Genex Kidston Connection Project:
Draft Environmental Assessment Report
Powerlink Queensland

Chapter 5

Climate

5.0 Climate

5.1 Regional Climatic Conditions

North Queensland is characterised by tropical and sub-tropical climates with pronounced wet and dry seasons. The region exists within the Tropic of Capricorn belt and as a result is sometimes affected by the seasonal migration of monsoon conditions as they move across the equator.

The Bureau of Meteorology (BoM) operates a network of monitoring stations around Australia that have long-term climatic data available for analysis. As the Draft Alignment spans a significant distance laterally, local meteorological conditions are likely to differ across this distance, especially at areas further inland and/or away from notable terrain features. Multiple BoM stations in the North Queensland region have been selected for review in this chapter, to provide a greater regional coverage of conditions. Details of the stations selected are provided in Table 5-1.

The Townsville Aero and Ingham Composite BoM stations have been selected to assist in describing the Project area meteorology as they are the closest available to the eastern end of the Draft Alignment. It should be noted that both these stations are situated in close proximity to the coast and therefore may experience greater influence from the sea-land interface and trade winds than the Project area. The Charters Towers Airport and Georgetown Post Office BoM stations provide meteorological data from an inland location at elevation greater than sea-level, although are located some distance from the Project. The Project area is likely to experience meteorological conditions that are a combination of the two coastal stations and the two inland stations.

Table 5-1 BoM stations relevant to the Project (BoM, 2018)

Station Name	No.	GPS	Distance from Project	Location Direction	Period Operational	Elevation (m)
Townsville Aero	032040	-19.2483, 146.7661	109 km	SE	1940 - Present	4
Ingham Composite	032078	-18.6494, 146.1769	43 km	ENE	1968 - Present	12
Charters Towers Airport	034084	-20.0464, 146.2708	140 km	SSE	1942 - Present	290
Georgetown Post Office	030018	-18.2922, 143.5483	89 km	NW	1872 - Present	292

**closest point from Draft Alignment.*

5.1.1 Temperature

Mean minimum and maximum temperatures have been collected from the four selected BoM stations, and are displayed in Table 5-2. Of the four locations, mean minimum temperatures are lowest at Charters Towers, with 11.6°C recorded for winter and 22.0°C for summer. Mean maximum temperature values are highest at Georgetown during winter (28.2°C) and summer (36.1°C).

At the Townsville Aero and Ingham Composite stations the mean maximum temperatures for winter (June, July and August) are 26.1°C and 26.2°C respectively, and the mean minimum temperature is higher in Ingham (13.8°C) than in Townsville (13.7°C). Temperatures in summer (December, January and February) are more variable in Ingham than Townsville; mean maximum is higher in Ingham (32.5°C) than in Townsville (31.5°C), and the mean minimum is lower in Ingham (22.1°C) than in Townsville (24.1°C). The two coastal stations (Townsville Aero and Ingham Composite) on average experience lower annual maximums and higher annual minimums, indicating less overall variation in temperature than the inland locations.

Overall, temperatures across the Project area are consistent with a warm tropical climate. Temperature maximums and minimums vary considerably more at the locations inland, but when assessing the four stations overall temperatures generally only differ by two to three degrees Celsius.

Table 5-2 Mean maximum (top, red) and minimum (bottom, blue) temperature values per month at the four BoM stations (BoM, 2018)

Mean Maximum and Minimum Temperature (°C)													
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Townsville Aero	31.4	31.2	30.7	29.7	27.7	25.6	25.1	26.1	27.8	29.5	30.8	31.5	28.9
	24.3	24.1	23.0	20.6	17.7	14.7	13.7	14.7	17.4	20.7	22.9	24.1	19.8
Ingham Composite [A]	32.4	31.8	30.8	29.1	27.1	25.3	25.0	26.2	28.4	30.4	31.8	32.5	29.2
	23.0	23.2	22.3	20.4	17.8	14.9	13.8	14.4	16.1	18.4	20.7	22.1	18.9
Charters Towers Airport	33.8	33.0	32.0	30.2	27.4	25.0	24.9	26.8	30.3	32.7	33.9	34.6	30.4
	22.5	22.4	21.0	18.3	15.3	12.8	11.6	12.4	15.3	18.1	20.5	22.0	17.7
Georgetown Post Office [B]	34.4	33.5	33.4	32.5	30.4	28.2	28.2	30.0	33.0	35.8	36.6	36.1	32.7
	22.9	22.7	21.5	19.4	16.1	13.1	12.0	13.1	16.2	19.7	21.7	22.8	18.4

[A]: Mean maximum temperature values have been calculated based on 49 years of data (1968 – 2018). Mean minimum temperature values have been calculated based on 47 years of data (1968 – 2018).
[B]: Mean maximum temperature values have been calculated based on 99 years of data (1901 – 2007). Mean minimum temperature values have been calculated based on 112 years of data (1894 – 2007).

5.1.2 Rainfall

The mean rainfall values collected from the four nominated BoM stations detailed in Table 5-3 below highlight the distinct wet (summer) and dry (winter) seasons experienced by the region. Also demonstrated is the large variation in rainfall amounts received across the wider area.

Annually, Ingham receives the highest amount of rainfall (2126.4 mm), followed by Townsville (1127.9 mm), Georgetown (819.8 mm) and then Charters Towers (643.4 mm). This indicates that rainfall is on average significantly higher in coastal locations.

In Townsville, Charters Towers and Georgetown, over half of average annual rainfall occurs during the three months of summer. Summer is also the distinct wet season for Ingham, with almost 50% of the average annual rainfall occurring. Of the four stations Georgetown has the least rainfall over the months of winter, with an average total of 21.4 mm (approximately 3% of total annual average rainfall). The months of winter are also driest for the other station locations: rainfall over winter accounts for approximately 5% of annual average rainfall in Townsville (51.6 mm), 6% in Ingham (121.6 mm), and 9% in Charters Towers (57 mm).

