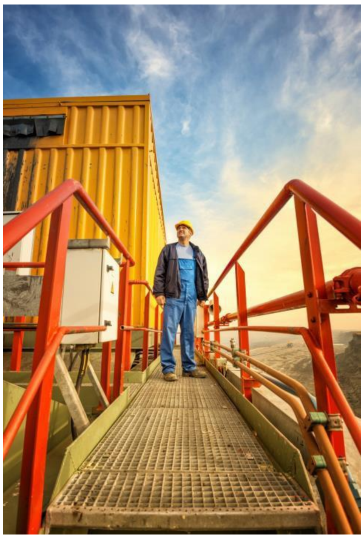

Taroborah Coal Project

Environmental Impact Statement

Section 4.1 – Environmental Values and Management of Impacts – Climate

Prepared for:

Shenhuo International Group Pty Ltd

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4.0 ENVIRONMENTAL VALUES AND MANAGEMENT OF IMPACTS

Section 4 describes the existing environmental values located on the Project site which may be affected by the Project. Environmental values, where appropriate, are defined in reference to Section 9 of the *Environmental Protection Act 1994* (EP Act), environmental protection policies and other guidelines. The description of the relevant environmental values were formulated based on background information and studies (where applicable), which are included as appendices to this Environmental Impact Statement (EIS).

Environmental aspects such as (but not limited to) water, air, noise, nature conservation, cultural heritage, economics and social characteristics were analysed. The impact on such environmental elements and their subsequent values are described quantitatively, where suitable, and a range of mitigation measures are described to alleviate proven and potential impacts.

4.1 CLIMATE

This section outlines general climatic conditions including seasonal rainfall variance, air temperature variability, humidity, wind speed and direction that are relevant to the management of the Project.

The climatic parameters for the vicinity of the Project site have been sourced from regional data collected from the closest Australian Bureau of Meteorology (BOM) Weather Stations.

Rainfall

Emerald Airport Station has recorded regional rainfall since 1992 and is located approximately 24.6 kilometres (km) east-south-east of the Project site. Anakie Richardson St Station, located approximately 19.3 km west of the Project site has rainfall records for the region extending back to 1889.

Data trends indicate that mean annual rainfall indicative of the Project site is between 650 millimetres (mm) (Anakie Station) and 559 mm (Emerald Airport Station) (BOM 2013). Figure 4.1 illustrates that rainfall is highly seasonal, with the dry season peaking between July and September and the wet season peaking from January through to February.

The Project site lies slightly north of the Tropic of Capricorn and experiences a subtropical climate with a wet summer season between November and March and a drier winter season from April through to October.

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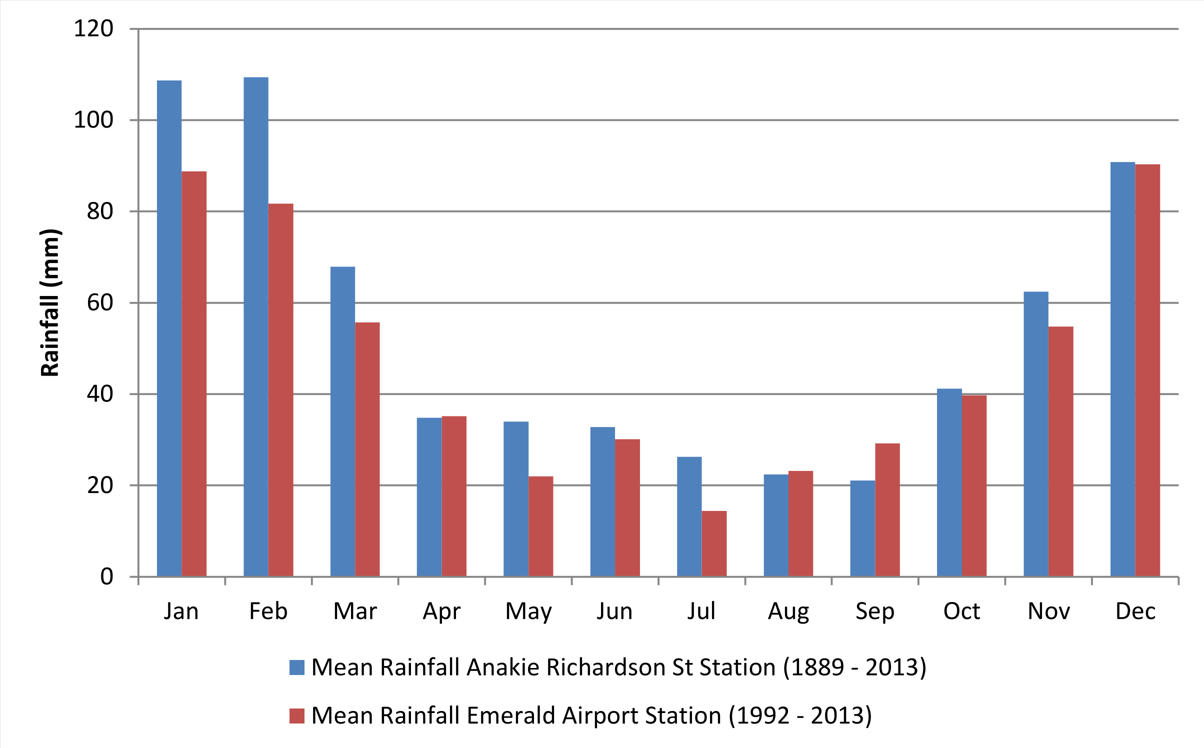


Figure 4.1 Mean Monthly Rainfall at Nearest Measurement Stations to the Project Site

Temperature

Statistical records sourced from the Emerald Post Office present the monthly temperature variations from 1882 to 1992 in Table 4.1. The high values are highlighted in red and the low values in blue. The data indicate July is the coolest month of the year with a mean minimum temperature of 6.9 degrees Celsius (°C) and a mean maximum temperature of 22.4°C. The warmest month of the year is December with a mean maximum temperature of 34.8°C. Mean minimum temperatures of 21.4°C and 21.0°C were recorded in January and February respectively. The statistical data is arranged graphically in Figure 4.2.

Table 4.1 Statistical records of mean minimum and mean maximum temperatures, 1882 -1992

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean minimum temperature (°C) for years 1889 to 1992	21.4	21.0	19.4	15.7	11.5	8.4	6.9	8.1	11.8	16.0	18.9	20.7	15.0	101
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Mean maximum temperature (°C) for years 1889 to 1992	34.2	33.2	32.0	29.4	25.7	22.7	22.4	24.8	28.3	31.6	33.7	34.8	29.4	100

Source: BOM (2013a)

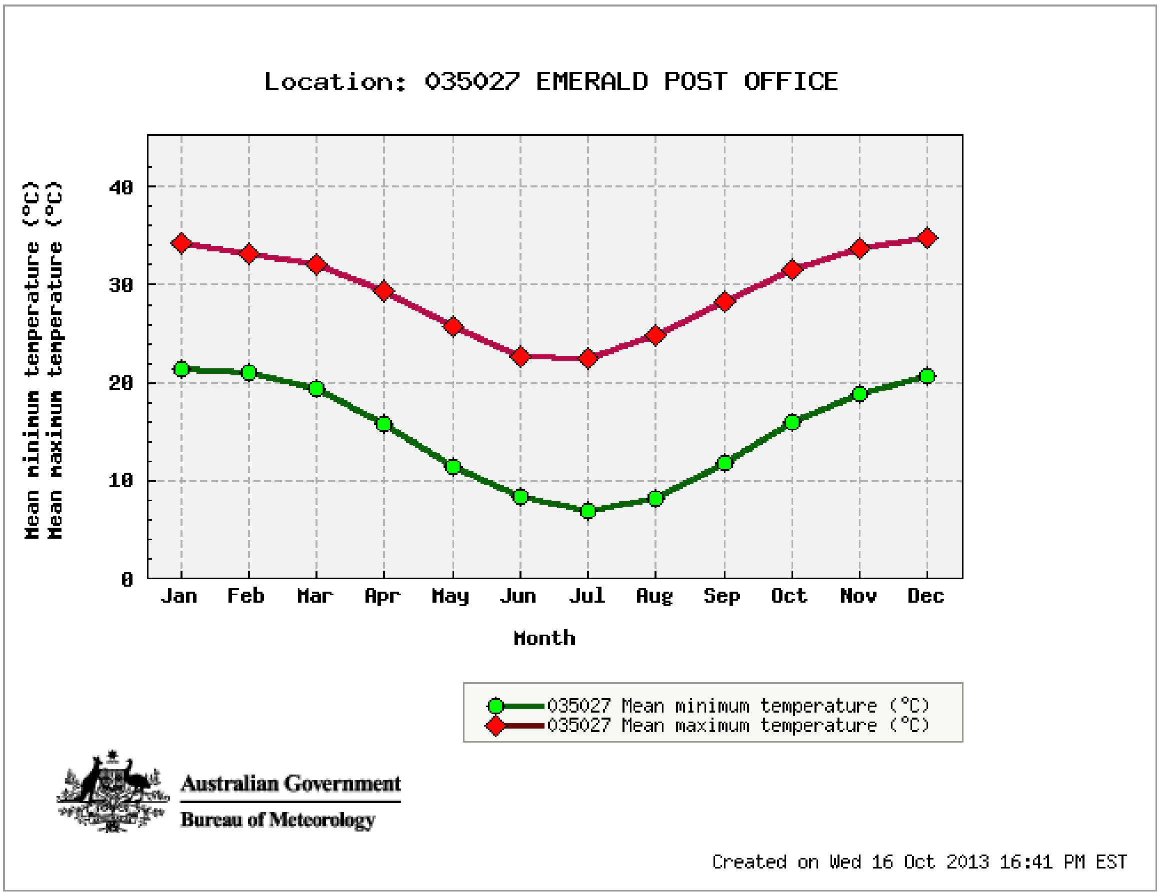


Figure 4.2 Mean Monthly Temperature (°C) for Emerald Post Office Weather Station for the period 1882-1992 (BOM 2013a)

Humidity

The Emerald Post Office monthly mean relative humidity taken at 9.00am and 3.00pm are recorded in Table 4.2. Highs are recorded in red and lows are recorded in blue. The highest means for relative humidity at 9.00am (68%) and 3.00pm (47%) were recorded in February. Equally high morning humidity was also registered in June. The lowest mean relative humidity for morning and evening was recorded in October and is typical for the spring season September through to November. The seasonal variance is graphically illustrated in Figure 4.3.

