Jellinbah Group

LAKE VERMONT RESOURCES ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 4 CLIMATE

aarc ENVIRONMENTAL SOLUTIONS

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4 Climate

A climate assessment of the Project site has been undertaken in accordance with the DES 'EIS Guideline–Climate' (2020a), with climate risks and potential impacts on the Project being considered (including climate change).

4.1 Existing climate

Long-term meteorological data has been reviewed with consideration of the following meteorological parameters:

- rainfall;
- evaporation and temperature;
- humidity; and
- wind speed and wind direction.

Meteorological data has been extracted from the Bureau of Meteorology (BoM 2022) and interpolated climate modelling sources detailed in Table 4.1, with the location of these data sources shown in Figure 4.1. Long-term meteorological data is summarised in Table 4.2.

Table 4.1: Source of meteorological data

Database	Weather station	Latitude	Longitude	Approximate distance to Project
BoM	Booroondarra (035109)	22.82° S	148.49° E	40 km south-east
	Clermont Airport (035124)	22.78° S	147.62° E	90 km south-west
	Moranbah Airport (034035)	22.06° S	148.08° E	35 km north-west
	Moranbah Water Treatment Plant (034038)	21.99° S	148.03° E	55 km north-west
	Clermont Post Office (035019)	22.83° S	147.64° E	95 km south-west
Scientific Information for Landowners (SILO)	Interpolated Project Grid Point (SILO Meadowbrook Grid)	22.35° S	148.40° E	On Project

