	Fuel consumed by maintenance plant and equipment	✗	B2	1 & 3
Stationary fuel	Fuel consumed by equipment for back-up generator testing	✓	B2	1 & 3
Embodied emissions	Emissions associated with the production of replacement materials and equipment over the Project life	✓	B3-B5	3

The following exclusions are noted:

- Maintenance plant and equipment are expected to relate to replacements of components at the end of their design lives as well as cleaning and general repair. This has been determined to be a minor contribution of the total emissions for the Project, and as such, has not been accounted for in this assessment. Construction energy is <3% of the total impact and this includes significant amounts of trenching, tunnelling and earthworks which are not likely to be repeated as part of maintenance activities.
- Sulfur hexafluoride (SF₆) is a strong GHG, commonly used in switchgear for power supply and transmission. Whilst there is likely to be some leakage of SF₆ within the Project's operations, these fugitive emissions have been excluded based on negligible materiality compared to total emissions.

3.2.3 In-use phase operational carbon assessment boundary

Emissions associated with operation of the Project are largely the result of electricity consumed for the operation of desalination plant equipment and pump stations in the transfer system; predominantly a range of pumps for intake, treatment and transfer systems as well as other miscellaneous equipment such as fans, conveyors, lighting and administration building operation.

The Project design life is based on the longest project asset and is 100 years, so operations are modelled over the 100-year period. The 100-year design life is attributed to the marine civil components of the Project including the intake and outlet tunnels and infrastructure, and marine pipework.

The boundary of emissions sources considered for the in-use operation of the project is presented in **Table 3-3**.

Table 3-3 System boundary: Sources of GHG emissions – in-use operational

Source of GHG emission	Activity	Included in inventory?	Life cycle stages	GHG Protocol Scope
Purchased electricity	Electricity consumed for the facility operations including water pumping, filtration, treatment and distribution	✓	B6	2 & 3

3.3 Calculation approach

In its simplest form, a GHG inventory is prepared by combining estimated activity data (quantitative information about the Project's emission sources, such as kilolitres (kL) of diesel or tonnes of concrete) with published emissions factors which are a proxy measure of the GHG emissions associated with each unit of activity (such as t CO₂e / kL of diesel). Emissions factors can be related to either direct release of GHG (such as through fuel combustion on-site) or indirect GHG emissions resulting from the activity (such as emissions associated with the production of steel, from resource extraction to steel mill and fabrication).

An upscaling factor is used to cover emissions that are not quantified due to time or information constraints consistent with the requirements of the ITMM (2024) *Embodied Carbon Measurement for Infrastructure Technical Guidance*. To upscale the assessment, it was applied to the following to the calculated emissions:

- A default completeness of 80% was assumed, covering all minimum inclusions of project elements, and applied a default factor to all module results to be then upscaled to 100%.
- Carbon intensity benchmarks have been used for unavailable construction data for transmission line in the module A5.
- Estimates of land clearing impact has aimed for 100% completeness based on the best information available, and therefore no upscale factor applied.
- Estimates of operational electricity consumption have targeted 100% completeness by using conservative assumptions based on maximum power consumption, supported by a fixed contractual requirement for the Project's desalination plant to remain within a specified energy consumption limit.

To scale the carbon emission calculation, the following methodology was used.

$$\text{Total whole life carbon (tCO}_{2\text{-e}}) = \frac{a}{80\%} + b + \frac{c}{80\%} + d$$

Where:

a is the calculated upfront carbon (A1-A5) emissions (80% completeness)

b is the calculated land-use change emissions (100% completeness)

c is the calculated in-use embodied carbon (B1-B5) emissions (80% completeness)

d is the calculated in-use operational carbon (B6) emissions (100% completeness)

The remainder of this section presents methodologies for establishing relevant activity data for upfront, in-use embodied and in-use operational carbon, and the sources of emission factors used for calculating GHG emissions. The estimated emissions from the assessment are provided in Section 4.

3.4 Upfront carbon

3.4.1 Product stage (A1-A3)

The material quantities for construction of the Project were provided by DIT and estimated from the available level of detail in the reference design constructability input for estimators and report (Systra, 2025a, Systra, 2025b, Systra 2025c and Systra, 2025e) at the time of assessment. These quantities are shown in **Table 3-4**.

Table 3-4 Estimated material quantities required for construction of the Project

Material / Activity	Quantity	Unit
Transfer System, Desalination Plant, Marine Works and Tunnelling		
Concrete	76,888	m ³
Backfilling and subbase	904,560	t
Crushed rocks	31,176	t
Reinforcing steel	12,533	t
Structural steel	2,317	t
Steel cladding	48,453	m ²
Grout	1,275	m ³
Galvanised steel for tanks	422	t
Aluminium	165	t
Asphalt	10,571	t
Fiber-Reinforced Plastic	26	t
Polyethylene stormwater pipe	116	t
Steel Fibre	8,087	t
Styrofoam	15	t
Steel for pumps and valves	187	t
Mild-steel cement lined (MSCL) Pipe	146,376	t
Ductile iron concrete lined DICL Pipe	5,395	t
Transmission Infrastructure		
Concrete	6,200	m ³
Gravel	94,380	t
Steel structural	3,100	t
Aluminium	386	t
Copper	12	t

Construction material quantities for the transmission infrastructure were provided by DIT. However, the assessment does not include the new network substations and facility substations, which are assumed to be captured within the upscaled emissions. These exclusions are likely accounted for within the upscaled emissions, given the immaterial contribution (<1%) of emissions associated with the calculated transmission infrastructure.

Notable exclusions due to limited data include mechanical and electrical equipment, internal pipework, cabling, pumps, treatment membranes, and chemical storages. These are assumed to be captured within the upscaled emissions, which has been confirmed as appropriate based on high-level quantity checks from the reference design. The carbon assessment at the detailed design stage may refine these inclusions to better understand key hotspots and reduction opportunities as more detailed data become available.

At the time of assessment, emissions from storages were calculated assuming reinforced concrete construction (Systra, 2025c) and did not consider potential alternatives such as earth-embankment (earthbound) storages. Any resulting change in emissions is expected to be immaterial to the Project's total impact, and has the potential to reduce emissions, particularly where spoil can be reused and carbon intensive materials, such as concrete and steel, are avoided.

The allocation of steel quantities by type has been determined based on high level groupings by asset class (e.g. pumping, intakes and outfalls, storages, desalination plant buildings, site civil works, etc) rather than by individual element, based on the primary steel use in each. This is considered appropriate for this stage of assessment to inform the approximate scale of emissions given other uncertainties, however, more detailed breakdowns by type of steel may be appropriate in later stages as the accuracy of quantity take-offs are improved.

3.4.1.1 Emission factors

GHG emissions associated with the production of construction materials are based on emissions factors typically provided as tCO₂e per tonne of material. The emissions factors for construction materials were predominantly derived from the NABERS National Emission Factor Database and Environmental Product Declarations (EPDs). These emissions factors are presented in **Table 3-5**.

The majority of steel utilised in the desalination plant, pipeline infrastructure and marine works is related to structural sections. Where steel is utilised for storages, pumps, valves and other types of equipment, a scale-up factor to account for additional emissions from product manufacturing has been included. This approach is based on Chartered Institution of Building Services Engineers (CIBSE, 2021), as specific emission factors for these equipment types is not available and/or practical to estimate at this time.

The emissions intensity of concrete and asphalt have conservatively assumed no use of supplementary cementitious materials or reclaimed asphalt product at the time of assessment, as the quantity which may be obtained for the Project, given its regional context, is uncertain. In practice, however, any use of these materials such as fly ash or slag to replace general purpose cement would be expected to reduce the emissions intensity.

Table 3-5 Emissions factors for construction materials

Material type	GHG emission ¹	Unit	Assumptions and source
Concrete	0.35	t CO ₂ e / m ³	NABERS National Emission Factor Database Normal class: Concrete in-situ, >40 MPa to ≤50 MPa
Sand	0.01	t CO ₂ e / t	NABERS National Emission Factor Database Quarried fill and base material
Backfilling and subbase	0.01	t CO ₂ e / t	NABERS National Emission Factor Database Quarried fill and base material

¹ Emissions factors have been simplified as presented herein to two decimal places, however, more detailed estimates have been used in the full calculations

Material type	GHG emission ¹	Unit	Assumptions and source
Crushed rock	0.01	t CO ₂ e / t	NABERS National Emission Factor Database Quarried fill and base material
Steel reinforcing bar	1.6	t CO ₂ e / t	NABERS National Emission Factor Database, Bar & mesh reinforcing steel
Structural steel sections	2.27	t CO ₂ e / t	NABERS National Emission Factor Database, structural sections steel
Steel cladding	0.02	t CO ₂ e / m ²	NABERS National Emission Factor Database, steel sheeting - metallic coat
Grout	1.14	t CO ₂ e / t	Transport for NSW Carbon Tool & ECCL
Galvanised steel for tanks	3.36	t CO ₂ e / t	NABERS National Emission Factor Database, Hot rolled - galvanised structural steel, combined with a Medium Complexity scale-up factor from CIBSE (2021)
Aluminium	11.8	t CO ₂ e / t	NABERS National Emission Factor Database, Aluminium sheeting
Asphalt	0.07	t CO ₂ e / t	NABERS National Emission Factor Database, Asphalt mix
Fiber-Reinforced Plastic	9.30	t CO ₂ e / t	Transport for NSW Carbon Tool & ECCL, Fibre reinforced plastic
Polyethylene stormwater pipe	3.07	t CO ₂ e / t	EPD Vinidex Polyethylene Pipes
Steel Fibre	0.44	t CO ₂ e / t	EPD ArcelorMittal Europe – Long Products Steel fibers
Styrofoam	3.29	t CO ₂ e / t	ICE (Inventory of Carbon & Energy) V4.1 (2025), Polystyrene, expanded
Steel for pumps, valves, etc	4.21	t CO ₂ e / t	NABERS National Emission Factor Database, cold-rolled structural sections steel, combined with a Medium Complexity scale-up factor from CIBSE (2021)
Mild-steel cement lined (MSCL) Pipe	1.97	t CO ₂ e / t	SINTAKOTE® Steel Pipeline System EPD - Product Group B
Ductile iron concrete lined DICT Pipe	0.23	t CO ₂ e / m	EPD Jindal Saw Ltd Ductile Iron Pipe (DN 450)

3.4.2 Transport to site (A4)

Transport to site emissions are GHG emissions associated with the use of fuel transporting materials to and from construction sites.