Table 4.2 Mean Monthly Relative Humidity at 9.00am and 3.00pm for Emerald Post Office Weather Station

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean 9am relative humidity (%) for years 1889 to 1992	65	68	67	64	64	68	65	60	56	55	56	60	62	96
Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean 3pm relative humidity (%) for years 1896 to 1992	43	47	45	42	43	45	42	37	33	32	35	37	40	89

Source: BOM (2013a)

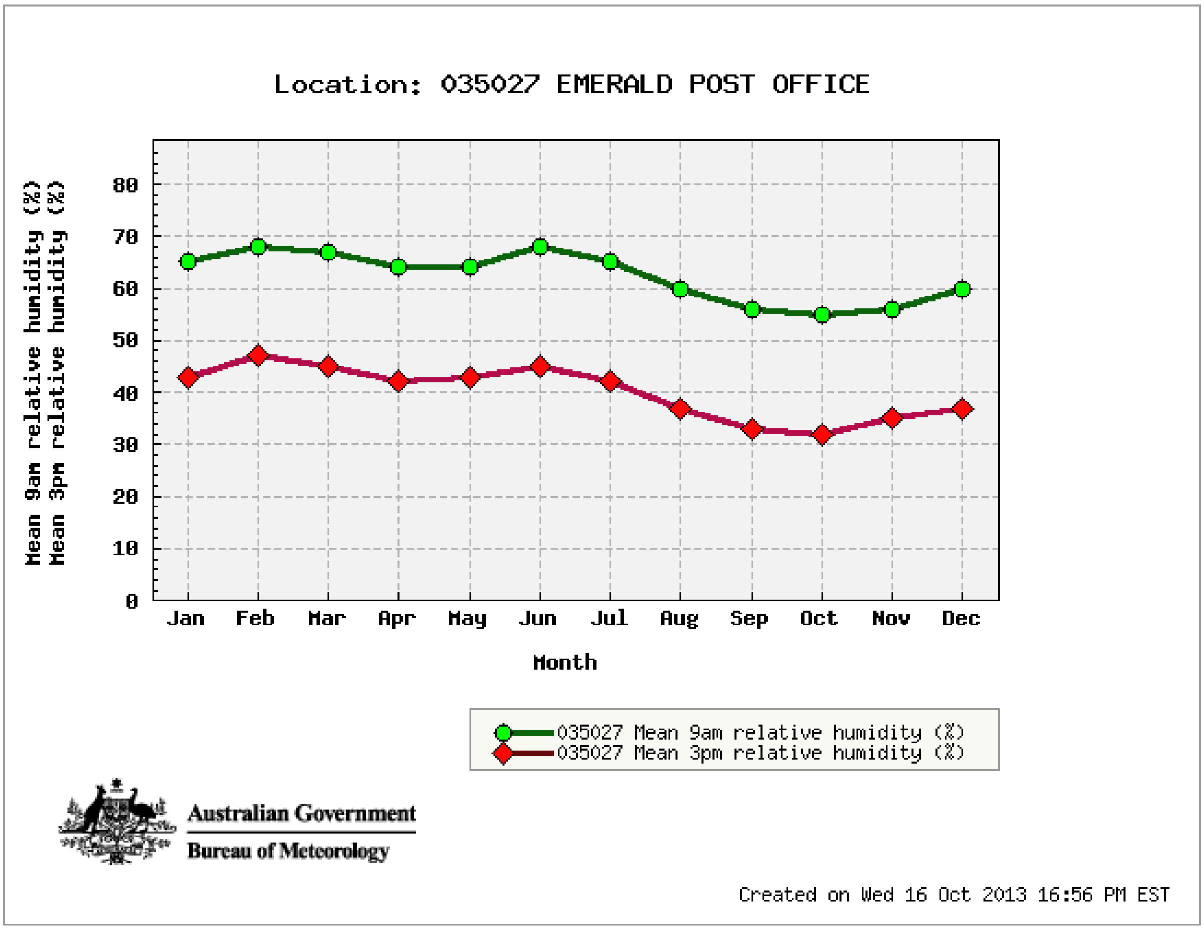


Figure 4.3 Mean Monthly Relative Humidity (%) for Emerald Post Office Weather Station (BOM 2013a)

Wind

One hundred years of wind data showed September as the windiest month at the Emerald Post Office Weather Station with the high mean wind speeds at 9.00am (9.7 kilometres per hour [km/h]) and

3.00pm (9.1 km/h). The calmest month was recorded in June at 9.00am (7.5 km/h) and in May at 3.00pm (7.4 km/h). The lowest mean wind speeds are highlighted in blue and the highest mean speeds are highlighted in red in Table 4.3.

Table 4.3 Mean Monthly Wind Speed at Emerald Post Office Weather Station

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean 9am wind speed (km/h) for years 1887 to 1992	8.0	8.1	8.4	8.5	8.4	7.5	7.8	8.6	9.7	9.4	8.7	7.8	8.4	102
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Mean 3pm wind speed (km/h) for years 1887 to 1992	8.1	8.2	7.9	7.7	7.4	7.6	7.7	8.6	9.1	8.9	8.3	7.7	8.1	90

Source: BOM (2013a)

Wind roses from the Emerald Post Office Weather Station illustrate the wind direction and speed in km/h from January 1887 to June 1992. The hour variance in mean annual wind speed and direction are captured in Figure 4.4 (BOM 2013a).

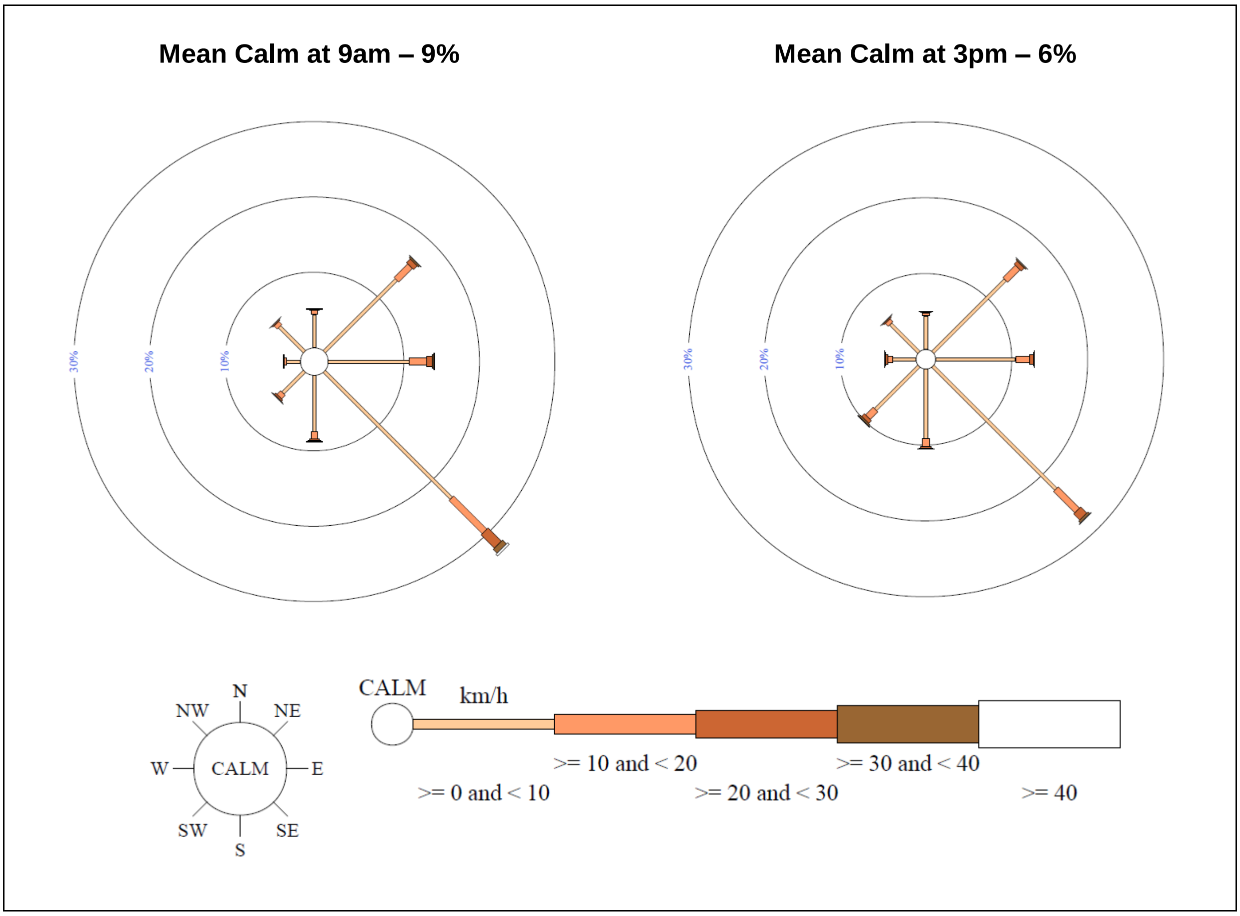


Figure 4.4 Mean Annual Wind Speed and Direction recorded at Emerald

Figure 4.5 and Figure 4.6 capture the seasonal variance in wind speed and direction for the nearest measuring station to the Project site.

