# Lake Vermont Meadowbrook Project
# Climate Change Assessment

**Prepared for:**

## AARC Environmental Solutions

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## Final


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# Glossary

| Term | Definition |
| --- | --- |
| °C | degrees Celsius |
| km | kilometre |
| km/h | kilometre per hour |
| kV | kilovolt |
| MW | megawatt |
| mm | millimetres |
| m/s | metres per second |
| $W/m^2$ | watts per square metre |
| **Nomenclature** | **Definition** |
| $CO_2$ | carbon dioxide |
| **Abbreviations** | **Definition** |
| AS | Australia Standard |
| AHD | Australian Height Datum |
| BoM | Bureau of Meteorology |
| HVAC | High voltage alternating current |
| HVDC | High voltage direct current |
| GCM | Global Climate Model |
| GHG | Greenhouse gases |
| IPCC | Intergovernmental Panel on Climate Change |
| NEM | National Electricity Market |
| NRM | Natural Resource Management |
| NW | North-West |
| NWTD | North-West Transmission Developments |
| OHTL | Overhead transmission line |
| RCP | Representative Concentration Pathways |
| REZ | Renewable energy zone |

# EXECUTIVE SUMMARY


Katestone Environmental Pty Ltd (Katestone) was commissioned by AARC Environmental Solutions Pty Ltd (AARC), on behalf of Bowen Basin Coal Pty Ltd (Bowen Basin Coal, BBC), to complete a Climate Change Assessment of the Lake Vermont Meadowbrook Project (the Project), near Dysart in central Queensland.

The Project is an extension of the existing Lake Vermont Coal Mine (open-cut) that will supplement the decline in coal output from the existing open-cut operation to maintain the approved 12 million tonnes per annum (Mtpa) Run-of-Mine (ROM) coal limit and extend the mine life by 20 years.

The Project involves the construction and operation of an underground multi-seam, longwall coal mine as well as an adjacent small-scale open-cut pit. Extraction rates from the Project are forecast to be up to 6 Mtpa of ROM coal, equivalent to approximately 5 Mtpa of metallurgical product coal. An infrastructure corridor will link the Project to the Lake Vermont Coal Mine processing area to utilise the existing processing plant and train loadout facility.

Unanticipated climate change has the potential to cause significant impacts on the operation of the Project. Key climate related issues that may affect the Project include:

- Changes in temperature
- Changes in the frequency or severity of bushfires
- Changes in rainfall.

The changes have various implications that may be beneficially addressed by changes in the design of the Project or other adaptive measures.

The Terms of Reference identifies the key objectives of the Climate Change Assessment as the following:

- Describe the site's climatic patterns that are relevant to the environmental assessment
- Describe how these climatic patterns are likely to change over the lifetime of the Project
- Assess the risk to Project components due to existing and future climate patterns
- Propose strategies to mitigate the predicted climate change effects.

The Climate Change Assessment of the Project forms a critical feature of environmental risk management. The Climate Change Assessment has been conducted based on the guidance provided in:

- Australian Standard AS 5334-2013 - Climate change adaptation for settlements and infrastructure - A risk based approach.
- ISO14091-2021 Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment.

The Project is located approximately 25 km north of Dysart and approximately 160 km southwest of Mackay, within central Queensland. The region is classified as subtropical with a moderately dry winter. The climate in this region is characterised by warm humid summers and mild winters.

The Climate Change Assessment has found the following potential changes in climatic variables:

- Increased temperatures
- Increased risk of bushfires

- Minor potential for decreased average annual rainfall.

The Climate Change Assessment has found:

- The key risks (where unmitigated risk has been assessed as either 'Medium' or 'High' risk) to the Project due to the potential changes in climate include:
    - Projected temperature increases:
        - Increased energy demand for cooling and reduced efficiency of electrical systems.
        - Higher levels of dust generation due to increased evaporation and, consequently, decreases in soil moisture levels.
        - Increased likelihood of spontaneous combustion of coal stockpiles.
    - Projected increased frequency of bushfire events:
        - Damage to infrastructure from bushfires.
        - Critical infrastructure is inaccessible due to bushfires.
        - Increased risk of coal stockpile catching fire.
    - Projected decrease in average annual rainfall:
        - Decreased water availability for coal processing
        - Decreased water availability for dust suppression.
- By implementing the following adaptation and mitigation measures, the risk can be reduced to 'Low' or 'Medium':
    - Infrastructure will be designed and operated to ensure that critical infrastructure and processes, and staff health and safety, are maintained under increased heat stress conditions
    - Dust levels can be managed but may require increased resources to ensure they are maintained at acceptable levels under extreme conditions
    - Coal stockpiles will be managed to ensure early detection of heat build-up or spontaneous combustion and enable heat reduction and rapid fire suppression
    - Bushfire risk will be managed through mine design, use of fire breaks and design and management of coal stockpiles.
    - Risk of failure of revegetation for site rehabilitation will be managed through practical soil and soil cover methods and use of mine water where appropriate for watering early establishment plantings during extended dry conditions.

The uncertainty associated with climate extremes means that it is not possible to successfully mitigate all risks and it may be necessary to have other measures in place to offset or remediate the effect of climate change hazards on infrastructure, assets, or processes.

# 1. INTRODUCTION

Katestone Environmental Pty Ltd (Katestone) was commissioned by AARC Environmental Solutions Pty Ltd (AARC) on behalf of Bowen Basin Coal Pty Ltd (Bowen Basin Coal), to conduct a Climate Change Assessment for the Lake Vermont Meadowbrook Project (the Project), a proposed underground coal mine located 25 km north of Dysart and approximately 160km southwest of Mackay, within the Bowen Basin of central Queensland.

Unanticipated climate change has the potential to cause significant impacts on the operation of the Project. Key climate related issues that may affect the Project include:

- Changes in temperature
- Changes in the frequency or severity of bushfires
- Changes in rainfall.

The changes have various implications that may be beneficially addressed by changes in the design of the Project or other adaptive measures.

The Terms of Reference identifies the key objectives of the Climate Change Assessment as the following:

- Describe the site's climatic patterns that are relevant to the environmental impact assessment, with particular regard to the proposed project's discharges to water and air and the propagation of noise
- Describe how these climatic patterns are likely to change over the lifetime of the Project
- Assess the risk to Project components due to existing and future climate patterns
- Propose strategies to mitigate the predicted climate change effects.

# 2. PROJECT DESCRIPTION

The Project is an extension of the existing Lake Vermont Coal Mine (open-cut) that will supplement the decline in coal output from the existing open-cut operation to maintain the approved 12 million tonnes per annum (Mtpa) Run-of-Mine (ROM) coal limit and extend mine life by 20 years. It is located approximately 20 km north of Dysart and 160 km southwest of Mackay, within central Queensland.

The Project involves the construction and operation of an underground double-seam, longwall coal mine with an adjacent small-scale open-cut pit. Extraction rates from the Project are forecast to be up to 6 Mtpa of ROM coal, equivalent to approximately 5 Mtpa of metallurgical product coal, over a life of 20-25 years. An infrastructure corridor will link the Project mining area to the Lake Vermont Coal Mine processing area to utilize the existing processing plant and train loadout facility.

The Project is located within the Isaac Regional Council Local Government Area across two Mineral Development Leases (MDLs) 429 and 3939, and the Lake Vermont Coal Mine Mining Leases (MLs) 70331, 70477, and 70528. Figure 1 shows the location of the Project within Queensland and Figure 2 shows the indicative Project layout.

The landscape surrounding the Project site is predominantly flat to slightly undulating pastoral land to the north, east and south. Large coal mines are located approximately 8km to the west with forested hills beyond. The township of Dysart is located approximately 25 km south of the Project and the township of Middlemount is approximately 45 km southeast.

Water for the Project will initially be sourced from Eungella Dam via SunWater's Eungella Water Pipeline Pty Ltd. The Eungella Dam is managed by Sunwater through the Bowen Broken Rivers Scheme. Once construction of the underground mine is completed, the Project will be a net producer of water.

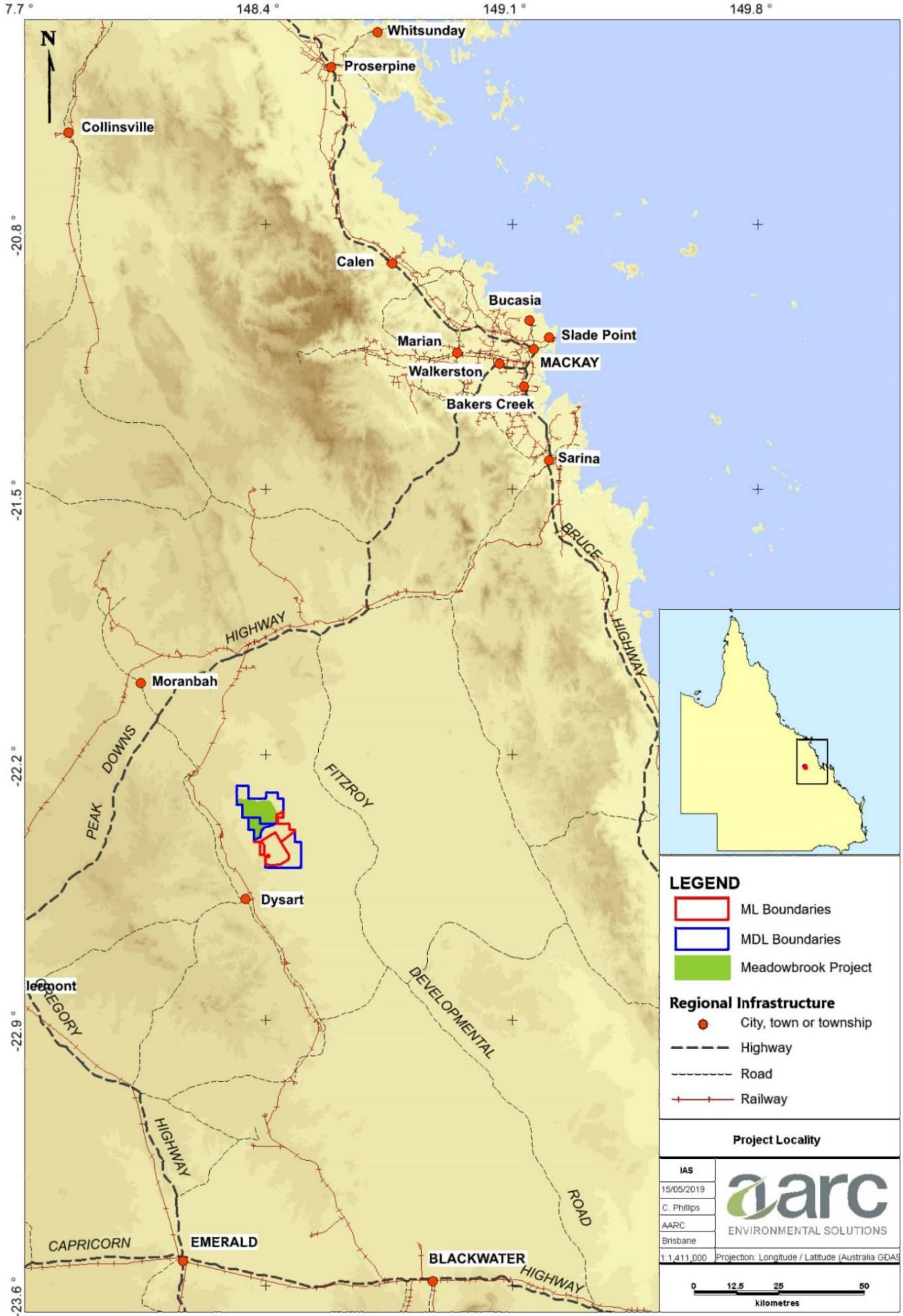



**Figure 1** **Regional location of the proposed Lake Vermont Meadowbrook Project (AARC, 2020)**

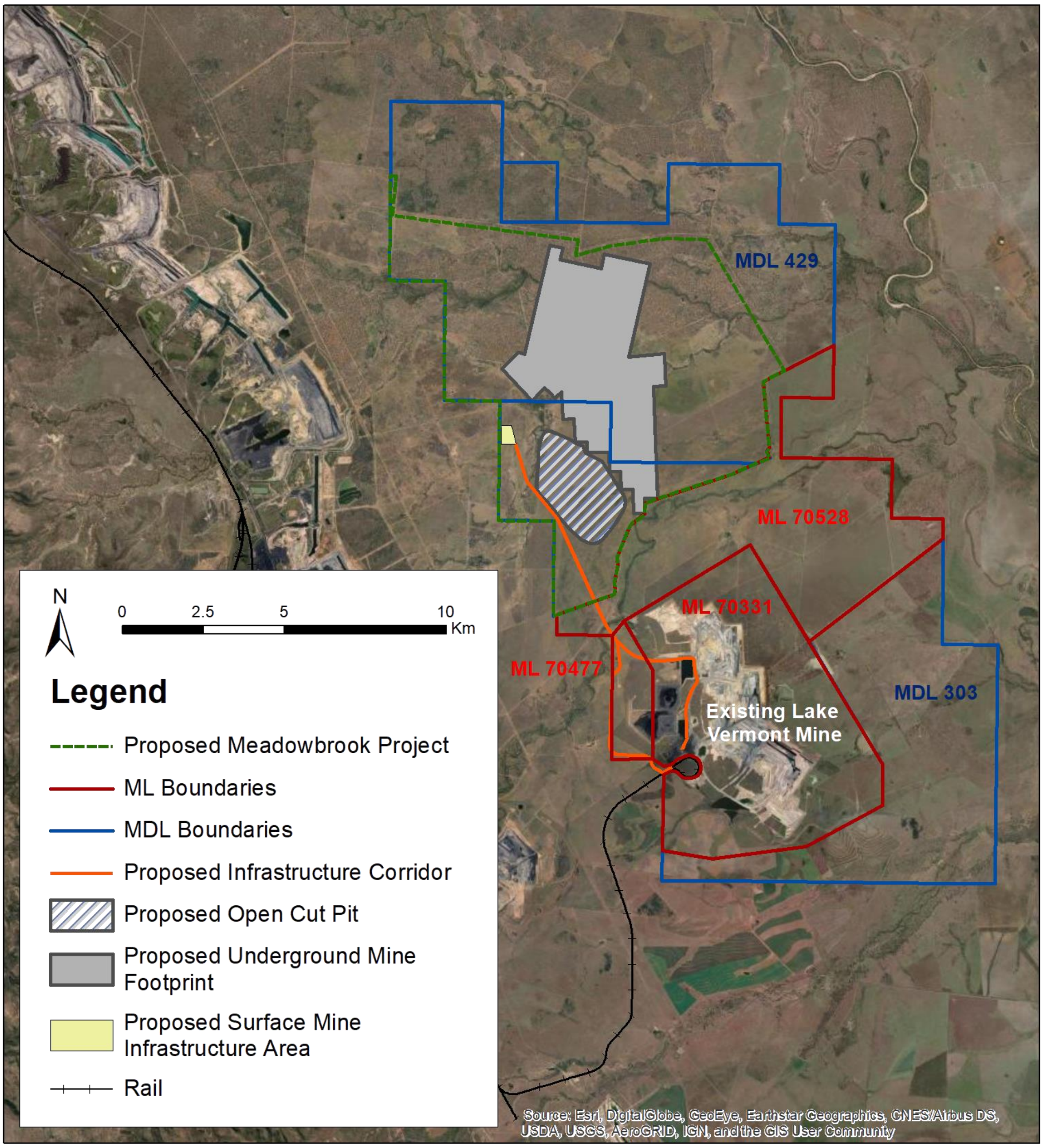



**Figure 2** **Conceptual proposed Project layout (AARC, 2020)**

# 3. REGULATORY FRAMEWORK AND POLICY CONTEXT

## 3.1 Relevant standards and guidelines

The Climate Change Assessment has been conducted with consideration of the following relevant standards and guidelines:

- Requirements of the TOR for the Lake Vermont Meadowbrook Project (Queensland Government, 2020)
- National Climate Resilience and Adaptation Strategy (Department of the Environment and Energy, 2015)
- Queensland's *Climate – EIS information guideline* (DES, 2020)
- Australian Standard AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach
- Australian and New Zealand Standard AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*
- *Guideline for Climate Change Adaptation*, Rev2.1: October 2011. (Australian Green Infrastructure Council, 2011).
- International Organization for Standardization ISO 14091-2021, *Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment*, First edition, 2021-02.