Table 3-6 shows the assumed transport distance which primarily assumes road transportation from Port Augusta to an average distance to Mullaquana Station or Olympic Dam for the transfer system and the distance to Mullaquana Station for the desalination plant and marine works.

For concrete, the majority of this is utilised at the desalination plant and intake/outlet tunnels and have been assumed to come from a batch plant in Whyalla (Boral) (Systra, 2025e). Other batch plants at Port Augusta (Holcim) and mobile plants throughout the pump stations and storages are assumed to be used (Systra, 2025e).

MSCL pipe manufactured in Australia is expected to come via rail from two possible locations in Victoria or Western Australia to Port Augusta before final delivery to the Project's five laydowns area/s via two trailer road train trucks from the railway offloading area. A conservative distance from Kwinana, Western Australia has been adopted. DCL pipe manufactured outside Australia has been assumed to be transported via sea freight from a global manufacturer to Port Augusta, based on the generic assumptions outlined in NSW ECD (2025).

The majority of sand and imported backfilling is used for the transfer system and the average distance from the available commercial quarries nearby have been utilised (Systra, 2025h).

The road transport distances for aluminium, copper, styrofoam, fibre-reinforced plastic, and polyethylene pipes have been taken based on ITMM (2024), in the absence of specific distances. The quantities of these materials are small and transportation impacts expected to be negligible.

This assessment assumes two-way transport of materials to the construction site/front due to the remote locations. Whilst haulage distances will vary across the Project extent and this is a simplified assessment of potential haulage distances, it is noted that the overall emissions results are not highly sensitive to these assumptions.

Table 3-6 Estimated transport distance and mode

Material / Activity	Assumed average transport Distance (km)	Transportation Mode
Transfer system		
Concrete	up to 102	Concrete Agitator Truck
Sand	65	Articulated truck
Subgrade	65	Articulated truck
Crushed rocks	65	Articulated truck
Reinforcing steel	95	Articulated truck
Steel structural	95	Articulated truck
Desalination plant, marine works and tunnelling		
Concrete	31	Concrete Agitator Truck
Engineered fill	111	Articulated truck
Reinforcing steel	111	Articulated truck
Structural steel	111	Articulated truck
Steel cladding	111	Articulated truck
Galvanised steel	111	Articulated truck
Aluminium roofing	111	Articulated truck

Material / Activity	Assumed average transport Distance (km)	Transportation Mode
Epoxy lining	111	Articulated truck
Asphalt	111	Articulated truck
Fiber-Reinforced Plastic	50	Articulated truck
Polyethylene stormwater pipe	500	Articulated truck
Steel Fibre	111	Articulated truck
Styrofoam	500	Articulated truck
Crushed rocks	111	Articulated truck
Mild-steel cement lined (MSCL) Pipe	2,137 km via rail, 172 km via road	Rail, Bulk Transport - Articulated truck
Ductile iron concrete lined (DACL) Pipe	8,600 km via sea freight, 38 km via road	Freight Shipping - Articulated truck
Transmission Infrastructure		
Concrete	95	Concrete Agitator Truck
Gravel	95	Articulated truck
Steel structural	95	Articulated truck
Aluminium	531	Articulated truck
Copper	50	Articulated truck

3.4.2.1 Emission factors

Transport mode emissions factors have been based on Australian Life Cycle Assessment Society AusLCI (ALCAS, 2025), which have been used to estimate emissions associated with transport of materials, as well as spoil, and other waste from construction outside of the Project site detailed in **Section 3.4.5**. The emissions factors used are based on a per tonne/kilometre rate, which is representative of the emissions associated with the fuel combustion from transporting a tonne of any material one kilometre for a given transportation type. These emissions factors are listed in **Table 3-7**.

Table 3-7 Emissions factors for transport

Transportation Type	GHG emission (kg CO ₂ e / t.km)
Concrete Agitator Truck (Truck 16-28t)	0.17
Articulated Truck (Lorry >28t, fleet average)	0.11
Rail, Bulk Transport	0.04

3.4.3 Construction fuel (A5)

Construction fuel would be used in several items of plant and equipment across sites during construction of the Project. Estimates of construction fuel use and power use were provided by Systra on behalf of DIT for each main construction area.

Major sources of fuel use are anticipated to be related to a range of machinery and equipment, such as excavators and dump trucks. As no permanent supply is expected to be available at any of the construction

areas, temporary power for all construction works, including transfer system and desalination plant, will be supplied by diesel generators (Systra, 2025e).

To determine total fuel consumption for electricity supplied by diesel generators, the following steps were undertaken:

- The average power use for each construction area and project schedule were provided by Systra on behalf of DIT.
- The required power was multiplied by the following schedules to calculate estimated energy consumption (Systra, 2025e).
 - 24/7 scheduling for tunnelling and marine works
 - a 7-day calendar on day shift only, 12 hrs per shift for the full Transfer System scope
 - 5.5-day calendar on day shift only, 12 hrs per shift for the full desalination plant scope
 - A 7-day calendar, 12-hour shifts for the wet commissioning scope.
- Fuel efficiency at full load was estimated to be 0.3 L/kWh based on the use of an 800kVA diesel generator(s) for all activities, consistent with tunnelling requirements (Systra, 2025e, FW Power, n.d.).
- The energy consumption was then multiplied by the number of months in use and fuel efficiency rates to estimate total fuel consumption.

The total construction fuel use by activity is presented in **Table 3-8**. This includes major equipment at the Project site but does exclude materials haulage – these are dealt with separately in **Section 3.4.2**.

Table 3-8 Fuel and energy consumption by activity type

Construction area	Diesel fuel use for plant and equipment (kL)	Diesel fuel use for temporary power by generators (kL)
Tunnelling	20,229	22,757
Transfer System	12,679	5,437
Marine	7,194	4,443
Desalination Plant	3,744	4,569
Hydrotesting	510	30
Wet Commissioning	286	-
Total	44,642	37,236

3.4.3.1 Emissions factors

The National Greenhouse Accounts (NGA) Factors (DCCEEW, 2025a) are the primary source of GHG emissions factors used to determine emissions associated with fuel consumption during construction. **Table 3-9** provides details of the emissions factors from this source used in the construction assessment.

Table 3-9 NGA (2025) Emissions Factors for Fuel Combustion

Fuel Type	GHG emission	Units
Diesel Combustion (Stationary Plant and Equipment - generators)	3.38	tCO ₂ e / kL
Diesel Combustion (Transport)	3.39	tCO ₂ e / kL

3.4.4 Construction of transmission lines (A5)

At the time of writing, there is insufficient detail available on the construction methodology for the transmission lines to estimate fuel and electricity consumption using the same methodology as the remainder of the Project. In order to account for these emissions, a more high-level estimate has been prepared using emissions intensity factors per km of transmission line based on ITMM (2024).

These carbon intensity benchmarks were originally prepared for Infrastructure Australia's Embodied Carbon Projections for Australian Infrastructure and Buildings and have been endorsed by the Infrastructure and Transport Ministers' Meetings for national use.

These factors separately estimate the emissions impacts of the production of products, their transportation and construction activities. As the materials and transportation impacts of the transmission lines have been estimated separately, only the construction emissions have been estimated through this methodology.

These emissions intensity factors and the related length for each type of transmission line is shown in **Table 3-10** based on information provided by the client. It has been assumed that 33kV lines will be single circuit and all other lines will be double circuit.

Table 3-10 Construction emissions intensity factors for transmission line infrastructure

Typecast	Construction Emission intensity (t CO ₂ e/km)	Length required for the project (km)
Transmission Line: Single Circuit	11,743	15
Transmission Line: Double Circuit	23,757	27

3.4.5 Construction waste (A5)

Construction waste emissions are GHG emissions associated with manufacture, transport, and end-of-life treatment of material that becomes construction waste.

The reuse of spoil from pipeline trenching will be sought where feasible. However, for the purposes of estimating the potential GHG impact of spoil haulage, the assumptions provided by Systra on behalf of DIT has been adopted (Systra, 2025c). These assumptions include surplus excavation, where 100% of bedding material and 50% of backfill material will originate from site-won material, following processing, screening, and stockpiling by the construction crew.

Spoil that is not reused for bedding or backfilling has been assumed to be recycled (and potentially reused) off-site. Average haulage distances have been based on the available commercial quarries identified for the reference design (Systra, 2025h).

No spoil is expected to be generated from the desalination plant or tunnelling activities. The reference design has balanced cut and fill requirements in these areas, identifying that engineered fill is required—this has already been accounted for in Section 3.4.1.

Spoil is assumed to be transported via articulated truck, with quantities and distances shown in **Table 3-11**.

Table 3-11 Spoil disposal quantity and distance

Source	Spoil Export (m ³)	Spoil Disposal Source	Average Distance (km)
Transfer pipeline spoil	21,100	Commercial quarries	65

Other construction waste quantities have been estimated based on the wastage rate from ITMM (2024).

Waste from the transfer system and transmission infrastructure has been assumed to be disposed of or recycled at facilities in Port Augusta. Waste generated from the desalination plant, marine works, and tunnelling activities has been assumed to be disposed of or recycled in Whyalla.

