Appendix F
Air Quality Assessment

Townsville Common User Facility

Air Quality Impact Assessment

RPS

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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with RPS (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

Table of Contents

Tables in Text

Figures in Text

1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by RPS AAP Consulting Pty Ltd (RPS) to undertake an air quality impact assessment to inform an application for a State Development Area (SDA) application for a Research and Technology Industry associated with the Queensland Resources Common User Facility (QRCUF, the Development).

The purpose of the assessment is to evaluate the air quality impacts associated with the proposed Development on neighbouring receptors.

2.0 Project Description

The Queensland Government plans to develop the QRCUF to support demonstration scale trials of processing methods and technologies for critical minerals and rare earth elements. The objective in developing the QRCUF is to accelerate the development of commercial projects, promote investment in advanced mineral manufacturing opportunities, enable development of supply chain and supporting industries, and position Queensland's resources industry for long-term, sustainable growth over the next 30 years.

QRCUF is intended to be a flexible, modern, efficient, and environmentally responsible mineral processing demonstration facility capable of processing a variety of ores to extract and produce high purity critical mineral chemical products. It will be designed with a focus initially on processing ores to produce high purity chemical products of vanadium, with future allowance for additional functionality for cobalt, molybdenum-rhenium, and rare earth elements (REE). Processing of other ores and materials may be accommodated over time.

2.1 Site Location

The Development will be based in Townsville, with construction and operation at 109 Penelope Road, Stuart (described as Lot 14 on SP 338024) within the Cleveland Bay Industrial Park (see **Figure 1**), approximately 6.5 km south of Townsville city centre. The site is bordered by a watercourse and residential zoning to the west as well as Special Purpose zoned lots 82, 96, 110 and 124 and Penelope Road to the east. Special Purpose zoned lots 131 and 91/77 are located to the north and south respectively. The special Purpose zone corresponds to the Townsville State Development Area which is intended to accommodate a range of industrial uses, including those which support or have a nexus to mineral processing.

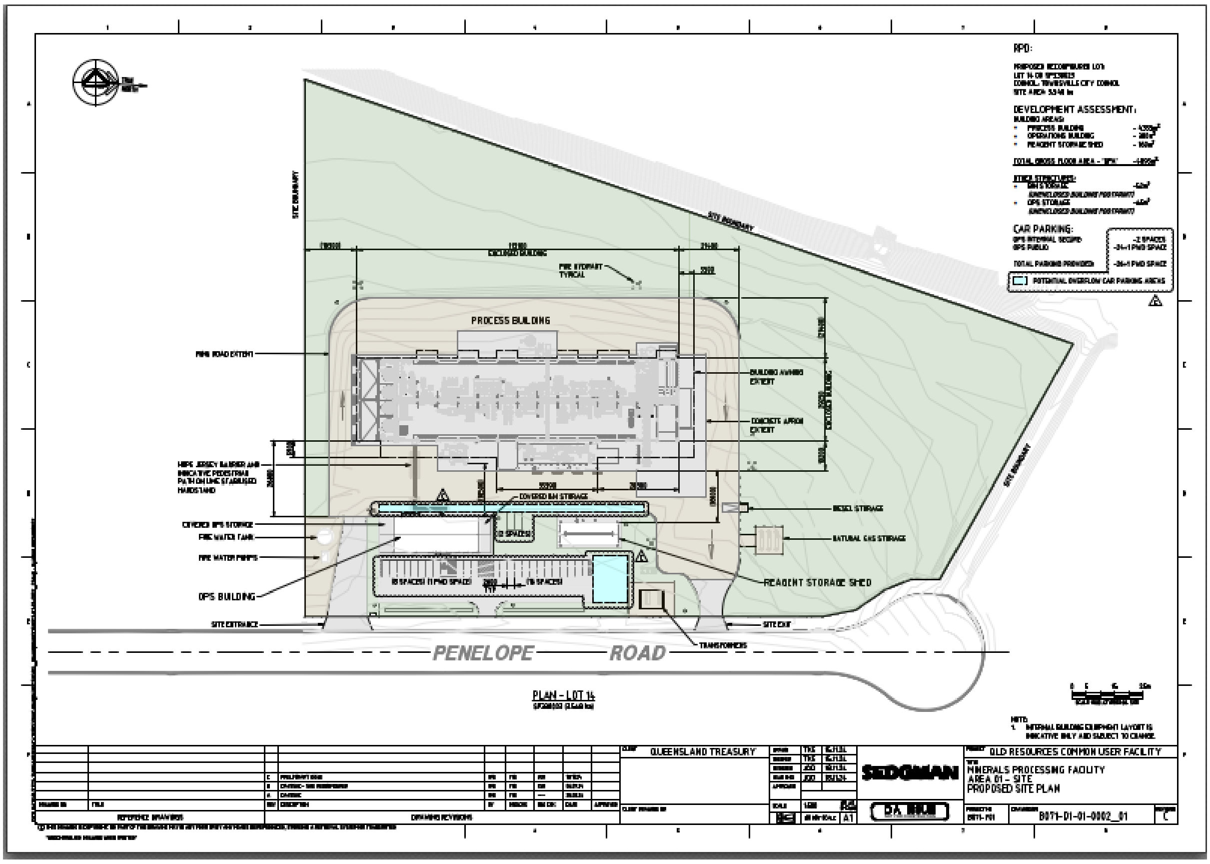
The proposed site layout for the facility is shown in **Figure 2** and incorporates the following primary features:

- Mineral processing facility (enclosed shed)
- Office and services building
- Site ancillaries including:
    - Gas and diesel storage
    - Reagent storage
    - Solid waste storage areas
    - Fire water pump station, hydrants and water storage
    - Electrical pad-mount transformer and substation
    - Site entry/ exits for heavy and light vehicles

- Light vehicle parking
- Heavy vehicle turning and unloading areas
- Fenced and gated compound

Figure 1 Location of Proposed Development Site

Figure 2 Proposed Site Layout – Stage 1



2.2 Proposed Activities

A detailed description of the proposed process is still being developed at this stage. However, the process will generically include the following key steps (shown schematically in **Figure 3**):

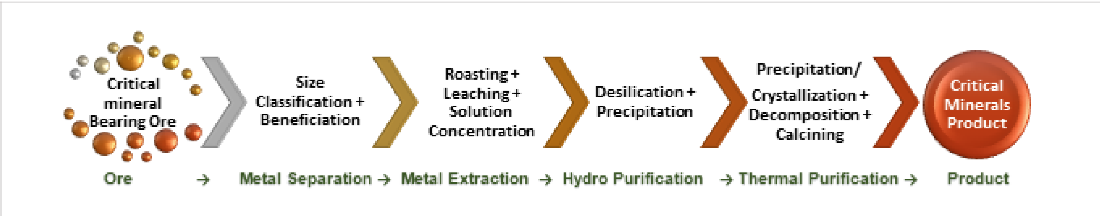
- Ore material will be delivered to site via truck and stored in an enclosed area of the facility.
- A front-end loader will retrieve the ore from the stockpile and load it into a hopper that will feed a conveyor.
- The conveyor will feed the material into a drum scrubber as the first step of the metal separation process. Oversized material will be discharged, and the remaining material will continue through the process where it will go through classification, dewatering, flotation and finally concentrate thickening and filtering. Tailings will be collected through this stage, thickened and sent to tailing storage.
- The metal extraction phase will include concentrate dryer and roasting, regrind, leaching, neutralisation and solvent extraction. LPG gas will be combusted to provide heat required for these operations. Off-gas will be created during drying and roasting, and also during the leaching process. The off gas will be sent to a gas scrubbing system.
- The product will then enter the hydro purification stage to remove impurities.

- The product will then enter the thermal purification process, where the product will be precipitated out of solution, dried, and roasted. LPG gas will be combusted to provide heat required for these operations. Off-gas produced during drying and roasting will be sent to a gas scrubbing system.
- Throughout the process waste product will be collected and sent to effluent treatment. Effluent treatment will produce solid and liquid waste. Waste product will be sent to waste storage where it is collected by a licensed waste contractor for disposal.

It is noted that all operations described above will be conducted within an enclosed shed.

The QRCUF is anticipated to operate in approximate 2-week campaigns followed by a period of downtime either due to future customer change-over, waiting for future customers or no demand. During the campaigns operations are expected to be 24 hours per day.

Figure 3 Draft Mineral Recovery Process



3.0 Identified Emission Sources and Air Pollutants

Based on proposed activities described in **Section 2.2**, the sources of air emission identified for the Development are discussed below -

- Air emissions generated by operations on site will be captured and treated via a gas scrubber and baghouse system prior to release via a stack.
- All material handling activities are proposed to be conducted in enclosed sheds thus significant emissions from these activities are not anticipated.
- Vehicle movements anticipated on site include truck and light vehicle movements and forklift operations. However, these emissions will be managed by the Site by minimising idling times and installing signage to turn off engines while loading/unloading etc. Furthermore, all areas accessed by these vehicles will be either paved or hard stand rather than dirt which will further mitigate any potential for particulate emissions due to vehicle movements. Given this, potential air quality impacts associated with vehicle movements within the site can be considered to be minimal and therefore have not been considered any further in this assessment.

Based on these considerations, the air emissions released via the stack after treatment using proposed baghouse and venturi gas scrubber has been identified to be the key source of air emissions associated with the Development. These emissions are discussed in detail below.

3.1 Air Emissions Released via Stack

The following gas feeds and pollutant contained in each feed are anticipated to be generated from the proposed operations:

- **Duty 1 Feed – from operations such drum scrubber and Run of Mine Ore (ROM) handling sent to Baghouse for treatment:**
  - Particulate matter
- **Duty 2 Feed – from operations such as drying and roasting, sent to venturi gas scrubber:**
  - Particulate matter
  - Oxides of nitrogen (NO_x)
  - Sulfur Oxides (SO_x)
  - Total Volatile Organic Compounds (VOC)
  - Ammonia (NH_3)

A description of these pollutants is provided below -

- Oxides of nitrogen (NO_x): NO_x is a mixture of gases that are composed of nitrogen and oxygen. The most toxicologically significant compound is nitrogen dioxide (NO_2). Other gases belonging to this group are nitric oxide (NO), nitrous oxide (N_2O) and nitrogen pentoxide (N_2O_5). The majority of NO_x (90 to 95%(v/v)) generated by the combustion of fossil fuels is in the form of NO, with NO_2 contributing the remaining 5 to 10%(v/v) along with traces of N_2O. However, the NO reacts in the atmosphere to form NO_2 as the plume travels downwind.
- Sulfur oxides (SOx): Emissions of SOx from fossil fuel combustion are directly proportional to the sulfur content of the fuel. Sulfur dioxide (SO_2) and Sulfur trioxide

(SO_3) are the main components of SOx. SO_3 readily combines with water to give sulfuric acid (H_2SO_4)

- Particulate matter: Small quantities of particulate matter are formed during gas combustion, predominantly in the fine particulate size range, from carry-over of non-combustible trace constituents in the fuel and lubricating oil and as products of incomplete combustion.

  From a health and nuisance impact perspective, particles are classified primarily by size, as TSP (total suspended particulates), PM_{10} (particulate matter with an aerodynamic diameter up to 10 microns (µm)) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter up to 2.5 µm).

  Emissions of TSP have the potential to result in nuisance impacts due to increased rates of dust deposition in the surrounding area.

  Human health effects of dust tend to be associated with particles with an aerodynamic diameter of 10 µm or less (≤ PM_{10}). These smaller particles tend to remain suspended in the air for longer periods and can penetrate into the lungs. The $PM_{10-2.5}$ fraction (coarse fraction) is termed “thoracic particles”. These particles are inhaled into the upper part of the airways and lung. $PM_{2.5}$ particles are fine particles that are inhaled more deeply and lodge in the gas exchange region (alveolar region) of the human lung and are termed “respirable dust”.

  It is noted that the $PM_{2.5}$ fraction is often associated with combustion emissions, thus only this fraction has been considered further for this source.

- Volatile Organic Compounds (VOCs): VOCs is a collective term used to describe organic carbon-based compounds with the ability to enter the atmosphere as a vapour. Due to the ubiquitous nature of organic compounds emitted from natural and anthropogenic processes, there is a myriad of organic compounds that fall under the definition of VOCs. The environmental, human-health and amenity (i.e. odour) impacts of ambient concentrations of VOCs depend on the composition of the gases, hence there are no ambient air quality criteria for “Total VOCs”, only for selected key individual VOC constituents.

- Ammonia (NH_3): NH_3 is a corrosive gas, and the severity of health effects depends on the dose of gas inhaled. Exposure to high concentrations of NH_3 in air causes immediate burning of the eyes, nose, throat and respiratory tract and can result in blindness, lung damage or death.

SLR was provided with the anticipated emission rates for these pollutants as well as removal efficiency for the air treatment equipment. This information is summarised in **Table 1**.

Importantly, from a nuisance perspective, no odour emissions are anticipated from the proposed operations. It is noted that only pollutants and emission rates provided were considered in the modelling.

