Prepared for
Esso Australia Pty Ltd
ABN: 49 000 018 566

Air Quality Assessment

Hastings Power Generation Project

25-Oct-2021
Hastings Power Generation Project, Victoria

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Client: Esso Australia Pty Ltd

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A	08-Oct-2021	Preliminary draft for Esso review	David Rollings Associate Director - Air Quality	
B	20-Oct-2021	Updated draft incorporating Esso comments	David Rollings Associate Director - Air Quality	
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Abbreviations and glossary of terms

Abbreviation/Term	Definition
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
AECOM	AECOM Australia Pty Ltd
AQM	Air Quality Management
BoM	Bureau of Meteorology
CO	Carbon monoxide
EPA	Environment Protection Authority Victoria
ERS	Environment Reference Standard
g/kWh	Grams per kilowatt hour
g/s	Grams per second
HAP	Hazardous air pollutants
hPa	Hectopascal
IAQM	Institute of Air Quality Management (UK)
Kg/day	Kilogram per day
kW	Kilowatt
m/s	Metres per second
mg/m^3	Milligrams per cubic metre
mm	Millimetres
MW	Megawatt
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
PAH	Polycyclic aromatic hydrocarbon
PM_{10}	Particulate matter 10 micrometres or less in diameter
$PM_{2.5}$	Particulate matter 2.5 micrometres or less in diameter
ppm	Parts per million
SEPP	State Environment Protection Policy
SOx	Oxides of sulfur
SO_2	Sulfur dioxide
TAPM	The Air Pollution Model
t/d	Tonnes per day
TIBL	Thermal Internal Boundary Layer
$\mu g/m^3$	Micrograms per cubic metre
µm	Micrometres
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by Esso Australia Pty Ltd (Esso) to undertake an air quality assessment of emissions from the proposed Hastings Power Generation Project (HGP) (Project).

Gippsland gas currently supplies around 40 per cent of eastern Australia's domestic gas needs through production of oil and gas from Bass Strait.

The Long Island Point Plant (LIP) has an important role in this supply of energy, processing the associated gas liquids from Longford gas production, to create ethane, propane and butane.

Propane and butane is sent to domestic and overseas customers via truck, ship or pipeline, while all ethane from LIP is currently provided as feedstock to a petrochemical manufacturing facility in Melbourne's west.

When the customer is unable to accept the ethane as a result of planned or unplanned maintenance, in most cases, there is a need to either reduce the gas liquids flowing to Long Island Point, reducing the supply of propane and butane to Victoria, or to flare the ethane. In some circumstances, this could even result in the need to significantly curtail natural gas supply to reduce the production of these gas liquids, which would impact the ability of Victorians to heat homes and power businesses.

To improve community and environmental outcomes, Esso have identified an alternative for managing excess ethane that benefits the community and will reduce the need to flare at LIP in the future.

Esso Australia Resources Pty Ltd and BHP Petroleum (Bass Strait) Pty Ltd, the other Gippsland Basin Joint Venture participant, are planning a project to install three small modern, efficient ethane power generation units on a site adjacent to LIP. These will be capable of converting ethane into 35-40 megawatts of electricity to power Victorian homes, while ensuring we can maintain a reliable supply of natural gas and natural gas liquids across the east coast.

The site is owned by Esso is currently being leased for the manufacture of garden supply products such as compost and mulches.

The Project scope can be summarised as:

- Install gas turbine generators on the Esso owned land (inclusive of associated equipment such as fuel gas conditioning skids, instrument air compressors, stacks, etc).
- Install associated equipment rooms and electrical infrastructure to enable power export 66 kV power
- Engage United Energy to install additional electrical infrastructure to enable 66 kV power export from the Evergreen site to the Tyabb Substation
- Install ethane supply piping from the LIP site to the Project site.
- Install facilities so that the new equipment at the Project site can be suitably operated and maintained (e.g. security requirements, crib rooms, offices, etc).
- Modify LIP DMC control systems to minimize operational variability at the generators while ensuring LIP operation/control is not unduly influenced by generator operation.

1.1 Objectives

The objectives of this air quality assessment are to:

- Consider current Victorian, national and international policies and regulations and how they relate to the Project.
- Assess the potential impact of air emissions resulting from operation and construction of the Project in accordance with EPA's *Environmental Reference Standard* and *Guideline for assessing and minimising air pollution in Victoria* (EPA Publication 1961).

1.2 Scope of Works

To deliver the objectives of this assessment, the following tasks were undertaken:

- Defined the existing environment in terms of meteorology and climate, pollutant concentrations and the location of sensitive receptors
- Compilation of an emission inventory for the project;
- Preparation of a five-year meteorological dataset using local meteorological data;
- Preparation of AERMOD atmospheric dispersion models for air emissions;
- Comparison of predicted ground level particulate concentrations to the adopted assessment criteria.

1.3 Project area

Esso Australia Pty Ltd (Esso) operates a gas fractionation plant at Long Island Point near Hastings in Victoria. Long Island Point (LIP) receives liquid petroleum gas (LPG) and crude oil from the Longford Plants, the onshore receiving point for oil and gas from the Bass Strait production facilities. At Long Island Point LPG is processed, stored and distributed to customers by ship, truck and pipeline.

The plant was commissioned in 1970 and contains gas fired heaters, gas turbine compressors, gas fired internal combustion engines, gas flares and other emission sources which give rise to products of combustion emissions and other pollutants.

The Project Area is situated on Long Island Point approximately two kilometres to the east of Hastings, Victoria. The project site would be located adjacent on the North side of Esso LIP Facility. An overview of the Project Area showing the proposed pipeline alignment is shown in Figure 1.

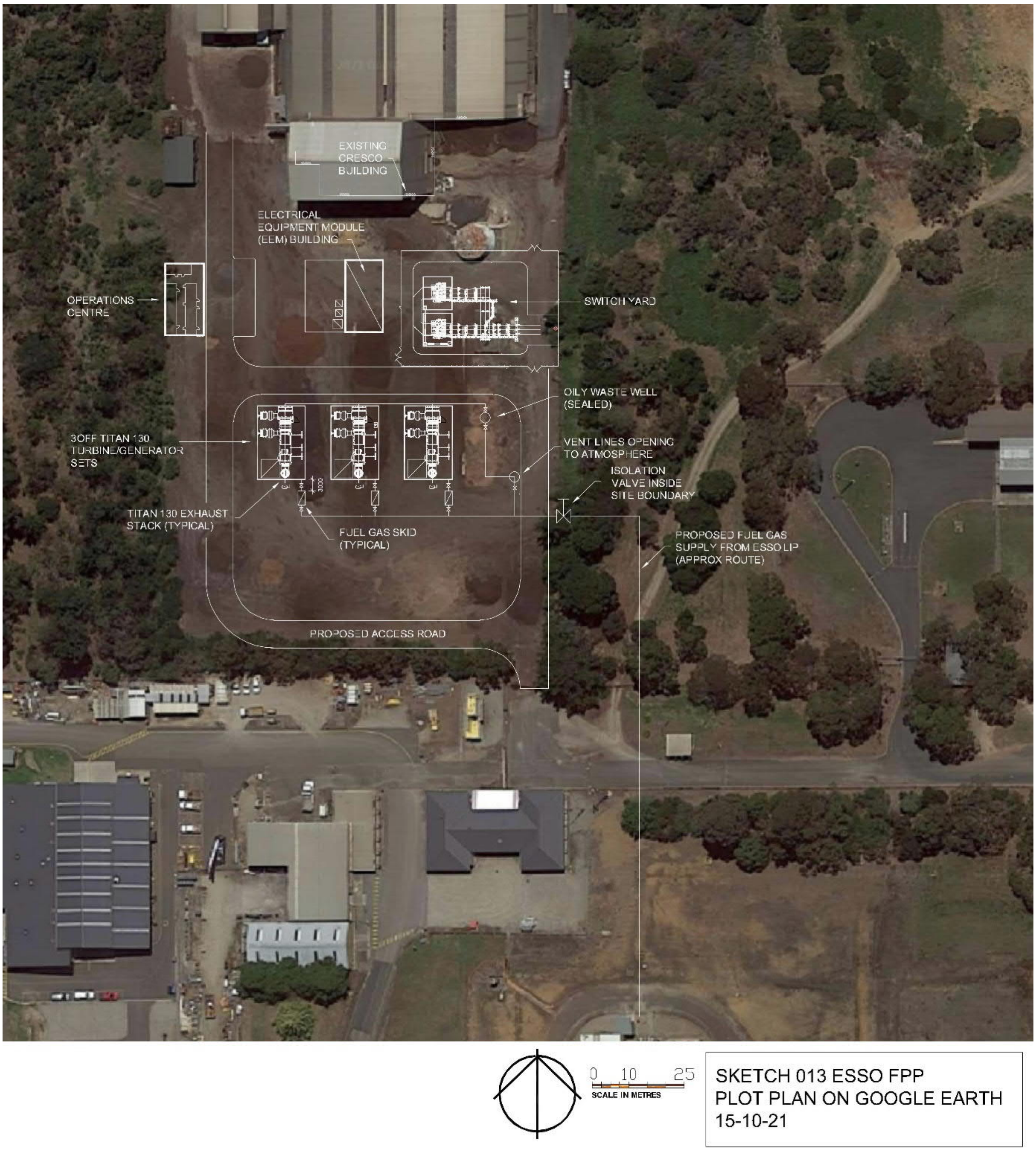


Figure 1: Project overview

1.4 Project activities relevant to the assessment

Potential air quality impacts associated with the project primarily relate to:

- air quality impacts associated with operation of the ethane generators
- particulate emissions from construction activities, which may include mechanically generated dust due to vehicle movements and wind generated particulate matter from disturbed soil or stockpiles
- emissions from diesel fuelled construction vehicles.

1.5 Pollutants of interest

The primary pollutants from the ethane-fuelled generators are expected to be NO_x, CO, SO_2, and to a lesser extent, VOC (USEPA 2000a) and particulate matter (PM_{10} and $PM_{2.5}$). For natural gas fired engines, formaldehyde accounts for about two-thirds of the total Hazardous air pollutants (HAP) emissions (USEPA 2000a). Benzene, PAH, toluene, xylenes, and others account for the remaining one-third of HAP emissions.

The pollutants of interest for the project under operational conditions are expected to consist of the pollutants listed (and explained) in Table 1.

Table 1 Pollutants of interest for the project: operational assessment

Pollutant	Description
Nitrogen dioxide	Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as nitrogen oxides (NO_x). Nitrogen oxides are a product of combustion processes. In urban areas, motor vehicles and industrial combustion processes are the major sources of ambient nitrogen oxides. Nitrogen dioxide can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. Sensitive populations, such as the elderly, children, and people with existing health conditions are most susceptible to the adverse effects of nitrogen dioxide exposure. Nitrogen dioxide can also cause damage to plants, especially in the presence of other pollutants such as ozone and sulfur dioxide. Nitrogen oxides are also primary ingredients in the reactions that lead to photochemical smog formation.
Carbon monoxide	Carbon monoxide (CO) is a colourless, odourless gas produced by the incomplete combustion of fuels containing carbon (e.g. oil, gas, coal and wood). Carbon monoxide is absorbed through the lungs of humans, where it reacts to reduce the blood's oxygen-carrying capacity. In urban areas, motor vehicles account for up to 90% of all CO emissions. Exposure to carbon monoxide can cause carbon monoxide poisoning, which can be attributed to symptoms such as headache, dizziness, weakness, vomiting and confusion. Chronic exposure can cause memory loss, confusion and depression. Acute poisoning is not limited to but can cause cardiac arrhythmia, seizures and death.
Particulate matter	Particulate matter refers to the many types and sizes of particles suspended in the air we breathe. The particle size fractions relevant to combustion emissions are PM_{10} and $PM_{2.5}$. Common sources of PM_{10} include dust from unsealed roads, sea salt, pollen and combustion activities such as motor vehicles and industrial processes. Motor vehicles, power plant emissions and bushfires are all major sources of $PM_{2.5}$. PM_{10} and $PM_{2.5}$ can remain suspended in the air for long periods and can penetrate human lungs. Exposure to particulate matter has been linked to a variety of adverse health effects, including respiratory problems (e.g. coughing, aggravated asthma, chronic bronchitis) and heart attacks.
Sulfur dioxide	Sulfur dioxide (SO_2) is a strong-smelling, colourless gas that can irritate the lungs, and can be particularly harmful for people with asthma. In Victoria, coal-fired power stations are a major source of SO_2 in the air. Smaller sources of SO_2 emissions include industrial processes, locomotives, ships and other vehicles and heavy equipment that burn fuel with a high sulfur content. SO_2 and other sulfur oxides can react with compounds in the atmosphere to form fine particles that reduce visibility (haze).
Volatile Organic Compounds	Volatile organic compounds (VOCs) are chemical compounds based on carbon with a vapour pressure of at least 0.01 kilopascals at 25˚C or having a corresponding volatility under the particular conditions of use. Emissions of VOCs may impact the beneficial uses of the local air environment due to their toxicity, bio-accumulation or odour characteristics. On a regional level, VOCs can be a major contributor to the formation of photochemical smog. The modelling results for VOCs were processed to determine fractions of the highest risk VOCs determined for emissions of benzene and formaldehyde.

Where available, background pollutant concentrations were used for the assessment of potential cumulative impacts (cumulative concentration represented by the project predicted concentrations plus background pollutant concentrations) as described in Section 3.4.

2.0 Legislation, policy and guidelines

Table 2 summarises the key environmental legislation and policy that apply to the project in the context of this air quality impact assessment, as well as the implications for the project and the required approvals (if any).

Table 2: Primary environmental legislation and associated information

Legislation/policy	Description	Implications for the project	Approval required
Commonwealth			
Legislation			
National Environment Protection Council Act 1994 (NEPC Act) – National Environment Protection Measure (Ambient Air Quality) (AAQ NEPM)	The NEPC Act establishes a framework for the preparation of National Environment Protection Measures (NEPMs). The NEPMs are a set of national objectives designed to assist in protecting or managing particular aspects of the environment. The AAQ NEPM sets national standards for the management of air emissions to the environment. It sets intervention levels, indicating levels of which air emissions would begin to be detrimental to human health on a national level.	The AAQ NEPM sets the standard and goals to achieve equivalent population exposure that protects the beneficial uses of the air environment. The assessment of the air emissions from the project will consider the AAQ NEPM for ambient air quality, in conjunction with the ERS and EPA Victoria Guideline for Assessing and Minimising Air Pollution in Victoria (May 2021).	None
State			
Legislation			
Environment Protection Act 2021 (Vic) (Environment Protection Regulations)	Schedule 1 of the Environment Protection Regulations lists activities that require a development and/or operational licence under the EP Act	Activities which exceed air emissions thresholds are included in the list of prescribed development or operating activities. These activities require a development licence and operating licence.	The project is expected to require a development licence and an operating licence.
Policy			
Environment Reference Standard (ERS)	The ERS sets out the environmental values of the ambient air that are sought to be achieved or maintained in Victoria and standards to support those values. The ERS generally adopts the objectives in the AAQ NEPM with some modifications. The ERS also contains other environmental values, indicators and/or objectives that are not in the AAQ NEPM.	EPA must consider the environmental values in the ERS when deciding whether or not to issue development, operating and pilot project licences.	The project is expected to require a development licence and an operating licence.
EPA Victoria Publication 1961 Guideline for Assessing and Minimising Air Pollution in Victoria (EPA 2021b)	Provides a framework and Air Quality Assessment Criteria (AQACs) to assess and control risks associated with air pollution. The guideline addresses potential human health and environmental impacts associated with outdoor air pollution emitted from commercial, industrial, agricultural, transport, mining and extractive activities	Ground level impacts of air emissions (construction and operation) should comply with the air quality standards and objectives provided in Guideline (EPA 2021b).	None

2.1 National Environment Protection (Ambient Air Quality) Measure

The *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) was formed in 1998 under the *National Environment Protection Council Act 1994* (NEPC Act). It was designed to create a nationally consistent framework for monitoring and reporting on common ambient air pollutants. For the purpose of the operational assessment, pollutants of interest are carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and particulate matter with a diameter less than 10 micrometres (PM_{10}). The AAQ NEPM was varied in 2003 to include particulate matter with a diameter of less than 2.5 micrometres ($PM_{2.5}$) and is therefore also considered in this assessment.

The standards in the AAQ NEPM are not intended to be applied as an environmental standard by regulators without consideration of regulatory impacts in their jurisdictions. The Explanatory Statement clarifies this intent of the AAQ NEPM as a standard for reporting representative ambient air quality within an airshed, and not as a regulatory standard. The AAQ NEPM does not constrain a jurisdiction's ability to manage local or regional air quality issues. Therefore, ERS criteria has been adopted for this assessment.

The AAQ NEPM was recently updated (May 2021) with new standards for NO_2 and SO_2 which are based on the latest scientific knowledge on health impacts of these pollutants. It is expected that ERS criteria will be amended to align with the new NO_2 and SO_2 AAQ NEPM standards.

2.2 Environment Protection Act 2017

Air quality in Victoria is managed primarily through the *Environment Protection Act 2017* (EP Act) and associated regulations. The EP Act applies to noise emissions and the air, water and land to protect the environment in Victoria.

The EP Act requires a development licence and operating licence for prescribed permission activities. The *Environment Protection Regulations 2021* classifies activities that discharge or emit to the atmosphere at least 100 kilograms per day of volatile organic compounds (VOC), particulates, SOx (oxides of sulfur) and NO_x (nitrogen oxides) or 500 kilograms per day of CO as permission activities type L01 (General discharges or emissions to the atmosphere).

Based on emissions data provided in Table 3, NO_x and VOC emissions are predicted to exceed the permission activity thresholds when three generators are operating at 100 per cent load.

Consequently, the project would require a development and operating licence for these air emissions. Table 3 compares emissions to the permission activity thresholds in Schedule 1, Item 73 of the regulations.

Table 3 Comparison of project emissions to scheduled premises thresholds

Substance	Operating Scenario	Total emissions		Permission activity threshold (kg/day)	Exceeds Threshold (Yes / No)
		g/s	kg/day		
NOx	Three 13.5MW generators at 100% load	5.2	451	100	**Yes**
CO		3.2	273	500	No
VOC		1.8	157	100	**Yes**
Particulates		0.6	50	100	No
SOx		0.033	3	100	No

2.3 Environmental Reference Standard objectives

The Environment Reference Standard (ERS) sets out the environmental values of the ambient air that are sought to be achieved or maintained in Victoria. Environmental values are the uses, attributes and functions of the environment that Victorians value, such as being able to breathe clean air.

The ERS replaced *State Environment Protection Policy (Air Quality Management)* (SEPP AQM) on 1st July 2021 and generally adopts the objectives in the AAQ NEPM with some modifications. The ERS also contains other environmental values, indicators and/or objectives that are not in the AAQ NEPM.

The indicators and objectives provide a basis for assessment and reporting on environmental conditions in Victoria. Although it is not a compliance standard, the EP Act requires the Authority to consider this ERS when assessing development, operating and pilot project licences. The ERS must also be taken into account by the Minister when recommending the making of regulations and compliance codes and deciding whether to declare an issue of environmental concern.

If not otherwise specified, the environmental values in this ERS apply to the whole of Victoria. ERS Indicators and objectives for the ambient air environment are presented in Table 4.

Table 4 ERS indicators and objectives for the ambient air environment

Pollutant	Objective	Averaging period	Maximum exceedances
Carbon monoxide (max. concentration)	9.0 ppm	8 hours	1 day a year
Nitrogen dioxide (max. concentration)	0.12 ppm	1 hour	1 day a year
	0.03 ppm	1 year	None
Sulfur dioxide (max. concentration)	0.20 ppm	1 hour	1 day a year
	0.08 ppm	1 day	1 day a year
	0.02 ppm	1 year	None
Particulate matter as PM_{10} (max. concentration)	50 µg/m^3	1 day	None
	20 µg/m^3	1 year	None
Particulate matter as $PM_{2.5}$ (max. concentration)	25 µg/m^3	1 day	None
	8 µg/m^3	1 year	None

2.4 Air Quality Assessment Criteria (AQACs)

The EPA Victoria Publication 1961 *Guideline for Assessing and Minimising Air Pollution in Victoria* (EPA 2021b) provides a framework to assess and control risks associated with air pollution. The guideline addresses potential human health and environmental impacts associated with outdoor air pollution emitted from commercial, industrial, agricultural, transport, mining and extractive activities.

Air Quality Assessment Criteria (AQACs) are concentrations of pollutants in air that provide a benchmark to understand potential risks to human health or the environment. They are risk-based concentrations that can help identify when or if an activity is likely to pose an unacceptable risk to the receiving environment.

Exceedance of one or more AQACs indicates that the activity has the potential to pose an unacceptable risk to human health or the environment. This prompts the need either for additional risk controls to be implemented, or for further investigation if there is reason to believe that the inputs used the model were unreasonably conservative.

EPA Victoria recommends that AQACs are reported for:

- the most impacted location at or beyond the boundary of the site
- any sensitive land uses that have been specifically identified.