Waste is assumed to be transported via articulated truck, with quantities shown in **Table 3-12**.

Table 3-12. Construction wastage rates and quantities

Material / Activity	Wastage rate (%)	Recycling quantity (t)	Landfill quantity (t)
Transfer System, Desalination Plant, Marine Works and Tunnelling			
Concrete	5%	8,304	923
Sand	5%	9,364	1,040
Backfilling and subbase	5%	40,705	4,523
Crushed rocks	5%	1,403	156
Reinforcing steel	5%	564	63
Structural steel	1%	18	2
Steel cladding	1%	1	1
Grout	5%	132	15
Galvanised steel for tanks	1%	4	0
Aluminium	1%	0	0
Asphalt	6%	634	0
Fiber-Reinforced Plastic	1%	0	0
Polyethylene stormwater pipe	6%	0	7
Steel Fibre	1%	73	8
Styrofoam	6%	0	1
Steel for pumps and valves	1%	2	0
Mild-steel cement lined (MSCL) Pipe	1%	1,317	146
Ductile iron concrete lined DICL Pipe	1%	49	5
Transmission Infrastructure			
Concrete	5%	670	74

Material / Activity	Wastage rate (%)	Recycling quantity (t)	Landfill quantity (t)
Gravel	5%	4,247	472
Steel structural	1%	28	3
Aluminium	1%	2	2
Copper	1%	0	0

3.4.6 Emissions factors

The NABERS National Emission Factor Database are the primary source of GHG emissions factors used to determine emissions associated with construction waste **Table 3-13** provides details of the emissions factors used in the construction assessment.

Table 3-13. Waste emission factors for recycling

Waste	GHG emission for recycling	Units
Inert waste (concrete, plastic, glass, rubble), including spoil waste recycling	0.0016	tCO ₂ e / t
Inert waste (metals) recycling	0.052	tCO ₂ e / t
Inert waste landfill	0.014	tCO ₂ e / t

Transport mode emissions factors outlined in **Table 3-7** are based on AusLCI (ALCAS, 2025), and have also been used to estimate emissions associated with transport of spoil and construction waste off the Project site.

3.4.7 Construction water and wastewater (A5)

Water supply during construction is required for hydrotesting of pipeline sections, the workforce (e.g. showering, ablutions, drinking water), tunnelling works, concrete batching, trenchless crossing, construction of pump stations, earthworks and dust suppression. For the GHG assessment, a conservative approach was taken and assumed all water will be potable. However, during construction, non-potable water sources are expected to be sought where feasible.

The total water demand figures have been supplied by Systra on behalf of DIT (Systra, 2025d).

For the assessment of GHG impact, an emission factor from the AusLCI database (2025) for South Australian tap water supply has been adopted, at 0.30 tCO₂e/ML.

This water is assumed to be hauled from the SA Water network at the Lincoln Gap storages, with the exception of water supplied to the Southern section camps for the transfer system, tunnelling and desalination plant, which is sourced from the existing camp infrastructure in Whyalla township, and the transfer system water requirements between Port Augusta and Olympic Dam, which are supplied from the Port Augusta township.

Total water quantities and haulage distances required over the course of the Project construction are outlined in **Table 3-14**.

All water used for the workforce has been assumed to result in an equivalent amount of wastewater creation which will require treatment. This is approximately 696 ML. An emission factor from the AusLCI database (2025) for South Australian wastewater treatment has been adopted, at 1.81 tCO₂e/ML.

Table 3-14 Construction water quantities and haulage

Construction area	Total water quantity (ML)	Distance from sourcing location (km)
Transfer system (between Port Augusta and Olympic Dam)	392	135
Transfer system (between Desalination Plant and Port Augusta)	149	20
Transfer system (hydrotesting)	309	87
Desalination plant	103	55
Tunnelling	105	55
Temporary construction workers camps for transfer system, tunnelling and desalination plant (Southern section)	659	0

3.4.8 Workforce commute (A5)

The workforce for the Project's construction will require fly-in fly-out staff to be able to cater to the construction requirements. Peak workforce numbers across the program have been provided for the Project (Systra, 2025e) with an assumption that approximately 50% will be on a fly-in fly-out arrangement with a two-week schedule.

Over the course of construction, this would result in approximately 25 million passenger kilometres travelled (PKT) via domestic flights. This is considered a worst-case upper limit as peak workforce numbers have been adopted and local workforces will be sought where feasible. The assessment outcomes are not highly sensitive to this assumption as workforce commute emissions are a negligible proportion of the Project's GHG emissions.

An emissions factor for domestic passenger flight emissions per PKT has been utilised from the UK GHG Conversion Factors 2025 (Department for Energy Security and Net Zero, 2025), at 0.23 kgCO₂e/PKT, which includes the direct and indirect climate change effects of high-altitude fuel combustion as well as the upstream impacts of extraction, refining and transport of the aviation fuel. Whilst an Australian specific factor is not available, this is considered an appropriate proxy.

3.4.9 Construction land use change (A5)

GHG emissions from clearing of vegetation (loss of the carbon sink) have been determined using the methodology within the Transport Authorities Greenhouse Gas (TAGG) Workbook (TAGG, 2013). The GHG impacts associated with clearing accounts for the carbon that exists in the vegetation at the time of clearing (assuming decomposition and release) and the carbon that could have been sequestered in the future if the vegetation was not cleared.

The vegetation areas to be cleared have been determined by aligning the TAGG Workbook categories with the ecology field classifications and clearance areas from a field assessment undertaken by Native Vegetation Council Accredited Ecologists of the Project footprint (Jacobs, 2025) and the Project's geospatial information system (GIS). For the carbon assessment purpose, the field classification system has been regrouped to meet the Department of Climate Change, Energy, the Environment and Water (DCCEEW) naming standards.

Using the inbuilt map for South Australia within TAGG (2013), the terrestrial section of the study area falls within biomass class 1 (0-50 tonnes of dry matter per ha). TAGG (2013) provides the GHG emission factors associated with clearing vegetation.

Within the marine environment, should the intake and outfall pipelines be placed on the seabed (rather than tunnelled below the sea bed), it is expected the clearance of (*Zostera*) seagrass is approximately 4 ha. Relative to the expected terrestrial vegetation clearance required to accommodate the project, the seagrass clearance areas are not material when compared to the overall clearance area of native vegetation for the Project.

The areas to be cleared and emissions factors used on this Project to calculate the emissions from vegetation clearing are listed in **Table 3-15**.

Table 3-15. TAGG Workbook Emissions Factors for Vegetation Clearing

Vegetation Type	Biomass Class	GHG emission tCO ₂ e/ha	Area Cleared (ha)
Class D (Woodland)	1	77	25
Class E (Callitris Forest and Woodland)	1	80	47
Class F (Mallee and Acacia Woodland and Shrubland)	1	106	580
Class G (Shrubland)	1	113	126
Class H (Heathlands)	1	115	1,300
Class I (Grassland)	1	110	23

3.5 In-use phase embodied carbon

3.5.1 Operational chemical Use (B1)

Chemicals are required at the desalination plant for water treatment, residuals management and cleaning process systems. The production and transport of these chemicals have associated emissions which are indirectly attributed to the carbon footprint of the Project.

The amount and nature of chemicals used is a function of water quality, specific treatment processes and design technology used. Estimated quantities presented in **Table 3-16**, are based on assumed typical applications and will be refined during further design development and selections of pre-treatment and RO process and membranes.

Table 3-16. Chemical Use during in-use phase

Chemical	Annual Use (t)
Sulphuric acid	6,855
Sodium bisulphite (SBS)	580
RO antiscalant	475
Sodium hypochlorite	6,670
Citric acid	394

Hydrochloric acid	876
Sodium hydroxide	1,128
Chlorine	153
Carbon dioxide	2,862
Lime	3,208
Sodium silicate	102
Polymer	9

There are no publicly available, recent, or reliable emissions factors for these chemicals, however, factors were predominantly derived from the AusLCI Shadow database via Jacobs' access to the Cerclos eTool software and from the City of Winnipeg, Canada (2012). These emission factors were adjusted for their proposed dosage concentrations.

Emissions factors were available for eleven of the twelve chemicals used, and an average emissions factor of the chemicals for which emission factors were available has been assigned to RO antiscalant. It's noted that this chemical is estimated to only make up a small (2%) portion of the overall Project footprint. As such, a lack of data is not expected to significantly alter the findings.

The location of chemical manufacture is currently uncertain and as a conservative assumption for the GHG assessment, they are assumed to be delivered from either Europe or the United States. The transportation impact of chemicals to the facility has been assumed to comprise international shipping and local road transport. This includes:

- Transport via an articulated truck from Port Augusta with a total average transportation distance of about 111 kilometres.
- International shipping, with an average shipping distance of 10,000 nautical miles (approximately 18,500km).

3.5.2 Operational waste disposal (B1)

Operational waste estimates have been provided by GHD on behalf of DIT (GHD, 2025) as part of the reference design, based on the residual solids generated from the water treatment and filtration processes. While most of the return water is released to the ocean via the outlet diffusers with no material emissions associated with it, dewatered lime sludge from the lime system contains high quantities of calcium carbonate with potential to produce direct carbon dioxide emissions upon disposal. The annual quantities of lime sludge and calcium carbonate content are presented in **Table 3-17**.

Table 3-17. In-use phase waste

Waste during in-use phase	Mass (t/annum)
Lime Sludge	552
Calcium carbonate	110

Emissions factors for liming to land have been determined based on the IPCC guidelines (IPCC, 2006), with an emissions factor of 0.12 t CO₂e-C / t CaCO₃.