Table 1 Emissions and treatment efficiency anticipated from proposed operations

Pollutant	Feed Source	Treatment Method	Untreated Emission rate estimated by preliminary process design (kg/h)	Expected removal efficiency (%) [(a)]	Treated Emissions (kg/h)
Particulates	Duty 1 Feed	Baghouse	25	99 [(b)]	0.25
	Duty 2 Feed	Venturi gas scrubber	0.29	99 [(c)]	0.003
NO_2			2.13	90	0.21
SO_2			2.01	90	0.20
SO_3			1.45	99 [(e,f)]	0.015
NH_3			0.64	99	0.0064
VOCs			0.005	90	0.0005
H_2SO_4 Mist			0.123	99 [(f)]	0.0012
(a)	(b) It is noted that the expected removal efficiency is based on conservative assumptions for these technologies unless mentioned otherwise (c) Based on PM control efficiency of 99% for baghouse filters as per *Chapter 11.24 Metallic Minerals Processing* (US EPA 1995) (d) Based on PM_{10} control efficiency of 99% as detailed in Table 17 of the *Emission Estimation Manual for Non-Ferrous Metal Manufacture* (NPI 2001) (e) All SO_3 contained in gas stream will turn into H_2SO_4. (f) Since H_2SO_4 is hygroscopic the removal efficiency with venturi scrubber is expected to be >99% (g) Since NH_3 is hygroscopic and highly soluble in water, with the venturi scrubber the removal efficiency is expected to be >99%				

4.0 Regulatory Framework

4.1 Queensland Environmental Protection Act 1994 (EP Act)

The *Environmental Protection Act 1994* (EP Act) enables the framework for environmental assessments to be developed in Queensland. The EP Act is applicable to all members and bodies in the community, including industry and government. It provides a method for government departments to incorporate environmental factors into their decision-making process.

A summary of the objective of the EP Act is as follows:

> *The object of the Environmental Protection Act 1994 is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.* (EPP (Air) Explanatory Notes, General outline).

There is a general environmental duty to prevent and minimise environmental harm under section 319 of the EP Act. The EP Act specifically states:

> *A person must not carry out an activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm (the general environment duty).*

To decide the measures required to meet the general environmental duty in accordance with the EP Act, regard must be had to:

- the nature of the harm or potential harm;
- the sensitivity of the receiving environment;
- the current state of technical knowledge for the activity;
- the current state of successful application of the different measures that might be taken; and
- the financial implications of the different measures as they would relate to the type of activity.

The EP Act allows the Environment Minister to produce Environmental Protection Policies, designed to protect environmental aspects in Queensland. The *Environmental Protection (Air) Policy* was developed under this framework in 2008, with the most recent revision being published in September 2019.

4.2 Queensland Environmental Protection (Air) Policy 2019

The *Environmental Protection (Air) Policy 2019* (EPP Air 2019) provides for the management and regulation of commercial and industrial air emissions that could adversely impact on sensitive receptors.

The purpose of the EPP (Air) is summarised below:

> *The purpose of the EPP (Air) is to achieve the object of the Act in relation to the air environment* (EPP (Air) Part 2, Section 3)*. The purpose of this policy is achieved by –*

a) *Identifying environmental values to be enhanced or protected; and*

b) *Stating indicators and air quality objectives for enhancing or protecting the environmental values; and*

c) *Providing a framework for making consistent, equitable and informed decisions about the air environment.*

The environmental values listed in the EPP (Air) that are to be enhanced or protected under the policy are:

a) *The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and*

b) *The qualities of the air environment that are conducive to human health and wellbeing; and*

c) *The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and*

d) *The qualities of the air environment that are conducive to protecting agricultural use of the environment.*

Queensland air quality guidelines are published in Schedule 1 of the EPP (Air) to protect the environmental values listed above. The air quality goals prescribed for the key pollutants of concern in this study are shown in **Table 2**.

Table 2 Relevant EPP (Air) 2019 Ambient Air Quality Objectives

Indicator	Environmental Value	Air Quality Objectives (μg/m^3 at 0°C)	Averaging Period
PM_{10}	Health and wellbeing	50	24 hours
		25	1 year
$PM_{2.5}$	Health and wellbeing	25	24 hours
		8	1 year
TSP	Health and wellbeing	90	1 year
NO_2	Health and wellbeing	250	1 hour
	Health and wellbeing	62	1 year
SO_2	Health and wellbeing	570	1 hour
		229	1 day
		57	1 year
	Protecting agriculture	31	1 year
	Health and biodiversity of ecosystems	21	1 year
Benzene	Health and wellbeing	5.4	1 year
Toluene	Health and wellbeing	4.1 mg/m^3	24 hours
		400	1 year
Xylenes (as a total of ortho, meta and para isomers)	Health and wellbeing	1.2 mg/m^3	24 hours
		950	1 year

4.3 NSW Approved Methods (2022)

In the absence of state specific guidelines for toxic pollutants such as H_2SO_4 gas and NH_3, the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* [hereafter the Approved Methods] (NSW EPA 2022) was used to establish ambient air quality guidelines for this Development. These are summarised in **Table 3**.

Table 3 Impact Assessment Citeria for Toxic Air Pollutants defined in the Approve Methods

Substance	Averaging period	Assessment criteria
NH_3	1hour	0.11 mg/m^3 110 µg/m^3
H_2SO_4	1hour	0.018 mg/m^3 18 µg/m^3
Ethylbenzene	1hour	8.0 mg/m^3 8000 µg/m^3

5.0 Existing Environment

5.1 Climate and Meteorology

Local climactic conditions can impact the dispersion of pollutant plumes. Parameters such as temperature, rainfall for its ability to scrub pollutants, wind speed and direction, solar radiation for its heating properties and relative humidity particular interest to air quality assessments. The nearest meteorological monitoring station to the proposed Development Site operated by the Bureau of Meteorology (BoM) is the Townsville Aero automatic weather station (AWS), located approximately 11 km to the northwest. This station (Station ID 032040) was commissioned in 1940 and has long-term meteorological data for the following parameters:

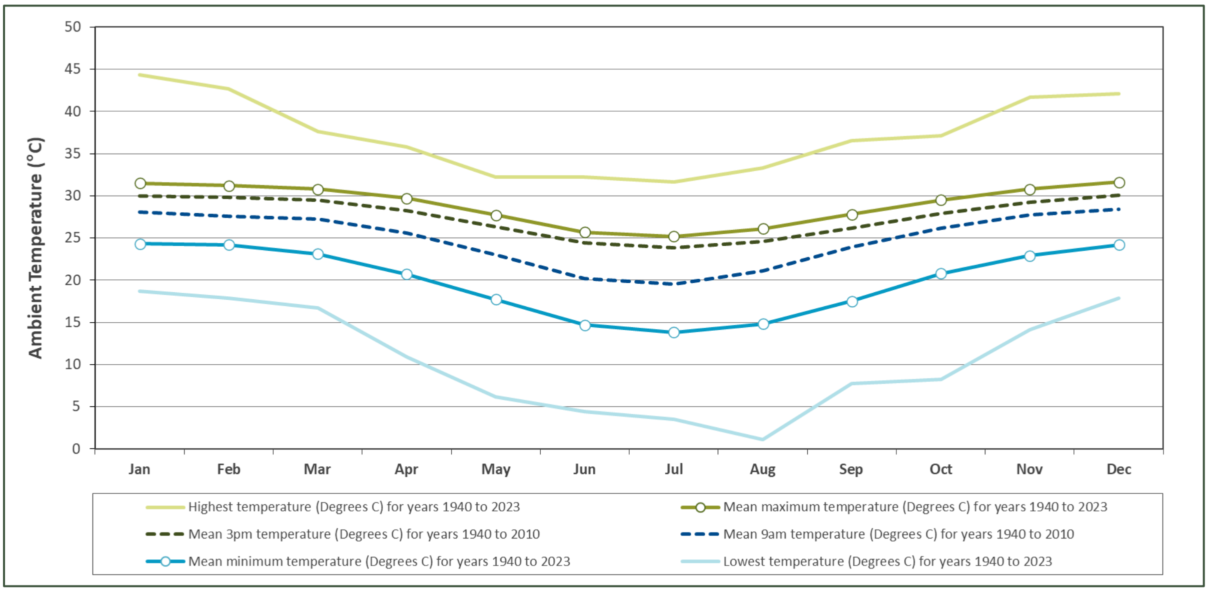
- Temperature (°C)
- Rainfall (mm)
- Solar radiation (MJ/m^2)
- Relative humidity (%)
- Wind speed (m/s) and wind direction (degrees).

A review of the long-term data collected is provided in the following sections below.

5.1.1 Temperature

Long-term temperature statistics for Townsville Aero AWS are summarised **Figure 4**. Mean maximum temperatures range from 25.2°C in winter to 31.6°C in summer, while mean minimum temperatures range from 13.8°C in winter to 24.3°C in summer. Maximum temperatures above 44°C and minimum temperatures less than 1.1°C have been recorded. Temperature impacts plume dispersion through thermal mixing of the atmosphere.

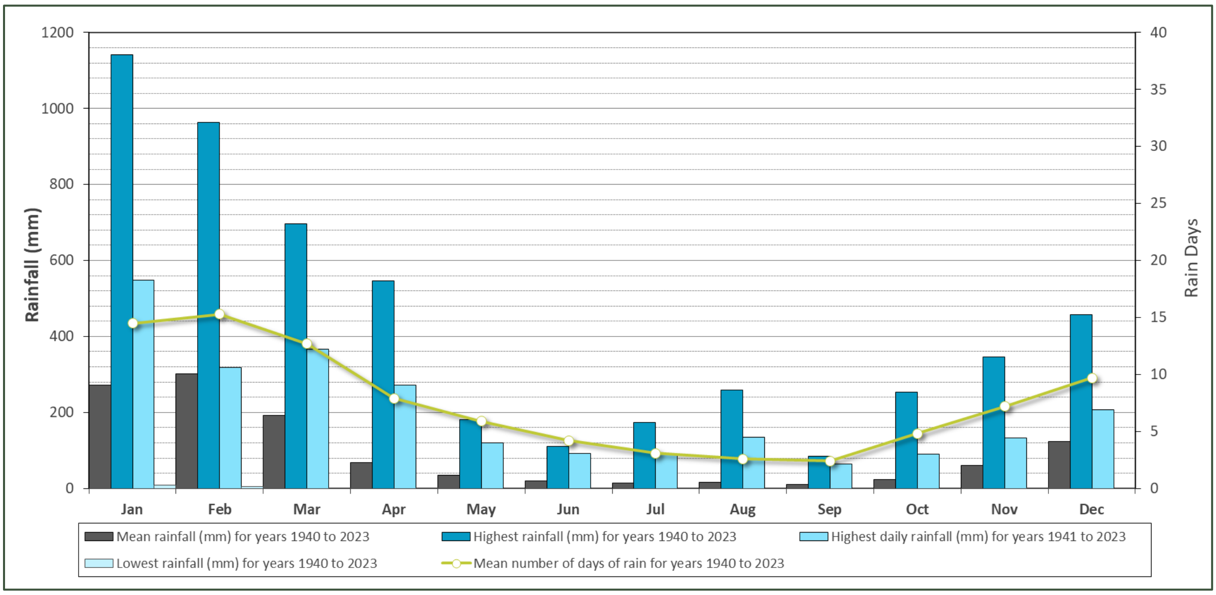
Figure 4 Long-term Temperature Data – Townsville Aero AWS



5.1.2 Rainfall

Long-term rainfall statistics reported for Townsville Aero AWS are summarised in **Figure 5**. Rainfall is relatively high in summer, reducing over autumn into winter, with the lowest average of 10 mm recorded during September. Rainfall has the potential to scrub pollutants from the atmosphere.

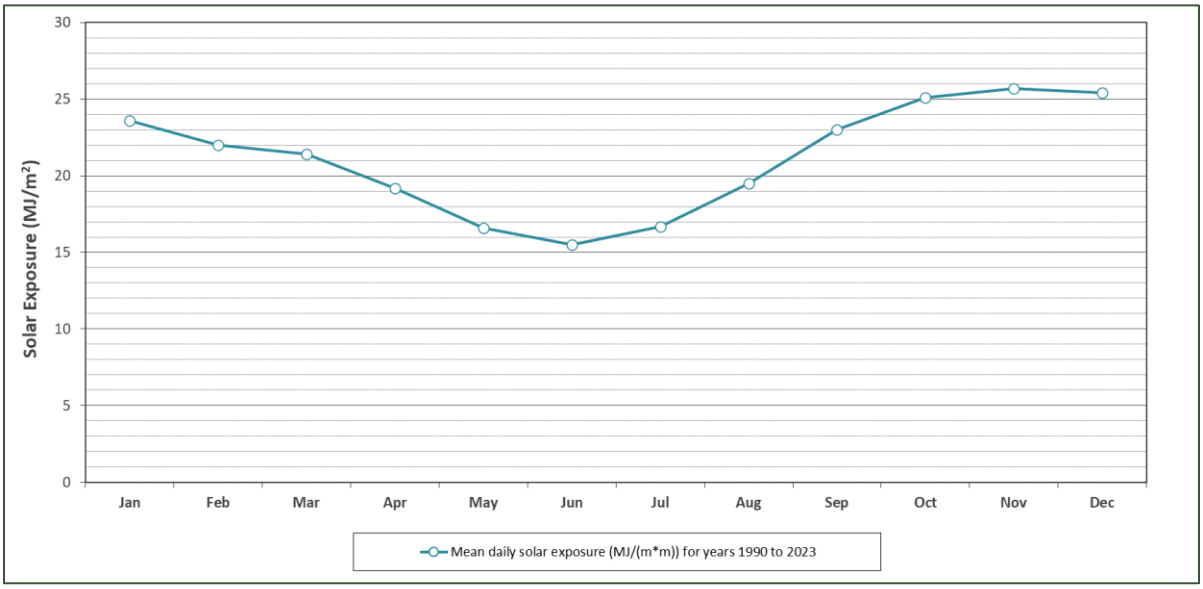
Figure 5 Long-term Rainfall Data – Townsville Aero AWS



5.1.3 Solar Radiation

As would be expected, the mean daily solar exposure levels (see **Figure 6**) are highest in summer (peaking at 25.4 MJ/m^2 in December) and lower in winter (dropping to 15.5 MJ/m^2 in June). Solar radiation impacts the ground temperature which can influence thermal mixing of the atmosphere.