## 3.2 Planning criteria

On 26 August 2019, DES approved an application for Bowen Basin Coal Pty Ltd to voluntarily prepare an EIS under the EP Act for the Project. Under Section 125 of the EP Act, the EIS will form the application documents for the requirements of Chapter 3 of the EP Act. The Project was determined to be a controlled action (per EPBC Referral 2019/8485) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth, EPBC Act) on 22 November 2019. The controlling provisions are Sections 18 and 18A (listed threatened species and communities); Sections 20 and 20A (listed migratory species); and 24D and 24E (a water resource, in relation to coal seam gas development and large coal mining development).

The EIS for the Project will be assessed under the EP Act, in accordance with the assessment bilateral agreement between the Australian Government and the State of Queensland. Climate is considered as a Project-specific matter under the ToR. Content requirements of the EIS relevant to the Climate Change Assessment include:

- Describe the proposed project area's climate patterns that are relevant to the EIS. At a minimum rainfall, wind speed and direction, air temperature, evaporation, humidity, and atmospheric pressure should be considered.
- Provide climate data in a statistical form, including long-term averages, seasonal variation, and extreme values. Climate data should be illustrated using maps, graphs, bar charts, windroses and other relevant graphics as necessary.
- Assess the vulnerability of the area to natural and induced hazards, including droughts, floods, bushfires, cyclones and other rainfall and wind events. Consider the relative frequency and magnitude of these events together with the risk they pose to the management of the Project including construction, operation and decommissioning and rehabilitation of the site.
- Describe measures that would be taken to minimise the risks of these events.
- Assess the potential change in climate at the project site over the expected life of the project using references as recommended by the 'Climate – EIS information guideline' (DES 2020).

- Assess the proposed Project's vulnerabilities to climate change (e.g., changing patterns of rainfall, hydrology, temperature and, extreme weather events). The assessment of climate hazards and risks should reference relevant climate projection data and employ standard risk assessment methodologies.
- Describe the adaptation and management strategies and/or activities designed to minimise climate change impacts to the proposed project, subsequent land uses on that site (e.g. rehabilitation projects) and surrounding land uses. Adaptation activities must be designed to avoid perverse outcomes, such as increased emissions of greenhouse gases or maladaptive outcomes for surrounding land uses.

# 4. METHODOLOGY

The Climate Change Assessment for the Project forms a critical feature of environmental risk management. The Climate Change Assessment has been conducted based on the guidance provided in:

- Australian Standard AS 5334-2013 - Climate change adaptation for settlements and infrastructure - A risk based approach.
- ISO 31000:2009 Risk management principles and guidelines.
- ISO14091-2021 Adaptation to climate change – Guidelines on vulnerability, impacts and risk assessment.

Based on the guidance provided in these documents, the Climate Change Assessment was conducted as a four-part process:

1. Climate risk screening
2. Climate assessment
3. Climate change assessment
4. Climate change risk assessment.

The methodology implemented for each of these parts is provided below.

## 4.1 Climate risk screening

Climate risk screening is used to focus the Climate Change Assessment on the physical risks that are of significance to the Project.

Climate screening involves consideration of historical weather and climate coupled with regional climate change projections to determine the physical risks that are most likely to interact with the Project.

## 4.2 Climate assessment

A climate assessment was conducted to establish existing climate conditions applicable to the Project. The climate assessment included consideration of the sensitivity of the Project, which identified critical climate parameters of relevance to the Project. The critical parameters were found to be temperature, rainfall, wind speed, sea level changes, and extreme weather events such as tropical cyclones and bushfires.

The climate assessment considered climatic conditions within the region surrounding the Project, in the context of its location and unique geographical features.

The Project is located approximately 25 km north of Dysart and approximately 160 km southwest of Mackay, within central Queensland. The region is classified as subtropical with a moderately dry winter under the BoM's modified Köppen Classification (BoM, 2020), as shown in Figure 3. The climate in this region is characterised by warm humid summers and mild winters.

Meteorological data for the Project has been acquired from the Scientific Information for Land Owners (SILO) climate database (interpolated grid cell, Stone et al, 2019) and from six long-term BoM weather stations; the locations of these weather stations and availability of datasets are provided in Table 1 and Figure 4.

SILO is a database of Australian climate data that provides gridded daily datasets for a range of climate variables at a national level. Gridded data sets are based on available observations combined with interpolated infills to estimate climate conditions for locations where observations are unavailable.

The data obtained from the SILO climate database and the weather stations has been used to collectively describe the climatic trends within the vicinity of the Project. Historical data is presented as a basis from which future climatic trends, patterns, cycles and extremes can be framed. A baseline period of 1986 – 2005 has been used consistent with climate change projections. In addition, climatic data from 2005 to present has also been considered.

Comparison of site data to available datasets has been used to determine the most representative data source for each of the climate variables included in the Climate Change Assessment.

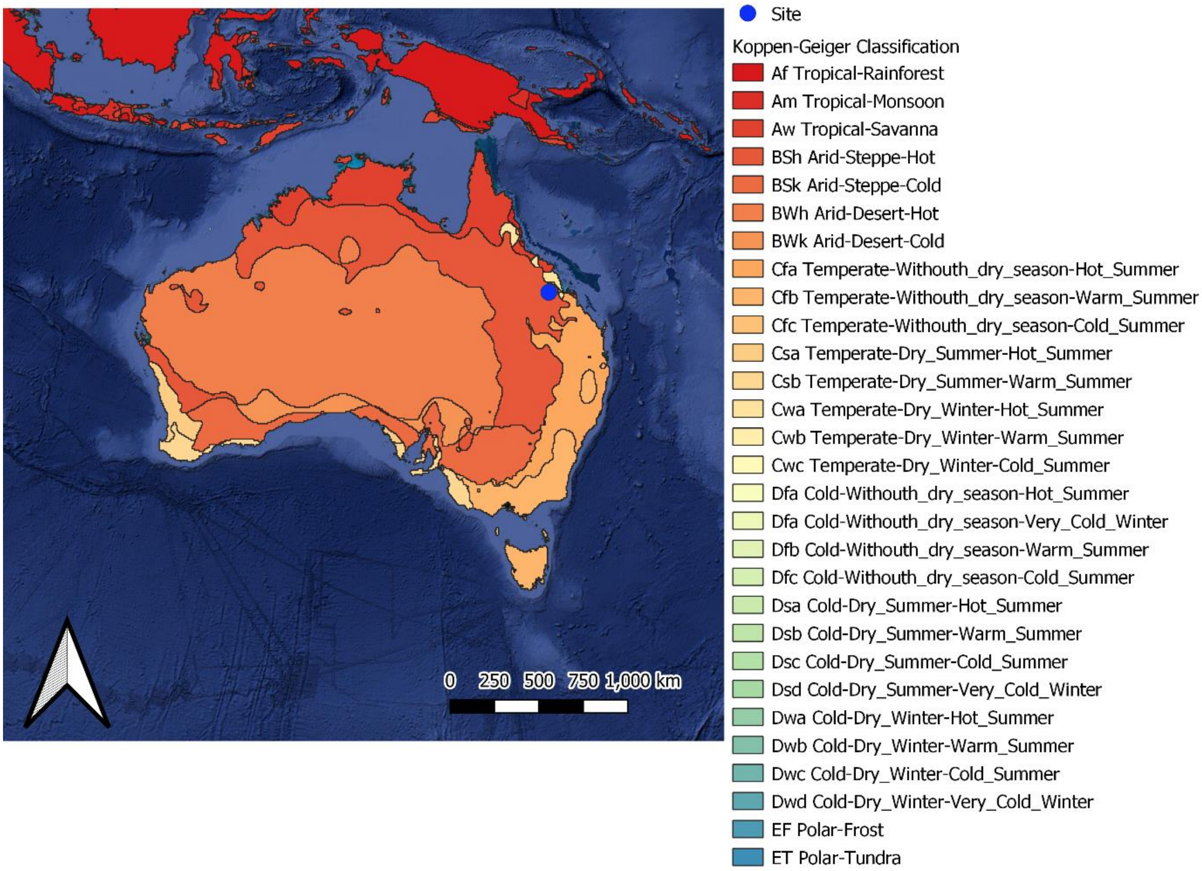



**Figure 3** **Climate Classification of Australia based on modified Köppen Classification (BoM, 2020)**

**Table 1 Sources of Historical Climate Data**

| Source | SILO Climate Database Grid Cell | Moranbah Water Treatment Plant | Clermont Post Office | Moranbah Airport | Clermont Airport | Dysart Post Office | Booroondarra |
|---|---|---|---|---|---|---|---|
| Locality | On Project | ~ 55 km NW of Project | ~ 95 km SW of Project | ~ 52 km NW of Project | ~ 86 km SW of Project | ~12 km SW of Project | ~ 36 km S of Project |
| Data Availability | | | | | | | |
| Temperature | 1889 – 2020 | 1986 - 2012 | 1910 – 2011 | 2012 – present | 2010 – present | N/A | N/A |
| Rainfall | 1889 – 2020 | 1972 – 2012 | 1870 – 2018 | 2012 – present | 2010 – present | 1988 - 2006 | 1929 - present |
| Wind Speed and Direction | N/A | 1986 – 2010 | 1938 – 2010 | 2012 – present | 2010 – present | N/A | N/A |
| Humidity | 1889 – 2020 | 1986 – 2010 | 1962 – 2010 | 2012 – present | 2010 – present | N/A | N/A |

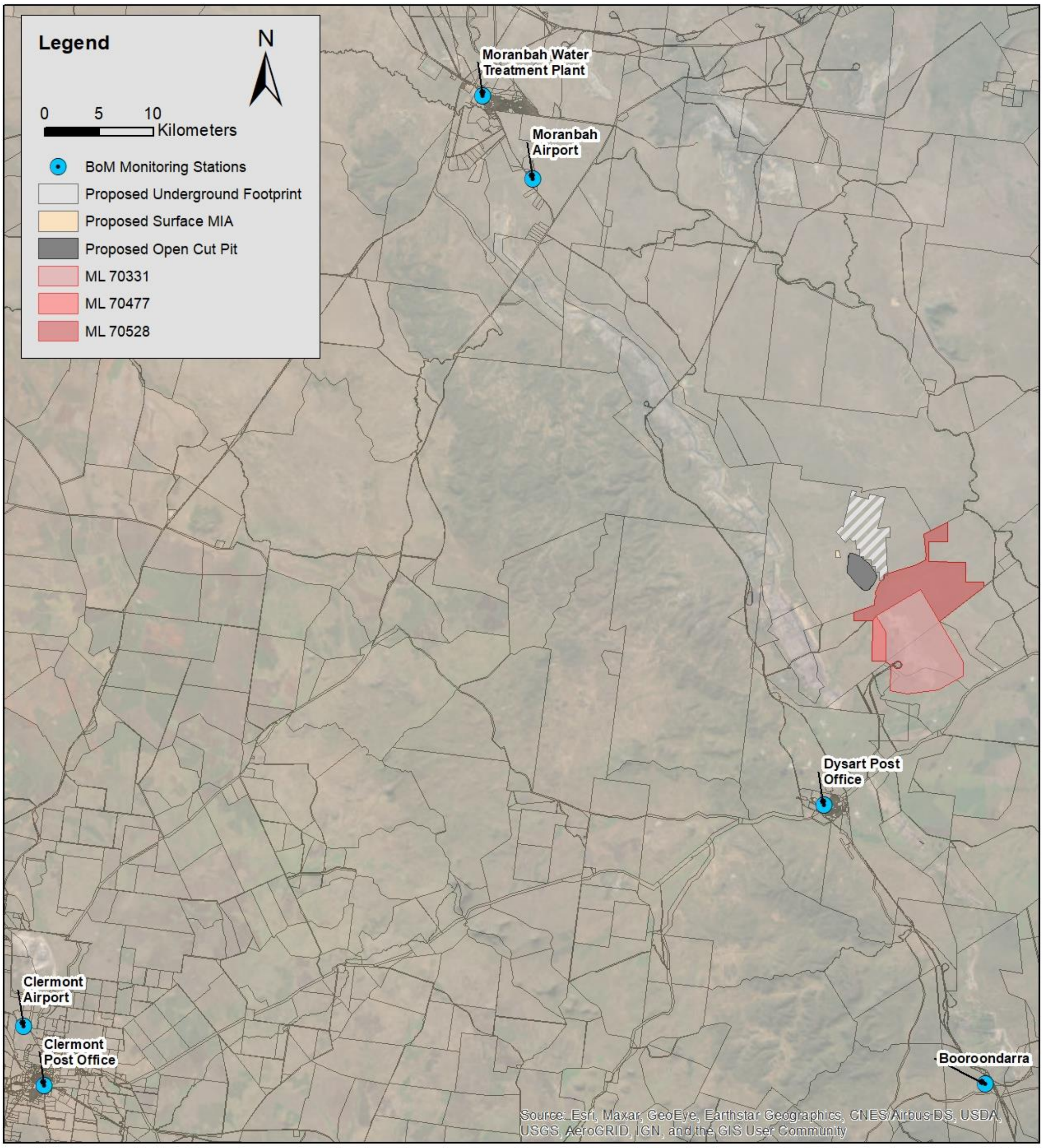



**Figure 4** **Bureau of Meteorology monitoring stations within the vicinity of the Project**

## 4.3 Climate change assessment

### 4.3.1 Climate change considerations

Australia's changing climate represents a significant challenge to individuals, communities, governments, businesses, and the environment. Australia has already experienced increasing temperatures, shifting rainfall patterns and rising oceans. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2021) rigorously assessed the current state and future of the global climate system. The report concluded that it is extremely likely that human activities that emit greenhouse gases (GHG) into the atmosphere are causing the climate to change through the accumulation of these gases, and unequivocal that human influence has warmed the atmosphere, ocean and land.

GHGs including carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) present in the atmosphere influence the stability of the climate relative to their capacity to absorb and radiate heat. Without these gases, the average global temperature would be about 30°C cooler. However, human activities since industrialisation, characterised by the use of fossil fuels for power generation and transport, agricultural activities, and deforestation, have increased the concentrations of these gases to levels where average global temperatures may rise to levels that could result in detrimental changes to the environment. Global average concentrations of all the major long-lived greenhouse gases continue to rise in the atmosphere, with the global annual mean carbon dioxide concentration reaching 410 ppm in 2019 marking a 47% increase from the pre-industrial concentration of 278 ppm in 1750 (BoM, 2020).

Climate change projections of Australia's future climate are delivered at a national level through the Climate Change in Australia (CCiA) website (CSIRO and BOM, 2021, Dowdy et al, 2015). In addition, state-based climate projections for Queensland are delivered by DES through the Long Paddock portal. The Long Paddock projections are provided at a higher resolution than the national projections and provide local-scale information that better represents the climate at a project levels. While the methodologies for producing the national and Long Paddock projections differ, the resulting information about the changing climate is broadly consistent but with some regional differences.

Climate change projections from both CCiA and the Long Paddock portal have been reviewed to provide an understanding of the climate drivers of the region to determine the climate change considerations of relevance to the Project. The potential interaction of the Project with changing weather and climate factors has been analysed to determine the climate parameters that require further consideration.

Climate change projections provided by CCiA have been based on natural resource management (NRM) regions (Figure 5). Australia has been divided into clusters and sub-clusters as indicated by Figure 5. The Project footprint is located within the East Coast (North) sub-cluster.

