# 8

# CLIMATE

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# 8 Climate

## 8.1 Introduction

This chapter presents a summary of climate statistics local to the Project area and predictions for future climate under a number of Greenhouse Gas (GHG) emission scenarios. A climate change impact assessment for the Project is described using the climate change predictions made in the Commonwealth Scientific and Industrial Research Organisation (CSIRO 2007) and the Queensland Office of Climate Change[1] (OCC 2010) reports. A summary of the local climate is provided in Section 8.2; the various future scenarios used in the assessment and a summary of predicted climate change are described in Section 8.3; the natural hazards and extreme events in the region and the potential impact of climate change on them are described in Section 8.4; and a summary of the assessment of risk to the Project from climate change along with how this risk is to be managed is presented in Section 8.5.

A cross reference to the locations where each of the requirements of the ToR has been addressed is given in Appendix B which references both the study chapters (Sections 1 through 34) and/or the Appendices (A through EE).

## 8.2 Existing Climate

This section discusses local climate characteristics and seasonal conditions within the Project area airshed (referred to as the ‘study area’)[2] based on long term meteorological monitoring data. It also describes the effect of certain meteorological parameters on the dispersion of air pollution.

### 8.2.1 Data Sources

Monthly climate statistics based on meteorological monitoring data from stations located in the study area and operated by the Bureau of Meteorology (BOM) (see Table 8-1 and Figure 8-1) were used to characterise long term air temperature, insolation and evaporation, relative humidity, rainfall, and wind speed and direction in the area. Additionally, 13 years of hourly meteorological monitoring data from the BOM stations at Emerald and Mackay were used in the analysis. Emerald is considered representative of the inland climatic conditions of the Project area. The Mackay Aero meteorological station is located on the coast approximately 80 km north-east from the Project area. Although the Project area and Mackay are separated by the Clarke Range, which forms part of the Great Dividing Range in central Queensland, coastal effects such as onshore breezes have been found to impact at this distance inland through meteorological modelling, as discussed within the Air Quality Technical Report (Appendix H) of this EIS. Mackay Aero is therefore included to provide the full range of meteorological conditions in the Project area.

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[1] OCC forms part of the EHP, formerly the DERM.

[2] The Project study area was defined as the Project tenement footprint plus 100 km north-south and 200 km east-west.

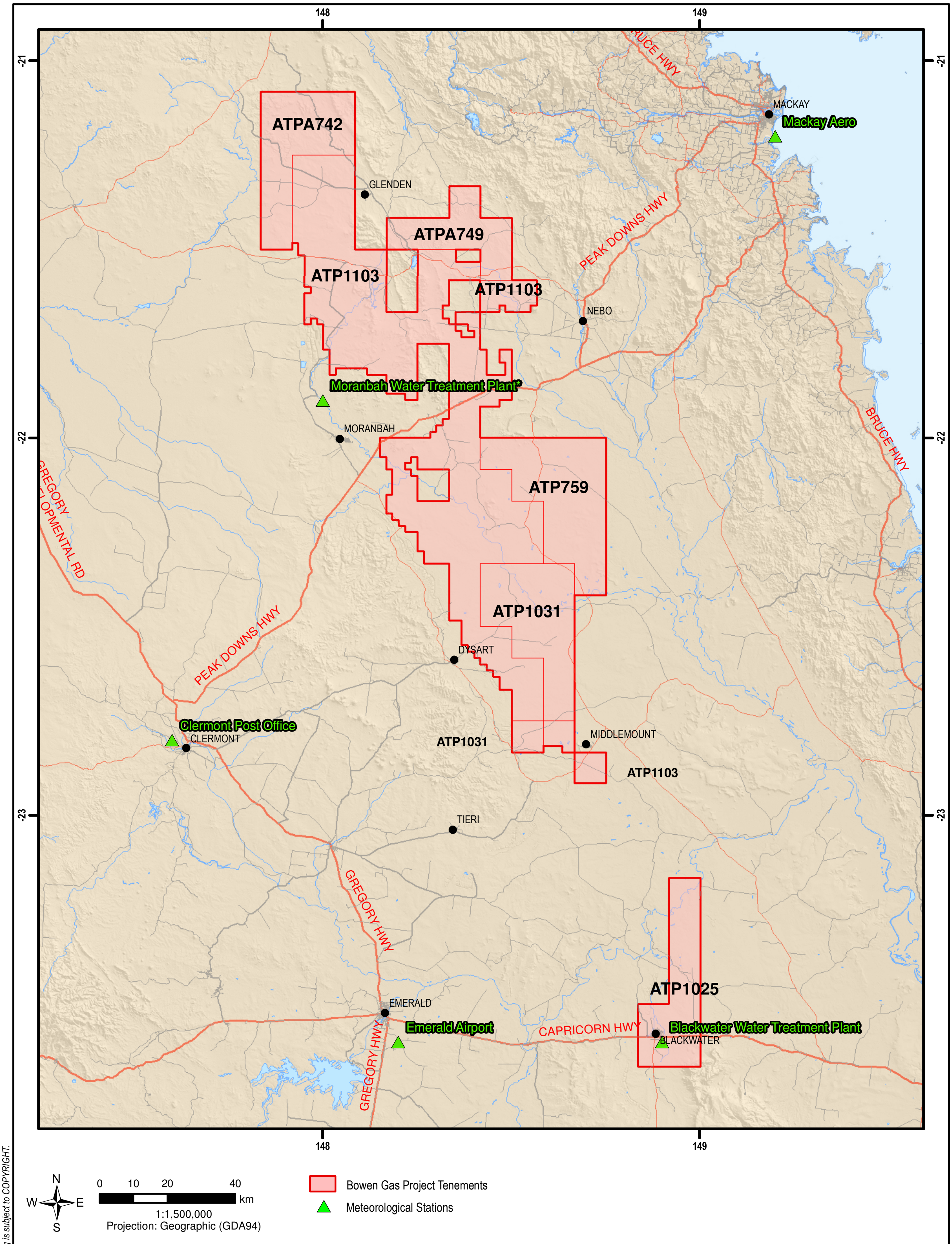
### Table 8-1 Meteorological Stations with Available Monthly Climate Statistics in the Study Area

| Station | Station Number | Latitude | Longitude | Operational Period |
|---|---|---|---|---|
| Blackwater Water Treatment Plant | 35290 | 23.6°S | 148.9°E | 1995-2010 |
| Clermont Post Office | 35019 | 22.8°S | 147.6°E | 1870-2012 |
| Emerald Airport | 35264 | 23.6°S | 148.2°E | 1981-2012 |
| Mackay Aero | 33045 | 21.2°S | 149.2°E | 1950-2012 |
| Moranbah Water Treatment Plant* | 34038 | 21.9°S | 148.0°E | 1972-2012 |

*Monitoring site at Moranbah Water Treatment Plant was replaced by the Moranbah Airport monitoring station (34035), which commenced operation in late February 2012.

The operational period shown in Table 8-1 corresponds to the period for which any meteorological data were collected. However the monitoring period for each variable does not necessarily correspond to the station operational period.

For atmospheric stability and mixing height, modelled data from The Air Pollution Model (TAPM) for a selected year (2009) were used, because it was not possible to obtain observational records of these variables. This year (2009) was selected as representative of long-term average meteorological conditions based on analysis of meteorological observations for the period of 1999 to 2011. For further details refer to the Air Quality chapter (Section 9 of this EIS) and the Air Quality Technical Report (Appendix H of this EIS).



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BOWEN GAS PROJECT EIS

**METEOROLOGICAL STATIONS**
**IN THE STUDY AREA**

**CLIMATE**

Figure: **8-1**

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### 8.2.2 Rainfall

Observations of daily rainfall are generally made at 9 am local time and record the total precipitation for the preceding 24 hours. Other, more frequent, observations are also made at some sites. The median rainfall represents the midpoint of the ordered (lowest to highest) monthly or yearly precipitation totals. The median is the preferred measure of 'typical' rainfall because this measure is less affected by extreme rainfall events than the arithmetic mean. The median monthly precipitation recorded at the stations within the study area for the reported years is presented in Figure 8-2.