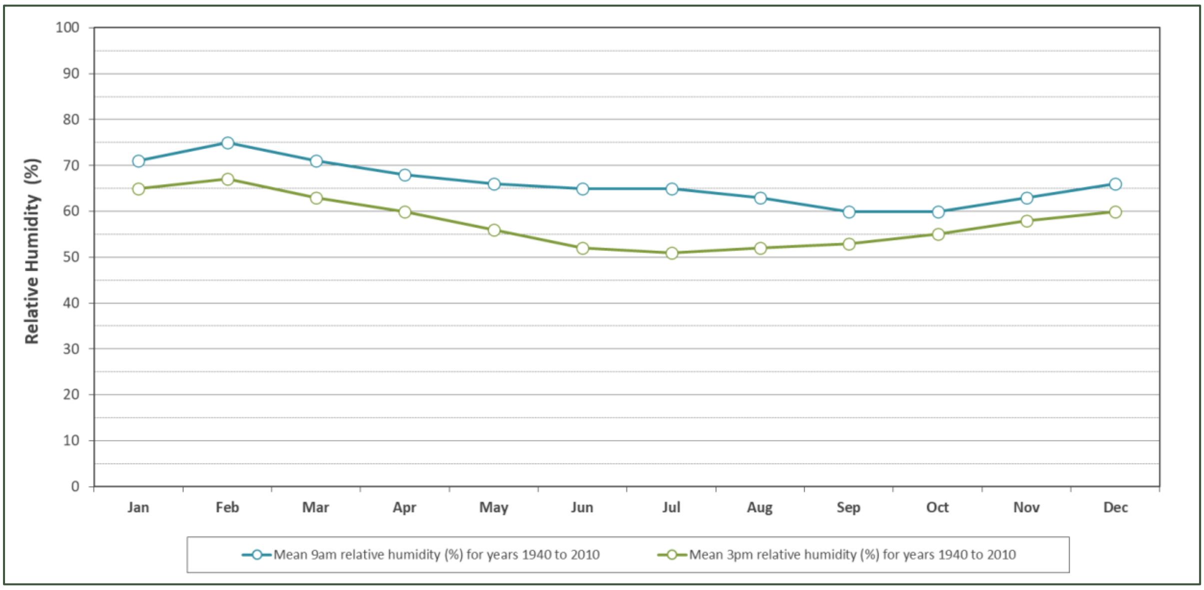
Figure 6 Solar Radiation Data – Townsville Aero AWS



5.1.4 Relative Humidity

Long-term humidity statistics (9 am and 3 pm monthly averages) are summarised in **Figure 7**. Morning humidity levels range from an average of around 60% in mid spring to around 75% in late summer. Afternoon humidity levels are lower, at around 55% in mid spring and 67% in late summer.

Figure 7 Humidity Data – Townsville Aero AWS



5.1.5 Wind Speed and Direction

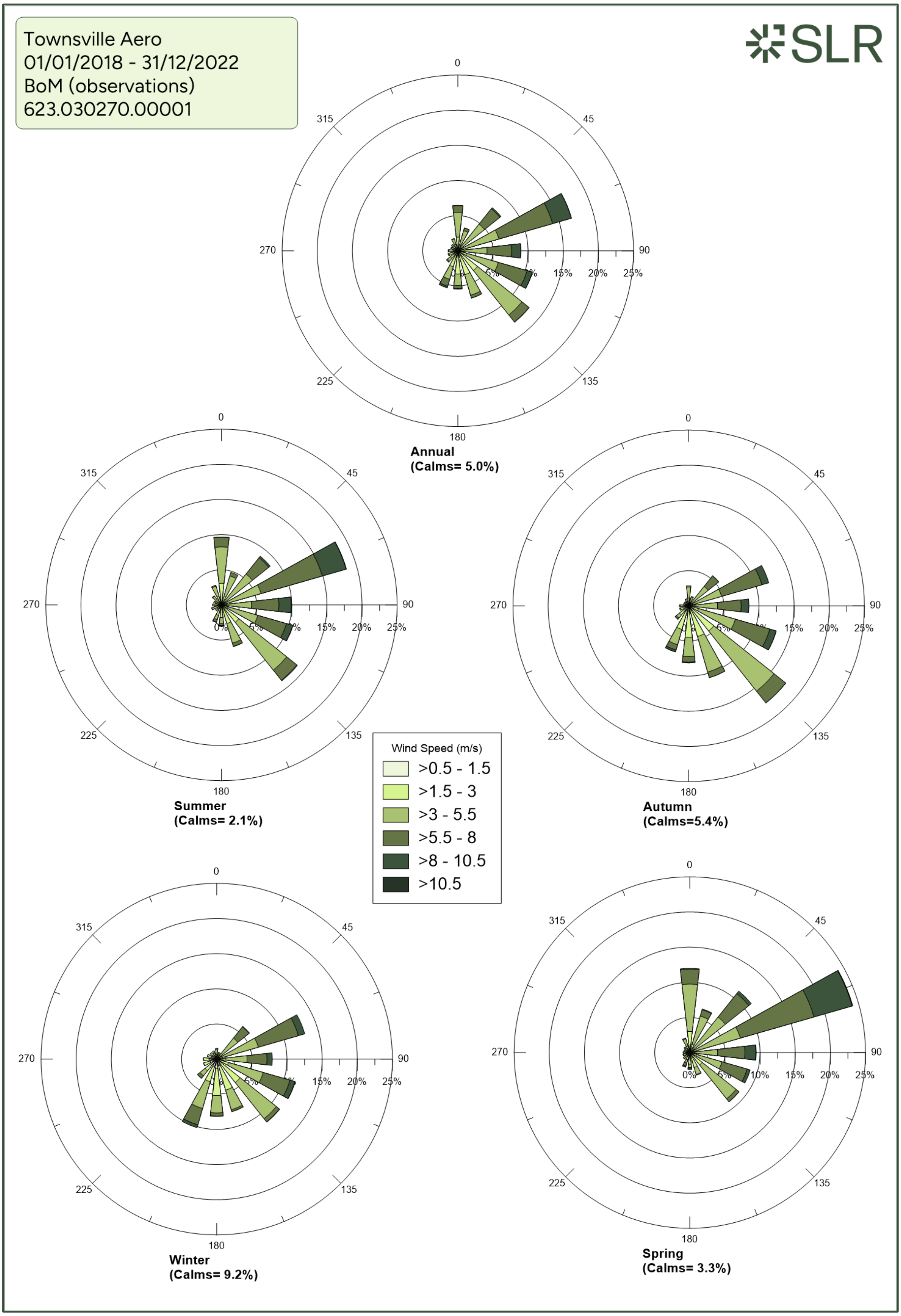
Wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from north). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus, it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

Hourly average wind data recorded over the five-year period 2018-2022 by the Townsville Aero AWS are also presented as wind roses in **Figure 8**.

On an annual basis the greatest frequency of wind occurs from the east-northeast direction with winds also occurring on a less frequent basis between the east and southeast directions. A similar distribution of winds occurs during summer. During autumn, winds occur most frequently between the southeast direction, with winds between the east and south occurring at a lower frequency. During winter, winds occur most frequently between the eastern and southern quadrants, with winds between the north and west occurring at lower frequency. Winds during spring are dominated by stronger winds occurring from the east-northeast and north direction, with winds between the east occurring at a lower frequency.

Overall, winds that would blow emissions from the Development Site towards the residences and Big 4 holiday park to the west occur frequently, approximately 35% of the time.

Figure 8 Wind Rose - Townsville Aero AWS (2018 – 2022)



5.2 Sensitive Receptors and Land Zoning

The closest sensitive receptors identified for this study are shown in **Figure 9** and **Table 4**. The nearest receptor (R2) is located approximately 550m to the southwest. Additionally, as shown **Figure 10** the proposed development and the area surrounding it is zoned as Special Purpose, where in the Townsville State Development Area applies (City of Townsville 2020). It is noted that as per the city plan this Development is located on area classified as Medium Impact Industry. Additionally, it is likely the areas within around the Development site may be approved for other industrial uses and thus may contain industrial receptors.

Figure 9 Residential Receptors

Table 4 Residential Receptor Location

Receptor Id	X Coordinate (m)	Y Coordinate (m)
R1	482,963	7,863,742
R2	482,866	7,863,898
R3	482,608	7,863,918
R4	482,477	7,864,046
R5	482,356	7,864,186
R6	482,351	7,864,386

Figure 10 Land Zoning

Source - (City of Townsville 2020)

5.3 Ambient Air Quality

The air quality in the region surrounding the Development Site is influenced by emissions generated by a range of sources, originating from both within and outside of the local area. This includes air emissions from other regional sources in the area and local traffic-generated pollution.

Queensland Government Department of Environment and Science undertakes air quality monitoring at a number of locations, to characterise air quality in the environment and to determine the potential exposure of sensitive receptors to dust and air contaminant emissions.

The North Ward Air Quality Monitoring Station (AQMS) is located approximately 8.5 km north from the Development Site and is the nearest station that monitors particulate matter as well as NO_2. Whilst the Lennon Drive AQMS is located closer to the Site, it is also located in a industrial area and is likely to not be representative of air quality at neighbouring receptors. Hence North Ward has been selected as a background location for this study.

5.3.1 Particulate Matter

A summary of the North Ward AQMS 24-hour average PM_{10} and $PM_{2.5}$ can be seen below in **Figure 11** for the 2022 calendar year. Additionally, a summary of data collected for this year is provided in **Table 5**.

5.3.2 NO_2 and Ozone

Figure 12 presents a summary of 2022 calendar year data for 1-hour average NO_2 from the North Ward AQMS and average 1-hour Ozone (O_3), sourced from the Deception Bay monitoring station in South East Queensland. The data is presented in **Table 5** and **Table 6**. The O_3 data was drawn from the Deception Bay AQMS, in preference to the nearest ozone monitoring station to Townsville located in Memorial Park, Gladstone which recorded relatively lower average concentrations. It was considered the Deception Bay data presented a more conservative approach, which was appropriate for this assessment.

5.3.3 SO_2

A summary of data collected for the 2022 calendar year for 1-hour and 24-hour average SO_2 is provided in **Table 5** and **Table 6.** It is noted that for extended periods of time the measured hourly SO_2 concentration were reported to very low, hence hourly variation of this data is presented as a chart.

Table 5 Air Quality Monitoring Data 24-hour average Summary (2022)

	North Ward AQMS		
	24 - hour average PM_{10} (µg/m^3)	24 -hour average $PM_{2.5}$ (µg/m^3)	24- hour average SO_2 (µg/m^3)
Maximum	71.1	55.1	2.1
Average	15.8	6.1	0.4
70th Percentile	17.1	6.5	0.5

Table 6 Air Quality Monitoring Data 1-hour average Summary (2022)

	North Ward AQMS		Deception Bay AQMS
	1-hour average SO_2 (µg/m^3)	1- hour average NO_2 (µg/m^3)	1- hour average O_3 (µg/m^3)
Maximum	17.2	49.2	134.8
Average	0.4	5.5	40.8
70th Percentile	<0.1	6.2	53.5

Figure 11 North Ward AQMS PM_{10} and $PM_{2.5}$ data (2022)