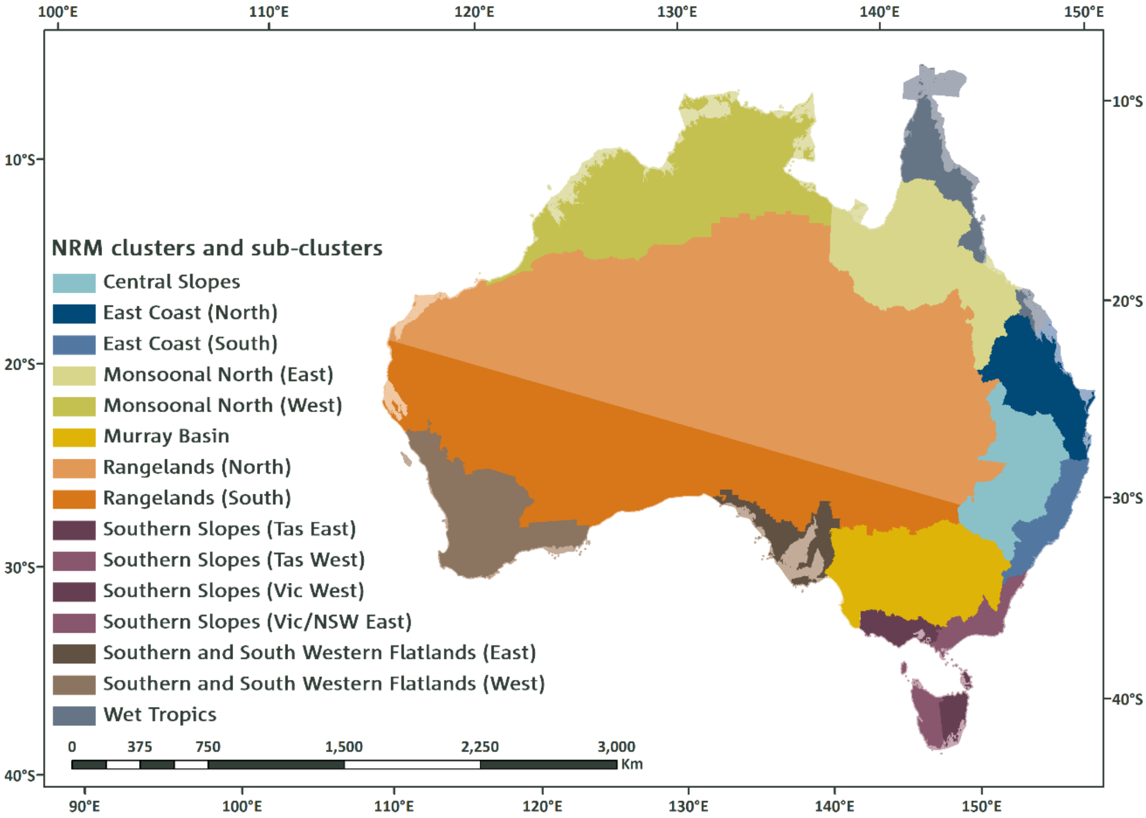



**Figure 5** NRM Cluster Map (CSIRO and BoM, 2015)

The Queensland Future Climate Dashboard (QFCD, available through the Long Paddock portal) provides regionalised summary statistics for Local Government Areas, Regional Plan Areas, Bioregions, Major River Basins, and Disaster Districts. Vector gridded data is also available on the QFCD for a range of metrics and seasons across for four 20-year time slices centred in 2030, 2050, 2070 and 2090. The Project is located in the Isaac Regional Council area. The Project is expected to increase the life of mine by 25 years, prolonging operations until approximately 2060. Consequently, climate projections based on time slices centred in 2050 and 2070 have been considered in the Climate Change Assessment. All climate change projections provided by the QFCD and CCiA are relative to a 1986-2005 baseline period.


**Figure 6** **Map of Queensland Local Government Areas – showing the location and extent of the Isaac Regional Council area (Source: QFCD, 2021)**

### 4.3.2 Climate change scenario

The global climate model (GCM) simulations provided by CSIRO and BoM (Grose et al, 2015) represent a range of emission scenarios, defined by the IPCC as Representative Concentration Pathways (RCPs). Each RCP represents a different trajectory for greenhouse gas concentrations in the atmosphere, and each reflects varying levels of greenhouse gas emissions, aerosols and land-use change. Given the uncertainty in future conditions, the RCPs allow for consideration of a range of potential future climate outcomes. The four RCPs, RCP2.6, RCP4.5, RCP6, and RCP8.5, are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 watts per square metre ($W/m^2$), respectively).

Figure 7 shows a plot of $CO_2$ emissions and concentrations used as the basis for modelling. Climate change projections based on RCP8.5 have been used for the Climate Change Assessment of the Project; this provides conservative assessment of the impact of climate change on the management of the Project as it is based on the highest projected future atmospheric $CO_2$ concentrations and as a result, the most significant changes to climate.

Section 7 of this report discusses the climate projections as they relate to the Project site.

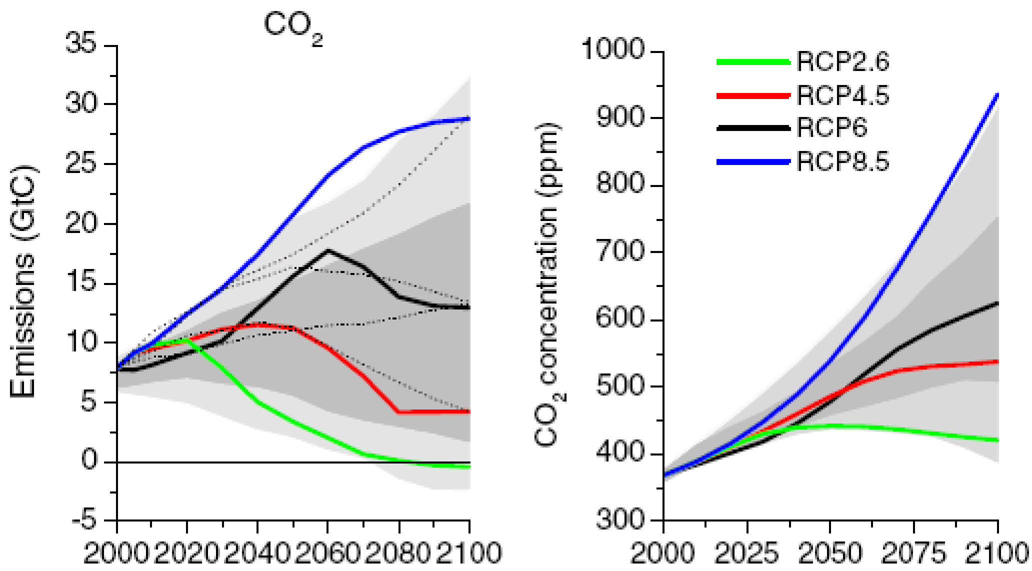



**Figure 7** **Emissions of carbon dioxide across the Representative Concentration Pathways (left), and trends in concentrations of carbon dioxide (right)**

## 4.4 Climate change risk assessment

To assess and appropriately manage the climate change risks that need to be addressed by the Project, a risk assessment process has been implemented. The risk assessment methodology adopted for the Project is based on guidance provided by the following standards:

- AS/NZS ISO 31000:2018 Risk management – Principles and guidelines
- AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach.

The risk assessment in Section 8 identifies and assesses the climate change risks to the Project for the construction and operation of the mine infrastructure, open-cut and underground mines. The purpose of the risk assessment is to identify potential climate change impacts to prioritise environmental management actions and mitigation measures, and to inform the decision-making process regarding the Project.

The risk management framework incorporates the Australian/New Zealand Standard for Risk Management (AS/NZS 31000:2018) and contains quantitative scales to define the **likelihood** of the potential impact occurrence and the **consequence** of the potential impact should it occur. The **likelihood** and **consequence** criteria adopted for the climate change impact assessment are based on AS5334-2013 shown in Table 2 and Table 3. A risk rating has been assigned to each potential impact based on the risk rating matrix presented in Table 4.

**Table 2 Climate change impact assessment - likelihood criteria**

| Likelihood | Description | Recurrent or Event Risks | Long Term Risks |
|---|---|---|---|
| **Almost Certain** | Could occur several times per year | Has happened several times in the past year and in each of the previous 5 years<br>or<br>Could occur several times per year | Has a greater than 90% chance of occurring in the identified time period if the risk is not mitigated |
| **Likely** | May arise about once per year | Has happened at least once in the past year and in each of the previous 5 years, or<br>May arise about once per year | Has a 60–90% chance of occurring in the identified time period if the risk is not mitigated |
| **Moderate** | Maybe a couple of times in a generation | Has happened during the past 5 years but not in every year, or<br>May arise once in 25 years | Has a 40–60% chance of occurring in the identified time period if the risk is not mitigated |
| **Unlikely** | Maybe once in a generation | May have occurred once in the last 5 years, or<br>May arise once in 25 to 50 years | Has a 10–30% chance of occurring in the future if the risk is not mitigated |
| **Very Unlikely (Rare)** | Maybe once in a lifetime | Has not occurred in the past 5 years<br>or<br>Unlikely during the next 50 years | May occur in exceptional circumstances, i.e. less than 10% chance of occurring in the identified time period if the risk is not mitigated |

**Table 3 Climate change impact assessment - consequence criteria**

| Consequence | Adaptive Capacity | Infrastructure, Service | Social / Cultural | Governance | Financial | Environmental | Economy |
|---|---|---|---|---|---|---|---|
| **Insignificant** | No change. | No infrastructure damage, no 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.<br>Early renewal of infrastructure by 10-20%. Need for new/ modified ancillary equipment. | Short-term disruption to employees, customers or neighbours.<br>Slight adverse human health effects or general amenity issues. | General concern raised by regulators, requiring 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.<br>Renewal or repair may need new design to improve adaptive capacity. | Limited infrastructure damage and loss of service.<br>Damage recoverable by maintenance and minor repair. Early renewal of infrastructure by 20-50%. | Frequent disruptions to employees, customers or neighbours.<br>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.<br>Some remedial action may be required. | High impact on the local economy, with some effect on the wider economy. |

| Consequence | Adaptive Capacity | Infrastructure, Service | Social / Cultural | Governance | Financial | Environmental | Economy |
|---|---|---|---|---|---|---|---|
| **Major** | Major loss in adaptive capacity.<br>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.<br>Severe disruptions to employees, customers or neighbours. | Notices issued by regulators for corrective actions. Changes required in management.<br>Senior management responsibility questionable. | Major financial loss 50-90%. | Significant effect on the environment and local ecosystems.<br>Remedial action likely to be required. | Serious effect on the local economy spreading to the wider 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.<br>Loss of infrastructure support and translocation of service to other sites.<br>Early renewal of infrastructure by 90%. | Severe adverse human health effects, leading to multiple events of total disability or fatalities.<br>Total disruption to employees, customers or neighbours.<br>Emergency response at a major level. | Major policy shifts.<br>Change to legislative requirements. | Extreme financial loss > 90%. | Very significant loss to the environment.<br>May include localised loss of species, habitats or ecosystems.<br>Extensive remedial action essential to prevent further degradation.<br>Restoration likely to be required. | Major effect on the local, regional and state economies. |

**Table 4 Climate change impact assessment - Risk Rating Matrix**

| Likelihood | Insignificant | Minor | Moderate | Major | Catastrophic |
|---|---|---|---|---|---|
| **Almost Certain** | Low | Medium | High | Extreme | Extreme |
| **Likely** | Low | Medium | Medium | High | Extreme |
| **Moderate** | Low | Low | Medium | High | Extreme |
| **Unlikely** | Low | Low | Medium | Medium | High |
| **Very Unlikely (Rare)** | Low | Low | Low | Medium | Medium |

# 5. CLIMATE RISK SCREENING

A preliminary climate assessment was conducted to provide an understanding of the climatic conditions of relevance to the Project. Climate parameters considered in the analysis include temperature, rainfall, wind speed and humidity and extreme weather events including bushfires and storms. The sensitivity of the Project to aspects of existing local and regional climate was used to establish the climate parameters that interact with the Project.

An assessment was conducted to identify the climate variables of relevance to the Project. Key climate risks and their potential impacts are identified in Table 5.

**Table 5 Climate variable identification**

| Climate hazard | Climate variable | Project exposure |
|---|---|---|
| Rainfall | Average annual rainfall | Initial water supply for the Project is via the Bowen Broken Rivers Scheme that sources its water from the Eungella Dam located 133km west of Mackay. Water availability from the scheme is governed by catchment rainfall. Once underground mine is constructed, the Project will be a net producer of water. |
| | | Soil moisture and the associated potential for dust generation. |
| | | Site rehabilitation. |
| | Extreme rainfall events | Stormwater management and waste containment. |
| | | Flooding causing damage to infrastructure and equipment and limiting site accessibility. |
| Temperature | Average annual temperature | Soil moisture and the associated potential for dust generation. |
| | | Equipment and machinery efficiency. |
| | Extreme temperature events | Incidence of heat stress. |
| | | Stockpile spontaneous combustion. |
| Wind | Gales and extreme wind events / Cyclones or storms | Dust generation and transport. |
| | | Damage to equipment and structures |
| Relative humidity | Average annual | Equipment and machinery efficiency |
| | | Incidence of heat stress |

| Climate hazard | Climate variable | Project exposure |
|---|---|---|
| Soil | Moisture | Dust generation |
| Bush fire risk | Fire danger index | Stockpile combustion |
| | | Damage to infrastructure |
| | | Site/infrastructure accessibility |

# 6. CLIMATE ASSESSMENT

The following sections provide a summary of climate data relevant to the Project area, including:

- Temperature
- Rainfall
- Wind speed
- Humidity
- Evaporation.

## 6.1 El Nino/Southern Oscillation

Australia's weather patterns are dictated by several climate drivers, which can have varying levels of influence depending on their relative strength at the time. These drivers include the Indian Ocean Dipole (IOD), Madden-Julian Oscillation (MJO), El Niño/Southern Oscillation (ENSO) and the Australian monsoon. Of these drivers, ENSO has the strongest influence on central eastern Queensland.

ENSO is an oceanic-atmospheric coupling that describes an oscillation in the difference in sea surface temperatures between the eastern and western Pacific Ocean and the strength of the Southern Oscillation Index (SOI). The SOI is a measure of the long-term difference in surface air pressure between Tahiti and Darwin (long-term refers to a period of around a month), which is indicative of the Walker circulation. The Walker circulation is caused by a pressure gradient force resulting from a high-pressure system over the eastern Pacific and a low pressure system over Indonesia.

During an El Niño event, there is warming across the central and eastern Pacific, off the coast of Peru, and relatively cooler temperatures in the western Pacific. This leads to below average rainfall across eastern Australia. During a La Niña event, the inverse occurs. The central and eastern Pacific Ocean experiences cooler than average temperatures and higher than average rainfall occurs across eastern Australia. Events are separated by neutral years where the difference in sea surface temperatures is not significant enough to have a substantial impact on weather patterns.