Table 5-3 Mean rainfall per month at the four BoM stations (BoM, 2018)

Station	Mean Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Townsville Aero	266.8	296.4	194.0	65.1	33.1	21.0	14.7	15.9	10.3	24.1	58.1	125.0	1127.9
Ingham Composite	375.6	463.5	397.7	198.7	107.2	46.1	38.6	36.9	39.0	54.5	119.3	195.6	2126.4
Charters Towers Airport	152.7	140.5	76.5	26.4	23.3	20.9	19.9	16.2	9.8	18.0	63.4	79.1	643.4
Georgetown Post Office	224.9	212.9	123.1	28.8	9.3	10.4	6.7	4.3	6.4	16.7	50.7	127.8	819.8

5.1.3 Wind speed and direction

Long-term annual wind roses from each of the four nominated BoM stations for morning and afternoon were available for review. As discussed in Section 5.1, the coastal location of the Townsville Aero and Ingham Composite stations may reduce their appropriateness of describing the general meteorology of the Project area.

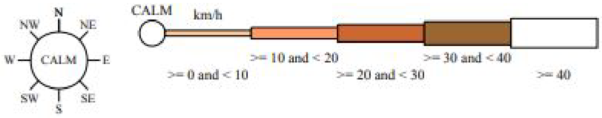
Morning winds at the Townsville Aero location are variable in direction and of moderate strength when not calm. The most frequent wind direction at this time is south east, accounting for over 25% of observations. At 3pm winds at Townsville Aero are predominately from the north east and easterly direction, and are stronger. Wind speed in the Ingham area is generally lower than conditions experienced in Townsville. At 9am winds are mostly less than 10 km/hr and from west and south east directions. Almost 40% of wind at 3pm in Ingham is easterly and of moderate strength.

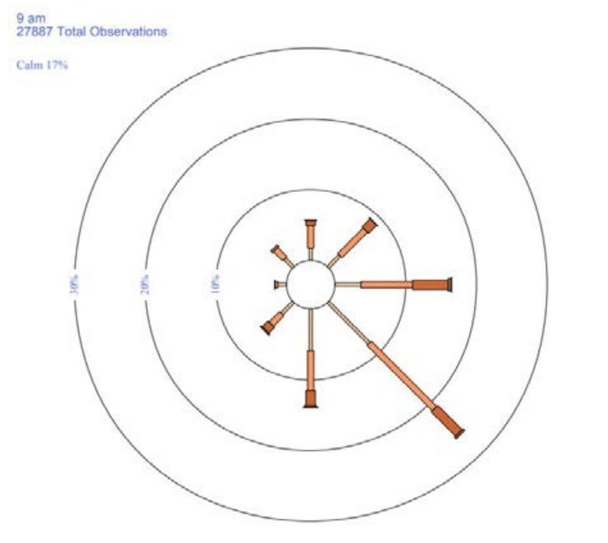
Wind conditions at Charters Towers have little variability during the day in terms of direction. Both morning and afternoon winds are most commonly (>30%) from the east, followed by south east and north east. Winds are normally of low speed becoming slightly stronger in the afternoon. Calm conditions account for 4% of both morning and afternoon observations. In Georgetown easterly winds are also most frequent. However wind speeds especially in the morning are greater than recorded in Charters Towers. The 9am wind rose shows that strong gusts of wind (>40 km/hr) occur in Georgetown.

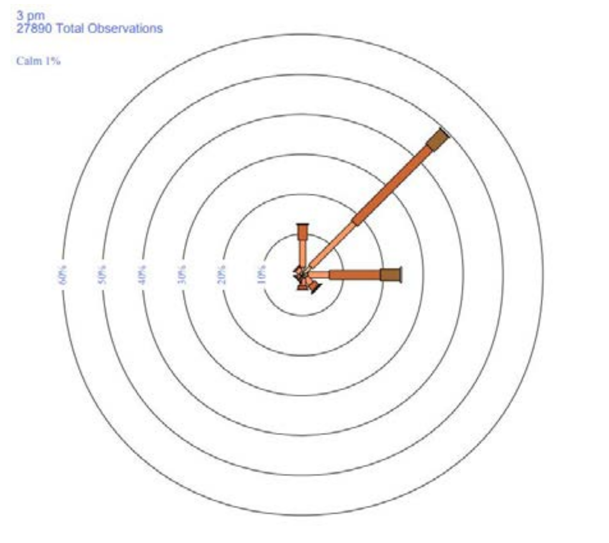
The annual wind roses from Charters Towers and Georgetown show that similar conditions are experienced at these locations, likely because they are both inland at similar elevations. Wind speed and direction are not greatly influenced on the local scale due to the mostly flat terrain. Synoptic scale winds modified by occasional afternoon sea breezes, and valley drainage flows originating from the nearby mountain ranges at night, affect wind speed and direction at the large scale. Topography of the Project area is discussed in detail in Chapter 4 Land, and summarised briefly below in Section 5.1.4.

5.1.4 Terrain

Terrain features and land use can influence meteorological conditions on both a local and regional scale. As discussed in Chapter 4 Land, the terrain along the Draft Alignment drops from an elevation of around 650 m AHD at Mount Fox to an elevation of around 420 m AHD across the Valley of Lagoons. A number of elevated peaks occur along the Draft Alignment, with terrain generally falling to the south and to the south east towards the Burdekin River and drainage system.