**Figure 8-2 Median Monthly Rainfall**

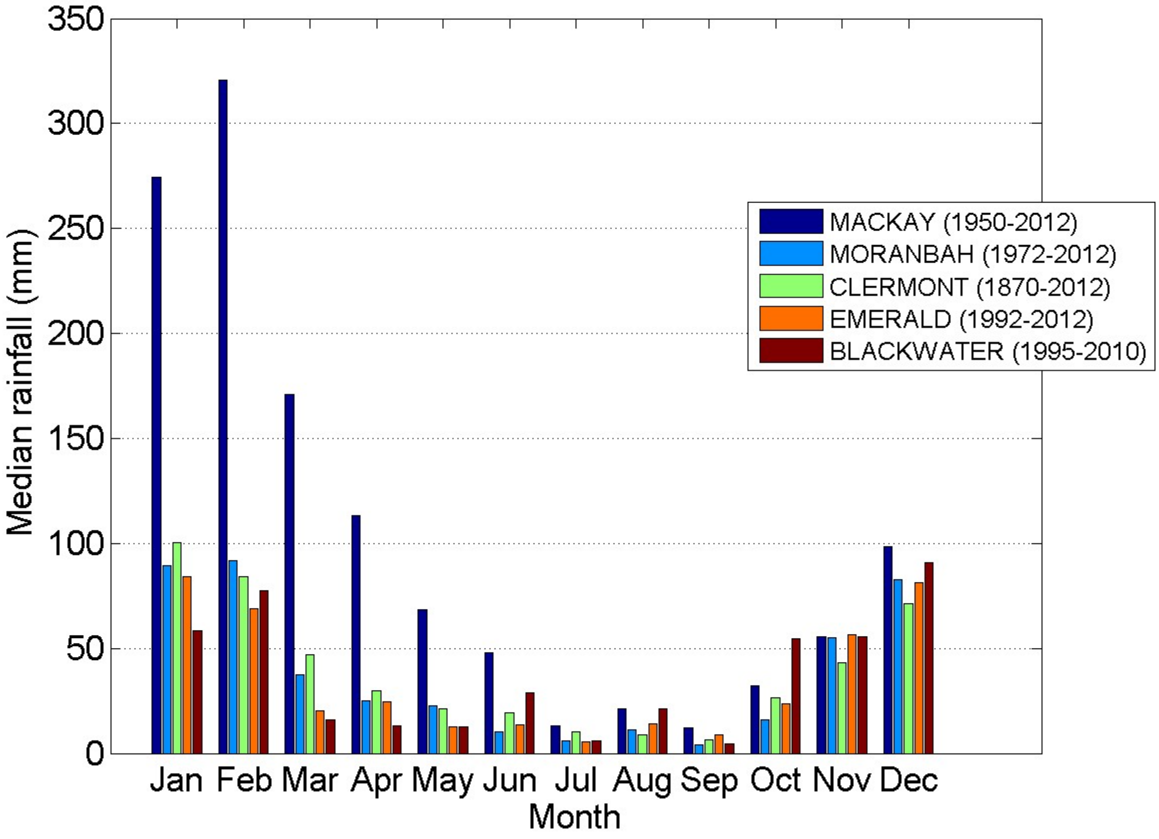


Figure 8-2 shows that the rainfall patterns differ between the coastal (Mackay) and inland locations (Blackwater, Clermont, Emerald and Moranbah). At the inland locations, the highest median monthly rainfall occurs over the summer months of December through to February, with up to 100 mm falling per month. The lowest rainfall is observed during the winter months July and August and in September, ranging from 4 to 21 mm per month. In general, Mackay reports higher rainfall values, with the highest median monthly rainfall of 321 mm in February, and the lowest of 12 mm in September.

### 8.2.3 Air Temperature

Long term temperature statistics for the stations in the study area are provided in Figure 8-3.

**Figure 8-3 Mean Daily Maximum and Minimum Temperature**

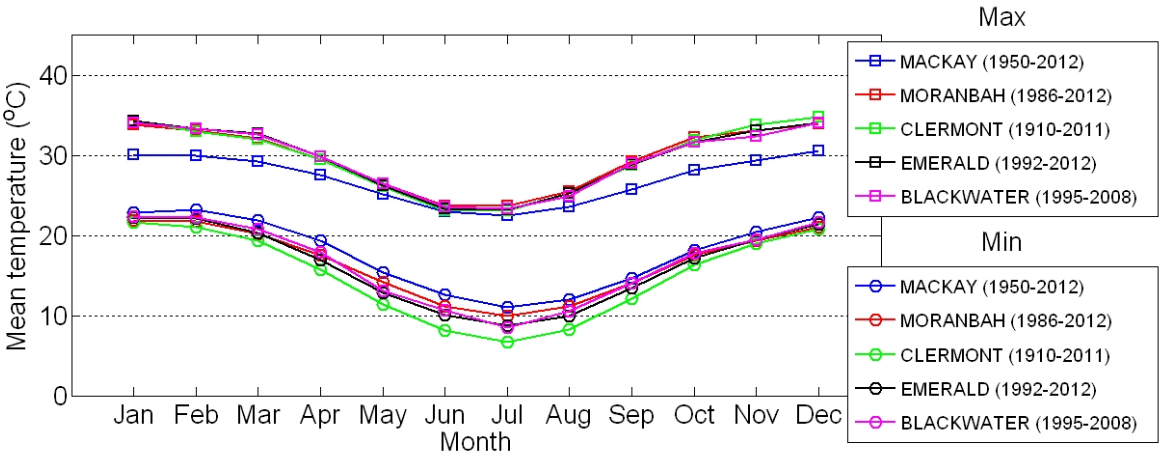


Figure 8-3 shows that the range of daily temperature extremes across the sites are similar, with mean maximum temperature ranging from approximately 30°C to 34°C in summer (December-February) falling to 22°C to 25°C during the winter months (June-August). The mean daily minimum temperatures vary from approximately 7°C (July) to 23°C (January). At coastal sites such as Mackay, the mean minimum temperature appears to be higher, with maximum temperatures lower than the inland sites. The highest temperature recorded at Mackay was 38.5°C in October 1955, and the lowest recorded temperature was -0.4°C in July 1951. At Clermont (the most inland site), the highest temperature of 45.0°C was recorded in January 1994, and the lowest temperature of -3.5°C in July 2009.

### 8.2.4 Insolation and Evaporation

Mean daily solar exposure (insolation) is the averaged amount of daily solar energy reaching a specific location in a calendar month, calculated over the period of record. Figure 8-4 shows mean daily solar exposure based on climatic data recorded at the sites within the study area.

**Figure 8-4 Mean Daily Solar Exposure at Weather Stations in the Study Area**

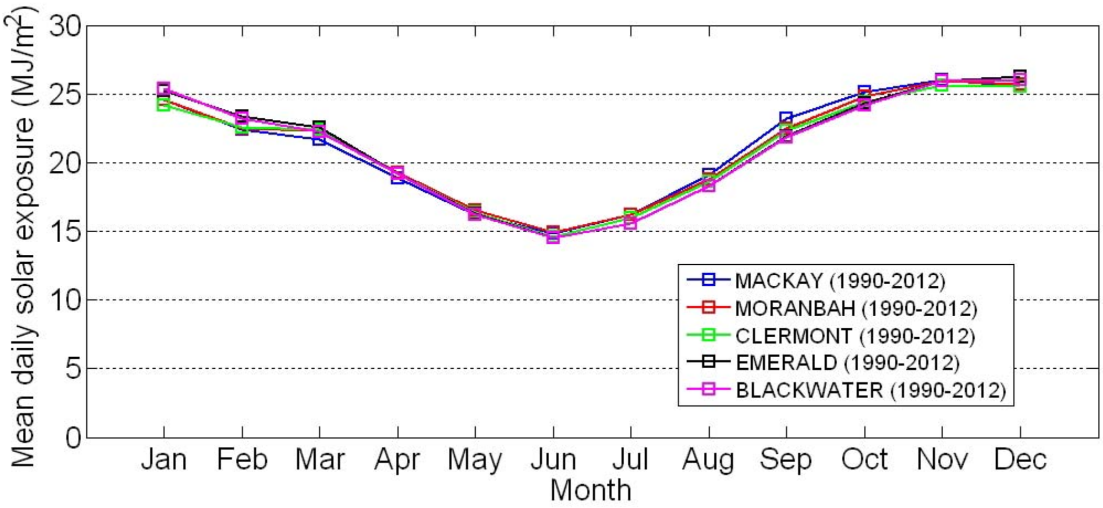


Figure 8-4 shows that mean daily solar exposure is similar across the sites and changes throughout the year in line with the seasons, with values ranging from 14.5 megajoules per square metre (MJ/m$^2$) in winter (June) to 26 MJ/m$^2$ in summer (December).

Mean daily evaporation based on climatic data for Moranbah and Clermont is presented in Figure 8-5.