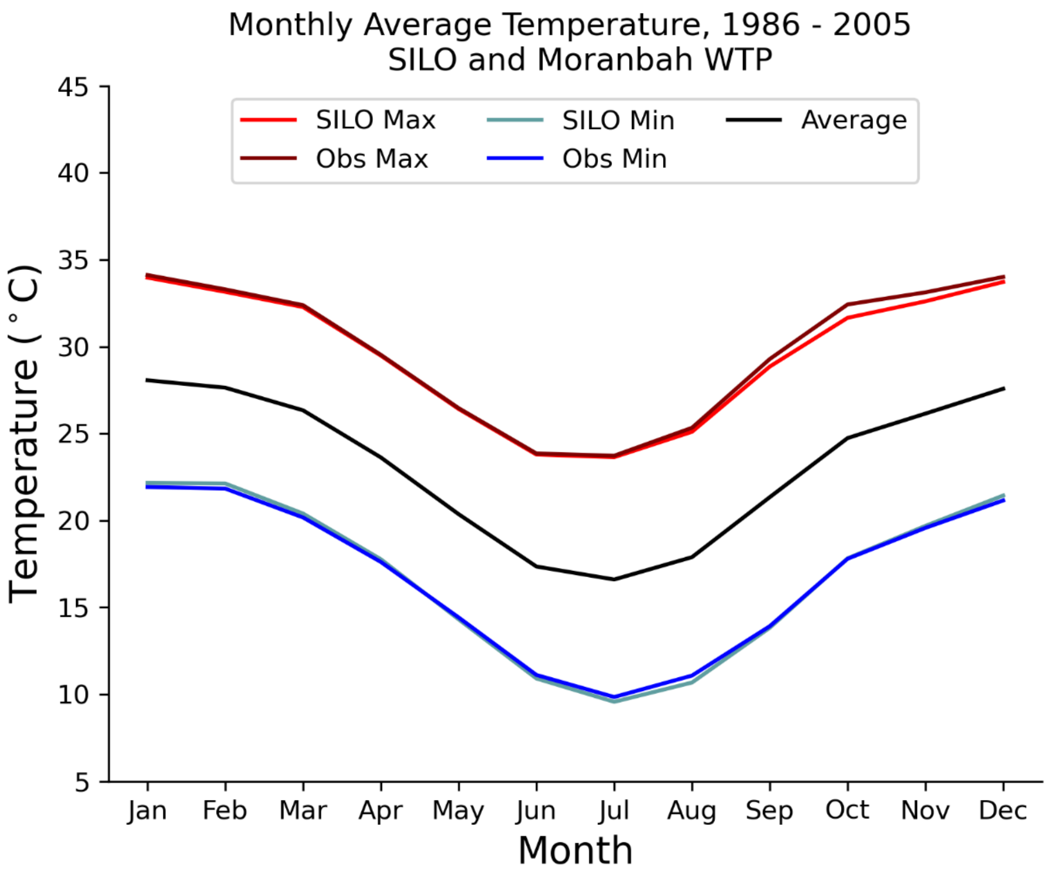
## 6.2 Temperature

This section provides a summary of historical temperatures followed by analysis of key temperature parameters against a background of relevant climate drivers. Extreme temperature events are considered separately in Section 6.6.1.

A comparison of historical temperature data from 1986 – 2005 from the SILO climate database and observations from the Moranbah Water Treatment Plant is presented in Figure 8. The daily mean temperature ranges from a low of 10.1°C to 34.3°C and the highest temperature recorded in the period was 43.7°C.

The data shows:

- There is close agreement between the SILO climate database and BoM weather station data for the baseline period.
- The annual average maximum temperature is 29.5 °C. The annual average minimum temperature is 16.7°C.
- The lowest minimum temperature occurs in July, and the highest maximum temperature occurs in December.




| Temperature | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SILO Climate Database (1986 – 2005)** | | | | | | | | | | | | | |
| Mean Max. (°C) | 34.0 | 33.1 | 32.3 | 29.5 | 26.4 | 23.8 | 23.6 | 25.1 | 28.9 | 31.7 | 32.6 | 33.7 | **29.5** |
| Mean Min. (°C) | 22.2 | 22.1 | 20.4 | 17.8 | 14.3 | 10.9 | 9.6 | 10.7 | 13.8 | 17.8 | 19.7 | 21.4 | **16.7** |
| Mean Temp (°C) | 28.1 | 27.6 | 26.3 | 23.6 | 20.4 | 17.3 | 16.6 | 17.9 | 21.3 | 24.7 | 26.1 | 27.6 | **23.1** |

**Figure 8** **Monthly mean max and min temperatures from the SILO Climate Database (SILO) and Moranbah WTP (Obs)**

## 6.3 Rainfall

This section provides a summary of historical rainfall followed by analysis of rainfall patterns. Extreme rainfall events are considered separately in Section 6.6.3.1.

Eungella Dam supplies the water requirements of the Project through the Bowen Broken Rivers Scheme. The Eungella Dam is within the Burdekin River Basin. Ongoing access to adequate water supplies is dependent on regional rainfall within the Burdekin River Basin. Historical water availability through the Bowen Broken Rivers Scheme is summarised in Figure 9. Accessible water volumes have declined in recent years mostly due to increasing water usage from the scheme and to a lesser extent change in annual rainfall.


**Figure 9 Bowen Broken Rivers System – Historical accessible water volumes**

Rainfall data from the SILO climate database and the BoM weather stations are presented in Figure 10. The data shows the following:

- SILO data is well aligned with BoM weather station data.
- Seasonal trends show less rain during autumn and winter, increasing during spring, and the highest rainfalls occurring during summer.

A timeseries showing the annual rainfall from 1960-2020 as a percent difference from the 1986-2005 annual mean (595 mm) is presented in Figure 11. The plot also indicates El Niño and La Niña events with red and blue shading, respectively. ENSO event records are not available from the BOM prior to 1980, which is indicated by the grey shading. Years with no shading indicate 'neutral' years in which climatic indicators were not sufficiently strong to declare an El Niño or La Niña event.

The plot shows a high level of interannual variability, which is closely tied to the occurrence of an ENSO event. In almost every year where annual rainfall is ±30% average, an ENSO event occurred. Years with smaller deviation from average typically had no event occur. As such, it would be prudent to monitor ENSO events, as discussed by the BoM, in order to anticipate rainfall and subsequent water availability for the region.

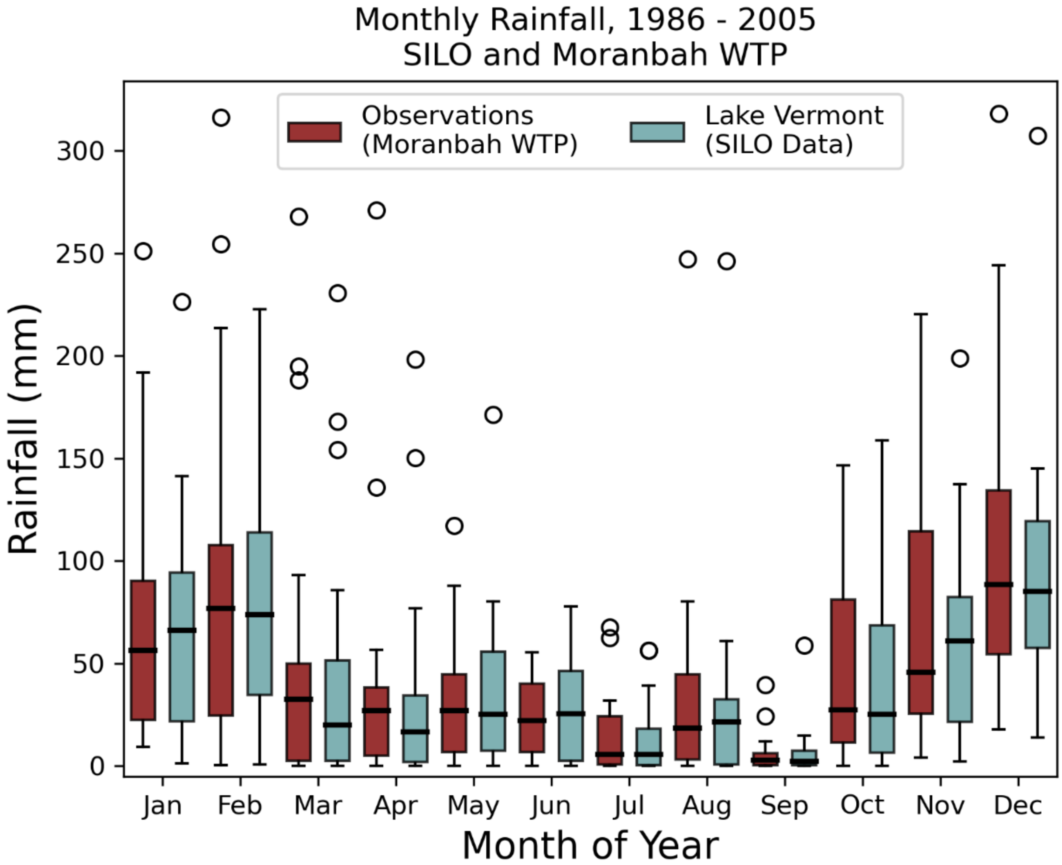



**Figure 10** **Monthly mean total rainfall for on-site SILO Climate Database and nearby BoM weather monitoring stations for the baseline period (1986 – 2005)**

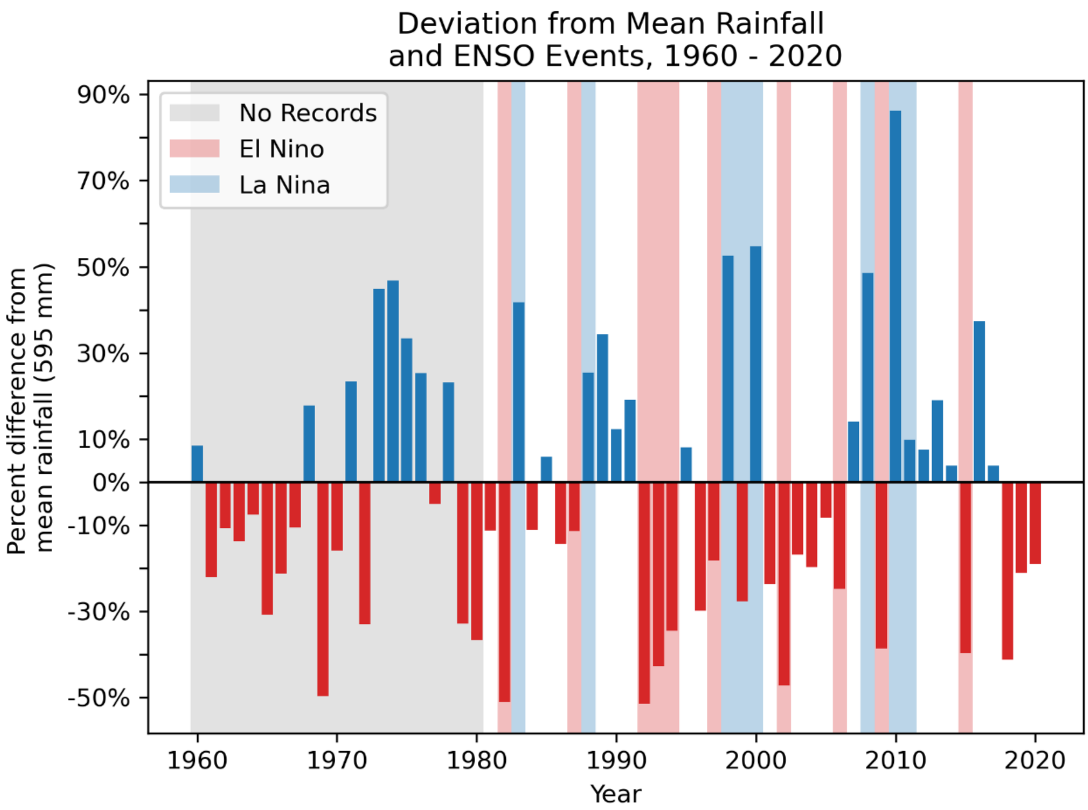



**Figure 11** **Deviation from Mean Rainfall and ENSO Events, Lake Vermont**

## 6.4 Wind Speed

This section provides a summary of historical wind speed and wind direction followed by analysis of wind characteristics. Extreme wind speed events are considered separately in Section 7.5.4. Historical wind speed and wind direction observations are not provided by SILO data. Although the Moranbah Airport monitoring station is closer to the Project, the Clermont Airport BoM site (2010 to 2021) has been selected to characterise the wind speed and wind direction at the Project site. This is due to a similar geographic location and the availability of hourly wind speed and wind direction data from the automatic weather station.

The surface wind climate is driven by the large-scale circulation pattern of the atmosphere. The Project is in the East Coast (North) NRM sub-cluster, approximately 135 km from the east Australian Coastline. Winds in this area are primarily influenced by synoptic level Trade Winds, which are predominantly east-southeasterlies.

The annual, diurnal and seasonal distribution of winds based on the Clermont Airport BoM site are presented in Figure 12, Figure 13 and Figure 14 for the period spanning 2011 to 2020. Annual average wind roses are presented for each individual year, while diurnal and seasonal wind roses depict the average conditions over this 10-year period. Analysis of the annual average wind direction and wind speed for the Clermont Airport (Figure 12) indicates windspeeds are light to moderate with an average of approximately 2 m/s, with the highest hourly average wind speed reported during the measurement period as 9.6 m/s.

Wind directions are predominantly from the east to southeast with the remainder coming from the northeast and to a lesser extent the southeast. This captures the prevalent impact of south-easterly Trade Winds. Diurnal distribution of winds shows strong southeasterlies during daylight hours from 6 am to 6 pm, and weaker overnight winds from 6 pm to 6 am, which exhibit a shift towards more north-easterly winds with some southwesterlies. Seasonal analysis shows average wind speeds ranging from 1.6 to 2.45 m/s. Wind directions move from dominant northeasterlies during spring gradually to very dominant southeasterlies during autumn and winter, while the strongest wind speeds occur during summer.

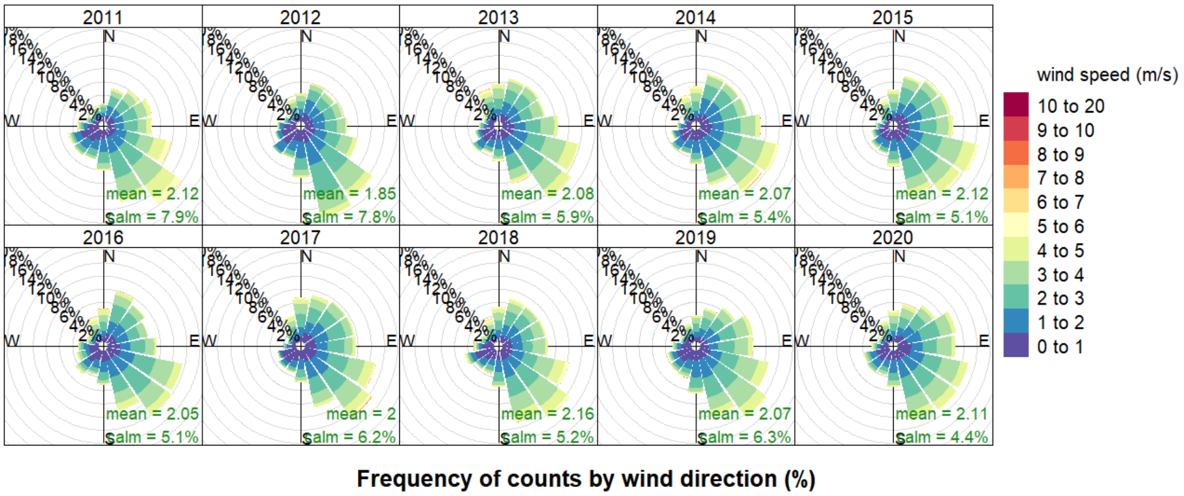



**Figure 12** **Annual average wind speeds and wind directions recorded at Clermont Airport BoM monitoring station (2011 – 2020)**

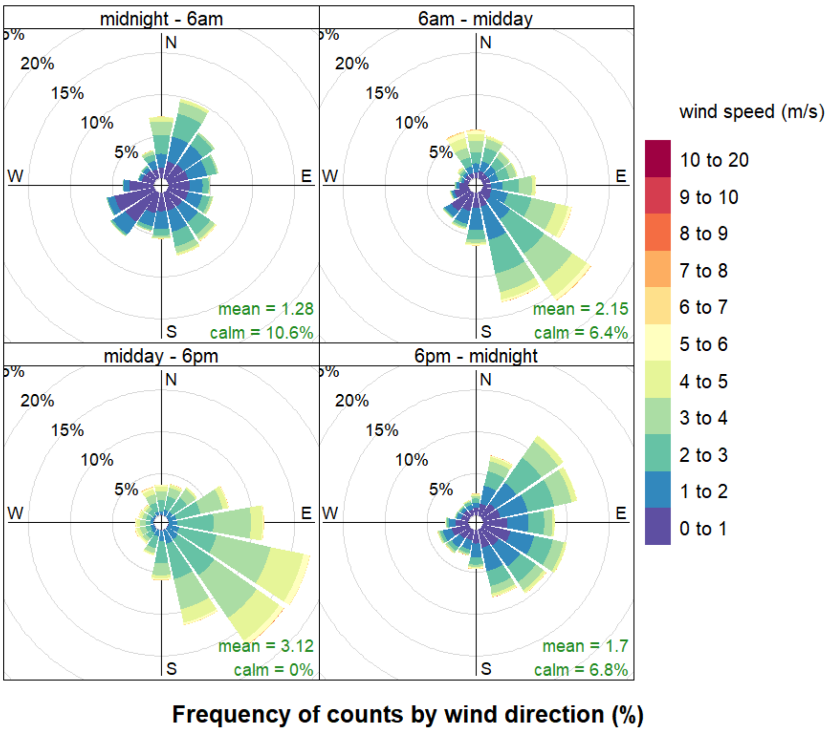



**Figure 13** **Diurnal wind speeds and wind directions recorded at Clermont Airport BoM monitoring station (2011 – 2020)**

