

6. Climate

6.1 Introduction

The region in which the McArthur River Mine Phase 3 Development Project (the Project) is located experiences a 'Grassland' climate, based on the Köeppen classification system (Australian Bureau of Meteorology (BOM) 2011). This classification consists of two distinct seasons: the wet season which lasts from December to March; and the generally dry conditions which last for the remainder of the year (winter drought).

6.2 Climatic Averages McArthur River Mine and Centre Island Weather Stations

Two weather stations in the region maintained by the BOM have recorded climatic data from 1968 to the present. Weather station 014704 is located at the existing McArthur River Mine (MRM). The Centre Island BOM weather station (station 014703) is considered representative of the region in which the Bing Bong concentrate storage and ship loading facility (Bing Bong) is located. Accurate long term synoptic data for MRM and Bing Bong weather conditions have been provided from these stations.

6.2.1 McArthur River Mine weather

For long-term climate data based on observations recorded by the meteorological station located at MRM refer to Table 6-1, which includes information on monthly mean temperatures, humidity, rainfall and wind speeds.

The monthly statistical data from MRM weather station indicates that:

- mean 9:00 am relative humidity is generally higher from December to March and lower from June to October at MRM, which coincides with seasonal patterns of the wet and dry seasons
- the mean relative humidity recorded at 3:00 pm is lower than 9:00 am recordings all year round, with mean 9:00 am recordings ranging from 46% in September to 75% in February
- mean maximum temperatures range from 29.8–38.6°C. Highest temperatures have historically been recorded in November, with the average maximum temperature of 38.6°C
- mean minimum temperatures range from 12.2–24.9°C. Coolest temperatures occur in July, with average minimum temperature of 12.2°C.

Refer to Figure 6-1 for the monthly averages for rainfall and temperature.

Rainfall data indicates that conditions at MRM are highly seasonal with distinct wet and dry seasons. The majority of rainfall occurs between December and March, with limited rainfall and drought like conditions occurring between May and September. According to the BOM data, January has the highest mean rainfall with 208.4 mm and August exhibits the lowest mean rainfall with 0.4 mm. The mean annual rainfall recorded at MRM is 790.2 mm.

Wind roses for the annual and the seasonal periods at MRM are presented in Figure 6-2. The figures indicate there is a north-easterly prevailing wind throughout the year, with a pronounced southerly during the dry season. The wet season, December to March, exhibits winds of lower velocity, which are highly variable in terms of direction.

Chapter 6 – Climate

Table 6-1 Long-Term Climate Data—McArthur River Mine (1968–2011)

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed (Km/H)		Rainfall (mm)		
	Mean Max	Mean Min	9am	3pm	9am	3pm	Mean Monthly	Highest Daily	Highest Monthly
Jan	35.9	24.9	71	50	6.9	10.2	208.4	173.4	782.3
Feb	35.1	24.7	75	53	5.9	9.4	186.7	197.6	660.9
Mar	34.9	23.3	71	47	5.5	10.1	143.7	124.1	548
Apr	34.7	20.6	59	34	6.9	10.7	33.7	162.2	213.6
May	32.2	16.5	50	28	8.7	10.2	7.3	86.4	160.1
Jun	29.8	12.5	48	25	8.7	10.5	1.7	15	18.2
July	30	12.2	48	24	8.1	11	2.5	49	56.6
Aug	31.9	13.4	47	21	8.6	11.8	0.4	11.6	12.6
Sept	35.2	17.2	46	21	9.4	13.1	5	48.4	89.6
Oct	37.8	21	48	23	9.3	13.2	21.1	90.6	184.6
Nov	38.6	24	53	30	8.2	12.5	49.1	72.4	182
Dec	37.7	24.9	62	39	7.2	11.4	122.1	122.4	435.2
Annual Average	34.5	19.6	57	33	7.8	11.2	790.2	-	-