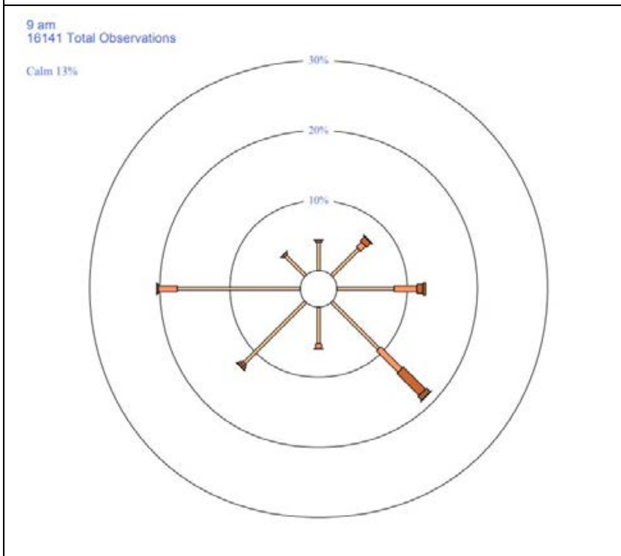


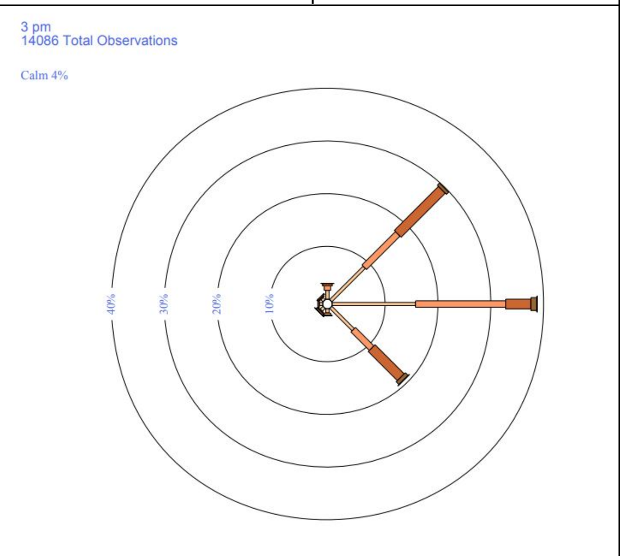




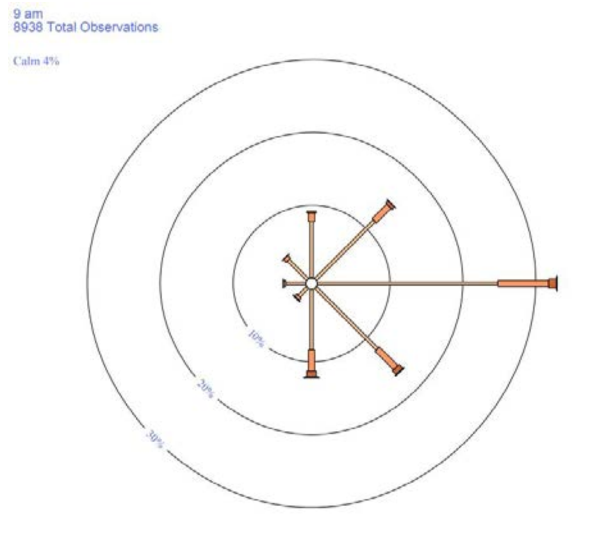
BoM Townsville Aero: Annual 9am wind rose

BoM Townsville Aero: Annual 3pm wind rose

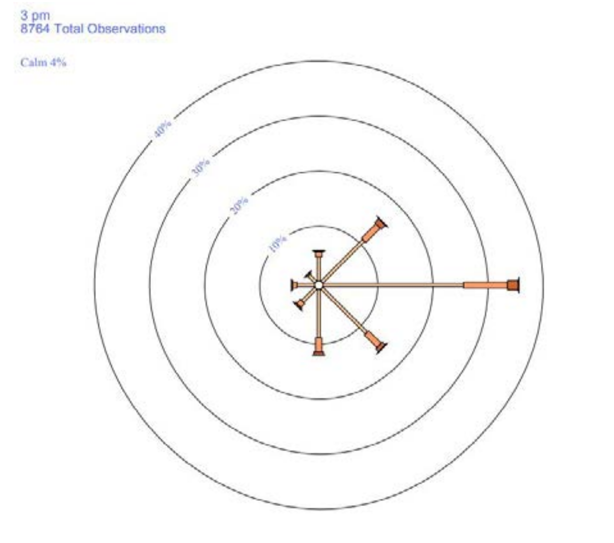




BoM Ingham Composite: Annual 9am wind rose

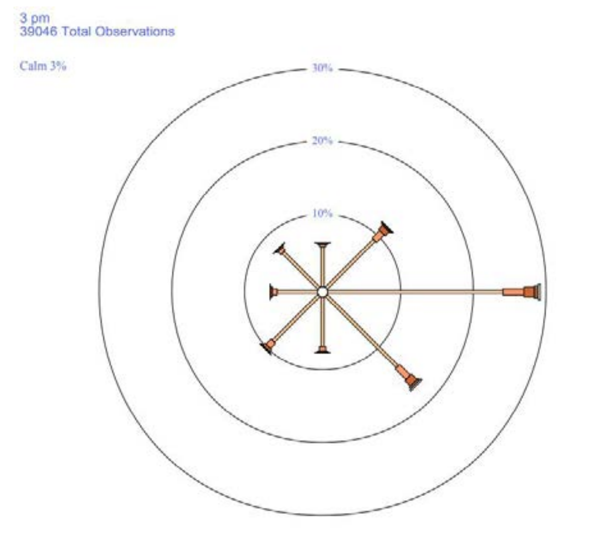


BoM Ingham Composite: Annual 3pm wind rose



BoM Charters Towers Airport: Annual 9am wind rose

BoM Charters Towers Airport: Annual 3pm wind rose



BoM Georgetown Post Office: Annual 9am wind rose

BoM Georgetown Post Office: Annual 3pm wind rose

Figure 5-1 BoM annual wind roses for Townsville, Ingham, Charters Towers and Georgetown (BoM, 2018)

5.2 Extreme Climatic Conditions

Extreme weather or atypical meteorological conditions have the potential to adversely affect the Project during any phase of its lifecycle. Their occurrence may result in construction and operation ceasing, damage to structures or the environment and subsequent maintenance. The history of extreme weather for the Project area is an important consideration, and will allow for any risks to be identified and assessed.