Haulage of operational waste has assumed to be approximately 35km for consistency with the remaining assumptions for disposal and usage in Whyalla.

3.5.3 Workforce commute for regular inspections (B2)

It is expected that each remote site will require a 2 worker patrol crew for weekly site visits, supplemented by a 4 worker specialist maintenance crew conducting monthly mechanical and electrical inspections. The resultant fuel consumption is calculated based on 1,036 km travelled per set of weekly and monthly inspections for the Project reference design. These travel distances are the sum of the visits from Port Augusta to each aboveground remote site (e.g., desalination plant, pump stations and storages).

Fuel consumption rates for passenger vehicles have been adopted from the average for passenger vehicles based on ABS (2020). It has been assumed that post-2056, all passenger vehicles will be electric, based on expected commercial collapse or no longer viability of internal combustion engine (ICE) to operate under the Step-Change scenario from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Electric vehicle projections (Graham, P., Mediawaththe, C. & Green, D., 2025). Electricity-related emissions are assumed to be immaterial post-2056, given South Australia's target to achieve 100% net renewable electricity generation by 2027.

3.5.4 Workforce commute for operations (B2)

The operation of the desalination plant will require a workforce of approximately 56 people, comprising 12 operators working day and night shifts, as well as an additional 32 personnel for daily management. The commute of this workforce to and from the plant is considered a relevant source of emissions under the GHG Protocol and hence this fuel consumption has been attributed to the project.

It has been assumed that the desalination plant site team will be located at Whyalla with an average commute of approximately 40km each way, commuting daily. Fuel consumption rates for passenger vehicles have been adopted from the average for passenger vehicles based on ABS (2020).

Post-2056, all passenger vehicles are assumed to be electric consistent with the Step-Change scenario from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Electric vehicle projections (Graham, P., Mediawaththe, C. & Green, D., 2025). The emissions for vehicle charging are immaterial.

3.5.5 Fuel for backup generator testing (B2)

The desalination plant will include a backup diesel generator sized for the essential load to enable safe shut down. This generator will require ongoing testing to ensure its continued functionality and will consume fuel during these testing events. It has been assumed that the generator will require monthly testing, with operation of approximately two hours per test at full load. It has been estimated 8.6kL of annual diesel consumption for this testing and the use of the emission factors from the NGA Factors (DCCEEW, 2025a). Whilst the exact testing schedule and requirements is yet to be determined, the results are not highly sensitive to this assumption, and this is a negligible proportion of overall emissions.

Pump stations will allow for the connection of a temporary diesel generator to cater for the essential loads in case of power supply failure. As there has been no provision of a permanent generator at these sites, no allowance for testing has been incorporated. Any potential use of temporary systems for backup power is expected to be negligible.

3.5.6 Materials and equipment replacement (B3-B5)

During the operation of the Project, materials which have reached their end of life will require replacement. A summary of minimum design lives, number of replacements has been provided in **Table 3-18**.

There are some materials, which if replaced towards the end of the 100-year assessment period, would only serve a fraction of their potential life (e.g. buried pipework with a life of 80 years). For these materials, it is

assumed that it would not be economical to be replaced entirely but rather would require some other form of maintenance to extend its use out to the 100-year assessment period.

Table 3-18. Design lives of project components

Asset Class	Minimum Design Life (Years)	Replacements
Marine structures, intake and outlet tunnels, concrete	100	0
Marine pipework	100	0
Marine replaceable components	50	1
Terrestrial civil assets (shafts, buried pipelines, piles)	80	0
Water retaining or excluding structures	50	1
Tanks – concrete	50	1
Earth bank storages	50	1
External slabs on ground/rigid pavement	50	1
Sealed roads and hardstands	50	1
Unsealed roads, access tracks	25	3
Concrete structures and substructures	50	1
Buildings (warehouse, office, pump station)	50	1
Structures (platforms, walkways etc)	50	1
Above ground pipework – metallic	50	1
Above ground pipe – non-metals	25	3
Tanks – non-concrete and vessels	25	3
Mechanical assets (valves, drives, motors)	25	3
Electrical/power supply assets (low voltage, high voltage)	25	3
Instrumentation/control assets	15	6
Controls/SCADA	15	6
Fibre Optic Cable	25	3
Cathodic protection	20	4
Ultrafiltration membranes	5	19
RO membranes	5	19
Protective coatings on steelwork or concrete	25	3

A summary of the quantities of materials to be replaced over the design life has been provided in **Table 3-19**.

Whilst the emissions intensity of materials production is expected to decarbonise over the life of the Project, the rate of this will vary across materials, suppliers and countries of production, and this rate of decarbonisation is uncertain. As such, no estimate of this impact has been included within the assessment, hence the emissions associated with materials replacements are expected to be a conservative estimate.

Table 3-19 Estimated material replacement quantities for each asset class (total for all replacements)

Material / Activity	Number of replacements	Replacement quantity	Unit
Transfer System, Desalination Plant, Marine Works and Tunnelling			
Concrete	1	76,888	m3
Crushed rocks	1	31,176	t
Reinforcing steel	1	12,533	t
Structural steel	1	2,317	t
Steel cladding	1	48,453	m2
Grout	1	1,275	m3
Galvanised steel for tanks	3	1,267	t
Aluminium	1	165	t
Asphalt	1	10,571	t
Fiber-Reinforced Plastic	3	79	t
Steel for pumps and valves	3	560	t
Transmission Infrastructure			
Concrete	1	6,200	m ³
Gravel	1	94,380	t
Steel structural	1	3,100	t
Aluminium	3	1,158	t
Copper	3	36	t

3.6 In-use phase operational carbon

3.6.1 Energy Consumption (B6)

Electricity use for the Project has been provided by GHD on behalf of DIT in the Reference Design Report (GHD, 2025) and includes a high level estimate of the maximum power demand based on benchmarking with other Australian seawater reverse osmosis (SWRO) desalination plants' peak power demand from the operation of the pump stations in the distribution system and desalination plant.

The average operational electricity use is presented in **Table 3-20**. Over the 100-year assessed life of the project, the total electricity consumption is estimated to be 38,325 GWh, ranging $\pm$ 5%.

Table 3-20. Operational Energy Use

Electricity use	Maximum power consumption (GWh/annum)
Desalination Plant	184 - 225
Transfer system (pump stations)	179
Total	363 - 404

3.6.1.1 Electricity accounting methods

Electricity consumption has been calculated using the location-based approach and the market-based approach to provide alternative perspectives on the emissions associated with electricity consumption. This is consistent with the GHG Protocol (WBCSD & WRI, 2015) which recommends dual reporting.

- The location-based approach estimates electricity emissions based on the emissions intensity of South Australia's average generation and import mix. Projections for the emissions intensity of the South Australian grid have been sourced from Australia's emissions projections (DCCEEW, 2025b). These projections are only available until 2040, and hence the emissions intensity after this point has been assumed to remain consistent. These projections incorporate South Australia's 2027 net renewable energy target.
- The market-based approach estimates emissions based on the electricity which has been intentionally procured. It includes the impact of the Project's commitment to sourcing 100% of its electricity from renewable sources. Renewable energy certificates are used to manage the attribution of renewable electricity, and are treated as zero emissions within the market-based calculation rules from the Clean Energy Regulator (CER, 2025).

A summary of the emissions intensity for the reporting of emissions under the location-based approach is presented in **Table 3-21**. Operational electricity consumption each year has been matched with the corresponding years' emissions intensity, with estimated operations from 2032 onwards.

The emission factors provided in **Table 3-21** below represent the varying activities related to Scope 2 and Scope 3 emissions. Scope 2 emissions for electricity consumption refer to the indirect GHG emissions associated with the generation of electricity (i.e. the combustion of fossil fuels). Scope 3 emissions for electricity consumption include the remaining indirect emissions such as the emissions related to the extraction, processing, and transportation of fuels used in power generation, as well as transmissions and distribution losses.

Table 3-21 Emissions Factor Projections for Electricity Consumption in South Australia

Fuel Type	GHG emission (tCO ₂ e / MWh) for the location-based approach		
	Scope 2	Scope 3	Combined
Electricity (2025)	0.22	0.04	0.26
Electricity (2030)	0.06	0.01	0.07
Electricity (2035)	0.03	<0.00	0.03
Electricity (2040)	0.03	0.01	0.04
Electricity (post-2040)	0.03	0.01	0.04

4. Estimated GHG emissions

This section presents a summary of the GHG footprint estimate for the Project and a summary of the relevant contributions of key emissions sources for upfront carbon, in-use embodied and in-use operational carbon phases of the Project. A full breakdown of all individual emissions sources is presented in **Appendix A**.

4.1 Upfront carbon emissions

Upfront carbon emissions are independent of assumed in-use phase scenarios. A breakdown of upfront carbon by life cycle modules is presented in **Table 4-1** and relative contribution to upfront carbon emissions by source is shown in **Figure 4-1**.