**Figure 8-5 Mean Daily Evaporation at Weather Stations in the Study Area**

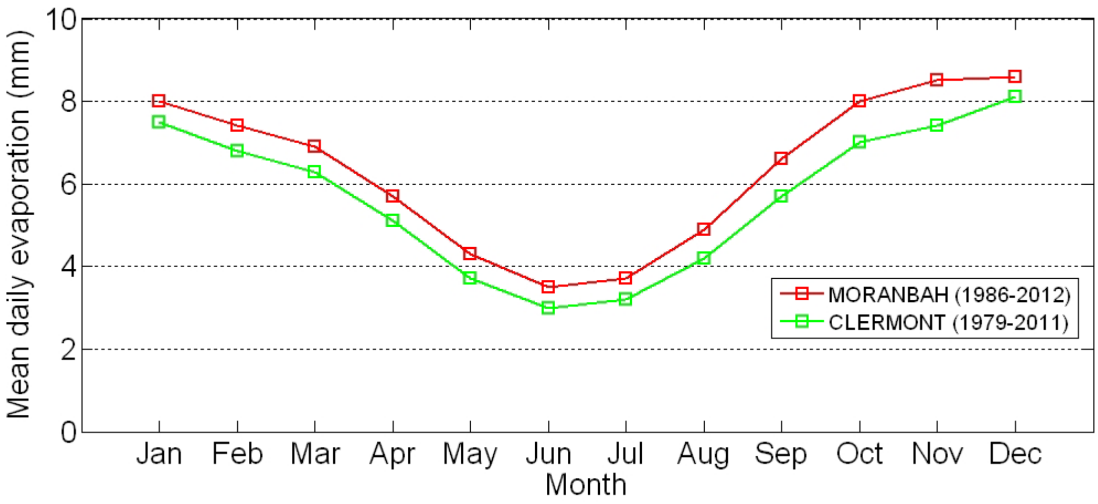


Figure 8-5 shows that the rate of evaporation depends on factors such as cloudiness, air temperature, humidity and wind speed. During the summer months, due to the longer hours of daylight, higher temperatures and higher solar radiation the evaporation rates are higher, ranging from 6.8 to 8.6 mm per day than those experienced during the cooler winter months, which range from 3.0 to 4.9 mm per day.

## 8.2.5 Relative Humidity

Relative humidity is the term used to describe the amount of water vapour in the air relative to the saturation point at a given temperature. A graphical representation of the monthly averaged relative humidity data at 9 am and 3 pm for each of the stations is shown in Figure 8-6.

**Figure 8-6 Mean Relative Humidity at 9 am and 3 pm**

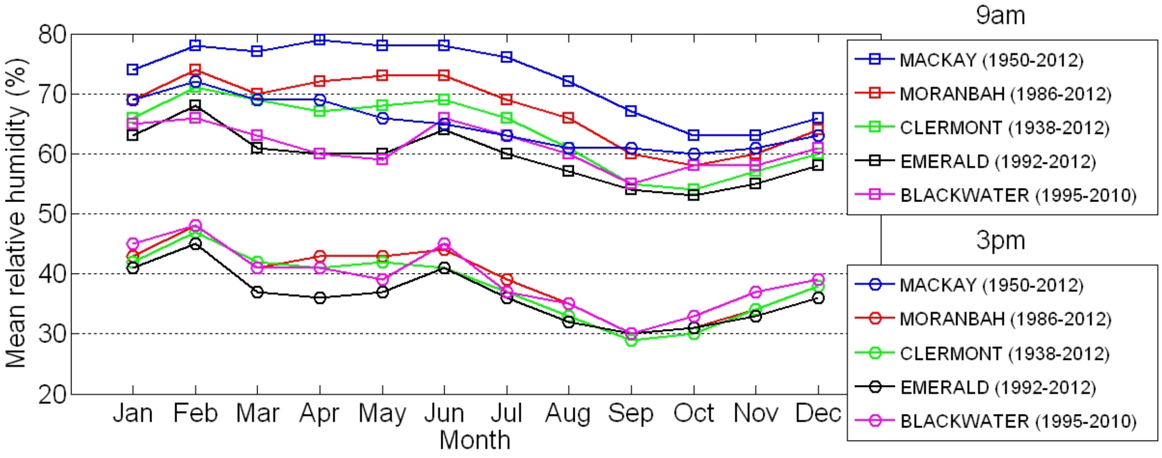


Figure 8-6 shows that relative humidity is higher at 9 am, ranging from approximately 53% to 79%, and lower at 3 pm, ranging from 29% to 48%, at the inland sites. Mackay, which is located on the coast, has higher relative humidity with a smaller difference between 9 am and 3 pm than the inland sites of Blackwater, Clermont, Emerald and Moranbah. The diurnal variation in temperature, which in general, corresponds to lower temperatures in the morning and higher temperatures in the afternoon, is the driver for this observed trend in relative humidity as it changes the water holding capacity of the atmosphere.

Relative humidity varies with the season, reaching a maximum in summer (February) and winter (June) and falling in autumn and spring. September and October (spring) have the lowest relative humidity levels across the sites. However, at Mackay the highest relative humidity is observed in April.

## 8.2.6 Wind Speed and Direction

Wind speed is generally measured at a height of 10 m above the surface, averaged over the ten minutes leading up to the time of observation. Winds in the study area are influenced by the global air circulation (i.e. trade winds east to south-easterly in direction), local terrain and surface roughness, slope-valley flows and land-sea breezes.

Figure 8-7 shows mean wind speed at 9 am and 3 pm.

**Figure 8-7 Mean Wind Speed at 9 am and 3 pm**

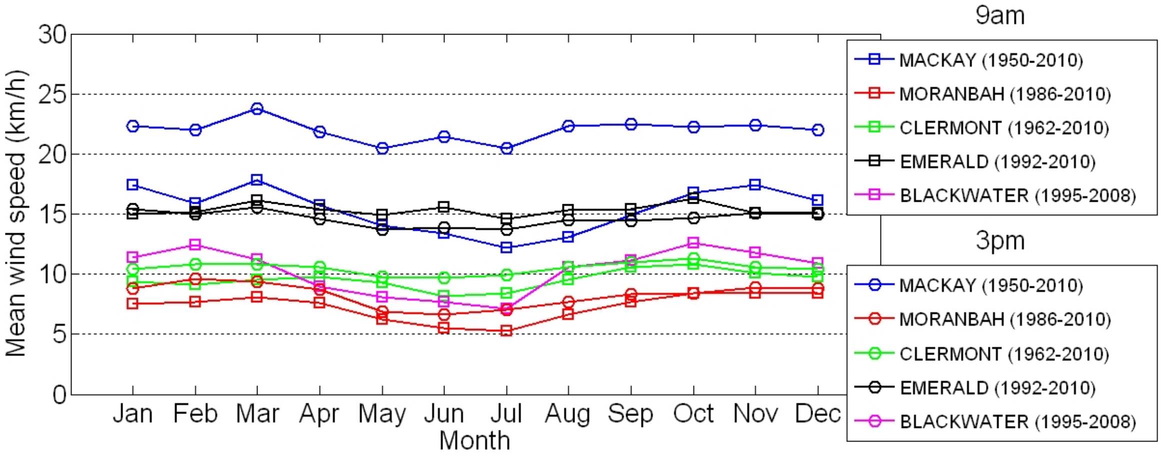
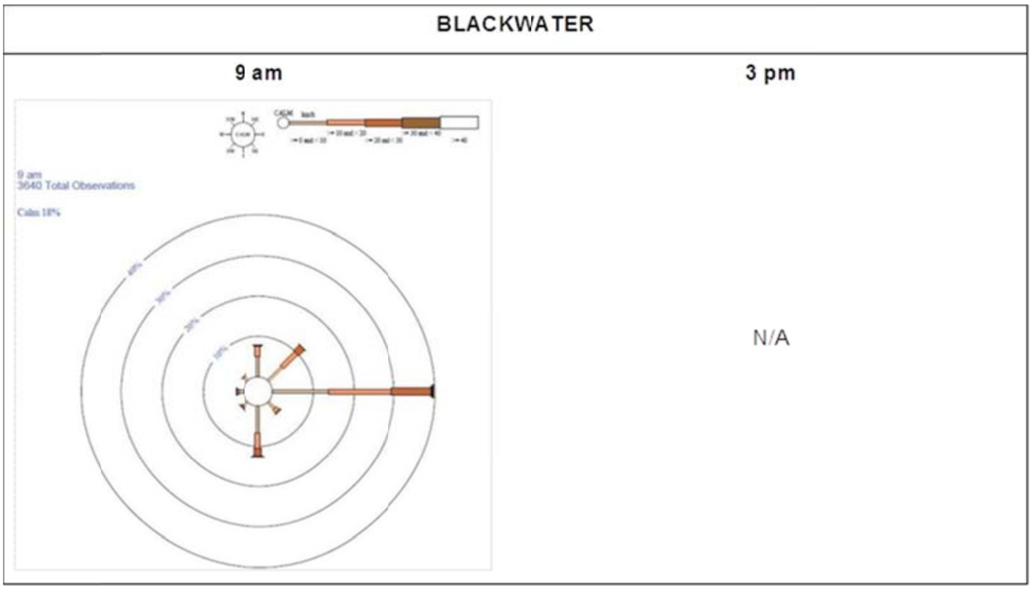


Figure 8-7 shows that wind speeds vary across the study area, with the highest mean wind speeds observed at Mackay (24 km/h at 3 pm in March) and the lowest observed at Moranbah (5 km/h at 9 am in July). The 9 am wind speed is generally lower than the 3 pm wind speed. The difference in morning and afternoon wind speeds is a result of the atmospheric pressure differences caused by daytime heating of the land surface. This difference is particularly marked at the coastal station of Mackay where it is observed to be over 5 km/h for the whole year. Here the effect is exacerbated by afternoon onshore sea breezes.