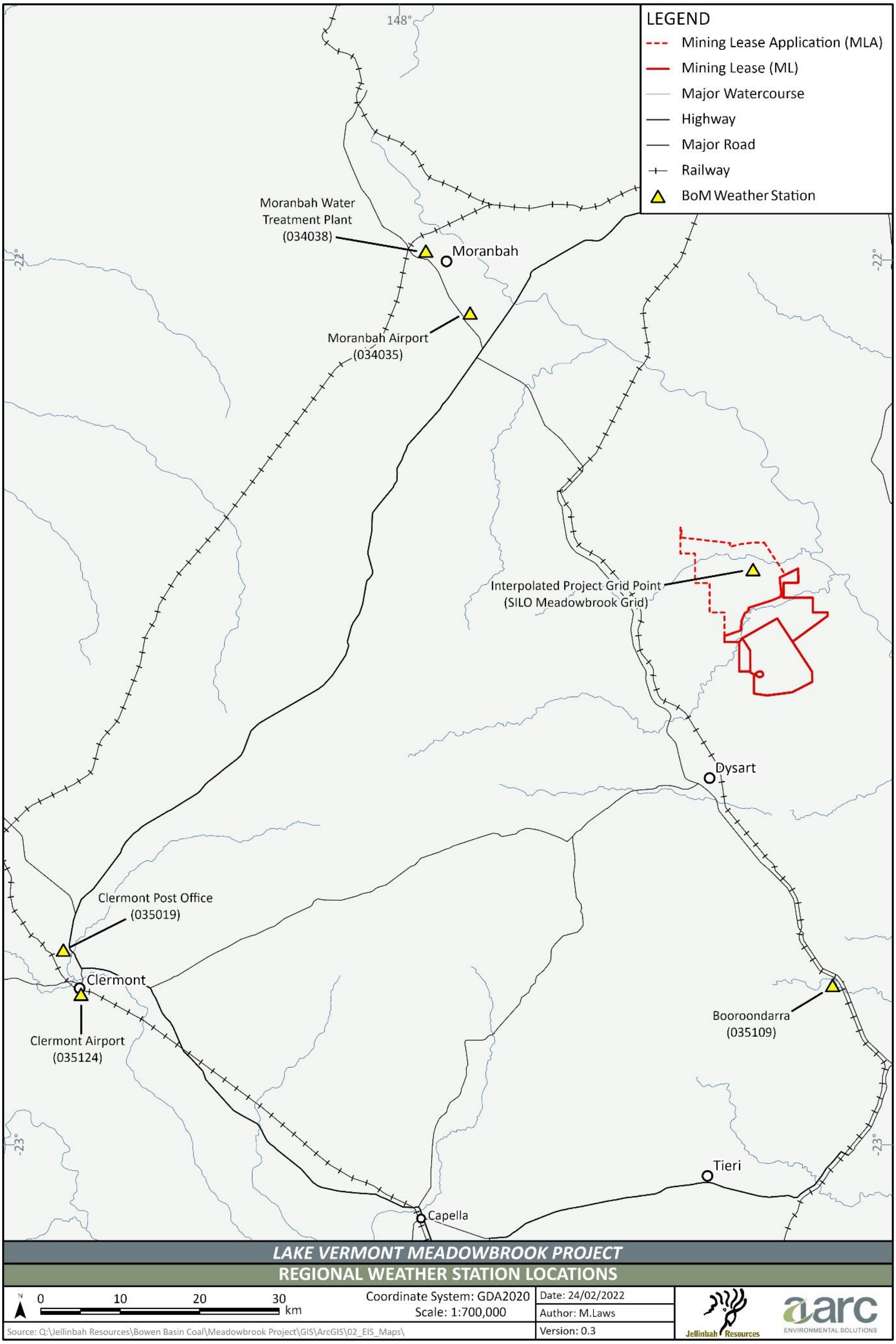

Figure 4.1: Regional weather station locations

Table 4.2: Long-term meteorological data summary—mean rainfall, evapotranspiration, temperature and humidity

Period of data	Mean monthly rainfall (mm)				Mean daily temperature (°C) (minimum-maximum)			Mean monthly humidity (%) (9 am–3 pm)	
	Booroondarra (035109)	Clermont Airport (035124)	Moranbah Airport (034035)	Interpolated Project Grid Point (-22.35, 148.40)	Clermont Airport (035124)	Moranbah Airport (034035)	Interpolated Project Grid Point (-22.35, 148.40)	Moranbah Water Treatment Plant (034038)	Clermont Post Office (035019)
	1953–2021	2010–2021[a]	2012–2021[b]	1968–2018	2010–2021[a]	2012–2021[b]	1968–2018	1986–2010	1938–2010
January	112.6	91.1	92.0	103.0	21.6–34.4	21.5–34.8	22.1–33.4	69–43	66–42
February	96.5	77.5	102.0	87.8	21.1–33.7	21.5–33.9	21.9–32.5	74–48	71–47
March	72.4	107.4	89.3	59.6	20.0–32.0	20.3–32.4	20.4–31.7	70–41	69–42
April	32.6	22.6	25.2	32.1	15.3–29.4	16.8–30.1	17.3–29.4	72–43	67–41
May	34.5	15.1	28.5	34.5	10.3–26.0	12.8–27.0	13.7–26.3	73–43	68 –42
June	24.5	22.3	19.9	23.4	7.5–23.2	9.9–24.1	10.2–23.7	73–44	69–41
July	23.4	25.5	29.1	21.1	6.3–23.7	8.7–24.6	9.1–23.5	69–39	66–37
August	23.4	16.9	14.3	23.2	7.0–26.0	8.8–26.9	10.3–25.4	66–35	61–33
September	15.5	25.8	9.7	13.6	11.6–29.2	12.6–30.2	13.5–28.5	60–30	55–29
October	38.2	32.4	22.6	36.0	15.6–32.3	16.2–33.3	17.0–31.1	58–31	54–30
November	54.3	58.4	49.5	61.6	18.9–33.8	18.9–34.7	19.5–32.7	60–34	67–34
December	95.7	70.8	65.1	95.8	20.9–34.5	20.6–35.3	21.3–33.6	64–38	60–38
Annual average	623.5	565.7	547.1	591.8	14.7–29.9	15.7–30.6	16.3–29.3	67–39	64–38

[a] No records for January to April 2010
[b] No records for January or February 2012

4.1.1 Rainfall

The Project region is classed as subtropical with a moderately dry winter (BoMs modified Köppen Climate Classification System, BoM 2021). The wet season for the region generally occurs from November to March, with rainfall during these months contributing approximately 70% to the region's total annual rainfall (Figure 4.2). The dry season generally occurs from April to October, with monthly rainfall usually less than 25 mm.

Recorded mean annual rainfall totals in the Project region from 1953 to 2021 were 623.5 mm at Booroondarra Station (035109) and 547.1 mm at Moranbah Airport (034035) (Table 4.2).