AQACs with an averaging time less than 24 hours apply at any location at or beyond the boundary of the facility. AQACs with averaging times of 24 hours or greater apply at discrete sensitive locations. This is because acute exposures can plausibly occur in most locations (for example, in a park, along a shopping strip or at a place of work), while longer exposures are more likely at sensitive locations.

The percentiles of the data are reported as follows:

- the 99.9th percentile for averaging times of an hour or less
- the 100th percentile (maximum) for all averaging times greater than an hour.

AQACs are not designed to evaluate risks from highly elevated single exposures of very short duration (in the order of minutes) such as might occur during an incident or emergency. In these instances, alternative assessment criteria should be considered that are designed for that purpose (for example acute exposure guideline levels from the US EPA, or the emergency response planning guidelines from the American National Oceanic and Atmospheric Administration).

2.5 Summary of adopted air quality criteria

For this assessment, predicted ground level concentrations have been compared against the shortest averaging periods provided in the ERS (for criteria air pollutants), AAQ NEPM and the AQACs (for air toxics). Operation will be variable throughout the year meaning hourly and thirty-minute averages are more relevant to this assessment. The indicators and objectives relevant to the project are summarised in Table 5. Note that NO_2 and SO_2 criteria have been adopted from the recently updated AAQ NEPM. It is expected that the new NO_2 and SO_2 criteria will be incorporated into the ERS. Pollutant concentrations are reported in µg/m^3 rather than parts per million (ppm) to reflect the units used in the dispersion model.

Table 5 Adopted criteria for air quality impact assessment

Substance	Reference	Averaging period	Statistic	Adopted criteria[1]	
				ppm	µg/m^3
Nitrogen dioxide (NO_2)	AAQ NEPM (2021)	1 hour	99.9th percentile	0.08	150
		1 year	Maximum	0.015	28
Carbon monoxide (CO)	ERS	8 hours	Maximum	9.0	10,310
Particles as PM_{10}	ERS	1 day	Maximum	-	50
		1 year	Maximum	-	20
Particles as $PM_{2.5}$	ERS	1 day	Maximum	-	25
		1 year	Maximum	-	8
Sulfur dioxide (SO_2)	AAQ NEPM (2021)	1 hour	99.9th percentile	0.10	260
		1 day	Maximum	0.02	50
Benzene	AQACs	1 hour	99.9th percentile	0.18	580
Formaldehyde	AQACs	30 minutes	99.9th percentile	0.08	100

[1] Gas volumes are expressed at 25˚C and at an absolute pressure of one atmosphere (1013 hPa)

2.6 Best practice design

As part of the development licence, best practice would be demonstrated for activities affecting the quality of the environment such as energy use, greenhouse gas emissions, discharges to air, noise emissions, discharge to surface water and solid waste generation. The EPA Victoria Guideline *Demonstrating best practice* (EPA 2017) defines 'best practice' as: '*the best combination of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity*'.

From an air quality perspective, best practice design parameters and emission standards would be applied to ensure emissions would be minimised to the extent practicable. As discussed further in Section 4.2, the candidate generators are Solar Turbines Titan 130 Gas Turbine Set. The use of ethane as a fuel is expected to provide lower pollutant emissions than other fuels. In addition, the candidate generators have low-NO_x emissions technology that is currently the best in class for gas-fired power plants. It is likely that no further major benefits in air quality could be gained by choosing different plant or power source technology.

3.0 Existing conditions

Impacts of air quality are related to the context of the receiving environment and existing conditions. Of particular importance are local topography and land use, location of nearby sensitive receptors, meteorology and background air quality.

3.1 Topography and land use

The terrain in the immediate area surrounding the project location is predominantly flat and approximately 30 kilometres north-east of open waters. A small mountain range, 9 kilometres from Long Island Point, runs north-south on the Mornington Peninsula with elevations up to approximately 200 metres above mean sea level, which may influence the local meteorology and air dispersion. However, topography is not expected to result in poor air dispersion from the site.

Terrain elevations of the model grid are presented in Figure 2.

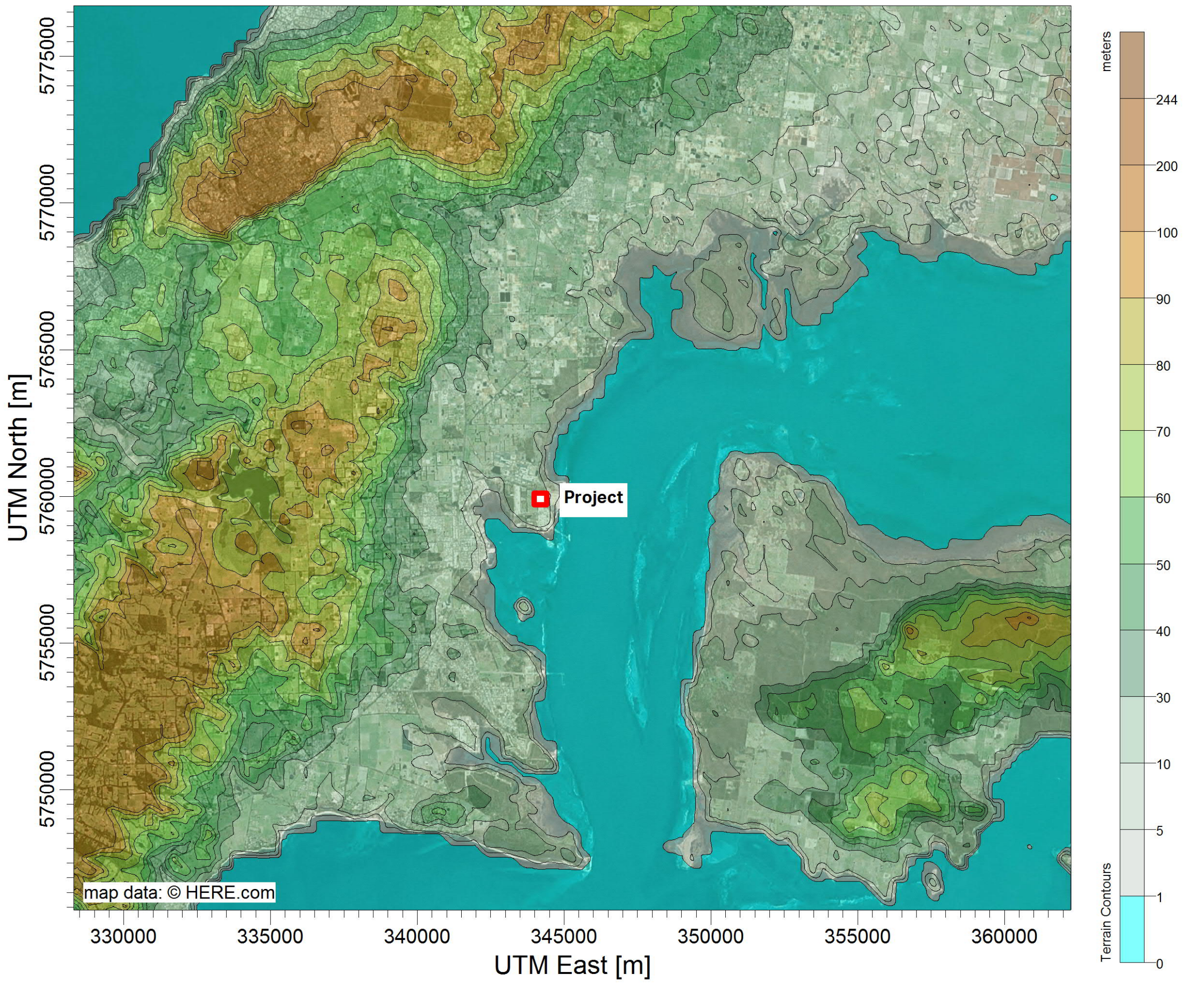
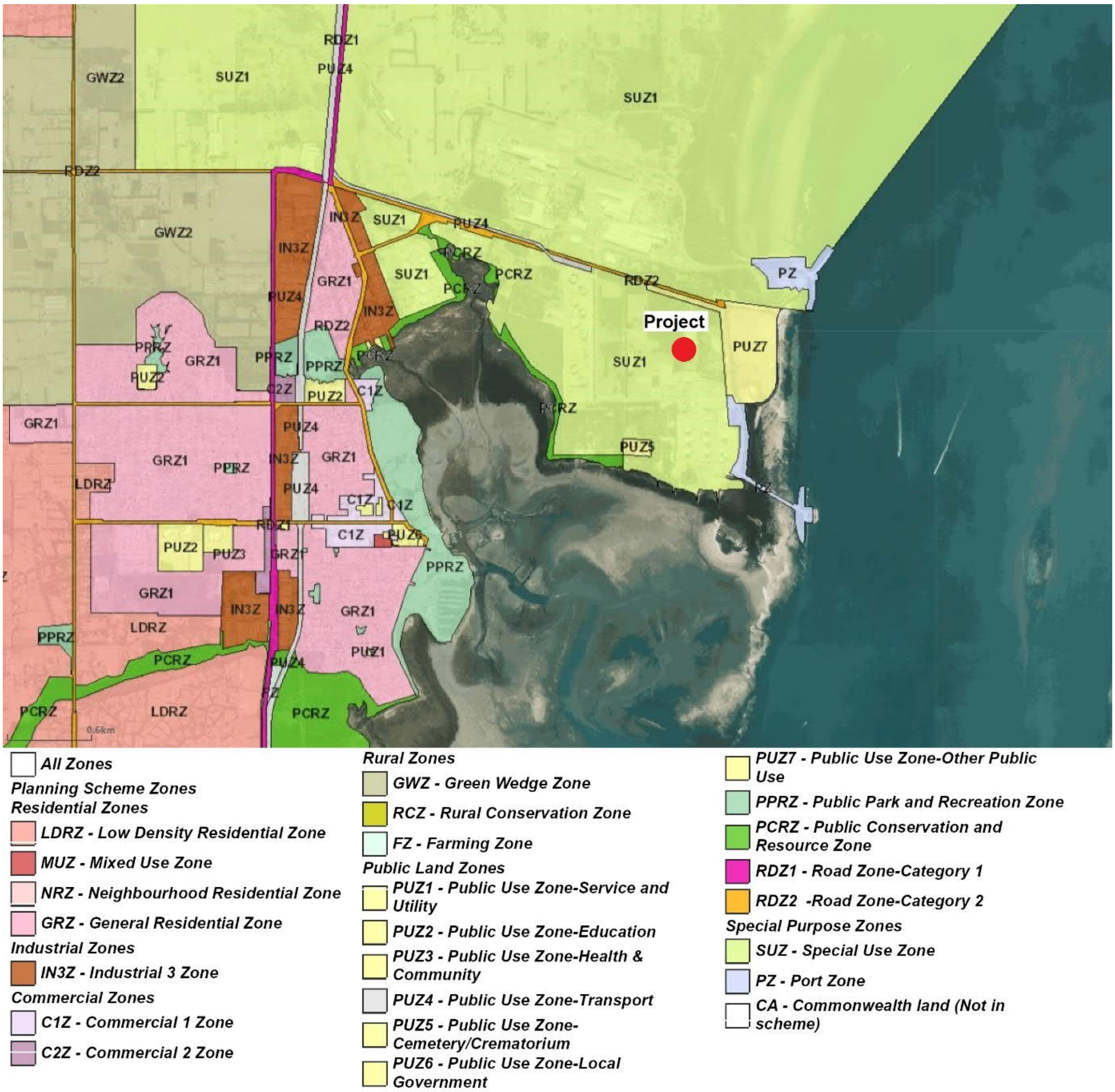


Figure 2 Terrain elevations of model grid

Figure 3 shows the proximity of the site to the various respective zoned lands. The site is surrounded predominately by Special Use Zone 1 and Public Use Zone 7. Other land zones further afield include transport corridors, public use and port.

Hastings Power Generation Project is compatible with its surrounding land uses and has substantial buffer areas separating it from sensitive receptors and land uses.



Adapted from: https://mapshare.vic.gov.au/vicplan/ (accessed September 2021)

Figure 3 Land uses in the vicinity of the project (red circle)

3.2 Sensitive receptors

Receptors in the context of an air quality impact assessment relate to locations where people may be affected by air pollutants emitted from a particular activity. Sensitive receptors are locations where the land use requires “a particular focus on protecting the beneficial uses of the air environment relating to human health and wellbeing, local amenity and aesthetic enjoyment” (EPA 2013). These may include:

- residential buildings
- community buildings
- outdoor recreation and public open spaces
- commercial and industrial buildings.

It is noted that receptors such as public footpaths, playing fields, parks and roads may be in the vicinity of the project. It is expected that human exposure at these locations will be ‘transient’; with people visiting irregularly (a few days per week) and for limited periods of time (less than eight hours). Although there is still a risk of health impacts for short-term exposure to poor air quality, transient receptor sensitivity is expected to be ‘Low’. This air quality impact assessment has therefore focused on sensitive receptors where people are expected to be present at a location regularly for extended periods (more than 8 hours a day), such as residences, hospitals, schools, residential care homes and places of work.

The classification and number of receptors in the vicinity of the project was undertaken using information from site personnel, aerial imagery and land use maps. In addition to the 1,201 gridded receptors (see Figure 9), 4 sensitive receptors and 5 industrial receptors were allocated to predict concentrations at specific locations in the model domain. Modelling results show that pollutant concentrations are greatest near the project and decrease over distance. Therefore, sensitive receptors were chosen based on proximity to the project.

A summary the sensitive and industrial receptors included in the model is provided in Table 6 and Figure 4. The nearest sensitive receptors are located approximately 600 metres to the southeast of the project boundary, and the nearest industrial receptor is located 600 metres to the north of the generator emission points.

Table 6 Summary of sensitive and industrial receptor locations

ID	Classification	Easting	Northing	Description
1	Sensitive	343758	5759223	11 Cemetery Road
2	Sensitive	343696.6	5759299	34 Cemetery Road
3	Sensitive	343621.5	5759054	7 Beach Drive
4	Sensitive	343511.9	5759110	28 Beach Drive
5	Industrial	344358	5760209	Scout Hall and LIP Emergency centre
6	Industrial	344470.2	5760240	Hydrogen Pilot Plant
7	Industrial	344982.1	5760323	Jetty infrastructure
8	Industrial	343613.8	5760465	BlueScope Steel
9	Industrial	343953.7	5760583	BlueScope Steel

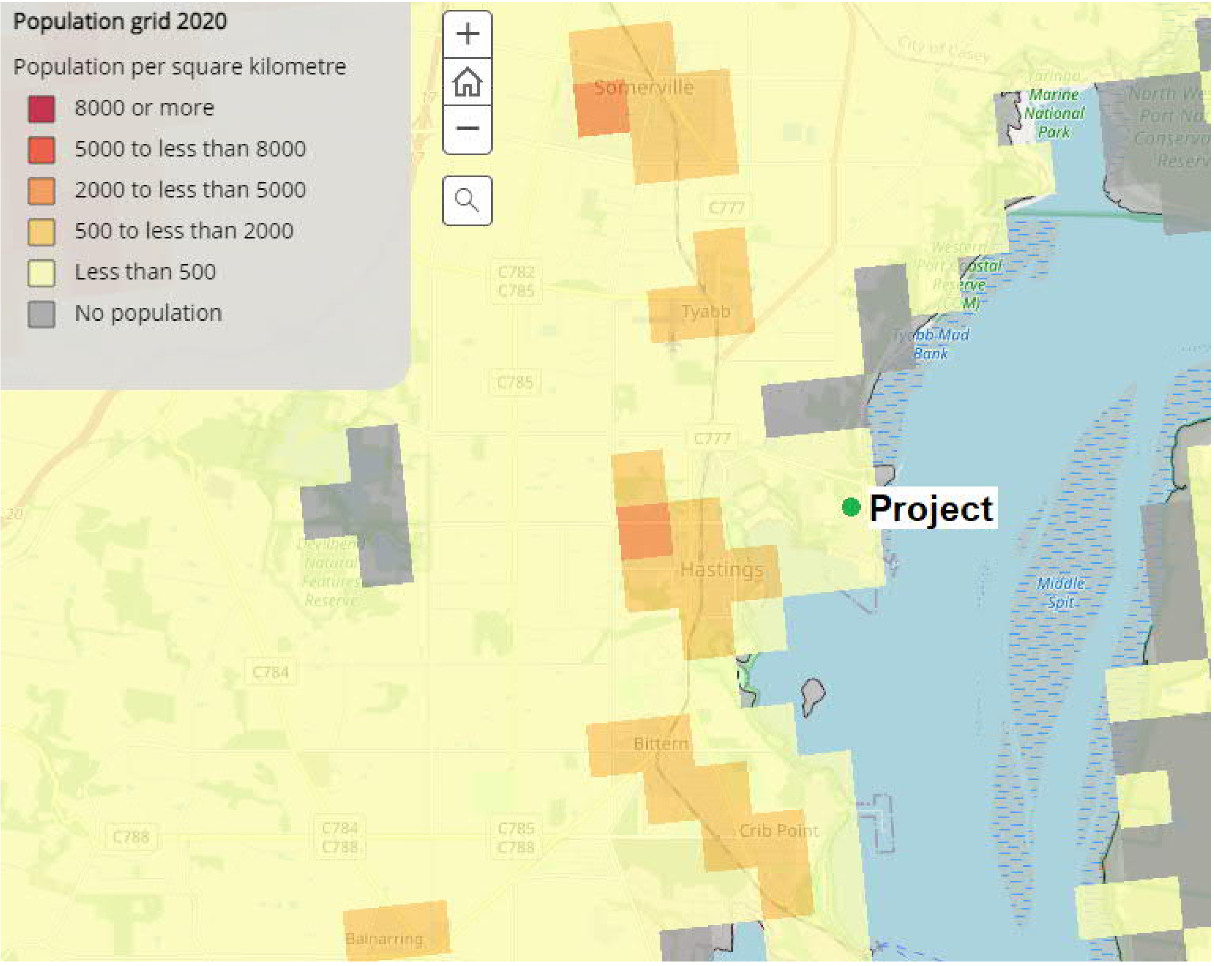
Figure 4 Sensitive receptors locations: operational impact assessment (red square represents project boundary)

3.2.1 Size and vulnerability of nearby population

In addition to the identification of sensitive receptors and land uses, EPA Victoria Guideline 1961 (EPA 2021) recommends that population density and vulnerability be included to provide context for the impacts being assessed. In particular, potential impacts to health from air pollution are related to the location, size and vulnerability of the exposed population.

Australian Bureau of Statistics (ABS) data was accessed to map Figure 5 and Figure 6 which show population density and vulnerability in the vicinity of the project area. An approximate indicator of the vulnerability of a community is the index of relative socio-economic disadvantage (IRSD) for the Statistical Area Level 1 (SA1).

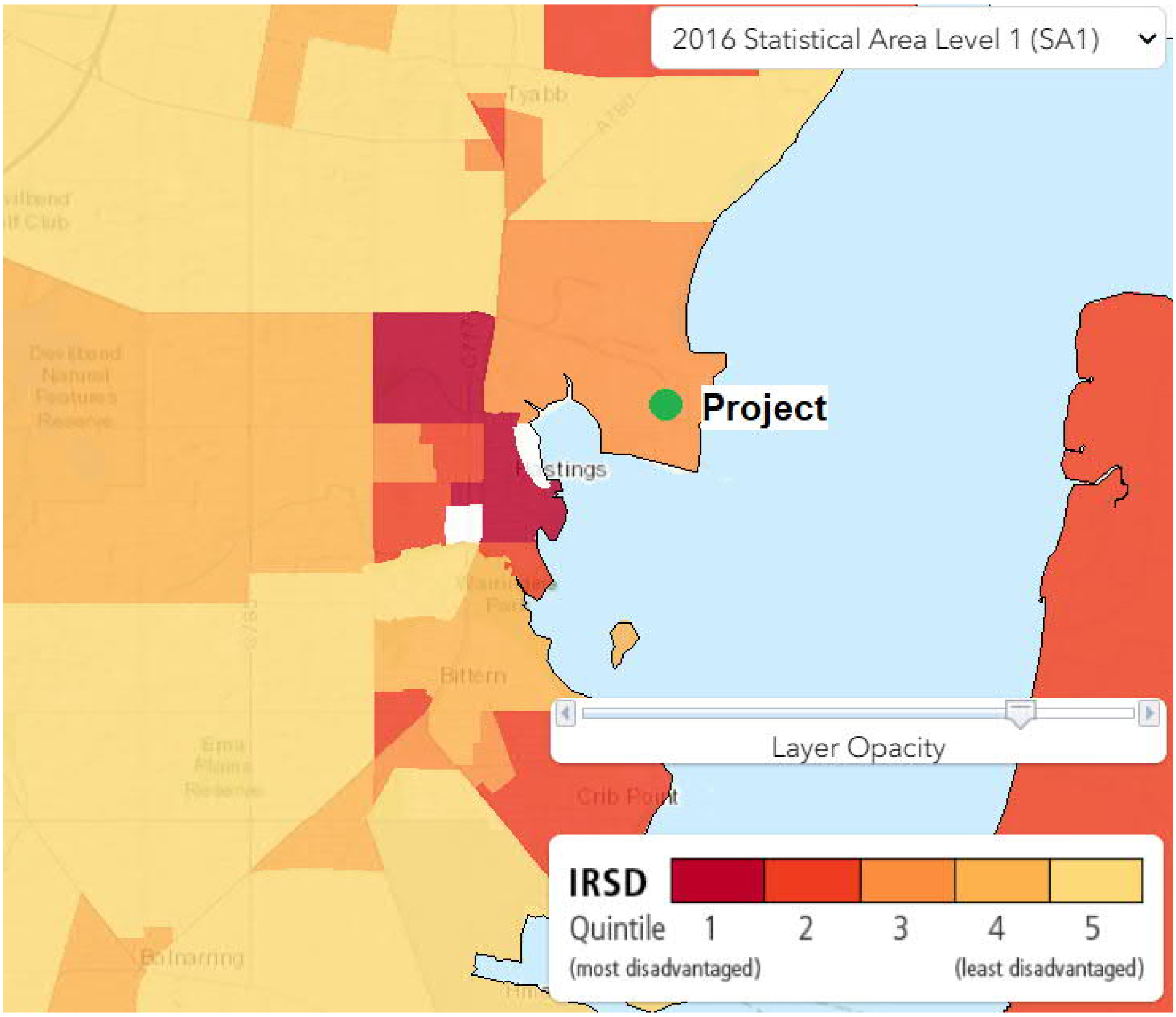
As shown in Figure 5, population density is generally less than 500 per square kilometre in the project area with some areas exceeding 500 people per square kilometre to the west in Hastings.