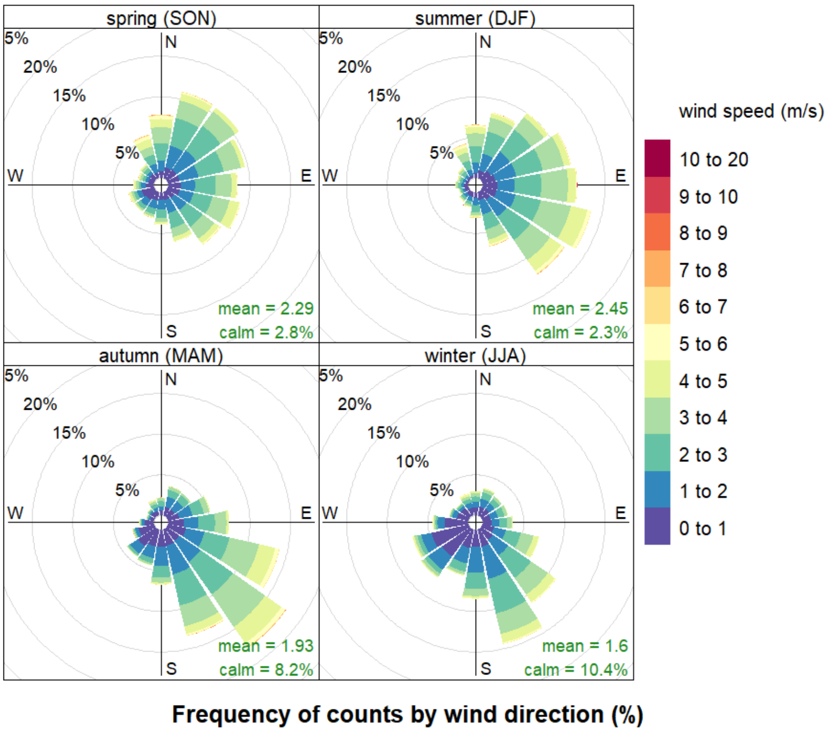



**Figure 14** **Seasonal wind speeds and wind directions recorded at Clermont Airport BoM monitoring station (2011 – 2020)**

## 6.5 Relative humidity

Dew point temperature and relative humidity indicate the moisture content of air. Dew point temperature reflects the minimum temperature that air can reach before the air is completely saturated after which condensation will occur. A high relative humidity indicates that the dew point temperature is close to the current temperature. SILO data does not include relative humidity. Relative humidity data from BoM Clermont monitoring station has been used to characterise relative humidity at the Project location.

Table 6 shows the monthly average fluctuations and annual average relative humidity for the BoM Clermont Airport monitoring station over the period 2011 - 2020.

**Table 6 Monthly and annual average fluctuations in relative humidity (%) for the BoM Clermont Airport monitoring station for the period 2011 – 2020**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2011** | 71.7 | 70.8 | 78.9 | 77.1 | 73.2 | 75.0 | 70.1 | 62.6 | 55.9 | 55.1 | 57.9 | 64.7 | 67.8 |
| **2012** | 68.4 | 69.5 | 73.4 | 64.9 | 69.9 | 75.2 | 83.7 | 68.0 | 58.0 | 51.5 | 53.1 | 52.8 | 65.7 |
| **2013** | 56.7 | 67.8 | ND | 74.7 | 74.0 | 67.1 | 67.3 | 46.9 | 42.0 | 43.9 | 56.2 | 48.6 | 58.7 |
| **2014** | 56.0 | 68.6 | 64.3 | 65.3 | 61.3 | 63.5 | 55.8 | 55.6 | 55.4 | 46.7 | 46.6 | 59.8 | 58.2 |
| **2015** | 67.2 | 63.1 | 55.9 | 52.7 | 54.0 | 61.9 | 53.5 | 49.6 | 43.0 | 47.1 | 51.6 | 52.0 | 54.3 |
| **2016** | 54.9 | 61.5 | 65.6 | 56.3 | 54.4 | 68.9 | 70.8 | 63.8 | 64.2 | 48.4 | 49.0 | 54.0 | 59.3 |
| **2017** | 59.6 | 50.6 | 66.8 | 61.7 | 67.2 | 59.4 | 58.1 | 44.1 | 36.8 | 60.2 | 53.0 | 49.3 | 55.6 |
| **2018** | 50.6 | 62.4 | 65.2 | 55.6 | 51.6 | 53.9 | 48.3 | 39.9 | 40.1 | 48.4 | 40.6 | 56.1 | 51.1 |
| **2019** | 56.7 | 52.8 | 61.5 | 62.0 | 65.3 | 66.4 | 63.0 | 46.9 | 36.0 | 38.8 | 38.7 | 38.0 | 52.2 |
| **2020** | 59.0 | 64.6 | 57.3 | 48.7 | 56.1 | 61.0 | 52.2 | 41.8 | 50.1 | 45.8 | 42.6 | 52.4 | 52.6 |

## 6.6 Extreme weather events

Key factors influencing weather events within the Project region revolve around synoptic level wind patterns, particularly:

- Trade Winds: east-southeasterly winds carrying moisture from the tropical Pacific Ocean, which bring rainfall to tropical and sub-tropical regions east of the Great Dividing Range, particularly from April to September.
- El Niño – Southern Oscillation (ENSO): This is the oscillation between El Niño events, associated with below average rainfall, and La Niña events, causing above average rainfall for eastern Australia.
- The inland trough: A semi-permanent barrier formed by intensive inland surface heating located along the western side of the Great Dividing Range. Rising daytime temperatures cause the trough to deepen and move eastward, causing rainfall and thunderstorms along the east coast.

Changing climate factors can exacerbate the behaviour of these synoptic patterns, resulting in extreme weather events. The following sections characterise the current status of these extreme weather events for the Project.

### 6.6.1 Extreme temperature

Extreme temperatures have been assessed on an annual basis for the SILO climate data extracted at the approximate site location covering the period 1889 – 2021. Annual maximum and minimum temperatures, and percentage of days for each month above 35°C and below 5°C, are presented in Table 7. Values are based on 24-hour average data.

**Table 7 Summary of temperature extremes for the on-site SILO Climate Data**

| Temperature | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SILO Climate Database (1889 – 2021) | | | | | | | | | | | | |
| Average Daily Max Temp | 33.5 | 32.6 | 31.6 | 29.4 | 26.3 | 23.6 | 23.5 | 25.4 | 28.5 | 31.3 | 32.9 | 33.9 |
| Average Daily min temp | 21.7 | 21.4 | 20.1 | 16.8 | 13.0 | 9.9 | 8.5 | 9.4 | 12.9 | 16.4 | 19.2 | 20.8 |
| % of days in mth >35 °C | 29% | 17% | 5% | 0% | 0% | 0% | 0% | 0% | 1% | 7% | 17% | 33% |
| % of days in mth <5 °C | 0% | 0% | 0% | 0% | 1% | 11% | 20% | 11% | 1% | 0% | 0% | 0% |

### 6.6.2 Bushfire zones

Bushfire prone areas are prominent throughout Queensland. Figure 15 presents the classified extent of bush fire prone areas within the vicinity of the Project. As shown, the Project area overlaps some areas classified as medium potential bushfire intensity. Historical bushfires are recorded as fire scars in Figure 16 for available data covering the period 2014 – 2016. This demonstrates that bushfires have occurred in close proximity to the Project site.

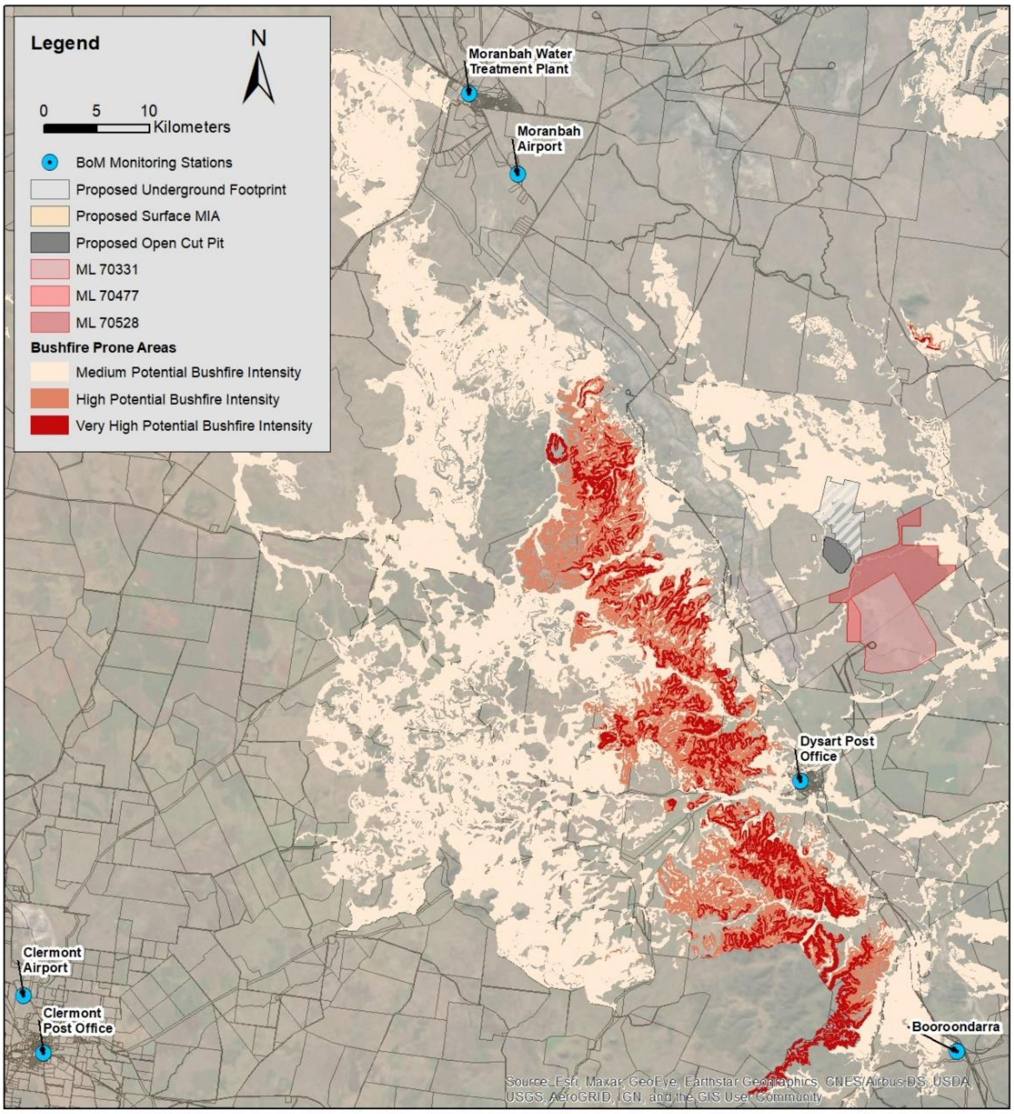



**Figure 15 Bushfire prone areas (Queensland Spatial Catalogue – QSpatial, 2021)**

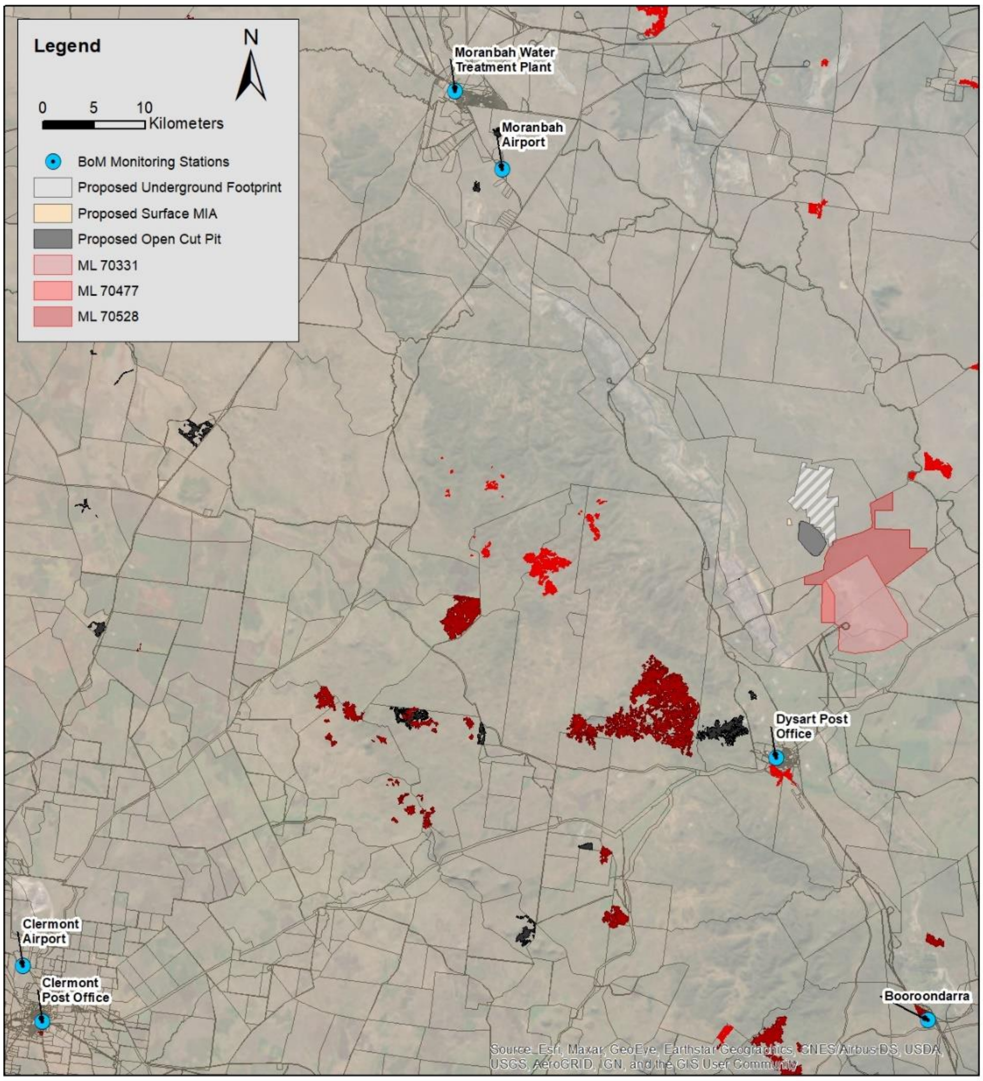



**Figure 16** **Available data on fire scars for 2014, 2015, and 2016 (bright red, dark red, and black, respectively)**

### 6.6.3 Storms and extreme winds

Moist trade winds, La Niña events, and expansion of the inland trough can cause high rainfall events in the East Coast (North) region.

#### 6.6.3.1 Extreme Rainfall

The Booroondarra BoM monitoring station has been used to characterise trends in historical rainfall for the Project area due to its close proximity and long-term coverage, from 1929 – 2021. Data before 1953 rarely had a capture rate greater than 50% and 2021 is an incomplete year, therefore, analysis has focused on the period 1953 – 2020. No data was available from this site in the period from 1969 – 1970. The highest rainfall recorded in a single day in this period was 229 mm and the maximum monthly rainfall was 274.2 mm.