At all stations and for observations taken at 9 am and 3 pm, the lowest wind speeds were observed in the winter months of May to July. The exception is the inland station of Emerald, where the minimum observed 9 am wind speed of 15 km/h is observed for several months in the year.

Climatic wind roses for 9 am and 3 pm obtained from the BOM for Blackwater, Clermont, Moranbah, Emerald and Mackay are presented in Figure 8-8 to Figure 8-12.

## Figure 8-8 Wind Roses Based on Long Term Records (1995 – 2008) from Blackwater



## Figure 8-9 Wind Roses Based on Long Term Records (1962 – 2010) from Clermont

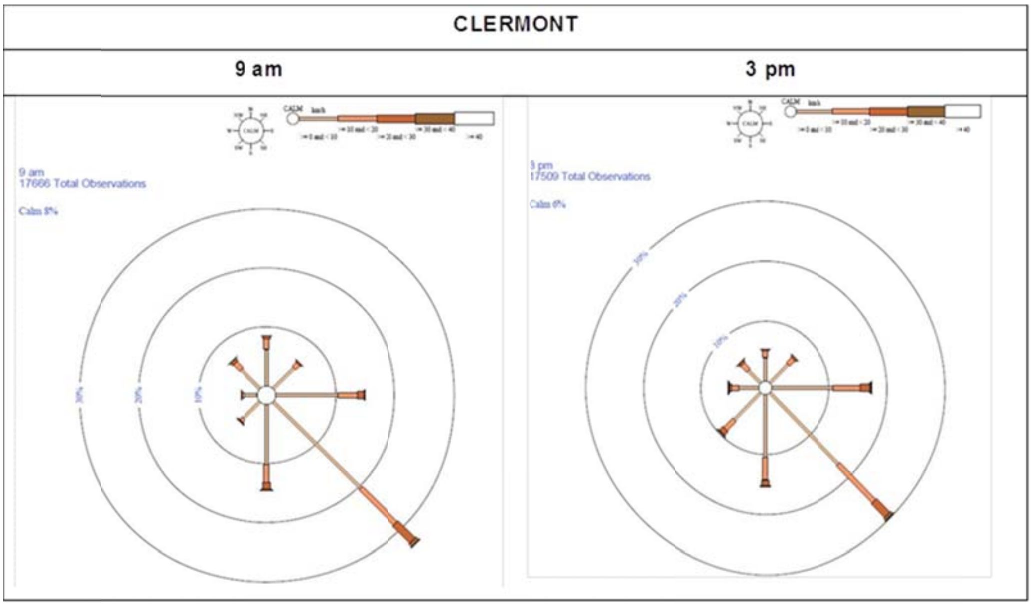


Figure 8-10 Wind Roses Based on Long Term Records (1986 – 2010) from Moranbah

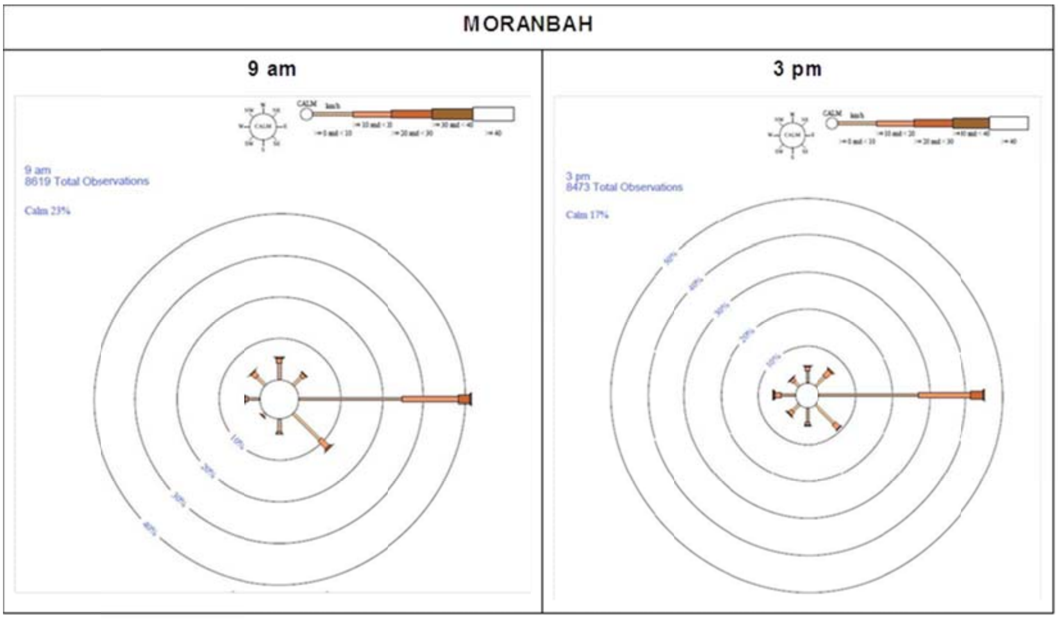


Figure 8-11 Wind Roses Based on Long Term Records (1992 – 2010) from Emerald

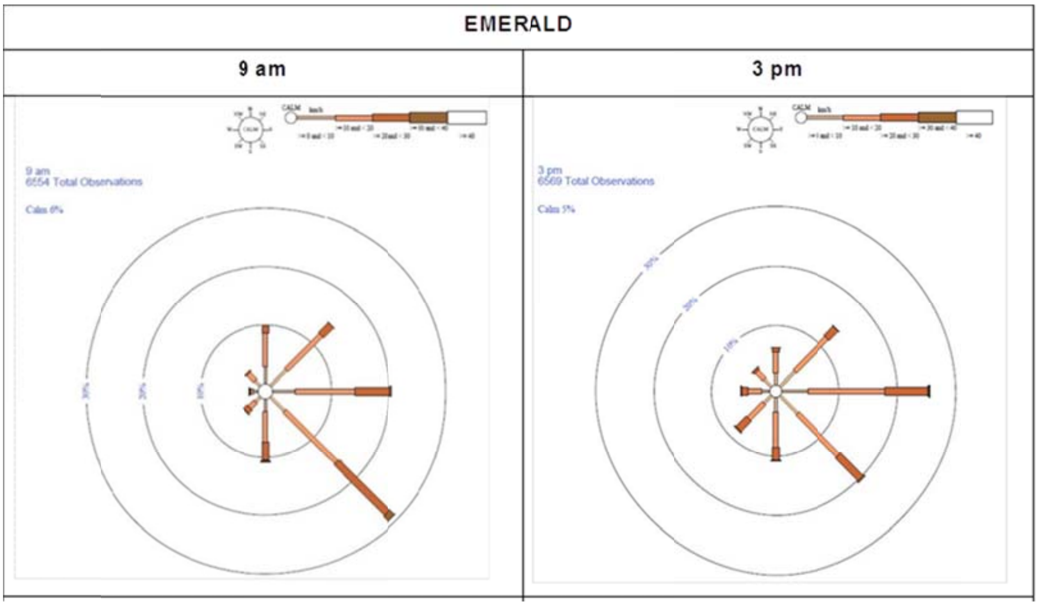


**Figure 8-12 Wind Roses Based on Long Term Records (1950 – 2010) from Mackay**

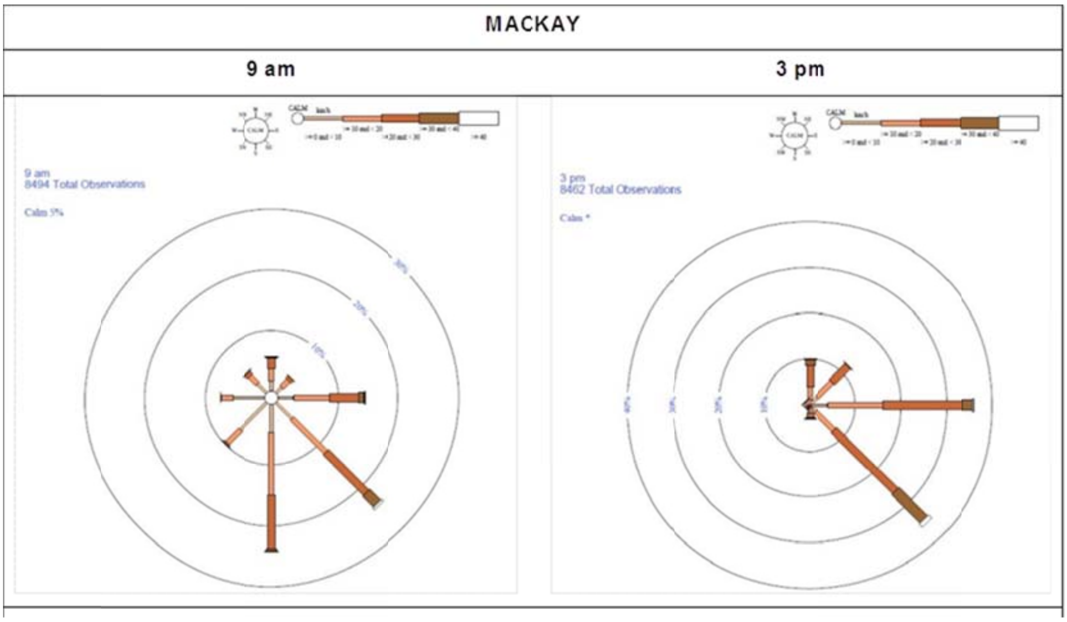


Figure 8-8 to Figure 8-12 show that wind speed and direction at the five sites are similar. In general, the predominant wind flow in the area is from the north-east to south-east. However, at Blackwater (located in the south-east of the study area) and Moranbah (centrally located within the study area) winds from the south-east are less frequent than at other stations. These locations also present a higher frequency of calm and light winds. Wind direction at Emerald in the south-west, the most western station Clermont, and Mackay located in the north-east of the study area are more evenly distributed.

The annual frequency distribution of wind speed at Emerald and Mackay based on data for 1999 – 2011 is presented in Table 8-2.

**Table 8-2 Distribution of Wind Speed at Emerald and Mackay Based on Long Term Records (1999 - 2011)**

| Station | Annual distribution of wind speed (% of total winds) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Calms (<0.3 m/s or <1.1 km/h) | Light air (0.3-1.5 m/s or 1.1-5.4 km/h) | Light (1.5-3.3 m/s or 5.4-11.9 km/h) | Gentle (3.3-5.4 m/s or 11.9-19.4 km/h) | Moderate (5.4-7.9 m/s or 19.4-28.4 km/h) | Fresh (7.9-10.7 m/s or 28.4-38.5 km/h) | Strong (10.7-13.9 m/s or 38.5-50 km/h) | Near gale (>=13.9 m/s or >=50 km/h) |
| Emerald | 5.3 | 6.6 | 32.0 | 36.8 | 17.1 | 2.0 | 0.1 | 0.02 |
| Mackay | 6.0 | 5.1 | 24.9 | 23.4 | 28.2 | 11.0 | 1.3 | 0.01 |

Table 8-2 shows that Emerald experiences much lighter winds than Mackay. Light to gentle winds contribute to 80% of the winds at Emerald and 59% of the winds at Mackay. Moderate winds blow for

17% and 28% of the time at Emerald and Mackay, respectively. Strong winds greater than 28.4 km/h occur for only 2% of the time at Emerald and for 12% of the time at Mackay.

### 8.2.7 Atmospheric Stability

Atmospheric stability is typically classified under the Pasquill-Gifford scheme. Classes range from ‘A’, which represents very unstable atmospheric conditions that may typically occur on a sunny day, to ‘F’ which represent very stable atmospheric conditions that typically occur during light wind conditions at night.