Adapted from: https://www.abs.gov.au (accessed September 2021)

Figure 5 Population density in the vicinity of the project (green circle)

Figure 6 shows there is a full range of vulnerability near the project area with 'most disadvantaged' areas 3 kilometres to the west (in Hastings) and 'least disadvantaged' areas to the north and north east of the project area. The project is situated in the third quintile for vulnerability.



Adapted from: https://www.abs.gov.au (accessed September 2021)

Figure 6 Population vulnerability in the vicinity of the project (green circle)

ABS information shows that the study area has low population density (generally less than 500 people per square kilometre) with 'most disadvantaged' areas located at least 3 kilometres from the proposed project location.

The combination of low population density and large buffer to vulnerable populations indicates that increased impacts on health from air pollution are unlikely in the study area.

3.3 Meteorology and climate

The closest BoM Station to the project site is located at Cerberus (Station number 086361), approximately ten kilometres to the southwest. Cerberus is situated in similar terrain to the project site and is near enough to provide an indication of wind conditions at the project site. However, there will be some differences due to the distance between the two locations.

Long-term climate data has been recorded at the Cerberus BoM site between 1986 and 2021. Temperature (1991–2021), precipitation (1986–2021), humidity, wind speeds and wind direction (1991–2010) records are summarised in Table 7.

As shown in Table 7, the warmest temperatures occur during the summer months, with the highest mean maximum temperature (25 degrees Celsius) occurring in February. July is the coldest month, with a recorded mean minimum temperature of 6.4 degrees Celsius. The annual mean rainfall is 720 millimetres over 106 days per year. August is the wettest month, with a mean rainfall of 75 millimetres, while February is the driest month with a mean rainfall of 37 millimetres. Humidity follows a diurnal cycle, with higher humidity in the morning compared to the afternoon.

Table 7: BoM climate average statistics at Cerberus station (1986 to 2021)

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C)	24.6	25	23.1	19.9	16.7	14.2	13.7	14.6	16.5	18.7	20.7	22.5	19.2
Mean minimum temperature (°C)	13.9	14.3	12.6	10	8.4	6.7	6.4	6.7	7.6	8.8	10.7	12	9.8
Mean rainfall (mm)	40.0	37.0	44.4	60.6	70.1	72.6	70.5	75.4	67.4	65.3	54.7	53.9	720.2
Decile 5 (median) rainfall (mm)	33.6	30.4	42.0	55.0	66.2	64.6	65.6	71.8	66.0	56.4	41.6	44.2	725.4
Mean number of days of rain ≥ 1 mm	5.1	4.2	6.3	8.3	11.4	11.0	11.5	12.6	11.1	10.2	7.6	6.7	106.0
Mean 9am temperature (°C)	18.3	18.3	16.5	14.7	12.1	9.8	9.2	10.2	12.0	13.8	15.2	16.9	13.9
Mean 9am relative humidity (%)	72	76	79	79	86	86	85	81	77	73	74	72	78
Mean 9am wind speed (km/h)	16.2	14.4	13.1	13.9	12.4	14.1	14.5	16.4	17.9	17.4	15.9	16.6	15.2
Mean 3pm temperature (°C)	22.3	23.0	21.2	18.2	15.4	13.1	12.6	13.5	14.9	16.5	18.5	20.4	17.5
Mean 3pm relative humidity (%)	58	56	57	60	68	72	69	64	63	61	62	59	62
Mean 3pm wind speed (km/h)	22.3	20.9	20.2	17.8	15.9	17.0	17.9	19.6	20.3	20.5	20.6	21.8	19.6
Latitude: 38°36"S Longitude: 145°18"E, Elevation: 13 m, Commenced: 1986 Status: Open, Accessed on: 04 Oct 2021													

Meteorological data for use in the model was sourced from BoM stations at Cerberus, Frankston and Rhyll. A full discussion on the meteorological data used in the modelling, including station location and rationale for inclusion in the modelling is presented in Appendix A.

No meteorological conditions were identified that could negatively impact on pollutant dispersion.

3.4 Background air quality

It is necessary to incorporate the background concentrations of air pollutants as they provide a baseline level, to which the predicted impact of the development can be added, thus producing a cumulative air quality impact that is suitable for comparison against regulatory criteria.

Although the project is located in an area with low population density, it is located adjacent to the Esso LIP facility which contains a number of gas heaters, turbine compressors, internal combustion engines, flares and other emission sources which give rise to products of combustion emissions and other pollutants.

The most recent air quality dispersion modelling of emissions from Esso LIP facility was undertaken in 2011 (NPIplus 2011). Modelling was undertaken to predict absolute worst case emissions from 33 site sources. Modelling demonstrated that absolute worst case NO_2, CO and SO_2 emissions complied with relevant criteria with any exceedances well within the site boundary or over water. Emission inventory data shows that the main sources of combustion gases are located:

- 400m to the south of the project (EPA Discharge points 18,19 ,20 ,21 and 22)
- 800m to the south of project (EPA Discharge points 12,13 and 17).

The distance between these discharge points and relatively small area of dispersion from the project means that short term (less than a day) cumulative impacts are unlikely to occur as winds will generally not blow from each of these plants towards any single receptor. Long term (annual) cumulative impacts may be possible however, modelling shows negligible increases in ground level concentrations attributable to the project (refer to Section 4.5).

Given that there is no site-specific background monitoring data available for this assessment, background concentrations have been adopted from areas which have a greater pollution potential as a function of population and industrial emissions. Whilst this will underpredict the actual scale of cumulative air quality impacts of the proposed project, it is conservative, and appropriate for the purposes of this assessment in demonstrating compliance with regulatory criteria.

The EPA operates air quality monitoring stations in Melbourne, Geelong and the Latrobe Valley. There is no air quality monitoring data available for the Western Port area. However, it is expected that air emissions from all parts of the airshed will be transported around the Port Phillip and Western Port airsheds. Air quality conditions in Western Port are expected to be better than in the metropolitan region given the distances between the majority of Melbourne's main air pollution sources, such as roadways and Long Island Point.

Figure 7 shows the EPA monitoring stations in metropolitan Melbourne, with the nearest to the Project area being in Brighton and Dandenong. However, each station has data limitations and therefore background pollutant data was sourced from several stations. In some instances, this results in the use of data from stations that are not necessarily the closest to the Project area. The monitoring stations, pollutants monitored and site types are summarised in Table 8. EPA operate Brooklyn monitoring station as an issue specific air monitoring station so results are not reported for comparison against the NEPM criteria.

Table 8 EPA monitoring stations, 2019

Station	Location category	Site Type				
		CO	NO_2	SO_2	PM_{10}	$PM_{2.5}$
Alphington	Residential/ light industrial	G*	G*	Pop*	G*	G*
Altona North	Industrial/ residential	-	-	G	-	-
Brighton	Residential	-	G	-	Pop	-
Dandenong	Light industrial	-	-	-	Pop	-
Footscray	Industrial/ residential	-	G*	-	G*	G*
Geelong South	Light industrial/ residential	G*	G*	G*	G*	G*
Melton	Residential	-	-	-	-	-
Mooroolbark	Residential	-	-	-	Pop	-
Point Cook	Rural/ residential		Pop*	G*		

Note: * Trend station operated in the same location for one or more decade(s)

G - performance monitoring stations sited to monitor the upper bound pollutant concentrations likely to be experienced by portions of the population, while avoiding the direct impacts of localised pollutant sources.

Pop - Population-average stations sited to ensure adequate monitoring of large portions of the populated area and of the total population within a region

- No Data

Given the limitations of EPA monitoring stations and the potential emission sources from Esso LIP facility, background data has been sourced from the following sites:

- 1 hour and annual NO_2 data was sourced from Geelong
- 8 hour CO data was sourced from Alphington
- 1 hour SO_2 data was sourced from Alphington and Geelong
- 24 hour PM_{10} data was sourced from Dandenong
- Annual PM_{10} data was sourced from Geelong
- 24 hour and annual $PM_{2.5}$ data was sourced from Alphington

Background concentrations measured by the EPA are expected to be generally higher than those near the project location and reported 70th percentiles are calculated from daily maximums, rather than from a year's observed hourly concentrations (as required in the SEPP (AQM)). Therefore, the background data used in this assessment is considered very conservative.

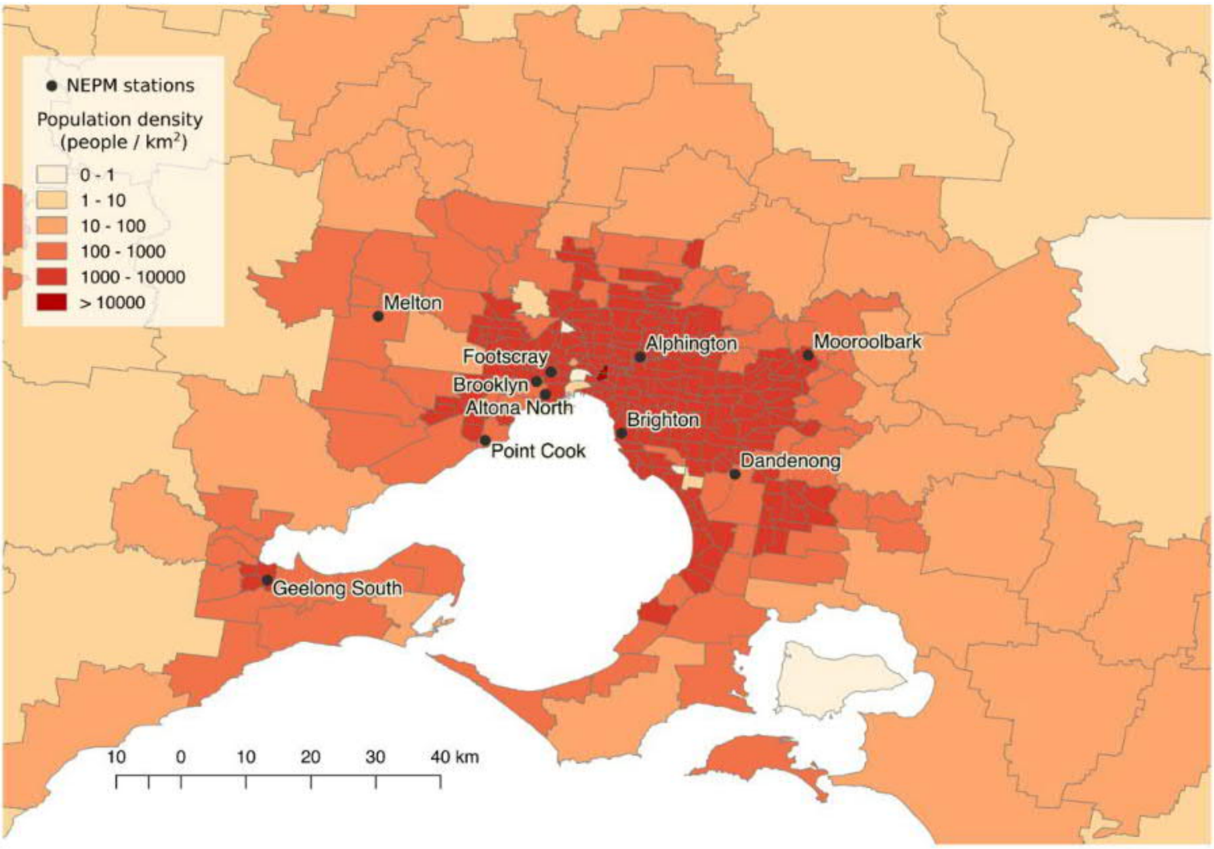


Figure 7 EPA monitoring stations and population density in Port Phillip region (EPA Victoria, 2017)

The EPA releases annual compliance monitoring reports that summarise the most recent several years results for various pollutants. The most recent report, used to gain the Project background data, is as follows:

- *Air monitoring report 2019 – Compliance with the National Environment Protection (Ambient Air Quality) Measure* (EPA, 2020c).

The *Air Monitoring Report 2019* (EPA, 2020c) summary includes provision of various percentile values, of which the required background 70th percentile under the ERS (formerly SEPP (AQM)) is one. Particulates are presented as 24-hour averages, while CO is presented as an eight-hour average, as the purpose of the reporting is to compare against the NEPM criteria, which are in these average periods. As such, the shorter one-hour average time required for comparison against the ERS (formerly SEPP (AQM)) has been calculated using the power law provided in EPA (2013a). Should the results approach the criteria then the use of the calculated data may be revisited. The highest value from the previous five years has been applied in the assessment as the background value. The relevant one-hour, 24-hour or eight-hour 70th percentile values are provided in Table 9 to Table 11.

Table 9 Measured background air pollutant concentrations, 1 hour NO_2 (ppm)

Year	70th percentile concentrations, 1 hour NO_2 (ppm)	
	Alphington	Geelong*
2015	0.025	0.020
2016	0.023	0.021
2017	0.027	**0.021**
2018	0.026	0.019
2019	0.025	0.021

Note * Geelong data used for background as Alphington NO_2 (50 µg/m^3) was considered unrealistic for the project site

Table 10 Measured background air pollutant concentrations, 8 hour CO (ppm)

Year	70th percentile concentrations, 8 hour CO (ppm)	
	Alphington	Geelong
2015	**0.5**	0.2
2016	0.5	0.3
2017	0.4	0.3
2018	0.4	0.3
2019	0.36	0.23

- No Data

Table 11 Measured background air pollutant concentrations, 1 hour SO_2 (ppm)

Year	70th Percentile Concentrations, 1 hour SO_2 (ppm)	
	Alphington	Geelong
2015	**0.003**	**0.003**
2016	0.002	0.002
2017	0.001	0.001
2018	0.002	0.002
2019	0.002	0.002

Table 12 Measured background air pollutant concentrations, 24 hour PM_{10} (µg/m^3)

Year	70th percentile concentrations, 24 hour PM_{10} (µg/m^3)	
	Alphington	Dandenong
2015	20.0	22.6
2016	20.3	20.0
2017	20.0	22.8
2018	22.5	**24.1**
2019	22.87	23.97

Table 13 Measured background air pollutant concentrations, 24 hour $PM_{2.5}$ (µg/m^3)

Year	70th Percentile Concentrations, 24 hour $PM_{2.5}$ (µg/m^3)	
	Alphington	Geelong
2015	10.0	-
2016	8.6	6.8
2017	**10.2**	8.5
2018	8.8	7.7
2019	9.27	7.56

Table 14 Maximum annual average background values EPA

Year	Annual Average Percentile concentration					
	NO_2 (ppm)		PM_{10} (µg/m^3)		$PM_{2.5}$ (µg/m^3)*	
	Concentration	Station	Concentration	Station	Concentration	Station
2015	**0.006**	Geelong	**19.9**	Geelong	6.9	Alphington
2016	0.006	Geelong	18.6	Geelong	7.4	Alphington
2017	0.006	Geelong	15.0	Alphington	**7.9**	Alphington
2018	0.006	Geelong	19.5	Geelong	7.6	Alphington
2019	0.006	Geelong	19.65	Geelong	6.95	Alphington

* Partisol method (manual sample once every three days)
- No Data

3.4.1 Summary of Adopted Background Pollutant Concentrations

A summary of the adopted background pollutant concentrations for the project are presented in Table 15. The concentrations adopted for the project are considered conservative. The background pollutant concentration for any given hour or day during operation of the project is likely to be much lower than those presented here. As such the addition of these to incremental project emissions can be viewed as a worst case and quite unlikely to occur.

Table 15 Adopted Project background concentrations

Pollutant	Averaging Period	Adopted Background Pollutant Concentrations	
		ppm	µg/m^{3*}
NO_2	1 hour	0.021	39.5
	Annual	0.006	11.3
CO	8 hour	0.5	570
PM_{10}	24 hour	-	24.1
	Annual	-	19.9
$PM_{2.5}$	24 hour	-	10.2
	Annual	-	7.9
SO_2	1 hour	0.003	7.9

* Gas volumes are expressed at 25˚C and at an absolute pressure of one atmosphere (1013 hPa)

4.0 Operation impacts

The following tasks were undertaken to assess the impact on air quality from project operation:

- identification of an expected worst case operational scenario for modelling
- compilation of an emissions inventory for the project
- selection of a dispersion model for use in the impact assessment
- preparation of AERMOD atmospheric dispersion model for project emissions
- comparison of predicted ground level pollutant concentrations to the adopted air quality criteria

Details on the above tasks are provided in the following sections.

4.1 Operating scenarios

Dispersion modelling assessments require a range of data to be used to try to best represent the actual operational conditions expected for a facility. To ensure this air quality assessment is as conservative as possible, a worst case operating scenario was chosen. The worst case scenario is described as follows:

- Continuous operation of three ethane fuelled generators a peak (100%) load.

Indicative NOx, CO, SO_2, Particulate and VOC pollutant emission factors were provided by Solar Turbines based on a 13.5MW generator burning sales gas or sour gas. SO_2 emissions are only expected for the sour gas scenario when the LIP amine plant is not operational.

Stack emission parameters were provided by Esso. NOx emissions rates were modelled at normal operation of 25ppm and during periods of transient flow the turbine pilot will be operational and NOx emissions may reach 100ppm. This will occur during commissioning.

To assess cumulative results of existing LIP facility and the proposed project, LIP emissions were modelled based on data from a previous dispersion modelling assessment (NPIplus 2011) with emission sources updated by Esso to reflect current site operations.

4.2 Air emissions inventory

In order to estimate pollutant dispersion in the atmosphere, dispersion models require a characterisation of emission properties at the point of release. This section provides a summary of the source configurations applied within the dispersion modelling.

A summary of the physical stack emission parameters for each point source modelled for the project and LIP facility is provided in Table 16 and Table 17, respectively. An aerial image showing emission locations is provided in Figure 8.

LIP emission sources were limited to combustion emissions from point sources as they have a potential to cause cumulative impacts with the projects three new generators. VOC emissions for LIP sources (such as storage tanks and vent DP29) were therefore excluded from this assessment. No particulate emission data was available for LIP emission sources. As discussed in Section 4.5.4, the potential impacts of Particulate and VOC emissions from the project are negligible.

Table 16 Modelled point source emission parameters, Hastings Power Generation Project

Point	Description	Easting (mE MGA94)	Northing (mS MGA94)	Stack Height (m)	Stack Diameter (m)	Velocity (m/s)	Temp. (˚C)	Emission Rate (g/s)*[1]				
								NOx	CO	PM_{10}	SOx*[2]	VOC
Hasting power generation Project Emissions												
HGP1	Generator 1 (13.5MW)	344,170	5,759,719	11	1.83	40.0	494	1.74 @ 25ppm 6.96 @ 100ppm	1.052	0.194	0.011	0.607
HGP2	Generator 2 (13.5MW)	344,190	5,759,719	11	1.83	40.0	494	1.74 @ 25ppm 6.96 @ 100ppm	1.052	0.194	0.011	0.607
HGP3	Generator 3 (13.5MW)	344,210	5,759,719	11	1.83	40.0	494	1.74 @ 25ppm 6.96 @ 100ppm	1.052	0.194	0.011	0.607

*[1] From Solar Turbine design specification – see Appendix B.

*[2] SOx emissions are only expected for the sour gas scenario when the LIP amine plant is not operational.