Source- http://www.bom.gov.au/climate/averages/tables/cw_014704_All.shtml

Chapter 6 – Climate

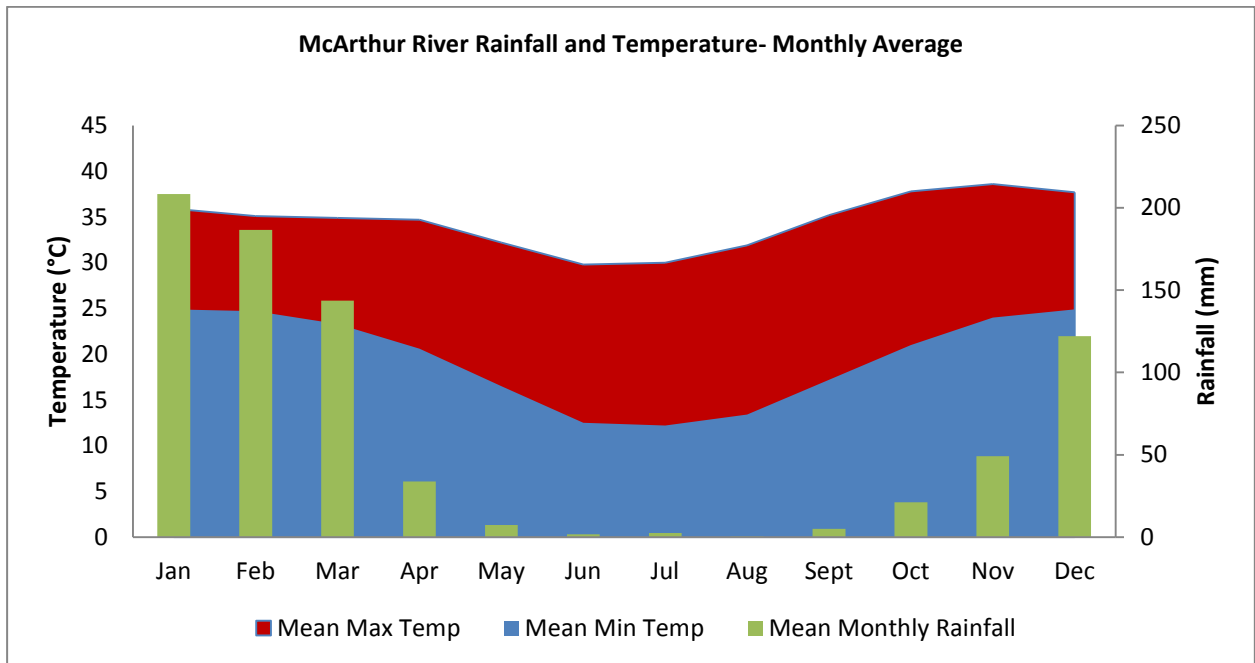


Figure 6-1 McArthur River Mine average monthly rainfall and temperature (1968–Present)

Source: http://www.bom.gov.au/climate/averages/tables/cw_014704_All.shtml

Further information on wind direction and speed, in reference to air quality, is provided in Chapter 11 – Air Quality and Greenhouse Gases.

Stability of the atmosphere is determined by a combination of horizontal turbulence (caused by wind) and vertical turbulence (caused by solar heating of the ground surface). Stability cannot be measured directly; instead it must be inferred from the available data, either measured or generated by an atmospheric model.

The Pasquill-Gifford scale categorises stability classes on a scale from A-G, A being the most unstable and stability class G being the most stable. The stability class data has been summarised using modelling data generated from CALMET which is shown in Table 6-2. In air quality models such as CALMET, the stability classes F and G are combined. The Pasquill stability class frequency shown in Table 6-2 shows stability class F (43%) occurred most frequently at MRM, indicating that the dominant conditions are moderately stable to very stable, resulting from little lateral and vertical diffusion (URS, 2011).

Data from the BOM MRM weather station for 2009 was assimilated into the meteorological model, in order to provide improved results for the meteorological parameters, such as stability in the vicinity of the Project site.