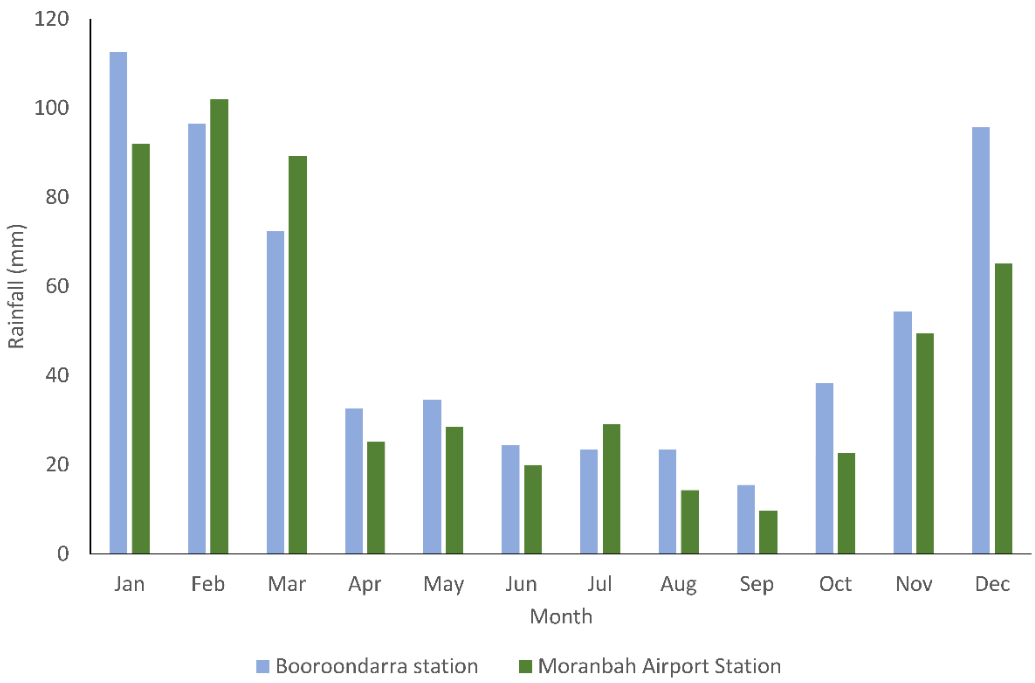

Figure 4.2: Mean monthly rainfall in the Project area surrounds

4.1.2 Temperature

Daily temperature records are available from the Clermont Airport (035124) and Moranbah Airport (034035) weather stations, and interpolated data is available from SILO. Recorded mean daily temperatures from 2012 to 2021 range between 14.7°C and 29.9°C at Clermont Airport and between 15.7°C and 30.6°C at Moranbah Airport. The SILO Meadowbrook Grid calculated mean daily temperatures of approximately 16.3°C to 29.3°C during the years between 1968 and 2018.

Temperature data from the Clermont Airport (035124) and Moranbah Airport (034035) weather stations is presented in Figure 4.3.