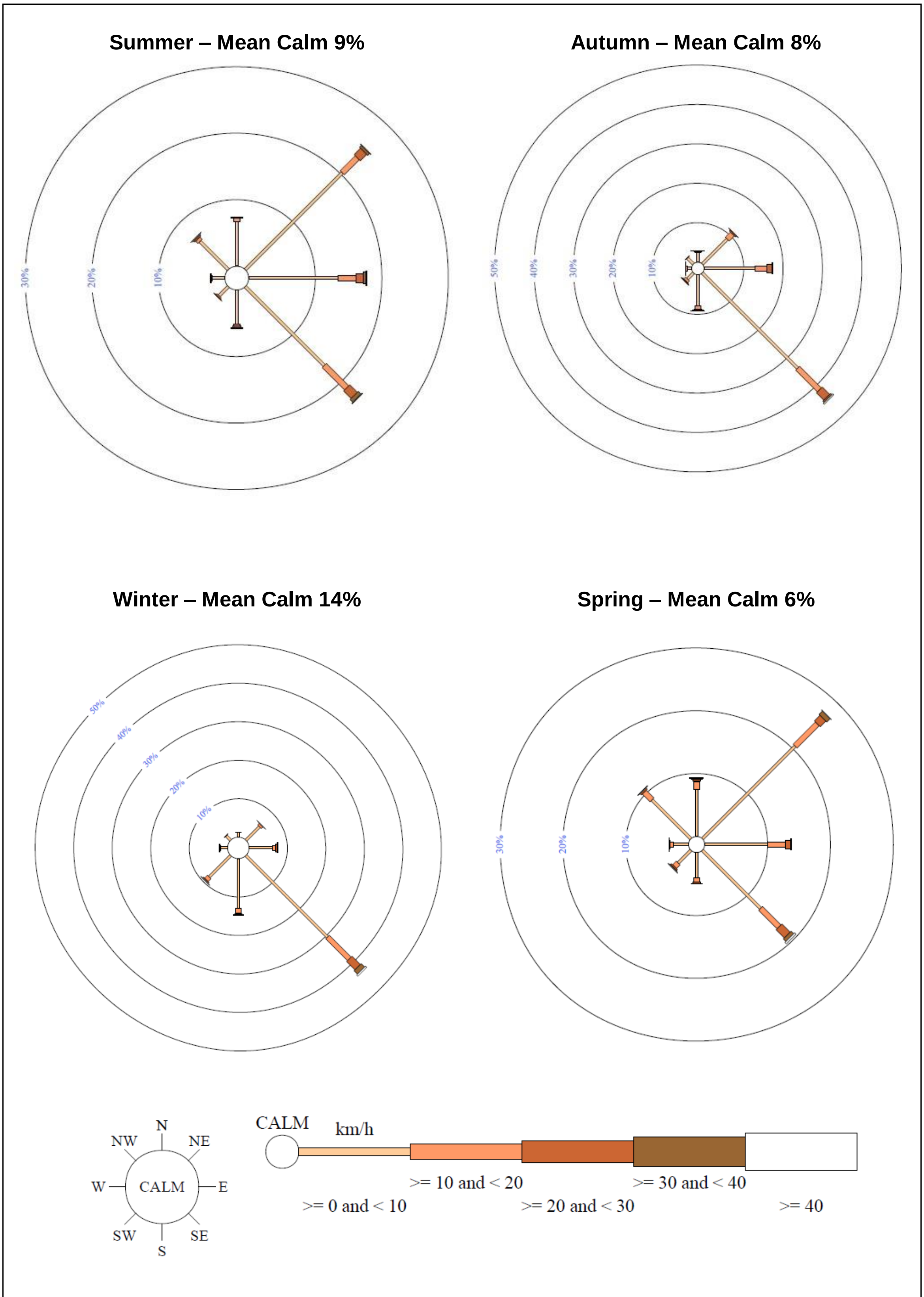


Figure 4.5 Mean Seasonal Wind Direction and Speed Recorded at 9.00am at Emerald

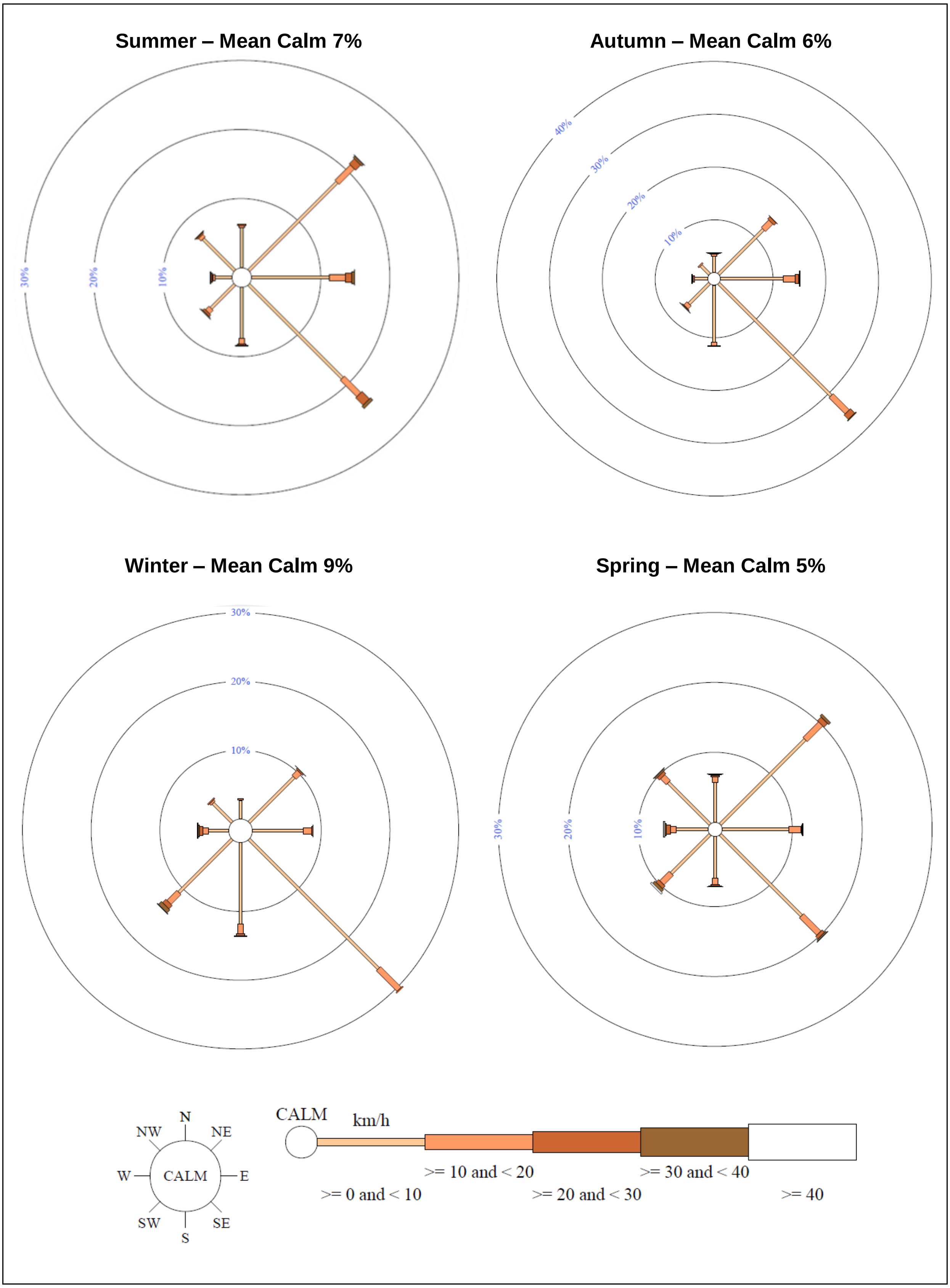


Figure 4.6 Mean Seasonal Wind Speed and Direction Recorded at 3.00pm at Emerald

Extreme Climatic Events

Extreme weather refers to weather at the extremes of the historical range. The occurrence of extreme weather events are rare (Hallerberg *et al* 2008) but it is the unexpected nature of extreme weather that makes these events significant. Their potential to influence Project management strategies are considered in this section.

Flooding and Cyclones

The modified Köppen's scheme is a commonly accepted method used to classify world climates (Stern *et al* n.d.). The classification may be applied to present day climatic conditions as well as supporting climate models for future climatology (Stern *et al* n.d.). The Köppen Climate Classification system has been used to assess the Project's potential exposure to flooding and cyclone events.

The Köppen classification is founded on the view that native vegetation reflects climate zone boundaries and can be used as an expression of the climate for a particular area (Stern *et al* n.d.). Köppen's classification specific to Australian climates identifies six principal vegetation groups, equatorial, tropical, subtropical, desert, grassland and temperate as described in Figure 4.7. The Köppen Climate scheme classifies the location of the Project site as subtropical with a moderately dry winter.

