Appendix P

Climate Change Impact Assessment

Marinus Link: Climate and Climate Change Assessment

Prepared for:

Tetra Tech Coffey Pty Ltd

May 2024

FINAL

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Document Control

Deliverable #:	D21046-26
Title:	Marinus Link: Climate and Climate Change Assessment
Version:	Rev 0
Client:	Tetra Tech Coffey Pty Ltd
Document reference:	D21046-26 Marinus Link Climate Change Assessment (Rev 0).docx
Prepared by:	PM
Reviewed by:	CM
Approved by:	CM 16/05/2024

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Glossary

Term	Definition
km	kilometre
km/h	kilometre per hour
kV	kilovolt
MW	megawatt
m	metres
mm	millimetres
m/s	metres per second
ppm	parts per million
W/m^2	watts per square metre
Nomenclature	**Definition**
°C	degrees Celsius
CO_2	carbon dioxide
Abbreviations	**Definition**
AS	Australian Standard
AHD	Australian Height Datum
BoM	Bureau of Meteorology
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture, Water, and the Environment
DCCEEW	Department of Climate Change, Energy, the Environment, and Water
DELWP	Department of Environment, Land, Water, and Planning
EE Act	*Environmental Effects Act 1978*
EES	Environment Effects Statement
EIS	Environmental Impact Statement
EMPC Act	*Environmental Management and Pollution Control Act 1994*
EPA	Tasmanian Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ESCI	Electricity Sector Climate Information
GCM	Global Climate Model
GHG	Greenhouse gases
HAT	Highest Astronomical Tide
HVAC	High voltage alternating current
HVDC	High voltage direct current
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
LAT	Lowest Astronomical Tide
LUPA Act	*Land Use Planning Control Act 1993*
MLPL	Marinus Link Pty Ltd
MNES	Matters of National Environmental Significance
NRM	Natural Resource Management
NWTD	North-West Transmission Developments
NZS	New Zealand Standard
RCP	Representative Concentration Pathways
ReCFIT	Renewables, Climate, and Future Industries Tasmania
Tas	Tasmania
TCCO	Tasmanian Climate Change Office
SSP5-8.5	Shared Socioeconomic Pathways (high emissions)

Term	Definition
Vic	Victoria

EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by Tetra Tech Coffey Pty Ltd (Tetra Tech Coffey), on behalf of Marinus Link Pty Ltd (MLPL) to conduct a desktop climate and climate change assessment for Marinus Link.

The effects of global warming on the current weather patterns, i.e., climate change, of northern Tasmania and southern Victoria has the potential to have significant impacts on the construction and operation of the Marinus Link project.

Key climate issues that have the potential to affect the project include:

- Increased maximum daily temperatures and increased frequency of maximum temperatures above 35°C affecting high voltage infrastructure (i.e., cables, transformers)
- Increased frequency and intensity of storm events (rainfall and wind) affecting ancillary infrastructure such as connecting transmission lines
- Sea level rise and increased intensity of storm surges affecting coastal infrastructure including the Heybridge Converter Station and cable joint pits
- Increased frequency of bushfire weather and extended bushfire seasons increases vulnerability to bushfire ignition by infrastructure failure.

There is high to very high scientific confidence in the direction of these trends with uncertainty around the timing or actual intensity of events. Modelled projections for the region based on the current global greenhouse gas (GHG) emissions trajectory are provided for guidance in design. Caution is advised given the uncertainty; Australian records for event return time or exceedance are currently being broken.

Interacting weather events or conditions pose a material risk to the structural and functional integrity of Marinus Link infrastructure, with potentially cascading consequences, affecting the delivery of essential services.

Some risks may be mitigated through improved design measures, such as increased engineering tolerances and inbuilt redundancy, and following construction and other technical standards updated to include climate change, e.g., *AS/NZS 1170.2:2021 Structural design actions: Wind actions*. However, design standards may be exceeded by extreme or chronic weather events, so the potential impact of these on the operation of the project should be evaluated through scenario analysis as part of the design process. For example:

- Periodic or progressive inundation of Heybridge Converter Station infrastructure through sea level rise or storm surge may interrupt supply and require increasing investment in remediation of infrastructure.
- Increased intensity of storm events and increased wind speed may damage incoming or outgoing transmission lines affecting capacity to supply required power transfer.
- Daily temperatures increasingly exceed design rating of incoming transmission lines so overheating and damage to lines leads to ignition of bushfires, which damage forest and private property and cause injury and/or loss of life.
- Increased frequency of extreme climatic events leads to increased outages of control systems, which cause cascading effects on Tasmanian and Victorian networks.

The following Environmental Performance Requirement (EPR) is proposed:

CC01: Implement measures to address the impacts of climate change on the project

Design the project to address potential impacts from climate change across the life of the project, considering:

- Increased ambient temperatures/soil temperatures/sea temperatures and their potential impact on the

operation of high voltage infrastructure.

- Sea level rise and coastal erosion and its potential impact on accessibility, and function of coastal infrastructure.

The design must be informed by a risk assessment completed to identify climate change risks and management measures based on:

- *AS/NZS ISO 31000:2018 Risk management – Principles and guidelines*
- *AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach*
- IPCC 2012 *Managing the risks of extreme events and disasters to advance climate change adaptation*

Include measures in the CEMP and OEMP (as relevant) to address:

- Extreme or chronic weather events such as bushfires, heavy rainfall events and extreme wind speeds and their potential impact on safety of employees, accessibility, and operation of infrastructure.

The EPR should cover increased temperatures, sea level rise, and extreme or chronic weather events such as bushfires, heavy rainfall, extreme wind speeds and their effects on the infrastructure and employee safety.

1. INTRODUCTION

Marinus Link (the project) comprises a high voltage direct current (HVDC) electricity interconnector between Tasmania and Victoria, to allow for the continued trading and distribution of electricity within the National Electricity Market (NEM).

The project was referred to the Australian Minister for the Environment on 5 October 2021. On 4 November 2021, a delegate of the Minister for the Environment determined that the proposed action is a controlled action as it has the potential to have a significant impact on the environment and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) before it can proceed. The delegate determined that the appropriate level of assessment under the EPBC Act is an environmental impact statement (EIS).

On 12 December 2021, the Victorian Minister for Planning under the *Environment Effects Act 1978* (Vic) (EE Act) determined that the project requires an environment effects statement (EES) under the EE Act, to describe the project's effects on the environment to inform statutory decision making. In July 2022, a delegate of the Director of the Environment Protection Authority Tasmania determined that the project be subject to environmental impact assessment by the Board of the Environment Protection Authority (the Board) under the *Environmental Management and Pollution Control Act 1994* (Tas) (EMPCA).

As the project is proposed to be located within three jurisdictions, the Victorian Department of Transport and Planning (TP), Tasmanian Environment Protection Authority (Tasmanian EPA) and Australian Department of Climate Change, Energy, Environment and Water (DCCEEW) have agreed to coordinate the administration and documentation of the three assessment processes. One EIS/EES is being prepared to address the requirements of DTP and DCCEEW. Two EISs are being prepared to address the Tasmanian EPA requirements for the Heybridge converter station and shore crossing.

This report has been prepared by Katestone Environmental Pty Ltd (Katestone) for the Tasmanian, Victorian, and Commonwealth jurisdictions as part of the EIS/EES and EIS's being prepared for the project.

1.1 Purpose of this report

The purpose of this report is to conduct an integrated assessment of the potential impacts of climate change on the design and operation of the project, and the potential impacts on the environment caused by the project and exacerbated by climate change. Key climate issues that have the potential to affect or be affected by the project include:

- Increased ambient temperatures/soil temperatures/sea temperatures and their impact on the design and operation of high voltage infrastructure
- Sea level rise and its impact of the design and accessibility of coastal infrastructure
- Changes in the distribution of surface water runoff due to the clearing of vegetation for the land cable easement
- Increased environmental susceptibility to bushfire ignition following transmission infrastructure failure.

2. PROJECT OVERVIEW

The project is a proposed 1500-megawatt (MW) HVDC electricity interconnector between Heybridge in northwest Tasmania and the Latrobe Valley in Victoria (Figure 1). Marinus Link is proposed to provide a second link between the Tasmanian renewable energy resources and the Victorian electricity grids enabling efficient energy trade, transmission, and distribution from a diverse range of generation sources to where it is most needed and will increase energy capacity and security across the NEM.

Marinus Link Pty Ltd (MLPL) is the proponent for the project and is a wholly owned subsidiary of Tasmanian Networks Pty Ltd (TasNetworks). TasNetworks is owned by the State of Tasmania and owns, operates, and maintains the electricity transmission and distribution network in Tasmania.

Tasmania has significant renewable energy resource potential, particularly hydroelectric power, and wind energy. The potential size of the resource exceeds both the Tasmanian demand and the capacity of the existing Basslink interconnector between Tasmania and Victoria. The growth in renewable energy generation in mainland states and territories participating in the NEM, coupled with the retiring of baseload coal-fired generators, is reducing the availability of dispatchable generation that is available on demand.

Tasmania's existing and potential renewable resources are a valuable source of dispatchable generation that could benefit electricity supply in the NEM. Marinus Link will allow for the continued trading, transmission, and distribution of electricity within the NEM. It will also manage the risk to Tasmania of a single interconnector across the Bass Strait and complement existing and future interconnectors on mainland Australia. Marinus Link is expected to facilitate the reduction in greenhouse gas emissions at a state and national level.

Interconnectors are a key feature of the future energy landscape. They allow power to flow between different regions to enable the efficient transfer of electricity from renewable energy zones to where the electricity is needed. Interconnectors can increase the resilience of the NEM and make energy more secure, affordable, and sustainable for customers. Interconnectors are common around the world including in Australia. They play a critical role in supporting Australia's transition to a clean energy future.

2.1 Project area

The project area is approximately 345 km in length and runs from Heybridge on the northwest coast of Tasmania across Bass Strait to Waratah Bay on the southeast coast of Victoria before heading inland north to the Driffield and Hazelwood areas.

(Most of the alignment (90%) crosses private freehold land, predominantly comprised of agricultural and forestry land uses (Figure 1). For the remainder there are community service facilities, roads, rivers, and residential properties. The Heybridge converter station is the only section of the project located in Tasmania. The land use classification of the Heybridge site is 'other minimal use', i.e., an area of land that is largely unused in the context of its prime use but that may have ancillary uses. The Victorian component of the project begins at Waratah Bay before travelling inland approximately 90 km to the Driffield and/or Hazelwood areas. The entire 90 km-long alignment will require a nominal 36 m wide (minimum 20 m wide) construction corridor.

The key terrain feature associated with the Tasmanian component of the project is the northwest coastline of Tasmania, directly north of the Heybridge construction footprint. The key terrain feature associated with the Victorian component of the project is Waratah Bay, where the sea cable reaches Victoria and the Grand Ridge Mountain range which exists to the east of the land project alignment.

2.2 Study focus

This study focuses on identifying the potential weather hazards and climate change risks arising from global warming that could impact the construction and operation of the HVDC interconnector, the Heybridge Converter Station in Tasmania and a converter station in Victoria located at either Hazelwood or Driffield. The potential impacts of both converter station sites in Victoria have been assessed because a preferred site had not been selected at the time of writing this report. The potential Victorian converter station sites are adjacent to the Hazelwood–Cranbourne/Rowville 500 kV transmission lines at Driffield and adjacent to Hazelwood Terminal Station. The Driffield site is in Hancock Victorian Plantations' Thorpdale plantation west of Strzelecki Highway. The Hazelwood site is in farmland adjacent to the southern boundary of the Hazelwood Terminal Station and Tramway Road.

2.3 Study Objectives

The objectives of this study are to:

- Describe the existing and the predicted future climate conditions of the project area.
- Describe the risks associated with projected, and resilience to these risks including consideration of the *Climate Change Act 2017* (Vic) principles of risk management and standards for risk assessment.

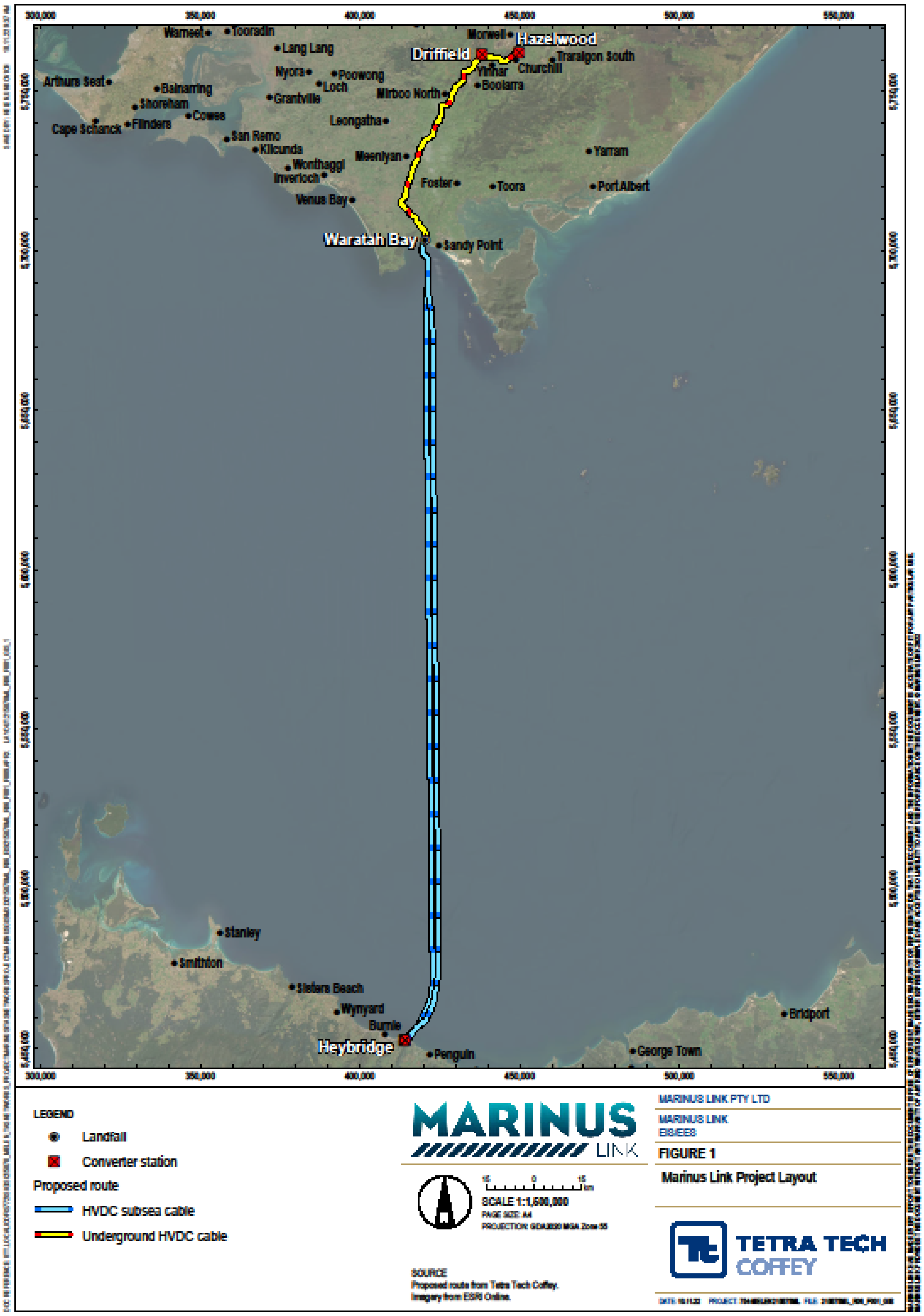

Figure 1 Marinus Link Project Layout (Tetra Tech Coffey, 2022)

3. REGULATORY FRAMEWORK AND POLICY CONTEXT

Adaptation to climate change is a core pillar of the Paris Agreement[1]. All Parties to the Agreement, including Australia, have agreed to the global goal of enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change.

The Commonwealth Government has established the *Climate Change Act 2022* (Cwlth) and the *Climate Change (Consequential Amendments) Act 2022* (Cwlth) in response. The *Climate Change Act 2022* (Cwlth) provides the legislative framework to implement Australia's net-zero commitments and codifies Australia's net 2030 and 2050 GHG emissions reductions targets under the Paris Agreement. *The Climate Change (Consequential Amendments) Act 2022* (Cwlth) embeds the GHG emissions reduction targets into fourteen Commonwealth Acts, including the *Clean Energy Regulator Act 2011* (Cwlth), *Infrastructure Australia Act 2008* (Cwlth), *National Greenhouse and Energy Reporting Act 2007* (Cwlth), and the *Renewable Energy (Electricity) Act 2000* (Cwlth).