Table 17 Modelled point source emission parameters, Long Island Point Facility

Point	Description	Easting (mE MGA94)	Northing (mS MGA94)	Stack Height (m)	Stack Diameter (m)	Velocity (m/s)	Temp (˚C)	Emission Rate (g/s)		
								NOx	CO	SOx
Long Island Point Emissions										
DP1	Fired Heater	344,186	5,759,337	24	1.32	10.1	526	0.373	0.011	0.003
DP2	Fired Heater	344,186	5,759,330	24	1.32	10.1	526	0.373	0.011	0.003
DP3	Fired Heater	344,178	5,759,337	24	1.32	10.1	526	0.373	0.011	0.003
DP4	Fired Heater	344,178	5,759,330	24	1.32	10.1	526	0.373	0.011	0.003
DP5	Fired Heater	344,170	5,759,337	15	1.22	9.5	434	0.463	0.031	0.014
DP6	Fired Heater	344,170	5,759,330	15	1.22	9.5	434	0.463	0.031	0.014
DP7	Fired Heater	343,433	5,759,474	17	1.3	4.8	380	0.147	0.333	0.001
DP8	Fired Heater	343,442	5,759,474	17	1.3	4.8	380	Out of service		
DP12	High Pressure Flare	344,280	5,758,787	27	0.76	5	500	0.434	8.086	1.158

Point	Description	Easting (mE MGA94)	Northing (mS MGA94)	Stack Height (m)	Stack Diameter (m)	Velocity (m/s)	Temp (˚C)	Emission Rate (g/s)		
								NOx	CO	SOx
DP13	High Pressure Flare	344,432	5,758,777	27	0.76	5	500	0.434	8.086	1.158
DP14	Low Pressure Flare	344,176	5,758,920	0	0.61	1	1000	0.003	0.030	0.008
DP15	Fired Heater	344,233	5,759,495	20	1.5	8.9	551	0.608	0.026	0.020
DP16	Fired Heater	344,233	5,759,488	20	1.5	8.9	551	0.608	0.026	0.020
DP17	MEA Incinerator	344,308	5,758,927	31	1.08	9.9	760	0.050	0.015	0.138
*DP18**	*Reciprocating Engine*	*344,360*	*5,759,306*	*10*	*0.29*	*36.3*	*483*	*4.667*	*0.240*	*0.002*
DP19	Reciprocating Engine	344,350	5,759,306	10	0.29	36.3	483	Out of service		
DP20	Reciprocating Engine	344,340	5,759,306	10	0.29	36.3	483	4.667	0.240	0.002
DP21	Reciprocating Engine	344,330	5,759,306	10	0.33	39.4	484	4.250	4.735	0.004
DP22	Reciprocating Engine	344,320	5,759,306	10	0.33	39.4	484	4.250	4.735	0.004
DP23	Gas Turbine	344,260	5,759,553	10	0.62	42.4	419	0.350	0.241	0.001
DP24	Gas Turbine	344,260	5,759,559	10	0.62	42.4	419	0.350	0.241	0.001
DP25	Gas Turbine	343,310	5,759,513	10	0.61	36.3	400	0.098	0.500	0.000
DP26	Gas Turbine	343,317	5,759,512	10	0.61	36.3	400	0.098	0.500	0.000
DP27	Gas Turbine	343,331	5,759,514	10	1	36	400	0.098	0.500	0.000
DP28	TEG Vent	344,322	5,759,416	20	0	5	55.3	0.000	0.000	0.000

Note * Three reciprocating engines typically operate at any one time, DP18 excluded from modelling

Figure 8 Location of are discharge points at LIP and the project (HGP)

4.3 Air dispersion model

The AERMOD (V21112)[1] dispersion modelling package has been used for this assessment. AERMOD is a Gaussian plume dispersion model, designed to predict ground level concentrations or the deposition of pollutants emitted from one or more sources, and is endorsed by EPA Victoria as the regulatory model for use in air quality assessments in Victoria, as per the draft guideline document (EPA 2014b) *Guidance notes for using the regulatory air pollution model AERMOD in Victoria* [Publication 1551].

It is noted that there are conditions in which alternative modelling approaches may be required in Victoria. These conditions are '*Complex geographical locations whereby factors such as: terrain, coastal and land-use influences; in combination with the spatial scale of the impact zone of the sources; require the use of fully 3-dimensional meteorological fields'* (EPA 2014b). The project is situated in a coastal setting, which triggers the consideration of whether AERMOD should be utilised. The concern in relation to coastal environments relates to the potential for a plume, released from a tall stack within a stable (or neutral) onshore breeze, to be entrained into the growing thermal internal boundary layer (TIBL) that forms over land. The plume is subsequently mixed to the ground by convective turbulence which may result in higher ground level concentrations downwind of the boundary layer. AERMOD does not currently take into account the development of a TIBL or the plume interaction with a TIBL. The formation of the internal boundary layer close to Long Island Point is unlikely due to turbulence generated by the French Island landmass five kilometres to the east. In addition, the proposed stack heights are approximately 11 metres (stack heights above 65m are more likely to interact with a TIBL).

On this basis, the AERMOD model is considered acceptable to use for this application.

4.3.1 AERMOD model settings

To run the model, a range of information is required including meteorological data, emission source locations, pollutant emission rates, emission source characteristics (e.g. source release heights, ambient temperatures and source dimensions), and dimensions of buildings that may cause building downwash. Default model options have been selected except for those noted within the following sections.

A summary of the AERMOD model settings are presented in Table 18.

Table 18 AERMOD model settings

Modelling parameter	Input
AERMOD version	Version 21112, 22/04/2021
Terrain data	Terrain elevations were extracted from the NASA Shuttle Radar Topography Mission data set (SRTM 30 metre).
Hours modelled	43,848 hours (1,827 days)
Meteorological data	Surface File: BoM Cerberus Profile File: TAPM
Meteorological data period	1 January 2016 – 31 December 2020
Dispersion coefficient	Rural (default)
Low wind speed algorithm	LOW WIND ALPHA

4.3.2 Low wind speed options

For non-buoyant ground level emission sources (such as key emission sources within this assessment), worst case dispersion conditions typically exist under low wind speed, stable meteorology, with near-field predictions being of greatest magnitude. These meteorological conditions are among the most challenging for dispersion models to replicate. The performance of AERMOD under these conditions has been assessed in recent years, with a focus on the development of model improvements to address issues associated with significant over prediction observed during low wind speed conditions.

[1] This is the current version of AERMOD at the time of writing.

As part of this work, modifications were incorporated into recent releases of the model (Versions 12345, 15181 and 16216r), comprising three separate low wind speed options, LOWWIND1, LOWWIND2 and LOWWIND3. These options restrict the minimum sigma v (σ_v), which is a parameter that is used to estimate rate of lateral and vertical plume growth, as well as the apportionment of emissions in the model, between the (radial) random/meander plume and traditional Gaussian coherent plume components.

The AERMOD upgrade to Version 18081 replaced the three BETA options with a new LOW WIND ALPHA option which enables the user to enter user-defined values for minimum wind speed, sigma-v, and maximum meander factor. For this impact assessment, the LOW WIND ALPHA option was selected with default parameters.

4.3.3 Airflow wake effects

As air passes over physical structures, aerodynamic wakes are produced. In these wakes strong turbulence and downward mixing can occur. Emissions from point sources located near to these wakes can be drawn downward, and recirculated within the lee of the wake, producing locally elevated concentrations, and reducing the extent of plume rise at a distance downwind. This effect is known as building downwash. In this assessment, point sources were screened for potential location within building wakes, where wakes were assumed to:

- Extend 5 times the lesser of the projected structure width or height downwind from the leeward edge of a structure; and
- Extend to a height of 2.5 times the height of the structure

Point emission sources are not attached to large buildings at LIP or the project and are located greater than 50 metres from storage tanks or sheds. It is therefore unlikely that building downwash influences exist at the site. However, if building downwash did exist, it is expected that this would reduce offsite impacts.

As a focus of this assessment is on higher concentrations at sensitive receptors, no buildings were incorporated into the model.

4.3.4 Conversion of NO_X to NO_2

Nitrogen oxides are produced in most combustion processes and are formed during the oxidation of nitrogen in fuel and nitrogen in the air. During high-temperature processes, a variety of oxides are formed including nitric oxide (NO) and NO_2. NO will generally comprise 95 per cent of the NO_X by volume at the point of emission with the remaining NO_X consisting of NO_2. Ultimately, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and then further to other higher oxides of nitrogen.

One of the challenges of modelling NO_x emissions is determining the amount of NO_2 at a receptor, due to uncertainties in the conversion rates. In concentrated plumes, NO_x to NO_2 reaction is initially ozone limited, such that all available ozone will be consumed. As a plume becomes more diluted and more ozone is mixed in, the reaction eventually becomes NO limited (EPA 2015).

AERMOD assumes that the pollutants are inert gases; i.e. the model does not account for any chemical transformations. As such, the transformation of NO_x to NO_2 needs to be done in the post-processing stage. There is no industry standard NO_x to NO_2 conversion ratio. For emission sources with a NO_2/NO_x in-stack ratio of five per cent, a conversion ratio of 20 per cent is well supported and recommended by the USEPA (USEPA 2017). As a focus of this assessment is on higher concentrations of NO_2, a more conservative value of 30 per cent was used to convert the AERMOD predicted NO_x emission rates to NO_2.

4.3.5 Averaging Period Conversion

The AERMOD dispersion model produces hourly averaged pollutant predictions. In order to allow direct comparison with 30-minute average criteria, the model predictions have been adapted in accordance with the method nominated within Section 5 of the Guidance notes (EPA 2014b). In the case of this assessment, to convert from a 60-minute to a 30-minute statistic requires the multiplication of model predictions by a factor of 1.15.

4.3.6 Gridded modelling domain

In accordance with the SEPP (AQM) [Drafting note: SEPP (AQM) is to be replaced with 'Guide to air pollution modelling (publication 1957)'. This guideline is not currently available to the public.], a receptor grid and sensitive receptors were identified and added to the model. A description of the modelling grid and location of the sensitive receptors is provided in the following sections. An 8 x 8 kilometre multi-tier receptor grid was chosen to cover nearby populated regions which include many sensitive receptors. In accordance with the Guidance notes (EPA 2014b) the gridded domain comprised the following:

- Grid centre coordinates (MGA94): 344 200 mE, 5759 750 mS
- A 100 m resolution inner tier grid extending to 3 x 3 km (i.e. 31 x 31 points)
- A 500 m resolution outer tier grid extending to 8 x 8 km (i.e. 17 x 17 points).

This equates to a total of 1,201 gridded receptors. Figure 9 shows an aerial overlay of the gridded modelling domain.

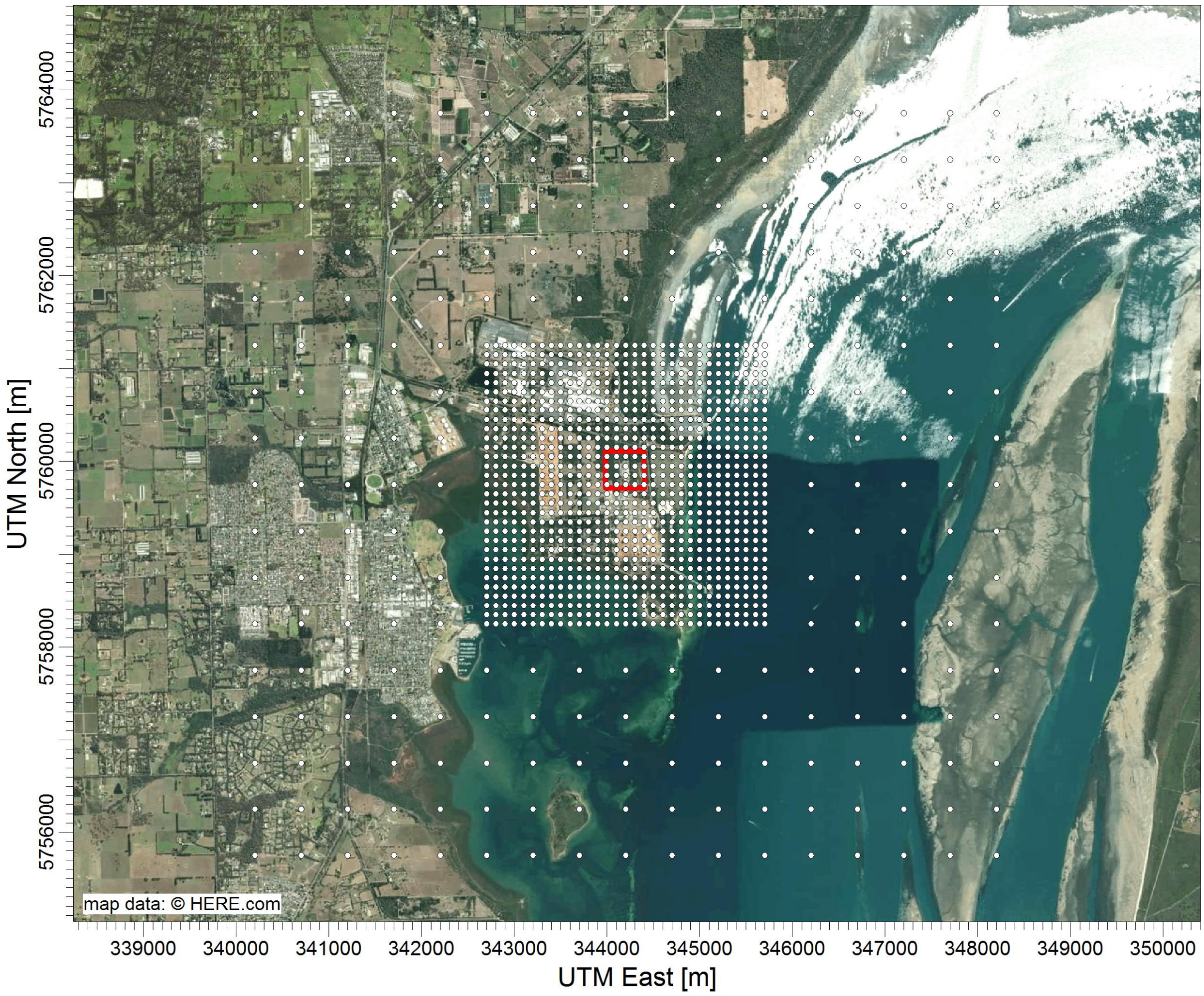


Figure 9 Aerial image showing extent of nested grid receptor modelling domain, and location of gridded receptors (white dots)

4.4 Assumptions and limitations

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on several variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve some level of simplification of these very complex processes, based on our understanding of the processes involved and their interactions, available input data, processing time and data storage limitations.

These simplifications come at the expense of accuracy, which particularly affects model predictions during certain meteorological conditions and source emission types. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those less than one metre per second) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these known deficiencies, the model outputs tend to provide conservative estimates of pollutant concentrations at particular locations.

The results of dispersion modelling, therefore, provide an indication of the likely level of pollutants within the modelling domain. While the models, when used appropriately and with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time.

The air quality impact assessment was limited by the equipment specifications and operational data provided by Solar Turbines and Esso. Critical air emissions parameters such as stack heights, exhaust velocities and air pollutant emission rates were used to determine input emissions data for dispersion modelling, which formed the basis of the assessment.

4.5 Modelling predictions

This section provides an assessment of the potential air quality impacts on sensitive receptors and the surrounding environment during operation of the three ethane-fuelled generators in comparison to the ERS and AQACs criteria listed in Table 5.

Air dispersion modelling was undertaken to predict generator emissions during worst case operating scenarios (refer to Section 4.1). EPA Victoria guidance states that modelling be conducted using five years of meteorological data (2016 to 2020), reporting the worst case year results. The year 2016 was found to predict the highest one hour average 99.9th percentile concentrations from the project at sensitive receptors (receptor 1 to 4) so was used for all graphical representations of model predictions.

The results of the dispersion modelling are expected to provide an indication of worst case concentration of pollutants within the modelling domain. Dispersion modelling when used with appropriately justified settings along with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations due to a particular emission scenario. However, it should be understood that modelling results are not representative of exact pollutant concentration at any given location at a particular point in time (due to the stochastic nature of the turbulence in the flow or air).

Quantifying the uncertainty in dispersion models is not a simple task as the uncertainty can vary depending on inputs that differ from project to project. As such, the level of uncertainty has been incorporated into the modelling through the use of conservative or 'worst-case' assumptions, which offers some degree of safety in the regulatory environment when assessing potential air quality impacts.

As discussed in Section 2.6, best practice design parameters and emission standards (maximum allowable pollutant concentrations) would be applied to ensure that the assessed emissions are minimised to the extent practicable in accordance with the requirements of the ERS policy. Remaining emissions data not addressed by design parameters or emission standards were modelled through the use of a worst-case scenario assumption of 100 per cent load to determine the predicted maximum concentrations.

4.5.1 Nitrogen dioxide results

Nitrogen dioxide concentrations resulting from operation of the project are presented in Table 19 and Table 20. A NO_x to NO_2 ratio of 0.30 (or NO_x conversion rate of 30 per cent) was used in this assessment for all emission sources as detailed in Section 4.3.4. Results are presented as maximum 1-hour average 99.9th percentiles and maximum annual average for meteorology year 2016 to 2020 for the following scenarios:

- Hasting power generation Project with 25ppm emissions
- Hasting power generation Project with 100ppm emissions
- LIP
- Hasting power generation Project with 25ppm emissions and LIP
- Hasting power generation Project with 100ppm emissions and LIP

The maximum cumulative result (with background) should be compared against the adopted criterion listed in Table 5. Figure 10 and Figure 11 provide a graphical representation of NO_2 model predictions from Hastings Power Generation Project with 25ppm and 100ppm emissions, respectively. Figure 12 and Figure 13 provide graphical representations of cumulative NO_2 model predictions across the gridded modelling domain for LIP with and without Hastings Power Generation Project at 100ppm. Figure 14 shows the total cumulative predictions for Hastings Power Generation Project at 100ppm, LIP and background concentrations.

Modelling results show that NO_2 concentrations from the project are well below the criteria at all sensitive and industrial receptors.

Table 19 NO_2 modelling predictions at receptor locations for operating scenarios, 1-hour average 99.9th percentile (µg/m³)

Receptor	NO_2 concentrations, 1-hour 99.9th percentile (µg/m³)				
	HGP 25ppm	HGP 100ppm	LIP	HGP 25ppm and LIP	HGP 100ppm and LIP
1	1.8	7.2	47.3	47.3	47.3
2	2.2	8.6	54.1	54.1	54.1
3	1.3	5.1	53.6	53.6	53.6
4	1.3	5.3	47.2	47.2	47.2
5	5.1	20.2	42.0	42.0	42.0
6	4.0	16.1	38.6	38.6	38.6
7	2.8	11.1	37.7	37.7	37.7
8	1.5	6.1	41.1	41.1	41.2
9	2.6	10.5	31.6	31.6	31.7
Max Incremental	**5.1**	**20.2**	**54.1**	**54.1**	**54.1**
Max Cumulative	**44.6**	**59.7**	**93.6**	**93.6**	**93.6**
Background	39.5				
Criterion (µg/m³)	150				

Table 20 NO_2 modelling predictions at receptor locations for operating scenarios, annual average (µg/m³)

Receptor	NO_2 concentrations, annual average (µg/m³)				
	HGP 25ppm	HGP 100ppm	LIP	HGP 25ppm and LIP	HGP 100ppm and LIP
1	0.04	0.15	0.99	1.02	1.13
2	0.04	0.15	0.94	0.98	1.07
3	0.03	0.12	0.85	0.87	0.94
4	0.03	0.11	0.71	0.73	0.80
5	0.17	0.69	1.41	1.58	2.10
6	0.16	0.63	1.38	1.53	2.00
7	0.08	0.33	1.33	1.40	1.63
8	0.04	0.16	0.67	0.71	0.82
9	0.06	0.24	0.67	0.73	0.91
Max Incremental	**0.17**	**0.69**	**1.41**	**1.58**	**2.10**
Max Cumulative	**11.47**	**11.99**	**12.71**	**12.88**	**13.40**
Background	11.3				
Criterion (µg/m³)	28				