Chapter 6 – Climate

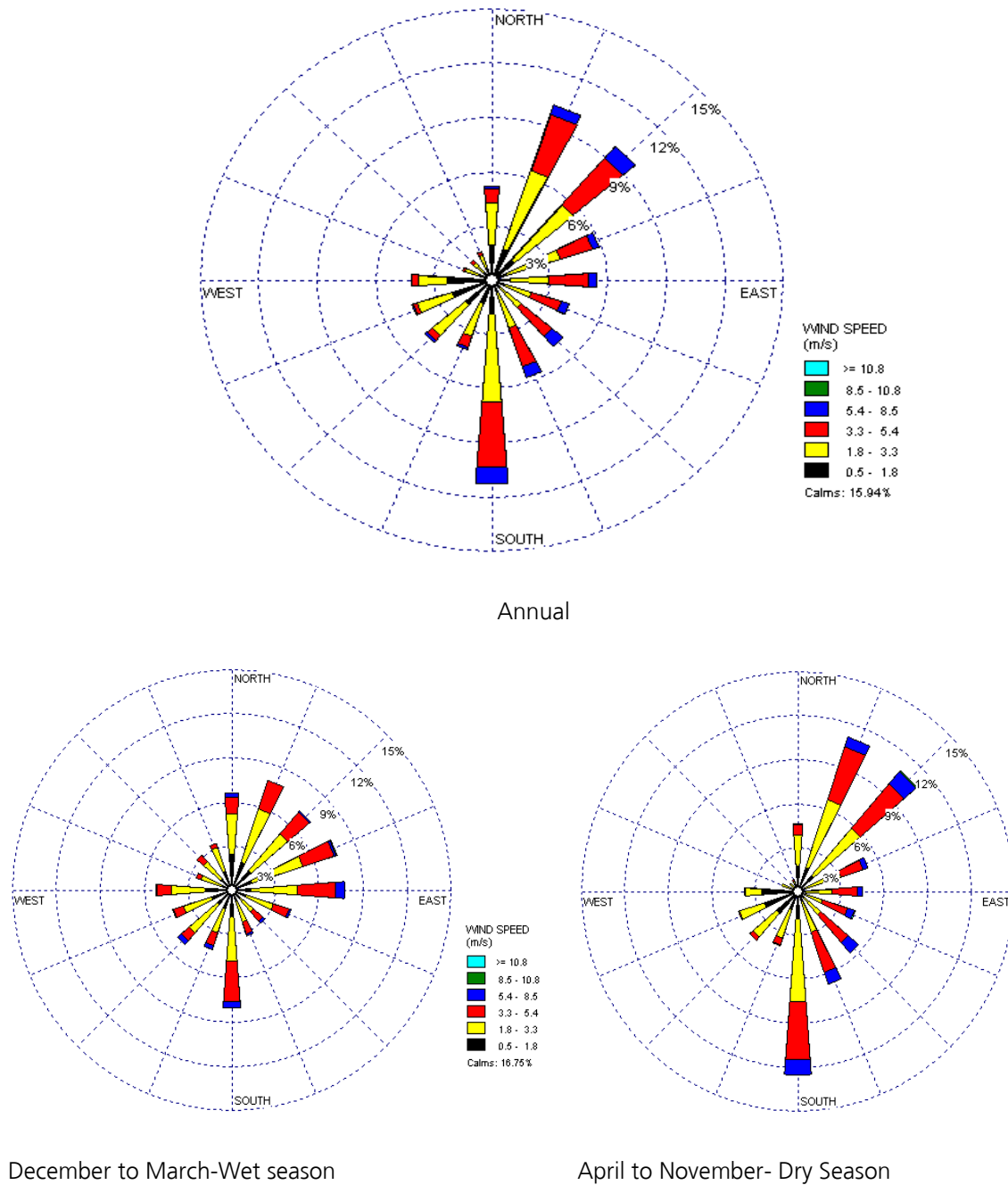


Figure 6-2 Annual and seasonal wind roses for McArthur River Mine weather station

Chapter 6 – Climate

Table 6-2 Frequency of atmosphere stability classes at McArthur River Mine

Stability Class	Description	Frequency of Occurrence (%)
A	Very Unstable	3
B	Moderately Unstable	19
C	Slightly Unstable	20
D	Neutral	10
E	Slightly Stable	6
F	Stable	43

At MRM, the evaporation rate is highest in the summer months with a mean daily rate of 9.9 mm in November and lowest in the cooler months, with a mean daily rate of 5.8 mm in June. The mean daily rate of evaporation is 7.5 mm. The annual average evaporation is 2,737.5 mm, which greatly exceeds the average annual rainfall of 790.2 mm (BOM, 2011).

6.2.1 Centre Island

Table 6-3 provides long-term climate data based on observations recorded by the meteorological station located at Centre Island. Information on monthly mean temperatures, humidity, rainfall and wind speed is recorded on this Table.