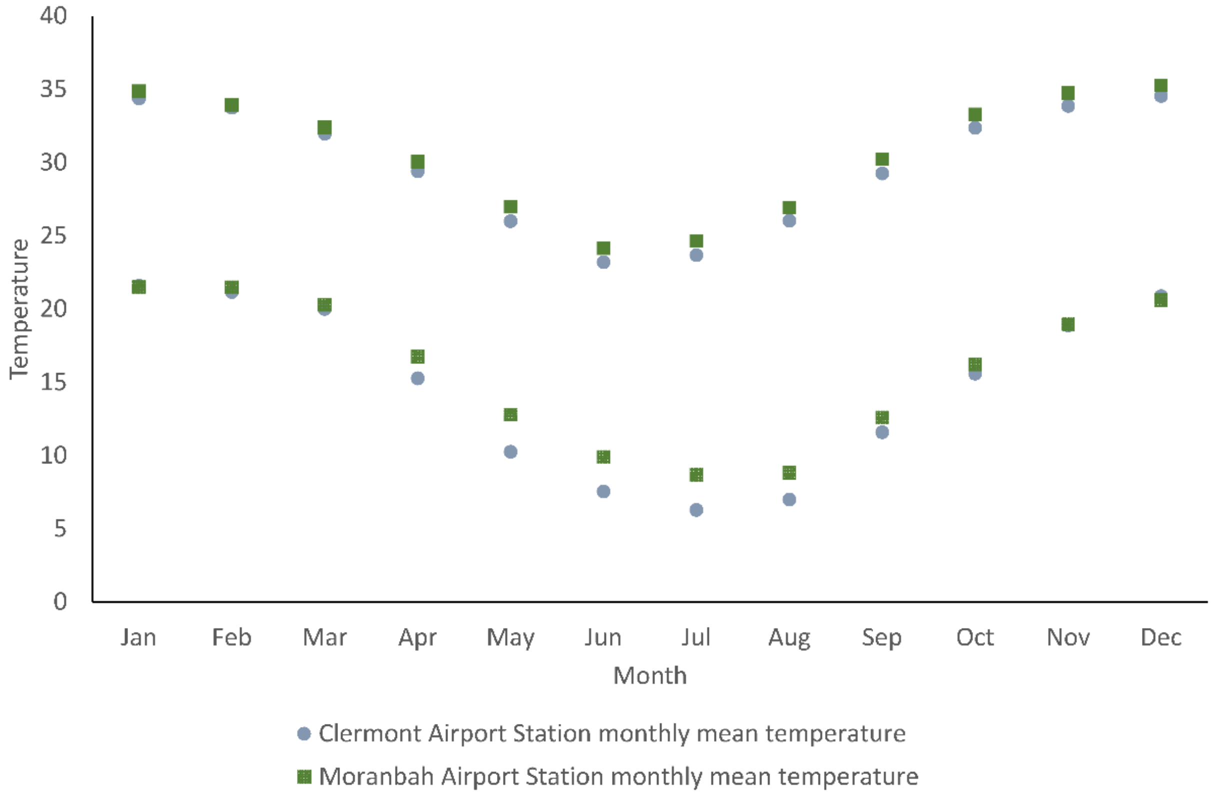

Figure 4.3: Mean monthly maximum and minimum temperatures in the Project area surrounds

4.1.3 Humidity

Relative humidity data is available from the Moranbah Water Treatment Plant (034038) (1968–2010) and Clermont Post Office (035019) (1938–2010) weather stations. Relative humidity in the Project region generally increases from November to January (during the onset of the wet season), peaking in February before gradually declining through to September/October. Relative humidity at 9 am is consistently higher than at 3 pm due to air moisture decreasing throughout the day in response to increasing air temperature. No humidity data was available from the other weather stations listed in Table 4.2.

4.1.4 Wind speed and direction

Wind speed and direction data is available from the Clermont Post Office (035019) weather station and is assessed in Appendix L Air Quality and GHG Assessment (Section 3.3). Wind speed and direction during 2011 to 2020 are presented in Figure 4.4. The wind within the Project region is primarily influenced by synoptic level trade winds that are predominantly south-easterlies. Wind directions vary from dominant north-easterlies during spring to very dominant south-easterlies in autumn and winter. Wind speeds for the assessed period (2011 to 2020) were light to moderate with an average of 2 m/s, with the highest hourly average wind speed recorded as 9.6 m/s.