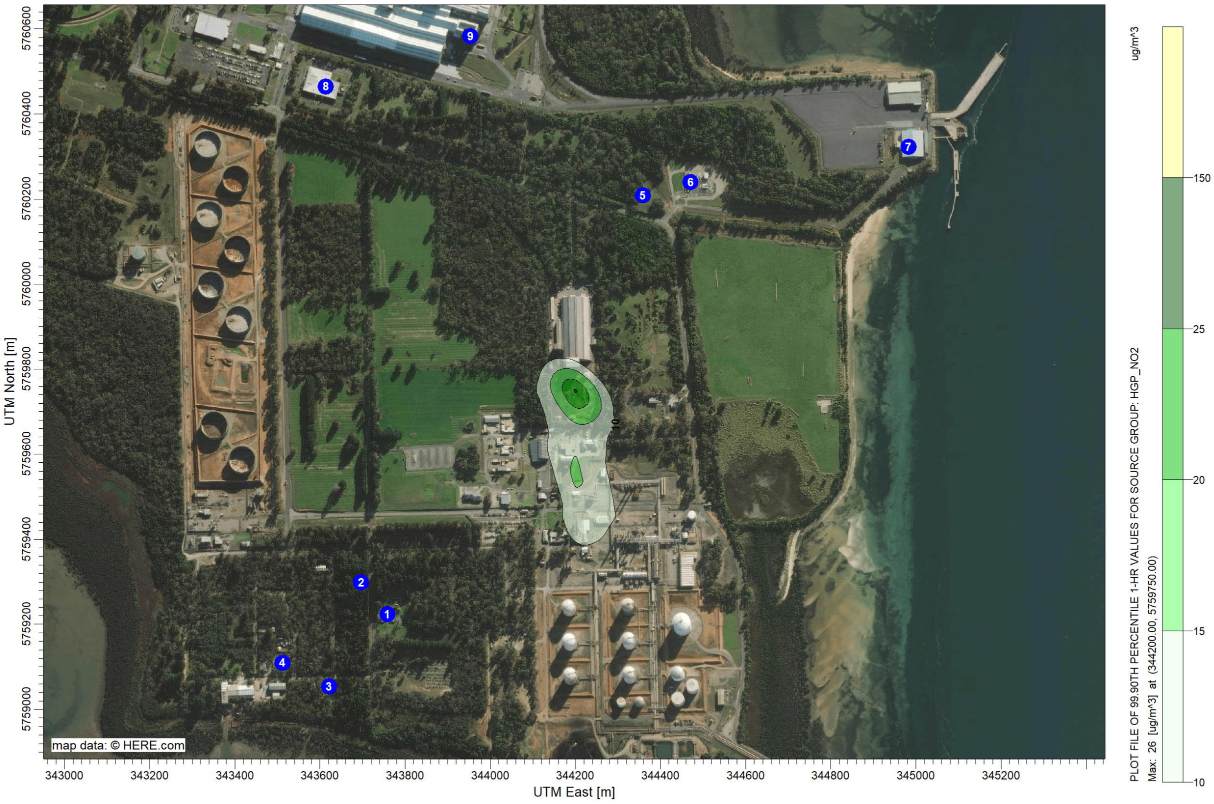


Figure 10 NO_2 results, Hasting power generation Project with 25ppm emissions, 1-hr average 99.9th percentile, no background, 2016 MET (µg/m³)

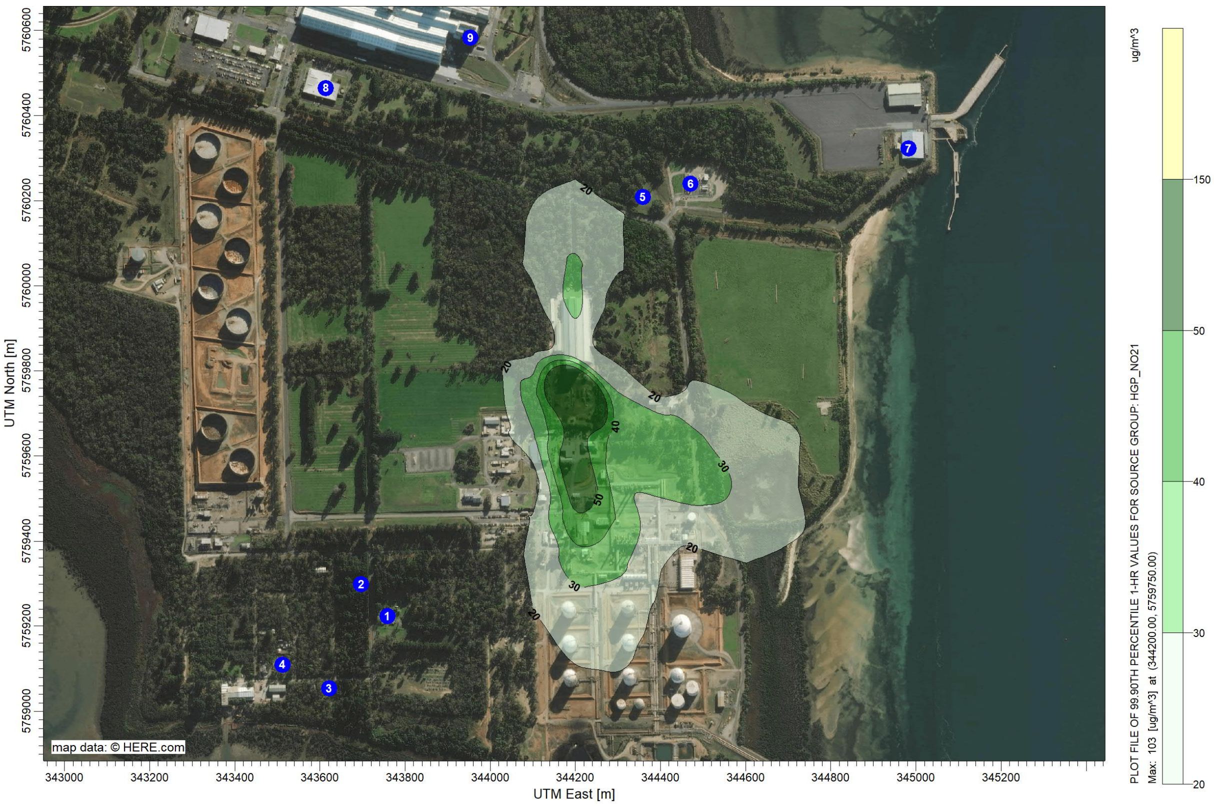


Figure 11 NO_2 results, Hasting power generation Project with 100ppm emissions, 1-hr average 99.9th percentile, no background, 2016 MET (µg/m³)

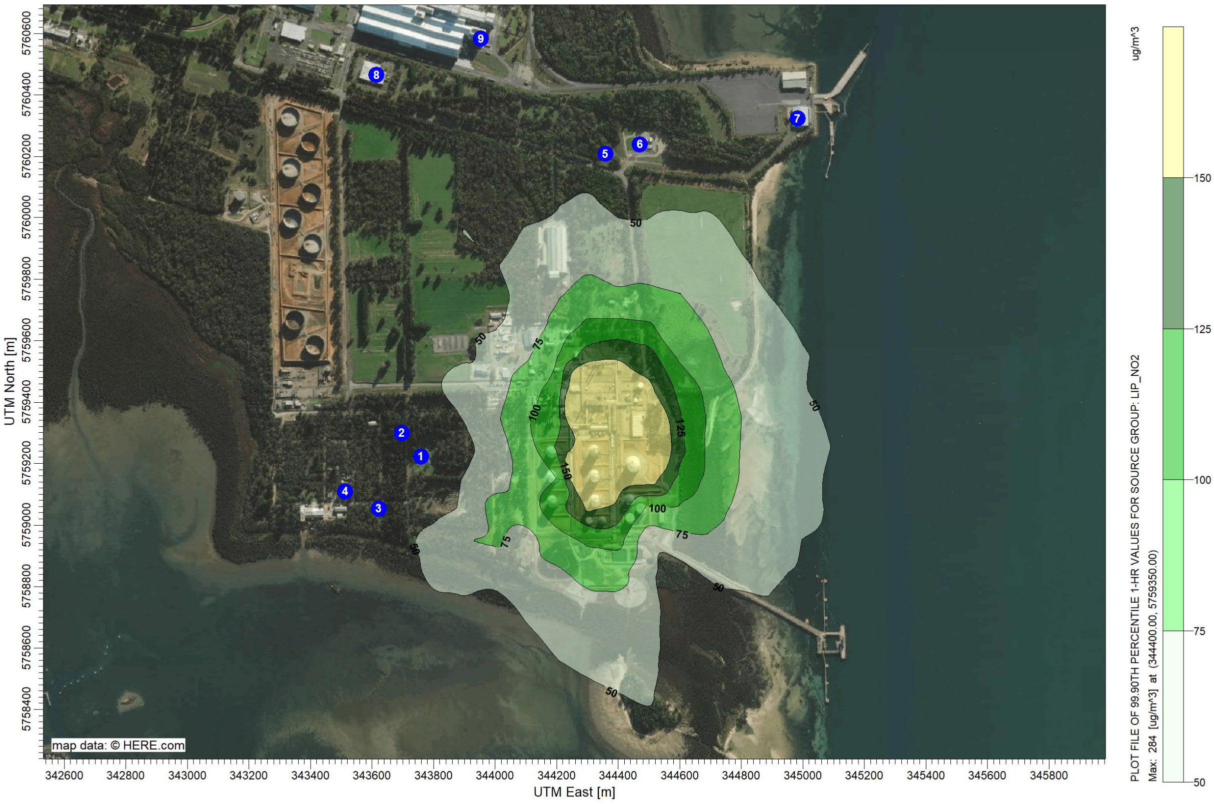


Figure 12 NO$_2$ results, LIP emissions, 1-hr average 99.9th percentile, no background, 2016 MET (μg/m^3)

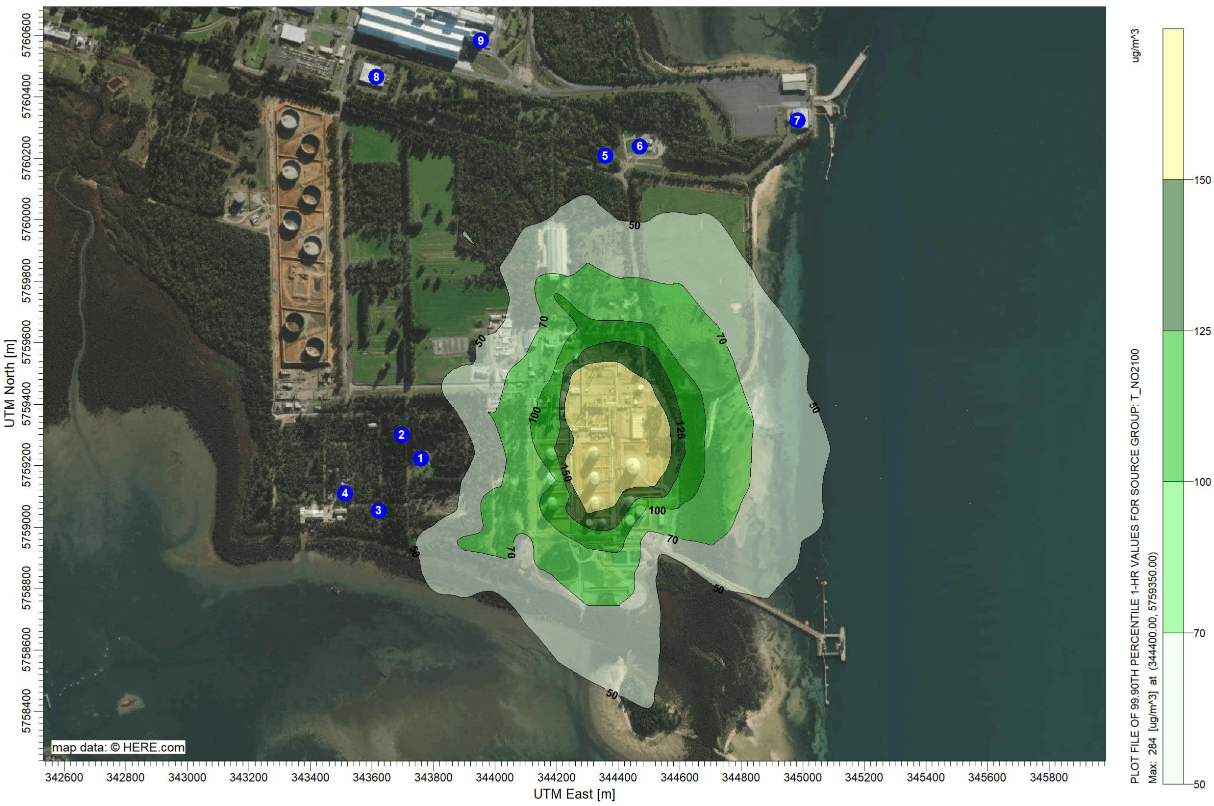


Figure 13 NO$_2$ results, LIP and Hasting power generation Project with 100ppm emissions, 1-hr average 99.9th percentile, no background, 2016 MET (μg/m^3)

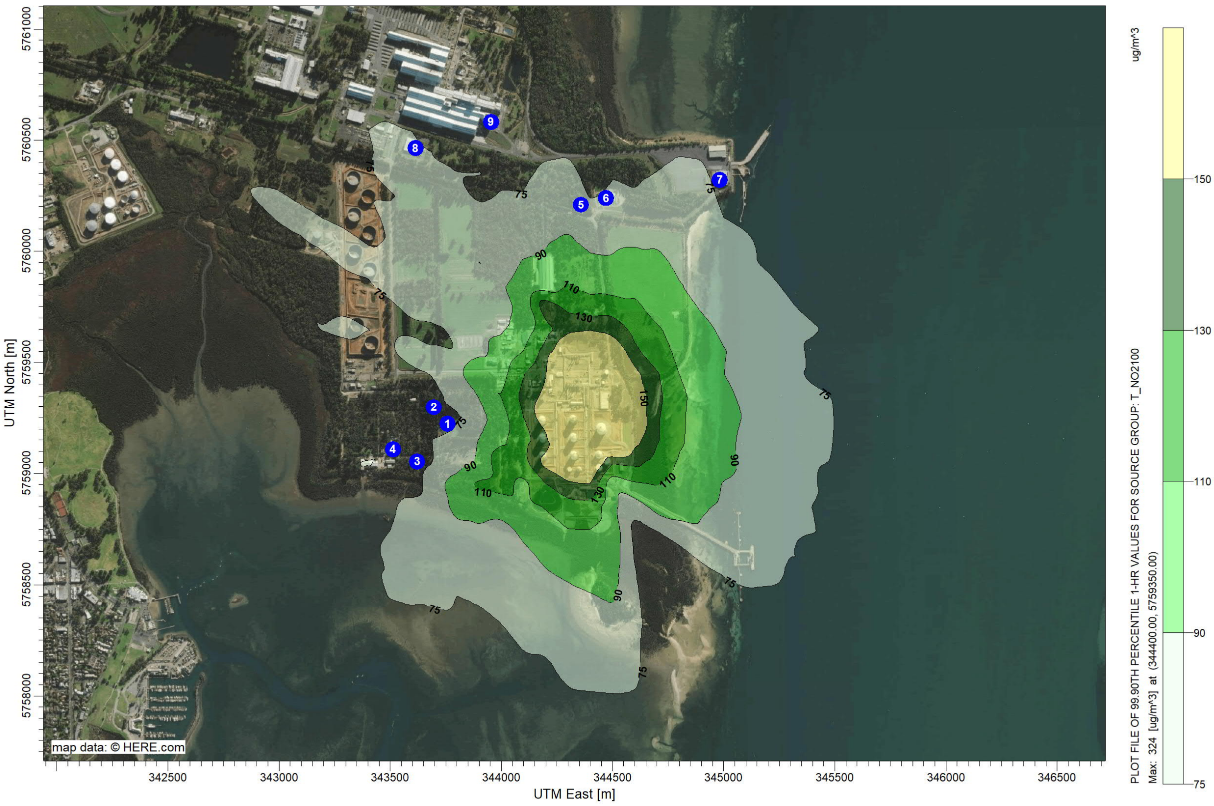


Figure 14 NO$_2$ results, LIP and Hasting power generation Project with 100ppm emissions, 1-hr average 99.9th percentile, including 39.5 µg/m³ background, 2016 MET (µg/m³)

4.5.2 Carbon monoxide results

Carbon monoxide concentrations resulting from operation of the project are presented in Table 21. Results are presented as maximum 8-hour averages (2016 to 2020) for Hasting power generation Project and LIP emissions excluding (incremental) and including (cumulative) background concentrations. The maximum cumulative result (with background) should be compared against the adopted criterion listed in Table 5. Figure 12 and Figure 13 provide graphical representations of incremental CO model predictions across the gridded modelling domain for Hasting power generation Project and LIP, respectively. Figure 17 shows Hasting power generation Project plus LIP.

Modelling results show that CO concentrations from the project are well below the criteria at all gridded, sensitive and industrial receptors. Max ground concentration anywhere (including onsite) plus 570 µg/m³ background is predicted to be just 12% of the criterion (1220 µg/m³).

Table 21 CO modelling predictions at receptor locations for operating scenarios, maximum 8-hour average (µg/m³)

Receptor	CO concentrations, maximum 8-hour average (µg/m³)		
	HGP	LIP	HGP and LIP
1	2.9	125.2	125.2
2	2.7	112.1	112.2
3	2.2	103.8	103.8
4	1.9	91.8	92.0
5	7.8	111.3	111.3
6	5.7	112.9	113.0
7	3.9	96.8	96.8
8	1.9	84.0	84.1
9	3.6	78.9	79.0
Max Incremental	**7.8**	**125.2**	**125.2**
Max Cumulative	**577.8**	**695.2**	**695.2**
Background	570		
Criterion (µg/m³)	10,310		

Figure 15 CO results, Hasting power generation Project emissions, maximum 8-hr average, no background, 2016 MET (µg/m³)

Figure 16 CO results, LIP emissions, maximum 8-hr average, no background, 2016 MET (µg/m³)

Figure 17 CO results, Hasting power generation Project and LIP emissions, maximum 8-hr average, no background, 2016 MET (µg/m³)

4.5.3 Sulfur dioxide results

Sulfur dioxide concentrations resulting from operation of the project are presented in Table 21. Results are presented as maximum 1-hour average 99.9th percentiles (2016 to 2020) for Hasting power generation Project and LIP emissions excluding (incremental) and including (cumulative) background concentrations. The maximum cumulative result (with background) should be compared against the adopted criterion listed in Table 5. Figure 12 provides graphical representations of incremental SO_2 model predictions across the gridded modelling domain for Hasting power generation Project plus LIP.

Modelling results show that SO_2 concentrations from the project are negligible and well below the criteria at all gridded, sensitive and industrial receptors. Hasting power generation Project emissions are predicted to result in a maximum ground level concentration (including onsite) of less than 1 µg/m³.

Table 22 SO_2 modelling predictions at receptor locations for operating scenarios, 1-hour average 99.9th percentile (µg/m³)

Receptor	SO_2 concentrations, 1-hour 99.9th percentile (µg/m³)		
	HGP	LIP	HGP and LIP
1	0.04	13.7	13.7
2	0.05	15.4	15.4
3	0.03	13.7	13.7
4	0.03	15.2	15.2
5	0.11	13.6	13.6
6	0.09	13.2	13.2
7	0.06	13.6	13.6
8	0.03	11.0	11.0
9	0.06	11.7	11.7
Max Incremental	**0.11**	**15.4**	**15.4**
Max Cumulative	**8.0**	**23.3**	**23.3**
Background	7.9		
Criterion (µg/m³)	260		

Figure 18 SO_2 results, Hasting power generation Project and LIP emissions, 1-hr average 99.9th percentile, no background, 2016 MET (µg/m³)

4.5.4 Particulate (PM_{10} and $PM_{2.5}$) and Total Volatile Organic Compounds results

Particulate (PM_{10} and $PM_{2.5}$) and total VOC concentrations resulting from operation of the Hasting power generation Project are presented in Table 21. Particulate (PM_{10} and $PM_{2.5}$) results are presented as maximum 24-hour and annual averages (2016 to 2020). VOC results are presented as 1-hour average 99.9th percentiles (2016 to 2020). The maximum cumulative result (with background) should be compared against the adopted criterion listed in Table 5. No figures were provided due to the negligible concentrations.

Modelling results show that particulate concentrations from the project are negligible and well below the criteria at all gridded, sensitive and industrial receptors. Particulate emissions from the Hasting power generation Project are predicted to result in a maximum ground level concentration (including onsite) of 2.2 µg/m³ (24-hour average) and 0.1 µg/m³ (annual average). Based on NPI emission factors for auxiliary engines (weighted average burn) (Australian Government, 2012), an expected $PM_{2.5}/PM_{10}$ ratio is 83.7 per cent. If it is conservatively assumed that all particulate emissions from the project are $PM_{2.5}$, concentrations are negligible in comparison to the adopted background concentrations, and 24-hour and annual criteria of 25 µg/m³ and 8 µg/m³, respectively. No further assessment was deemed necessary.

Modelling results show that total VOC concentrations from the project are negligible and well below the criteria at all gridded, sensitive and industrial receptors. VOC emissions from the Hasting power generation Project are predicted to result in a maximum ground level concentration (including onsite) of 33.1 µg/m³. As the maximum total VOC concentration was well below the criteria for speciated VOC emissions of Benzene (580µg/m³) and Formaldehyde (30min 100µg/m³, 1-hour 87µg/m³), no further assessment was deemed necessary.

Table 23 Particulate and VOC modelling predictions at receptor locations for HGP (µg/m³)

Receptor	Concentrations (µg/m³)		
	Particulate ($PM_{2.5}$)* (max 24-hour average)	Particulate ($PM_{2.5}$)* (max annual average)	VOC (1-hour 99.9th percentile)
1	0.26	0.02	2.1
2	0.24	0.01	2.5
3	0.19	0.01	1.5
4	0.18	0.01	1.6
5	0.82	0.05	5.9
6	0.66	0.05	4.7
7	0.46	0.03	3.2
8	0.15	0.01	1.8
9	0.37	0.02	3.1
Max Incremental	0.82	**0.05**	5.9
Max Cumulative	**11.0**	**7.95**	**5.9**
Background	10.2	7.9	-
Criterion (µg/m³)	25	8	-

Note * All particulate emissions conservatively assumed as $PM_{2.5}$

4.6 Summary of operation impacts

The potential air quality impact of the project has been assessed using the AERMOD dispersion model. The pollutants assessed included NO_2, CO, PM_{10}, $PM_{2.5}$, SO_2 and VOCs. The dispersion modelling has used a conservative approach based on worst case operational scenarios, high NOx to NO_2 conversion rate and background concentrations from areas which have a greater pollution potential.