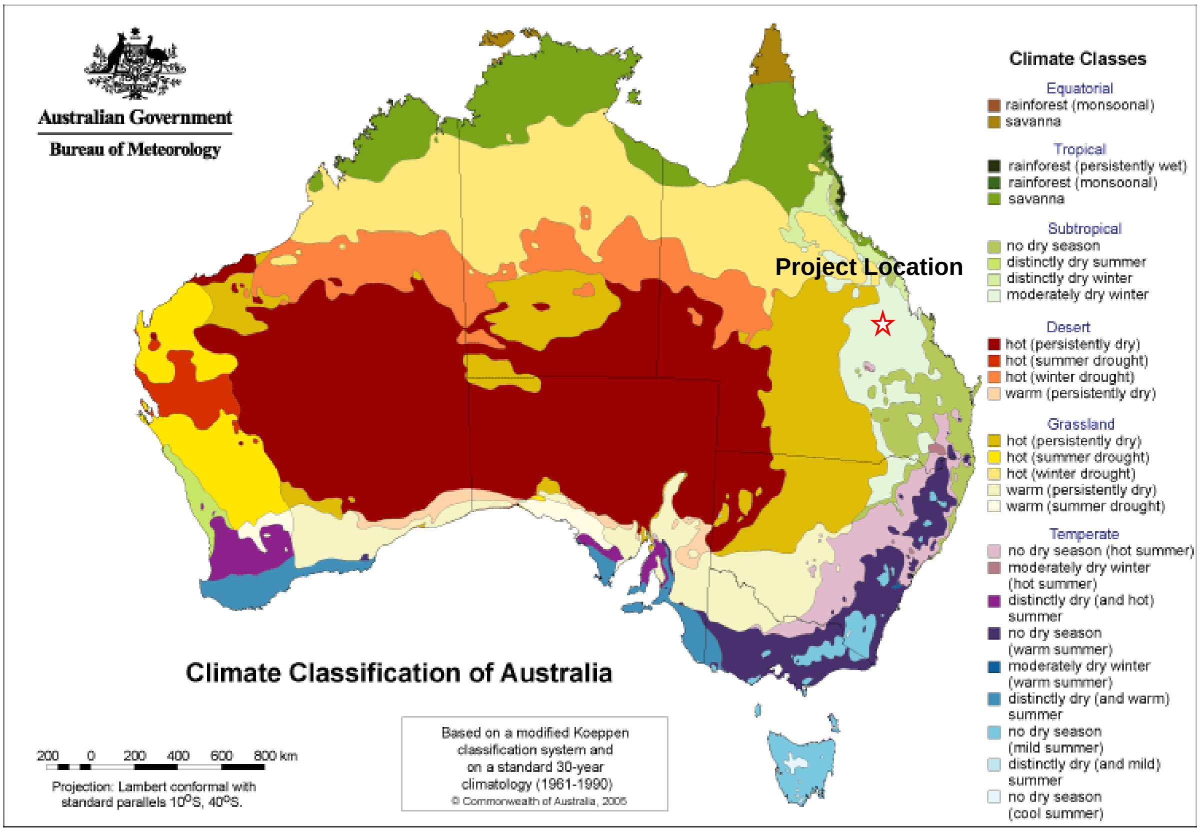


Figure 4.7 Köppen's Climate Classification Scheme for Australia (BOM 2013b)

The Australian average annual number of tropical cyclones, using 36 years of data from 1969-2006 is captured in Figure 4.8. The South Pacific Ocean Basin sees an average of nine tropical cyclones annually.

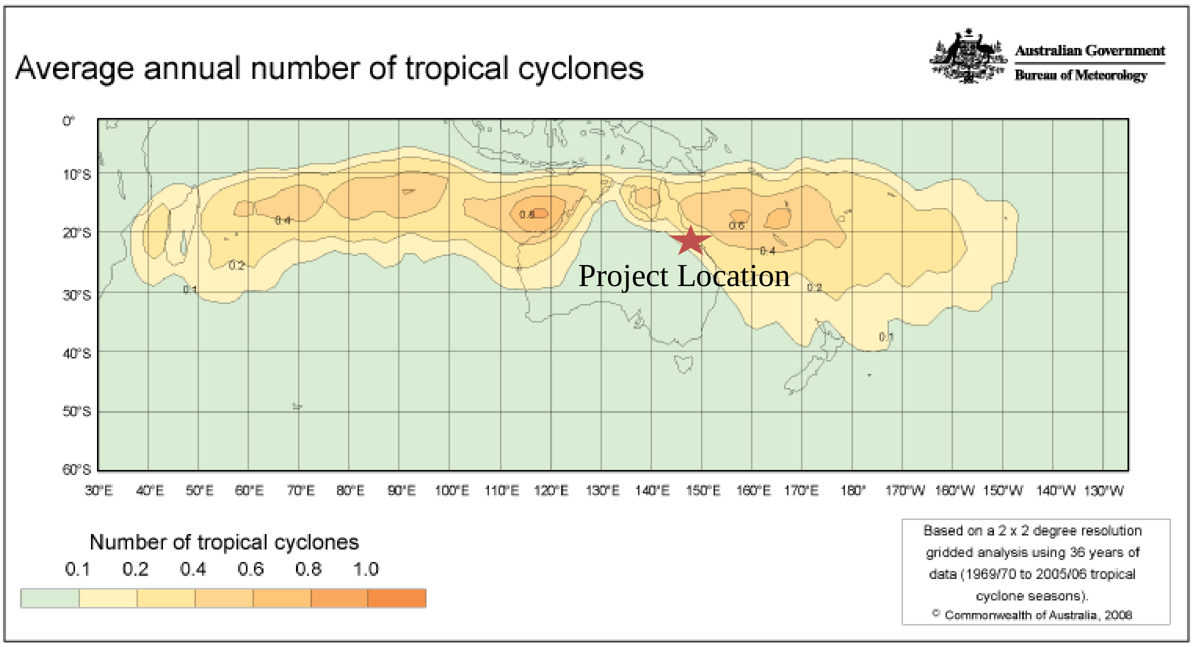


Figure 4.8 Average Number of Tropical Cyclones

Tropical cyclones in the Queensland region mostly form from lows within the monsoon trough, between November and April. The Australian BOM maintains a database containing the details of all tropical cyclones that are known to have occurred since 1906. Figure 4.9 provides an illustration of the tracks of the 25 cyclones that have passed within 200 km of the Project site over the 100 year period 1906 to 2006. The average annual number of tropical cyclones within the vicinity of the Project Area is less than 0.4.

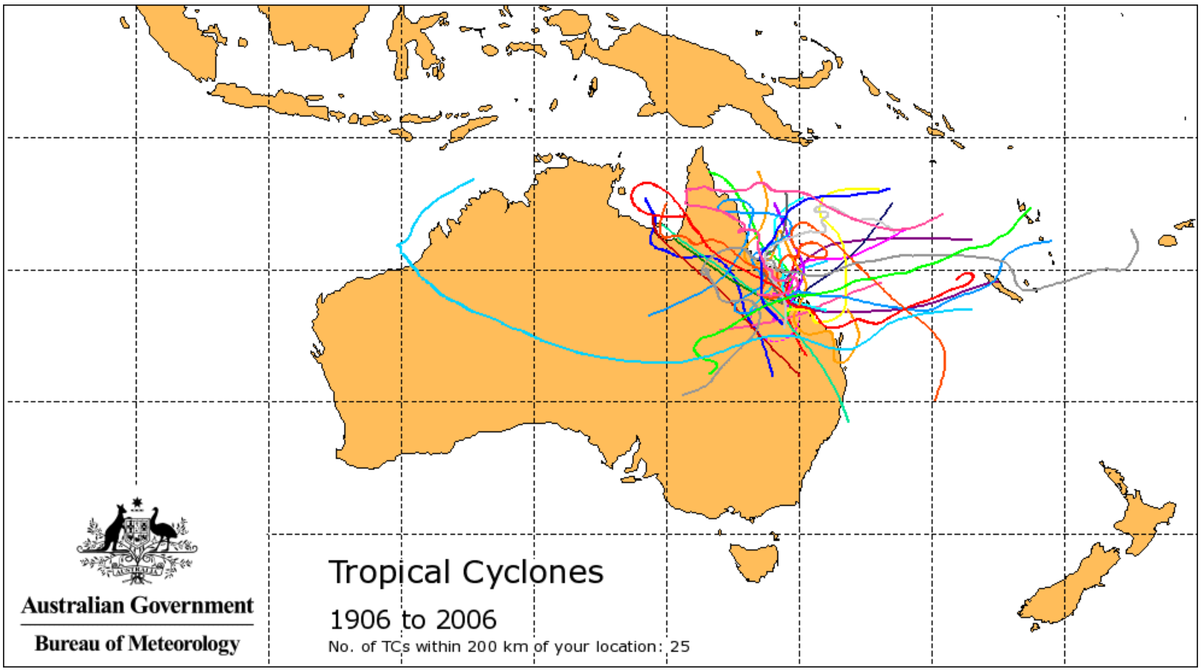


Figure 4.9 The Number of Tropical Cyclones Passing within 200 km of the Project Site Between 1906 and 2006 (BOM 2013d)

Tropical cyclones are hazardous because they produce destructive winds and heavy rainfall with flooding (BOM 2013c). Flooding has the ability to create surface water run-off, potentially causing contamination of land and waterways within and surrounding the Project site.

Flooding will be considered and incorporated in the design of water management structures which will be constructed to provide adequate Annual Exceedance Probability (AEP) flood protection.