5.2.1 Droughts

Droughts are an increasingly common occurrence in Australia, and affect grazing and agricultural land most significantly. Prolonged periods of water shortage (not unusual for the region) can have negative effects on vegetation growth, erosion and overall land quality. Information about climate risk, including droughts, for rural Queensland is provided by the Queensland Government's 'The Long Paddock' initiative (DES, 2018).

Historical data shows that Queensland experiences some of the highest rainfall variability in the world (DES, 2018), and as such droughts at some stage have affected most of the state. A review of recent Queensland Drought Situation maps generated by DES indicates that, as of May 2018, the Project area (LGAs Etheridge, Charters Towers and Hinchinbrook) is not drought declared. However, the majority of the Project area has been fully drought declared as recently as March 2017 (DES, 2017). Queensland Rainfall Deciles from 2014 to 2018 (BoM 2018) also indicate that the eastern section of the Project area has received 'below average' to 'very much below average' rainfall (Figure 5-2).

It is likely that during the Project's life-cycle drought conditions will be experienced, possibly more than once, and the risks associated should therefore be considered. Both Etheridge Shire Council and Charters Towers Regional Council have established drought management plans that address this ongoing issue.

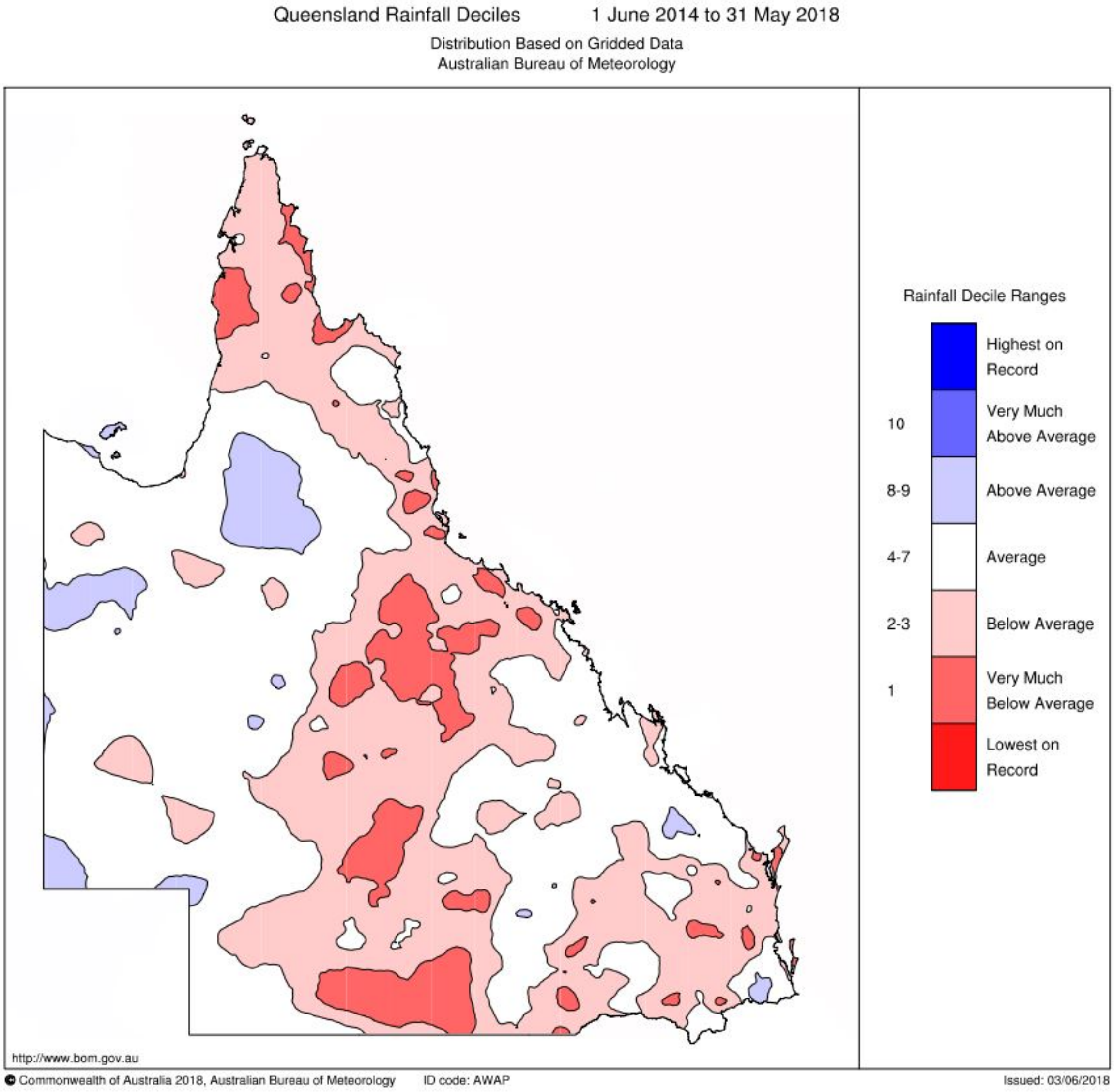


Figure 5-2 BoM 2018 Queensland Rainfall Deciles map

5.2.2 Cyclones

Rotating low-pressure systems that form over warm tropical waters are known as tropical cyclones. Tropical cyclones produce destructive gale force winds (sustained winds of 63 km/h or more) which are generally strongest near the centre, but can extend for hundreds of kilometres. In severe systems peak wind gusts can exceed 360 km/h. The damage associated with gale force winds often includes extensive damage to infrastructure and agriculture, power failure and sometimes loss of life. Storm surges are also created by gale force winds, and can result in flooding of coastal areas.