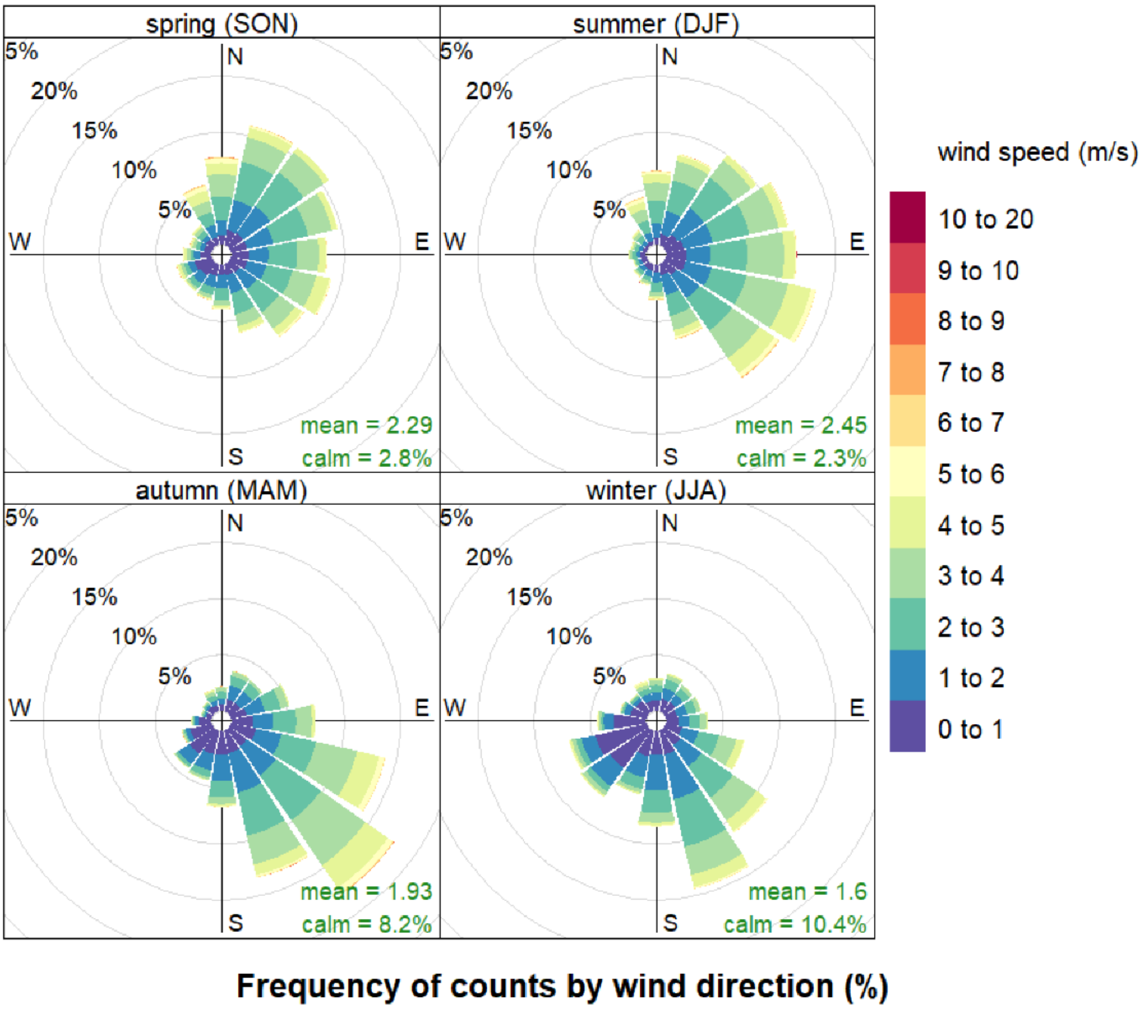

Figure 4.4: Seasonal wind speeds and direction recorded at Clermont Airport BoM monitoring Station (2011–2020)

4.1.5 Atmospheric stability

Atmospheric stability may be monitored on-site or modelled from meteorological datasets. The stability classes can range from class A (very unstable atmospheric conditions typically occurring on sunny days) to class F (very stable atmospheric conditions typically occurring during light wind at night). Atmospheric stability for the Project region has been determined from the prognostic model TAPM and the diagnostic meteorological model CALMET and is presented in Appendix L, Air Quality and GHG Assessment (Section 3.3). The atmospheric stability of the Project region is predominantly neutral (41% of the time) and stable (29% of the time). The complete distribution of atmospheric stability as modelled at the Project site is presented in Appendix L, Air Quality and GHG Assessment (Section 3.3.3.2).

4.2 Project vulnerability to natural and induced hazards

The Project is located in an area subject to natural and induced climate hazards. The assessment of risks posed by these hazards has been considered across construction, operation and decommissioning of the Project.

4.2.1 Bushfire

The Project is located within an area mapped as medium potential bushfire intensity by State Planning Policy Integrated Mapping Systems (DILGP 2016a). This classification indicates a greater than one in a 100-year ARI for bushfire events. Historical bushfires recorded as fire scars have occurred close to the Project from 2014–2016 (Appendix V, Climate Change Assessment, Section 6.6.2).

There is high confidence that climate change will result in harsher fire weather in the future (Appendix V, Climate Change Assessment, Section 7.5.2). 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.