All modelled scenarios demonstrated there are no exceedances of criteria at any of the sensitive or industrial receptor locations. Emissions from the project are negligible in comparison to the adjacent LIP facility and adopted criteria. The air modelling assessment demonstrates that air quality impacts from the project would be minor and emissions are unlikely to have significant effects on the air environment.

5.0 Construction impacts

The three construction components of the project can be summarised as:

- Installing a new pipeline which will be primarily above-ground and buried for road crossings to transfer ethane from LIP to the adjoining, Esso owned project site
- Installing generators producing approximately 40MW of electricity on the project site and connecting it to the new ethane pipeline
- Installing a high voltage electricity line from the generator and linking it to the existing transmission network powerline on Bayview Road.

It is anticipated that project construction would commence in 2Q 2022 and take 6 months to complete. As the Project area is predominantly cleared, minimal tree clearing is expected (less than 0.2 hectares) and some soil movement will be necessary for pipeline support footings and construction pads for the generator units.

It is anticipated that the facility will remain in operation for 11 years (2023 – 2033).

Air emissions of interest for the construction of the project are expected to be primarily related to vehicle movements, earthworks and materials handling, in particular for the underground pipeline. There would also be emissions from plant and equipment associated with the aboveground pipeline.

Potential air quality impacts due to construction of the project were assessed using semi-quantitative methodologies provided in the UK Institute of Air Quality Management (IAQM) document, Guidance on the assessment of dust from demolition and construction (IAQM, 2014). Pollutants of interest for the construction of the project include particulates (including PM_{10} and $PM_{2.5}$) and vehicle exhaust emissions.

5.1 Screening Assessment

Step 1 of the IAQM method involves a screening assessment of the number of sensitive receptors located near the project. Sensitive receptors identified near the project are residential and industrial buildings. The location of sensitive receptors that were considered for the assessment are presented in Figure 19.

There are no sensitive receptors located within 350 metres of the project.

Figure 19 Comparison of sensitive receptors to 350m buffer from the Project site

5.2 Dust Emission Magnitude

Potential dust emission magnitudes for the construction of the project were estimated based on the IAQM guidance. The dust emission magnitudes are based on the scale of the anticipated works and are classified as ‘small’, ‘medium’, or ‘large’. Activities on construction sites have been divided into four types to reflect their different potential impacts. These are:

- demolition
- earthworks
- construction
- trackout.

Justification and the factors used in determining the dust emissions magnitudes are presented in Table 24.

Table 24 Dust emission magnitudes in accordance with IAQM guidance

Activity	Potential Dust Emission Magnitude*	Justification
Demolition	**Small** Total building volume <20,000 m^3, construction material with low potential for dust release (metal and wood), demolition activities <10m above ground	• No demolition proposed during construction phase.
Earthworks	**Small** Total site area <2,500 m^2, soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, total material moved <20,000 tonnes	• Clearing of vegetation less than 0.2 hectares • Trench excavation volume = 1.0 x 2.0 x 50 m = 100 m^3 = 160 tonnes at 1.6 t/m^3 density. • Decommissioning phase expected to require less earthworks than construction
Construction	**Small** Total building volume <25,000 m^3, construction material with low potential for dust release	• Construction of site office and installation of generators and infrastructure • Concreting pads for Transformer yard • Assumed construction materials have low dust generating potential (e.g. steel, cladding).
Trackout	**Small** <10 HDV (>3.5t) outward movements in any one day, surface material with low potential for dust release, unpaved road length <50 m	• Plant and spoil trucks leaving site (note that as much soil will be re-used on site as practicable) • Total number of outward heavy truck movements is not expected to exceed 5 per day at any particular worksite during construction or decommissioning

Note: * Definitions for potential dust emission magnitude are defined in IAQM guidance

5.3 Potential for unmitigated dust impacts

As there are no sensitive receptors located within 350 metres of the project construction works and estimated dust emission magnitudes are classified as ‘small’, unmitigated dust impacts due to construction of the project are expected to be ‘negligible’. Therefore, further quantitative assessment of construction dust impacts is not deemed necessary.

5.4 Management Strategies

Measures to avoid, minimise and manage potential environmental impacts, health risks and nuisance to receptors during construction and decommissioning of the project should be implemented with reference to the EPA Victoria Publication 1834, *Civil Construction, Building and Demolition Guide* (EPA 2020). The guidelines recommend a dust prevention strategy be developed during the project planning stage and outlines a range of dust control and suppression measures such as water sprays, water carts or other devices. In addition to implementing dust management measures such as dust suppression, restricted vehicle movements, placing crushed rocks on existing unsealed access tracks if required and agreed, speed restrictions and covering loads would minimise air quality impacts on nearby receptors. Weather monitoring is recommended in order to enable scheduling of work to avoid adverse weather conditions that are likely to result in air quality impacts (e.g. extremely hot days or windy days). Observational dust monitoring is also recommended to monitor dust levels during construction and modify work where required to avoid or minimise dust generation.

Management and mitigation measures would be able to maintain potential dust impacts during construction at low levels. Management measures and a monitoring program could be incorporated into the Construction Environment Management Plan for the project to minimise off-site impacts.

6.0 Conclusion

Construction dust and operation of the three generators were identified as the main sources of potential air quality impacts. The outcome of the construction and operation assessment showed that unmitigated impacts of the project would be negligible or low. With implementation of appropriate mitigation measures, it is anticipated that air quality impacts would be negligible at all nearby sensitive receptors during the decommissioning phase of the project.

All modelled scenarios demonstrated there are no exceedances of criteria at any of the sensitive, or industrial receptor locations. The air modelling assessment demonstrates that air quality impacts from operation of the Hasting Generation Project would be minor and emissions are unlikely to have regionally or State significant effects on the air environment.

Best practice design parameters and emission standards (maximum allowable pollutant concentrations) should be applied to ensure that the assessed emissions are minimised to the extent practicable in accordance with the requirements of the ERS policy.

7.0 References

AAQ NEPM. National Environment Protection (Ambient Air Quality) Measure, 2021

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Appendix A

Model Meteorological Data

Appendix A Model Meteorological Data

Overview

Surface weather data from 2016 to 2020 nearby Bureau of Meteorology (BoM) stations (all within about 20 km) of the Project site were used as the basis for the modelled meteorology for the Project.

The BoM surface observations and upper profile data from The Air Pollution Model (TAPM) were input into CALMET. Surface predictions from CALMET extracted at the Project site were used as input into the AERMET model. A flow diagram summarising the meteorological data generating process is presented in Figure 20.

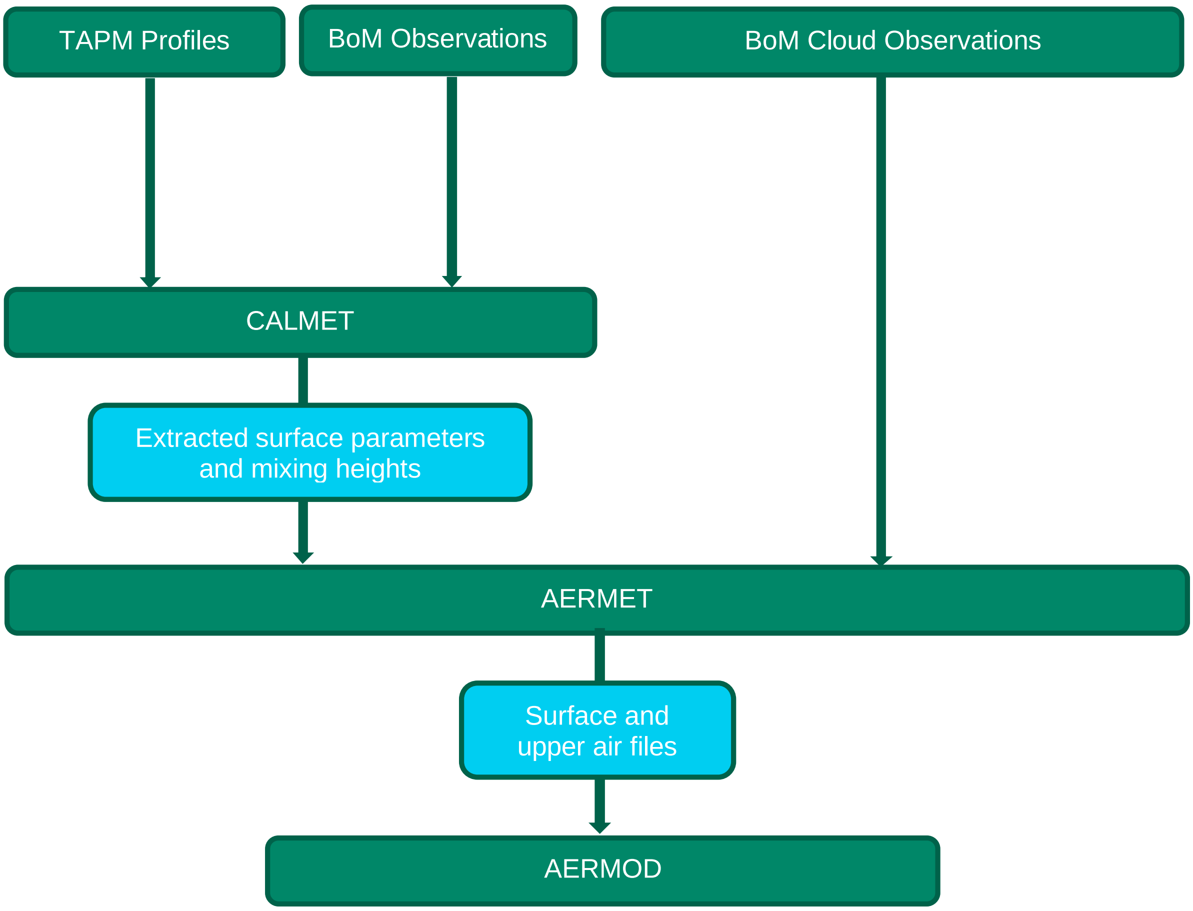

Figure 20 Meteorological data process flow diagram

Data for the period 2016 to 2020 from the BoM stations at Cerberus (about 8 kilometres southwest of the Project site), BoM station Frankston (about 18 kilometres northwest of project site) and BoM station RHYLL (about 20 kilometres southeast of project site) were used as a comparison with the meteorological data used in the model. Wind rose comparisons between each BoM station and AERMET-generated winds are presented in Section 0.

Cloud cover is an important parameter that AERMET uses to determine dispersion characteristics. Cloud cover data was input into AERMET directly from observations made at BoM Moorabbin Airport station with cloud cover observations. Missing cloud data was interpolated linearly from the available data.

A description the models and the settings used for each is provided in the following sections.

TAPM

TAPM predicts three-dimensional meteorology, including terrain-induced circulations. TAPM is a PC-based interface that is connected to databases of terrain, vegetation and soil type, leaf area index, sea-surface temperature, and synoptic-scale meteorological analyses for various regions around the world.

For this assessment, TAPM was used to predict five-years' worth of three-dimensional meteorology from which four upper profiles were extracted. The extracted data was then used as input into CALMET. Settings used in the TAPM model are presented in Table 25.

Table 25 Summary of TAPM parameters

Modelling Parameter	Input
Horizontal Grid Points	25 x 25 grid points
Outer Grid Resolution	30,000 m
Nested Grids	Three nested grids. Resolution of 10,000, 3,000m and 1,000m
Grid centre coordinates (mX, mY)	345,000 mE, 5,760,000 mS
Vertical levels	25 vertical levels
Land use data	Default TAPM database
Simulation length	1 January 2016 – 31 December 2020

CALMET

CALMET is the meteorological pre-processor for the CALPUFF dispersion model. CALMET has been used in this process to collectively process the TAPM outputs in conjunction with terrain and land use data to produce hourly 3-dimensional gridded arrays of meteorological parameters.

BoM surface and TAPM upper profile data were used within CALMET as an 'initial guess' field in which meteorological parameters are initialised prior to the application of a range of diagnostic flow corrections, which are based on physical and empirical algorithms. This process involves resolving blocking, channelling, slope flow and kinematic effects across the CALMET grid, as based on iterative processes. Once this stage is complete, surface observations are incorporated in an objective process, using domain specific weighting values. This approach allows the model to incorporate actual observations, whilst also reflecting variations in micrometeorology across the modelling domain.

Selection of surface meteorological stations

Stations within 20 km of the Project that were operating for the full 2016 to 2020 period were selected for analysis as potential stations to use in the modelling. Three stations fitting the criteria were identified and are summarised in Table 26. The location of these stations in relation to the Project site is presented in Figure 21.

Table 26 Details of weather stations considered for the modelling

Station	Latitude/ Longitude	Distance from Project	Operator
Cerberus	-38.364; 145.179	8 km	BoM
Frankston AWS	-38.148; 145.116	18 km	BoM
Rhyll	-38.461; 145.310	20 km	BoM

Figure 21 Location of available surface meteorological stations

Physical characteristics for these stations were examined to determine whether these locations were acceptable for use in the modelling. The examination was undertaken in terms proximity of the monitoring station to physical obstructions i.e. proximity of buildings or trees to the monitoring station examined though comparison with AS3580.14-2011, *Methods for sampling and analysis of ambient air Meteorological monitoring for ambient air quality monitoring applications* (as per diagram shown in Figure 22.

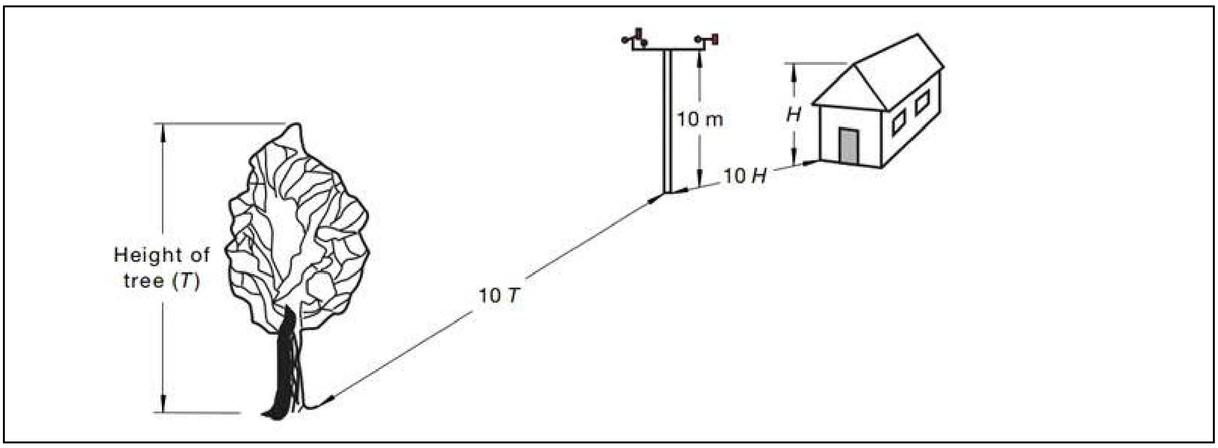

Figure 22 Wind Measurement Siting Guidance (Source: AS 3580.14-2011)

The local setting of the stations in terms of proximity to obstructions are presented in Table 26.

The Cerberus BOM station is located in the middle of a field with no obstructions within 80 m of the wind sensor.

The Frankston AWS BoM stations is located within a stand of short shrubs, with a short building (about 4 m tall) to the north (not visible on the aerial view). While there are some short obstacles near to the station, the wind sensor itself is at 10m above ground level and appears relatively unimpeded.

The Rhyll station is located at the NE end of a coastal bay with trees within 10 meters of the station on the eastern and southern sides. The trees are mostly less than 5m in height and are unlikely to affect winds measured at the station.

All three BoM stations are located such that they provide representative measurements of the wind in the region and all three statins were therefore included in the model.

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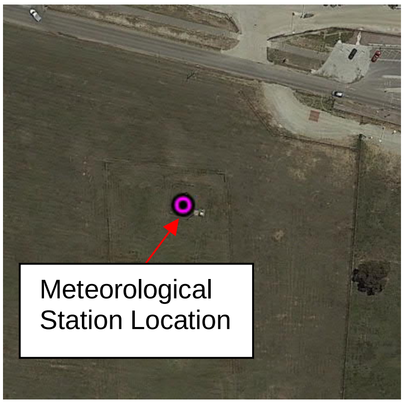
<td>
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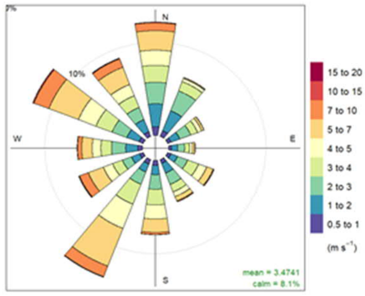
<td>
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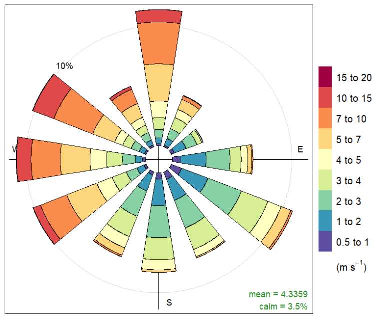
<td>
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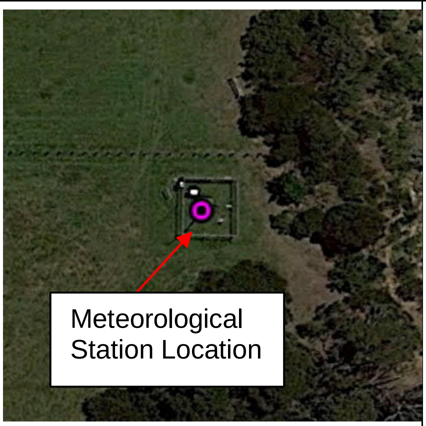
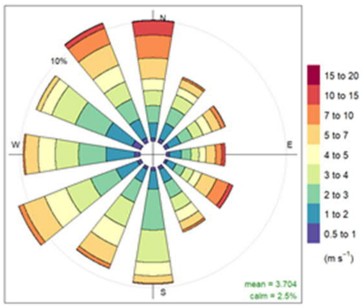
<td>
</td>
<td></td>
<td>
</td>
</tr>
<tr>
<td>RHYLL - aerial view of station</td>
<td>Rhyll – ground view</td>
<td>RHYLL – wind rose 2016 to 2020</td>
</tr>
</table>

Figure 23 Local setting of available surface meteorological stations

CALMET Settings

The CALMET meteorological modelling domain was configured to encompass the region surrounding the Project site, covering nearby sensitive receptors and key terrain features.

Table 27 presents a summary of the domain settings along with key model parameters used within CALMET to generate the meteorological fields. Explanations of these parameters are available in the following guidance document:

- TRC, 2011, Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'.

Table 27 CALMET modelling parameters for the Project domain

Parameter	Value
Meteorological grid domain	40 km x 40 km
Meteorological grid resolution	300 metre resolution (133 x 133 grid cells)
Reference grid coordinate (centre)	343.950 km E, 5760.250 km S
Cell face heights in vertical grid (m)	0,20,40,80,160,320,640,1200,2000,3000,4000
Simulation length	5 years (2016-2020)
Surface meteorological stations	BoM Cerberus BoM Frankston AWS BoM Rhyll
Upper air meteorology	3 x TAPM up.dat files extracted at: 337.0 km E, 5750.0 km S 345.0 km E, 5769.0 km S 352.0 km E, 5757.0 km S
CALMET Modelling Mode	Observations mode
Terrain data	Terrain elevations were extracted from NASA Shuttle Radar Topography Mission Version 3 data set (SRTM1 30 metre resolution).
Land use Data	ABARES National scale land use version 5 – converted to USGS Codes
Wind field guess	Compute internally
Seven critical CALMET parameters	TERRAD = 8 km RMAX1 = 4 km R1 = 3 km RMAX2 = 7 km R2 = 4 km IEXTRP = -4 BIAS = -1,-0.5,0,0.5,1,1,1,1,1
Surface parameters passed to AERMET	Wind speed Wind direction Temperature Mixing height

The location of each of the BoM surface stations, extracted TAPM profiles, radius of influence (RMAX1, R1, RMAX2, R2 parameters listed in the table above), terrain, and the location for the extracted surface file at the Project site are presented in Figure 24.