Tropical cyclones generally begin to weaken after reaching land due to changes in temperature, moisture and friction. Large rainfall events are then produced as the system decays. According to BoM (2018), often the most significant impact from a tropical cyclone is flooding.

In Queensland, tropical cyclones mostly form from lows within the monsoon trough and affect the northern areas of the state (BoM, 2018). While relatively uncommon, these systems are generally formed during summer months and affect coastal areas most. Since the year 2000 there have been seven tropical cyclones of significance in Queensland, and are listed below:

- **Severe Tropical Cyclone Debbie – 25 to 29 March 2017**
- Severe Tropical Cyclone Marcia – 15 to 21 February 2015
- **Severe Tropical Cyclone Yasi – 31 January to 3 February 2011**
- Tropical Cyclone Monica – 17 to 27 April 2006
- **Tropical Cyclone Larry – 17 to 21 March 2006**
- Tropical Cyclone Ingrid – 6 to 17 March 2005
- Tropical Cyclone Steve – 27 February to 11 March 2000.

Of these seven significant tropical cyclones, three (bolded) would have hit the Project area directly, at least on the eastern side. The climatic conditions of the area and historical frequency of tropical cyclones indicates that one or more is likely to occur in the Project area at some point in the Project life-cycle. Direct effects (i.e. gale force winds), and indirect effects such as high rainfall and flooding should be considered in the design of the infrastructure and maintenance of access pathways.

5.2.3 Thunderstorms

Thunderstorms are a common weather event characterised by thunder, lightning, strong wind and often rain. Severe storms can also create hail. The combination of these effects can result in significant damages to infrastructure and restrict access to the Project. Thunderstorms are produced by a rapid upward movement of warm air. While they can develop anywhere, most frequently they occur at the border of tropical areas where warm air meets cool air.

In the Project area, the average number of thunder days is approximately 20, increasing towards the west to 30 - 40 days (BoM, 2018). Thunderstorms may be a more common occurrence in the western section of the Project area due to the presence of mountain ranges, which can forcibly move air upwards.

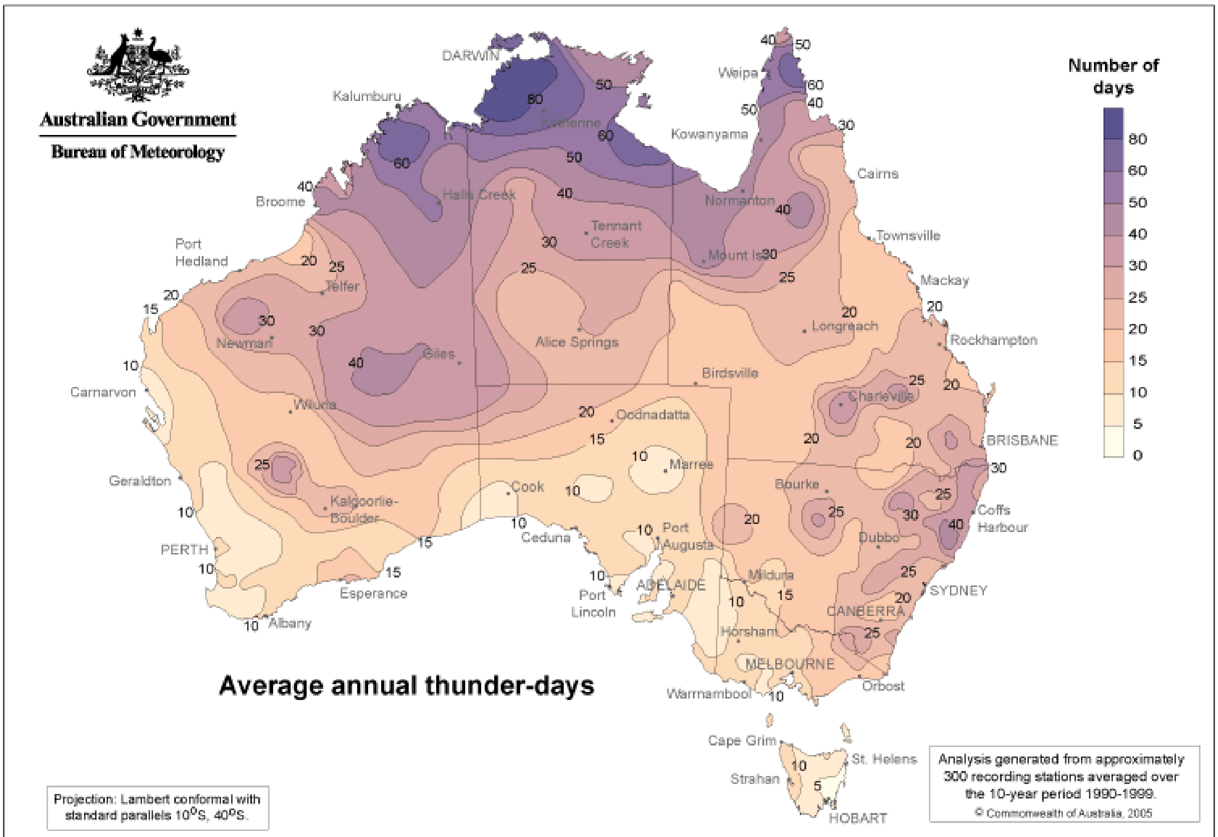


Figure 5-3 Average annual thunder-days (BoM, 2018)

5.2.4 Flooding

Rainfall across Queensland varies considerably both spatially and over time. However, high rainfall is known to occur in North Queensland as a result of monsoonal troughs, and can lead to flooding. Impacts from flooding events can include damage to infrastructure foundations, increased erosion and general land degradation. Elevated water levels can result in major road closures, and restrict access especially in rural areas.