Table 4-1. Upfront carbon emissions breakdown by life cycle module

Life cycle module	Emissions (t CO ₂ e)
Manufacturing of construction products and materials (A1-A3)	380,803
Transport of products to site (A4)	39,185
Construction energy use (A5)	276,719
Construction water and wastewater (A5)	36,149
Construction waste (A5)	2,441
Vegetation clearance (A5)	233,557
Workforce commute (A5)	5,714
Upscaled emissions (A1-A5)	185,413
Total upfront carbon (A1-A5)	1,159,981

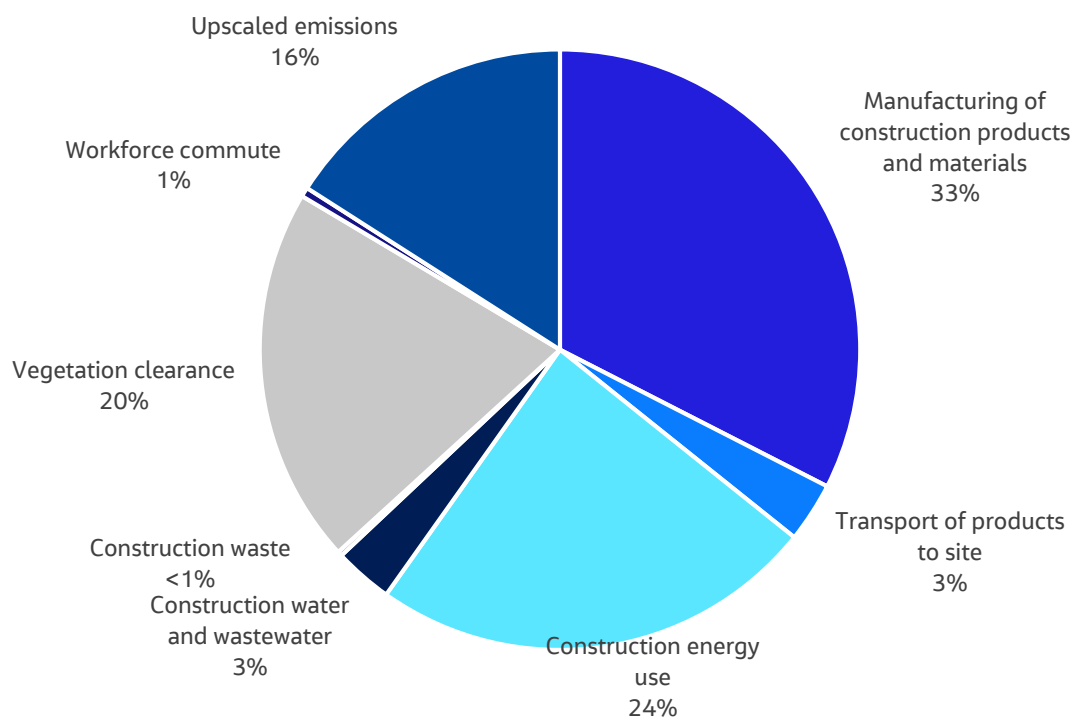


Figure 4-1. Upfront carbon emissions source contributions

The primary contribution to upfront carbon emissions is associated with the production of construction materials and products (33%). Over three quarters (77%) of this is associated with the MSCL pipe. Other emission sources are associated with concrete and steelwork for marine tunnels and launch box, and concrete tanks and civil structures at the desalination plant.

Energy consumption and vegetation clearance and are the next largest impact at 24% and 20%, respectively, followed by the upscaled emissions mostly related to unquantified construction materials (16%). Transport of materials to site and consumption of water and wastewater make up 3% and 3%, respectively. Construction waste and conservative assumptions for workforce air travel both represent a negligible (<1%) impact on emissions.

4.2 In-use phase embodied emissions

A breakdown of in-use phase embodied carbon by life cycle modules is presented in **Table 4-2** and relative contribution to in-use embodied carbon emissions by source is shown in **Figure 4-2**.

Table 4-2. In-use embodied carbon emissions breakdown by life cycle module

Life cycle module	Emissions (t CO ₂ e)
Use phase material emissions and removals (B1)	2,001,783
Maintenance (B2)	4,641
Repair, refurbishment and replacement (B3-B5)	70,376
Total in-use embodied carbon (B1-B5)	2,076,800
Average annual in-use embodied carbon emissions (B1-B5)	20,768

The average annual emissions presented are based on an average over the 100-year life, however, this is expected to be variable for the replacement of materials at the end of their lives. Replacements will occur irregularly as required, and hence major replacement years are likely to have a higher emissions footprint than the average associated with the production of these materials. Years without replacements are likely to be lower.

Chemical usage is calculated based on the assumed 51 GL/y production capacity over 100-year life..

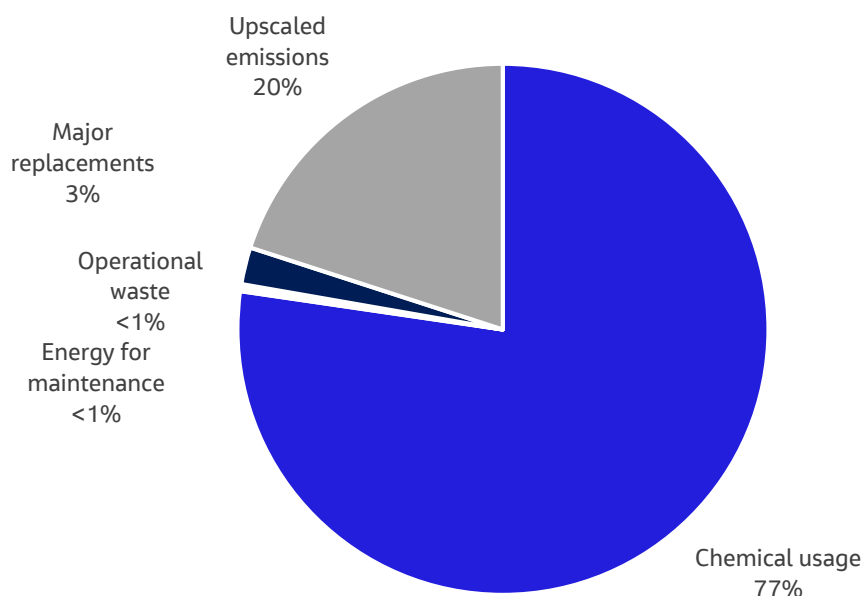


Figure 4-2. In-use embodied carbon emissions source contributions

The primary contribution to in-use embodied carbon emissions is the consumption of chemicals (77%). More than one-third of this (38%) is associated with sodium hypochlorite used at the intake screens for chlorination and UF cleaning. This is followed by emissions from the use of carbon dioxide and the assumed transport of chemicals from overseas to the desalination plant at 16% and 15% respectively.

Upscaled emissions are mostly related to unquantified chemical consumption driven by uncertainties in their usage over the 100-year life of the Project but also covers unquantified replacements such as for RO and pretreatment filtration membranes.

Key contributors to estimated major replacements are associated with the replacement of tanks (concrete and reinforcing steel) and transmission lines at the end of their design life.

4.3 In-use phase operational emissions

As introduced in Section 3.6.1.1, in-use operational emissions are calculated using the location-based and market-based approaches. The location-based approach is used to report GHG emissions, while the market-based approach is applied to assess the impact of the Project's commitment to sourcing 100% of electricity demand through renewable electricity.

The in-use operational emission for each accounting method is presented in **Table 4-3**.

Table 4-3. In-use operational emissions by electricity accounting method

	Electricity accounting method	
	Location-based approach	Market-based approach
Operational energy (B6) (tCO ₂ e)	1,544,498	-
Total in-use operational emissions (tCO ₂ e)	1,544,498	-

Average annual in-use operational emissions (tCO ₂ e/y)	15,445	-
--	--------	---

For the location-based approach, the average annual emissions presented are based on an average over the 100-year life, however, this is expected to be variable due to variances in the emissions intensity of the South Australian grid and its ability to decarbonise, aligned with the 100% net renewable electricity generation target by 2027.

4.4 Total emissions

Over the life of the Project (construction and 100 years of operation), the total GHG emissions are expected to be approximately 4.8 MtCO₂e (using location-based approach to account for electricity consumption). The primary contributor to total emissions (42%) is use-phase material emissions and removals (B1), largely driven by chemical consumption. The second largest contributor is electricity consumption during operations, accounting for 33%, followed by product stage emissions (A1-A3) related to manufacturing of construction products and materials at 10%.

When operational electricity is calculated using the market-based approach to account for the benefits of procuring renewable electricity, total GHG emissions are approximately 3.2 MtCO₂e. Under this accounting method, more than 60% of total GHG emissions are attributed to use-phase material emissions and removals (B1), primarily from chemicals consumption. This is followed by product-stage emissions (A1-A3) at 15%, and emissions from construction activities at 12%.

A detailed breakdown is provided in **Table 4-4** and relative contribution by source is shown in **Figure 4-3**.

Table 4-4. Percentage of Estimated Emissions by life cycle stage and electricity accounting method

	Electricity accounting method	
	Location-based approach	Market-based approach
Product stage (A1-A3)	10%	15%
Transport to site (A4)	1%	2%
Construction (A5)	8%	12%
Land use change (A5)	5%	7%
Use phase material emissions and removals (B1)	42%	62%
Maintenance (B2)	<1%	<1%
Repair, refurbishment and replacement (B3-B5)	1%	2%
Operational energy (B6)	32%	<1%