Droughts

The BOM database provides rainfall percentile rankings of Australia's current rainfall. The data, captured in Figure 4.10, identifies Queensland rainfall deficiencies from 1st October 2010 to 30th September 2013 and indicates no areas within the State of Queensland have experienced serious or sever rainfall deficiencies over the 36 months to September 2013 (BOM 2013e).

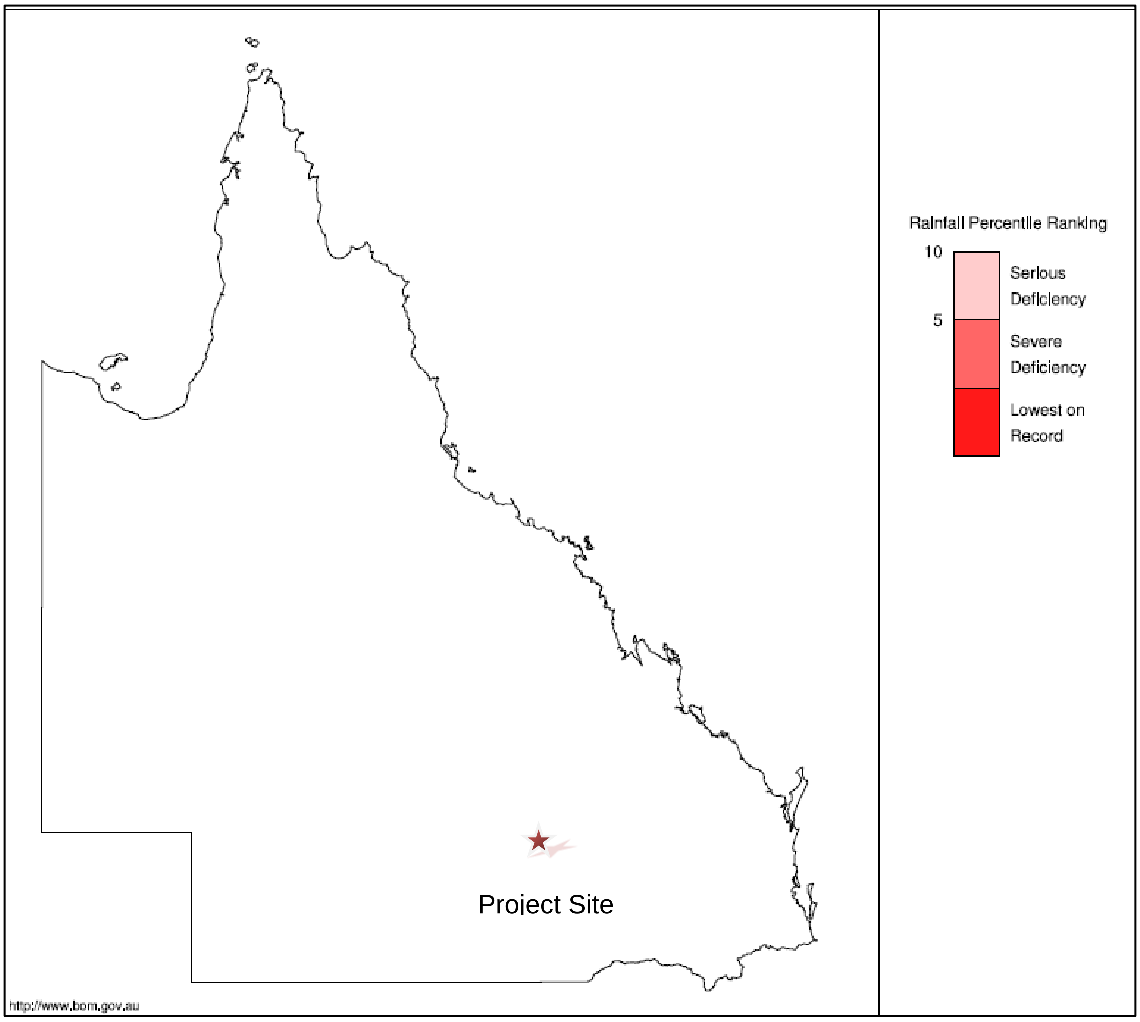


Figure 4.10 Rainfall deficiencies for the last 36 months

Fires

A bushfire is a fire that burns in grass, bush or woodland. A number of factors determine the risk of fire including the slope of the land, availability of dry vegetation, wind speed, humidity, and heat. The hotter and drier the weather, the greater is the risk of a bushfire. Wind speeds dry the air by reducing moisture and influence a bushfire by providing oxygen resulting in the fire's rapid spread. Rainfall dampens potential fuels so in periods of rainfall deficiency the risk of bushfires is increased.

The fire season in the vicinity of the Project site is during the dry spring months. The Project site's fire season correlates with the seasonal drop in relative humidity in September, October and November together with an increase in the mean wind speeds in September. These conditions are eased by the summer rains. Refer to Figure 4.11 for a summary of the fire season for the Project site and Figure 4.12 for the risk of bushfires occurring within the vicinity of the Project site. In terms of the Project site, the main fire season occurs in spring and therefore, appropriate fire management procedures will need to be instigated at this time of year.

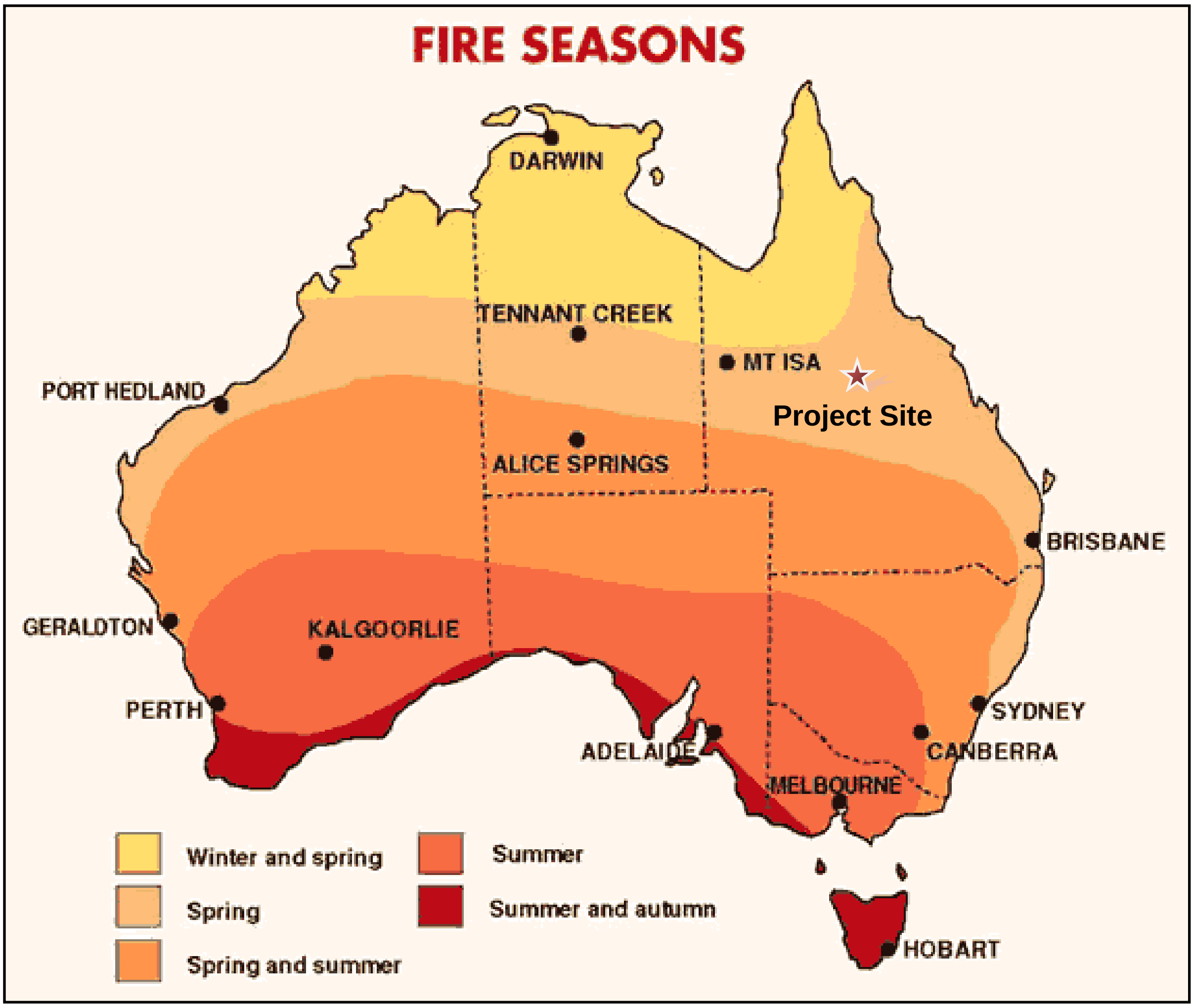
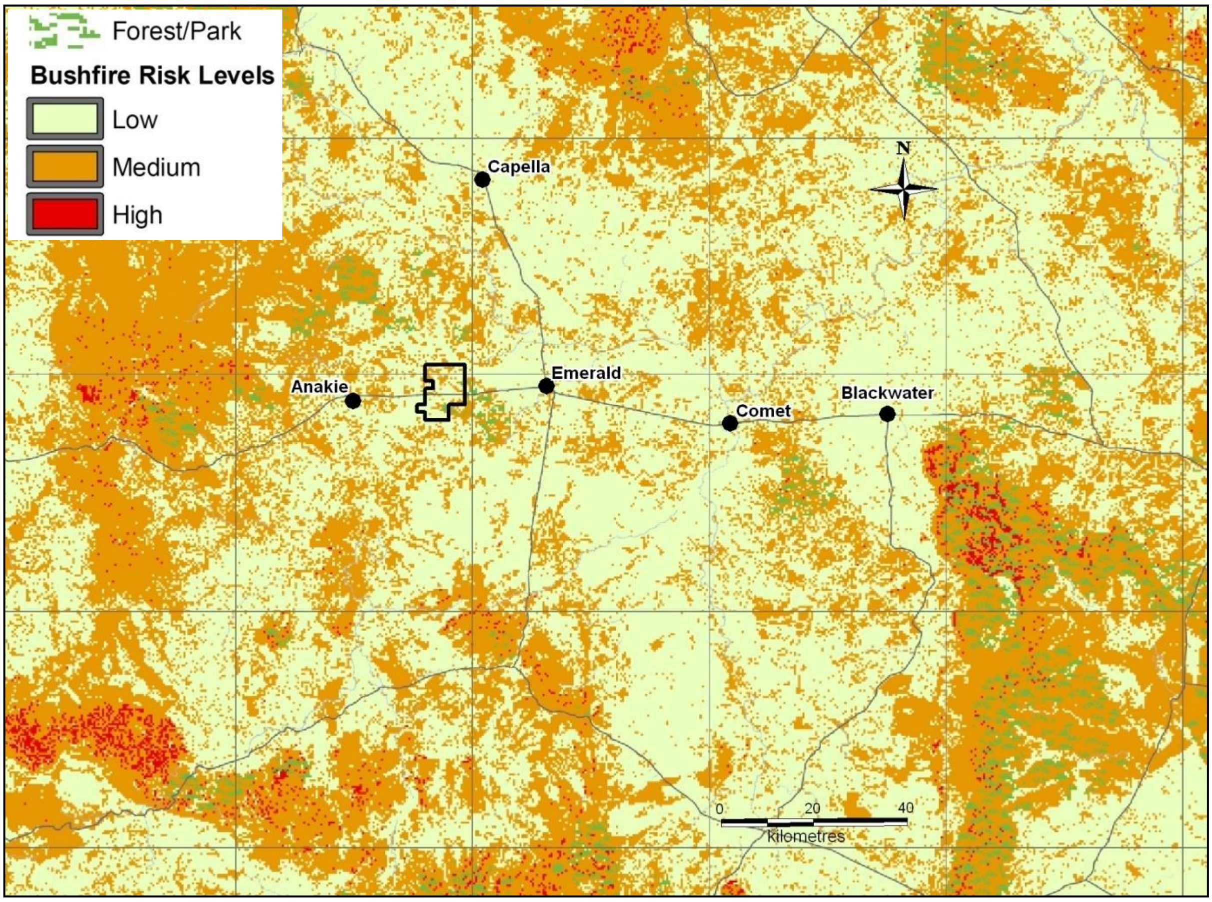