The mitigated risk of increased occurrence of bushfires to infrastructure damage, coal stockpiles and rehabilitation plantings is assessed to be medium and the risk to critical infrastructure access is assessed to be low (Appendix V, Climate Change Assessment, Section 8). Fire breaks and hazard reduction burns are key control measures to support bushfire risk management across all Project phases. The assessment of the Project bushfire risk is also presented in Chapter 16, Hazards and Safety.

4.2.2 Cyclone

The Project is in a non-cyclonic wind region; therefore, the risk of cyclones and severe weather events impacting the Project has been assessed as low. However, the Project may experience indirect impacts of cyclones and significant rainfall from ex-tropical cyclones and tropical lows, and proposed site buildings will be required to meet relevant construction standards for the region.

Cyclones occurring within the Gladstone region may potentially impact the weather in the Project area. There have been 118 tropical cyclones recorded in the Gladstone region between 1908 and 2018, and on average 1.1 cyclones can be expected to occur in the Gladstone region annually. The formation of cyclones is expected to become less frequent under climate change scenarios (Appendix V, Climate Change Assessment, Section 6.6.3.3).

The assessment of the Project cyclone risk is presented in Chapter 16, Hazards and Safety. Assessment of risk from extreme rainfall as a consequence of cyclones is addressed in section 4.2.3.

4.2.3 Extreme rainfall

Short but intense rainfall events can occur in the Project area, most commonly during summer. The highest rainfall recorded in a single day was 229 mm, and the maximum monthly rainfall recorded was 274.2 mm (Appendix L, Air Quality and GHG Assessment, 6.6.3.1). The Project area experiences 316 days without rain per year on average, with a maximum recorded of 319 days. Historical rainfall records are presented in Appendix V, Climate Change Assessment, Section 6.3.

The risk of extreme rainfall impacting the Project has been assessed as low with climate projections for the East Coast indicating that the formation of cyclones is expected to become less frequent (Appendix V, Climate Change Assessment, Section 7.5.3) and with proposed levee structures facilitating the protection of key infrastructure areas (including the MIA and open-cut pit). Production impacts associated with coal haulage have also been considered across a range of rainfall events as part of the design of watercourse crossings along the Project infrastructure corridor (Appendix F, Surface Water Assessment, Section 4.2). Rehabilitation of disturbed land post-mine closure will also retain existing land uses (e.g. grazing), utilise a range of vegetation species known to thrive within the existing area and provide a drainage plan to manage the stability of the final landform (Chapter 6, Rehabilitation). The assessment of extreme rainfall risk is presented in Chapter 16, Hazards and Safety.

4.2.4 Flood

The Project is located in an area that may be subject to flooding. Extreme rainfall events, leading to floods, are predicted to decrease under climate change scenarios (Appendix V, Climate Change Assessment, Section 7.5.3). Flood risk impacts including depth and extent for modelled flood scenarios is presented in Chapter 9, Flooding and Regulated Structures, Section 9.4.1. Flood risk has been considered as part of the Project design, with proposed levee structures facilitating the protection of key infrastructure areas. Flood risk to the construction and operation of the Project is considered in Chapter 9, Flooding and Regulated Structures Flood risk associated with the final landform (post-mine closure) has also been considered as part of the Project's Progressive Rehabilitation and Closure Plan (Chapter 6, Rehabilitation).

4.2.5 Extreme temperatures

Extreme temperatures can occur in the Project region. Modelled extreme temperatures from SILO climate data is presented in Appendix V, Climate Change Assessment, Section 6.1.1 with a summary shown in Table 4.3. Conditions of daily temperatures above 35°C can occur between September and March, while low temperatures (< 5°C) can occur between May and September.

Risks associated with extreme temperatures are well understood and managed by the existing Lake Vermont Mine that has been operating since 2009. Controls include the following:

- provision of sufficient drinking water supplies for all personnel;
- provision of suitable personal protection equipment;
- provision of sunscreen;
- provision of induction material that addresses dehydration risks and enables identification of early signs; and
- provision of pre-start and tool-box talks regarding extreme temperature risks.

Site buildings will also be constructed/imported with consideration of extreme temperature management, while mine rehabilitation will utilise a range of vegetation species known to thrive in the Project region.