The Department of Climate Change, Energy, the Environment and Water (DCCEEW) is responsible for Australia's national response to climate change, including adaptation, climate science and emissions reductions, guided by the National Climate Resilience and Adaptation Strategy (DAWE, 2021). The strategy defines the roles and responsibilities of state and local government and businesses:

- State governments
  - Influence climate adaptation through planning laws and investments in public infrastructure
  - Provide science and information at local and regional scales.
- Local governments
  - Ensure that local factors are adequately considered in overall adaptation response.
- Businesses
  - Manage climate adaptation risks including maintaining and protecting assets.

State based responses to climate change adaptation include:

- Tasmania – Tasmania's amended *Climate Change (State Action) Act 2008* requires that the government work with industry and businesses to develop sector-based emissions reduction and resilience plans, and prepare a climate change action plan, every five years. The recently formed Renewables, Climate and Future Industries Tasmania (ReCFIT) provides whole of government advice for climate adaptation including providing tailored information to business and industry to minimise climate risks through informed decisions. Progress against the recently concluded Climate Change Action Plan 2017-2021 (TCCO, 2021) has been assessed and the follow up action plan is currently under development.
- Victoria – Victoria's response to climate change is documented in Victoria's Climate Change Strategy (DELWP, 2021a). In terms of climate change adaptation, the objectives include improving the ability of the built environment and infrastructure to withstand and recover from the impacts of climate change, and actively managing biodiversity, ecosystems, and natural resources to improve resilience to climate change.
- Victoria – Victoria's response to climate change is driven by the *Climate Change Act 2017* (Vic) and documented in Victoria's Climate Change Strategy (DELWP, 2021a). Under the *Climate Change Act 2017* (Vic), the Victorian Government is required to publish five yearly adaptation action plans (AAP) across 7 key systems. The Built Environment AAP (DELWP, 2022) includes strategies for ensuring the resilience of electricity infrastructure to climate change.

[1] The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at COP 21 in Paris on 12 December 2015 and entered into force on 4 November 2016.

Regional responses to climate change adaptation include:

- Gippsland – The Draft Gippsland Regional Climate Change Adaptation Strategy (DELWP, 2021b) focuses on actions that will allow the community, business, industry, and environment to adapt to the changing climate. Of relevance are strategic actions for the built environment with adaptation planning being informed by assessment of key infrastructure vulnerability, and through contributing to the resilience of the regional economy.

Consideration of climate change in the design, construction, and operation of a project is essential to ensure the resilience of the project to climate related risks and ensure business continuity. The potential impacts of the weather and changing climate on the electricity sector has been recognised by the Commonwealth Government through the Electricity Sector Climate Information (ESCI) project[2]. The ESCI project provides hazard analysis and climate and weather information to support electricity sector resilience to climate change and extreme weather events.

3.1 Assessment Guidelines

This section outlines the assessment guidelines relevant to Climate Change and the linkages to other EIS/EES technical studies. A single consolidated EIS/EES is being prepared to address the requirements of Commonwealth and Victorian jurisdictions including the requirement for an EES. This report will use the term EIS going forward.

3.1.1 Commonwealth

DCCEEW has published the following guidelines for the EIS: 'Guidelines for the Content of a Draft Environmental Impact Statement – Environment Protection and Biodiversity Conservation Act 1999 – Marinus Link underground and subsea electricity interconnector cable (EPBC 2021/9053)'.

The sections relevant to the climate and climate change assessment include:

Section 5.11 Cumulative impacts:

- *The cumulative effects of climate change impacts on the environment must also be considered in the assessment of ecosystem resilience and listed species attributes only where scientific information on the effects of climate change on ecosystem resilience is available.*
- *The discussion must include an evaluation of the likely short term and long-term cumulative impacts on the general environment and ecosystem function where relevant to MNES. In this regard consideration must be given to the potential magnitude of effects and the duration and reversibility of effects.*

3.1.2 Victoria

The EES Scoping Requirements issued by the Minister for Planning (February 2023) outline the specific matters to be assessed across a number environmental and social disciplines relevant to the project, and to be documented in the EES for the project.

The EES Scoping Requirements inform the scope of the EES technical studies and define the EES evaluation objectives. The EES evaluation objectives identify the desired outcomes to be achieved and provide a framework for an integrated assessment of the environmental effects of a proposed project.

[2] https://www.climatechangeinaustralia.gov.au/en/projects/esci/

3.1.2.1 EES evaluation objective

There is no singe EES evaluation objective for climate change however it is addressed in the following objectives relevant to climate and climate change:

Section 4.2 Marine and catchment values

- *Avoid and, where avoidance is not possible, minimise adverse effects on land and water (including groundwater, surface water, waterway, wetland, and marine) quality, movement and availability.*

3.1.2.2 EES Scoping Requirements

The relevant sections of the EES Scoping requirements that this assessment has addressed are summarised in **Table 1.**

Table 1 - EES scoping requirements relevant to climate change

Aspects to be addressed	Scoping requirement	Report section
Existing environment	The potential for adverse effects on nearby and downstream water environments due to changed flow regimes, floodplain storage, run-off rates, water quality changes, or other waterway conditions, including in the context of climate change projections	Section 5
Likely effects	Identify and evaluate potential effects of the project on groundwater, waterway, wetland, and marine waters, including with appropriate consideration of climate change scenarios and cumulative effects	Section 7

3.1.3 Tasmania

EPA Tasmania has published two sets of guidelines (September 2022) for the preparation of an EIS for the Marinus Link converter station and shore crossing. A separate set of guidelines have been prepared for each of these project components:

- Environmental Impact Statement Guidelines Marinus Link Pty Ltd Converter Station for Marinus Link, September 2022, Environment Protection Authority Tasmania (Converter station EIS guidelines)
- Environmental Impact Statement Guidelines Marinus Link Pty Ltd Shore Crossing for Marinus Link, September 2022, Environment Protection Authority Tasmania (Heybridge shore crossing EIS guidelines)

The Guidelines for preparing an environmental impact statement (EPA Tasmania 2019) current at the time of this assessment required that a proponent:

- Describe the potential impacts of climate change upon the proposal.
- Discuss impacts of the proposal in terms of the evolving national response to climate change and greenhouse gas emissions and the targets set in the Climate Change Action Plan 2017 – 2021.

The relevant sections of the EIS Guidelines that this assessment has addressed are summarised in Table 2.

Table 2 - EIS requirements relevant to climate and climate change

Aspects to be assessed	Requirements
Converter station	
Section 6.10 Greenhouse gases and ozone depleting substances	• Consideration of the evolving national response to climate change and greenhouse gas emissions, and the targets set in the Tasmanian Climate Change Action Plan 2017-2021 or any updated versions thereof available at the time of preparing the EIS.
	• Provide an estimate of greenhouse gas emissions, energy production and energy consumption for both construction and operational phases of the proposal, including emissions associated with vegetation removal (as relevant). Calculators are available on the Australian Government Clean Energy Regulator website.
	• Demonstration that the development will implement cost-effective greenhouse best practice measures to achieve on going minimisation of greenhouse gas emissions. Where less emissions-intensive options are not adopted, justification should be provided and/or mechanisms to offset greenhouse gas emissions identified.
Shore crossing	
Section 10.11 Greenhouse gases and ozone depleting substances	• Consideration of the evolving national response to climate change and greenhouse gas emissions, and the targets set in the Tasmanian Climate Change Action Plan 2017-2021 or any updated versions thereof available at the time of preparing the EIS.
	• Provide an estimate of greenhouse gas emissions, energy production and energy consumption for both construction and operational phases of the proposal, including emissions associated with vegetation removal (as relevant). Calculators are available on the Australian Government Clean Energy Regulator website.
	• Demonstration that the development will implement cost-effective greenhouse best practice measures to achieve on going minimisation of greenhouse gas emissions. Where less emissions-intensive options are not adopted, justification should be provided and/or mechanisms to offset greenhouse gas emissions identified.

3.2 Linkages to other reports

This report is informed by or informs the technical studies outlined in Table 2.

Table 2 Linkages to other reports

Technical assessment	Relevance to this assessment
Air quality (Katestone, 2023)	This report assesses the potential impacts of dust emissions during construction. The air quality assessment has informed the review of the existing environment, meteorological and climate sections of this report.
Greenhouse gas (Katestone, 2023)	This report assesses the greenhouse gas emissions generated from construction, operation, and maintenance activities. The greenhouse gas assessment has informed the existing environment, meteorological and climate sections of this report.
Surface water (Alluvium, 2023)	This report assesses the surface water impacts associated with the project. The surface water assessment has informed the impact of 100-year ARI flood and 200-year ARI flood flows on the project. Flood modelling has informed the 1 in 200 year flood level design for the Heybridge converter station, and 1 in 100 year flood level design for the Hazelwood converter station.
Bushfire (ELA, 2023)	This report assesses the bushfire risks in the project area and surrounds.

4. ASSESSMENT METHOD

4.1 Climate assessment

Climate change is a consequence of global warming, i.e., the accumulation of heat energy in the atmosphere and oceans due to the rate of heat loss to space being reduced by the increased concentration of greenhouse gases (GHGs) in the atmosphere.

Climate is the long-term pattern of weather in a region (generally averaged over 30 years). Weather is the state of the atmosphere at a point in time. Key weather variables of relevance are temperature, rainfall, wind speed, and humidity.

The climate system also includes land and water, with key variables including soil and sea temperature. These are relevant to the climate risk assessment.

Sea level rise is a response to global warming, driven by thermal expansion of water and addition of water from melting land-based ice sheets. This is relevant to the climate risk assessment.

4.1.1 Weather

The weather patterns of the project footprint are assumed to be like the nearest Bureau of Meteorology (BoM) monitoring stations (Figure 2, Figure 3) and these are used to characterise the climate of the project area.

Weather data for the Tasmanian site are derived from Burnie NTC AWS (1992-2022), Burnie (Park Grove) (2009-2022), and Wynyard Airport (1947-current). Weather data for the Victorian sites are derived from Corner Inlet (Yanakie) (2013-2022), Morwell (Latrobe Valley Airport) (1984-2022) and Wonthaggi (1911-2022).

These are broadly representative of the current climate experienced across the project area for all sites, being the closest locations to them, from the start of data collection until the present. Not all sites have all forms of data (Table 3).

Data is sourced from http://www.bom.gov.au/climate/data/stations/.

4.1.2 Soil temperature

Soil temperature projections for eight (8) land sites were provided to Jacobs (unpublished report) by CLIMsystems Pty Ltd.

4.1.3 Sea temperature

Sea temperature data are sourced from Jacobs (unpublished report). Sea temperature profiles were obtained at twenty-five (25) locations between Heybridge and Waratah Bay.

4.1.4 Sea level

The BoM maintains an array of 14 standard and two supplementary stations that measure sea level very accurately (Figure 4). The vertical stability of the gauges is surveyed by State organisations and the survey data is archived by Geoscience Australia.

The closest stations of relevance to the project are Burnie and Stony Point (Figure 4). Data is sourced from http://www.bom.gov.au/oceanography/projects/abslmp/data/monthly.shtml.

Table 3 BoM Monitoring Site summary

BOM Monitoring Site	Site number	State	Opened	Last Record	Distance from the project	Parameters	Climate Summary
Burnie NTC AWS	091344	Tasmania	1992	Current	5.6 km NW	Temperature and meteorological data	Coastal site, 0 m AHD
Burnie (Park Grove)	091355	Tasmania	2009	Current	8.4 km W	Rainfall	Coastal site, 99 m AHD
Wynyard Airport	091107	Tasmania	1947	Current	22.4 km NW	Rainfall, temperature, solar exposure, and climate statistics	Coastal site, 12 m AHD
Corner Inlet (Yanakie)	085301	Victoria	2013	Current	7.9 km E	Rainfall, temperature, and meteorological data	Coastal site, 13.3 m AHD
Morwell (Latrobe Valley Airport)	085280	Victoria	1984	Current	9.3 km N	Rainfall, temperature, meteorological data, and climate statistics	Aviation site, 56.3 m AHD
Wonthaggi	086127	Victoria	1911	Current	36 km W	Climate statistics	Coastal site, 51.9m AHD

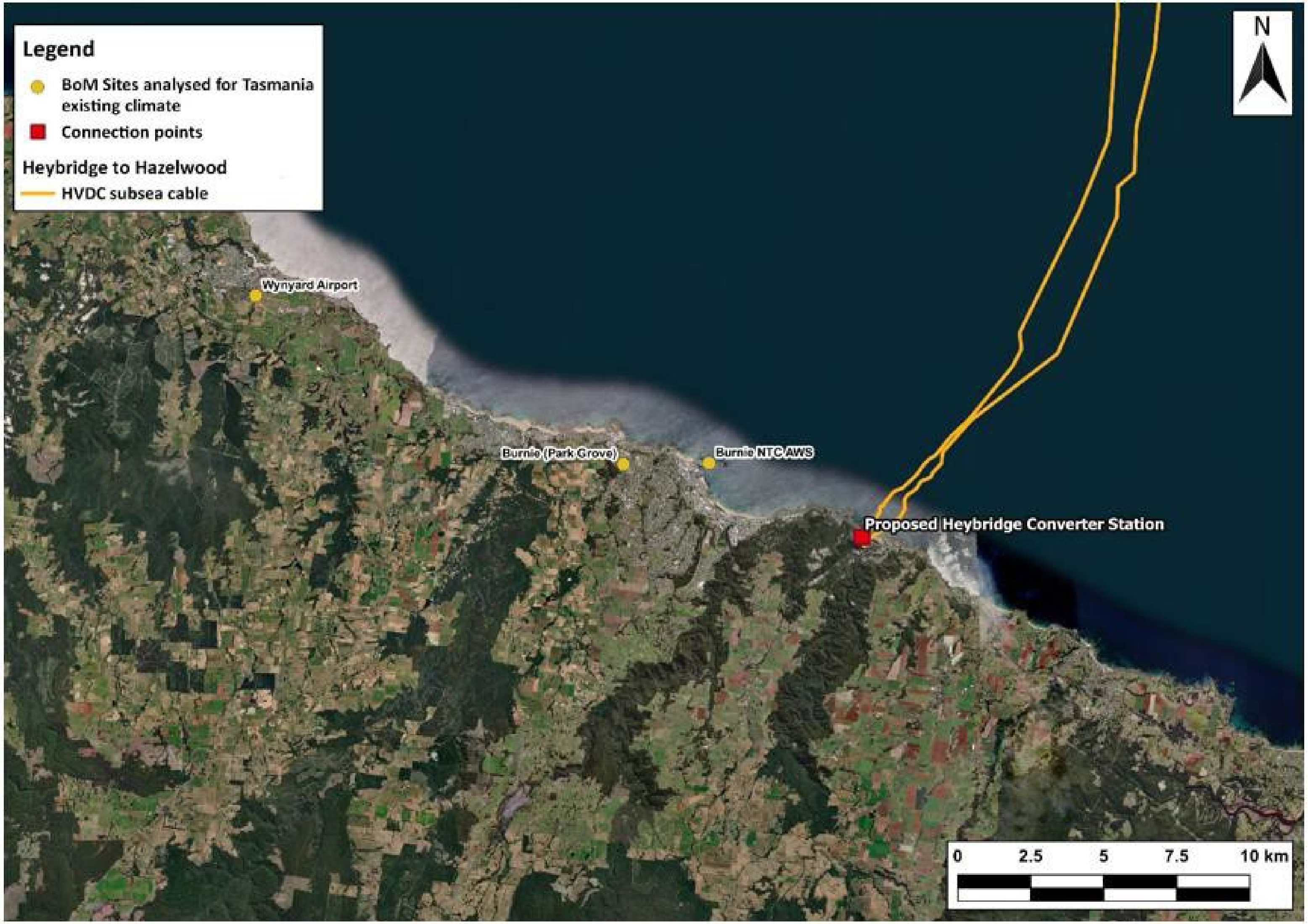

Figure 2 **Bureau of Meteorology monitoring stations within the vicinity of the Heybridge Converter Station, Tasmania**