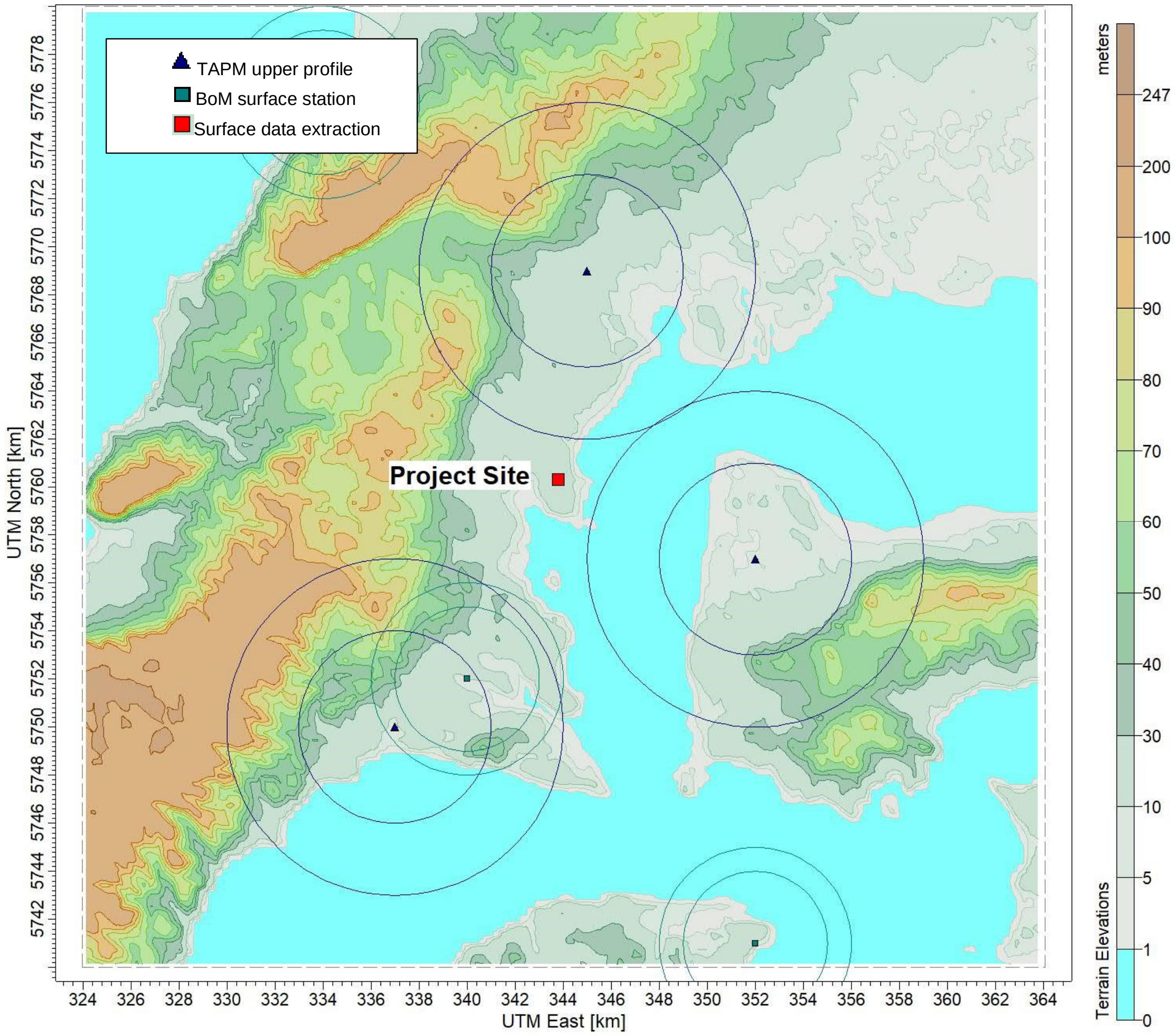


Figure 24 CALMET – terrain and locations of input and output

Wind roses extracted at the location of the Project (shown as a red square in Figure 24) are presented in Figure 25 .The CALMET run shows wind speeds averaging 3.2 m/s, which is slightly lower than average wind speed measured at BoM Cerberus.

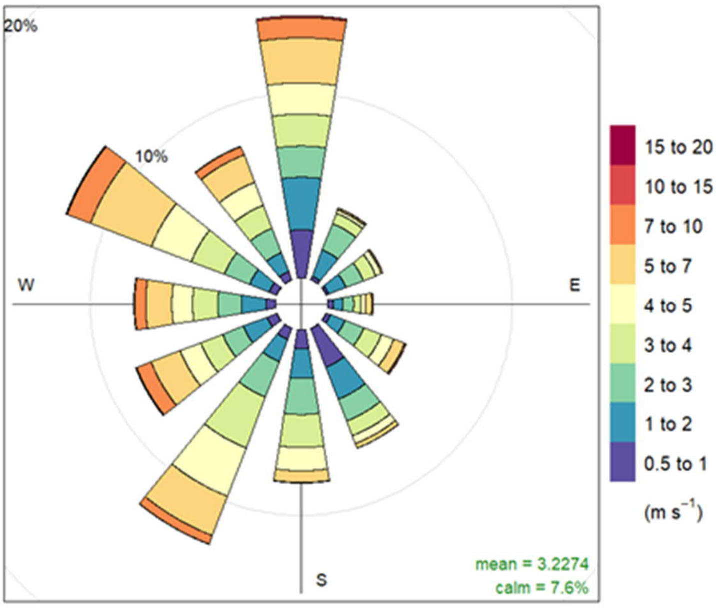


Figure 25 CALMET winds at the Project site

The data extracted at the Project site for the CALMET run was analysed further to determine its suitability for use in AERMOD. Temperature data for the period 2016 to 2020 from the CALMET model are presented in Figure 26. The temperature profile shows temperatures that are typical for those expected in coastal Victoria, with average summer temperatures ranging from about 17 to 25 degrees Celsius and average winter temperatures from about 7 to 15 degrees Celsius.

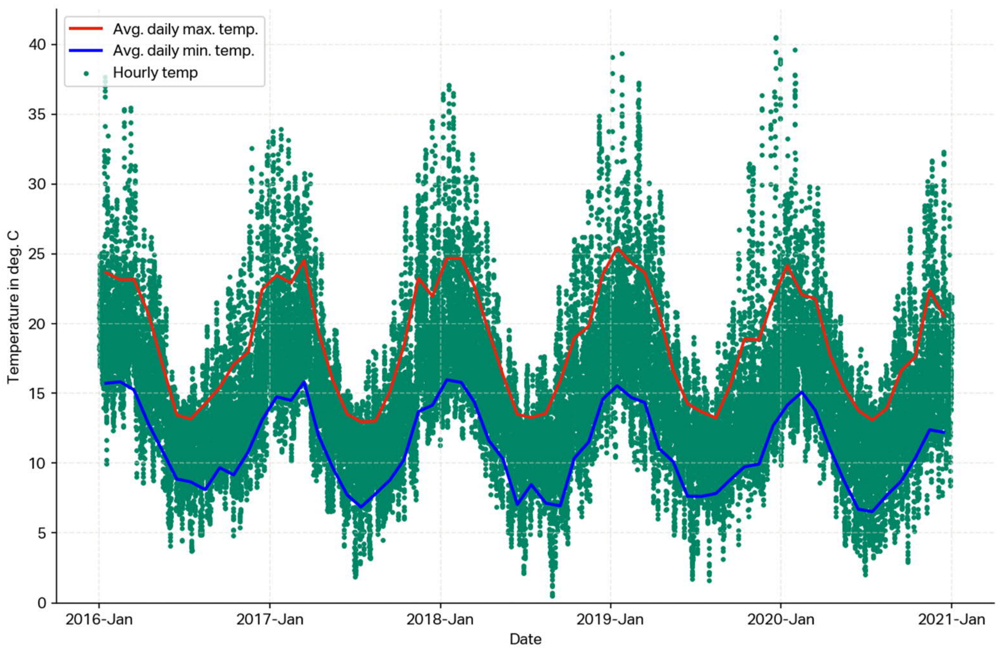


Figure 26 CALMET hourly temperatures

Mixing heights predicted by CALMET were used as input into the AERMET model and are presented in Figure 27. These mixing heights were extracted from CALMET at overland location immediately adjacent to the Project. Mixing heights range from a minimum of 50 m (typically at night-time) to a maximum of 2753 m during the afternoons. The CALMET mixing heights represented a typical pattern for a coastal Victorian location, with relatively low mixing heights compared with locations further inland.

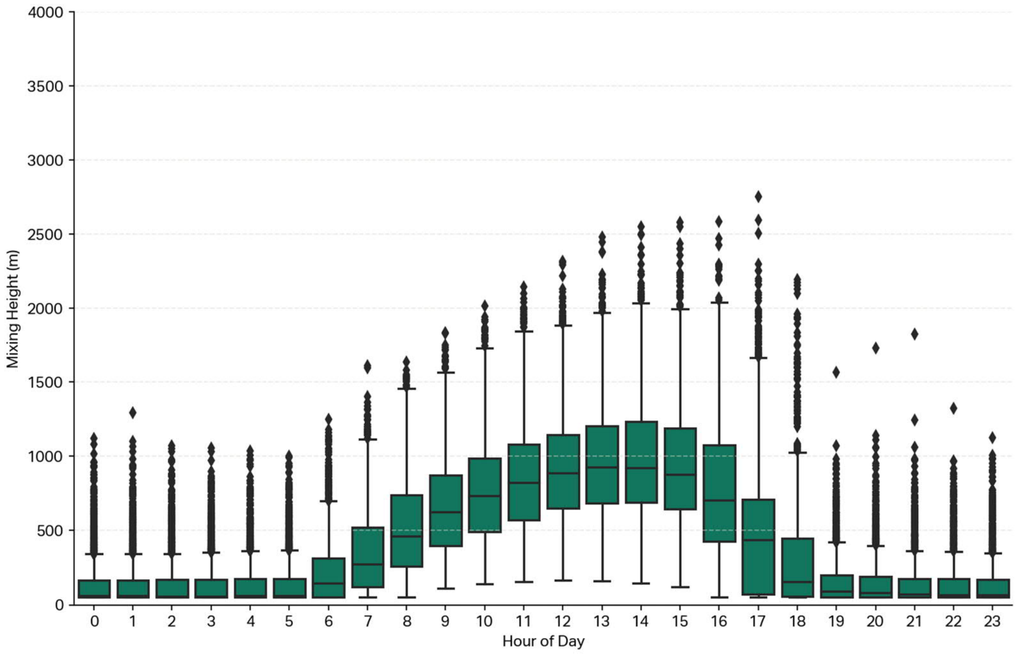


Figure 27 CALMET mixing heights by hour of day

AERMET

Surface meteorological data generated by CALMET was used as input into AERMET as an "onsite" file. Inputs parameters used in the onsite file mostly came from data extracted from CALMET at the location of the Project site. Cloud cover data was sourced from the BoM Avalon station. Missing cloud cover data were linearly interpolated to ensure that AERMET was able to calculate mixing heights for these hours. No specific upper data was used as input in AERMET as mixing heights were input from CALMET via the onsite data file.

A summary of the main parameters used in the set-up of AERMET are presented in Figure 22.

Table 28 AERMET modelling parameters for the Project domain

Parameter	Value
Surface data	CALMET extracted at 343,968 mS 5,760,389 mE UTM
Mixing heights	CALMET extracted at 343,968 mS 5,760,389 mE UTM
Onsite station elevation	10 m
Data records in onsite file	Mixing height (CALMET) Temperature (CALMET) Wind speed (CALMET) Wind direction (CALMET) Cloud cover (BoM Moorabbin)
Low wind option	ADJ_U*
Number of land use sectors	3
Threshold wind speed	0.2 m/s

Land use values are critical to the calculating of dispersion parameters in AERMET. The method for calculating land use values is based on guidance provided in the USEPA's *User's Guide for AERSURFACE Tool*, last updated in February 2020. Surface roughness values are calculated using an inverse distance-weighted geometric mean for land use types within a 1-kilometre radius of the Project site. Albedo and Bowen ratio values are calculated using an arithmetic mean for land use types within a 10 km x 10 km area centred on the Project site.

The 1-kilometre radius area used for determination of surface roughness land use values is presented in Figure 28. Three sectors (covering all 360 degrees of the compass) were identified to describe the surface roughness surrounding the Project site.

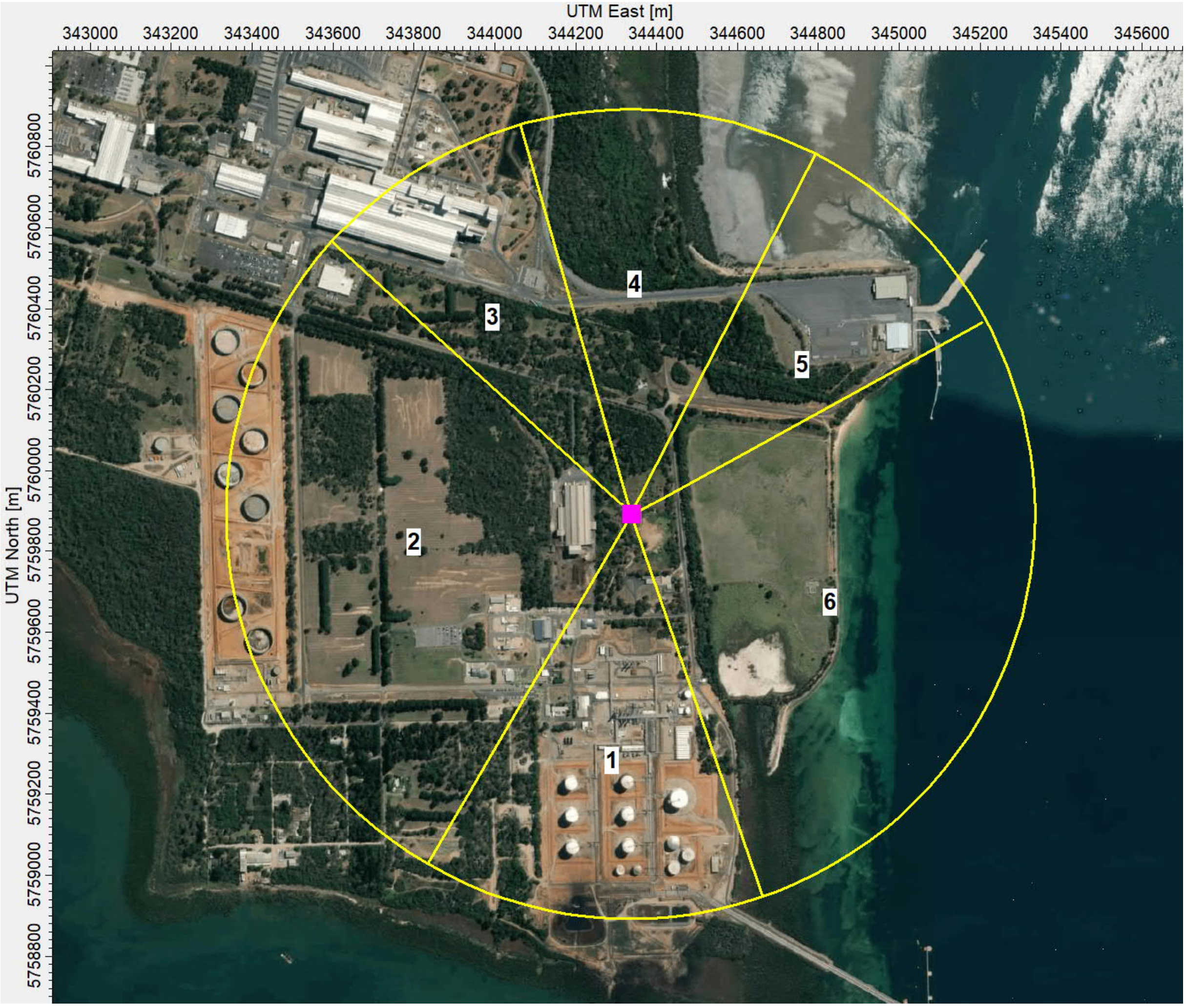


Figure 28 Areas for land use value calculations – surface roughness

Surface roughness calculations for the Project are presented in Table 29. The raw surface roughness value was taken from EPA Victoria's Publication 1550 where available or estimated based on land use type.

Table 29 Surface roughness values used in AERMET

Segment	Land Use	Surface Roughness	Fraction of Land Use (%)			
			Fraction of Land Use (%)	Distance (km)	Weighting (frac/dist.)	Geometric mean surface roughness
1	Industrial/commercial	0.7	80	0.60	1.33	0.807
	Forest	1.3	20	0.50	0.40	
2	Industrial/commercial	0.7	15%	0.60	0.25	0.315
	Forest	1.3	45%	0.50	0.90	
	Grass area	0.05	40%	0.50	0..80	
3	Industrial/commercial	0.7	20	0.80	0.25	1.276
	Forest	1.3	80	0.10	8.00	
4	Forest	1.3	70	0.40	1.75	0.502
	Industrial/commercial	0.7	10	0.30	0.33	
	Open water	0.001	20	0.70	0.29	
5	Industrial/commercial	0.7	40	0.50	0.80	0.142
	Grass area	0.05	15	0.20	0.75	
	Open water	0.001	25	0.90	0.28	
	Forest	1.3	20	0.50	0.40	
6	Grass area	0.05	40	0.40	1.00	0.018
	Open water	0.001	50	0.70	0.71	
	Forest	1.3	10	0.40	0.25	

The 10 km by 10 km area used for determination of albedo and Bowen ratio land use values is presented in Figure 29.

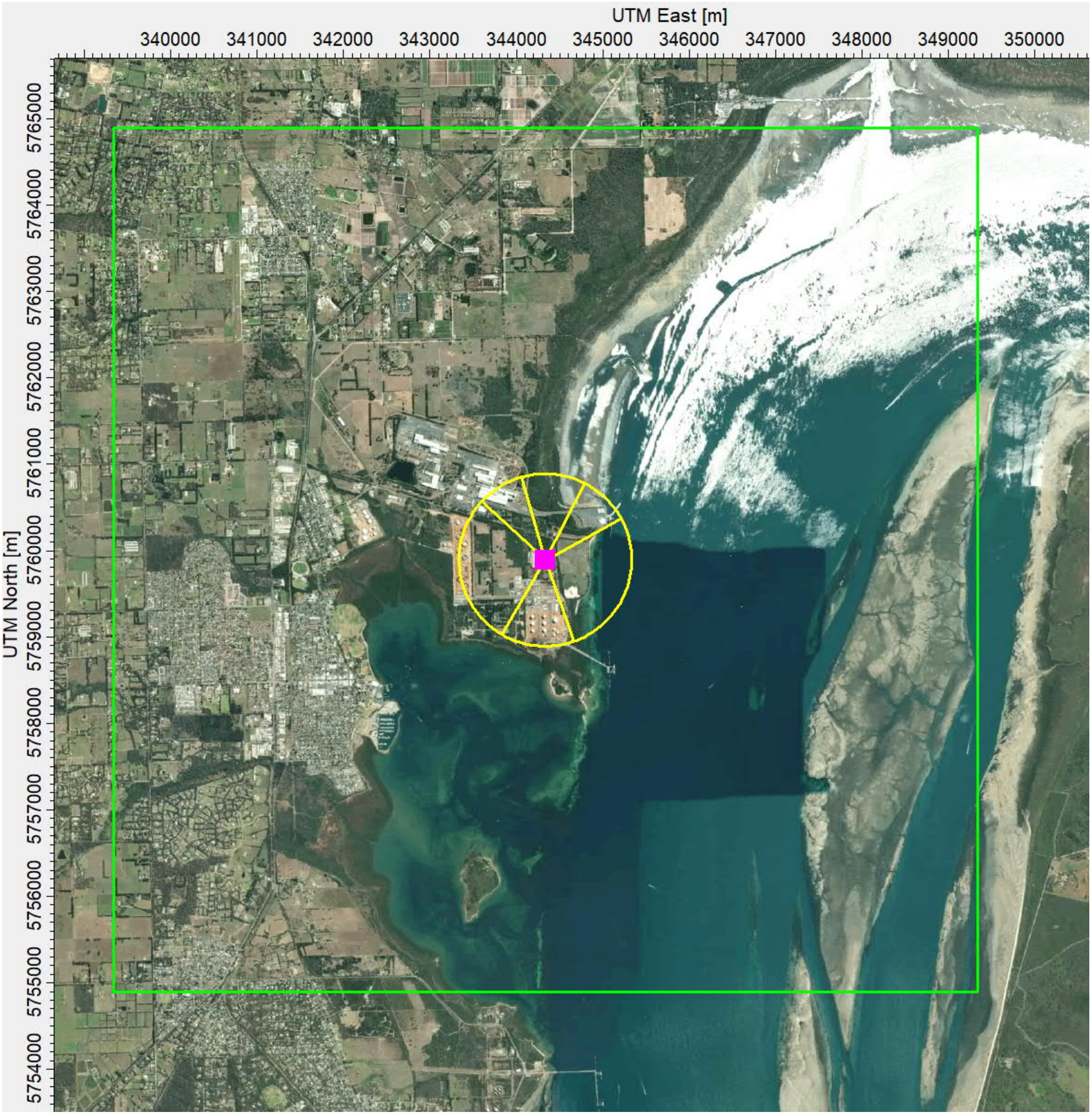


Figure 29 Areas for land use value calculations – albedo and Bowen ratio (pink square)

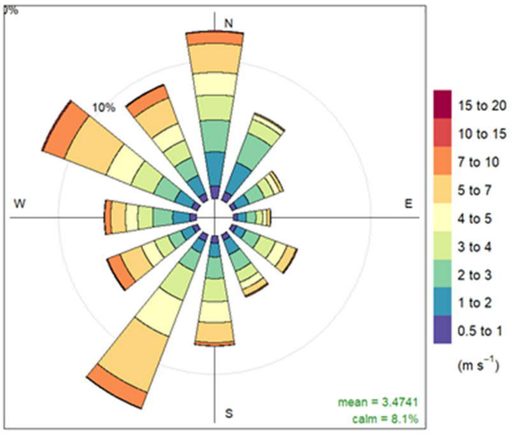
The determination of albedo and Bowen ratio values used in AERMET are presented in Table 30. The raw surface roughness values were taken from EPA Victoria's Publication 1550.