Figure 8-13 shows the percentage frequency distribution of stability classes at the selected subregions within the study area for 2009. The subregions are the same regions used in the atmospheric dispersion modelling of air pollutants as described in the Air Quality chapter (Section 9 of this EIS) and Section 9 of the Air Quality Technical Report (Appendix H of the EIS).

**Figure 8-13 Stability Categories Calculated from TAPM Modelling Results for 2009 for Four Selected Subregions**

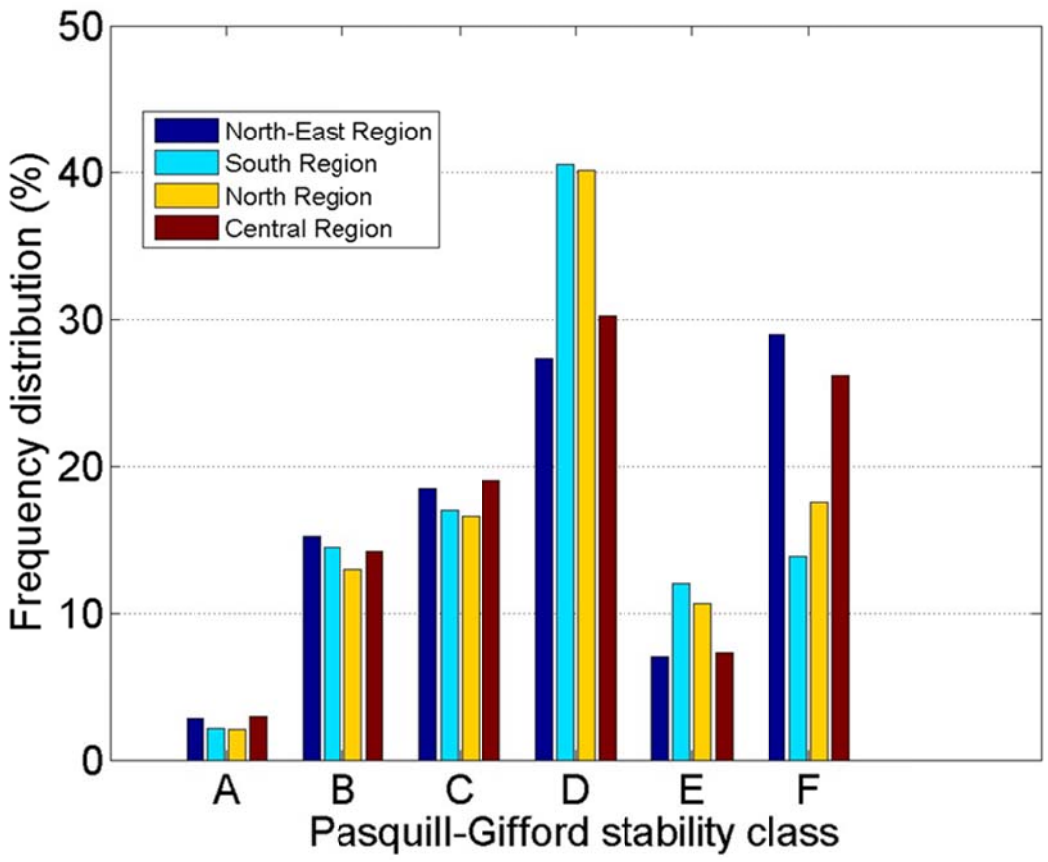


Figure 8-13 shows that there is a high percentage of D class (neutral stability) at all the selected subregions. Neutral stability accounts for approximately 40% of all hours for subregions 2 (South) and 3 (North). Dispersion processes for neutral conditions are dominated by mechanical turbulence generated as the wind passes over local surface irregularities, such as terrain features and building structures. The relatively higher percentage of class D conditions at subregions 2 and 3 may be linked to the close proximity of Blackdown Tableland (South) and the Sarina Range (North), which create a barrier to easterly / south-easterly winds. This creates an area of low pressure on the lee side of the mountainous terrain, and therefore neutral atmospheric conditions prevail for a higher percentage of hours. At night, the D class stability is indicative of a stable boundary layer with moderate winds.

The stability categories also indicate a high proportion of stable class (F) conditions and a smaller proportion of slightly stable (E). Class F conditions are experienced for approximately 25-28% of all hours in subregions 1 (North-east) and 4 (Central), with a lower percentage of between 13% and 17% for subregions 2 (South) and 3 (North). Subregions 1 (North-east) and 4 (Central) will experience less of an influence from terrain features than at subregions 2 (South) and 3 (North). Therefore, with night time cooling and relatively calm winds, conditions are suited for the formation of a stable atmosphere. A higher percentage of slightly stable (Class E) conditions are observed at subregions 2 (North) and 3 (South), than at subregions 1 (North-east) and 4 (Central), due to the presence of terrain features. During stable conditions, the plume released from the stack will be subject to minimal atmospheric turbulence. However, the elevated temperature and vertical velocity of emissions from compressors, power plant and flares are likely to generate sufficient thermal and mechanical buoyancy for the plume to penetrate any low night time inversion conditions, resulting in good plume dispersion.

Unstable conditions (Class A-C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground. It is evident that a similar percentage of unstable hours are observed for all subregions, indicating that solar heating is the principal driver to creating unstable conditions. This turbulent mixing forms the main component of dispersion during unstable conditions, but can also lead to plume grounding.