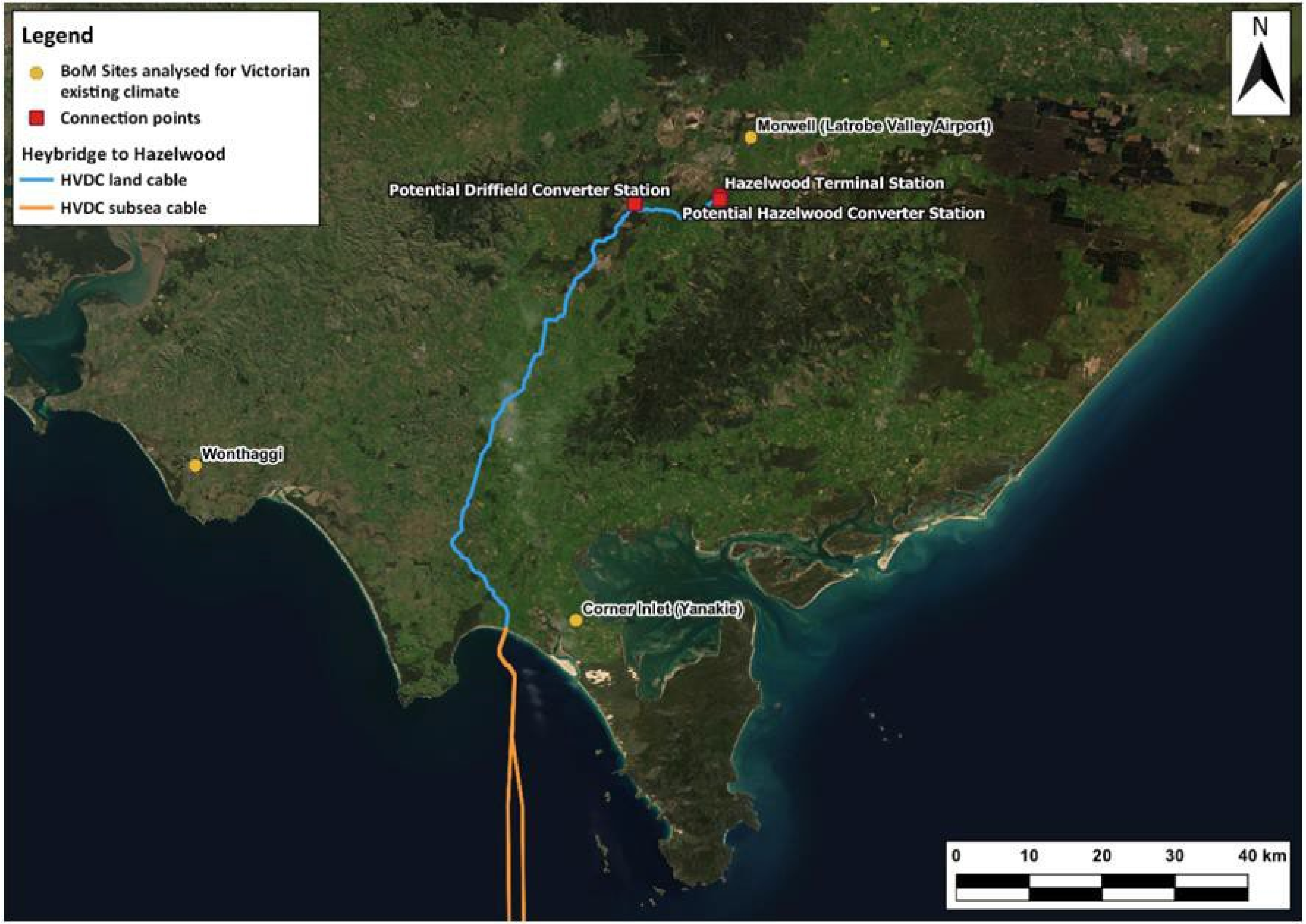

Figure 3 Bureau of Meteorology monitoring stations within the vicinity of the project footprint, Victoria

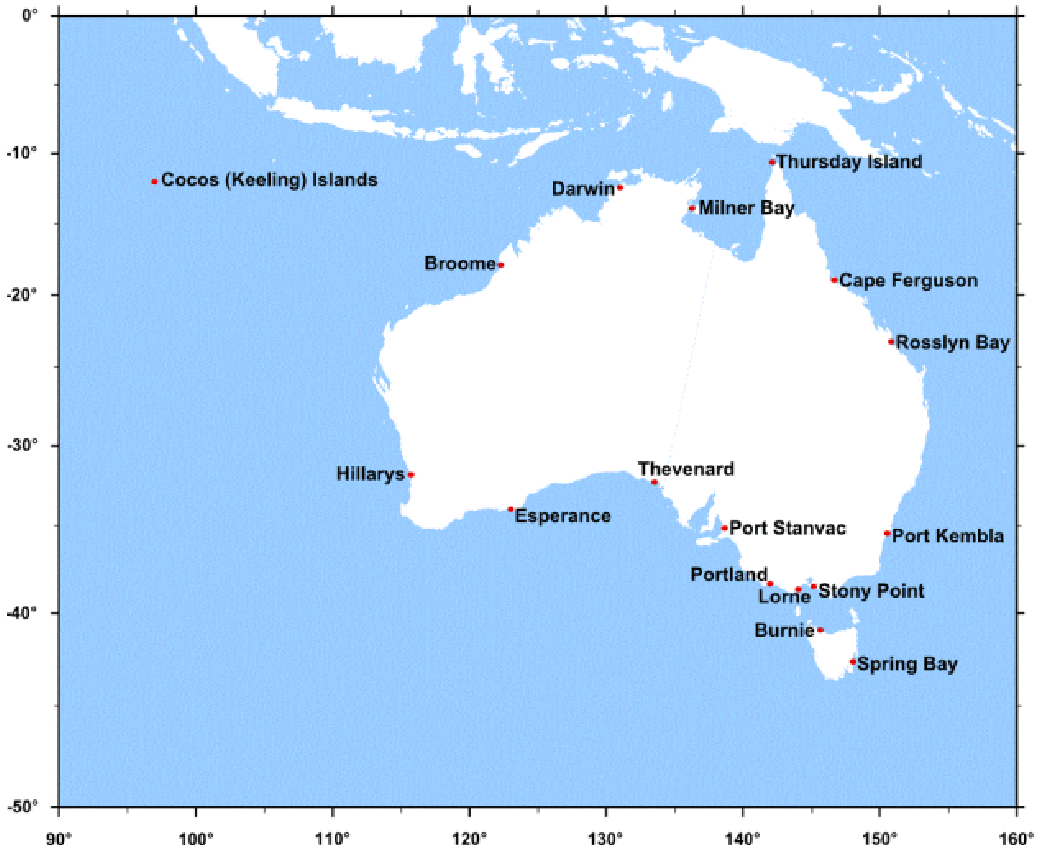

Figure 4 Sea level observations station locations (BoM)

4.2 Climate change assessment

The Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) has determined that human influence on the climate system is an established fact by weight of scientific evidence. This includes changes in the global water cycle and the increased frequency and/or intensity of some weather and climate extremes, in particular temperature, but also including extreme precipitation, droughts, tropical cyclones, and compounding extremes such as fire weather.

It is generally accepted that the original Paris Treaty goal of keeping mean global temperature change at or below 2.0 °C (and preferably 1.5 °C) compared to pre-industrial levels (1800s) will not be met. The earth is currently 1.1 °C warmer than it was in the 1800s and models using the current trajectory of GHG emissions suggest that the mean global temperature could increase by 4.4 °C by 2100.

The emissions trajectory conforms to Representative Concentration Pathway (RCP) 8.5 used to develop future climate scenarios in the previous Coupled Model Intercomparison Project Phase 5 (CMIP5) models and SSP5-8.5 used to develop future climate scenarios in current Coupled Model Intercomparison Project Phase 6 (CMIP6) models (Meinshausen et al, 2020). We apply these projections for impact assessment purposes, acknowledging that there may be a rapid reduction in global GHG emissions post 2030, but that many of the climatic trajectories will continue towards 2100.

This assessment considers the projections calculated for the Tasmanian and Victorian regions containing the project footprint applying CMIP5 models (Grose et al. 2015) with relevant updates from The State of the Climate 2020 (CSIRO and BOM 2020) and the Sixth IPCC Assessment Report (AR6) (Arias et al. 2021).

Key parameters of relevance to project design and operation are:

- Mean or median temperature
- Maximum temperature
  - Days above 35°C
- Total precipitation
- Surface wind
- Total sea level rise
- Fire weather.

4.3 Climate change assessment

This climate change assessment has been conducted with consideration of the following relevant standards and guidelines:

- AS/NZS ISO 31000:2018 Risk management – Principles and guidelines
- AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach
- IPCC 2012 Managing the risks of extreme events and disasters to advance climate change adaptation.

The approach also follows the process articulated in the ESCI project[3].

Risk is defined as the effect of uncertainty on objectives (ISO 31000), i.e., the objective of the project is to construct critical infrastructure that will provide a continuous supply of 1500 MW of electricity to the NEM from Tasmania. This is consistent with the Australian Energy Market Commission's National Electricity Objective[4]. Climate change poses a risk with varying degrees of uncertainty to achievement of this objective during construction and operation.

A key challenge for impact assessment is that the changing climate variables are not independent of each other. The likelihood of compounding and cascading impacts is increased by climate change (Glasser 2019). This includes:

- Increased severity of sudden onset hazards, e.g., bushfires, floods, storms
- Increased frequency of sudden onset hazards, e.g., bushfires, floods, storms
- Changed pattern of occurrence of extreme events, e.g., fire seasons, tracking of cyclones
- Increased slow-onset hazards, e.g., heatwaves, droughts.

Another challenge for impact assessment is that the real state or trend of a climate variable becomes more uncertain the further a projection moves into the future.

This provisional impact assessment considers risk to the successful construction and operation of the following elements of this critical infrastructure:

- Converter station and switching station at Heybridge in Tasmania
- Underground shore crossing in Tasmania adjacent to the converter station

[3] https://www.climatechangeinaustralia.gov.au/en/projects/esci/

- Subsea cable from Heybridge, Tasmania to Waratah Bay in Victoria
- Underground shore crossing at Waratah Bay
- Transition station where the subsea cables will connect to the land cables in Victoria
- Land cables in Victoria from the transition station to the converter station site in the Driffield or Hazelwood areas
- Converter station at Hazelwood or Driffield in Victoria, where the project will connect to the existing Victorian transmission network.

5. EXISTING WEATHER AND CLIMATE

The project has construction activities in both northwest Tasmania and southern Victoria. The region is classified as temperate with no dry season, mild summers, and cold winters under the Koppen Classification (BoM, 2020). The region receives regular cold-fronts and troughs embedded in a westerly flow, as well as low pressure systems from the north (extratropical cyclones). The project footprint varies significantly in elevation, ranging between 0 m at the Heybridge and Waratah shore crossings to a peak along the land cable at 276 m above Australian Height Datum (AHD).

The main drivers of weather in the region[5] are:

- Southern Annular Mode – north/south movement of strong westerly winds that dominate mid-high latitudes in the Southern hemisphere (influence rainfall)
- Low pressure cold fronts from west to east (rainfall)
- Cut off low pressure systems (associated with sustained heavy rainfall and gusty winds)
- East Coast lows (associated with heavy rainfall and gusty winds)
- High pressure sub-tropical ridge (stable and dry conditions in summer)
- El Nino Southern Oscillation (ENSO) – lower than average winter/spring rainfall (El Nino) or higher than average winter, spring, and early summer rainfall (La Nina)
- Indian Ocean Dipole (IOD) – less rainfall and higher temperatures (positive IOD) or above-average winter–spring rainfall (negative IOD).

The following sections provide a summary of historical climate data including:

- Temperature
- Rainfall
- Wind speed
- Humidity.

5.1 Temperature

5.1.1 Minimum and maximum temperatures

The minimum temperature for Burnie NTC AWS is 7.1 °C in summer and 2.1 °C in winter. Morwell (Latrobe Valley Airport) recorded a minimum temperature of 1.7 °C in summer and -4.8 °C in winter. Corner Inlet (Yanakie) recorded a minimum temperature during summer of 3.2 °C and -3.0 °C during winter.

The maximum temperature for Burnie NTC AWS is 31.5 °C in summer and 18.6 °C in winter. Morwell (Latrobe Valley Airport) recorded a maximum summer temperature of 46.3 °C and maximum winter temperature of 26.8 °C. Corner Inlet (Yanakie) recorded a maximum temperature during summer of 43.7 °C and 21.5 °C during winter.

[5] http://www.bom.gov.au/climate/about/australian-climate-influences.shtml

Table 4 Maximum and minimum daily temperatures recorded at Burnie NTC AWS, Morwell (Latrobe Valley Airport), and Corner Inlet (Yanakie)

Season	Maximum Temperature (°C)[1]			Minimum Temperature (°C)[1]		
	Burnie NTC AWS	Morwell (Latrobe Valley Airport)	Corner Inlet (Yanakie)	Burnie NTC AWS	Morwell (Latrobe Valley Airport)	Corner Inlet (Yanakie)
Autumn	26.6	40.4	36.6	3.5	-2.8	-0.3
Spring	25.8	38.6	36.8	3	-2.6	0.6
Summer	31.5	46.3	43.7	7.1	1.7	3.2
Winter	18.6	26.8	21.5	2.1	-4.8	-3

Table notes:

[1] Maximum and minimum daily temperature obtained from http://www.bom.gov.au/climate/data/stations/

Median, lower and upper quartiles, and lower and upper extremes of the daily maximum temperatures at Burnie, Morwell, and Yanakie are presented in Figure 5, Figure 6, and Figure 7, respectively. These show a high daily variability in seasonal maximum temperatures.

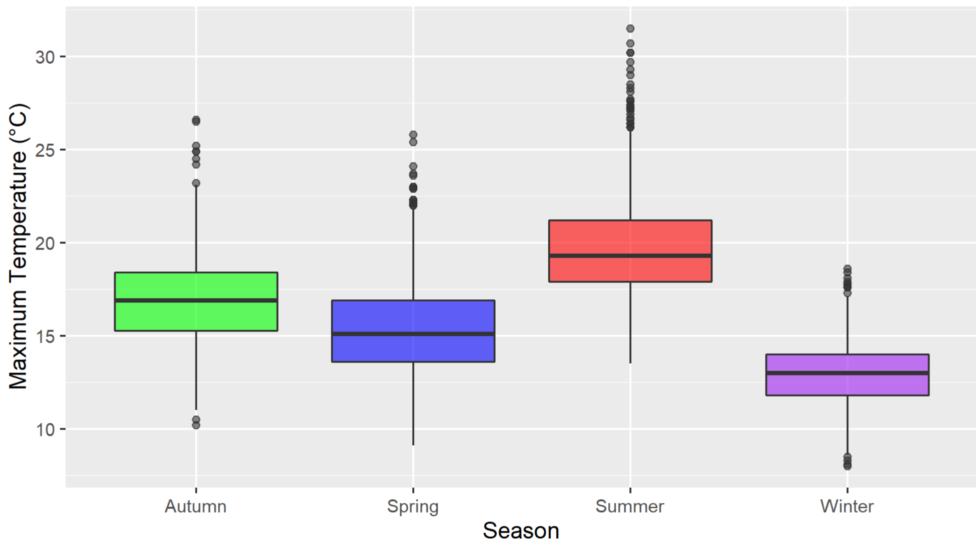

Figure 5 Daily maximum temperatures at Burnie NTC AWS (2013 - 2022)

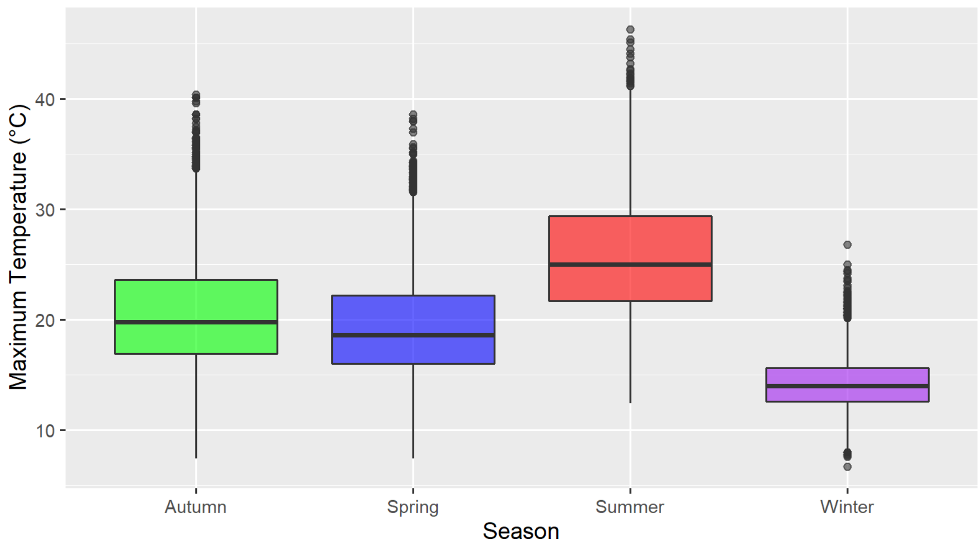

Figure 6 Daily maximum temperatures at Morwell (Latrobe Valley Airport) (1984 - 2022)