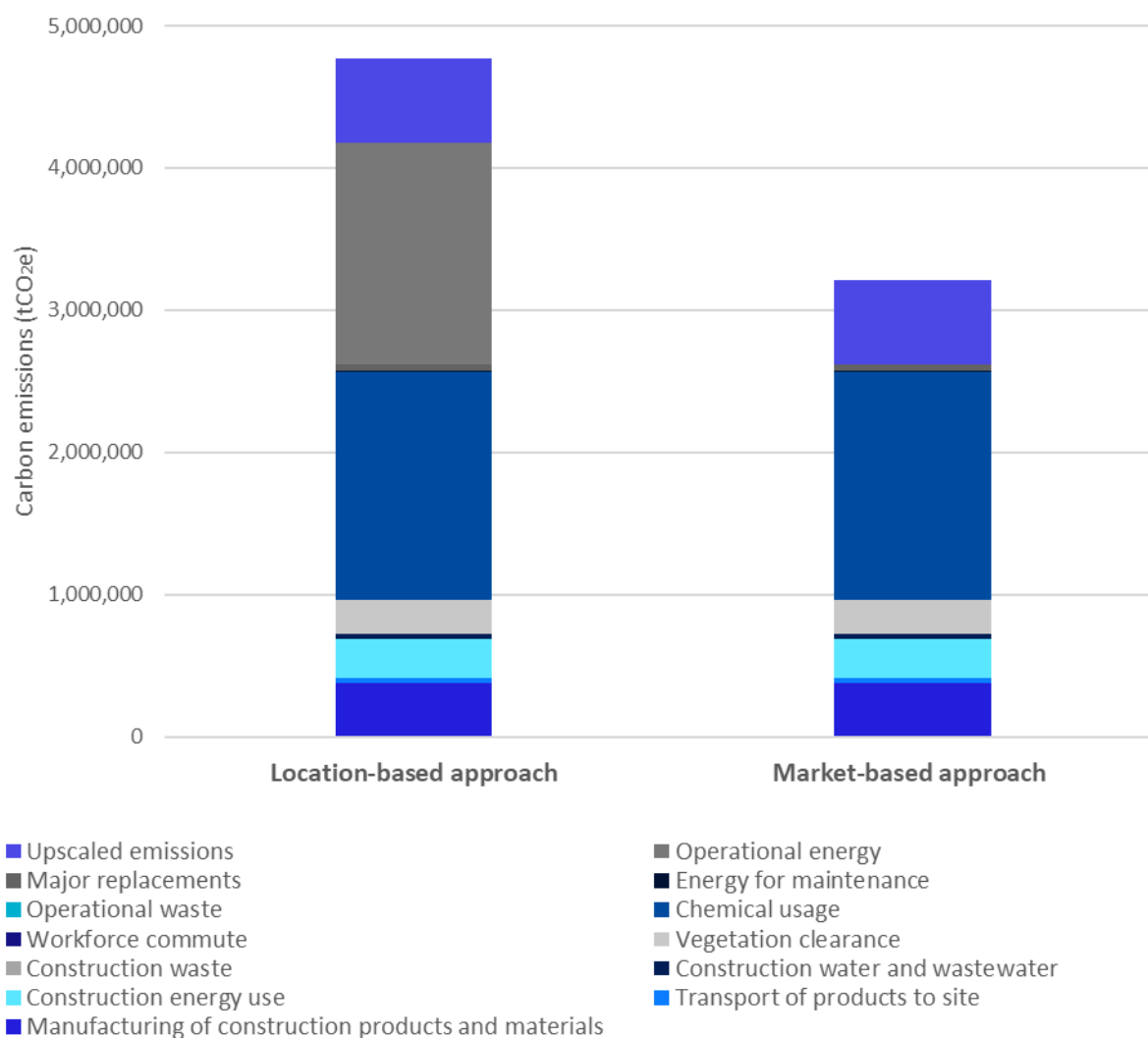


Figure 4-3. Estimated Emissions by Emission Source and Electricity Accounting Method

4.5 Total and annual emissions per scope

A breakdown of total emissions by scope is presented in **Table 4-5**.

Under a location-based approach, 66% of total emissions are associated with indirect Scope 3 emissions, about 25% of emissions are associated with Scope 2 emissions and the remaining 10% of total emissions associated with Scope 1.

Table 4-5. Breakdown of total emissions per scope over the life of the development

Scope	Emissions (location-based) (t CO ₂ e)	Emissions (market-based) (t CO ₂ e)
Scope 1	459,147	459,147
Scope 2	1,161,248	0
Scope 3	3,106,059	2,722,809
Total	4,726,453	3,181,956

Annual emissions by scope are presented in **Table 4-6**. Peak annual emissions are expected during the construction phase, primarily due to upfront (embodied) carbon. Scope 1 emissions are primarily associated with fuel combustion and vegetation clearance, while Scope 3 emissions are largely driven by the production of construction materials and products. The annual emissions presented are a simplified average over four years of construction, however, in delivery these will vary over the construction period.

Over the 100-year operational period, annual Scope 2 and Scope 3 emissions are expected to fluctuate, driven by changes in the emissions intensity of the South Australian grid (using a location-based approach) and periodic emissions associated with the replacement of major design elements at the end of their design life. Scope 1 emissions are expected to remain minimal throughout the life of the development, associated with fuel consumption for maintenance.

Table 4-6. Average annual emissions per scope over the life of the development

Scope	Average annual emissions (t CO ₂ e/y) during construction (location and market-based)	Average annual emissions (t CO ₂ e/y) during operations (location-based)	Average annual emissions (t CO ₂ e/y) during operations (market-based)
Scope 1	113,856	4,591	4,591
Scope 2	0	11,612	-
Scope 3	162,433	31,061	27,228

4.6 Uncertainty assessment

The uncertainty in the GHG emissions is generally linked to two key areas:

- 1) Uncertainty in the activity data
e.g. the estimated quantities of materials, plant and equipment requirements, chemical dosage, electricity consumption etc will change as the design is refined.
- 2) Uncertainty in the emission factors
e.g. generic emission factors have been assigned to some materials to reflect average conditions, but as final materials are specified and suppliers confirmed, more specific emission factors can be obtained such as through EPDs. The emissions intensity of materials will also change over time.

Given the early stage of the Project at the time of assessment (prior to engagement of a construction contractor, detailed design and procurement of materials, plant and machinery), there are likely to be changes related to these areas of uncertainty. What is important however, is that the magnitude and relative scale of emissions have been appropriately identified to inform key areas for mitigation. The GHG assessment has aimed to include all emission generating activities as far as feasible.

The assessment is most sensitive to assumptions related to:

- **Chemicals:** Dosing rates and the source / emissions intensity of chemical production.
- **Electricity:** Efficiency rates and emissions intensity projections for the South Australian grid.
- **Production:** Annual supply volumes (as this is inherently linked to many operational activities).
- **Waste:** The organic fraction and emissions intensity of operational waste streams.

The assessment has adopted an upscaling factor (as defined in Section 3.3) to cover emissions that are not quantified due to time or information constraints consistent with the requirements of ITMM (2024). The assumptions made in the assessment have been reviewed to ensure that all minimum inclusions required under ITMM (2024) are captured, and the approach is considered appropriate given the magnitude and

relative scale of unquantified emissions. Variations in these assumptions are not expected to significantly alter the required mitigation measures recommended for the Project.

Additional GHG assessment refinements in later stages of the Project will improve the accuracy of the findings and an iterative assessment of key opportunities for reduction.

4.7 Benchmarking

As the emissions associated with the Project are largely a result of emissions sources outside the direct control of the Project, such as chemicals consumption during in-use phase, production of construction materials, and operational energy use, benchmarking of emissions between SWRO desalination plants is difficult across a national or even global scale. This difficulty is predominantly due to high uncertainty in the sourcing and emission factors for chemicals and construction products, as well as inherent differences in the emissions intensity of the electricity grid between locations.

Therefore, a more suitable metric for benchmarking of SWRO desalination plants is the Specific Energy Consumption (SEC) which is a measure of the energy used per volume of product water produced. This is independent of the additional specific energy consumption associated with the delivery pipeline supplying water to Carrapateena and Olympic Dam. It should be noted, however, that benchmarking of SEC is still difficult due to uncertain boundaries and inherent correlation to the properties of the intake feedwater and required product water quality which also vary with location as well as plant elevation, site configuration and design (Kim et al, 2019. Schunke et al, 2020).

As an indicative comparison, the SEC values for other SWRO desalination plants around Australia range from 3.5 – 4.6 kWh/m³ (see **Table 4-7**) with a global average of 4.3 kWh/m³ and a global range from 3.0 - 6.7 kWh/m³ (Kim et al, 2019). Based on the adopted conservative and robust estimate of power demand requirements, derived from Australian SWRO desalination plants' peak power demand, the Project is just below the global average range of SEC values, with estimated average value of 4.0 kWh/m³, ranging from 3.6 – 4.4 kWh/m³ (GHD, 2025).

Global plants with a lower SEC value presented in Kim et al, 2019 (Ghalilah - UAE, Marsa Matrouh - Egypt and Arucas-Moya - Spain) also have less stringent product water quality targets (in terms of total dissolved solids) and a higher product water quality is correlated with higher SEC.

The SEC efficiency can be partially attributed to the use of a best practice pressure exchange type energy recovery device such as that proposed for the Project, which is noted as assumed for the reference design, with the lowest range of SEC typically found in plants that utilise such a system (Kim et al, 2019. Schunke et al, 2020).

Whilst it currently appears that compared to other Australian desalination plants, the current predicted SEC value would be in line with the average, this is a conservative expectation for preliminary planning and negotiations with power suppliers and regulators at this early stage of the Project, and additional efforts will be sought throughout the detailed design and operation to minimise energy consumption. Other plants in the past have significantly improved upon the SEC value between initial reference design estimates and as-built conditions, with the Adelaide plant originally stipulating a maximum SEC of 4.5 kWh/m³ within tender documents, which was well exceeded in operations (Blesing and Pelekani, 2016).

Table 4-7. SEC Values for Other Australian SWRO Plant (Kim et al, 2019)

Plant Location	SEC Value (kWh/m ³)
Adelaide (Port Stanvac)	3.6
Gold Coast	3.5
Melbourne	<4.6

Perth (Kwinana)	3.6
Perth (Southern)	3.5
Sydney	<3.9
Northern Water (expected average)	4.5

5. Mitigation measures

DIT has nominated sustainability priority topics and objectives for the Project in the technical requirements (DIT, 2025). This GHG assessment is relevant to the emissions reduction and resource efficiency topic, which includes the following committed objectives and requirements:

- Minimise the generation of GHG across the asset lifecycle.
- Contribute to circular economy outcomes by optimising the use of resources and materials, avoiding and reducing waste and using recycled materials where feasible.
- Optimise energy use across the asset lifecycle.
- Maximise efficient water use and water reuse.