Monthly statistical data from the Centre Island Weather Station indicates that:

- mean 9:00 am relative humidity is generally higher from December to March and lower from June to October, coinciding with seasonal patterns of the wet and dry seasons
- mean relative humidity recorded at 3:00 pm is lower than 9:00 am recordings all year round, with mean 9:00 am recordings ranging from 63% in June, to 79% in February
- mean maximum temperatures range from 26.2–34.6°C. The highest temperatures have historically been recorded in December, with the average maximum temperature of 34.6°C
- mean minimum temperatures range from 18.5–27.3°C. Coolest temperatures occur in July, with average minimum temperature of 18.5°C.

Refer to Figure 6-3 for the monthly averages for rainfall and temperature.

Chapter 6 – Climate

Table 6-3 Long-term climate data—Centre Island (1968–2011)

Month	Temperature (°C)		Relative Humidity (%)		Wind Speed (Km/H)		Rainfall (mm)		
	Mean Max	Mean Min	9am	3pm	9am	3pm	Mean Monthly	Highest Daily	Highest Monthly
Jan	33.6	26.7	76	64	15	17.3	217.6	223.4	631.2
Feb	32.9	26.5	79	67	15	16.5	278.1	197.2	732.2
Mar	32.8	26.3	77	62	15.7	17.6	272	383.5	1214
Apr	32	25.3	71	57	19.8	20.3	95.5	358.4	666.9
May	29.5	22.5	65	55	22.3	19.8	11.9	74.2	201.4
Jun	26.7	19.4	63	53	23	18.7	7.2	72	140
July	26.2	18.5	64	52	21.5	18.7	1.8	14	14.4
Aug	27.8	19.5	66	52	19.1	20.1	1.6	11.8	12.4
Sept	30.5	22.2	67	53	16.9	21.3	1.5	20	23
Oct	33	24.9	67	54	15.8	21.4	8.8	45.2	79
Nov	34.5	26.8	67	55	15.4	21.2	36.9	68.6	249.5
Dec	34.6	27.3	71	59	14.6	18.9	130	137	580.2
Annual Average	31.2	23.8	69	57	17.8	19.3	1,064.7	-	-