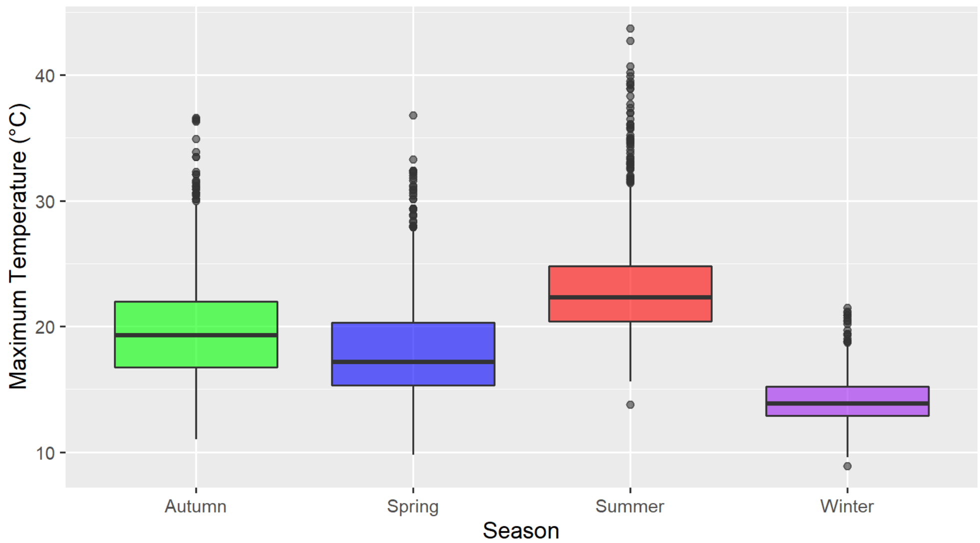

Figure 7 Daily maximum temperatures at Corner Inlet (Yanakie) (2013 - 2022)

The highest annual maximum and minimum temperatures are presented for Burnie NTC AWS (Figure 8), Morwell (Latrobe Valley Airport) (Figure 9), and Corner Inlet (Yanakie) (Figure 10). The annual maximum temperature at Burnie NTC AWS did not exceed 35 °C, whereas the annual maximum temperatures at Morwell and Yanakie regularly exceed 40 °C. The highest annual minimum temperatures (overnight) track at about 20 °C at all sites, with the greatest variability observed at Morwell.

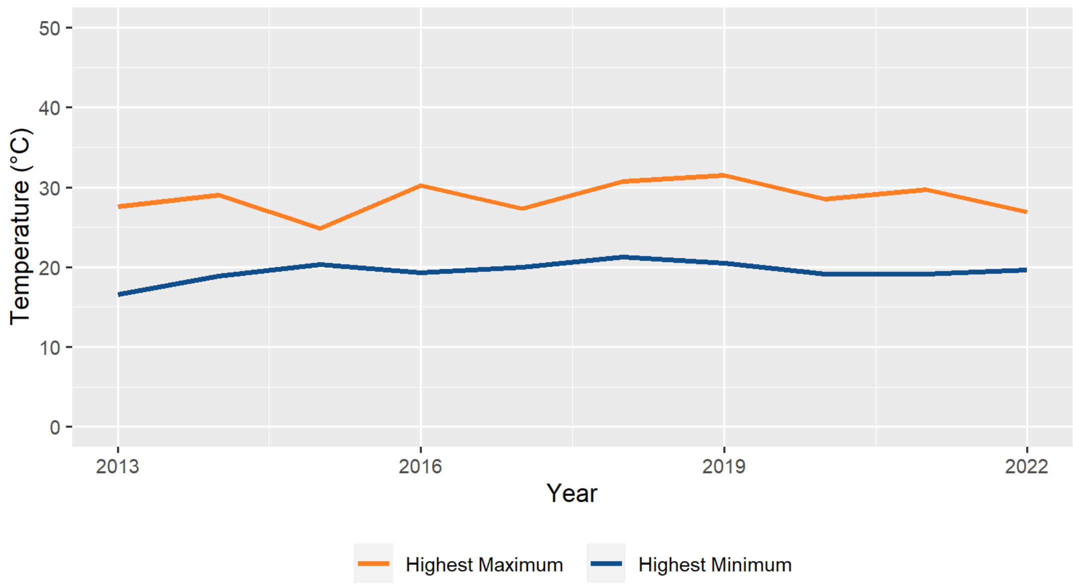

Figure 8 Highest daily maximum and highest daily minimum temperature recorded at Burnie NTC AWS

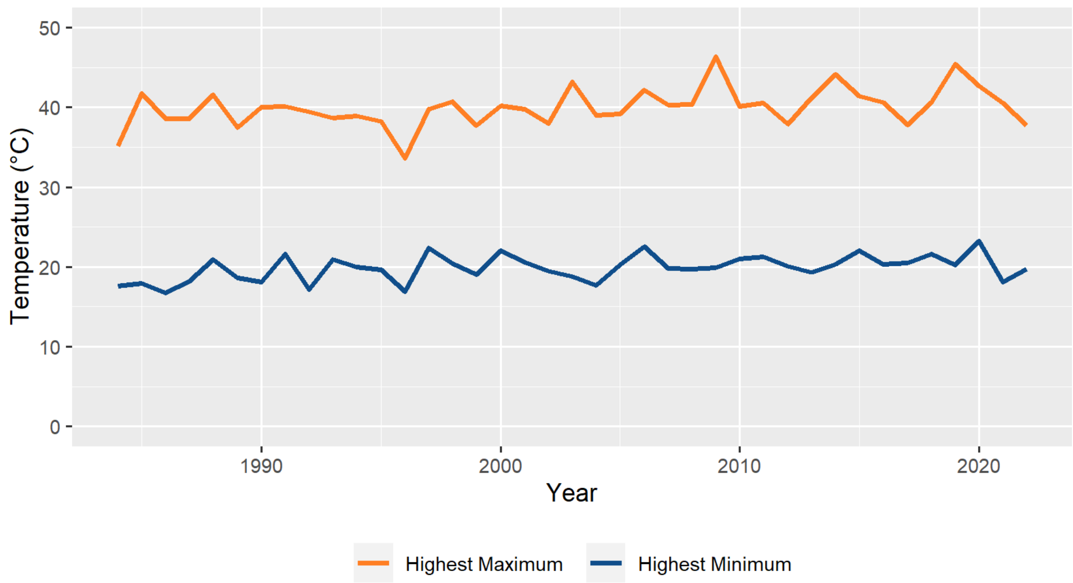

Figure 9 Highest daily maximum and highest daily minimum temperature recorded at Morwell (Latrobe Valley Airport)

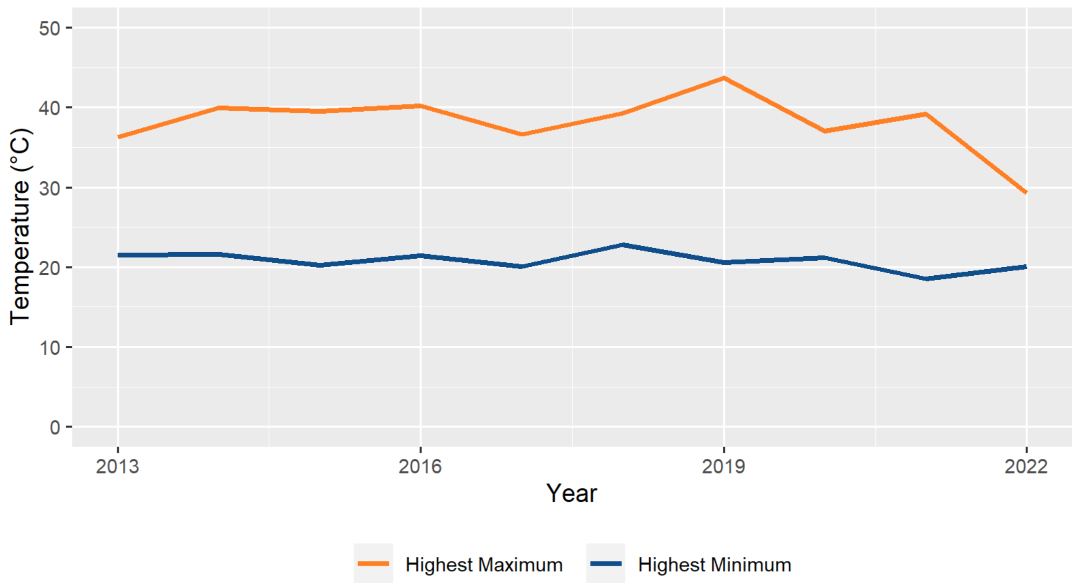

Figure 10 Highest daily maximum and highest daily minimum temperature recorded at Corner Inlet (Yanakie)

5.2 Rainfall

5.2.1 Annual rainfall

The average, minimum, and maximum rainfall at Burnie (Park Grove), Morwell (Latrobe Valley Airport), and Corner Inlet (Yanakie) are presented in Table 5. The Tasmanian site is wetter on average than the two Victorian sites, with a maximum annual total higher by ~500 mm, although it has also experienced a lower minimum annual total by ~100 mm.

Table 5 Annual rainfall statistics for Burnie (Park Grove), Morwell (Latrobe Valley Airport) and Corner Inlet (Yanakie)

Station	Rainfall statistic during data period		
	Annual average total	Maximum annual total	Minimum annual total
Burnie (Park Grove)	876 mm	1411 mm	221 mm
Morwell (Latrobe Valley Airport)	711 mm	947 mm	384 mm
Yanakie (Corner Inlet (Yanakie)	725 mm	966 mm	319 mm

Total annual rainfall at Burnie (Park Grove) by year is shown in Figure 11. The minimum annual rainfall was recorded during a transition from neutral ENSO conditions to drying El Nino conditions and a preceding positive IOD event. The maximum annual rainfall observed in 2016 was also during a drying El Nino event but this was initially counteracted by warm conditions in the Indian Ocean (negative IOD). Low rainfall (and high temperatures) in the latter part of the year saw an early start to the bushfire season and burning in areas previously not burnt for centuries.

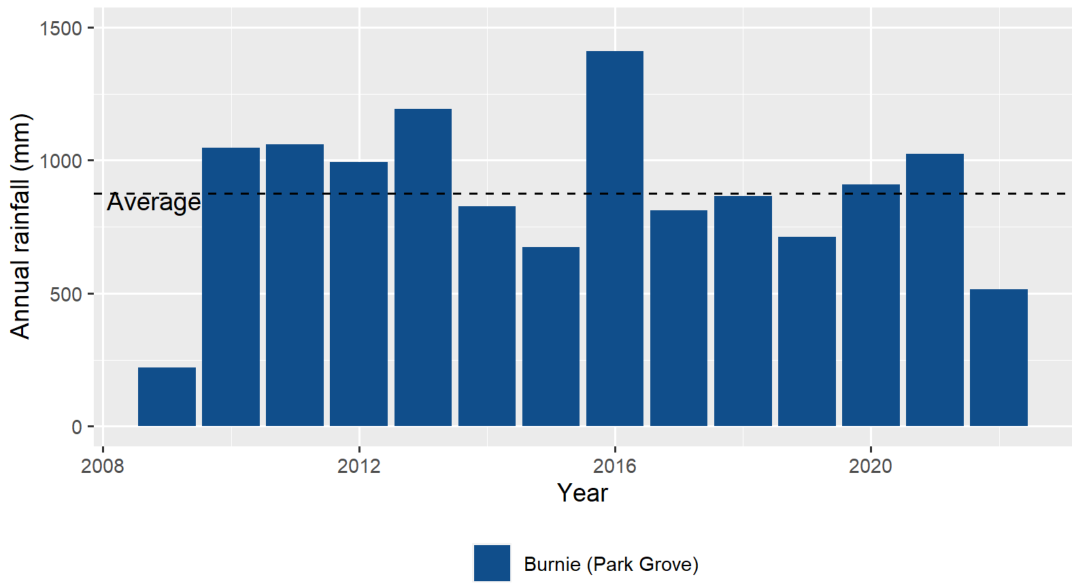

Figure 11 **Annual total rainfall at Burnie (Park Grove) (2009 - 2022)**

Total annual rainfall at Morwell (Latrobe Valley Airport) is shown in Figure 12. The annual total is the sum of validated months of rainfall data for each year. The annual average rainfall at this site for the monitoring period is 711 mm with a maximum annual total of 947 mm and a minimum annual total of 384 mm. As with Burnie (above) the annual rainfall in 2009 and 2016 is related to the interaction between the IOD and ENSO, although rainfall at the Morwell site is less influenced by the maritime environment than at Burnie.

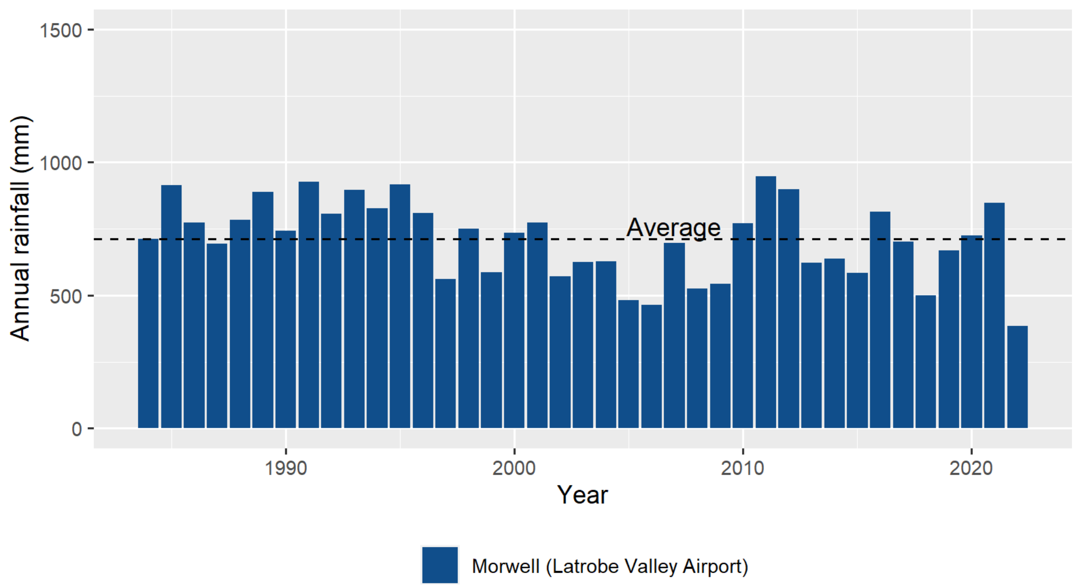

Figure 12 **Annual total rainfall at Morwell (Latrobe Valley Airport) (1984 - 2022)**

Total annual rainfall at Corner Inlet (Yanakie) is shown in Figure 13. The annual total is the sum of validated months of rainfall data for each year. The annual average rainfall at this site for the monitoring period is 725 mm with a maximum annual total of 966 mm and a minimum annual total of 319 mm.