Figure 17 presents the total annual rainfall and the number of days per year without rain. The mean number of days without rainfall is approximately 316 days. The longest consecutive period without rain from 1953 to 2020 was 319 days, or approximately 0.9 years. Figure 18 shows the variation in total annual number of days without rain compared to the average number of days without rain for the examined period. Of the 64 years assessed, 42 years had an above average number of days without rain, while the last 5 years have all seen a greater number of dry days than the average. Comparing annual rainfall totals to annual days without rain indicates that large rainfall events occur over short periods, fluctuating between long periods of dry weather with short intense periods of rain.

Figure 19 depicts the highest amount of rain to fall in 1-hour over the period 2011 – 2020 for each month as recorded at the BoM Clermont monitoring station. This further indicates the prevalence of short but intense rainfall events near to the Project area, with the most intense falls occurring during the summer months of December and January.

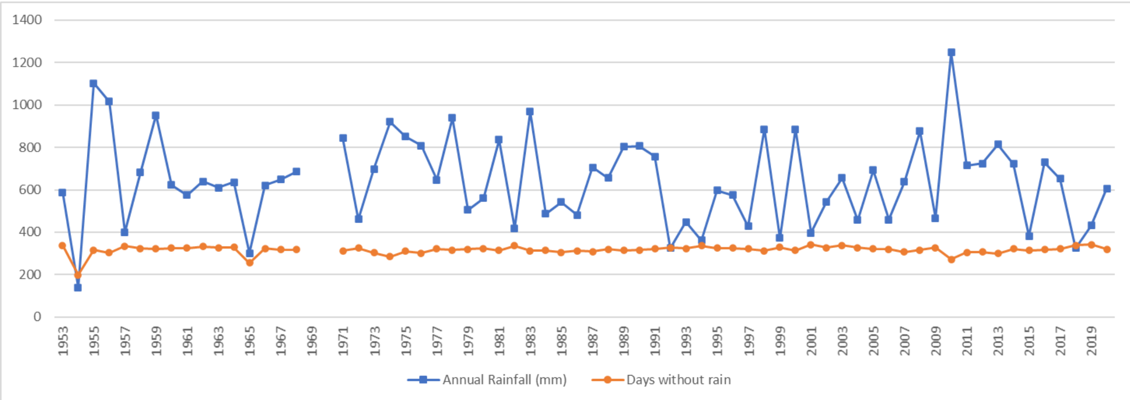



**Figure 17** **Annual total rainfall and annual days without rain recorded at the Booroondarra BoM monitoring station (1953 – 2020)**

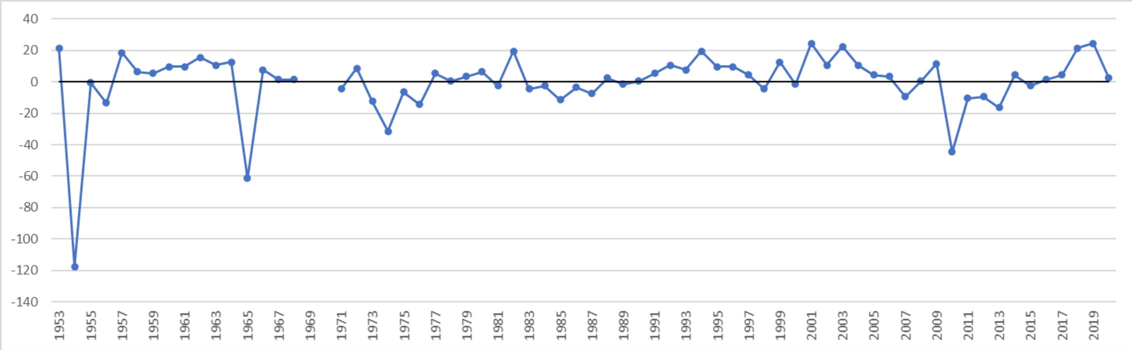



**Figure 18** **Annual days without rain compared to the mean number of days without rain recorded at the Booroondarra BoM monitoring station (1953 – 2020)**

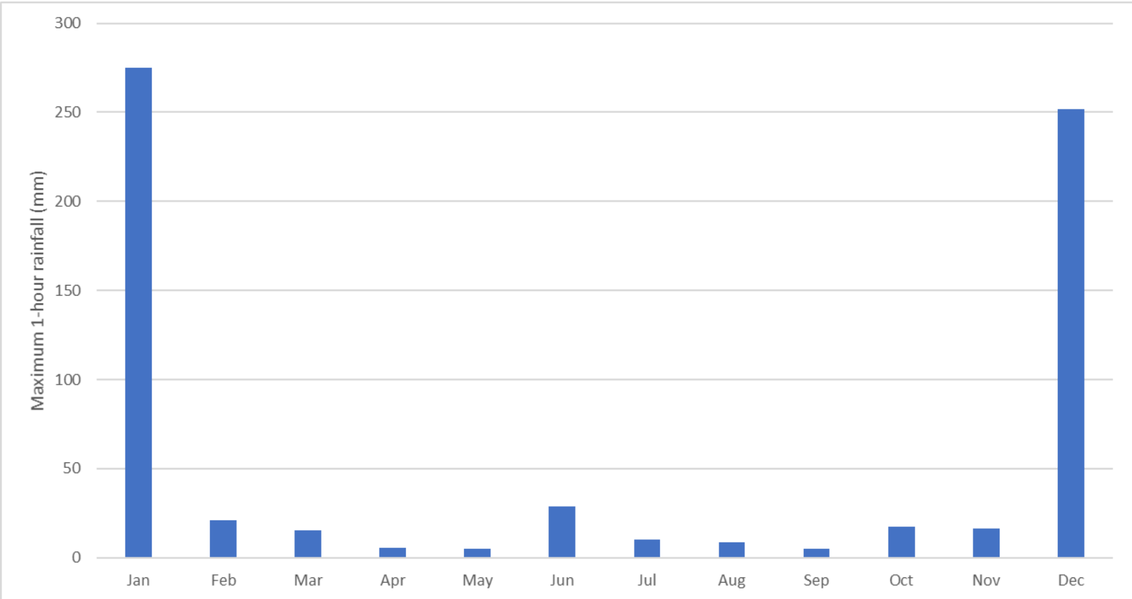



**Figure 19** **Highest 1-hour rainfall event for each month from 2011 – 2020 recorded at the BoM Clermont monitoring station**

### 6.6.3.2 Extreme wind speed

Maximum wind gusts are based on windspeeds measured over 10-minute intervals. However, wind gust measurements are not recorded at the BOM Clermont Airport site. The maximum hourly wind speed recorded at the site is 9.6 m/s

### 6.6.3.3 Tropical Cyclones

The International Best Track Archive for Climate Stewardship (IBTrACS: Knapp et al. 2010) is a global archive of all tropical cyclone tracks from 1897 to 2017. It is updated annually with the best estimate of each individual storm track across all Ocean Basins. The analysis presented here uses a subset of the IBTrACS archive for the South Pacific Basin and East Australian sub basin. The dataset was refined to eliminate those events that would not have a direct impact on the weather and climate of Gladstone; the dataset was constrained to identify tropical cyclones whose eye approached within a 400km radius of Gladstone. The analysis identified 118 tropical cyclones covering the period from 1908 to 2018.

The impacts of cyclone activity (wind or induced water level) can range in severity from heavy rain and little wind to high velocity wind and rain causing major structural damage and flooding over a wide area. For example, Tropical Cyclone Hamish which passed near the Gladstone coastline in March 2009, although it did not cross the coast, closed the Port of Gladstone temporarily due to severe weather conditions (GPC 2009). Tropical Cyclone Debbie, however, in 2017 created a mini tornado which swept through Miriam Vale, Agnes Water, Baffle Creek and Boyne Valley, and other areas were cut off completely and isolated due to flooding (GRC 2017).

On average 1.1 tropical cyclones can be expected to pass within 400km of Gladstone per year. However, this can range from zero to a maximum of seven, as was experienced in 1963 (refer Figure 20 ). The majority of tropical cyclones occur during the tropical cyclone season (1 November to 30 April); however, tropical cyclones have also occurred in May, June and July.

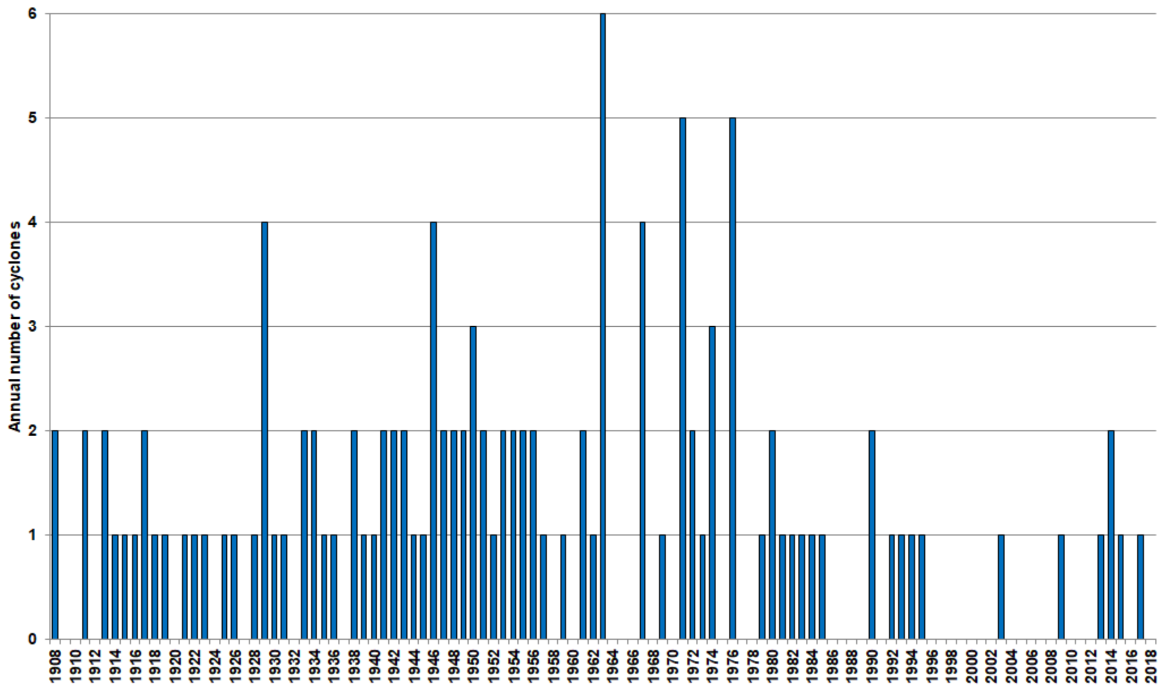



**Figure 20** **Annual total number of tropical cyclones that passed within 400km of Gladstone for the period 1908 to 2018**

# 7. CLIMATE CHANGE

## 7.1 Overview

Climate change projections for key climate parameters and extreme weather events are provided in the following sections. The most recent Queensland climate change projections are based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) endorsed in 2008 by the World Climate Research Programme (WCRP) Working Group on Coupled Modelling (WGCM) (WCRP, 2021). Data from this model was downscaled in a series of steps to improve resolution for Queensland, first to a 50 km resolution via dynamical downscaling using a global variable resolution climate model CCAM (conformal-cubic atmospheric model), then to ~10km using global stretched version of CCAM, covering the period 1980 – 2099.

Data obtainable from the Queensland Future Climate Dashboard (QFCD) (Queensland Government, 2021) as generated via the abovementioned process, has been used to inform the following sections on Climate Change based on predictions for the Isaac Regional Council area.

## 7.2 Temperature

Surface air temperatures in the East Coast (North) sub-cluster have been increasing since national records began in 1910, particularly since 1960. Between 1910 and 2013, daily maximum temperatures increased by 1.0°C in the East Coast (North) sub-cluster. The East Coast (North) sub-cluster is projected to warm at a rate that strongly follows the increase in global greenhouse gas concentrations. Projected increases in median temperatures are presented in Table 8.

Climate change projections compared to corresponding baseline averages for key temperature indicators associated with the Project are illustrated in:

- Figure 21 – mean daily temperature
- Figure 22 – maximum daily temperature.

These figures indicate that average and maximum daily temperatures are likely increase significantly over the life of mining activities due to climate change.

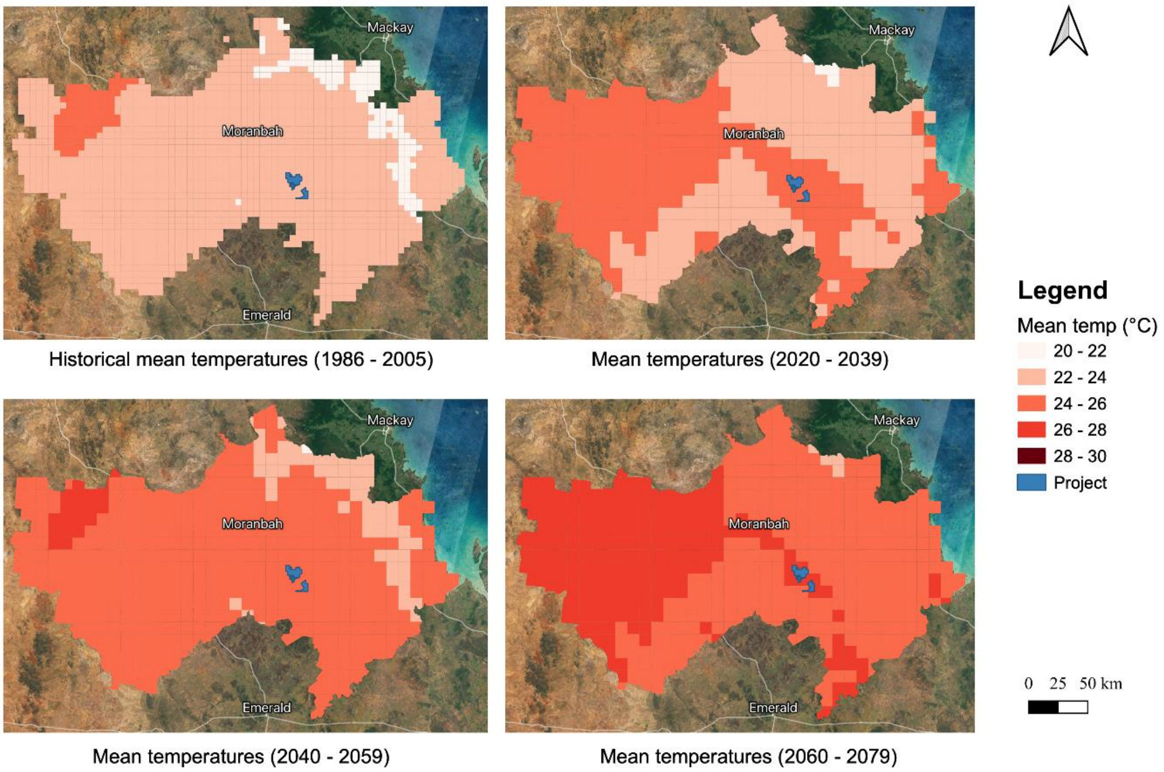



**Figure 21** **Mean daily temperature - Climate change projections for Isaac Regional Council (RCP8.5)** [1]

[1] Notes: Gridded historical data from SILO and gridded climate change projections from Queensland Future Climate Dashboard

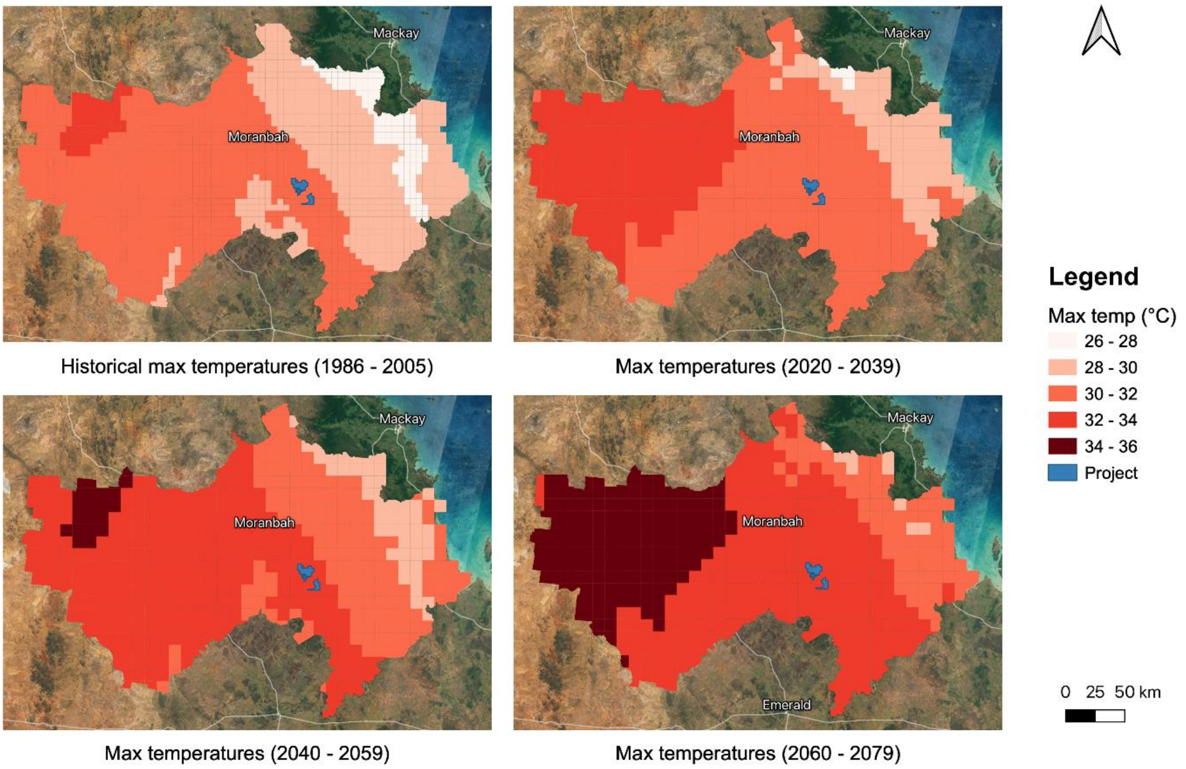



**Figure 22** **Maximum daily temperature - Climate change projections for Isaac Regional Council (RCP8.5)**

QFCD projected changes in daily temperatures for Project location are shown in the following figures:

- Figure 23 – Projected increases in daily mean temperatures
- Figure 24 – Projected increases in daily maximum temperatures
- Table 8 - Projected increases in daily mean and daily maximum temperatures.