Figure 4.11 Fire Seasons for Australia Relative to the Project Site (BOM 2013f)



Source: Department of Community and Safety 2013

Figure 4.12 Bushfire Risk Levels

4.1.1 Climate Change Adaptation

A desktop assessment of the potential medium and long-term impacts of both climate change and adverse weather conditions upon Project construction, operations and decommissioning was conducted. The assessment was comprised of both a desktop study and risk workshop, with the outputs of this assessment potentially proving beneficial to the Project as follows:

- The Project can be designed and managed to ensure that the non-renewable community resources provided to the Proponent for development (e.g. Taroborah's thermal coal deposit) are not depreciated due to Project closure or costly remedial actions, which may be required in order to address impacts from climate change and / or adverse weather conditions;
- Potential climate change or adverse climatic condition impacts upon the integrity of the Project's waste storage facilities can be minimised at the design stage;
- Infrastructure damage due to an increase in flooding or cyclonic events can be anticipated and managed;
- Variations in water availability for the Project (as a result of adverse weather conditions and / or climate change) can be forecast and addressed; and
- Fluctuations in power supply to the Project as a result of elevated local temperatures can be

accommodated.

An adaptive approach to Project design will be required, in order to ensure that the above climate-related Project risks are effectively managed. A number of adaptation strategies have been developed for this Project and are summarised in this EIS section. Please refer to Appendix 16 for the *Adaptation to Climate Change and Variability Assessment for the Taroborah Coal Project* (Katestone Environmental Pty Ltd 2013) technical report.

Note that Project impacts which arise as a result of changes in sea levels due to climate variations have been excluded from this EIS, since the Project site is located approximately 220 km from the nearest coast line and changes in sea levels are not anticipated to impact the Project.

It is recognised that changes in climate patterns are inherently difficult to accurately predict and that therefore, the cost of preparing for climate change should be planned and managed in the light of the uncertainties associated with climate prediction outcomes. In addition, it is also acknowledged that government, industry and other sectors need to adopt a cooperative approach in order to effectively manage the potential impacts of climate change upon both Project operations and resource accessibility.

4.1.2 Regional Climate Variability

The following sections outline the various global climatic influences driving national and regional climatic conditions.

4.1.2.1 General Atmospheric Circulation

On a global scale, weather systems are based upon a general circulation of the atmosphere (wind), as a result of pressure gradients (due to differential heating of the Earth's surface), the Earth's rotation and surface friction. Such circulation is then modified by differential heating of the Earth's surface, spatial variability of the oceans and land surface and terrain features. The movement of wind across the Earth's surface occurs as three, latitudinal circulation-cells due to the fact that the winds are first heated and then cooled as they move from the Equator to the Pole and then warmed up again, as they move back towards the Equator.

The weather (atmospheric state at a point in time) and climate (weather conditions observed over a longer period) of a region are influenced by specific configurations of land and sea in that region, season and decadal variations and chaotic perturbations within the circulation cells.

4.1.2.2 El Niño Southern Oscillation Periods

Extensive warming of the central and eastern tropical Pacific Ocean results in a major shift in weather patterns every three to eight years. Such a shift is termed the El Niño Southern Oscillation (ENSO). These oscillations are characterised by below average rainfall, above average daily-maximum temperatures and below-average overnight minimum temperatures.

During El Niño years, the trade winds weaken and the central and eastern tropical Pacific Ocean warms up with a weaker than average Walker Circulation - an east-west circulation of the atmosphere above the tropical Pacific.

In terms of temporal duration, ENSO phases tend to persist for six to 18 months and occur over three to eight year periods.

Since autumn tends to represent the build up and decay periods for ENSO related effects, weather data collected in the autumn is often excluded from any climate analysis.

4.1.2.3 La Niña Periods

La Nina climatic conditions represent the reverse phase of the ENSO, with extensive cooling of the central and eastern tropical Pacific Ocean and a stronger than average Walker Circulation. These periods are generally associated with above average rainfall across much of Australia, below average daily-maximum temperatures and increased overnight minimum temperatures.

Note that La Niña periods tend to have a greater impact upon temperatures then El Niño phases.

4.1.2.4 Pacific Decadal Oscillation

The Pacific Decadal Oscillation (PDO) lasts twenty to thirty years, is located in the North Pacific (with secondary signatures evident in the tropics) and represents a long-lived version of the ENSO. The PDO exists as both cool (negative) and warm (positive) phases and only two full PDO phases have been recorded in the past century.

Forecasting the impacts of the PDO upon regional climates is often challenging, since the cause of the PDO is not understood to any great degree.

Since PDOs last longer than ENSOs, their climatic variations span periods of time which are comparable to Project lifetimes and are therefore important.

4.1.2.5 Regional Climate

Climate conditions in sub-tropical Queensland are largely driven by the southeast trade winds and seasonal variations in these winds. Since the trade winds transport moist oceanic air to the coastal regions of eastern Australia, they are the main drivers of rainfall and climatic variability in this region. These winds also interact with surface topography; creating sub-tropical ridges (heat highs) and troughs (heat lows).

During cooler months, the sub-tropical ridge is located over central parts of Australia, however, as the continent warms up, the ridge moves southward. Such a movement creates an area of low pressure, which draws the monsoon trough over northern Australia and can create unstable, thunderstorm conditions. The monsoon trough is characterised by a moist, tropical, north-westerly flow of wind, which is a major contributor to regional rainfall in both the tropics and sub-tropics.

The Australian monsoon exhibits both active (heavy rains and trough movement towards the pole) and break phases (lighter rains and trough movement towards the equator), which is thought to be influenced by the Madden-Julian Oscillations (MJO), an eastward pulse of convection that occurs, on average, every 30 to 90 days and coinciding with active phases of the monsoon. The MJO also interacts with the trade winds in winter and spring, where pressure differentials between the Indian Ocean and Australian Pacific Ocean enhances rainfall along the east coast of Australia.

Interactions between the ENSO, monsoon and MJO tend to dominate climate conditions in the tropics, bringing heavy rains, warmer temperatures and high levels of humidity to the tropics, sub-tropics and sometimes to the mid-latitudes.

4.1.3 Regional Climate Change History and Predictions

In order to predict climate change, both historical weather data and climate projections have been assessed. The following sections provide a summary of the data that was employed to conduct the climate change assessment.

4.1.3.1 Historical Climate Change

In terms of historical information, the following Emerald climate parameters for the last 120 years were reviewed:

- Temperature;
- Rainfall;
- Solar radiation;
- Evaporation; and
- Relative humidity.

Wind speed and tropical cyclone data collected over this period were also analysed. Historical variations in temperature and rainfall for each season and phase of the ENSO (comprises of El Niño, neutral and La Niña phases) and warm and cool phases of the PDO were reviewed, except for the autumn season which is considered to be an un-representational transition period.