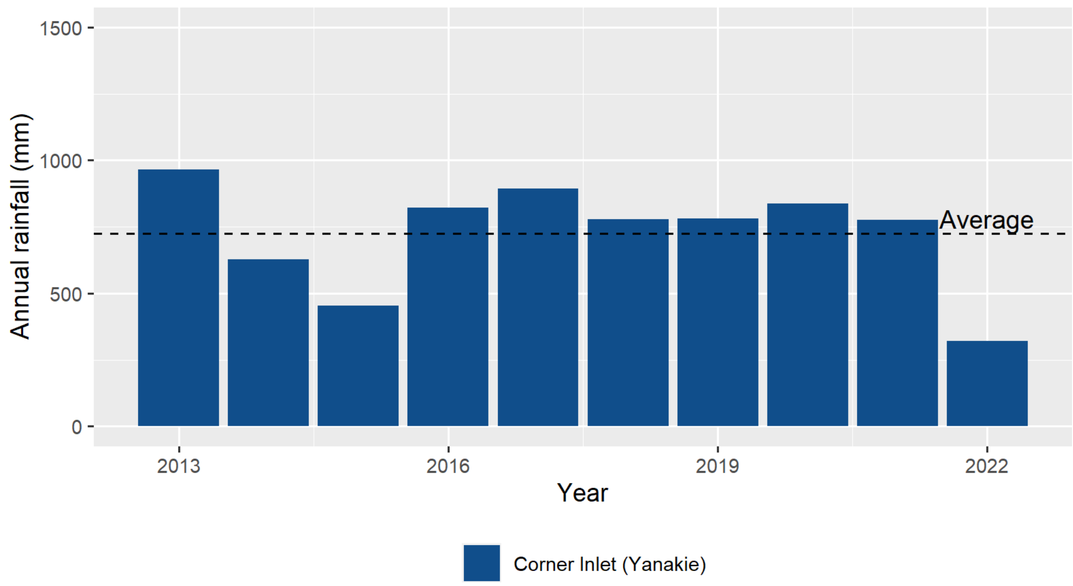

Figure 13 **Annual total rainfall at Corner Inlet (Yanakie) (2013 – 2022)**

5.2.2 Seasonal rainfall

The seasonal distributions of rainfall at Burnie (Park Grove) (Figure 14), Morwell (Latrobe Valley Airport) (Figure 15) and Corner Inlet (Yanakie) (Figure 16) are shown for the available data periods. The mean total rainfall peaks during the winter months at Burnie (Park Grove) and Corner Inlet (Yanakie) and is at its lowest during summer. This seasonal rainfall is characteristic of the southern oceanic climate, with the absence of a dry season and the distribution of rainfall across the year. At Morwell (Latrobe Valley Airport), the mean total rainfall peaks during spring and winter while still maintaining a low during summer.

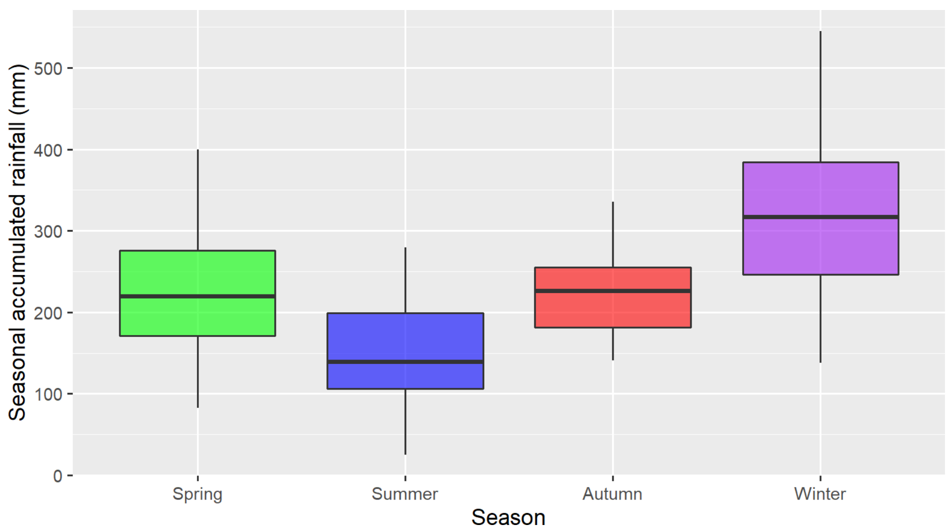

Figure 14 **Season rainfall at Burnie (Park Grove) monitoring station (2009 – 2022)**

At the Burnie (Park Grove) site, the winter period accounts for 35% of the mean annual rainfall while summer only accounts for 17%. The shoulder seasons of spring and autumn at this site account for 22% and 26%, respectively.

At the Morwell (Latrobe Valley Airport) site, the winter period accounts for 27% of the mean annual rainfall while summer only accounts for 22%. The shoulder seasons of spring and autumn at this site account for 30% and 21%, respectively.

At the Corner Inlet (Yanakie) site, the winter period accounts for 33% of the mean annual rainfall while summer only accounts for 17%. The shoulder seasons of spring and autumn at this site account for 26% and 24%, respectively.

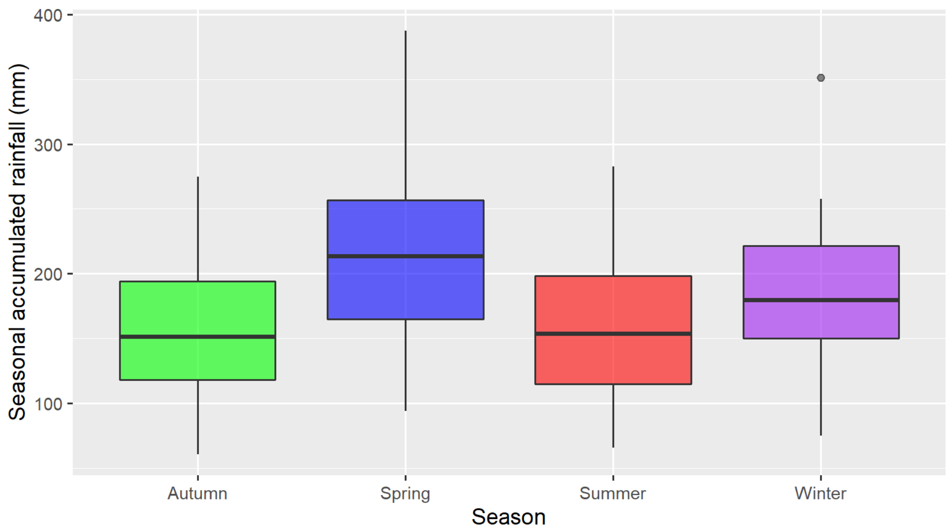

Figure 15 **Season rainfall at Morwell (Latrobe Valley Airport) monitoring station (1984 - 2022)**

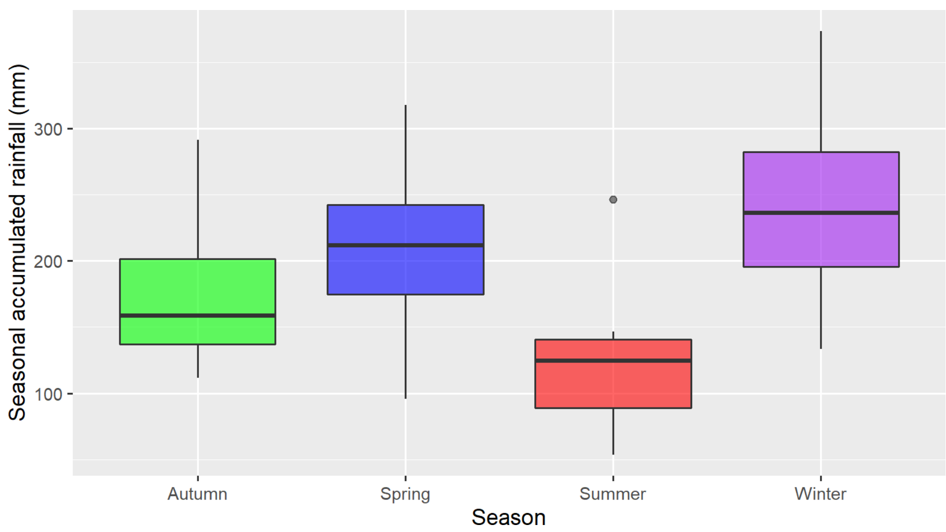

Figure 16 **Season rainfall at Corner Inlet (Yanakie) monitoring station (2013 – 2022)**

5.2.3 Extreme rainfall

Figure 19 to Figure 22 show the rainfall extremes recorded at Burnie (Park Grove) (2009 - 2022), Morwell (Latrobe Valley Airport) (1984 - 2022) and Corner Inlet (Yanakie) (2013 - 2023), respectively. Rainfall extremes have been presented as the maximum monthly rainfall per year as well as the highest daily rainfall per year.

The highest monthly rainfall totals occurred during 2013 for Burnie (Park Grove) (neutral ENSO and negative IOD), in 1985 (neutral ENSO and negative IOD) for Morwell (Latrobe Valley Airport), and in 2013 (neutral ENSO and negative IOD), for Corner Inlet (Yanakie). The Burnie (Park Grove) site recorded a maximum monthly rainfall of 279 mm and a minimum of 95 mm in 2009. The Morwell (Latrobe Valley Airport) site recorded a maximum monthly rainfall of 203 mm and a minimum of 72 mm in 2002. The Corner Inlet (Yanakie) site recorded a maximum monthly rainfall of 174 mm and a minimum of 62 mm in 2015.

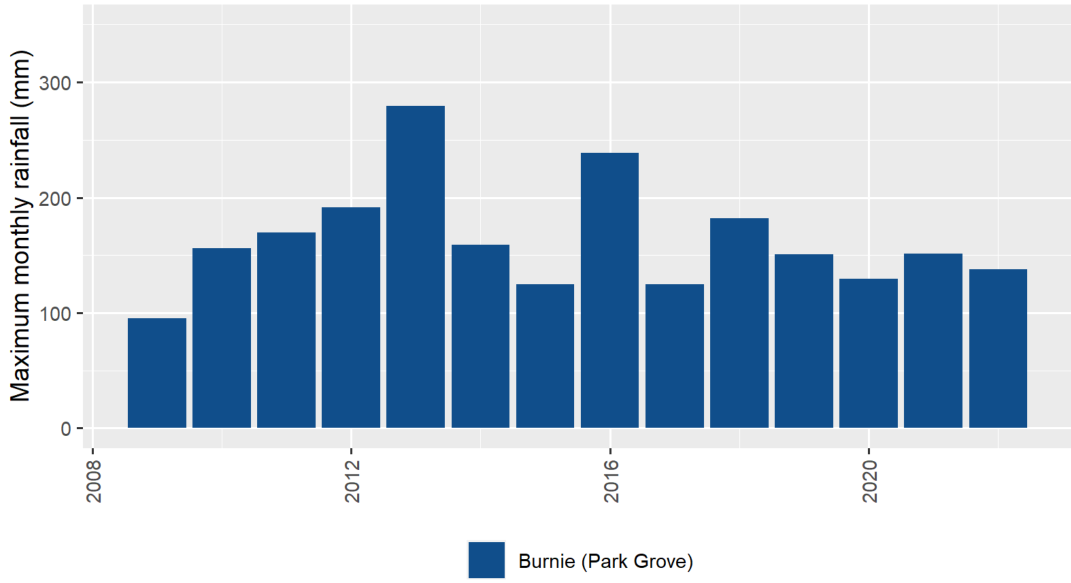

Figure 17 **Highest monthly rainfall observed at Burnie (Park Grove) (2009 - 2022)**

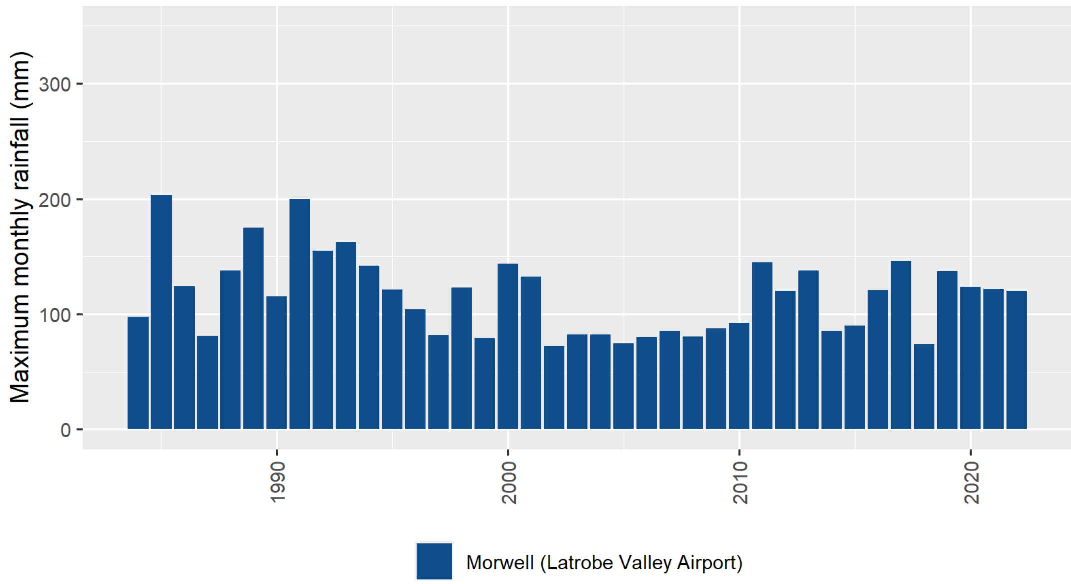

Figure 18 **Highest monthly rainfall observed at Morwell (Latrobe Valley Airport) (1984 – 2022)**

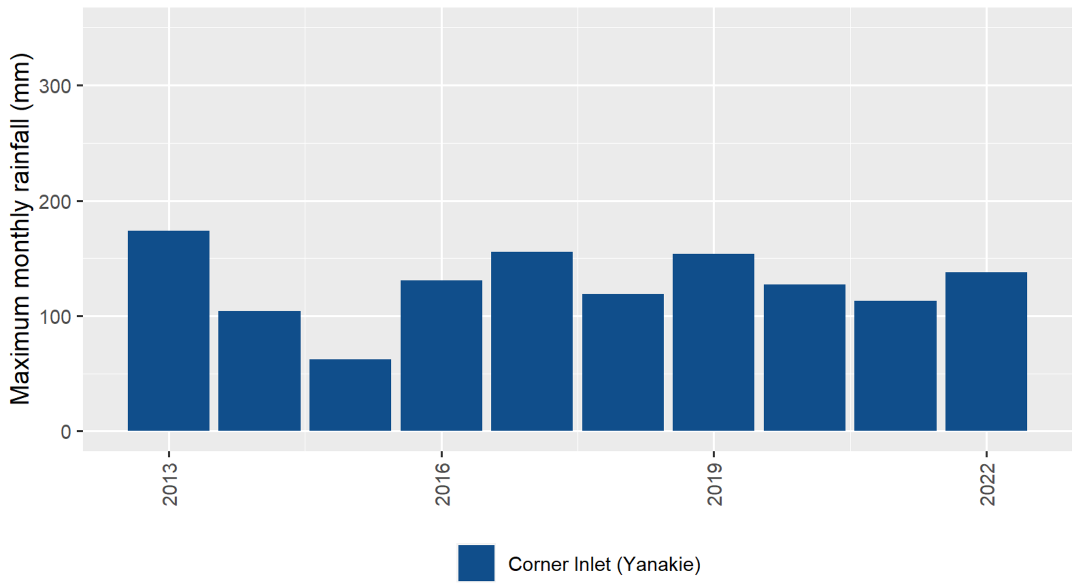

Figure 19 **Highest monthly rainfall observed at Corner Inlet (Yanakie) (2013 - 2022)**

The highest daily rainfall for the Burnie (Park Grove) BoM site occurred on the 6 June 2016 with a maximum of 111.6 mm. For Morwell (Latrobe Valley Airport) BoM site, the highest daily rainfall occurred on the 12 March 2011 with a maximum of 70.0 mm. For Corner Inlet (Yanakie), the highest daily rainfall occurred on the 6 February 2017 with a maximum of 52.0 mm.