Source- http://www.bom.gov.au/climate/averages/tables/cw_014703_All.shtml

Chapter 6 – Climate

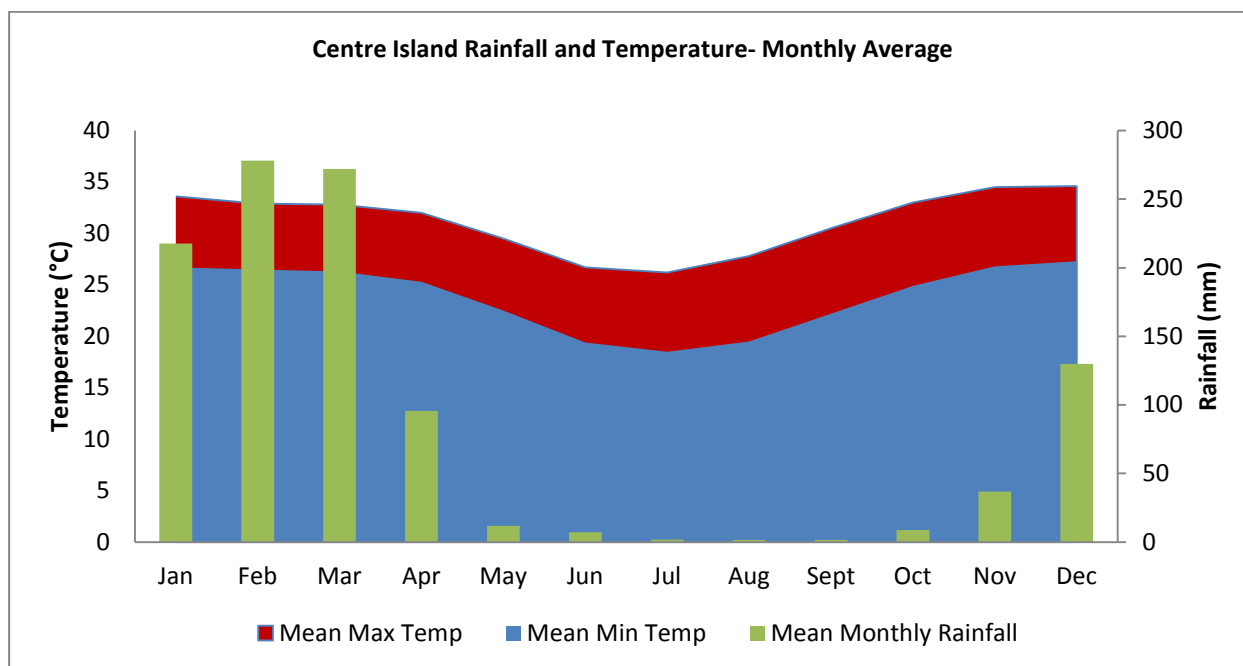


Figure 6-3 Centre Island average monthly rainfall and temperature (1968–Present)

Source - http://www.bom.gov.au/climate/averages/tables/cw_014704_All.shtml

Rainfall data indicates that conditions at Centre Island are highly seasonal with distinct wet and dry seasons. The majority of the rainfall occurs between December and March, with limited rainfall and drought like conditions occurring between May and September.

According to the BOM data, February has the highest mean rainfall (278.1 mm) and September exhibits the lowest mean rainfall (1.5 mm). The mean annual rainfall recorded at Centre Island is 1,064.7 mm.

Wind roses for annual and the seasonal periods at Centre Island are presented in Figure 6-4. These figures indicate there is a south-easterly prevailing wind throughout the year. During the wet season, December to March, the wind is predominantly northerly.