The results of the historical climate assessment have been summarised as follows:

- Historical ENSO and PDO phases – cool PDO phases were recorded from 1900 to 1924 (including five La Niña periods lasting one to two years and six El Niño periods lasting two to three years) and 1947 to 1976 (including five La Niña periods lasting one to three years and six El Niño periods lasting one year). Warm PDO phases were noted from 1925 to 1946 (including three La Niña periods lasting one to two years and four El Niño periods lasting one year) and 1977 to 2011 (including five La Niña periods lasting one to three years and ten El Niño periods lasting one year);

- Temperature – during a cool PDO phase, El Niño years have on average four more days above 30^{o}C than La Niña years and 28 more days above 35^{o}C than La Niña years. For the warm PDO phase this difference is even more exaggerated, El Niño years have on average 26 more days above 30^{o}C than La Niña years and 33 more days above 35^{o}C than La Niña years. The number of hot days for neutral years tends to lie in between those for El Niño and La Niña years. Also during a warm PDO phase, daily minimum temperatures tend to be 0.5 to 0.9^{o}C higher on average than cool PDO phases;

- Rainfall – regardless of the PDO phase, significantly more rainfall occurs during La Niña in winter, spring and summer than El Niño conditions, both in terms of the number of rain days and heavy rain days (greater than 25 mm). Neutral years tend to have a number of rain days intermediate between those of La Niña and El Niño;

- Solar radiation – no significant variation in solar radiation was identified during either El Niño,

La Niña or PDO phases;

- Evaporation – found to be higher during El Niño periods due to the higher level of solar radiation reaching the earth's surface during this period; and

- Relative humidity – PDO and ENSO appear to have minimal impact upon relative humidity values, although humidity during the cool phase PDO is higher by 2 – 4 % than the warm phase PDO; and

- Tropical cyclone activity – it appears that the frequency of tropical cyclone events is higher during the PDO cool phase and in La Niña, rather than El Niño years.

4.1.3.2 Predicted Climate Change

Climate predictions were considered in terms of the following parameters:

- Climate variability – climate extremes over a short 10 to 20 year period, based upon PDO and ENSO projected trends and historical values;

- Climate change – a medium term assessment based upon model predictions for 2035, including atmospheric warming caused by greenhouse gases; and

- Climate data evaluation - comparison of modelled climate predictions with historical climate data, incorporating ENSO and PDO effects.

The outputs from 23 global circulation models (OzClim) were assessed for the year 2035 (near the end of mine life) assuming increases in population growth, economic development and energy demands over this period, that are similar to current growth rates (the Intergovernmental Panel on Climate Change (IPCC) A2 greenhouse gas emissions scenario).

Both climate variability (a range of climatic conditions experienced between two average states over the short-term) and climate change (difference between the current, average state of the climate and the average state of atmosphere at some point in the future – measured over the long-term) can occur during the life of the Project.

It should be noted that near term (20 to 30 years), extreme weather conditions which arise as a result of general circulation patterns (e.g. La Niña) are considered to pose more of a Project risk than the longer-term effects of climate change. Since the region appears to be moving into a La Niña phase, weather conditions associated with this phase will probably have the greatest Project impacts during the life of the mine.

The following outputs for each climate factor were obtained from the OzClim climate prediction models that were run for 2035:

- Rainfall – annual average rainfall in 2035 is predicted to lie within the range 500 to 600 mm, with average summer rainfall varying from 200 to 280 mm and average winter rainfall varying from 60 to 80 mm. Average seasonal rainfall values will be similar to historical neutral conditions and El Niño years rather than those anticipated under La Niña climatic conditions;

- Temperature – the maximum temperature has been predicted to exhibit a difference of approximately 11^{o}C between summer and winter, the minimum temperature shows a 13^{o}C

difference between summer and winter, whilst the average exhibits an 11°C difference. Daily average minimum and maximum temperatures for all seasons are predicted to be higher by approximately 0.2 to 2°C;

- Relative humidity – little seasonal variation in relative humidity has been predicted by the models, however, average relative humidity values are generally higher than relative humidity values modelled at 09:00 hour (h), which in turn, are greater than those predicted for 15:00 h. The greatest variations in model predictions occurred for 15:00 h for all seasons;

- Evaporation – predicted values for evaporation were modelled to be higher in spring and summer than autumn and winter, with average annual evaporation values predicted to be in the range 2,200 mm to 2,300 mm; and

- Solar radiation – in general, solar radiation is not anticipated to increase, however, more solar radiation is predicted to be received in spring and summer than in autumn and winter, due to the longer days and stronger sun during summer. The average annual daily solar radiation is predicted to be 20 megajoules per square metre (MJ/m^2) in 2035.

4.1.3.3 Comparison of Historical and Predicted Climate Changes

In order to assess whether or not climate change will potentially impact the Project (in addition to that of climate variability), past climate characteristics have been compared with predicted climate profiles for 2035. For each of the climate parameters that were considered for the Project, the following comparisons were derived:

- Rainfall – the projected seasonal average rainfall is expected to lie in between those typical of neutral and El Niño years. Summer rainfall values are expected to be comparable with rainfall recorded in El Niño years. Therefore, it has been predicted that climate change will result in lower average rainfall values in central Queensland;

- Temperature – average daily temperature minima and maxima are predicted to be 0.2 to 2°C higher than historical values for various PDO, ENSO and seasonal combinations;

- Relative humidity – although the historical and predicted relative humidity datasets are not comparable, warmer and wetter climatic conditions will produce more humid conditions for the Project site. El Niño years being drier, will produce less relative humidity, than La Niña years;

- Evaporation – in general, the predicted average evaporation values are higher than the historical data and therefore (as indicated by the OzClim models), there may be an increase in average evaporation over the medium term to 2035; and

- Solar radiation – no significant differences were observed between the historical solar radiation daily-average values and those predicted for 2035. Winter, spring and summer predicted solar radiation values were found to be most similar to a neutral ENSO phase during both warm and cool PDO phase.

4.1.4 Climate Variability and Change Risk Assessment

4.1.4.1 Risk Assessment Methodology

The Project risks associated with climate change were assessed in the context of regional climate patterns that are anticipated to occur during the lifespan of the Project, i.e. construction, operations and post-mining rehabilitation phases.

A standard risk assessment approach was employed (in line with ISO31000:2009 and Australian Standard DR AS5334) in order to rank applicable climate-change risks, as a function of risk likelihood and consequence (refer to Appendix 16 for details of the risk assessment methodology).

Climate adaptation options were then identified, in order to minimise the potential risks and impacts of climate change upon the Project.

The main sources of climate change risk were identified from the dominant weather patterns that are expected to occur during the mine life. The primary and secondary Project impacts which may arise as a result of these climate changes were developed via a preliminary desktop risk assessment and initial, collaborative risk assessment workshop.

It is recognised that further, more detailed workshops may be required with Project designers, engineers, operators and external stakeholders as Project details develop, in order to refine the risk assessment outputs.

Climate change will also have an impact outside the EIS study, for example the transportation of equipment, materials and supplies to the Project site could be impacted by adverse weather conditions.

4.1.4.2 Project Impact Probability

As a result of climate modelling, five key climate parameters (which contribute to climate variation) were found to exhibit the greatest potential for Project impacts. The probability of each climate parameter exceeding their threshold under El Niño and La Niña climatic conditions has been summarised as follows:

- Intense rainfall – 80% probability of threshold exceedance during La Niña conditions and 30% probability during El Niño events;
- Cyclones – the probability of threshold exceedance during La Niña circumstances is 70%, compared with 40% for El Niño conditions;
- High temperatures - 10% probability of threshold exceedance during La Niña conditions and 80% probability during El Niño events;
- Drought - 30% probability of threshold exceedance during La Niña conditions and 80% probability during El Niño conditions; and
- Strong and damaging winds - 70% probability of threshold exceedance during La Niña conditions, but only 30% under an El Niño situation.

These probabilistic results were then employed to develop a likelihood rating, which indicates the

probability of a particular impact actually occurring.

4.1.4.3 Risk Assessment Results

For the desktop risk assessment, the consequence for each Project impact has been assessed in terms of the following categories:

- Adaptive capacity – the extent to which infrastructure can adapt to climate variation and change, without compromising the infrastructure's performance;
- Infrastructure service disruption / damage – infrastructure disruption and / or damage caused by climate variability and change;
- Social and cultural impacts – measures potential climate variability and change impacts upon human health and the local community;
- Governance – addresses the effect of climate variations upon management control of the Project site and compliance with local, state and federal legislation;
- Financial – gauges the depth of financial losses that may be caused by regional variations in climate;
- Environmental – relates to the environmental effects that are potentially caused by climate variability and change; and
- Economy – measures the effects that climate variations could have upon the broader economy.

The likelihood of each impact occurring has also been categorised as follows:

- Event risk – frequency of event occurring during the year or mine life;
- Recurrent risk – frequency of event happing over the last five years; or
- Long-term risk – potential frequency of event occurring over the mine life.

A summary of sources of climate risk that contribute to each potential Project impact are presented in Table 4.4. Note that specific sources of climate risk contribute to each Project impact and that in some cases only one source of climate risk contributes towards the impact in question.

The outputs from the climate desktop risk assessment and workshop have been summarised and are presented in Table 4.5.

The main climate risk identified for this Project in terms of likelihood is increased equipment outages due to storm activity. The other risks that were identified for the Project were either categorised as moderate (four potential impacts) or low risk (six potential impacts).