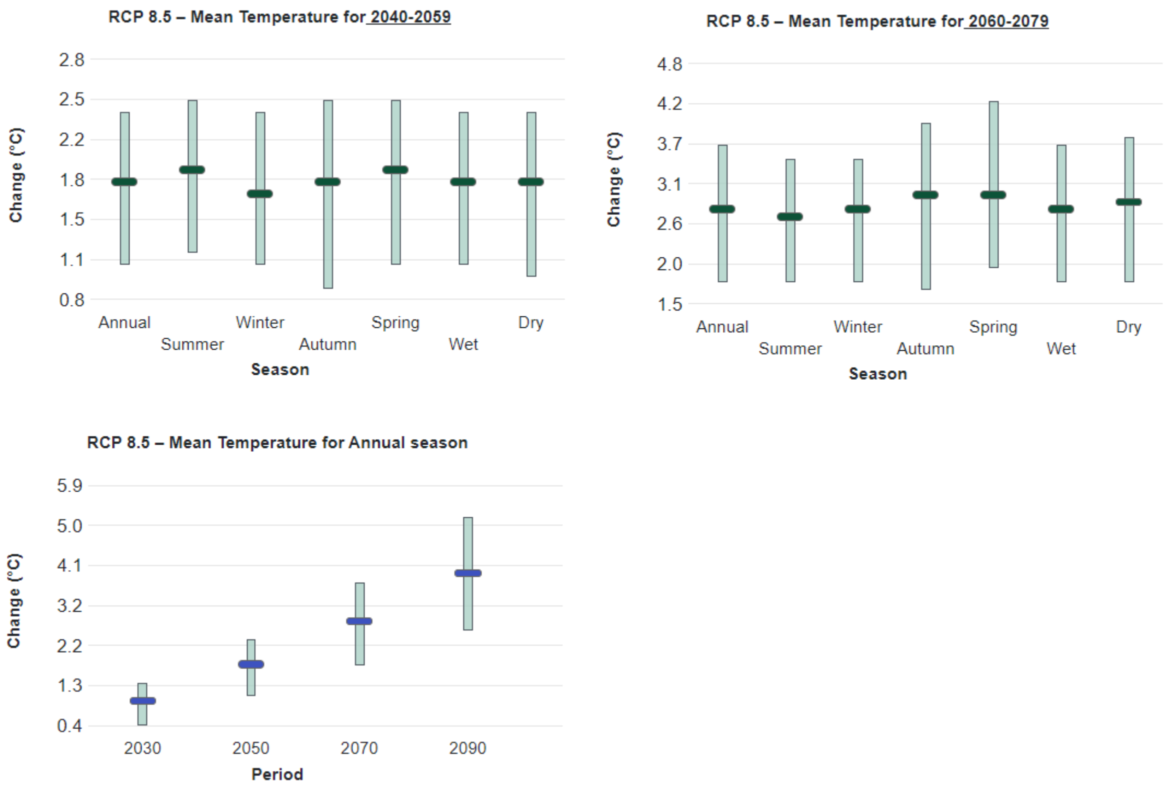



**Figure 23** **Climate Change Projections average daily temperature at the Project location under RCP8.5 for 2040-2056 (centred on 2050) and 2060 - 2079 (centred on 2070)** [2]

Based on the RCP8.5 emission scenario, the mean projected change in average daily temperature for the Project location ranges from 1.8ºC (2050) to 2.8ºC (2070). QFCD projections indicate that increases in average daily and maximum temperatures will be similar in all seasons:

[2] Note: Data represents Change (°C) relative to reference period 1986-2005, horizontal bar indicates the mean temperature

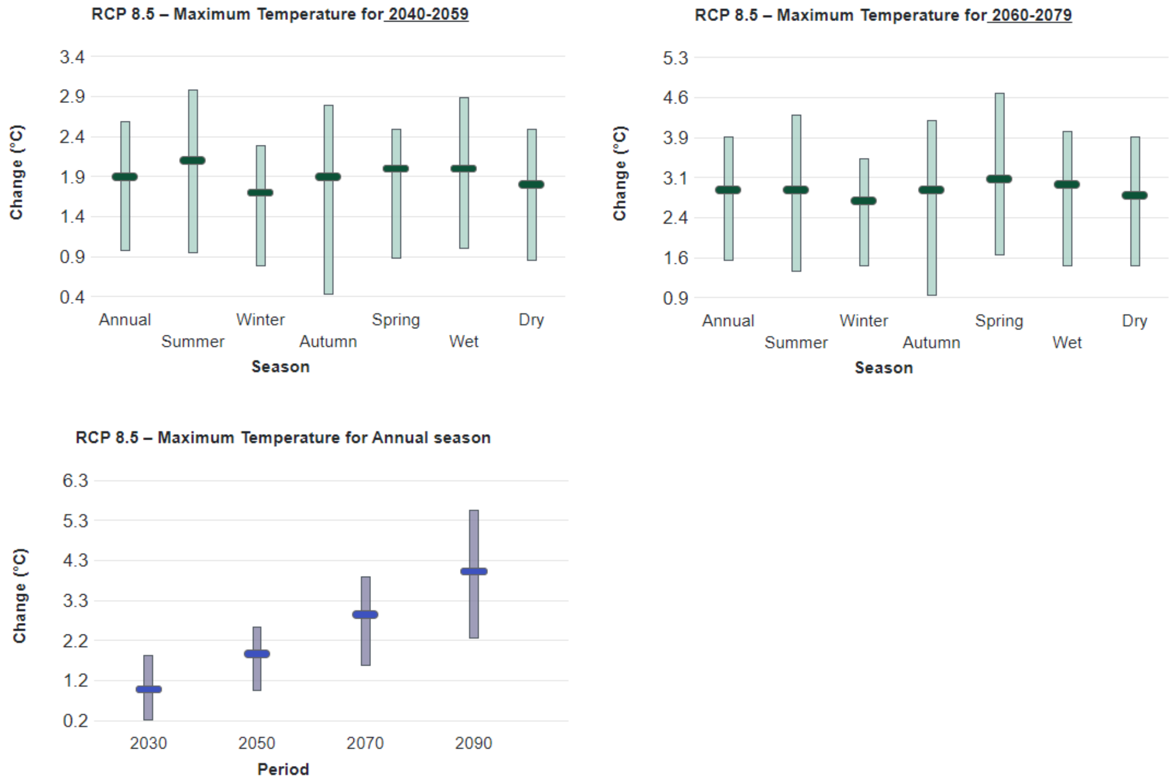



**Figure 24** Climate Change Projections maximum daily temperature at the Project location under RCP8.5 for 2040-2056 (centred on 2050) and 2060 - 2079 (centred on 2070) [3]

**Table 8** Summary of projected average temperature variation for RCP 8.5 at the Project location

| Variable | Season | 2050 | | 2070 | |
|---|---|---|---|---|---|
| | | Mean | Range | Mean | Range |
| Temperature (°C) | Annual | 1.8 | (1.1 to 2.4) | 2.8 | (1.8 to 3.7) |
| | Summer | 1.9 | (1.2 to 2.5) | 2.7 | (1.8 to 3.5) |
| | Autumn | 1.8 | (0.9 to 2.5) | 3.0 | (1.7 to 4.0) |
| | Winter | 1.7 | (1.1 to 2.4) | 2.8 | (1.8 to 3.5) |
| | Spring | 1.9 | (1.1 to 2.5) | 3.0 | (2.0 to 4.3) |
| | Wet | 1.8 | (1.1 to 2.4) | 2.8 | (1.8 to 3.7) |
| | Dry | 1.8 | (1.0 to 2.4) | 2.9 | (1.8 to 3.8) |
| Temperature maximum (°C) | Annual | 1.9 | (1.0 to 2.6) | 2.9 | (1.6 to 3.9) |
| | Summer | 2.1 | (1.0 to 3.0) | 2.9 | (1.4 to 4.3) |
| | Autumn | 1.9 | (0.4 to 2.8) | 2.9 | (1.0 to 4.2) |
| | Winter | 1.7 | (0.8 to 2.3) | 2.7 | (1.5 to 3.5) |
| | Spring | 2.0 | (0.9 to 2.5) | 3.1 | (1.7 to 4.7) |
| | Wet | 2.0 | (1.0 to 2.9) | 3.0 | (1.5 to 4.0) |

[3] Note: Data represents Change (°C) relative to reference period 1986-2005.

| Variable | Season | 2050 | | 2070 | |
|---|---|---|---|---|---|
| | | Mean | Range | Mean | Range |
| | Dry | 1.8 | (0.9 to 2.5) | 2.8 | (1.5 to 3.9) |
| Note: Data represents Change (°C) relative to reference period 1986-2005. | | | | | |

## 7.3 Rainfall

As indicated in section 6.3, rainfall in the East Coast (North) sub-cluster has not shown any long-term historical trends. However, annual rainfall records indicate extended periods of wetter or drier conditions rather than being consistent from one year to the next.

Climate change projections for average annual rainfall across the Isaac Regional Council are illustrated in Figure 25. These figures indicate that there is little change in average annual rainfall projections for 2050 (2040-2059) and 2070 (2060-2079) compared to the baseline period.

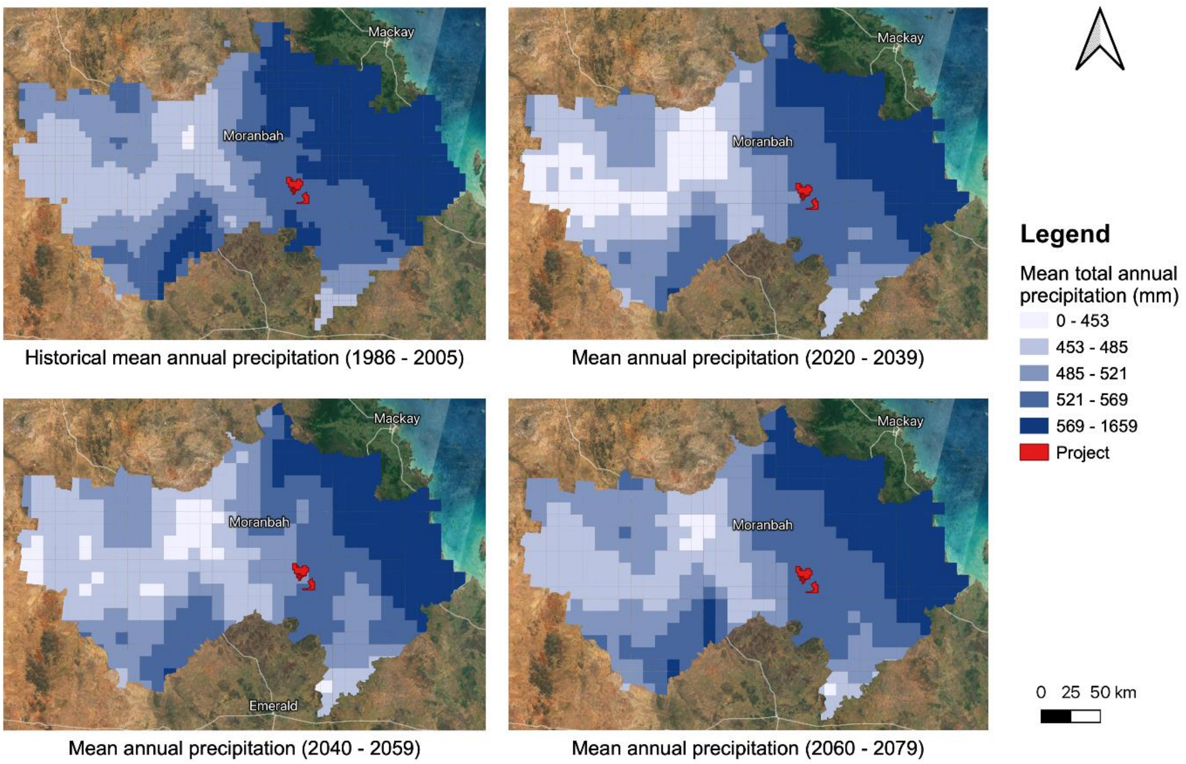



**Figure 25 Mean annual rainfall - Climate change projections for Isaac Regional Council (RCP8.5)**

Seasonal projections of changing rainfall patterns for the site location are summarised in Figure 26, indicating:

- Climate projections provided by QFCD indicate that there will be little change in average daily rainfall in the Isaac Regional Council area
- Projections for 2050 indicate a very small decrease in average annual daily rainfall, with a more obvious decrease projected for spring
- Projections for 2070 indicate a very small decrease in average annual daily rainfall, with an expected increase in summer rain and a more obvious decrease projected for spring.