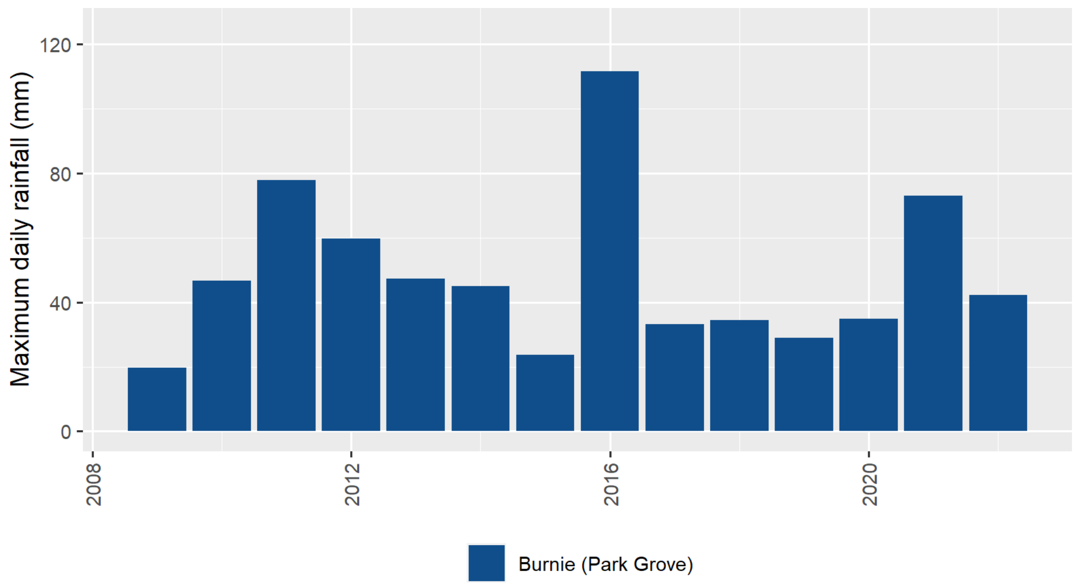

Figure 20 **Highest daily rainfall observed at Burnie (Park Grove) (2009 - 2022)**

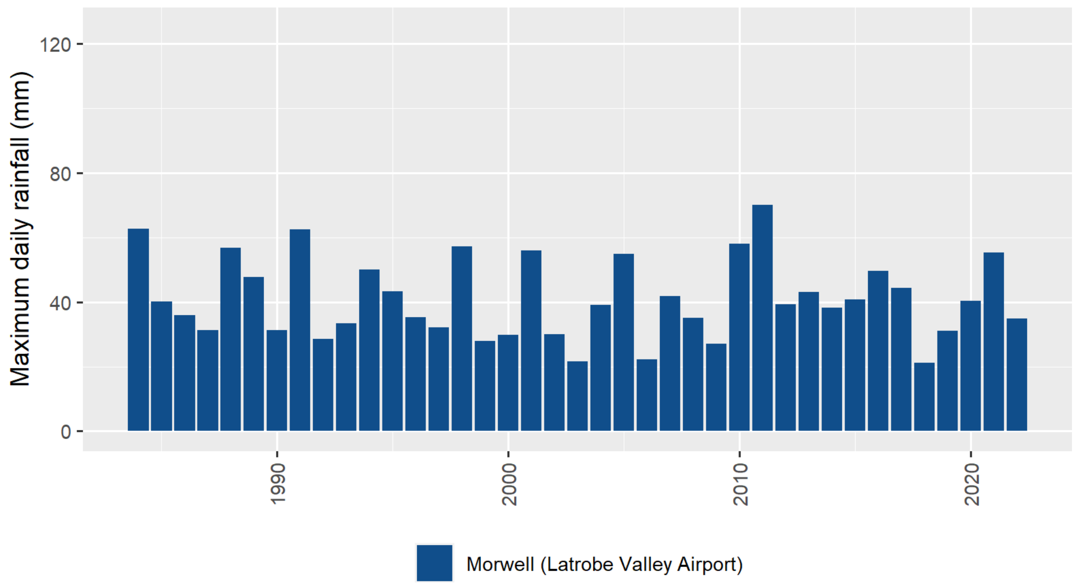

Figure 21 Highest daily rainfall observed at Morwell (Latrobe Valley Airport) (1984 – 2022)

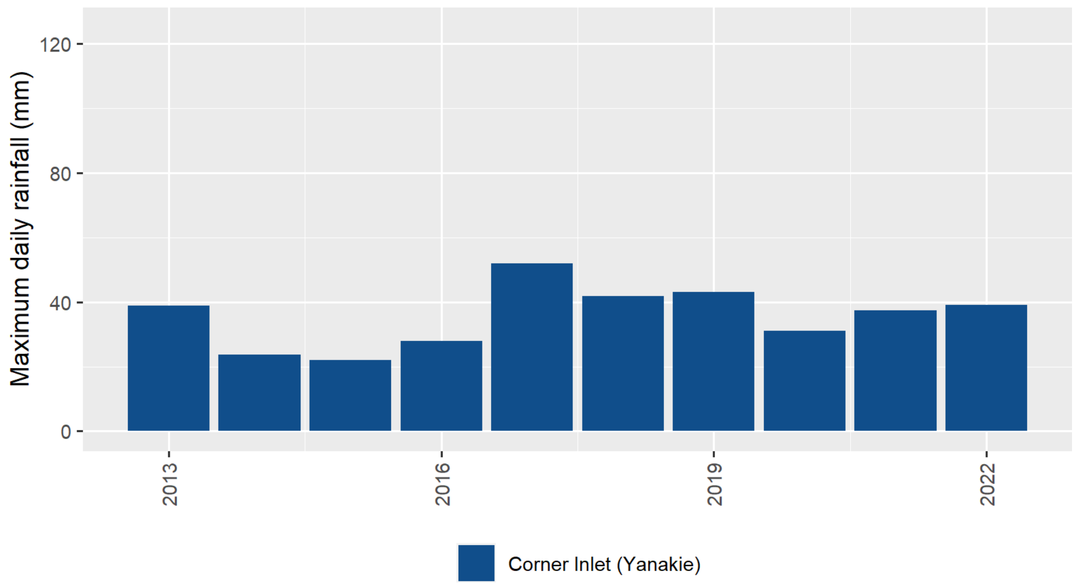

Figure 22 Highest daily rainfall observed at Corner Inlet (Yanakie) (2013 – 2022)

5.3 Wind speed

The winds recorded at the Burnie NTC AWS site (Figure 23) are generally moderate to strong with an average wind speed of 4.36 m/s. Approximately 67% of winds are from the southwest to northwest with approximately 22% of winds from the southeast. There is some diurnal and seasonal variation in both wind direction and wind speed throughout the year.

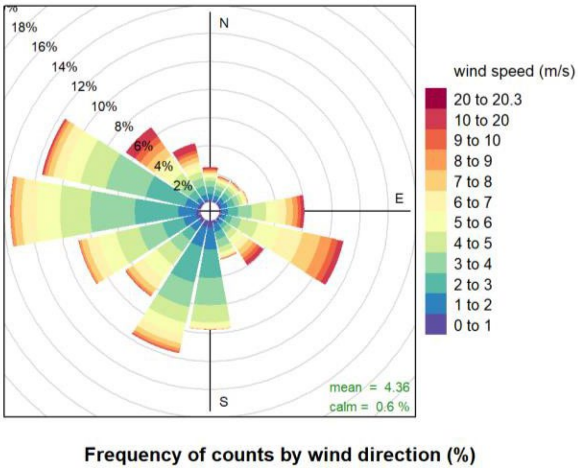

Figure 23 **Annual distribution of wind speed and wind direction derived from Burnie NTC AWS**

The winds recorded at the Morwell (Latrobe Valley Airport) site are generally moderate to strong with an average speed of 3.74 m/s (Figure 24). Approximately 47% of winds are from the westerly direction with approximately 16% of winds from the northeast. There is some diurnal and seasonal variation in both wind direction and wind speed throughout the year.

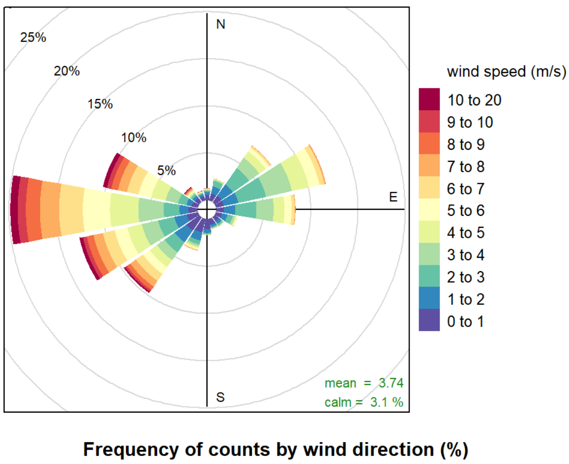

Figure 24 **Annual distribution of wind speed and wind direction derived from Morwell (Latrobe Valley Airport)**

The winds recorded at the Corner Inlet (Yanakie) site are generally strong with an average speed of 4.63 m/s (Figure 25). Approximately 50% of winds occur from the southwest to northwest with a further 25% occurring from the east-northeast. There is some diurnal and seasonal variation in both wind direction and wind speed throughout the year.

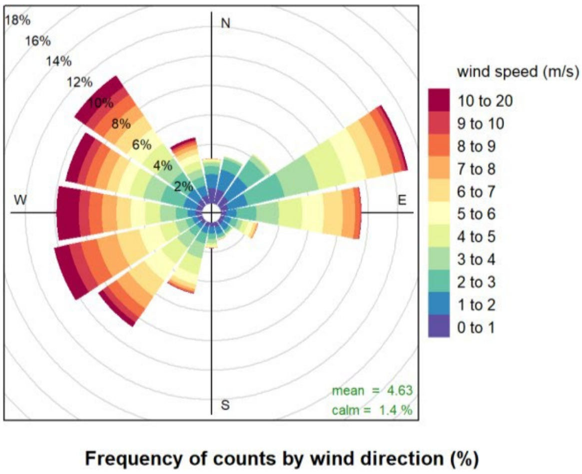

Figure 25 **Annual distribution of wind speed and wind direction derived from Corner Inlet (Yanakie) (2013 to 2022)**

5.3.1 Extreme wind speed

Maximum wind gusts at Wynyard Airport and Morwell (Figure 26, Figure 27) are typically 9 (Strong/severe gale) or 10 (Storm, whole gale) on the Beaufort scale. The maximum wind gusts recorded at both sites were Hurricane force (118 km/h at Wynyard Airport (6 September 1961) and 122 km/h at Morwell (Latrobe Valley Airport) (29 November 2011).

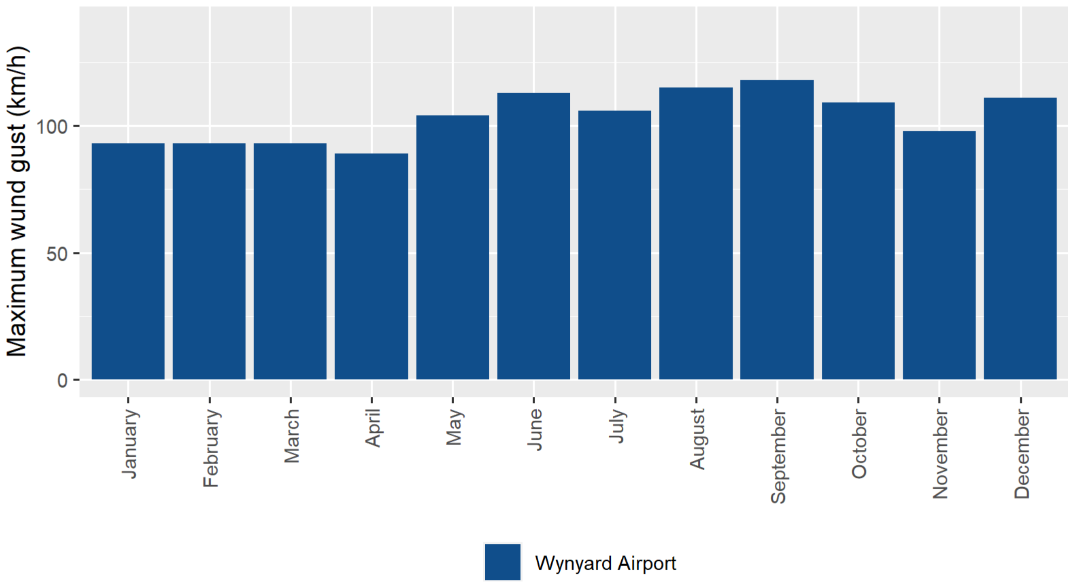

Figure 26 **Monthly maximum wind gust speed (km/h) for Wynyard Airport**

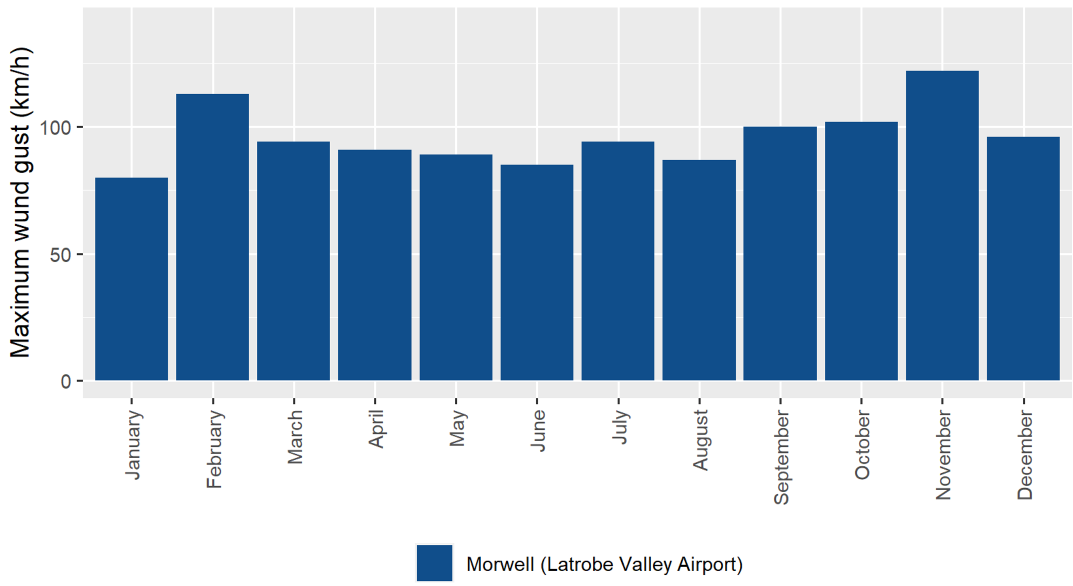

Figure 27 **Monthly maximum wind gust speed (km/h) for Morwell (Latrobe Valley Airport)**

5.4 Soil temperature

Soil temperatures measured at eight (8) sites indicate a clear north-south gradient, with Hazelwood experiencing higher average soil temperatures than Heybridge along the alignment, although cool soil temperatures are similar across the study area as can be seen in Figure 28 (Jacobs, unpublished report). The upper limit of monthly average soil temperature along the land project alignment at 1 m depth is approximately 18 ^{o}C.

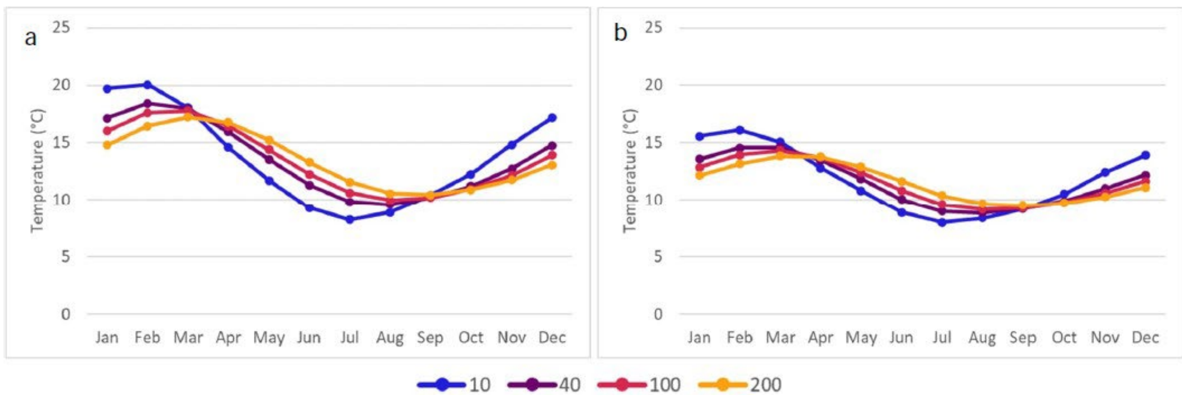

Figure 28 **Monthly average temperature variation for four depths (cm) in the soil profile for a) Hazelwood and b) Heybridge**

5.5 Sea level

The maximum sea levels are up to 4.133 metres above the Australian Height Datum at Burnie (Tasmania), and 3.670 metres above the Australian Height Datum at Stony Point (Victoria) (Table 6).