### 8.2.8 Mixing Height

The mixing height is the height to which the atmosphere is uniformly mixed, and determines the height above the ground within which the plume can mix with the ambient air. During the day, solar radiation heats the air at ground-level and causes the mixing height to rise.

Hourly mixing height data for four selected subregions, as per Figure 8-13, were generated for 2009 using TAPM and are presented in Figure 8-14 to Figure 8-17 as box-and-whisker plots.

Figure 8-14 Mixing Height Derived from TAPM Modelling Results for 2009 for North-East Subregion

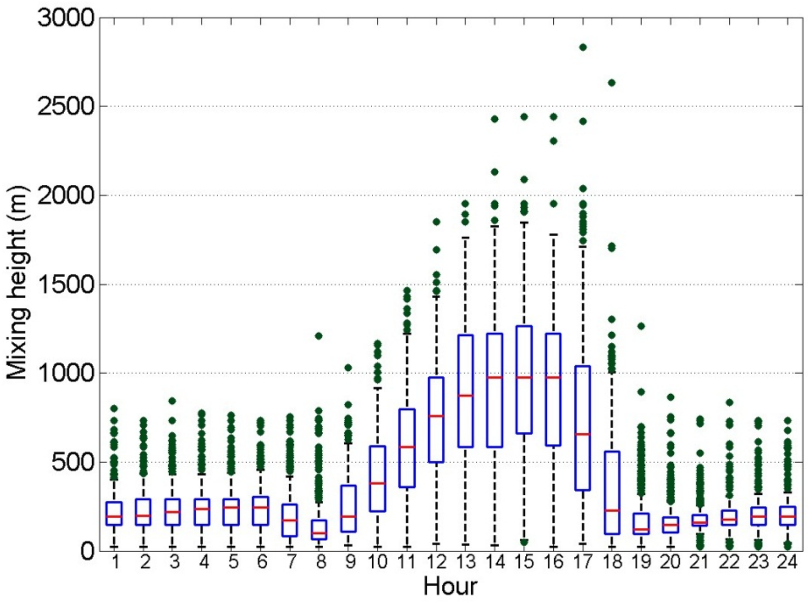


Figure 8-15 Mixing Height Derived from TAPM Modelling Results for 2009 for North Subregion

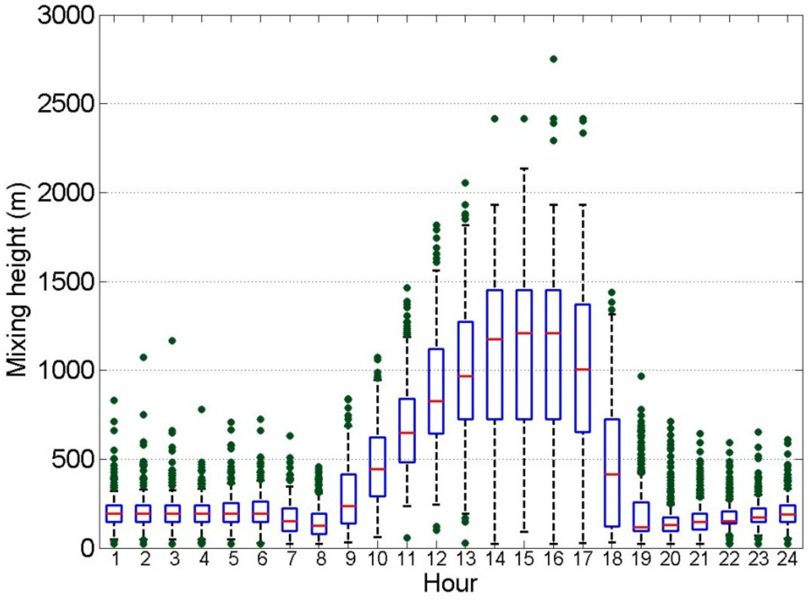


**Figure 8-16 Mixing Height Derived from TAPM Modelling Results for 2009 for South Subregion**

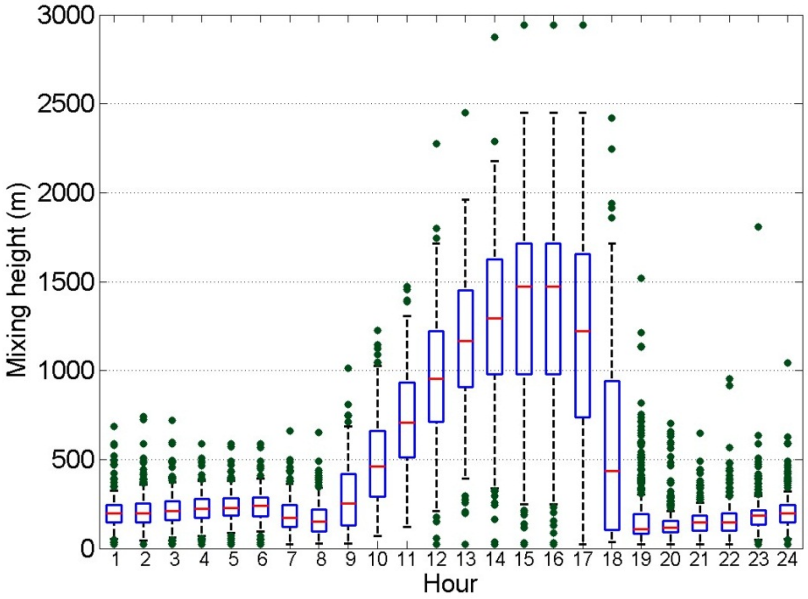


**Figure 8-17 Mixing Height Derived from TAPM Modelling Results for 2009 for Central Subregion**

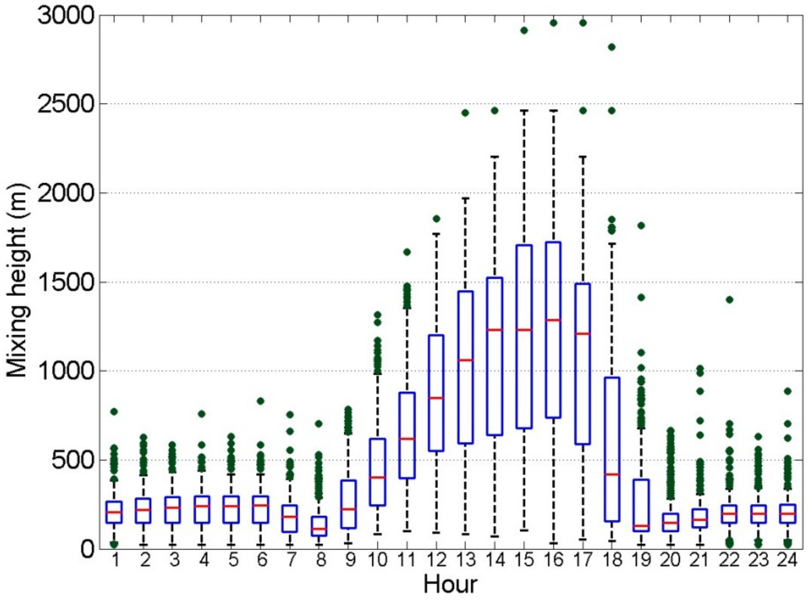


Figure 8-14 to Figure 8-17 shows 25th and 75th percentiles as the box, data coverage (99.3%) as whiskers and outliers (those outside this range) as dots. The red line within a box shows the median value.

The data show that the mixing height tends to increase between 9 am and 10 am, with the peak height occurring in the afternoon between 3 pm and 4 pm. The mixing height decreases again around sunset (5 pm to 7 pm). Mixing, and therefore dispersion of the plume, is likely to be more effective in the daytime hours than at night.

### 8.2.9 Extreme Events

The Project area is subject to extreme climate events such as droughts, floods and cyclones. These events, and the likely impact of climate change on these events, are described in Section 8.4.

## 8.3 Future Climate

In 2007, CSIRO released the technical report *Climate Change in Australia* (CSIRO, 2007), which provides the most up-to-date assessment of observed Australian climate changes, causes and projections for 2030 to 2070. It is based upon international climate change research including the latest Intergovernmental Panel on Climate Change (IPCC 2007) conclusions, and builds on a large body of climate research that has been undertaken for the Australian region in recent years. The purpose of this report was to provide an up-to-date assessment of observed climate change over Australia, the likely causes, global climate change projections, regional projections for Australia, and guidance on using projections in risk assessments. In 2010, the OCC released the technical report, *Climate Change in Queensland what the science is telling us* (OCC, 2010), which elaborates on the findings of the CSIRO report specifically for Queensland.