Chapter 6 – Climate

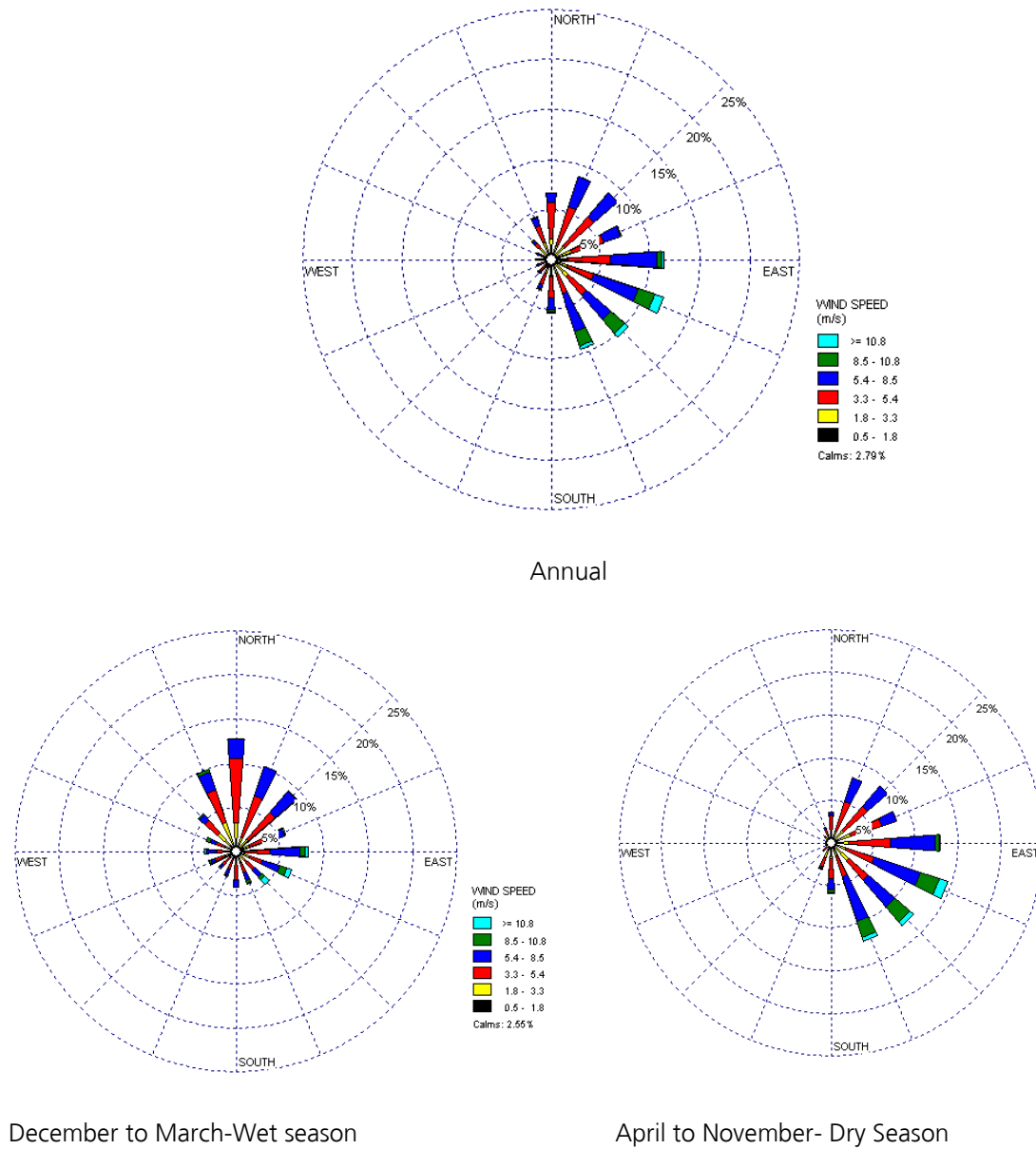


Figure 6-4 Annual and seasonal wind roses for Centre Island weather station

6.3 Extreme Events

The following section discusses the magnitude and frequency of potential extreme events such as flooding, cyclones, bushfires, landslides and earthquakes.

6.3.1 Flooding/Cyclones

Generally, the cyclone season at MRM and Centre Island is from November to April, with peak activity in January and February. An influential factor is the El Niño-Southern Oscillation (ENSO) fluctuations which have a strong impact on patterns of tropical cyclone occurrence in the region. BOM cyclone tracking indicates there have been numerous tropical cyclones in the past 100 years (yr) within close proximity to MRM. Proximity of MRM to the tropical coastline may see increased rainfall events over the wet season from December to March due to associated cyclonic activity. For Bing Bong loading facility located on the coast, BOM predicts an average of 0.2–0.4 cyclones for the area annually, in comparison to 0.1–0.2 cyclones predicted annually for MRM.

Meteorological monitoring has been conducted at MRM weather station since 1968. The highest daily rainfall event recorded since 1968 was 197.6 mm on 15 February 1974. Potential impacts from flooding and heavy rainfall events assessed for the MRM area are detailed in Chapter 10 – Water Resources.

The potential impacts of flooding will be managed in accordance with the MRM Emergency Response Plan. Flood levees will be constructed progressively throughout the MRM site as required, to minimise impacts of flooding on mining activities and any potential for release of contaminants to the environment.

6.3.2 Drought

The Commonwealth Department Agriculture, Fisheries and Forestry (DAFF) have identified different regions around Australia deemed drought affected as areas of exceptional circumstances (EC). EC identification comprises extreme weather conditions, including very low rainfall, exceptionally high temperatures and low soil moisture (DAFF, 2011). Neither MRM nor Bing Bong region is considered to be an EC area.

6.3.3 Bushfires

Bushfires and grassfires are an intrinsic component of Australia's environment. Natural ecosystems evolved with fire and the landscape, along with its biodiversity, have been shaped both by historic and recent fires. Many of Australia's native plants are fire prone and very combustible, while numerous species depend on fire to regenerate. Indigenous Australians have long used fire as a land management tool. Fire continues to be used to clear land for agricultural purposes and to protect properties from intense, uncontrolled fires.

Grassfires are fast moving and smoulder briefly. They have a low to medium intensity and primarily damage crops, livestock and farming infrastructure such as fences. Bushfires are generally slower moving, but have a higher heat output and can smoulder for days. Fire in the crowns of the tree canopy can move rapidly.

Fire management or controlled burns within MRM area are a common occurrence. Every two years, areas within the MRM region are subject to controlled burns to reduce the possibility of uncontrolled fires and to assist in land management (e.g. local Indigenous people in traditional hunting activities).

The peak fire season for MRM is during the dry season (refer to Figure 6-5). At those times, the rainfall is considerably lower than the wet season (refer Table 6-1 and Figure 6-1), increasing the amount of dry vegetation available to fuel potential bushfires. Effects may be amplified by natural climatic cycles such as El Niño, which result in periods of increased temperature and reduced rainfall and humidity.

In order to prepare for and manage the threat of bushfires, MRM will adopt management strategies set out in the Northern Territories *Bushfire Act* 2004, implemented by a fully trained MRM Mines Rescue Team. The Team will be comprised of senior employees and contractors who are fully qualified, skilled and experienced in occupational first aid and fire fighting.