As discussed in Section 5.2.1, the Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP) provide mapping of local government natural hazard areas. A natural hazards 2018 DSDMIP map including Queensland Floodplain Assessment Overlay (QFAO) data indicates that sections of the Project area, specifically those that cross the Burdekin River and connecting waterways, are prone to flooding. Major flooding of the Burdekin River has occurred as recently as February 2008 and February 2000 (BoM, 2018). Almost a third of Queensland was declared a natural disaster by the State Government after the flooding event of 2000.

Flooding is likely to occur in the Project area within the Project life-cycle, and the risks to the Project especially in low-lying land should be considered. A detailed study of the hydrology of the Project area, including a risk assessment of flooding is discussed in Chapter 7 Hydrology.

5.3 Climate Influence on Design and Construction

Historical meteorological data indicates that the proposed Project area has a tropical climate, and is likely to experience the effects of a range of extreme weather including drought, flooding, bushfire and cyclones. Most of these events are expected to individually affect the area more than once throughout the Project life-cycle. The risks associated with bushfire are discussed in detail in Chapter 22 Bushfire Risk. The risks associated with flooding are discussed in detail in Chapter 7 Hydrology.

The electricity transmission infrastructure will be designed and constructed to reasonably withstand severe weather events, including potential cyclonic conditions near the North Queensland coast. Other impacts to be considered are those associated with flooding such as soil erosion and land degradation, which can lead to reduced or limited access to areas of the Project for construction and maintenance.

5.4 Climate Change

To investigate regional climatic trends in Australia, climate projections were modelled by the CSIRO and BoM. The high emissions future scenario (RCP 8.5) assumes that greenhouse gas emissions continue to be released at present day rates with CO_2 concentrations continuing to rise. Climate change in North Queensland during high emissions scenario in 2030, 2050 and 2070 are presented in Table 5-4. The high emissions scenario was selected to determine worst-case future conditions for the region. The potential impacts these climatic changes may have on the Project have been identified in Table 5-5.

Table 5-4 CSIRO and BoM climate change projections for 2030, 2050 and 2070.

Variable	Season	2030 – High Emissions	2050 – High Emissions	2070 – High Emissions
Mean Temperature (°C)	Annual	+1.0	+1.7	+2.6
	Summer	+0.9	+1.7	+2.4
	Autumn	+1.0	+1.6	+2.6
	Winter	+1.0	+1.8	+2.9
	Spring	+0.9	+1.6	+2.4
Rainfall (mm, %)	Annual	-8	-7	-9
	Summer	-6	-1	+2

Variable	Season	2030 – High Emissions	2050 – High Emissions	2070 – High Emissions
	Autumn	-6	-2	-2
	Winter	-9	-5	-11
	Spring	-9	-12	-18
Potential Evaporation (mm, %)	Annual	+3	+6	+9
	Summer	+3	+5	+8
	Autumn	+4	+8	+11
	Winter	+4	+7	+12
	Spring	+3	+6	+8

Table 5-5 Potential impacts of climate change and proposed mitigation measures

Potential Climate Change Impacts	Risk Scenario	Risk to Project	Mitigation Measures (if required)
Increase in annual average temperature	High temperatures lead to increased demand for electricity while also negatively affecting reliability and efficiency of infrastructure and/or equipment.	Low	Not applicable.
	Health impacts on work personnel from increased temperatures (i.e. heat stress).	Medium	Implementation of heat stress management procedures including as low as reasonably practicable controls for workers.
Change in seasonal average rainfall	Decrease in rainfall especially during winter and spring may lead to greater potential for erosion. Decrease in rainfall in conjunction with increased temperatures will also increase bushfire risk.	Low	Monitoring of erosion during routine service maintenance. Emergency response procedures for bushfire.
Increase in annual average potential evaporation	Increased dust emissions due to drier surface conditions, resulting in increased water demand for dust suppression during construction. Increased dry foliage and vegetation will increase amount of fuel available for bushfires.	Low	Dust control measures including watering of haul roads and stockpiles during construction. Regular routine service maintenance of vegetation for transmission line easements and substation buffers.
Increased risk of tropical cyclone impact	Increased impacts from gale force winds and flooding.	Medium	Emergency response procedures for natural disasters.
	Increased risk of erosion especially from exposed areas due to increase in rainfall intensity.	Medium	Identify flood prone areas of Project area (Chapter 7). Adaptive management as soon as practical to minimise risk.

As the population in Queensland continues to increase, so too will energy requirements and the need for efficient energy distribution. In 2008 the Australian Academy of Technological Science and Engineering (ATSE) identified that the electricity production and distribution sector had a very high degree of vulnerability to climate change due to power stations traditionally being located in coastal regions. However, due to the Project's inland location (most eastern point is 45km from the coast) it is expected to have mostly low vulnerability, with the greatest potential impact an increased risk of extreme weather events and potential for increased soil erosion and access restrictions.

Extreme weather events such as cyclones, thunderstorms and floods are likely to increase in frequency with the changing climate and have the ability to severely impact infrastructure. Power losses due to damaged or ageing infrastructure have a high likelihood of occurring, however efficiency in response and maintenance scheduling should allow for risks to be managed. The risk of bushfire is also considered likely to increase in the future, but continued routine maintenance of easements and access tracks should suffice in line with current bushfire management techniques. A detailed assessment including the potential impacts fire may have on the Project is discussed in Chapter 22 Bushfire Risk.