### 8.3.1 Data Sources

For this assessment, future climate change predictions are based on data from the following; *Climate Change in Australia – Technical Report 2007* (CSIRO), Queensland Government *Climate Change in Central Queensland Report 2010*, and the Queensland Government *Climate Change in Queensland Report 2010*. The 50th percentile (mid-point) forecast values are presented in the Queensland Government (2010) report, which represent the best estimate approach (CSIRO, 2007). The projections give an estimate of the average climate around 2030, 2050 and 2070, taking into account consistency among climate models. The emission scenarios are from the IPCC *Special Report on Emission Scenarios* (2007). As a result of limited data availability, there are a number of limitations with the predictions presented. IPCC (2007) projections are relative to the period 1980 to 1999, but have been applied to current climate data averages for the period 1992 to 2012. For variables such as maximum and minimum temperature daily averages, wind speed and relative humidity at 9 am and 3 pm, no specific climate change forecast was available. In this case, annual average seasonal change was applied.

### 8.3.2 Climate Change Scenarios

There are various scenarios developed by the IPCC (2007) that reflect different assumptions about emissions such as changes in population, rate of adoption of new technologies and economic growth. The scenarios are based on four sets of assumptions (A1, A2, B1 and B2), describing possible alternative futures. Each set of assumptions produces a family of scenarios. Three IPCC scenarios have been used in this assessment:

- B1 lower emissions scenario – assumes a rapid shift to less fossil-fuel intensive industries;
- A1B medium emissions growth scenario – assumes a diversity of energy sources; and
- A1FI higher emissions growth scenario – assumes a continued dependence on fossil fuels.

These three scenarios cover a range of possible futures for climate change modelling.

### 8.3.3 Predicted Climate Change

The climate change predictions provided in Table 8-3 are to be used to assist in the assessment of impacts, adaptation and mitigation of any future climate change projections that may occur within the Project area. According to the IPCC (2007) the possibility that any single emissions path will occur is highly uncertain.

The following is an overview of the estimated changes between now and 2070 for temperature, rainfall, wind speed and relative humidity:

- **Temperature**: Daily maximum temperature is projected to increase by 0.3˚C and 0.9˚C under low (B1) and high (A1FI) emission scenarios, respectively. Daily minimum temperatures are also projected to increase by 0.2˚C to 0.6˚C.
- **Rainfall**: annual rainfall is expected to decrease by 53 and 88 mm under the low and high emissions scenarios respectively.
- **Wind speed**: 9 am wind speeds are predicted to increase by 2.5 and 6.1 km/h for low and high emission scenarios respectively. The 3 pm wind speed projections indicate an increase in annual wind speed of 0.7 and 2.9 km/h.
- **Relative humidity**: 9 am relative humidity is expected to increase 0.2% under the low and high emissions scenarios. 3 pm relative humidity is predicted to increase under both the low and high emissions scenario.

Table 8-3 presents a summary of existing climatic conditions and projections under the three IPCC emission scenarios.

Table 8-3 Summary of Projections for the Project Area

| Variable | Existing Climate | Emission Scenarios | | | | |
|---|---|---|---|---|---|---|
| | | 2030 | 2050 | | 2070 | |
| | | $A_1B$ Medium | $B_1$ low | $A_1FI$ high | $B_1$ low | $A_1FI$ high |
| | | Projected Parameter Changes | | | | |
| Average Daily Maximum Temperature (˚C) | 29.7 | 30.0 | 30.0 | 30.3 | 30.3 | 30.6 |
| Average Daily Minimum Temperature (˚C) | 16.2 | 16.4 | 16.4 | 16.4 | 16.6 | 16.8 |
| Rainfall (mm) | 572 | 545 | 541 | 530 | 519 | 484 |
| 9am Wind Speed (km/h) | 55.1 | 57.6 | 57.6 | 57.6 | 57.6 | 61.2 |
| 3pm Wind Speed (km/h) | 52.6 | 53.3 | 53.3 | 53.3 | 53.3 | 55.4 |
| 9am Relative humidity (%) | 59.0 | 58.5 | 59.2 | 59.2 | 59.2 | 59.2 |
| 3pm Relative humidity (%) | 36.0 | 35.6 | 36.1 | 36.1 | 36.1 | 36.1 |
| Number of hot days | 16 | 26 | 29 | 40 | ND | ND |
| Sea level Rise (cm) | 0.8 m by 2100 (IPCC 2007) | | | | | |
| Drought | Increase in the frequency of droughts from an average of one in 2.2 years to an average of one every 1.7 years by the period 2010-2040 | | | | | |
| Bushfires | Increased occurrence | | | | | |
| Severe Weather (cyclones, flooding, etc.) | Decrease in total rainfall and increase in intensity of individual rainfall events | | | | | |

## 8.4 Natural Hazards / Extreme Weather Events

Climate change projections for the Central Queensland region include a decline in rainfall, with increase in temperature, in conjunction with more extreme climate events. This section describes the Project's vulnerability to natural hazards such as drought, flooding, bushfires and storm events. As the Project site is located in Central Queensland, extreme coastal weather events such flooding will not be discussed in this section.

The following impacts are addressed in the EIS:

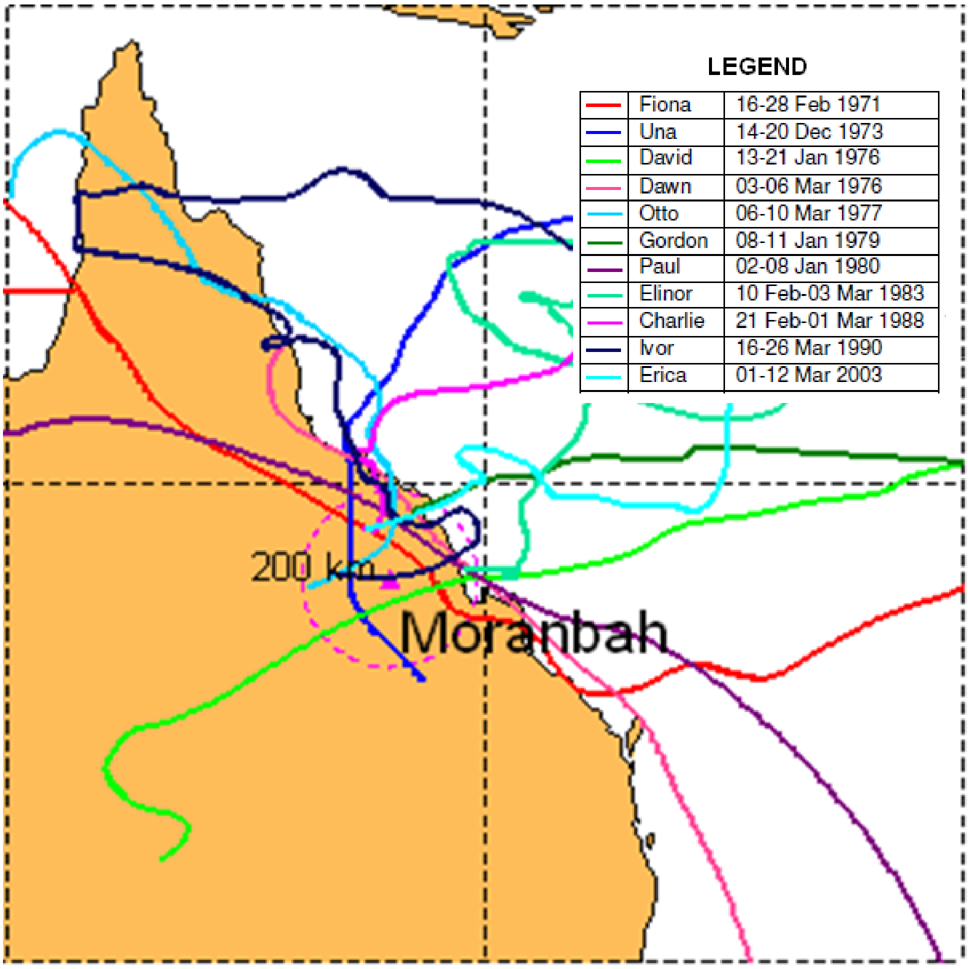
- Rainfall on soil erosion - Soils chapter (Section 12 of this EIS) and the Soils and Land Technical Report (Appendix K of this EIS);
- Storm events on the capacity of waste containment systems (including site bunding / stormwater management) - Waste Management chapter (Section 28 of this EIS); and
- The contamination of waterways and design of the waste containment systems - Surface Water chapter (Section 15 of this EIS) and the Surface Water Technical Report (Appendix N of this EIS).

### 8.4.1 Tropical Cyclones

The Queensland region experiences frequent storm events such as tropical cyclones and thunderstorms. On average 4.7 tropical cyclones per year affect the Queensland area (Queensland Government, 2010). Examples of such events include Cyclones Charlotte and Ellie that resulted in widespread flooding across north and west Queensland in January and February 2009. The most recent tropical cyclone to affect northern Queensland was cyclone Yasi, which hit landfall on the 3 February 2011. Wind gusts were estimated at 290 km/h and the cyclone destroyed structures and caused significant damage throughout the Northern Queensland region.