It is considered that climate variability rather than climate change will have the greatest climatic impact upon the Project.

Table 4.4 Summary of Sources of Climatic Risk for each Potential Project Impact

Project Impact Description	Source of Climate Risk and Contribution to Impact (Y=Yes, N=No)					
	Intense Rainfall	Cyclones	High temperatures	Drought	Strong winds	Damaging winds
Failure of water storage dams due to intense rainfall	Y	Y	N	N	N	N
Disruption of operations due to flooding	Y	Y	N	N	N	N
Reduced surface water flows across the site due to lower rates of precipitation	N	N	Y	Y	N	N
Increased equipment outages due to storm activity	Y	Y	N	N	Y	Y
Infrastructure damage due to cyclones and severe storm events	N	Y	N	N	Y	Y
Disruption of operations issues due to bushfire	N	N	Y	Y	Y	Y
Increased dust levels causing disruption to operations	N	N	Y	Y	Y	Y
Decreased workforce productivity relating to higher temperatures	N	N	Y	N	N	N
Higher instance of spontaneous combustion in stockpiles	N	N	Y	Y	Y	Y
Increased operations costs relating to energy requirements equipment efficiency	N	N	Y	N	N	N
Power outages due to increased energy demand caused by higher temperatures	N	N	Y	N	N	N

Table 4.5 Details of Project Climate Impacts and Mitigation Measures

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
Failure of water storage dams	Likely – long term risk	Major – governance / environmental issues	**HIGH**	• Suspension of operations until discharge can be controlled • Environmental impacts due to the release of contaminated water to surrounding water courses, state forest and productive farming land • Breach of environmental license conditions resulting in significant fines and ongoing requirements for testing and reporting at considerable cost to the operator	• Design of water storage dams should take periods of intense rainfall into consideration • Investigate alternate disposal methods or locations and implement where practical	Periods of intense rainfall could lead to dam overtopping or structural failure of the dam and subsequent release of dam contents into the environment
Disruption of operations due to flooding	Likely – long term risk	Minor – all category issues	**MODERATE**	• Site access issues can lead to: mine shutdown due to mine workers being unable to get to site; coal product unable to be transported offsite; supplies including diesel and consumables	• Ensure adequate storage of diesel and • Consumables onsite to cater for likely flood period • Ensure adequate pumping capability	Site flooding could occur due to periods of intense rainfall and lower temperatures

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
				cannot be delivered to site • Pumping requirements to clear water from inundated areas can be significant both in terms of power and workforce requirements. Larger capacity pumps will limit the time required to return to normal operation, but will also have more significant power requirements • Power outages due in part to damage of infrastructure but also due to the sudden spike in electricity demand across the region	exists on the Project site • Avoid major construction during the wet season • Implement an emergency response plan in the event of a flood incident	
Reduced water availability for mine site operations	Rare – no long term risk	Moderate – social / financial / economic issues	**LOW**	• Adequate water supply is essential to the mine site operations for extraction and processing for coal	• A conservative approach to water use across the Project site is required only if groundwater levels decline significantly. If found to be	Increased evaporation rates and periods of drought which arise as a result of elevated temperatures are not considered to

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
					necessary this should consist of ensuring a high standard of water efficiency across operations including the utilisation of recycled water where possible	impact groundwater levels significantly and thus water availability. An increase in local demand for groundwater under drought conditions could restrict water availability
Increased equipment outages due to storm activity	Almost certain – recurrent risk	Minor - all category issues	**MODERATE**	• Shutdown of individual pieces of equipment due to lightning strike • Power outages caused by local infrastructure damage or substation damage • Storm conditions causing general site shutdown due to safety concerns	• Provide adequate protection of equipment from lightning strike where possible • Localised hourly updated weather forecasting to enable management action in sufficient time to protect personnel and equipment	The frequency of intense rainfall and strong wind events are predicted to increase during the coming decades. It is likely that a number of storm events will occur on an annual basis

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
Cyclone and storm event infrastructure damage	Likely – long term risk	Moderate – infrastructure / financial issues	**MODERATE**	• Damage to mine site infrastructure could result in disruptions to operations, to varying extents • Costs relating to maintenance and repair would likely increase	• Design mine layout and equipment configuration to limit the adverse effects of severe storm activity • Implement an emergency response plan	Sever storm events are anticipated during the life of the Project
Disruption of operations due to bushfire	Possible – long term risk	Minor – all category issues	**LOW**	• Visibility for conducting mining operations could be compromised causing temporary mine shutdown • Potential employee health and safety issues relating to site access and smoke inhalation • Damage to powerlines	• Ensure adequate fire breaks are maintained • Operational procedures must recognise this risk and manage appropriately	The predicted hotter and drier climate conditions associated with El Niño weather patterns and the adjacent State Forest will increase the risk of bushfire events occurring
Disruption of operations due to increased dust levels	Possible – long term risk	Minor – all category issues	**LOW**	• Increased dust levels on site could cause visibility issues leading to temporary closure of haul out roads and pit	• Ensure adequate dust management plan is in place • Localised hourly	Dust generation is exacerbated in hot, dry weather conditions and

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
				operations • Health issues relating to dust inhalation both on site and for surrounding dwellings	updated weather forecasting to enable management action in sufficient time to protect personnel and equipment	higher wind speeds
Decreased workforce productivity due to elevated ambient temperatures	Possible – long term risk	Minor – social issues	**LOW**	• Increased workforce costs	• Adequate health and safety management	Although ambient air temperatures are predicted to increase, such changes are not expected to pose a significant risk to human health
Increased incidence of stockpile spontaneous combustion	Possible – long term risk	Minor – governance / environmental issues	**LOW**	• Increased operational costs as a function of monitoring and responding to stockpile fire events • Potential product loss	• Minimise residency time of accumulated coal around coal handling facilities (e.g. application of the first in first out method in association with a residency management system)	The predicted hotter and drier conditions with potentially elevated wind speeds could increase the risk of spontaneous combustion in stockpiles

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
					• Implement scheduled housekeeping procedures • Undertake regular scheduled stockpile observations • Keep the stockpile's angle of repose to a minimum, particularly on the prevailing windward side to reduce airflow into and through the Stockpile (NCIG, 2010)	
Higher energy requirements and increased costs	Possible – long term risk	Minor – financial issues	**LOW**	• Amplified cost due to increased energy requirement • Increased greenhouse gas emissions and related costs	• Design to minimise the effects of higher ambient temperature where possible • Schedule mining operations to occur during cooler part of	The elevated temperatures that have been predicted for the Project, could reduce the operational efficiency of on-

Project Impact	Likelihood Measure	Consequence Measure	Risk Rating	Impact on Mine	Mitigation Measures	Climate Variability / Change Comments
					day or incorporate night time operations if practical	site equipment and electrical infrastructure
Regional power outages due to higher ambient temperatures	Possible – long term risk	Minor – infrastructure / financial issues	**LOW**	• Ongoing temporary disruption to operations • Note that electrical failure may lead to secondary impacts associated with electricity dependent equipment, such as water pumps becoming unavailable and affecting controlled dewatering	• Consider the robustness of electricity supply to site (e.g. substation vulnerability) • Design to minimise the effects of higher ambient temperature where possible • Schedule mining operations to occur during cooler parts of the day or incorporate night time operations, if practical • Incorporate additional standby generation capacity	Both on site and regional power outages could increase, as a result of the predicted elevation in regional temperatures

4.1.4.4 Residual Risk

High and moderate Project climate variation / change risks can be reduced to more acceptable levels (residual risk), via the implementation of one or more of the mitigation measures that are presented in Table 4.5.

Following further development of Project mine and infrastructure engineering details, a more detailed risk assessment should be conducted in order to refine the individual, residual, climate adaptation risk ratings for the Project.

For example, the impacts that periods of intense rainfall and cyclonic activity may have upon the Project, can be reduced via optimised engineering designs for water management infrastructure, inspection, maintenance and monitoring of infrastructure condition and real time tracking of weather patterns.

4.1.5 Climate Change Adaptation and Cooperation

It has been recognised by the Department of Environment and Heritage Protection (EHP) that, although climate change predictions and their potential impacts exhibit inherent uncertainties, a balance must be found between the costs of preparing for climate change and the uncertainty of climate change outcomes. The Project must therefore employ best efforts to incorporate adaptation to climate change in its design.

4.1.5.1 Climate Adaptation Strategies

In response to the climate variability / change risks that have been identified by the climate adaptation risk assessment, the following climate adaptation risk mitigation actions have been identified:

- Conduct a more detailed risk assessment with Project designers, engineers, operators and external stakeholders etc., in order to refine the Project climate-change risks and mitigation actions that have been developed to date;
- Ensure that the site water management systems are designed and constructed in order to address any La Niña-induced adverse weather conditions;
- Implement a weather intelligence system so that risk management actions can be developed in response to local changes in weather conditions;
- Include climate risk management actions into the Project's management system; and
- Periodically amend the risk assessment process and associated adaptation actions in response to new Project information and site experience.

4.1.5.2 Cooperative Approach to Adaptation

Since a variety of stakeholders are involved in climate-change adaptation (e.g. workforce, local communities, local and state government, supply chain participants, export companies, environmental regulators, community groups, investors, financial regulators, industry bodies and neighbouring mines), a cooperative approach to this subject will be required.

Part of this collaboration will require effective communication between all parties during mine development, operation and rehabilitation.

Since a high level of community interest and concern exists world-wide and in Australia on the subject of climate change, the volume of scientific climate information is increasing and adaptation strategies are rapidly evolving. Therefore, effective cooperation among stakeholders and with government is particularly important.