A study completed by PB Associates (2007) found that increased peak and average temperatures are likely to reduce transmission line capacity, transformer capacity and the longevity of switchgear and other components. Increased temperatures, ground water and subsequent ground movements may also accelerate the degradation of materials such as concrete, which in turn will reduce the life of infrastructure foundations (Department of Climate Change, 2009). However as these risks are not isolated to the Project, there is the potential that equipment specifications and standards will change in the future in response to climate change pressures.

5.4.1 Greenhouse gas

This section provides an assessment of greenhouse gas (GHG) emissions associated with the Project. The potential GHG impacts of the Project have been assessed by:

- outlining the regulatory framework for GHG management in Australia
- estimating the direct and indirect GHG emissions resulting from activities during the Project.

5.4.1.1 Legislative and policy context

International Policy

The Kyoto Protocol was negotiated and concluded at the third United Nations Framework Convention on Climate Change in late 1997. It generally entered into force in 2005, with Australia ratifying the Kyoto Protocol in December 2007. The objective of the Kyoto Protocol is to reduce human-induced GHG emissions by setting country-specific GHG emissions targets relative to 1990 GHG emission levels. In November 2016, Australia ratified the Doha Amendment to the Kyoto Protocol, the objective of which is to further reduce GHG emissions between 2013 and 2020.

The Kyoto Protocol sets out three flexible mechanisms for achieving GHG targets:

- The Clean Development Mechanism
- Joint Implementation
- International Emissions Trading.

In essence, all three mechanisms allow GHG reductions to be made at the point where the marginal cost of that reduction is lowest. An industrialised country sponsoring a GHG reduction project in a developing country can also claim that reduction towards its Kyoto Protocol target and subsequently trade those GHG reductions.

Australia's Climate Change Policy

A review of Australia's climate change policies was completed in 2017 by The Department of the Environment and Energy (DoEE). This review found that the Australian Government is committed to addressing climate change while concurrently ensuring energy security and affordability, and the competitiveness of the energy industry. Australia ratified the Paris Agreement in November 2016, an extension of the Kyoto Protocol, which further demonstrates the Australian Government's stance on acting on climate change.

National Greenhouse and Energy Reporting Act 2007

The Commonwealth *National Greenhouse and Energy Reporting Act 2007* (NGER Act) establishes a national system for reporting corporate GHG emissions, energy consumption and energy. The NGER Act commenced on 1 July 2008. The NGER Act requires corporations that exceed certain GHG emission thresholds to publicly report their GHG emissions, energy consumption and energy production each financial year.

The current GHG reporting thresholds for corporations are as follows:

- emission of more than 50,000 tonnes (t) of carbon dioxide equivalents ($CO_{2\text{-}e}$), or
- consumption of more than 200 Tera joules (TJ) of energy per year.

The current GHG reporting thresholds for individual facilities are as follows:

- emission of more than 25,000 t $CO_{2\text{-}e}$, or
- consumption of more than 100 TJ of energy per year.

Powerlink Queensland currently reports its GHG emissions and energy use annually as per the NGER Act. The Contractor must report on annual GHG emissions and energy use associated with the Project as this meets the definition of the term *facility* under the Contractors *operational control* as defined in the NGER Act, Section 11. Subsequent reports post construction will be included in Powerlink Queensland's annual submissions.

5.4.1.2 Inventory methodology

GHG emissions attributable to the Project have been considered in terms of three 'scopes' of emission categories. These three 'scopes' are described below and in Figure 5-4.

- **Scope 1 emissions -** releases of GHG into the atmosphere as a direct result of a Project activity or series of Project activities. For example, emissions from diesel consumed onsite in Powerlink Queensland vehicles.
- **Scope 2 emissions -** releases of GHG into the atmosphere as a direct result of one or more Project activities that generate electricity, heating, cooling or steam that is consumed by the Project but that do not form part of the Project. For example, the consumption of electricity by Project infrastructure, where the electricity has been generated outside of the Project footprint.
- **Scope 3 emissions -** other indirect GHG emissions that occur outside the Project footprint. For example, third party emissions from transportation of coal and subsequent use of the coal.