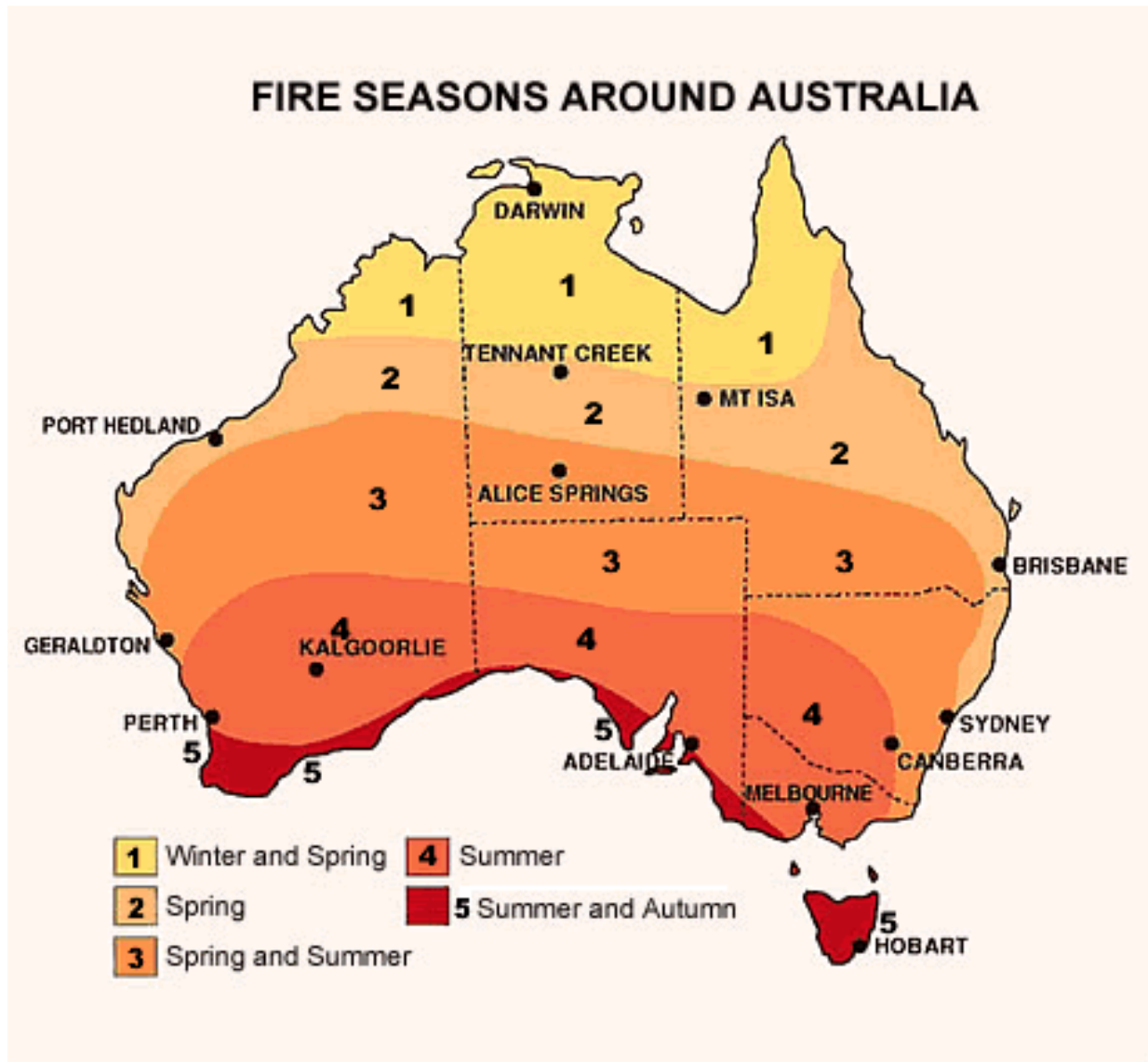


Figure 6-5 Distribution map for various Australian Fire Seasons (BOM, 1997)

Fire management at Bing Bong is based on the maintenance of suitable firebreaks around the lease area, which benefits from the sea on one side and Mule Creek Road on the other.