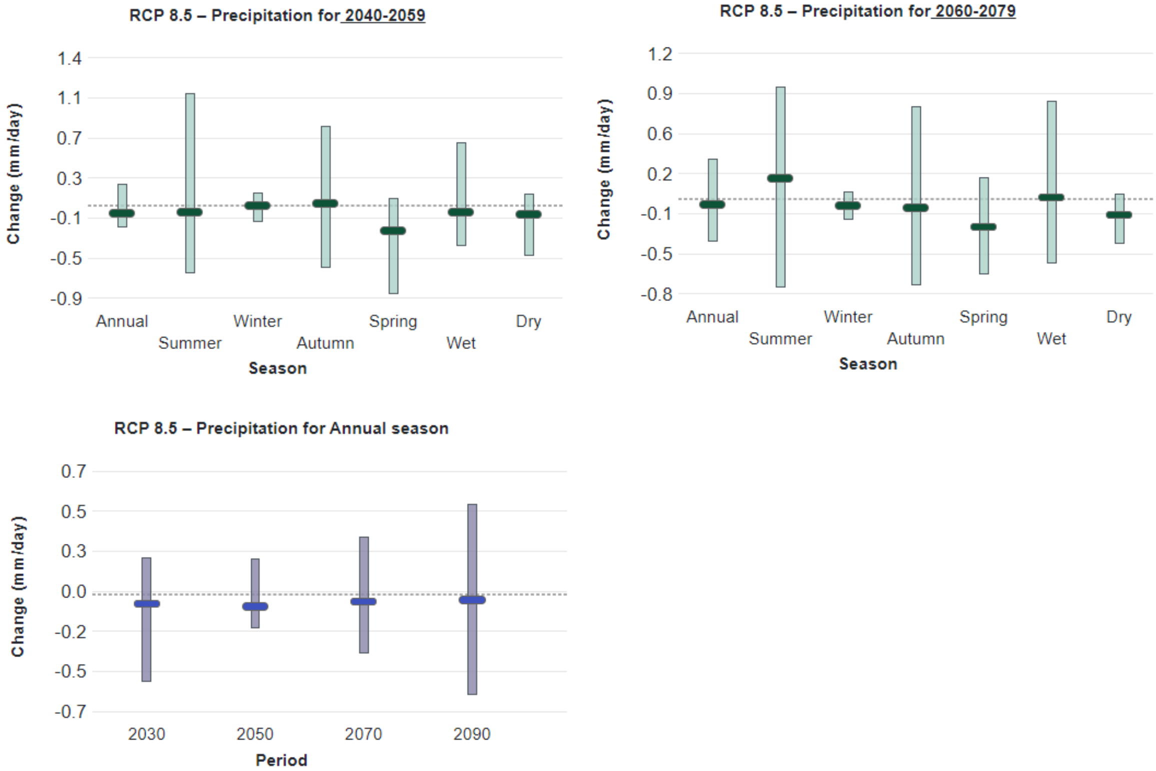



**Figure 26** **Climate Change Projections for daily rainfall at the Project location under RCP8.5 for 2040-2059 (centred on 2050) and 2060 - 2079 (centred on 2070)**

## 7.4 Wind Speed

Climate change projections for wind speed are provided by the CCiA. There is high confidence in little change through to 2070 throughout the East Coast (North) sub-cluster. Predicted wind speed changes for the region, expressed as percentage, are presented in Table 9. On average wind speed is projected to remain unchanged through to life of the Project.

**Table 9 Summary of average windspeed variation (m/s) for RCP 8.5 in the Isaac Regional Council area**

| Season | 2050 | | 2070 | |
|---|---|---|---|---|
| | Median | Range | Median | Range |
| Annual | 0.0 | (-0.1 to 0.1) | 0.0 | (-0.1 to 0.2) |
| Summer | -0.1 | (-0.2 to 0.1) | -0.2 | (-0.4 to 0.2) |
| Autumn | 0.0 | (-0.2 to 0.2) | 0.0 | (-0.3 to 0.2) |
| Winter | 0.1 | (-0.1 to 0.2) | 0.1 | (-0.1 to 0.3) |
| Spring | 0.0 | (0.0 to 0.1) | 0.1 | (0.0 to 0.2) |

## 7.5 Extreme weather events

The cumulative effect of climate change on climate factors can alter the frequency of extreme weather events.

### 7.5.1 Extreme temperatures

Hot days for the East Coast (North) sub-cluster are defined as days with a maximum temperature above 35°C, and very hot days defined as days with a maximum temperature above 40°C.

The frequency of occurrence of hot days and very hot days for the Project location are projected to increase due to climate change. Table 10 provides a summary of projected changes. The instance of hot and very hot days is expected to increase significantly by 2070.

**Table 10 Summary of projected increase in the number of hot and very hot days for RCP 8.5 at the Project location**

| Variable | Season | 2050 | | 2070 | |
|---|---|---|---|---|---|
| | | Mean | Range | Mean | Range |
| Hot days | Annual | 34 | (13 to 53) | 51 | (19 to 74) |
| | Summer | 13 | (2.1 to 21) | 18 | (3.5 to 30) |
| | Autumn | 6 | (0.5 to 12) | 11 | (-0.5 to 20) |
| | Winter | 0.092 | (0 to 0.29) | 0.39 | (0 to 1) |
| | Spring | 14 | (7.1 to 20) | 22 | (13 to 32) |
| Very hot days | Annual | 7.4 | (2.5 to 15) | 16 | (4.9 to 30) |
| | Summer | 4 | (1.1 to 10) | 7.7 | (1.1 to 16) |
| | Autumn | 0.19 | (-0.1 to 0.7) | 0.77 | (0 to 2.5) |
| | Winter | 0.0001 | (0 to 0) | 0.000018 | (0 to 0) |
| | Spring | 3.1 | (1 to 6.1) | 7.3 | (2.5 to 16) |
| Note: Data represents Change days) relative to reference period 1986-2005. | | | | | |

### 7.5.2 Bushfire weather

There is high confidence that climate change will result in harsher fire weather in the future. However, the magnitude of change is dependent on seasonal variations and difficult to predict. Estimates provided for the East Coast (North) sub-cluster indicate that the number of days with 'severe' fire danger will increase by 45% in 2030 and 130% in 2090 under an RCP 8.5 scenario.

### 7.5.3 Extreme rainfall

Extreme rainfall events in the Isaac Regional Council area have generally been associated with cyclone activity. Climate projections for the East Coast (North) sub-cluster indicate that the formation of tropical cyclones is expected to become less frequent. Maximum 1-day precipitation can be used as an indicator of an extreme rainfall event. Climate change projections for the Isaac Regional Council area, indicate that the intensity of extreme rainfall events is expected to decrease in 2050 and 2070 compared to the baseline period.

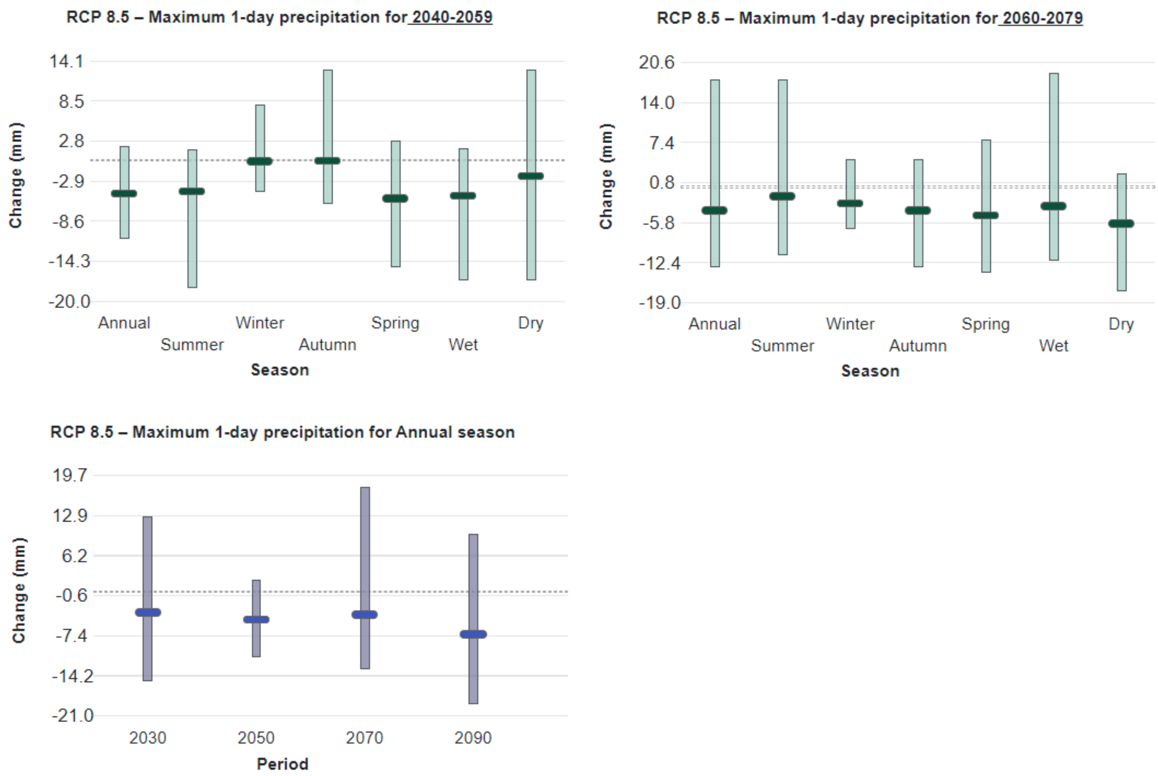



**Figure 27 Climate Change Projections for maximum 1-day rainfall at the Project location under RCP8.5 for 2040-2059 (centred on 2050) and 2060 - 2079 (centred on 2070)**

### 7.5.4 Extreme wind speed

Extreme wind projections for the Project area are less certain than projections for other meteorological parameters due in some part to the influence of surrounding terrain (Grose, M. *et al.,* 2015). Current projections for the East Coast (North) sub-cluster indicate that the annual maximum 1-day wind speed and the 20-year return value for 1-day wind speed are projected to decrease in frequency and intensity.

## 7.6 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 11.

**Table 11 Summary of climate projections for key climate variables associated with the Project**

| Parameter | Statistic | Existing Climate (SILO) | Climate change projections | Comments |
|---|---|---|---|---|
| Temperature | Daily mean temperature | 10.1 to 34.3°C | 2050: +1.8°C<br>2070: +2.8°C | There is consensus that temperatures will increase at a rate that is strongly connected to global GHG emissions rates. |
| | Daily maximum temperature | 43.7°C | 2050: +1.9°C<br>2070: +2.9°C | |
| Rainfall | Average annual rainfall | 595 mm | Little change | There is consensus that the average rainfall will experience little change or a minor decrease in the short term and in the longer term |
| Extreme rainfall | Highest daily rainfall | 134.8 mm | Decrease | The intensity of heavy rainfall extremes is projected to decrease over time as a result of climate change. |
| | Highest monthly rainfall | 307 mm | Decrease | |
| Wind speed | Seasonal mean | 1.6 to 2.45 m/s [a] | Little change | There is consensus that wind speed and maximum wind gusts will experience only minor variations into the future. |
| | Maximum hourly wind speed | 9.6 m/s [a] | Little change | |
| Extreme weather conditions | Bushfire weather | Infrequent and localised | 130% increase in bushfire risk by 2090 | The Project is located in a bushfire prone area; however, historical records indicate a limited occurrence of localised bushfires in the area. |

[a] Data from Clermont Airport BOM. SILO does not maintain wind data

# 8. CLIMATE CHANGE RISK ASSESSMENT

The climate change risk assessment framework for the Project, detailed in Section 4.3 was applied to the potential impacts of climate change on the design, construction and operational activities associated with the Project. A summary of the risk assessment for the climate change impacts together with proposed mitigation measures to manage risk to acceptable levels is provided in Table 12. The assessment of unmitigated risk considers the risk of impacts associated with the Project where the adaptation/mitigation measures have not been considered.

In general, the potential risks identified can be managed through a combination of design measures and management guidelines/procedures.

**Table 12 Climate change risk assessment for operations and rehabilitation - Risk Rating Summary**

| Risk ID | Climate hazard | Potential risk of harm (Risk Statement) | Initial risk assessment | | | Adaptation/mitigation measures | Mitigated risk rating | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk | | Likelihood | Consequence | Risk |
| 1 | Higher average and maximum temperatures | Operations: Increased energy demand for cooling and reduced efficiency of electrical systems | Almost certain | Minor | Medium | Temperature variation during the life of mine will be significant. Energy supply and associated cooling systems will be designed to have sufficient capacity for atmospheric variations under the high emissions scenario (RCP 8.5). | Moderate | Minor | Low |
| 2 | | Operations: Higher levels of dust generation due to enhanced evaporation and, therefore, decreases in soil moisture levels. | Almost certain | Moderate | High | Dust management will include consideration of soil moisture and implement dust control measures as necessary to manage dust to acceptable levels. Dust suppressants will be used that optimise water demand. | Moderate | Minor | Low |

| Risk ID | Climate hazard | Potential risk of harm (Risk Statement) | Initial risk assessment | | | Adaptation/mitigation measures | Mitigated risk rating | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk | | Likelihood | Consequence | Risk |
| 3 | | Operations: Spontaneous combustion of coal stockpiles. | Moderate | Major | High | Increasing temperatures will be considered in the management of coal stockpiling including stockpile size and shape and application of water and other dust suppressants.<br>Stockpile design to facilitate effective control of fires. | Unlikely | Minor | Low |
| 4 | | Rehabilitation: Heat stress leading to poor growth and elevated rates of mortality | Likely | Major | High | Ensure hardening of seedlings before planting; provide mulch and/or establish nurse crop of hardy pioneer species; add biochar to soil mix; ensure deep watering during establishment | Moderate | Moderate | Medium |
| 5 | Increased occurrence of bushfires | Operations: Damage to infrastructure from bushfires | Moderate | Major | High | Adequate fire breaks maintained as part of operations management. Mine design considerate of potential risk of bushfire | Moderate | Moderate | Medium |

| Risk ID | Climate hazard | Potential risk of harm (Risk Statement) | Initial risk assessment | | | Adaptation/mitigation measures | Mitigated risk rating | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Likelihood | Consequence | Risk | | Likelihood | Consequence | Risk |
| 6 | | Operations: Critical infrastructure is inaccessible due to bushfires | Moderate | Major | High | Accessibility to critical infrastructure and emergency response equipment is considered in the mine design | Unlikely | Minor | Low |
| 7 | | Operations: Increased likelihood of coal stockpile catching fire | Moderate | Major | High | Apply early detection warning systems; frequently move or agitate stockpiles to reduce heat accumulation; maintain supply of sprinkler water to cool stockpiles | Moderate | Moderate | Medium |
| 8 | | Rehabilitation: Bushfires cause mass mortality of rehabilitation plantings | Moderate | Major | High | Establish firebreaks, ensure ability of fire crews to access all sites | Moderate | Minor | Medium |
| 9 | Decrease in average annual rainfall | Rehabilitation: Decreased water availability for plant growth during establishment and extended dry periods | Likely | Moderate | Medium | Consider use of mine water for watering of revegetated areas during extended dry conditions | Moderate | Minor | Low |

# 9. CONCLUSION

Unanticipated climate change has the potential to have significant impacts on the operation of the Project. Key climate related issues that may affect the Project include:

- Changes in temperature
- Changes in the frequency or severity of bushfires
- Changes in rainfall.

The changes have various implications that may be beneficially addressed by changes in the design of the Project or other adaptive measures.

The climate change assessment has found:

- The key changes in climate parameters are likely to include:
  - Increases in temperature
  - Increased risk of bushfires
  - Minor potential for decreased average annual rainfall.
- The key risks (where unmitigated risk has been assessed as either ‘Medium’ or ‘High’ risk) to the Project due to the potential changes in climate include:
  - Due to projected temperature increases:
    - Increased energy demand for cooling and reduced efficiency of electrical systems.
    - Higher levels of dust generation due to increased evaporation and, consequently, decreases in soil moisture levels.
    - Increased likelihood of spontaneous combustion of coal stockpiles.
  - Projected increased frequency of bushfire events:
    - Damage to infrastructure from bushfires.
    - Critical infrastructure is inaccessible due to bushfires.
    - Increased risk of coal stockpile catching fire.
  - Projected decrease in average annual rainfall:
    - Decrease water availability for coal processing
    - Decreased water availability for dust suppression.
- By implementing the following adaptation and mitigation measures, the risk can be reduced to ‘Low’ or ‘Medium’:
  - Infrastructure will be designed and operated to ensure that critical infrastructure and processes, and staff health and safety, are maintained under increased heat stress conditions
  - Dust levels can be managed but may require increased resources to ensure they are maintained at acceptable levels under extreme conditions
  - Coal stockpiles will be managed to ensure early detection of heat build-up or spontaneous combustion and enable heat reduction and rapid fire suppression

- Bushfire risk will be managed through mine design, use of fire breaks and design and management of coal stockpiles.
- Risk of failure of revegetation for site rehabilitation will be managed through practical soil and soil cover methods and use of mine water where appropriate for watering early establishment plantings during extended dry conditions.

The uncertainty associated with climate extremes means that it is not possible to successfully mitigate all risks and it may be necessary to have other measures in place to offset or remediate the effect of climate change hazards on infrastructure, assets, or processes.

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