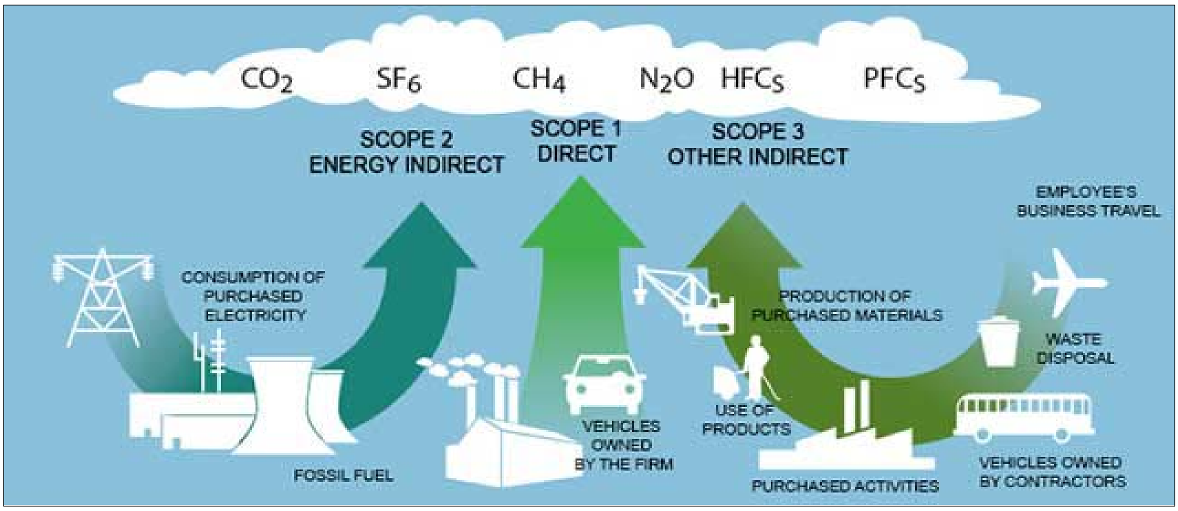


Figure 5-4 Overview of scope and emissions across a reporting entity

The purpose of separating different types of emissions into scopes is to avoid the potential for double counting. Double counting occurs when two or more organisations assume responsibility for the same emissions. Scope 1 and Scope 2 emissions must be reported under the NGER Act; however, reporting Scope 3 emissions is voluntary. The NGER Act states that the following gases must be reported:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- hydrofluorocarbons (HFC)
- perfluorocarbons (PFC)
- sulphur hexafluoride (SF_6).

Carbon dioxide equivalent ($CO_{2\text{-}e}$) has been used to assess GHG emissions from the Project. For a given mixture and amount of GHG, $CO_{2\text{-}e}$ describes the amount of CO_2 that would have the same global warming potential (GWP) when measured over a specified time scale (100 years). The GWP of a GHG is the radiative forcing impact contributing to global warming, relative to one unit of carbon dioxide. Because CO_2 is used as the reference gas, it has a GWP of one.

5.4.1.3 Project GHG emission sources

Potential GHG emission sources for the Project and their corresponding category have been listed in Table 5-6 below.

Table 5-6 Summary of all emissions associated with the Project

Project Phase	Category	Source of Greenhouse Gas Emission
Construction	Scope 1	• Vegetation clearing • Power consumption at site offices/substation locations • Diesel fuel consumption by site vehicles • Diesel fuel consumption by equipment and plant • Power generation from generation sets, which will provide power to equipment
	Scope 3	• Transportation of vehicles and equipment to site • Diesel fuel consumption during transportation of transmission structures conductors and steel by sea from China/India • Diesel consumption in light vehicles for transportation of workforce
Operation and maintenance	Scope 1	• Diesel consumption in light and heavy vehicles for general maintenance of transmission structures and lines • Aviation fuel consumption in helicopters for maintenance of transmission lines • Diesel consumption in light and heavy vehicles for substation facilities operation and maintenance • Vegetation maintenance
	Scope 2	• Loss of power via transmission lines
	Scope 3	• Diesel consumption in light vehicles and machinery used to maintain easements and access tracks
Decommissioning	Scope 3	• Earth moving and fuel usage • Gathering infrastructure • Activities associated with decommissioning

5.4.1.4 Key assumptions in GHG emission estimations

While multiple potential GHG emission sources exist within the various phases of the Project, only the key GHG sources have been included in this assessment. The determination of source significance itself required the use of assumptions. Assumptions that have been used in this assessment are intended to be conservative due to the high level nature of input data currently available. More finite data is expected to become available once the design development phase of the Project is completed.

As identified in Table 5-6, construction of the Project has potential to generate GHG emissions through its various activities. The Scope 1 GHG emissions created during the construction phase have the highest potential to be the largest contributor to the total GHG emissions inventory of the Project (all phases).

The following conservative assumptions were made for the construction phase of the Project.

- The approximate Project disturbance area (1,704 ha Option A and 1,756 ha Option B) has potential to be cleared of vegetation.
- Potential maximum biomass for the Project area is between 50-100 (t dry matter/ha).
- The Project area is generally comprised of 85% remnant vegetation (open woodland) and 15% non-remnant vegetation (grasslands).
- Temporary construction camps and Contractor site offices are likely to be erected during construction of the Project due to its rural location. Diesel generators will be used to provide at these locations for a period likely greater than 12 months.
- Due to the size and linear nature of the Project, material transportation distances are likely to change per worksite and over time. For the construction phase of the Project it has been assumed material will travel up to 200 km from the nearest material suppliers/quarry/city (no known supplier to the west).
- Although both diesel and unleaded petrol fuel is likely to be used, for the purposes of the GHG calculations it has been assumed that only diesel is used by equipment and vehicles.
- Concrete will be used to lay foundations.
- Heavy vehicles will be used to transport cement, concrete and steel.

4.2.3.5 Estimated Project GHG emissions

The NSW Government's department of Roads and Maritime Services (RMS) provides a workbook developed by the Transport Authorities Greenhouse Group (TAGG) for the estimation of GHG emissions. Although the workbook was designed primarily for use on road projects, it has been utilised to estimate Project emissions as it is designed for linear infrastructure projects (Table 5-7). As discussed in Section 5.4.1.4, GHG emission estimations have been completed for the construction phase of the Project only.

The construction phase of the Project is estimated to result in approximately 240,582 t CO_2-e of GHG during construction of the Project. The annual GHG emissions for the Project (construction phase) represent 0.05% of Australia's 2016 GHG emissions and 0.16% of Queensland's 2016 GHG emissions.

Table 5-7 Annual GHG emissions by Project source

Emission Source	Scope 1 (t CO2-e)	Scope 3 (t CO2-e)	Total (t CO2-e)
Electricity consumption	100	8	107
Fuel combustion by site vehicles	109	8	118
Fuel combustion by plant and equipment	564	43	606
Fuel combustion by earthworks	209	16	225
Fuel combustion by vegetation removal	3053	233	3286
Vegetation removal resulting in lost carbon sink	220,943	-	220,943
Material usage – aggregate, concrete, cement, steel	-	15298	15298
Total	**224,977**	**15,605**	**240,582**