During subsequent stages of detailed design and construction, the Project is committed to define targets and actions to support achievement of the DIT's objective of minimising the Project's whole of life GHG emissions.

It is recommended that the Project consider carbon emissions in significant decisions and investigate and assess mitigation opportunities aligned with the carbon reduction hierarchy —prioritising avoidance, adoption of alternative solutions, and improved resource efficiency to reduce whole-of-life emissions, while applying best available techniques that are economically achievable.

Based on the GHG assessment and a review of the significant contributions to the Project's emissions sources, several potential mitigation measures are available to further reduce GHG emissions.

The major source of emissions for the Project is the chemical usage over the 100-year life. Significant opportunities to reduce these emissions are related to adopting efficient processes and optimising chemical dosage.

The second largest emission source is operational energy usage, even with best practice efficiency measures implemented in reference design. Hence, another significant opportunity for emissions reduction is the potential for identifying and assessing energy efficiency and recovery measures and the procurement of electricity supply based on low carbon renewable sources of electricity.

The Project has committed to the purchase of 100% renewable electricity and plans to integrate on-site solar energy at the storage facilities. The design of the desalination plant has also integrated a pressure exchange type energy recovery device to improve the efficiency of the process.

The Project will result in an increase in the State's GHG emissions overall. This installation and purchase of renewable electricity for the Project is consistent with South Australia's targets of 100% net renewable energy by 2027, however, given the Project is creating a large additional electricity demand, sourcing of renewable electricity should ensure that the renewable electricity supply for the project is from additional sources to the extent reasonably practicable.

Several potential mitigation measures have been identified for the design, construction and operational phases of the Project. Adoption of these measures will assist in meeting DIT's carbon reduction and resource efficiency goals and targets, while aligning the Project with the South Australian government's commitments to at least a 60% emissions reduction below 2005 levels by 2030, and zero net emissions by 2050.

During design and construction, opportunities include:

- Incorporation of energy efficiency and recovery measures into the design, including:
 - optimising desalination plant layout to support hydraulic performance and maximise gravity flows
 - optimising pipe sizing for transfer system to minimise energy losses

- optimising intake and outfall tunnel diameters and lengths for flow velocities and energy use whilst meeting environmental performance requirements
 - using energy recovery devices to optimise recovery of energy within the RO process
 - selecting energy efficient desalination and membrane technology
 - selecting high efficiency pumps, fans, and motor systems while ensuring appropriate sizing, and
 - using variable speed drives.
- Adopting, where reasonably practicable, of electrified or alternative fuel vehicles, plant and equipment.
 - Investigating the potential for on-site renewable energy and storage systems, where reasonably practicable, to reduce diesel use in on-site generators.
 - Optimising pipeline alignment during design to minimise vegetation clearance, where reasonably practicable.
 - Maximising the reuse of excavated material as backfill to minimise haulage and use of new aggregates.
 - Integrating criteria for local and/or low-carbon sourcing in construction materials procurement arrangements.
 - Identifying, and where practicable, optimising freight logistics to integrate lower emission options for transporting material to site
 - Maximising efficient water use and water reuse, where reasonably practicable.

During operations, opportunities include:

- Monitoring plant performance indicators to ensure operational efficiency.
- Implementing a regular inspection, maintenance, and audit regime for high energy use systems (e.g., pump efficiency testing) to reduce the risk of inefficiencies associated with deterioration.
- Monitoring trends in specific energy use per kL of water produced to identify and support efficiency improvements
- Maximising plant utilisation to reduce inefficiencies associated with start-up, stopping, or ramping of the desalination plant.
- Integrating criteria for local and/or low-carbon sourcing in chemical procurement arrangements.
- Using power factor correction measures, where appropriate.

The assessment of GHG emissions and evaluation of opportunities should be revisited throughout the design and delivery of the Project to continue to identify the most effective means of reducing GHG emissions and meet DIT sustainability requirements.

6. Conclusion

The South Australian government has set goals to achieve at least a 60% emissions reduction below the 2005 level by 2030 and zero net emissions by 2050, as well as 100% net renewable electricity generation by 2027.

DIT has nominated the following committed objectives and requirements for emissions reduction and resource efficiency for the Project (DIT, 2025):

- Minimise the generation of GHGs across the asset lifecycle.
- Contribute to circular economy outcomes by optimising the use of resources and materials, avoiding and reducing waste and using recycled materials where feasible.
- Optimise energy use across the asset lifecycle.
- Maximise efficient water use and water reuse.

The purpose of this report is to identify and quantify the main sources of GHG emissions from the Project and recommend mitigation measures in alignment with these goals.

During construction of the Project, the greatest upfront carbon emissions are associated with manufacturing of construction products and materials, vegetation clearing and construction energy. The Projects' remote location and significant length of pipeline contribute to the scale of each of these sources of GHG emissions.

During in-use phase of the Project, the most significant emissions are associated with embodied emissions from chemical usage, and the operational electricity use for water treatment and distribution under the location-based accounting method. Other contributions arise from operational waste treatment.

Over the life of the Project (construction and 100 years of operation), the total GHG impact is expected to be approximately 4.8 mega tonnes of carbon dioxide equivalents (MtCO_{2e}).

Under a location-based approach, Scope 3 emissions account for 66% of total emissions, primarily from operational chemical use and materials. Scope 2 emissions contribute 25%, associated with electricity consumption, while Scope 1 emissions account for 10%, mainly from vegetation clearance and diesel use.

Annual emissions are expected to peak during the construction phase. During operations, Scope 2 and Scope 3 emissions are projected to fluctuate with changes in grid emissions intensity and asset replacement cycles.

When operational electricity is calculated using the market-based approach, total GHG emissions are approximately 3.2 MtCO_{2e}. The market-based approach reflects the benefits of the Project's commitment to procuring 100% renewable electricity for operations.

The commitment to source 100% renewable electricity is consistent with the State of South Australia's targets of 100% net renewable energy by 2027. However, as the Project is creating a large additional electricity demand, to the extent reasonably practicable, the sourcing of renewable electricity for the Project should ensure that such supply is additional to the existing supply.

Whilst the Project will result in an increase in the State's GHG emissions overall, it will enable the continued operation and growth of industries critical for broader decarbonisation including copper extraction.

Opportunities and recommendations have been identified for the design, construction and operational phases of the Project to minimise GHG emissions. Incorporation of these opportunities into further design development and during the construction and operational phases will also support alignment with the South Australian government's emissions reduction commitments.

The assessment of GHG emissions and evaluation of opportunities should be revisited throughout the design and delivery of the project to continue to identify the most effective means of reducing GHG emissions and meet DIT SA sustainability requirements.

7. References

- ArcelorMittal Europe – Long Products (2025), Steel Fibres EAF-DRI-base Environmental Product Declaration, available at <https://environdec.com/library/epd16438>
- Australian Bureau of Statistics (ABS), (2020), Survey of Motor Vehicle Use, available at <https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/latest-release>
- Australian Lifecycle Assessment Society (ALCAS), (2025), Australian Lifecycle Inventory (AusLCI) v1.45 Construction Database, available at <https://www.alcas.asn.au/auslci-emissions-factors>
- British Standards Institution (2023) PAS2080:2023 Carbon management in buildings and infrastructure
- Chartered Institution of Building Services Engineers (CIBSE) (2021), Embodied carbon in building services: a calculation methodology, CIBSE TM65: 2021.
- Circular Ecology (2025) The Inventory of Carbon & Energy (ICE) Database v4.1
- City of Winnipeg, Canada (2012), Emission factors in kg CO₂-equivalent per unit, available at https://legacy.winnipeg.ca/finance/findata/matmgt/documents/2012/682-2012/682-2012_appendix_h-wstp_south_end_plant_process_selection_report/appendix%207.pdf
- Clean Energy Regulator (CER) (2025) Voluntary market-based scope 2 emission factors, Australian Government, available at <https://cer.gov.au/document/voluntary-market-based-scope-2-emissions-guideline>
- Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2025a), Australian National Greenhouse Accounts Factors Workbook 2025, Australian Government Department of Climate Change, Energy, the Environment and Water.
- Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2025b), Australia's emissions projections 2025, Department of Climate Change, Energy, the Environment and Water, Canberra, November. CC BY 4.0.
- Department for Energy Security and Net Zero (2025), Greenhouse gas reporting: conversion factors 2025, published 10th June 2025.
- Department for Infrastructure and Transport (DIT) (2025), 24C347 Northern Water NW-PC-ST1 Sustainability in Design and Construction, Government of South Australia, issued 14th November 2025
- FW Power (n.d.), Diesel Generator Fuel Consumption Chart in Litres, available at <https://fwpower.co.uk/wp-content/uploads/2018/12/Diesel-Generator-Fuel-Consumption-Chart-in-Litres.pdf>
- GHD (2024), Electrical Transmission Material Take Off (ISA-04-044), issued 16th May 2024
- GHD (2025), Reference Design Report (12601676), issued 3rd October 2025
- Graham, P., Mediawathe, C. & Green, D. (2025), Electric vehicle projections 2024. CSIRO, Australia.
- Infrastructure and Transport Ministers (2024) Embodied Carbon Measurement for Infrastructure Technical Guidance
- Intergovernmental Panel on Climate Change (IPCC) (2006) IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 11: N₂O Emissions from Managed Soils, and CO₂ Emissions from Lime and Urea Application
- Jacobs (2025). Northern Water Project – Vegetation polygon Rev 5 Construction Footprint, clearance type.

JE Blesing, C Pelekani (2016), Seawater Desalination - A Sustainable Solution to World Water Shortage, Planning, Design, Construction and Operation of the Adelaide Desalination Plant, Online Journal of the Australian Water Association

Jindal Saw Ltd (2025), Ductile Iron Pipe (DN 450) Environmental Product Declaration, available at <https://www.environdec.com/library/epd18402>

Kim, J., Park, K., Yang, D. R., & Hong, S. (2019). A comprehensive review of energy consumption of seawater reverse osmosis desalination plants. Applied Energy, 254, 113652.