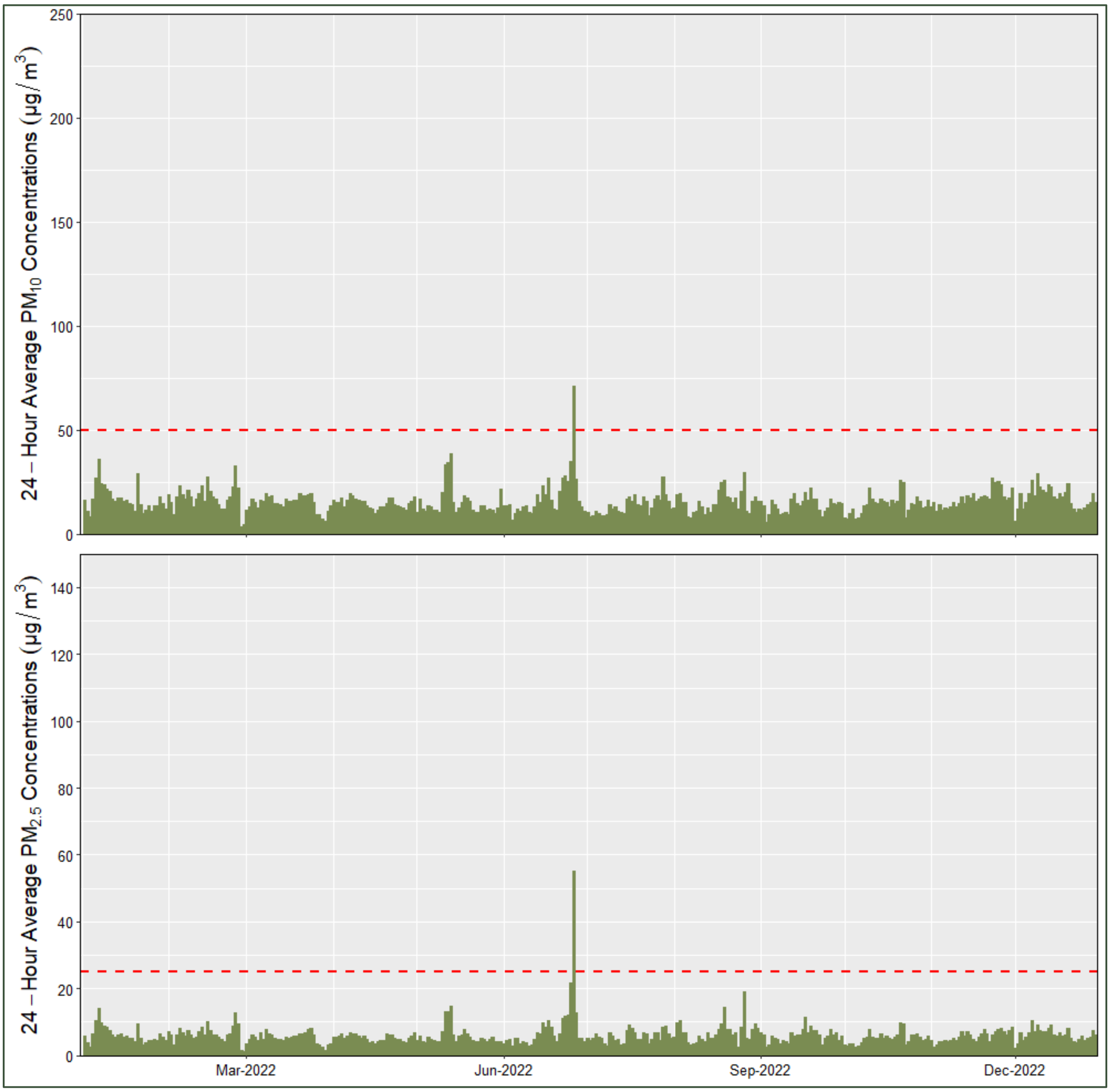
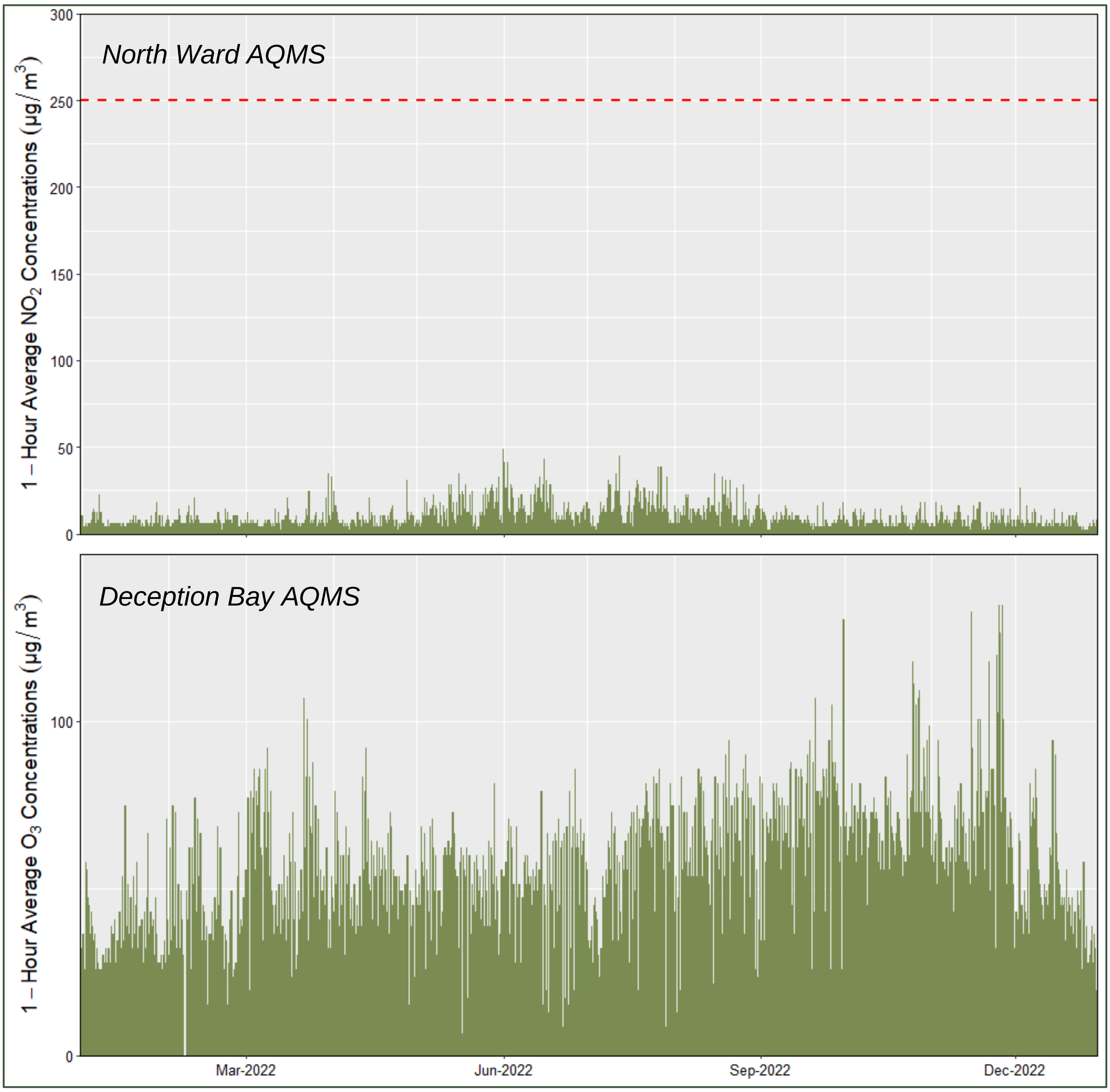


Figure 12 North Ward AQMS NO_2 and Deception Bay AQMS O_3 data (2022)



5.3.4 Adopted Background

The site-representative background ambient air quality concentrations adopted for use in this assessment are summarised in **Table 7**.

Table 7 Adopted Background Data

Pollutant	Averaging Period	Regional Background ($\mu g/m^3$)	Notes
NO_2	1-hour	6.2	70th percentile of North Ward data (2022)
	Annual	5.5	Average of North Ward data (2022)
SO_2	1-hour	17.2	Maximum of North Ward data (2022) as 70th Percentile was estimated to be 0 $\mu g/m^3$
	24-hour	0.5	70th percentile of North Ward data (2022)
	Annual	0.4	Average of North Ward data (2022)
$PM_{2.5}$	24-hour	6.5	70th percentile of North Ward data (2022)
	Annual	6.1	Average of North Ward data (2022)
O_3	1-hour	53.5	70th Percentile of data recorded at Deception Bay

It is noted that no major sources of NH_3 were identified around the proposed development, thus it assumed that NH_3 background concentrations are negligible.

6.0 Assessment Methodology

6.1 Modelling Methodology

6.1.1 Model Selection and Configuration

Emissions from the stack at the proposed facility have been modelled using a combination of TAPM, CALMET and CALPUFF models to predict the potential impacts at ground level receptors. CALPUFF is a transport and dispersion model that ejects “puffs” of material emitted from modelled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by a meteorological pre-processor CALMET, discussed further below. Temporal and spatial variations in the meteorological fields selected are explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentration or hourly deposition fluxes evaluated at selected receptor locations. The CALPOST post-processor is then used to process these files, producing tabulations that summarise results of the simulation for user-selected averaging periods.

Steady state models assume that meteorology is unchanged by topography over the modelling domain and may result in significant over or under estimation of air quality impacts. The CALPUFF dispersion model has the ability to handle calm wind speeds (<0.5 m/s) and complicated terrain and therefore was considered to be appropriate for this assessment.

6.1.1.1 TAPM

TAPM prognostic model, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to generate the upper air data required for CALMET modelling.

TAPM model predicts wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence. The program allows the user to generate synthetic observations by referencing databases (covering terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses) which are subsequently used in the model input to generate 1 full year of hourly meteorological observations at user-defined levels within the atmosphere.

Additionally, the TAPM model may assimilate actual local wind observations so that they can optionally be included in a model solution. The wind speed and direction observations are used to realign the predicted solution towards the observation values. Wind data from surrounding Bureau of Meteorology (BOM) stations (Townsville Airport and Mount Stuart (Defence)) were used to nudge the TAPM predictions. **Table 8** details the parameters used in the TAPM meteorological modelling for this assessment.

Table 8 Meteorological Parameters used for this Study – TAPM

TAPM (v 4.0)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km and 1 km)
Number of grid points	25 x 25 x 35
Year of analysis	2022
Centre of analysis	483,442 m E 7,864,317 m S
Data assimilation	Townsville Airport and Mount Stuart (Defence)

6.1.1.2 CALMET

In the simplest terms, CALMET is a meteorological model that develops hourly wind and other meteorological fields on a three-dimensional gridded modelling domain that are required as inputs to the CALPUFF dispersion model. Associated two dimensional fields such as mixing height, surface characteristics and dispersion properties are also included in the file produced by CALMET. The interpolated wind field is then modified within the model to account for the influences of topography, sea breeze, as well as differential heating and surface roughness associated with different land uses across the modelling domain. These modifications are applied to the winds at each grid point to develop a final wind field. The final hourly varying wind field thus reflects the influences of local topography and land uses.

TAPM generated three-dimensional meteorological data was used as the initial guess wind field and the local topography and land use data for the modelling domain were used to refine the wind field predetermined by TAPM data. **Table 9** details the parameters used in the meteorological modelling to drive the CALPUFF model.

Table 9 Meteorological Parameters used for this Study – CALMET (v 6.2)

CALMET	
Meteorological grid	10 km × 10 km
Meteorological grid resolution	0.1 km
Initial guess filed	3D output from TAPM modelling
Surface station data	No surface data

6.1.2 Meteorological Data

A one year, site-representative meteorological dataset, containing hourly records of key meteorological parameters, has been compiled for the development site using the methodology outlined above. This dataset is based on predicted data collected in the region for the 2022 calendar year, and key characteristics of the meteorological dataset, as relevant to the dispersion of air emissions from the site is presented below.

6.1.2.1 Wind Speed and Direction

A summary of the annual wind behaviour predicted at the development site for the 2022 calendar year is presented as wind roses in **Figure 13**. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (degrees from North). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds. Thus, it is possible to visualise how often winds of a certain direction and strength occur over a long period, either for all hours of the day, or for particular periods during the day.

Figure 13 indicates that winds predicted at the site predominantly blow from the southeast quadrant followed by lower frequency of winds from the northeast quadrant. The seasonal wind roses indicate that typically:

- In summer and spring, winds are predicted to be predominantly light (0.5 m/s - 3 m/s) and generally blow from the southeastern and northeastern quadrants, with very low frequency of winds from the southwest and northwest quadrants.
- In Autumn and winter, light to moderate (0.5m/s to 5m/s) winds from the southern quadrant are predominant with very low frequency of winds predicted to be blowing from the north.

A wind speed frequency chart is shown in **Figure 14**. This chart shows that the proposed development site is predicted to experience predominantly low to moderate wind speeds (up to 6 m/s).

6.1.2.2 Atmospheric Stability

Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Gifford-Turner (PGT) assignment scheme identifies six Stability Classes, A to F, to categorise the degree of atmospheric stability as follows:

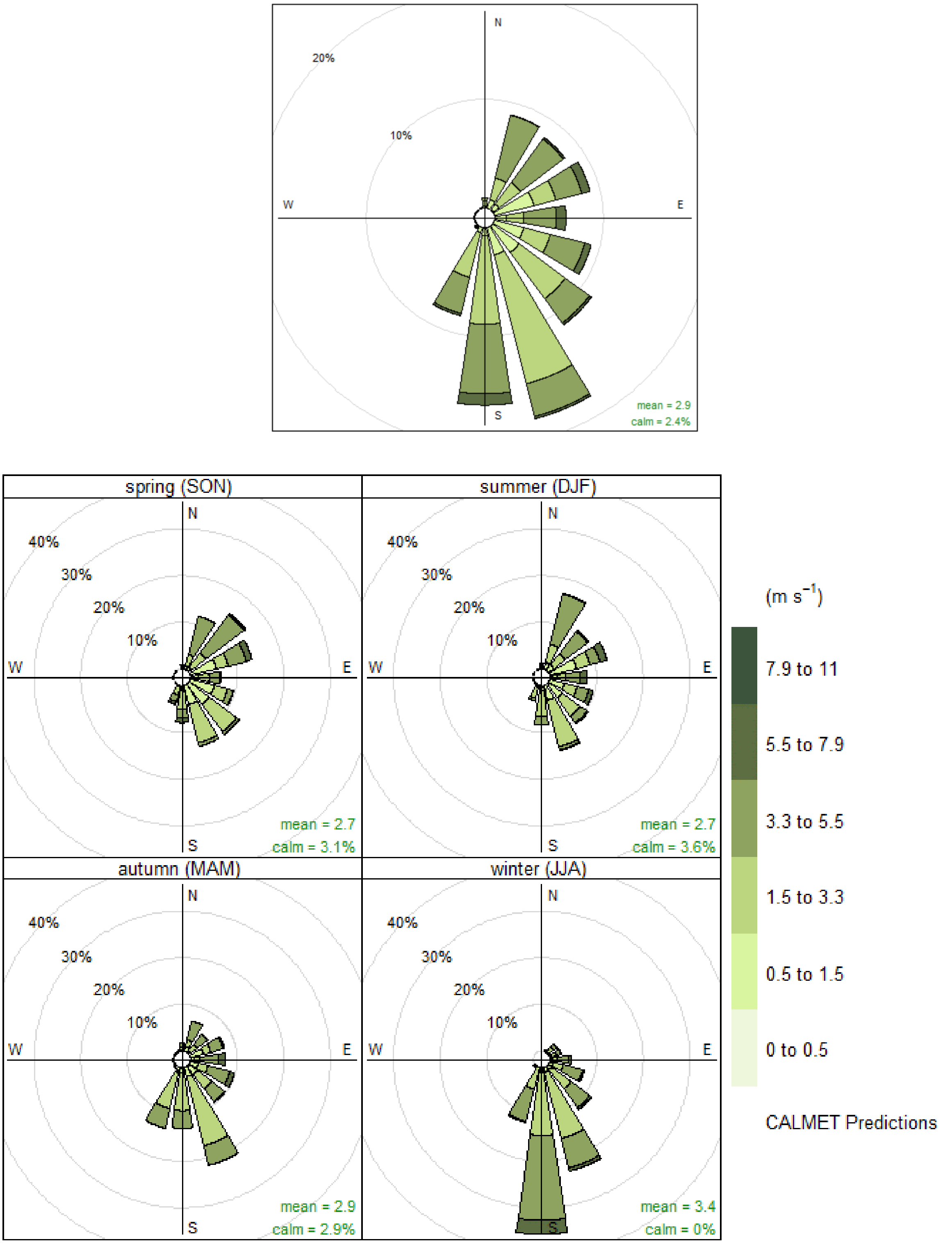
- A = Extremely unstable conditions
- B = Moderately unstable conditions
- C = Slightly unstable conditions

- D = Neutral conditions
- E = Slightly stable conditions
- F = Moderately stable conditions

The meteorological conditions defining each PGT stability class are shown in **Table 10**. The frequency of each stability class predicted by CALMET at the site during the modelling period is presented in **Figure 15**.

The results indicate a high frequency of conditions typical to Stability Class F, with a low frequency of very unstable conditions (Stability Class A). Stability Class F represents moderate stability conditions that tend to inhibit pollutant dispersion at night time.

Figure 13 Seasonal Wind Roses for the Development Site



Frequency of counts by wind direction (%)

Figure 14 Wind Speed Frequencies at the Development Site (CALMET, 2022)

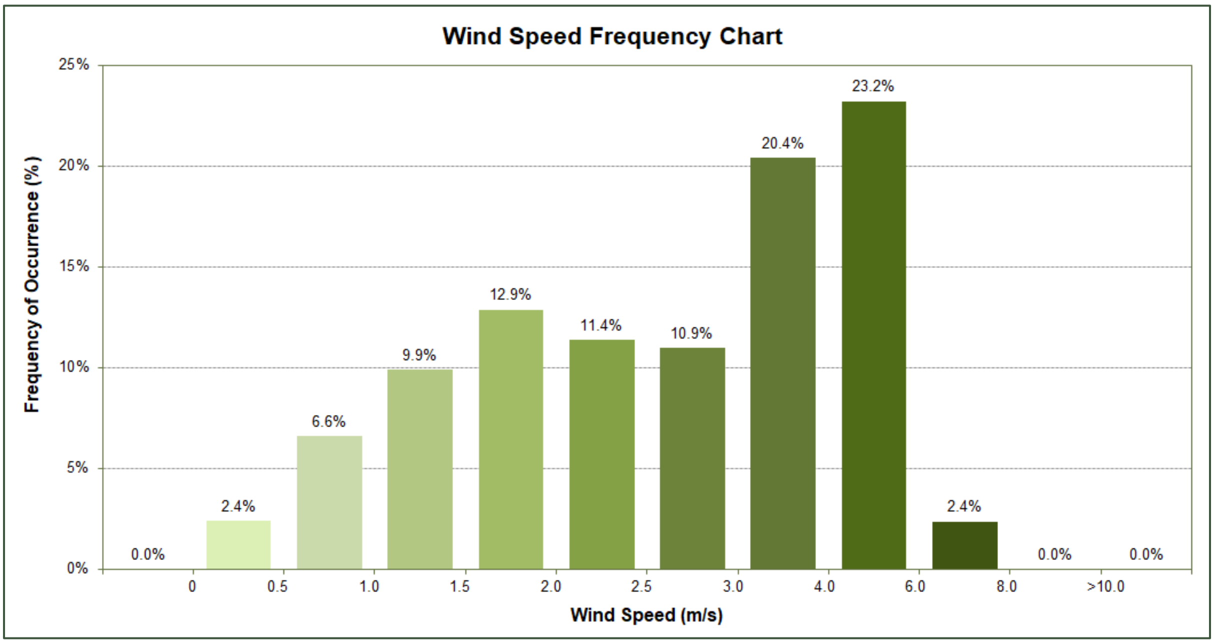


Table 10 Meteorological Conditions Defining PGT Stability Classes

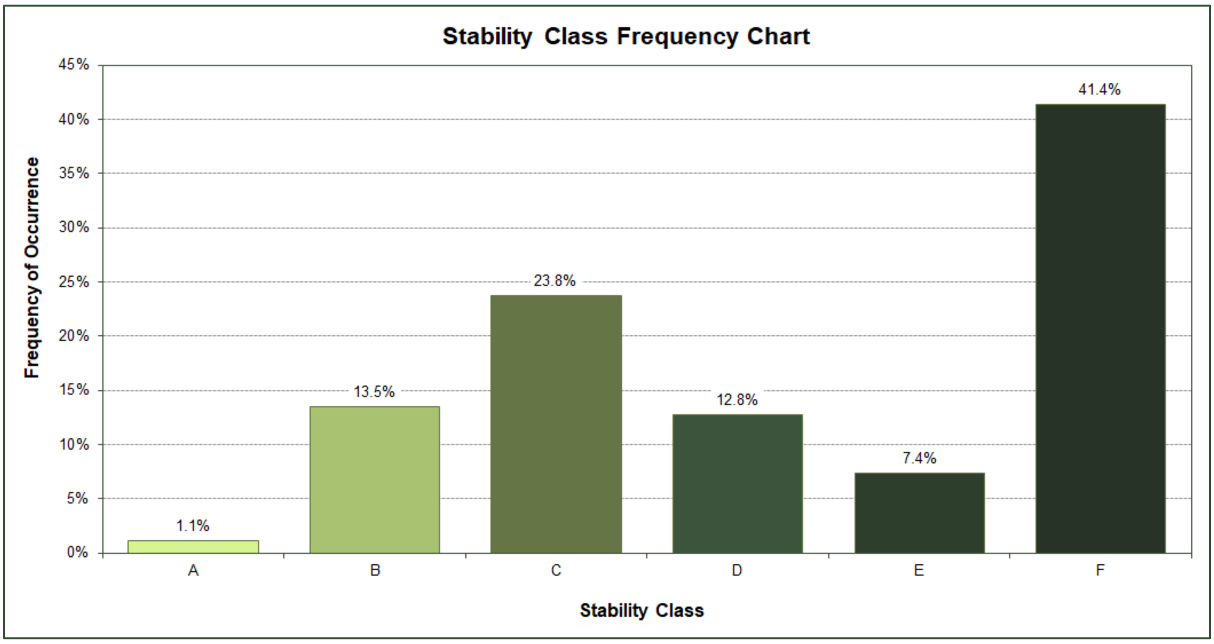
Surface Wind Speed (m/s)	Day-time Insolation			Night-time Conditions	
	Strong	Moderate	Slight	Thin overcast or > 4/8 low cloud	≤ 4/8 Cloudiness
< 2	A	A - B	B	E	F
2 - 3	A - B	B	C	E	F
3 - 5	B	B - C	C	D	E
5 - 6	C	C - D	D	D	D
> 6	C	D	D	D	D

SOURCE: (NOAA 2018)

Notes:

1. Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.
2. Night refers to the period from 1 hour before sunset to 1 hour after sunrise.
3. The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

Figure 15 Stability Class Frequencies at the Development Site (CALMET, 2022)

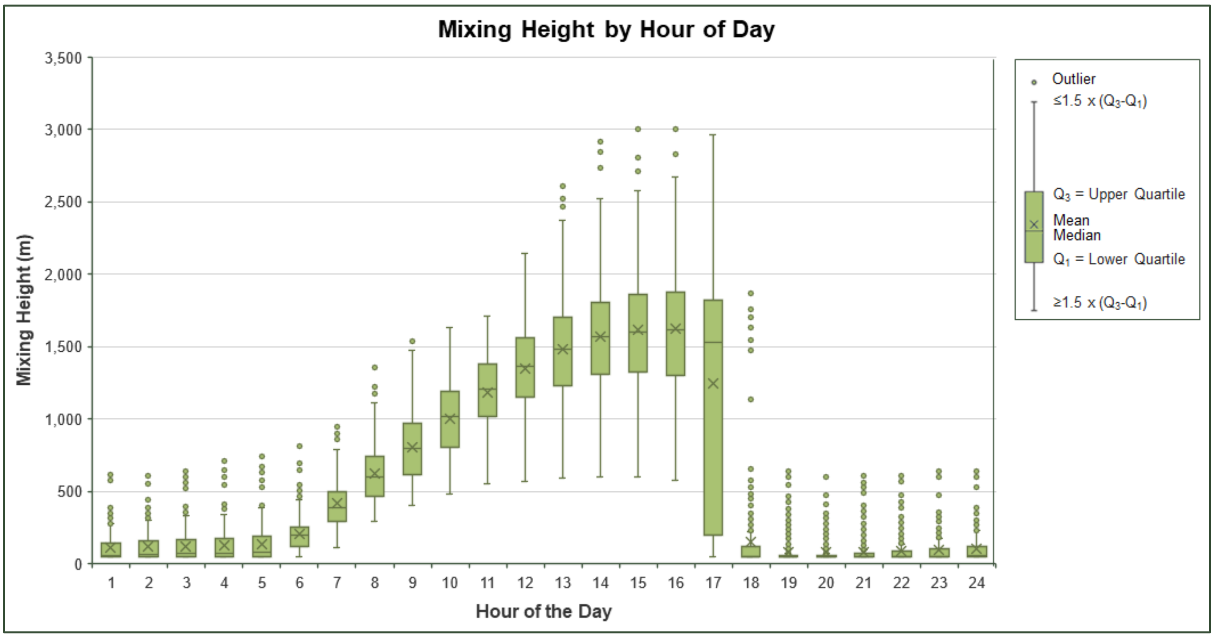


6.1.2.3 Mixing Heights

Diurnal variations in maximum and average mixing depths predicted by CALMET at the site during the 2022 modelling period are illustrated in **Figure 16**.

As would be expected, an increase in mixing depth during the morning is apparent, arising due to the onset of vertical mixing following sunrise. Maximum mixing heights occur in the mid to late afternoon, due to the dissipation of ground based temperature inversions and growth of the convective mixing layer.

Figure 16 Predicted Mixing Heights at the Development Site (CALMET, 2022)



6.1.3 Stack Parameters and Modelling Scenarios

The stack parameters provided by RPS based on preliminary design used in this study are presented in **Table 11**.

Table 11 Modelling parameters

Parameter	Data	Unit
Source Location	483,450 E 7,864,360 N	UTM
Flowrate	10,000	Am³/hr
	12,198	m³/hr
Temperature	45	°C
Diameter	0.7	m
Height	15	m
Exit velocity	8.8	m/s
Modelled minimum exit velocity *	6	m/s
* modelled exit velocity is below those provided as it represents a conservative approach		

Emission rates adopted for the modelling as presented in **Section 3.1** are shown in **Table 12**.

Table 12 Emission Rates Used for Modelling

Pollutant	Modelled Emission Rates	
	kg/h	g/s
$PM_{2.5}$	0.25[(a)]	0.07
NO_x	0.47	0.131
SO_2	0.45	0.125
NH_3	0.012	0.0032
VOCs[(b)]	0.0005	0.00014
H_2SO_4/SO_3[(c)]	0.023	0.007

(a) Conservatively assumed all particulate emissions are $PM_{2.5}$

(b) It is noted that as there is no ambient air quality criteria applicable to impacts associated with VOCs emissions, it is conservatively assumed that all VOCs released will be assessed against the benzene criterion defined in **Section 4.0**. Compliance with the benzene criterion is likely to indicate low risk of exceedance of other VOCs.

(c) As mentioned in **Section 3.1**, all SO_3 contained in gas stream will convert to H_2SO_4 when it comes in contact with water. Thus, emission rates presented here represent emissions of H_2SO_4 after this conversion.