Table 6 Minimum, maximum, and mean seal level (m) at Burnie and Stony Point

Statistic	Burnie	Stony Point
Minimum	-0.234 m	-0.284 m
Maximum	4.133 m	3.670 m
Mean	1.943 m	1.744 m5

5.6 Sea temperature

The annual average sea surface temperature at 25 locations between Waratah Bay and Heybridge range between 15.8 °C near the Victorian coast and 15.0 °C near the Tasmanian coast (Jacobs, unpublished report). Annual average water temperature declines with depth, to a minimum of 13.5 °C at about 92 m.

Average sea temperatures at the surface are 2.5-3 °C warmer in January than the annual average and about 2.5 °C cooler in July (Jacobs, unpublished report). Temperatures at depth (~90 m) change little throughout the year (Jacobs, unpublished report).

5.7 Bushfire zones

Bushfire prone areas are prominent throughout Tasmania and Victoria.

The Heybridge Converter Station is within a bushfire prone area as defined in the Burnie Local Provisions Schedule of the Tasmanian Planning Scheme. Figure 29 shows the extent of historical fires in the area near the Converter Station.

Figure 30 presents Victoria's classified extent of bushfire prone areas and the extent of historical fires within the vicinity of the project occurring from 1991 to 2022. The majority of the HVDC land cable is in bushfire prone areas. Historically, bushfires have occurred along the northern section of the proposed HVDC land project alignment and at the proposed Driffield converter site. The potential Hazelwood site has not historically experienced bushfires.

The National Council for Fire and Emergency Services has established a new Australian Fire Danger Rating System[6]. The four ratings for Tasmania, West and South Gippsland, and East Gippsland fire weather districts are now Moderate, High, Extreme, and Catastrophic[7].

6 https://www.afac.com.au/initiative/afdrs/afdrs-overview/afdrs-design

7 http://www.bom.gov.au/vic/forecasts/fire-danger-ratings.shtml

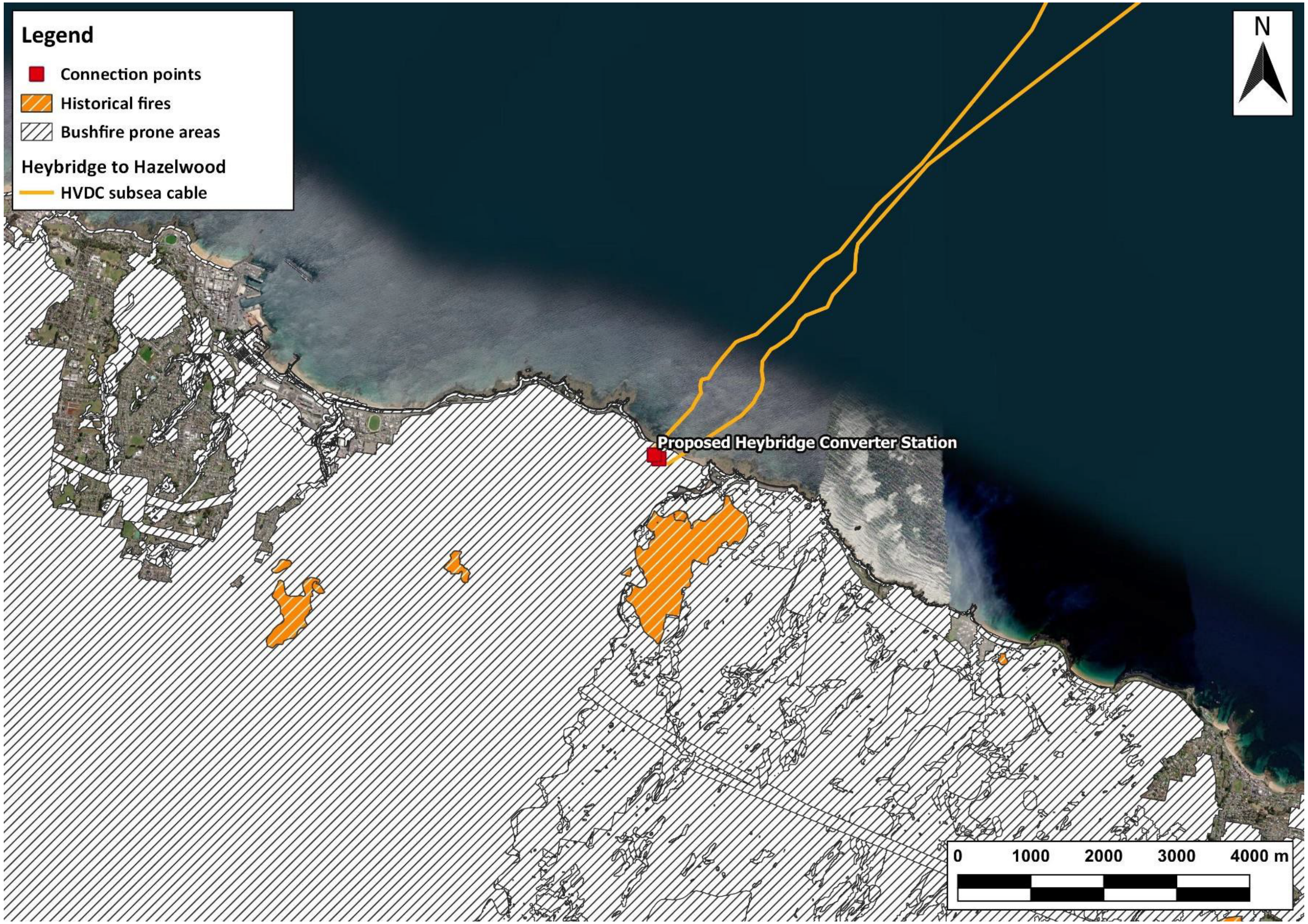

Figure 29 **Bushfire prone areas and historical fires in the vicinity of the project – Tasmania Component (Tasmania Fire Service, 2022)**

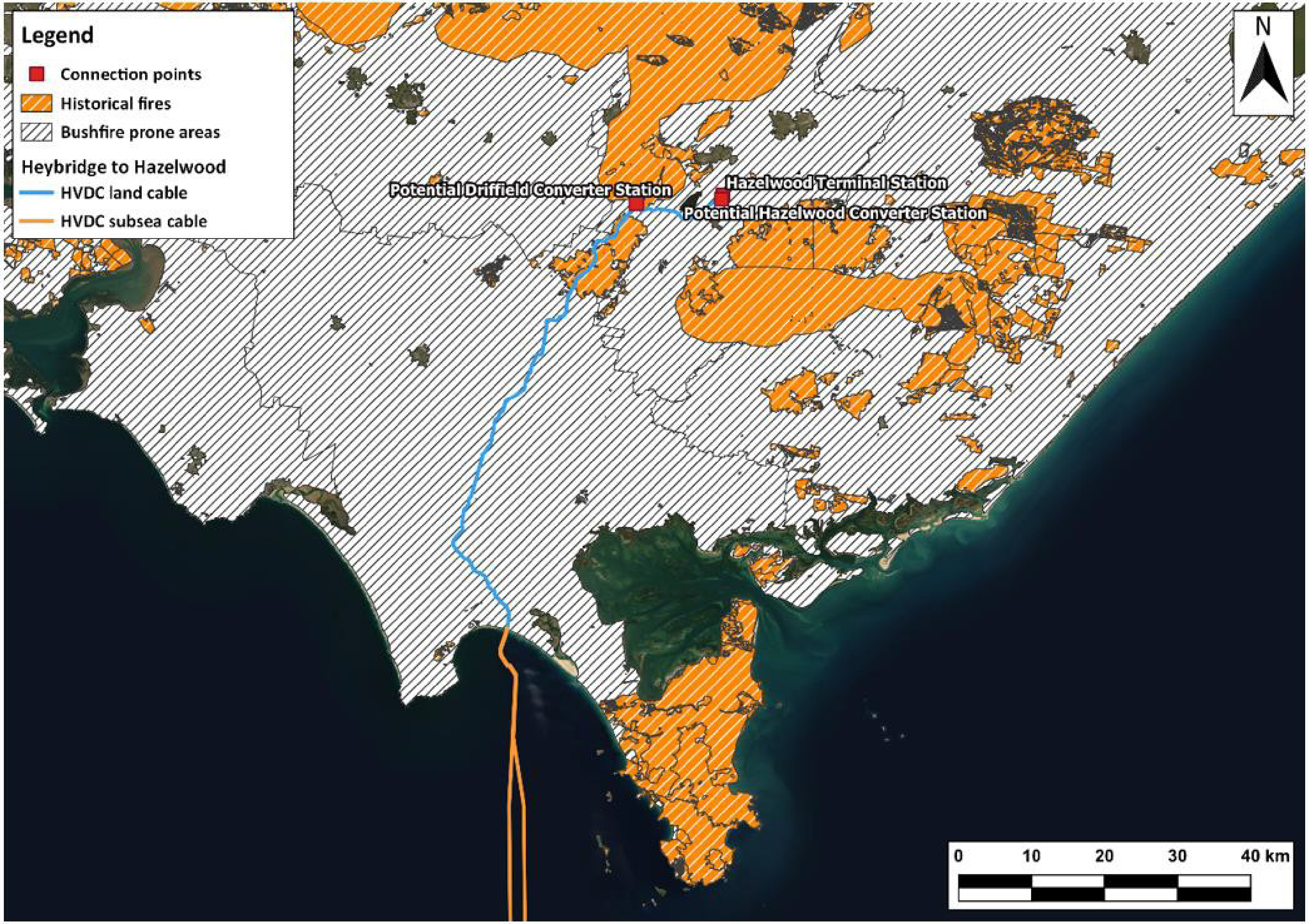

Figure 30 Bushfire prone areas and historical fires in the vicinity of the project – Victoria Component (Tasmania Fire Service, 2022)

6. CLIMATE CHANGE

Climate change projections for key climate parameters and extreme weather events are provided in the following sections. Climate change projections are based on Grose (2015), CSIRO and BOM (2020), and Arias et al (2021).

6.1 Temperature

Australia's annual average temperature has increased by 1.44 ± 0.24 °C since national records began in 1910, with the average annual temperature in 2020 being 22.65 °C (CSIRO and BOM 2020). Most warming has occurred since 1950 with each succeeding decade being warmer than the previous decade. La Nina conditions can drive relatively cool years, but these are superimposed on a continued warming trend.

Day time and night-time temperatures, and the frequency of extremely warm to very hot days, are increasing. For example, there were 33 days in 2019 when maximum temperatures in Australia exceeded 39 °C; in contrast, between 1960-2018 there were 24 days when maximum temperatures exceeded 39 °C.

The mean temperature across northern Tasmania and southern Victoria rose between 0.8 °C and 1.0 °C between 1910 and 2013 (Grose et al, 2015). Projected increases in median temperatures in this region are presented in Table 7. The maximum projected median summer temperatures increase from 0.9 °C (2030) to 3.3 °C (2090) with the hottest day at the Heybridge site projected to increase from 37 °C to 39 °C.

Table 7 Summary of temperature variation for RCP 8.5 in the northern Tasmania and southern Victoria

Parameter	Season	2030		2090	
		Median	Range	Median	Range
Temperature (°C)	Annual	0.8	(0.5 to 1.1)	3.1	(2.5 to 4)
	Summer	0.9	(0.5 to 1.4)	3.3	(2.4 to 4.6)
	Autumn	0.8	(0.5 to 1.2)	3.2	(2.5 to 4.2)
	Winter	0.7	(0.5 to 1)	2.9	(2.3 to 3.6)
	Spring	0.8	(0.4 to 1.2)	3	(2.4 to 3.9)
Temperature maximum (°C)	Annual	0.8	(0.6 to 1.2)	3.5	(2.5 to 4.3)
	Summer	0.9	(0.6 to 1.3)	3.5	(2.5 to 4.6)
	Autumn	0.8	(0.5 to 1.4)	3.4	(2.4 to 4.4)
	Winter	0.8	(0.6 to 1.1)	3.1	(2.4 to 3.9)
	Spring	0.8	(0.5 to 1.3)	3.7	(2.7 to 4.4)

6.2 Rainfall

There has been a trend towards decreased annual rainfall in southern Australia with a decline of 12% in April to October rainfall since 1970 (CSIRO and BOM 2020), particularly as the number of low-pressure systems that bring heavy rainfall to southern Australia is declining.

El Nino, La Nina, the IOD, and the Southern Annular Mode continue to be key drivers of above or below average rainfall; however, these are mediated by the increase in heat energy in the climate system. The warming atmosphere can hold greater amounts of moisture and, consequently, heavy rainfall events are becoming more intense, leading to more flash flooding and larger flood events (CSIRO and BOM 2020). These are particularly extreme after dry periods when soil infiltration is limited or wet periods when the soil is saturated.

There has been a decline in mean annual rainfall in northern Tasmania and southern Victoria since the mid-1970s, with a very dry period in the late 1990s and 2000s known as the Millennium drought. Projected changes in rainfall for the region, expressed as percentage change, are presented in Table 8.

Rainfall declines in the area are strongest in the summer and the spring. Median annual rainfall is projected to decrease by 2% by 2030 and 5% by 2090.

Table 8 Projected median rainfall with 10th and 90th % range

Season	2030		2090	
	Median	Range	Median	Range
Annual	-2	(-6 to 2)	-5	(-17 to 4)
Summer	-5	(-16 to 6)	-13	(-26 to 6)
Autumn	-3	(-9 to 8)	-4	(-21 to 5)
Winter	1	(-4 to 9)	6	(-6 to 20)
Spring	-5	(-13 to 4)	-14	(-33 to 1)

The occurrence of drought conditions is dependent on annual rainfall. The projected decrease in median annual rainfall will likely result in an increase in average time spent in drought conditions across the region (Grose et al 2015).

6.3 Wind speed

Predicted wind speed changes for the region, expressed as percentage, are presented in Table 9. The projected change in median annual wind speed is 0.4% by 2030 and 0.3% by 2090, indicating little or no change in median wind speed throughout the duration of the projections.

Table 9 Projected median wind speed with 10th and 90th % range

Season	2030		2090	
	Median	Range	Median	Range
Annual	0.4	(-2.1 to 2.4)	0.3	(-2.5 to 2.9)
Summer	-0.1	(-2 to 1.9)	-1.6	(-4.7 to 0.5)
Autumn	-0.2	(-3.1 to 3.2)	-2.5	(-7 to 0.2)
Winter	1.6	(-0.4 to 5.6)	4.5	(-1.1 to 10.6)
Spring	-0.2	(-4 to 3.5)	-0.1	(-4.9 to 3.8)

6.4 Soil moisture

Increasing temperatures and decreasing humidity and average annual rainfall have implications for soil moisture and run-off. Decreases in soil moisture are projected in all seasons (Grose et al. 2015) with a greater decline in soil moisture during winter and spring in southern Victoria, and a greater decline during summer and autumn than in the other seasons in Tasmania. The annual changes for RCP8.5 by 2090 range from around -14% to -3 % with very high model agreement on substantial decrease.

6.5 Soil temperature

Soil temperatures at 1 m depth are expected to experience an increase due to heat transfer from the warming atmosphere. However, monthly average soil temperatures are projected to exceed only marginally 20 °C by 2080 at the warmest part of the alignment (Figure 31).

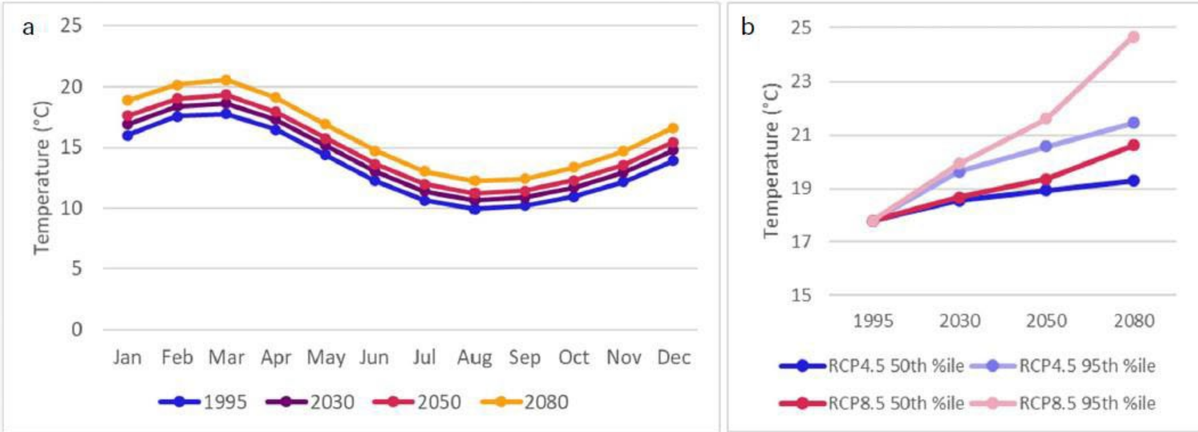

Figure 31 **Average monthly soil temperature for 100 cm depth at Hazelwood: a) change in average monthly temperature; median projections, and b) change in temperature during the hottest month across projections.**
(Source: Jacobs, unpublished report)

6.6 Sea temperature

The average sea surface temperature around Australia has increased by more than 1 °C since 1900, with the greatest warming occurring around southeastern Australia and Tasmania (CSIRO and BOM 2020). The trend in the Bass Strait between 1950 and 2019 was between 0.16ºC and 0.2ºC per decade. The ocean heat content continues to increase, and marine heatwaves are increasing in frequency.