NSW Government (2025) Embodied Carbon Databook, Version 1.0, issued 28th March 2025

NSW Government (2025) NABERS National Material Emission Factors Database Technical Document, Version 2025.1, issued 28th April 2025

Standards Australia (2006), AS ISO 14064.2, Greenhouse Gases Part 2: Specification with guidance at the project level for quantification and reporting of greenhouse gas emission reductions and removal enhancements

Steel Mains Pty Ltd Australia (2022), SINTAKOTE® Steel Pipeline System Environmental Product Declaration, available at https://epd-australasia.com/wp-content/uploads/2022/12/SP05494_Steel-Mains-EPD_Dec22.pdf

Systra (2025a), Northern Water, Desalination Plant Constructability Input for Estimators (SB-DIT-ST-SB000129-007), Rev 3, issued 9th June 2025

Systra (2025b), Northern Water, Desalination Plant Constructability Input for Estimators (SB-DIT-ST-SB000129-007), Rev 4, issued 11th June 2025

Systra (2025c), Northern Water, Transfer System Constructability Input for Estimators (SB-DIT-ST-SB000129-0004), Rev 8, issued 23rd July 2025

Systra (2025d), Northern Water, Construction Water Requirements (SB-DIT-TN-SB000129-021-R2), issued 28th October 2025

Systra (2025e), Northern Water Supply Project, Reference Design Constructability Report (SYS-R-NWSP-006-R3), issued 20th November 2025

Systra (2025f), Northern Water, Overall Program – Reference Design – Combined Scope 140 ML/day (SB-DIT-PG-SB000129-008). Draft Rev 6

Systra (2025g), Time Chainage Technical Note (SB-DIT-TN-SB000129-022-R1), issued 2nd December 2025

Systra (2025h), Transfer System, Trench Bedding & Backfill Strategy (SB-DIT-TN-SB000129-015-R3), issued 23rd July 2025

Transport Authorities Greenhouse Group (TAGG), (2013) Greenhouse Gas Assessment Workbook for Road Projects

Transport for NSW (2025) Baseline Carbon Library, Version 1.3 (beta), issued 28th May 2025

Vinidex Pty Limited (2022), Polyethylene Pipes Environmental Product Declaration, available at https://epd-australasia.com/wp-content/uploads/2018/04/SP00719-Vinidex-EPD-Polyethylene-Pipes_v2-Sep22.pdf

World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI), (2004), The Greenhouse Gas Protocol (GHG Protocol) Corporate Accounting and Reporting Standard, available at <https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf>

WBCSD and WRI, (2011), The Greenhouse Gas Protocol (GHG Protocol) Corporate Value Chain (Scope 3) Accounting and Reporting Standard, available at https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporting-Standard_041613_2.pdf

WBCSD and WRI (2015), GHG Protocol Scope 2 Guidance, available at <https://ghgprotocol.org/sites/default/files/2023-03/Scope%20%20Guidance.pdf>

Yu, M., Wiedmann, T., Crawford, R. and Tait, C., 2017. The carbon footprint of Australia's construction sector. *Procedia engineering*, 180, pp.211-220.

Appendix A. Detailed Greenhouse Gas Inventory

Emissions Source	Quantity	Unit of Measurement (UoM)	Emissions Factors (tCO2e/UoM)	Total emissions (tCO2e)
A1-A3 Raw material supply, transport and manufacturing				
Transfer system (pipeline, pump stations, storage tanks)				
Mild-steel cement lined (MSCL) Pipe	146,376	t	1.97	288,361
Ductile iron concrete lined DICL Pipe	46,527	m	0.23	10,562
Sand	208,080	t	0.01	1,386
Backfilling	842,410	t	0.01	5,610
Concrete	7,789	m3	0.35	2,757
Subgrade	12,039	t	0.01	80
Crushed rocks	26,784	t	0.01	178
Reinforcing steel	1,316	t	1.60	2,106
Structural steel	126	t	2.27	285
Steel wall and roof cladding	5,588	m2	0.02	107
Grout	1,275	m3	2.62	3,343
Steel for pumps and valves	152	t	4.21	639
Desalination plant (structure, tanks)				
Engineered fill	48,800	t	0.01	325
Gravel	1,311	t	0.01	9
Concrete	25,069	m3	0.35	8,874
Reinforcing steel	6,548	t	1.60	10,477
Structural steel	1,864	t	2.27	4,231
Steel cladding	42,865	m2	0.02	819
Galvanised steel	422	t	3.36	1,419
Aluminium roofing	12	t	11.8	142
Epoxy lining	3	t	1.14	3
Asphalt	10,571	t	0.07	755
Fencing	327	t	3.01	985
Fiber-Reinforced Plastic	26	t	9.30	245
Polyethylene stormwater pipe	116	t	3.07	356
Steel for pumps and valves	35	t	4.21	147
Marine works and tunnelling				
Concrete	43,831	m3	0.35	15,516
Reinforcing steel	4,669	t	1.60	7,470
Steel Fibre	8,087	t	0.44	3,566
Styrofoam	15	t	3.29	50
Shotcrete	199	m3	0.35	71
Rock armour	4,392	t	0.01	29
Transmission Infrastructure				
Concrete	6,200	m3	0.35	2,195
Gravel	94,380	t	0.01	629
Steel structural	3,100	t	2.27	7,037
Aluminium	386	t	0.02	7
Copper	12	t	2.71	33
Upscaled emissions (A1-A3)	Varies	Varies	25%	93,408
A4 Transport of products to site				
Articulated Truck	221,739,133	t.km	0.11	25,183
Concrete Agitator Truck	14,357,293	t.km	0.17	2,425
Rail transport	311,099,981	t.km	0.04	11,321
Sea transport	46,401,295	t.km	0.01	256
Upscaled emissions (A4)	Varies	Varies	25%	9,214
A5 Construction and installation process				
Construction Energy				
Diesel fuel use (plant and equipment)	44,642	kL	3.38	150,778
Diesel fuel use (to supply electricity via diesel generators)	37,236	kL	3.38	125,765
Construction energy (transmission line - single circuit)	15	km	11.74	176
Construction energy (transmission line - double circuit)	27	km	23.76	641
Construction Water				
Potable Water	1,715,944	kl	0.00	505
Wastewater Treatment (camps only)	696,600	kl	0.00	1,262
Transport of water to site (hydrotesting)	94,167,500	tkm	0.00	34,382
Construction Waste				
Total spoil to recycling - inert	40,090	t	0.00	65

Emissions Source	Quantity	Unit of Measurement (UoM)	Emissions Factors (tCO2e/UoM)	Total emissions (tCO2e)
Total waste to recycling - inert	65,461	t	0.00	107
Total waste to recycling - metals	2,057	t	0.05	108
Waste to landfill – inert waste (concrete/metals/plastics/glass)	7,443	t	0.01	107
Transport of waste to end destination	18,089,348	t.km	0.000011	2,054
Vegetation Clearance				
Open Woodlands	25	ha	77	1,954
Callitris Forest and Woodland	47	ha	80	3,769
Mallee and Acacia Woodland and Shrubland	580	ha	106	61,513
Open Shrubland	126	ha	113	14,263
Heathlands	1,300	ha	115	149,483
Grassland	23	ha	110	2,575
Workforce commute				
Workforce flights	24,919,315	pass.km	0.00023	5,714
Upscaled emissions (A5)	Varies	Varies	25%	80,484
B1 Use - Material emissions				
Chemical usage				
Sulphuric acid	685,470	t	Confidential – Emissions factors utilised licenced data	
Sodium bisulphite (SBS)	58,035	t		
RO antiscalant	47,450	t		
Sodium hypochlorite	666,977	t		
Citric acid	39,420	t		
Hydrochloric acid	87,600	t		
Sodium hydroxide	112,785	t		
Chlorine	15,330	t		
Carbon dioxide	286,160	t		
Lime	320,835	t		
Sodium silicate	10,220	t		
Polymer	913	t		
Transport of chemicals to desalination plant (road)	258,762,553	t.km	0.00	29,388
Transport of chemicals to desalination plant (shipping)	43,127,092,083	t.km	0.00	237,646
Operational waste				
Lime sludge (containing calcium carbonate)	11,038	t	0.12	4,857
Transport of lime sludge to end destination	386,316	t.km	0.00	44
Upscaled emissions (B1)	Varies	Varies	25%	400,357
B2 Maintenance				
Energy for Maintenance				
Diesel consumption (O&M crew inspections)	7,102	GJ	0.09	623
Diesel consumption (O&M crew commute)	1,954	GJ	0.09	171
Generator testing for desalination plant	33,350	GJ	0.09	2,918
Upscaled emissions (B2)	Varies	Varies	25%	1,025
B3-B5 Repair, replacement, refurbishment				
Materials for major replacement	Varies	Varies	Varies	49,973
Transport of materials to site by truck	Varies	Varies	Varies	6,019
Waste to recycling	Varies	Varies	Varies	43
Waste to landfill – inert waste (concrete/metals/plastics/glass)	Varies	Varies	Varies	21
Transport of waste to end destination	Varies	Varies	Varies	245
Upscaled emissions (B3-B5)	Varies	Varies	25%	14,075
B6 Operational energy use				
Electricity use (desalination plant and pump stations, excl. solar and renewables) (location-based approach)	38,325	GWh	Varies	1,544,498
Total				4,781,920
Total Upfront Carbon (A1-A5)				1,160,622
Total In-use Embodied Carbon (B1-B5)				2,076,800
Total In-use Operational Carbon (B6-B7)				1,544,498