Table 13 Emission rate mitigation summary

Pollutant	Emission source	Untreated Emission rate	Reduction Efficiency	Treated Emissions	Modelled Emission Rates
		(kg/h)	(%)	(kg/h)	(g/s)
Particulates as $PM_{2.5}$	Baghouse	25	99	0.25(a)	
	Scrubber	0.29	99	0.003	
Total $PM_{2.5}$				0.253	0.070
NO_2	Scrubber	4.7	90	0.47	0.131
SO_2	Scrubber	4.5	90	0.45	0.125
SO_3	Scrubber	1.5	99	0.015	0.0040
NH_3	Scrubber	1.16	99	0.0116	0.0032
Volatile Organics	Scrubber	0.05	90	0.0050	0.00014
H_2SO_4 Mist	Scrubber	0.12	99	0.0012	0.00034

(a) Conservatively assumed all particulate emissions are $PM_{2.5}$

(b) It is noted that as there is no ambient air quality criteria applicable to impacts associated with VOCs emissions, it is conservatively assumed that all VOCs released will be assessed against the benzene criterion defined in **Section 4.0**. Compliance with the benzene criterion is likely to indicate low risk of exceedance of other VOCs.

(c) As mentioned in **Section 3.1**, all SO_3 contained in gas stream will convert to H_2SO_4 when it comes in contact with water. Thus, emission rates presented here represent emissions of H_2SO_4 after this conversion.

6.2 Building Downwash

Building downwash is a phenomenon caused by structures near to pollutant emission sources influencing atmospheric turbulence. Airflow is rapidly mixed to the ground as frictional forces and pressure gradients cause stagnations and eddies to develop in the wake of buildings downwind of elevated sources. CALPUFF contains the Prime algorithm, which was used in this study to predict building downwash effects. Influencing building dimensions were calculated using the USEPA's Building Profile Input Program (BPIP).

The proposed buildings at the Development site were included in the modelling to account for potential building wakes. All buildings were modelled with a height of 10 m in the absence of detailed design information.

7.0 Assessment of Potential for Air Impacts

7.1 NO_2

A summary of the predicted incremental and cumulative maximum 1-hour and annual average NO_2 concentrations at the identified nearest residential receptors are presented in **Table 14**.

The modelling results show that the cumulative maximum 1-hour average and annual average NO_2 concentrations are well below the relevant air quality objectives (as per **Section 4.0**) at the identified residential receptors.

In order to assess impacts at neighbouring industrial receptors, predicted maximum off-site impacts are also presented in **Table 14.** It can be observed that impacts at adjacent industrial receptors are also predicted to be below relevant air quality objectives.

The isopleths of predicted incremental 1-hour and annual average NO_2 concentrations are presented in **Appendix A.**

Table 14 Predicted Incremental and Cumulative NO_2 Concentrations

Receptors	Maximum 1-hour Average NO_2 Concentrations		Annual Average NO_2 Concentrations	
	Incremental	Cumulative	Incremental	Cumulative
R1	5.6	11.7	0.2	5.7
R2	5.3	11.5	0.2	5.7
R3	3.7	9.8	0.1	5.6
R4	3.3	9.4	0.1	5.6
R5	3.0	9.2	0.1	5.6
R6	3.0	9.2	0.1	5.6
Max- Offsite	28.3	34.4	2.7	8.3
Guideline	**-**	**250**	**-**	**62**

7.2 $PM_{2.5}$

A summary of predicted maximum 24-hour and annual average $PM_{2.5}$ concentrations at the identified residential receptors are presented in **Table 15**.

The modelling results show that the cumulative 24-hour average and annual average $PM_{2.5}$ concentrations are well below the relevant air quality objectives (as per **Section 4.0**) at the identified residential receptors as well as at maximum offsite locations (that represent industrial receptors).

The isopleths of predicted incremental 1-hour and annual average NO_2 concentrations are presented in **Appendix A.**

Table 15 Predicted Incremental and Cumulative $PM_{2.5}$ Concentrations

Receptors	Maximum 24-hour Average $PM_{2.5}$ Concentrations (µg/m³)		Annual Average $PM_{2.5}$ Concentrations (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative
R1	0.6	7.1	<0.1	<6.2
R2	0.4	6.9	<0.1	<6.2
R3	0.4	6.9	<0.1	<6.2
R4	0.4	7.0	<0.1	<6.2
R5	0.4	6.9	<0.1	<6.2
R6	0.3	6.8	<0.1	<6.2
Max- Offsite	7.1	13.6	1.5	7.6
Guideline	**-**	**25**	**-**	**8**

7.3 SO_2

A summary of the predicted incremental and cumulative maximum 1-hour and24-hour average and annual average SO_2 concentrations at the identified nearest residential receptors are presented in **Table 16**. The modelling results show that the predicted SO_2 concentrations are well below the relevant air quality objectives (as per **Section 4.0**) at the identified residential receptors as well as at maximum offsite locations (that represent industrial receptors).

The isopleths of predicted incremental 1-hour, 24-hour and annual average SO_2 concentrations are presented in **Appendix A.**

Table 16 Predicted Incremental and Cumulative SO_2 Concentrations

Receptors	Maximum 1-hour Average SO_2 Concentrations (µg/m³)		Maximum 24-hour Average SO_2 Concentrations (µg/m³)		Annual Average SO_2 Concentrations (µg/m³)	
	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative
R1	5.3	22.5	1.1	1.6	0.2	0.6
R2	5.1	22.3	0.7	1.2	0.2	0.6
R3	3.5	20.7	0.7	1.2	0.1	0.5
R4	3.1	20.3	0.8	1.3	0.1	0.5
R5	2.9	20.1	0.7	1.2	<0.1	<0.5
R6	2.9	20.1	0.5	1.0	<0.1	<0.5
Max-Offsite	27.1	44.3	45.2	45.7	2.6	3.0
Guideline	**-**	**570**	**-**	**229**	**-**	**57**

7.4 Other pollutants

A summary of the predicted incremental maximum 1-hour average NH_3 and H_2SO_4 concentrations and annual average benzene concentrations at the identified nearest residential receptors are presented in **Table 16**. The modelling results show that the predicted concentrations for these pollutants are well below the relevant air quality objectives (as per **Section 4.0**) at the identified residential receptors as well as at maximum offsite locations (represent industrial receptors).

Table 17 Predicted Incremental Concentrations of Other Pollutants

Receptors	Maximum 1-hour Average NH_3 Concentrations (µg/m³)	1-hour Average H_2SO_4 Concentrations (µg/m³)	Annual Average Benzene Concentrations (µg/m³)
R1	<0.1	<0.1	<0.1
R2	<0.1	<0.1	<0.1
R3	<0.1	<0.1	<0.1
R4	<0.1	<0.1	<0.1
R5	<0.1	<0.1	<0.1
R6	<0.1	<0.1	<0.1
Max-Offsite	0.7	<0.1	<0.1
Guideline	**110**	**18**	**5.4**

8.0 Mitigation Measures

The following additional measures are recommended to further reduce the risk of air quality or nuisance impacts:

- Signage should be displayed to remind drivers to turn off vehicle engines when stationary to minimise exhaust emissions.
- All staff and contractors should be instructed to report any undue pollutant release (including odour) and visible emissions from the exhaust vents to the site manager.
- Ensure paved areas accessed by truck and other heavy vehicles will be maintained to ensure no excessive build up of spilt material.
- The site should be inspected daily and good housekeeping practices employed (e.g. ensuring the timely clean-up of any spills, identifying and rectifying any leaks that could contribute to fugitive emissions, etc.).
- In the event of any complaint, ensure these are investigated as soon as possible so that effective appraisal of the complaint can be carried out by subjective assessment.
- Upon commissioning emission testing from stack is to be conducted. If measured emission parameters are different from those adopted in this study, the assessment may require to be updated to ensure compliance with relevant criteria.

9.0 Conclusion

SLR Consulting Australia Pty Ltd has been engaged by RPS to undertake an air quality impact assessment to inform an application for a State Development Area application for a Research and Technology Industry associated with the Queensland Resources Common User Facility.

Based on preliminary design and emission information provided to SLR, dispersion modelling of these emissions was conducted.

Dispersion modelling of emissions from the Development site showed that predicted impacts at all existing residential receptors and potential future industrial receptors are well below the relevant criteria for all pollutants assessed in this report.

Additionally, mitigation measured were also provided to address any residual impacts from the proposed development. Given the proximity to industrial receptors it is recommended that mitigation measures are adopted, air emission treatment are designed appropriately, maintained and serviced as per manufacturers recommendations.

It is also recommended that emission testing from stack is to be conducted upon commissioning. If measured emission parameters are different from those adopted in this study, the assessment may require to be updated to ensure compliance with relevant criteria.

Based on the findings of this assessment, it is concluded that the proposed operations are unlikely to cause any adverse air quality impacts at the surrounding sensitive receptors and would comply with the relevant ambient air quality guidelines.

10.0 References

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Appendix A Contour Plots Scenario 1 (highest predicted impact scenario)

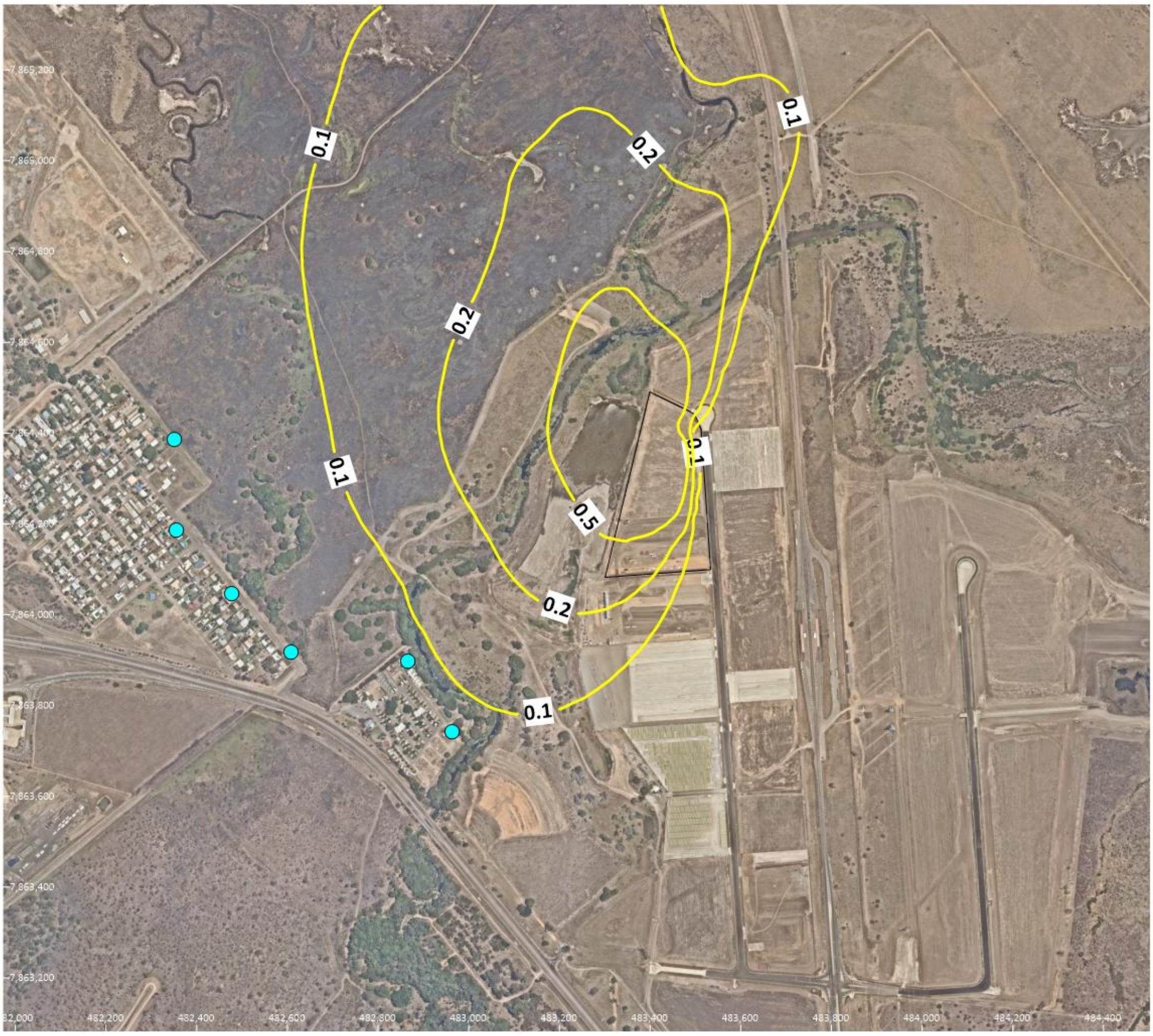
Townsville Common User Facility

Air Quality Impact Assessment

RPS

SLR Project No.: 623.030270.00003

10 December 2024



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Dispersion Model:	CALPUFF
Modelling Period:	2022
Projection:	GDA 1994 MGA Zone 55
Date:	11/09/2024