The mitigated risk of higher than average maximum temperatures to energy demand, dust generation and spontaneous combustion assessed to be low and the risk to rehabilitation assessed to be moderate. The assessment of extreme temperature risk is presented in Chapter 16, Hazards and Safety.

Table 4.3: Summary of SILO modelled extreme temperatures for the Project area

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Days > 35°C	29%	17%	5%	0%	0%	0%	0%	0%	1%	7%	17%	33%
Days < 5°C	0%	0%	0%	0%	1%	11%	20%	11%	1%	0%	0%	0%

4.3 Climate change projection

Assessment of the impact of future climate conditions on the Project requires an understanding of climate change. Projections of climate change involve predictions of biophysical, social, economic, institutional and technological processes—all of which are subject to some uncertainties.

Assessment of the impact of climate change on the Project has been conducted according to projections generated by the *Coupled Model Intercomparison Project Phase 5* and information contained in the *Queensland Future Climate Dashboard, Qld 2021*. The assessment is presented in Appendix V, Climate Change Assessment, Section 7, and Table 4.4 summarises climate projections for key climate variables associated with the Project under representative concentration pathway 8.5 (RCP8.5)—a conservative standardised greenhouse gas (GHG) concentration scenario used for climate change modelling.

Average and maximum daily temperatures are likely to increase over the life of the mine due to climate change. Pan evaporation is also expected to increase with the projected increased temperatures (Queensland Government 2021a).

Average annual rainfall is projected to decrease slightly by 2050, continuing to decrease until at least 2070. Seasonal rainfall projections indicate that spring rainfall will decrease slightly by 2050, continuing to decrease until 2070, while summer rainfall will increase by 2070.

Windspeed is expected to remain unchanged for the life of the Project. The frequency of days above 35°C and 40°C is projected to increase.

The number of days with severe fire danger is projected to increase by 45% in 2030 and 130% in 2090. The intensity of extreme rainfall events is expected to decrease between 2050 and 2070, and extreme wind is projected to decrease in frequency and intensity.

Table 4.4: Climate change projection summary under RCP8.5

Parameter	**Statistics**	**Existing climate (SILO)**	**Climate change projections**	**Comments**
Temperature	Daily mean temperature	10.1 to 34.3°C	2050 + 1.8°C 2070 + 2.8°C	There is consensus that temperatures will increase at a rate that is strongly connected to global GHG emission rises.
	Daily maximum temperature	43.7°C	2050 + 1.9°C 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 longer-term.
Extreme rainfall	Highest daily rainfall	134.8 mm	Decrease	The intensity of heavy rainfall extremes is projected to decrease over time due to climate change.
	Highest monthly rainfall	307 mm	Decrease	
Windspeed	Seasonal mean	1.6 to 2.45 m/s [a]	Little change	There is consensus that wind speed and maximum wind gusts will experience minor variations in 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 station; SILO does not maintain wind data

4.4 Mitigation and management measures

Project vulnerability to natural and induced climate hazards has been assessed as medium to low, resultant of mitigations and management measures proposed within Appendix V, Climate Change Assessment, Section 8, and Chapter 16, Hazards and Safety. The proposed measures include the following:

- mitigation for impacts of higher-than-average temperatures;
  - maintaining existing site practices (that manages occupational exposure to extreme temperature conditions);
  - energy supply system designed for predicted extreme temperatures;
  - dust suppression measures (refer Chapter 13, Section 13.5 for detailed discussion);
  - coal stockpile design and management to facilitate prevention and control of fires;
  - hardening and establishment measures for rehabilitation plantings;

- mitigation measures for increased occurrence of bushfires will be provided within a BMP (refer Chapter 16, Section 16.9.3 for detailed discussion) and include;
    - constructing fire breaks and undertaking hazard reduction burns;
    - provision for accessibility to critical infrastructure and emergency response equipment in Project design; and
    - early fire detection and water sprinkler systems for critical areas;
- mitigation measures for increased occurrence of cyclones, extreme rainfall and flooding;
- developing infrastructure designed to meet local cyclone protection standards;
- constructing levees to protect key infrastructure areas from flooding and extreme rainfall events; and
- mitigation measures for decreased average annual rainfall include;
    - developing a progressive rehabilitation and closure plan that considers climate hazards and climate change; and
    - establishment support for rehabilitation plantings.