6.7 Sea level rise

The global mean sea level has increased by approximately 25 cm since 1880, with about 12 cm of this occurring since 1970 (CSIRO and BOM 2020). The rate of global mean sea level rise is increasing and was 3.5 ± 0.4 cm from 1993 to 2019 as derived from offshore satellite altimetry. The rate of sea level rise in southeast Australia is higher than the global average.

The projected sea level rise at Burnie and Stony Point is summarised in Table 10.

Table 10 **Projected median sea level rise (m) with 10th and 90th % range**

Location	2030		2090	
	Median	Range	Median	Range
Burnie	0.13	(0.08-0.18)	0.61	(0.41-0.83)
Stony Point	0.12	(0.08-0.17)	0.59	(0.38-0.81)

6.8 Extreme weather events

6.8.1 Bushfire weather

Fire seasons are starting earlier and finishing later than previously, and the frequency of extreme fire weather is increasing, across Australia (CSIRO and BOM 2020). This trend is particularly evident in southern Australia, with regions of Tasmania and mainland Australia burning that have not previously burnt. Grose *et al*. (2015) project that the fire risk in Tasmania and southern Victoria could increase by 30% by 2090. Modelling by Clark *et al*. (2021) suggests that the mean number of days with very high FFDI (>25) could increase by 120% for the period between 2045-2060 and by 216% by the end of the century, while CSIRO and BoM (2015) project that the mean number of severe fire days per year (Forest Fire Danger Index (FFDI) >50) in southern Australia could almost double by 2090 (Table 11).

The frequency of forest megafires is also likely to increase under current climate trends (Canadell *et al*. 2021).

Table 11 Mean number of severe fire days (FFDI > 50) per year in southern Australia centred on 1995 (1981 – 2010) and RCP8.5 projections for 2030 and 2090 (CSIRO and BoM 2015)

	1995	2030	2090
Days FFDI >50	2.8	3.4	5.3

The Australian Fire Danger Rating System has recently been upgraded to Moderate, High, Extreme, and Catastrophic, recognising the change in fire conditions and behaviour due to climate change.

6.8.2 Extreme rainfall

Extreme rainfall for the project is represented by the wettest day, sourced from the climate change projections based on daily data used the standard reference period (1986-2005). While total rainfall is declining in the region (Grose et al. 2015), it is projected that the intensity of rainfall events may increase by 21% by 2080 (Jacobs, unpublished report).

6.8.3 Extreme wind speed

Extreme wind projections for the project area are less certain than projections for other weather parameters due in part to the influence of surrounding terrain (Grose et al., 2015). Current projections indicate that the mean wind speed, annual maximum 1-day wind speed, and the 20-year return value for 1-day wind speed are projected to increase in Tasmania by 2090.

6.8.4 Extreme coastal conditions

A modelling study conducted by Liu et al. (2022) applying SSP5-8.5 suggests that the mean significant wave height will increase in Bass Strait by the end of the twenty-first century (2071–2100) but that there may be a decrease in wave height in nearshore regions, mainly due to projected decreases in local wind speed.

6.9 Climate change summary

A summary of climate projections against existing conditions for each of the key climate variables with the potential to impact the project is provided in Table 12. These climate projections apply to both the Tasmania and Victorian components of the project.

Table 12 Summary of climate projections for key climate variables associated with the project

Climate factor	Climate variable	Existing Climate			Climate change projections	Confidence in Projection (Grose et al 2015)
		Burnie	Morwell (Latrobe Valley Airport)	Corner Inlet (Yanakie)		
Temperature	Daily maximum temperature	31.5 °C	46.3°C	43.7°C	2030: +0.9 °C 2090: +3.5 °C	Very high confidence in increase in occurrence and frequency of daily maximum temperatures
Rainfall	Average annual rainfall	876 mm	711 mm	725 mm	2030: -2% 2090: -5%	High confidence in winter/spring decline in rainfall
Extreme rainfall	Highest daily rainfall	111.6 mm	70 mm	52 mm	Increase	High confidence in increase in intensity and frequency
	Highest monthly rainfall	279.4 mm	203.2 mm	173.8 mm	Increase	
Wind speed	Seasonal mean	4.16 to 4.69 m/s	3.4 to 4.11 m/s	4.27 to 4.89 m/s	2030: +0.4% 2090: +0.3%	High confidence in small increase in frequency and intensity Medium confidence in increased winter wind speed in western Tasmania
	Maximum wind gusts	118 km/h[1]	122 km/h	NR[2]	Increased frequency	
Sea level	Highest Astronomical Tide	4.13 m above AHD	-	3.67 m above AHD[3]	2030: 0.13 m 2090 0.61 m	Very high confidence in continued rise
Extreme weather conditions	Bushfire weather	Infrequent and localised			30% increase in bushfire risk by 2090	High confidence in occurrence of harsher fire-weather
Soil temperature	Average monthly temperature	18 °C			2030: 18.9°C 2090: 21.3°C	High confidence in continued rise

Climate factor	Climate variable	Existing Climate			Climate change projections	Confidence in Projection (Grose et al 2015)
		Burnie	Morwell (Latrobe Valley Airport)	Corner Inlet (Yanakie)		
Sea temperature	Average monthly temperature	15.8 °C			2050: 16.8 °C	High confidence in continued rise

Table Note:

[1] Maximum wind gust recorded at the Wynyard Airport site.

[2] Not reported

[3] Highest Astronomical Tide (HAT) recorded at the Stony Point site

7. CLIMATE CHANGE ASSESSMENT

Climate change due to continued global warming has implications for the project through:

- Frequency of extreme heat days
- Frequency and intensity of storms
- Frequency and intensity of bushfires, including fire storms
- Frequency and scale of flooding
- Frequency and intensity of droughts
- Soil expansion, contraction, mass movement, and change in thermal conductivity
- Coastal erosion and inundation.

These may individually or in combination have a negative impact, at various times in the lifetime of the project, on the capacity of the Marinus Link to provide a continuous supply of 1500 MW of electricity to the NEM from Tasmania and may pose a range of financial and reputational risks to MLPL.

Potential impacts arising during construction of the project, may include:

- Heat waves or continued high temperatures exceeding industry guidelines and/or worker capacity to safely work on site, leading to delays in construction
- Sparks or hot surfaces on construction machinery and equipment ignite dry vegetation and lead to local or regional fires
- Soil saturation or soil drying followed by intense rainfall leading to localised erosion or mass movement of soil from construction areas into waterways.
- Coastal erosion due to sea level rise affecting infrastructure and causing breaks in transmission.

Some of the potential impacts to operation of the Marinus Link can be mitigated through improved design measures, such as increased engineering tolerances and inbuilt redundancy, and following construction and other technical standards updated to include climate change, e.g., *AS/NZS 1170.2:2021 Structural design actions. Wind actions* (Table 13). However, design standards may be exceeded by extreme or chronic weather events, so the potential impact of these on the operation of the project should be evaluated through scenario analysis as part of the design process. For example:

- Periodic or progressive inundation of Heybridge Converter Station infrastructure through sea level rise or storm surge may interrupt supply and require increasing investment in remediation of infrastructure
- Increased intensity of storm events and increased wind speed may damage incoming or outgoing transmission lines affecting capacity to supply required power transfer
- Daily temperatures increasingly exceed design rating of incoming transmission lines so overheating and damage to lines leads to ignition of bushfires, which damage forest and private property and cause injury and/or loss of life
- Increased frequency of extreme climatic events leads to increased outages of control systems that cause cascading effects on Tasmanian and Victorian networks.

The following Environmental Performance Requirement (EPR) is proposed for the project.

EPR CC01: Implement measures to address the impacts of climate change on the project.

Design the project to address potential impacts from climate change across the life of the project, considering:

- Increased ambient temperatures/soil temperatures/sea temperatures and their potential impact on the operation of high voltage infrastructure.
- Sea level rise and coastal erosion and its potential impact on accessibility, and function of coastal infrastructure.

The design must be informed by a risk assessment completed to identify climate change risks and management measures based on:

- *AS/NZS ISO 31000:2018 Risk management – Principles and guidelines*
- *AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach*
- IPCC 2012 *Managing the risks of extreme events and disasters to advance climate change adaptation*

Include measures in the CEMP and OEMP (as relevant) to address:

- Extreme or chronic weather events such as bushfires, heavy rainfall events and extreme wind speeds and their potential impact on safety of employees, accessibility, and operation of infrastructure.

The measure should cover increased temperatures, sea level rise, and extreme or chronic weather events such as bushfires, heavy rainfall, extreme wind speeds and their effects on the infrastructure and employee safety.

Table 13 provides risk statements and potential control measures that could be applied to reduce the impact of weather events or climatic conditions on the project as per EPR CC01.

Table 13 Climate change risk statements and potential control measures

Climate Change Hazard	Risk Statement – Potential Effect on Project Objectives	Potential risk Control Measures
Higher average and maximum temperatures	Construction: Temperatures above 35°C leads to possible heat stress in workers and stop work action	Consultation with Construction, Forestry, Mining and Energy Union (CFMEU) and Electrical Trades Union (ETU) on measures to minimise the likelihood of heat stress and/or stop work action
	Operations: Reduced carrying capacity of lines and transformers within converter stations due to higher temperatures	Ensure that line and transformer capacity exceed projected maximum load under high temperature conditions Ensure that transformer cooling system can effectively transfer heat under high ambient temperatures Ensure that ambient conditions allow for effective transfer of heat from transformer cooling systems
	Operations: Increased losses in lines and transformers within converter stations due to higher temperatures	Ensure that dielectric strength of insulation exceeds projected maximum load under high temperature conditions
	Operations: Increased likelihood of arcing of electricity cables within converter stations due to overloading resulting in increased risk of fires	Ensure that the appropriate level of liaison and planning with emergency management agencies are undertaken so that the location, strategic importance, and any technical constraints to undertaking fire prevention and suppression activities within the vicinity of infrastructure are understood and implemented
	Operations: Higher temperatures and changes in water vapour leading to increased corrosion rates of metal infrastructure	Procurement specification for materials with greater corrosion resistance (refer *AS/NZS 2312.2 2014 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings*) Servicing, testing and repair of the transition station and converter stations equipment and infrastructure

Climate Change Hazard	Risk Statement – Potential Effect on Project Objectives	Risk Control Measures
Increased intensity of heavy rainfall events	Construction: Erosion or mass movement of sediment into waterways	Undertake site risk management process to understand local erosion and sediment hazards and risks. Establish site specific controls, with consideration of relevant guidelines such as the following EPA Victoria Publications: • 1893: Erosion, sediment, and dust: treatment train • 1894: Managing soil disturbance • 1895: Managing stockpiles • 1896: Working within or adjacent to waterways • 1897: managing truck and other vehicle movement
	Operation: Stormwater drainage system at both converter stations overloaded	Design stormwater retention and drainage systems to cope with peak flow rates based on minimum 100-year average recurrence interval (ARI) flood flows[8]
	Operations: Damage and flooding of buildings and infrastructure for both converter stations	Converter station infrastructure designed to a level to be protected from inundation from a minimum 100-year ARI rainfall event
	Operations: Damage and flooding of underground infrastructure such as the land cable	Routine inspection of the land cable easement for potential operational and maintenance issues including: • Land stability • Cover at watercourse crossings

8 https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/standards-and-specifications/hydrologic-and

Climate Change Hazard	Risk Statement – Potential Effect on Project Objectives	Risk Control Measures
	Operations: Remote electrical infrastructure is inaccessible due to flooding at converter station and transition stations	Design access tracks, roads, and drainage to ensure accessibility during a minimum 100 ARI flood event
Increased frequency of extreme wind speed	Operations: Damage to buildings and infrastructure for both converter stations	Refer *AS/NZS 1170.2:2021 structural design actions. Wind actions.*
	Operations: Damage to buildings and infrastructure for both converter stations due to vegetation carried by wind	Scheduled maintenance of vegetation at all converter stations to ensure that easements remain free of potential flying debris
Increased occurrence of bushfires	Operations: Damage to buildings and infrastructure from bushfires Operations: Damage to environment from bushfires ignited by transmission infrastructure faults	Establish the defendable space required to protect infrastructure from bushfires Scheduled maintenance of all converter stations to maintain firebreaks, ensuring fuel load management within the firebreak Ensure fire response and management plans are fully integrated with Local Area Fire Management Plans
	Operations: Remote electrical infrastructure at both converter stations is inaccessible due to bushfires	Maintenance of access tracks to converter and transition stations to ensure fuel load management and reduction
Sea level rise	Operations: Inundation of Heybridge converter station and Waratah Bay transition station and surrounding infrastructure	An elevated bench will be constructed to provide a stable base for the converter station and situate it above the projected 200-year ARI flood event

Climate Change Hazard	Risk Statement – Potential Effect on Project Objectives	Risk Control Measures
	Operations: Accessibility to conduct repairs of Heybridge converter station and Waratah Bay transition station and associated infrastructure to the impacts of sea level rise on surrounding areas	Maintenance of access tracks to converter and transition stations
Soil temperature increase / Sea temperature increase	Operations: Reduction in transmission efficiency and capacity in both land and subsea cables	Servicing testing of subsea and land cables, including scheduled minor and major outages

8. CONCLUSION

Katestone was commissioned by Tetra Tech Coffey, on behalf of MLPL, to conduct a climate and climate change desktop assessment to identify risks for the Marinus Link project.

Projected changes in weather patterns due to global warming, i.e., climate change, with implications for the lifetime of the project are:

- Increased maximum daily temperatures and increased frequency of maximum temperatures above 35°C affecting high voltage infrastructure (i.e., cables, transformers)
- Increased frequency and intensity of storm events (rainfall and wind) affecting ancillary infrastructure such as connecting transmission lines
- Reduced total rainfall.

Associated environmental changes due to global warming with implications for the lifetime of the project are:

- Sea level rise and increased intensity of storm surges affecting coastal infrastructure including the Heybridge Converter Station and cable joint pits
- Increased frequency of bushfire weather and extended bushfire seasons increases vulnerability to bushfire ignition by infrastructure failure.

There is high to very high scientific confidence in the direction of these trends with uncertainty around the timing or actual intensity of events.

Some risks may be mitigated through improved design measures, such as increased engineering tolerances and inbuilt redundancy to ensure, for example, that thermal tolerances exceed potential maximum temperatures.

Consequently, the following EPR is proposed:

EPR CC01: Implement measures to address the impacts of climate change on the project.

Design the project to address potential impacts from climate change across the life of the project, considering:

- Increased ambient temperatures/soil temperatures/sea temperatures and their potential impact on the operation of high voltage infrastructure.
- Sea level rise and coastal erosion and its potential impact on accessibility, and function of coastal infrastructure.

The design must be informed by a risk assessment completed to identify climate change risks and management measures based on:

- AS/NZS ISO 31000:2018 Risk management – Principles and guidelines
- AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach
- IPCC 2012 Managing the risks of extreme events and disasters to advance climate change adaptation

Include measures in the CEMP and OEMP (as relevant) to address:

- Extreme or chronic weather events such as bushfires, heavy rainfall events and extreme wind speeds and their potential impact on safety of employees, accessibility, and operation of infrastructure.

The measure should cover increased temperatures, sea level rise, and extreme or chronic weather events such as bushfires, heavy rainfall, extreme wind speeds and their effects on the infrastructure and employee safety.

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