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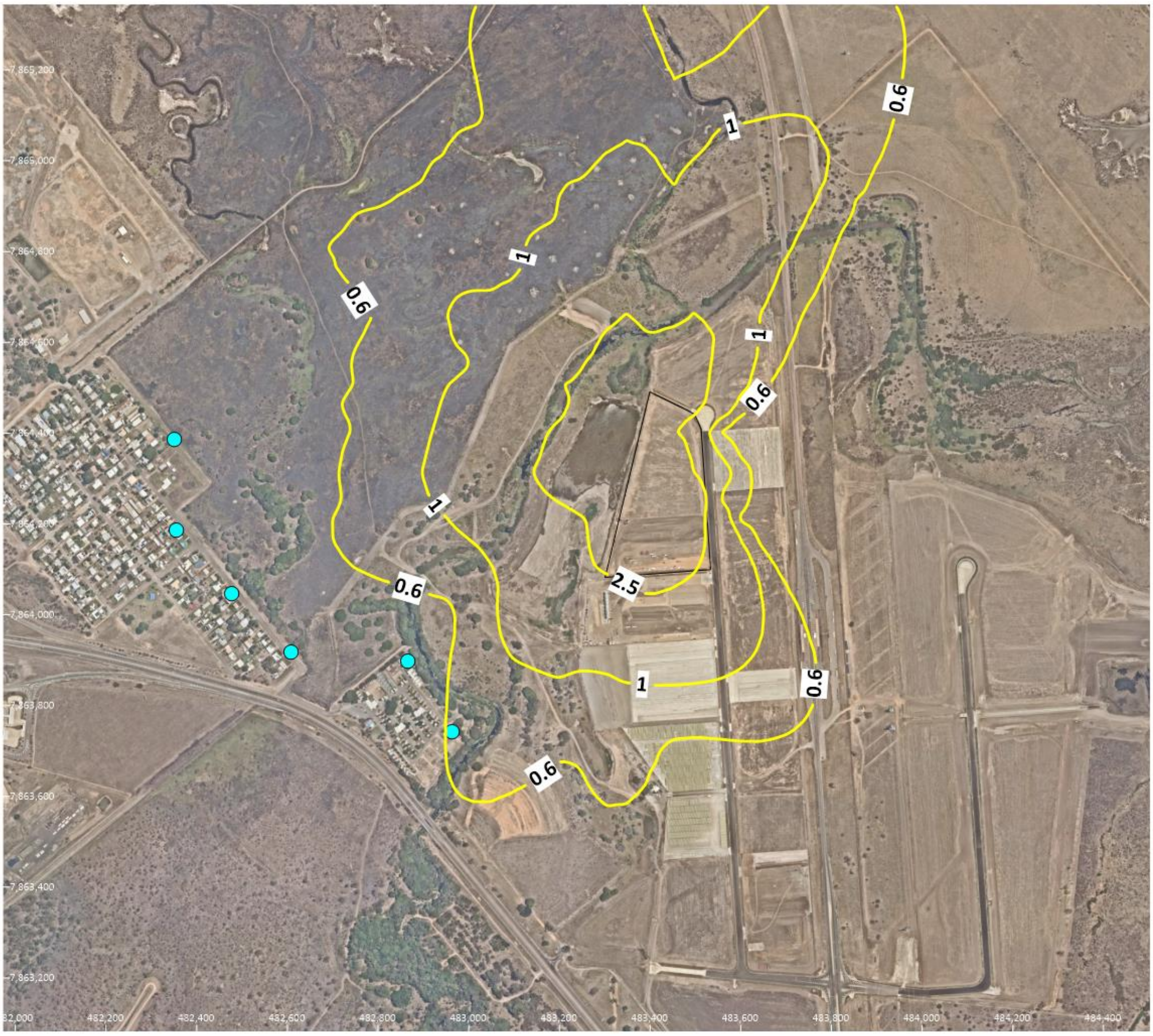
Townsville Common User Facility
Air Quality Impact Assessment

Incremental Impact

Pollutant	$PM_{2.5}$	Avg Period	Annual	Unit	µg/m³



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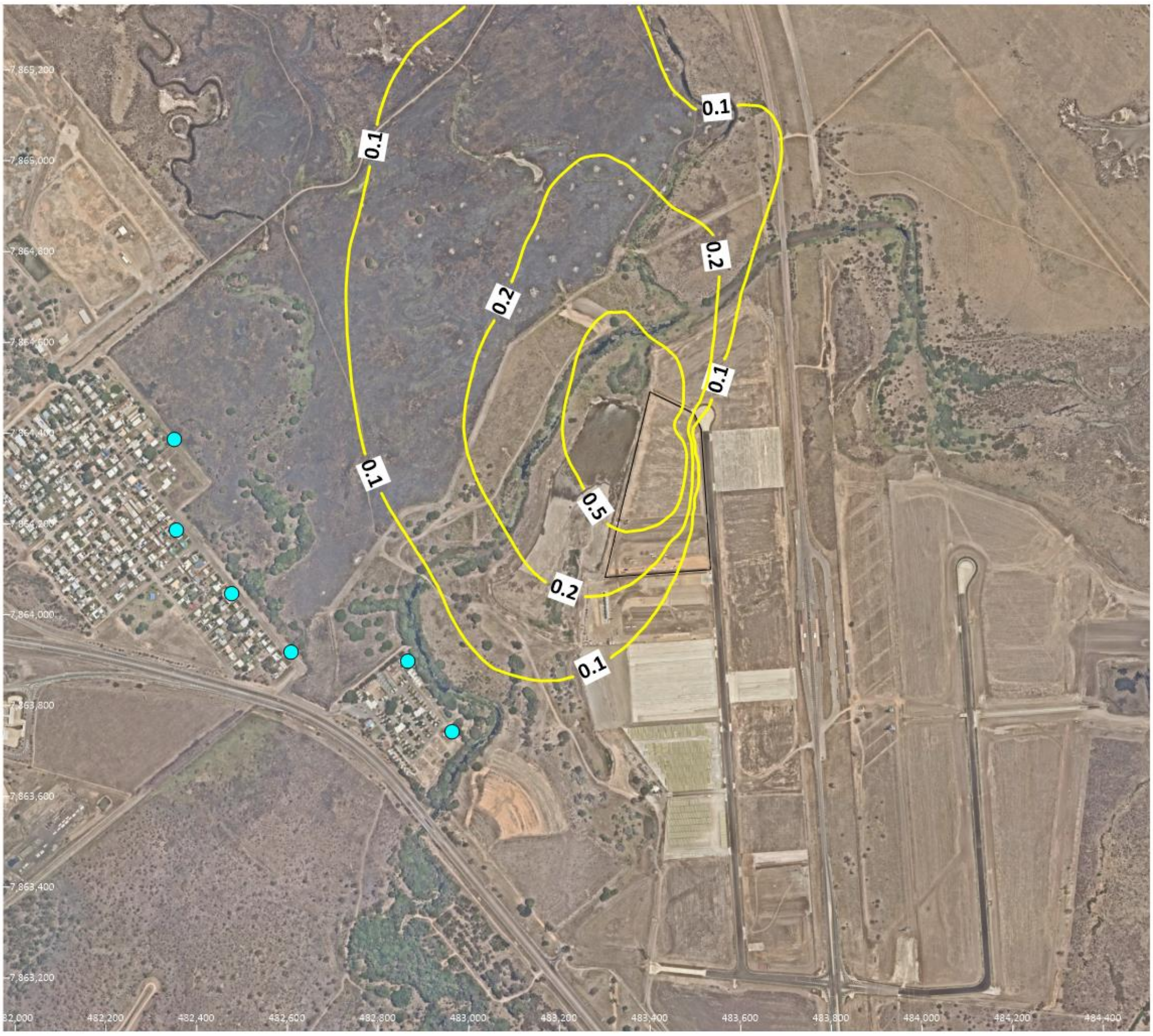
Air Quality Impact Assessment

Incremental Impact

Pollutant	$PM_{2.5}$	Avg Period	24-Hour	Unit	$\mu g/m^3$



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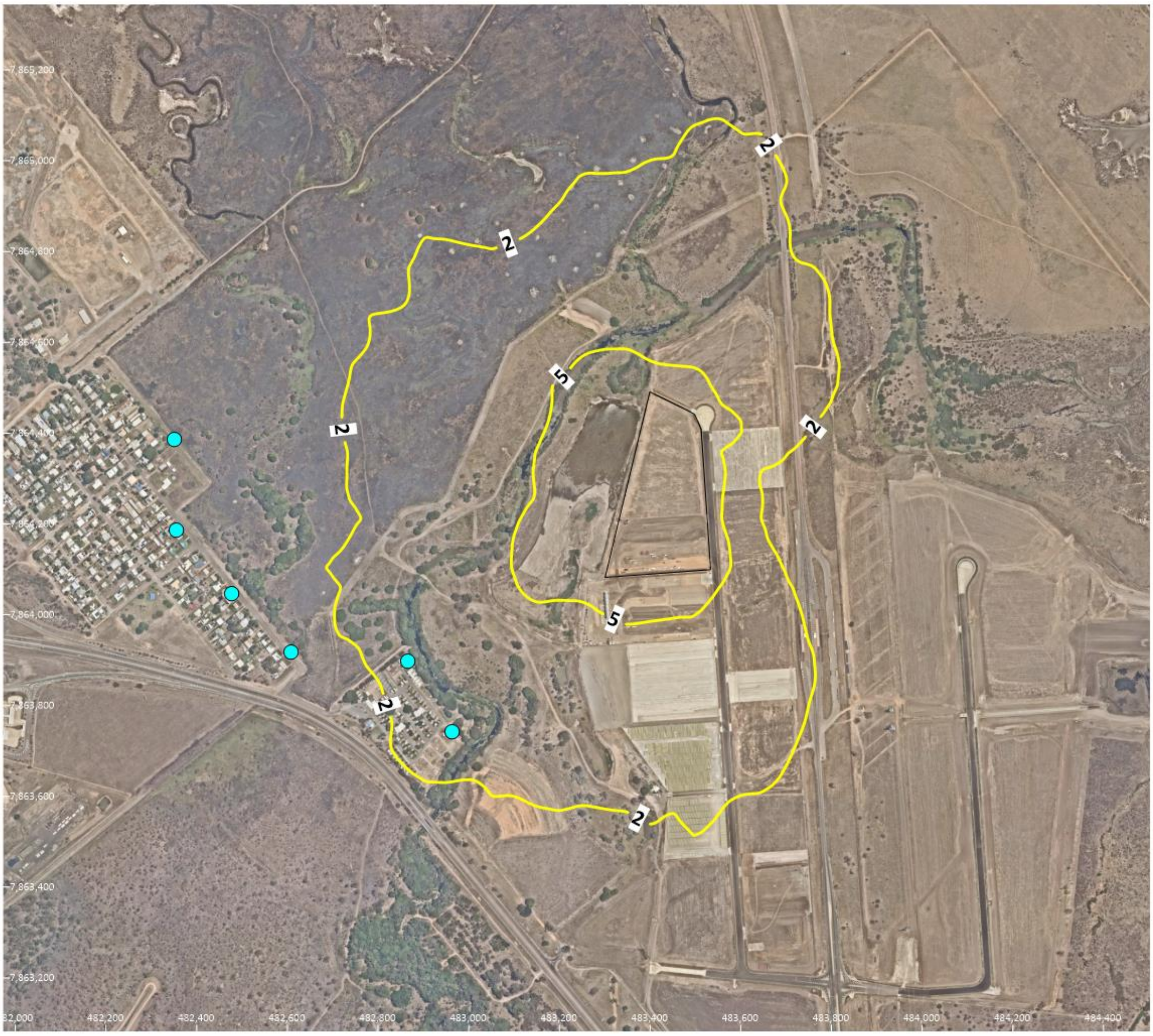
Incremental Impact

Pollutant	NO_2	Avg Period	Annual	Unit	µg/m³



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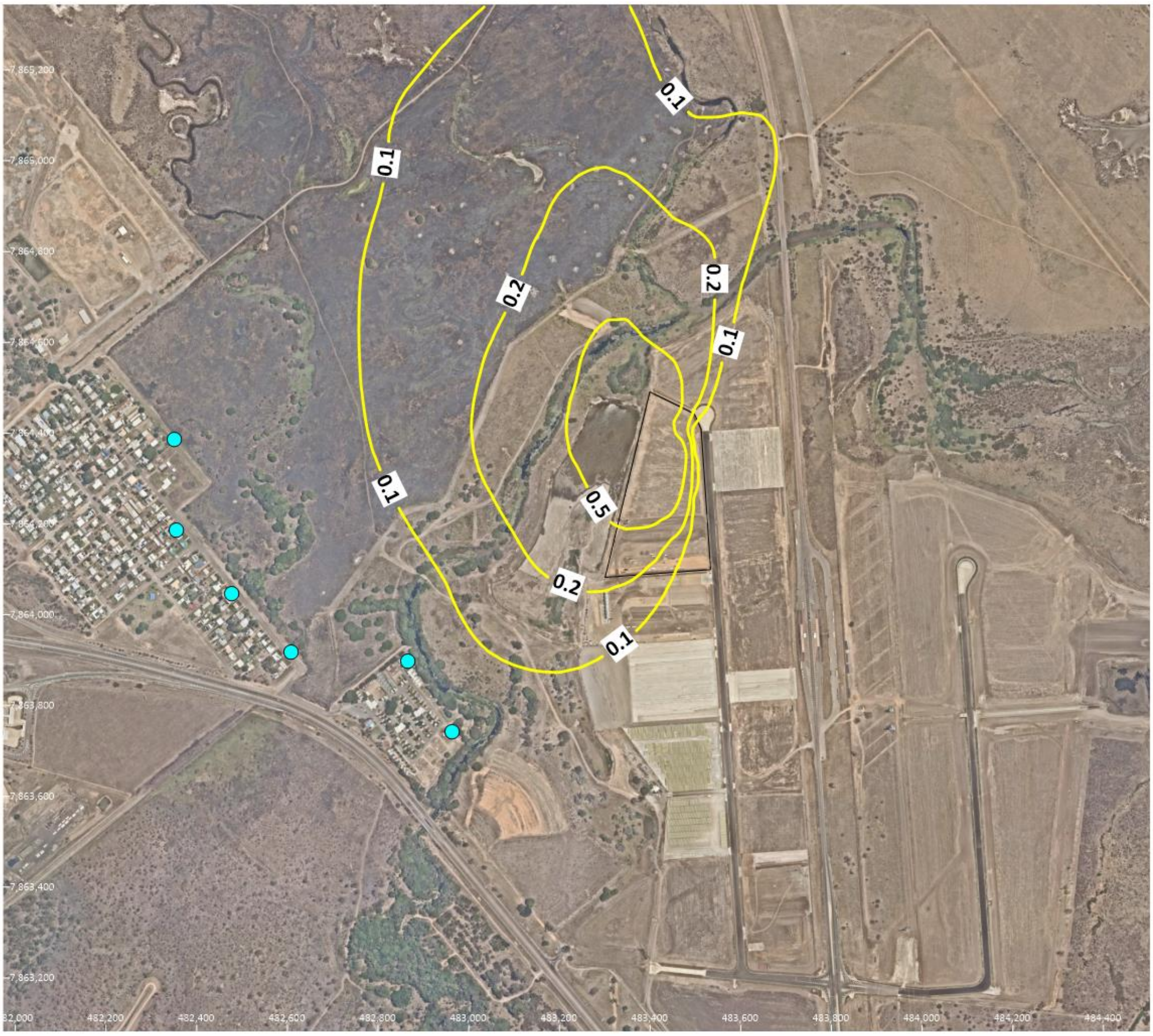
Incremental Impact