In the investigation of the frequency of severe storm events, two different studies predicted that the number of cyclones will increase by 56% by 2050 (Walsh *et al.,* 2004) and 22% by 2050 (Leslie *et al,*, 2007). The variation in these projections is due to the lack of good observational data and the limited ability of global climate models to represent cyclone behaviour. Figure 8-18 shows the tropical cyclone activity within a distance of 200 km of Moranbah between 1970 and 2006.

**Figure 8-18 Tropical Cyclone Activity Tracking (1970 to 2006) within a Distance of 200 km of Moranbah (BOM)**



### 8.4.2 Extreme Rainfall

Extreme rainfall is defined as the amount of rain falling in the top one percent of rainfall days. Future projections that were based on the different climatic models used have projected a 4% increase in extreme rainfall events in Queensland under a medium emissions scenario. Although climate change is expected to decrease rainfall across most of Queensland, future projections have predicted climate change to cause an increase in rainfall intensity that could result in more frequent flooding events.

### 8.4.3 Drought

Drought is an extended period of months or years when a region experiences a rainfall deficiency below 10% of all records for the period in question (BOM, 2012). The most recent drought experienced in Queensland was from 2001 to 2008 and this was the most severe on record. The previous worst recorded drought was the Federation Drought from 1898 to 1903 (DERM, 2011). Projections for 2030, 2050 and 2070 in Queensland have indicated that there is likely to be an increase in drought because of an increased mean temperature and decrease in rainfall and soil moisture. Projections have shown that an increase in the frequency of droughts from an average of one per 2.2 years to an average of one per 1.7 years by the period 2010 to 2040.

### 8.4.4 Bushfires

Some areas of Queensland are characterised by long periods of dry, hot weather. Where this coincides with highly flammable natural vegetation, these areas are vulnerable to bush fires. The bushfire season in the region varies from year to year depending on the weather conditions throughout the previous winter. An extended bushfire season is dependent on a very dry preceding winter. The bushfire season can last as long as seven months (from early August to February) or not exist at all. Although bushfires in the region have not been as severe as the worst fires in the southern states, serious events do occur in the region. Predicted decreases in rainfall and humidity, together with increased evaporation rates, are expected to increase the risk of bushfires (QFRS, 2012).

## 8.5 Impact Risk Assessment

### 8.5.1 Methodology

The following semi-quantitative risk assessment procedure was used to evaluate the risks as a result of the various potential climate change impacts on the Project. This approach is consistent with the AS/NZS ISO31000:2009 for Risk Management. The key steps in undertaking the risk assessment involved:

- Identification of the potential climatic impacts on Project operations;
- Analysis of the risks in terms of consequence and likelihood; and
- Evaluation of risks, including risk ranking to identify priorities for their management.

The measures used to assign levels of likelihood are presented in Table 8-4.

### Table 8-4 Measures of Likelihood

| Level | Descriptor | Description |
|---|---|---|
| 1 | Rare | Occurs only in exceptional circumstances |
| 2 | Unlikely | Could occur but not expected |
| 3 | Possible | Could occur |
| 4 | Likely | Will probably occur in most circumstances |
| 5 | Almost Certain | Is expected to occur in most circumstances |

The measures used to assist in the process of assigning levels of consequence are presented in Table 8-5.

### Table 8-5 Measures of Consequence

| Level | Descriptor | Environmental Impact | Project Functionality | Financial Impact (per event or per year) |
|---|---|---|---|---|
| 1 | Negligible | Consequence measured in weeks | No loss of use | <$50,000 |
| 2 | Minor | Consequence <12 months | Short term loss of use (all / part) <1 week | $50,000 to $500,000 |
| 3 | Moderate | Consequence 1-2 years | Loss of use (all / part) 1 week to 1 month | $500,000 to $1 million |
| 4 | Major | Consequence 2-5 years | Loss of use (all / part) 1 month to 1 year | $1 million to $10 million |
| 5 | Severe | Consequence >5 years | Loss of use (all / part) >1 year | >$10 million |

Table 8-4 and Table 8-5 show the descriptors and measures of consequence used in the assessment to interpret the likelihood and impacts of an event shown in Table 8-7.

The risk assessment matrix presented in Table 8-6 was used to establish the level of risk based on likelihood and consequence scores. Scenarios with a combined score of 20 or greater are considered to pose an extreme level of risk. Scenarios with a combined score of between 10 and 16 are considered to pose a high level of risk. Scenarios with a combined score of between five and nine are considered to pose a medium level of risk. Scenarios with a combined score of less than five are considered to pose a low level of risk.

**Table 8-6 Risk Matrix**

| | Likelihood | | | | |
|---|---|---|---|---|---|
| | Rare or practically impossible | Unlikely or uncommon | Possible, has occurred in the past, but not common | Likely, has occurred in recent history | Almost certain or common |
| Consequence | **Rare (1)** | **Unlikely (2)** | **Possible (3)** | **Likely (4)** | **Almost Certain (5)** |
| **Severe (5)** | Medium (5) | High (10) | High (15) | Very High (20) | Very High (25) |
| **Major (4)** | Medium (4) | Medium (8) | High (12) | High (16) | Very High (20) |
| **Moderate (3)** | Low (3) | Medium (6) | Medium (9) | Medium (12) | High (15) |
| **Minor (2)** | Very Low (2) | Low (4) | Low (6) | Medium (8) | Medium (10) |
| **Negligible (1)** | Very Low (1) | Very Low (2) | Low (3) | Low (4) | Medium (5) |

## 8.5.2 Results

A series of risk scenarios were identified for qualitative assessment using the methodology outlined above. The results of the risk assessment for each scenario are presented in Table 8-7.

**Table 8-7 Risk Assessment of Potential Impacts of Climate Change on the Project**

| Risk Scenario | Likelihood | Consequence | Risk |
|---|---|---|---|
| Increased flood risk due to increased rainfall intensity. | Possible (3) | Moderate (3) | Medium (9) |
| Decrease in soil moisture, increased winds and reduced availability of water, which increases generation of dust and reduces ability to manage dust. | Likely (4) | Minor (2) | Medium (8) |
| Increased maintenance costs for infrastructure due to more severe storm / cyclone events. | Possible(3) | Minor (2) | Medium (6) |
| Unsuccessful rehabilitation planting due to reduced rainfall and more severe storm events. | Possible(3) | Minor (2) | Medium (6) |
| Health impacts on site staff from increased temperatures (e.g. heat stress). | Unlikely (3) | Minor (1) | Low (4) |
| Increased soil erosion due to decrease in soil moisture and increased rainfall intensity (including access tracks). | Possible(3) | Negligible(1) | Low (3) |
| Increased bushfire events due to increased temperatures and evaporation potential. | Possible (3) | Negligible (1) | Low (3) |
| Decrease in efficiency of equipment due to increased temperature resulting in increased operational costs. | Rare (1) | Moderate (3) | Low (3) |
| Community / workforce isolation due to higher risks of flooding events. | Rare (1) | Minor (2) | Low (2) |

Table 8-7 shows that the highest level of risk is expected to come from flooding from increased rainfall intensity. This event is possible with a moderate consequence which determines a risk rating of Medium (9).

### 8.5.3 Risk Management Measures

Whilst the risk assessment has identified a number of risk scenarios with a medium level of risk; the predicted effects of climate change are likely to have a positive effect on the Project in some instances. For example, the predicted decreases in rainfall and increases in evaporation allow for the management of CSG water (typically stored in large dams / ponds) easier to account and allow for.

Given that the Project has a life span of approximately 40 years, the likely effects of climate change are expected to be minimal.

However, the following risk management measures would be adopted in the development of the Project to address other risk scenarios:

- Increased risk of flooding:
  - Flood mitigation measures are described in the Surface Water chapter (Section 15.5.3 of this EIS).
- Increased dust generation:
  - Limit the extent of site disturbance; and
  - Undertake rehabilitation, including earthworks, drainage and revegetation, progressively.
- Unsuccessful rehabilitation planting:
  - Monitor rehabilitated areas on a regular basis to ensure that original objectives are achieved. Monitoring will include regular inspections for soil erosion, rehabilitation success, weed infestation, and integrity of water diversion drains, waterways and sediment control structures.
- Increased maintenance costs for infrastructure:
  - Regularly maintain and service all equipment per the technical specifications.

### 8.5.4 Conclusions

An assessment of climate change risks to the Project has been carried out. The key risks were identified as increased flooding, increased dust generation, unsuccessful rehabilitation planting and increased maintenance costs. However, given the limited extent of climate change anticipated over the 40 year life of the Project, it is likely that the mitigation measures proposed will be sufficient to avoid any significant impact on the Project.