6.3.4 Landslides

Landslides can be caused by earthquakes, volcanoes, soil saturation from rainfall, seepage or by human activity (e.g. vegetation removal, construction on steep terrain). Landslides usually involve the movement of large amounts of earth, rock, sand or mud, or a combination of these materials.

Considering the low-lying topography of MRM area, landslides resulting from natural causes are unlikely. Mining activities have the potential to create localised land slippages within the mine pit.

The risk of slumping from the settlement of overburden materials may be reduced with the design and creation of stable landforms. Ongoing monitoring will be undertaken so that MRM maintains landforms in a stable and safe condition.

Despite the low risk of occurrence, should a land slide occur at MRM, the potential impacts will be managed in accordance with the principles set out in the site Emergency Response Plan.

Chapter 6 – Climate

6.3.5 Earthquakes

The majority of the world's earthquakes occur at tectonic plate boundaries. Australia is located centrally within the Indo-Australian tectonic plate and consequently experiences minor intraplate seismicity compared with locations on the plate boundaries. A search of the Geoscience Australia database indicated that no earthquakes have been recorded within a close proximity to MRM from 1955 to July 2011. The closest significant earthquake (2.8 magnitude) occurred approximately 400 km west of MRM on 12 April 2010.

In the unlikely event of an earthquake, MRM will follow the site Emergency Response Plan.

6.4 Climate Change

Climate change refers to a change in the state of the climate that can be identified (through statistical tests) by changes in the mean and/or variability of its properties that persists for an extended period, typically decades or longer. Climate change may be attributed to natural internal processes, external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or land use (IPCC, 2007).

Warming of the climate system is now undeniable due to observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level (IPCC, 2007, CSIRO, 2011).

It is difficult to predict precisely what the impacts of climate change will be, as they vary with each region. The potential effects of climate change for Australia include:

- increased temperatures
- altered rainfall patterns
- rising sea level
- acidification of Oceans
- loss of Biodiversity
- increased intensity of extreme rainfall events and cyclones
- increased fire weather risks.

Site specific climate change information for the location of MRM is limited. However there is some literature on the changes expected in other regions in Northern Australia such as Cairns. This research provides insight into the predicted changes for the regions surrounding MRM, which is located at similar latitudes. Annual average temperatures in the Cairns area are expected to increase between 1.0 and 4.2°C by 2070 (compared to 1990 temperatures) (Suppiah et al, 2007), with an increased number of days above 35°C (Australian Greenhouse Office, 2004).

Estimates of total sea-level rise remain uncertain due to unknown rates of polar ice cap melting. However, there is growing consensus among scientists that sea-level rise of 0.5 to 1.0 m (compared to 1990 levels) is plausible by 2100, and that a rise of 1.5 m or more cannot be ruled out (Steffen, 2009).

Extreme rainfall events are expected to become more intense due to a warmer, wetter atmosphere, although changes in summer tropical rainfall in northern Australia remain highly uncertain (CSIRO, 2011). In terms of cyclone activity due to climate change, there is no clear picture with respect to regional changes in frequency and movement, but increases in intensity are indicated (IPCC 2007, Short and Woodroffe 2009).

Although the effects of climate change are measurable, there are still a number of key uncertainties in relation to climate change. It is important to note however, that these uncertainties are in connection to data coverage and not scientific accuracy. Data coverage remains limited in some regions and there is a notable lack of geographic balance in data and literature on observed changes in natural and managed systems, particularly in developing countries.

Chapter 6 – Climate

The Project is expected to extend the life of the mine to 2036. For this reason, impacts of climate change on the operation of the Project and Bing Bong are relevant only up to that point. Consequently, changes in sea level and temperature from climate change are not expected to have a significant impact on the Project's mining operation or the operation of Bing Bong.

As the effects of climate change will vary from region to region, it is difficult to assess quantitatively. Impacts related to possible increases of intensity of rain events and cyclone activity will be closely monitored by McArthur River Mining Pty Ltd, the Project's proponent, and will be considered in the surface water management plan and subsequent surface water infrastructure design.

The objective of the Project's rehabilitation and decommissioning plan is to return any disturbed land to a self-sustaining and stable revegetated landform that will tolerate impacts of climate change. Further information on the Project's rehabilitation and decommissioning strategy is detailed in Chapter 5 - Rehabilitation and Decommissioning.