Pollutant	NO_2	Avg Period	1-Hour	Unit	$\mu g/m^3$



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N W E S

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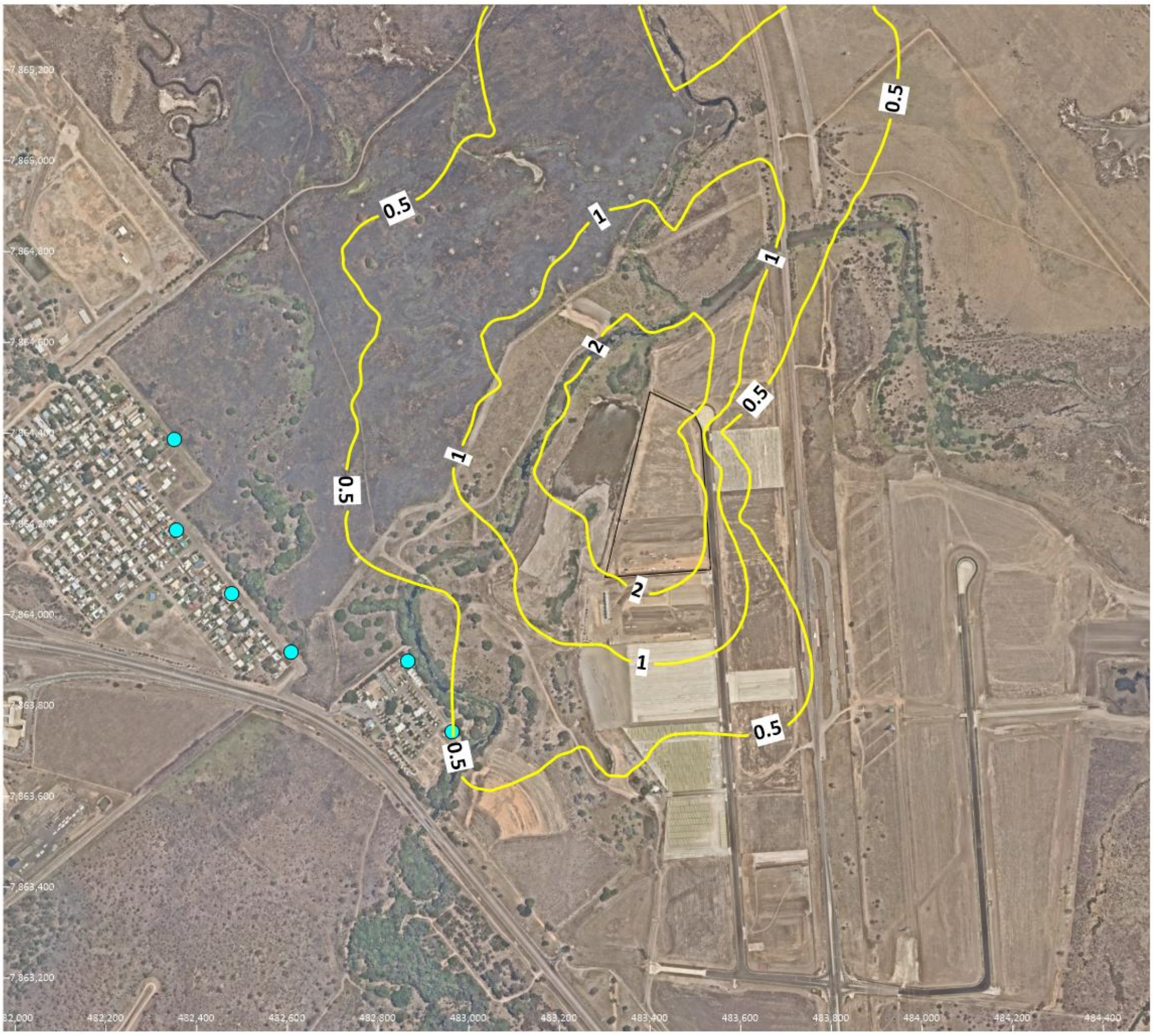
Air Quality Impact Assessment

Incremental Impact

Pollutant	SO_2	Avg Period	Annual	Unit	µg/m³



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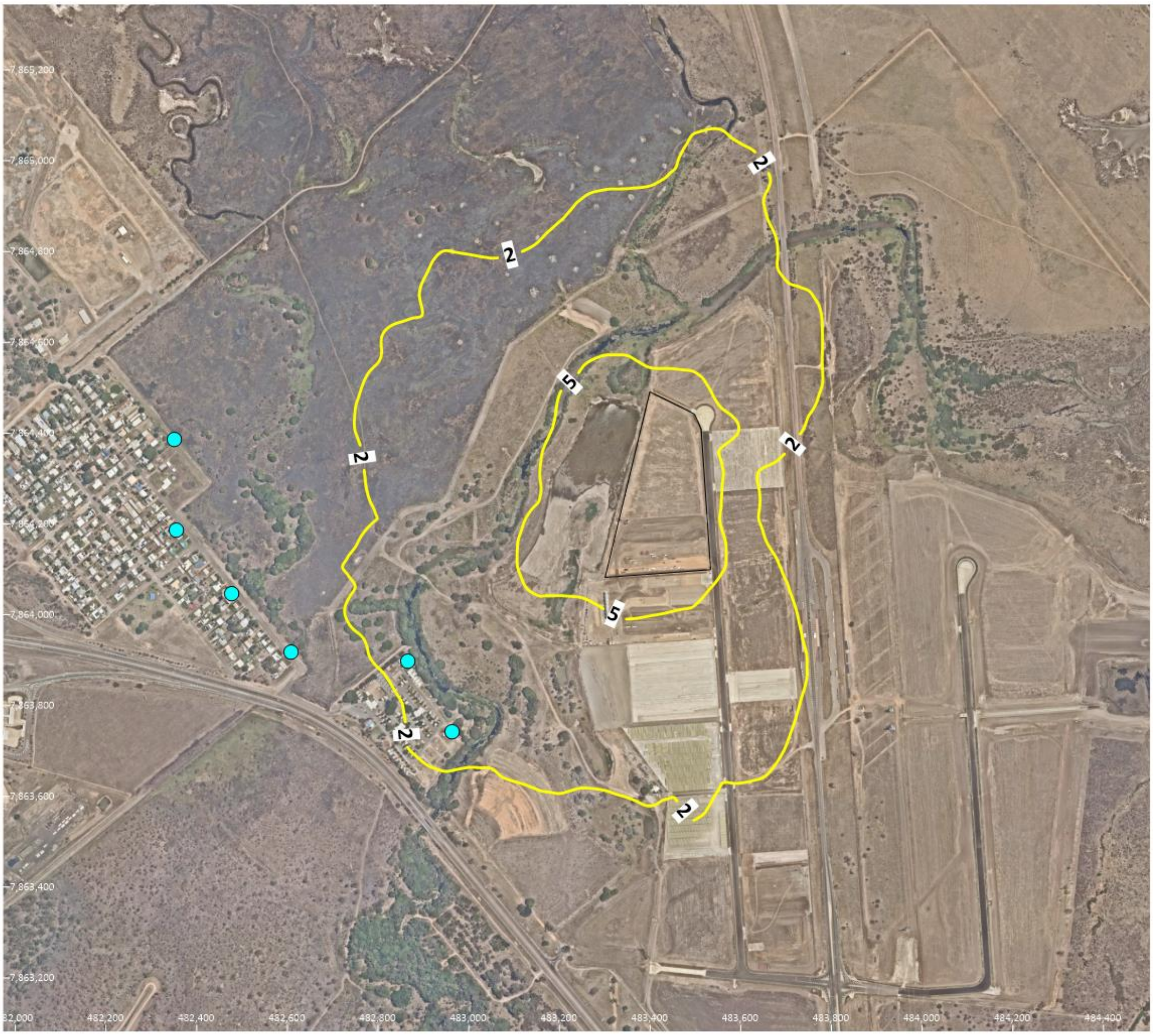
Air Quality Impact Assessment

Incremental Impact

Pollutant	SO_2	Avg Period	24-Hour	Unit	µg/m^3



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Incremental Impact

Pollutant	SO_2	Avg Period	1-Hour	Unit	µg/m³

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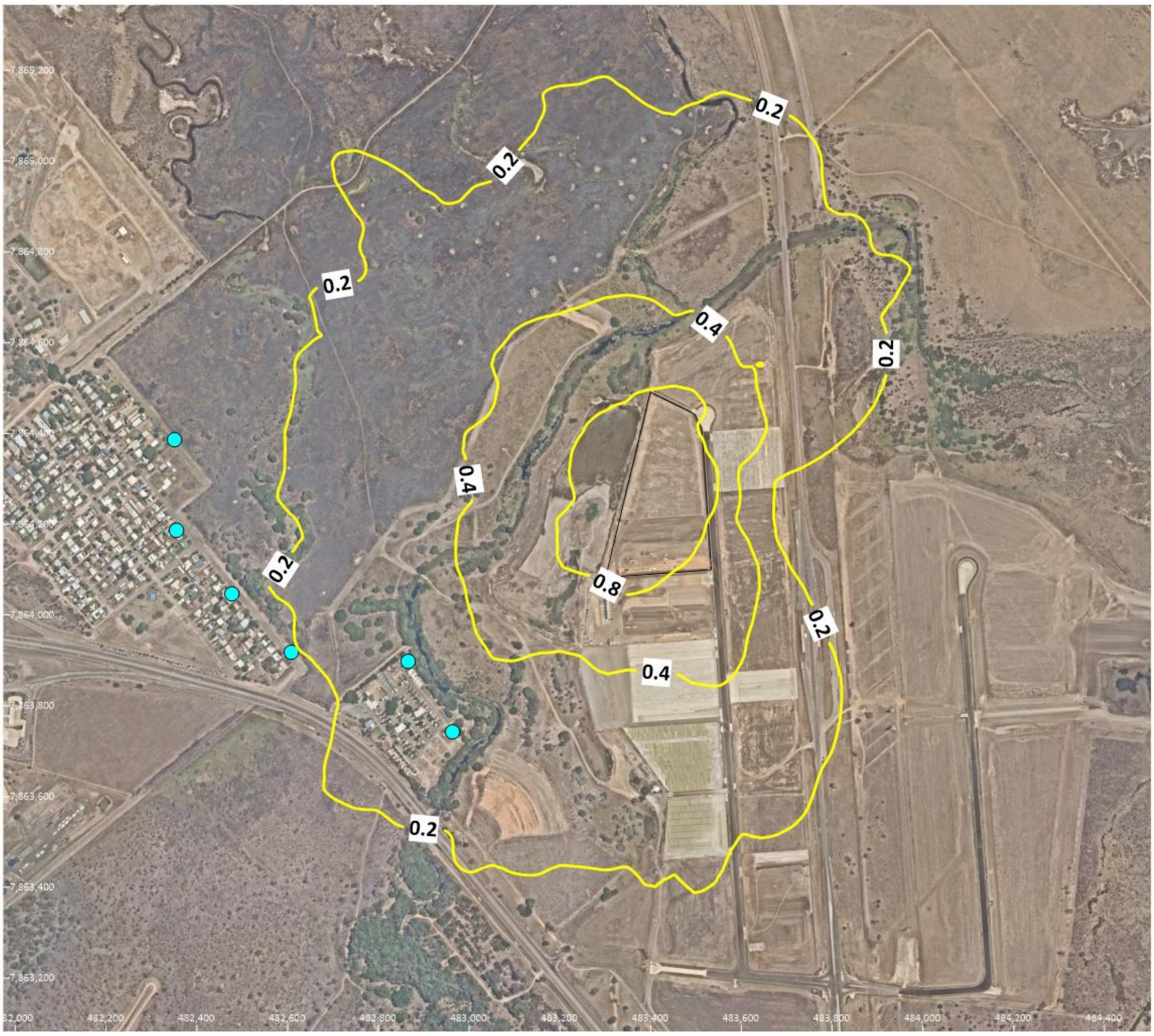

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Air Quality Impact Assessment

Incremental Impact

Pollutant	H_2SO_4	Avg Period	1-Hour	Unit	µg/m³

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