Table 30 Albedo and Bowen ratio values used in AERMET

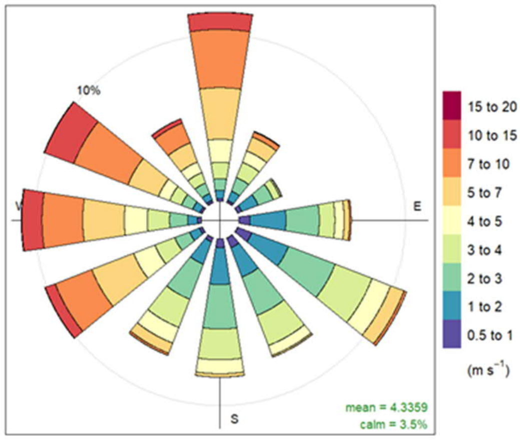
Land use Type	Fraction of Land Use	Albedo				Bowen Ratio			
		Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Open water	40%	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Forest	10%	0.14	0.14	0.14	0.14	0.3	0.9	0.9	0.7
Industrial/ commercial	10%	0.18	0.18	0.18	0.18	1.5	1.5	1.5	1.5
Grassland	25%	0.18	0.18	0.2	0.18	0.8	1	1	0.4
Low intensity residential	15%	0.16	0.16	0.18	0.16	0.8	1	1	0.8
Mean value for AERMET		**0.117**	**0.117**	**0.122**	**0.117**	**1.345**	**1.361**	**1.361**	**1.337**

AERMET-generated wind roses for the period 2016-2020 are presented in the following figures and are compared alongside equivalent wind roses for the three BoM stations.

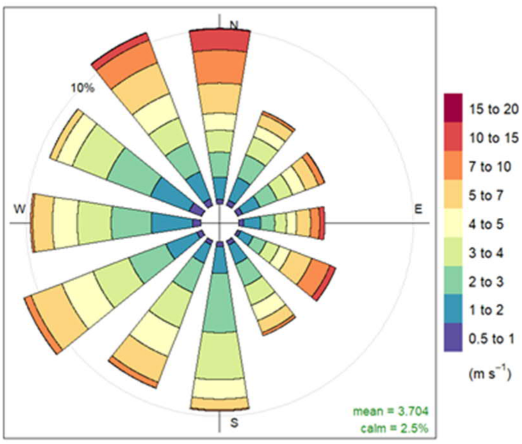
All-hour wind roses for the full five-year period for BoM and AERMET are presented in Figure 30. The AERMET winds show a good correlation with the BoM data, with winds mostly from the northwest, west and south. The BoM data show a slightly higher averages wind speed over this period with 3.5 m/s at Cerberus, 4.3 m/s at Frankston and 3.7 m/s at RHYLL compared with 3.2 m/s for the AERMET data. There frequency of calms (winds < 0.5 m/s) are similar in the BoM Cerberus data (8.1 %) compared with AERMET (6.3 %) with Frankston (2.5 %) and RHYLL (3.5 %) respectively. Differences between the four datasets are expected as the BoM stations vary in location from the site. Similarities between Cerberus and the AERMET data is expected as the BoM Cerberus station is located about 8 km southwest of where the CALMET data was extracted for AERMET.



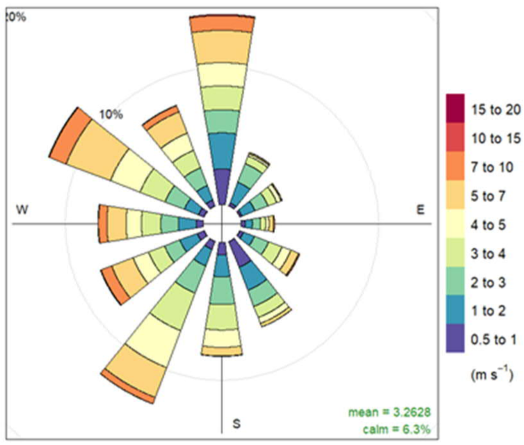
BoM Cerberus (2016-2020)



BoM Frankston (2016-2020)



BoM Rhyll (2016-2020)



AERMET (2016-2020)

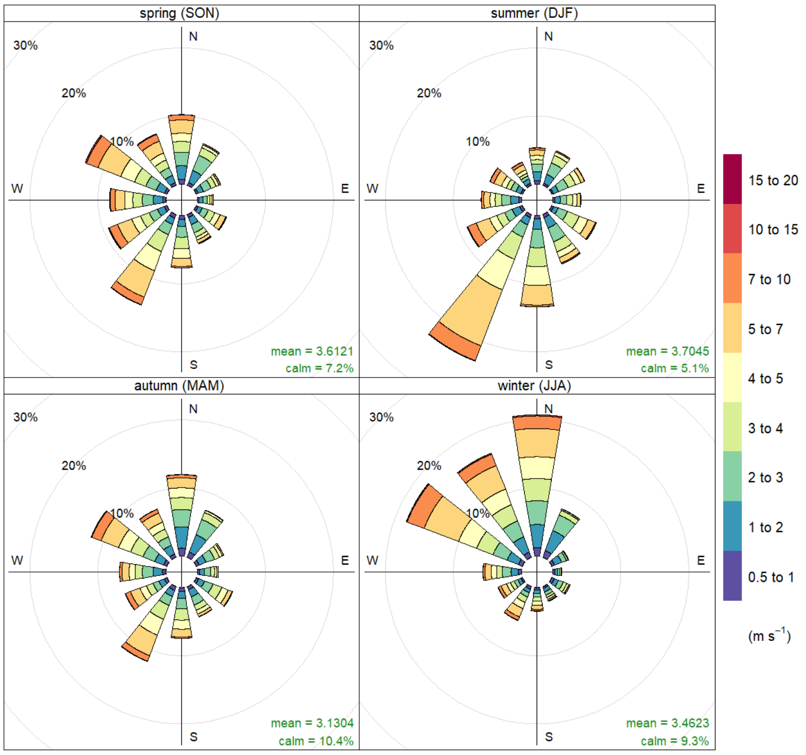
Figure 30 All-hours wind rose comparison – BoM Stations vs AERMET

Seasonal wind roses for the BoM Cerberus and AERMET data are compared in Figure 31. There is a good correlation between the observed BoM data and the predicted AERMET data, with winds tending northerly or north-westerly during winter and south westerly during summer. Wind speeds are slightly higher in the BOM data compared with AERMOD, and calms (winds less than 0.5 m/s) occur at a slightly higher frequency in the BoM data.

Annual wind roses for each BoM station and AERMET for the period 2016 to 2020 are presented in Figure 32. Overall, the wind roses show only minor variations in wind patterns over the five-year period, although there was a high frequency of calms in 2016 compared with the other years in the BoM data (and therefore also the AERMET predictions). The wind sensor at Cerberus has not been changed since 2011[2] and the data capture rate for wind speed in 2016 was over 95%, so it is likely that the higher calms in 2016 were due to actual variation in meteorology.

[2] http://www.bom.gov.au/clim_data/cdio/metadata/pdf/siteinfo/IDCJMD0040.086361.SiteInfo.pdf

BoM Cerberus (2016-2020)



AERMET (2016-2020)

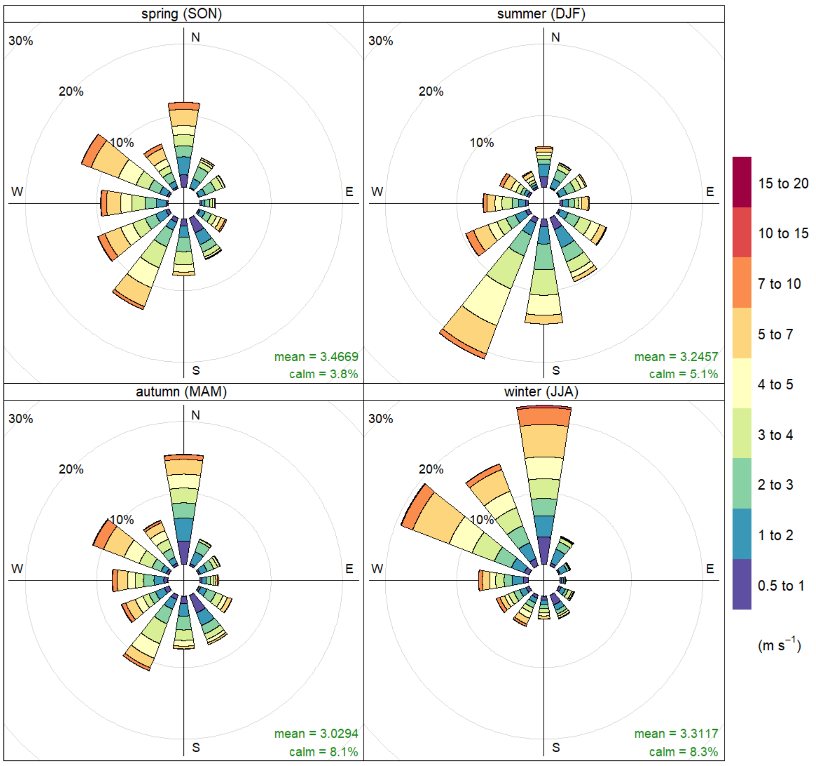


Figure 31 Seasonal wind roses comparison – BoM Cerberus (top) and AERMET (bottom)

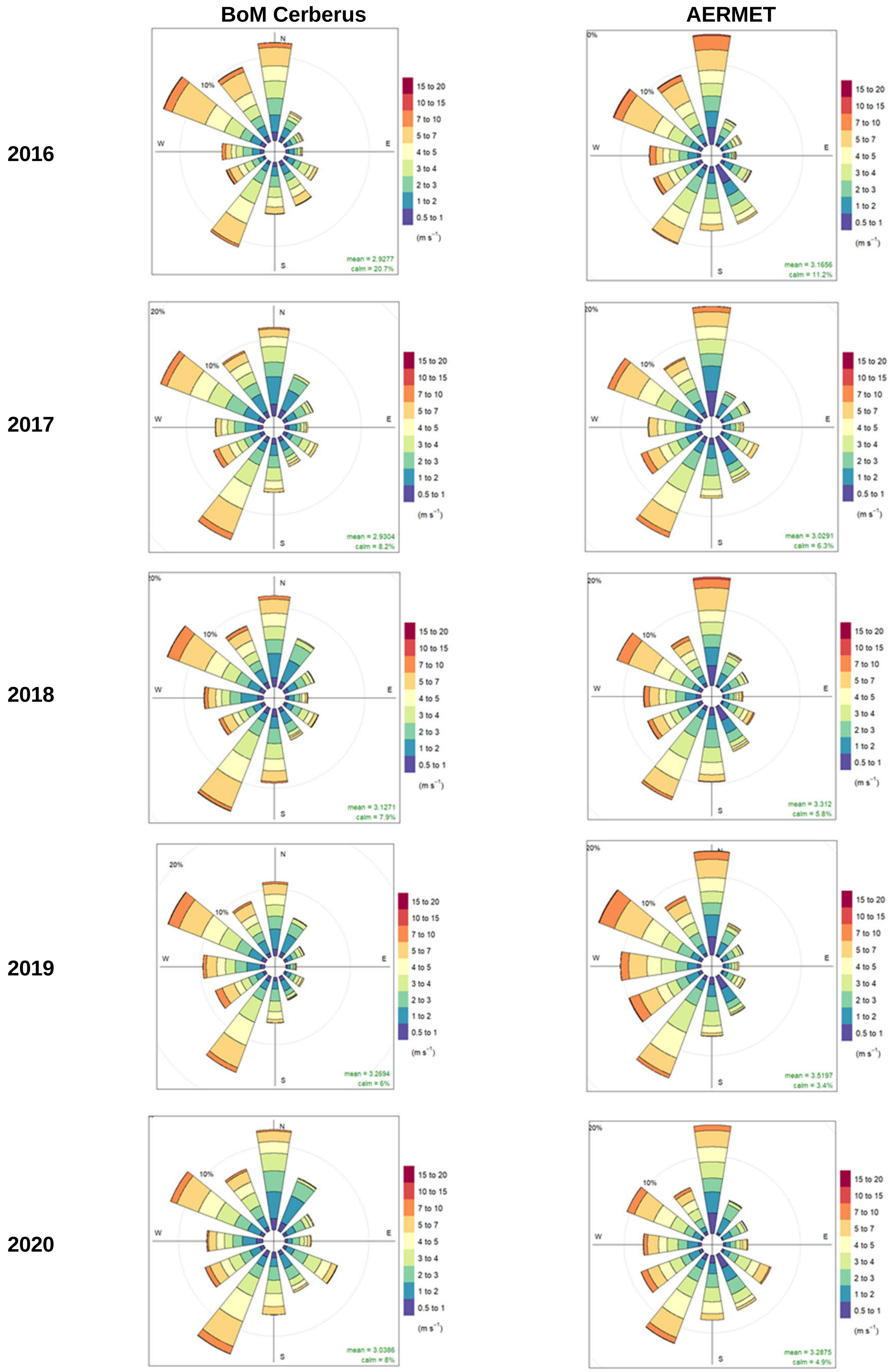


Figure 32 - Annual wind rose comparison, Bom Cerberus vs AERMET

Mixing heights predicted by AERMET are handled in two different sets of data, the convective mixing heights, which occur only during the daytime, and mechanical mixing heights, which may occur at any time. The convective daytime mixing heights are based on the mixing height data provided via CALMET. The mechanical mixing heights are calculated based on surface parameters such as roughness and albedo.

Convective and mechanical mixing heights in the AERMET surface file by hour of day are presented in Figure 33. The convective mixing heights for the daytime hours are very similar to those passed from CALMET (shown in Figure 27). The mechanical mixing heights calculated by AERMOD show a typical pattern with higher mixing heights during the daytime hours due to increased heat flux.

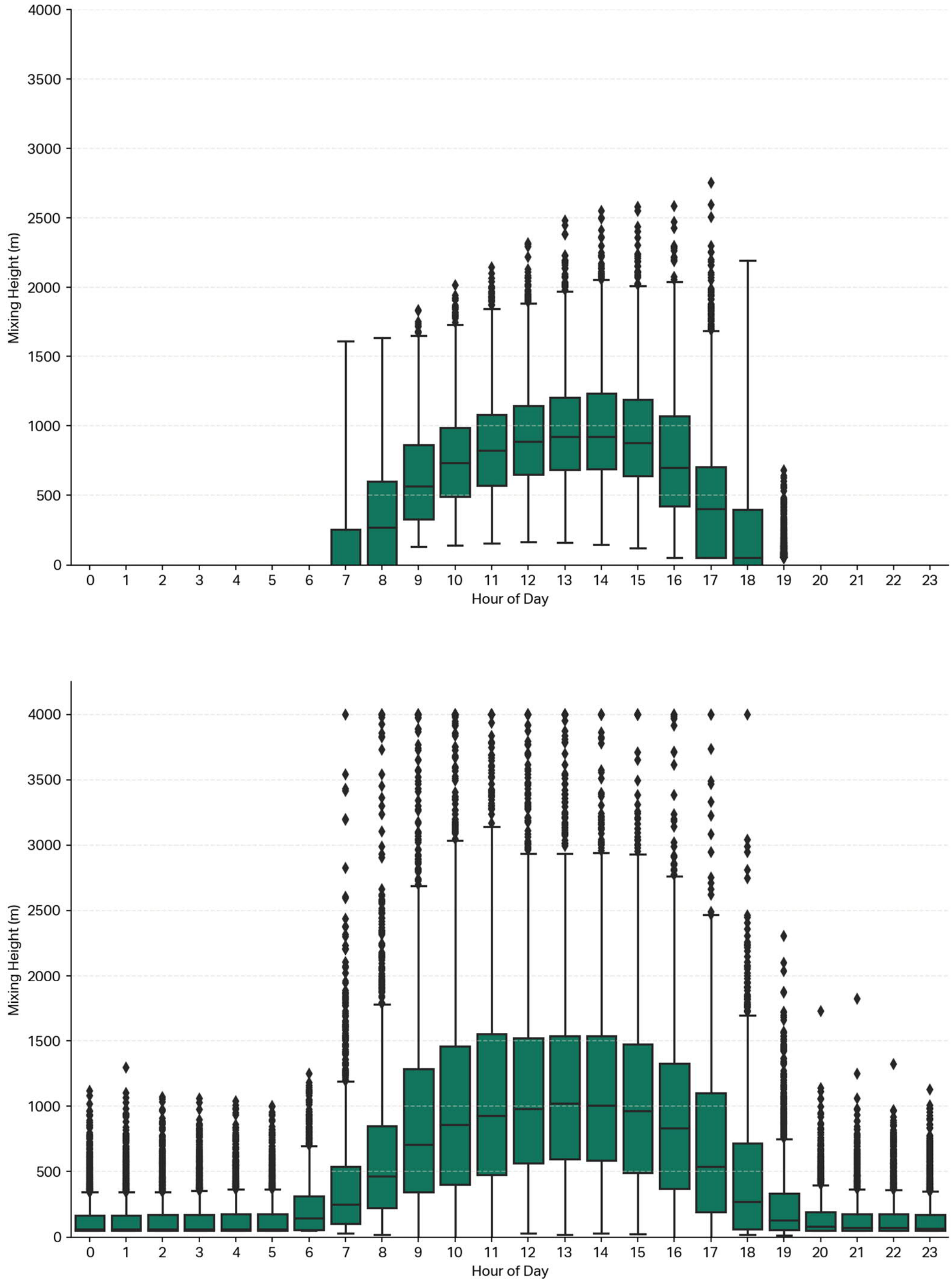


Figure 33 AERMET mixing heights – convective (top) and mechanical (bottom)

Conclusion

A five-year meteorological data set was produced for use in the AERMOD dispersion model. Overall, modelled wind patterns were shown to correlate with observed winds in the region. The modelled winds were in general slightly lighter than the observed winds at the nearby Cerberus BoM station. However, there is a 10 km distance between the Project site (modelled winds) and the BoM station and some differences are expected.

The use of five years' worth of meteorological data nullifies the need to justify the selection of a specific 12-month period of data. All possible local meteorological conditions are expected to occur at some time during the five years, including potential worst-case conditions where dispersion is poor and pollutant concentrations may remain elevated for a greater distance from the source. The generated data set is therefore considered appropriate for use in this assessment.

Appendix B

Exhaust Gas Emission Data

Appendix B Exhaust Gas Emission Data

Solar Turbines Emissions Estimates - Sales Gas Emissions

T130-19501S

Assumptions: Site fuel, 10m elevation, 101.6" inlet/outlet losses

100% Load									
Temp, C	NOx (g/kWhr)	CO (g/kWhr)	VOC (g/kWhr)	PM10/2.5 (g/kWhr)	SO2 (g/kWhr)	Exhaust Temp (C)	Exhaust Flow (Nm3/hr)	Exhaust Veloc (m/s)	O2%
5	0.45	0.28	0.16	0.05	0.0000	480	142500	41.6	14.56
15	0.46	0.27	0.16	0.05	0.0000	486	138909	40.8	14.53
25	0.46	0.28	0.16	0.05	0.0000	494	134503	40.0	14.44
35	0.48	0.29	0.17	0.05	0.0000	509	127928	38.8	14.21
40	0.49	0.30	0.17	0.06	0.0000	518	124463	38.1	14.02
45	0.50	0.30	0.17	0.06	0.0000	528	121051	37.6	13.79

FUEL GAS COMPOSITION (VOLUME PERCENT)
LHV (kcal/Nm3) = 14498.7 SG = 1.0596 W.I. @15C (Btu/Scf) = 1498.7
W.I. @15C (kcal/Nm3) = 14085.3
Gas Fuel Suitability (GFS)# 86416
Methane (CH4) = 1.1710
Ethane (C2H6) = 93.1985
Propane (C3H8) = 1.0120
Carbon Dioxide (CO2) = 4.6180
Hydrogen Sulfide (H2S) = 0.0005

Solar Turbines Emissions Estimates - Sour Gas Emissions

T130-19501S

Assumptions: Site fuel, 10m elevation, 101.6" inlet/outlet losses

100% Load									
Temp, C	NOx (g/kWhr)	CO (g/kWhr)	VOC (g/kWhr)	PM10/2.5 (g/kWhr)	SO2 (g/kWhr)	Exhaust Temp (C)	Exhaust Flow (Nm3/hr)	Exhaust Veloc (m/s)	O2%
5	0.45	0.28	0.16	0.05	0.0029	480	142500	41.6	14.56
15	0.46	0.27	0.16	0.05	0.0029	486	138909	40.8	14.53
25	0.46	0.28	0.16	0.05	0.0029	494	134503	40.0	14.44
35	0.48	0.29	0.17	0.05	0.0031	509	127928	38.8	14.21
40	0.49	0.30	0.17	0.06	0.0032	518	124463	38.1	14.02
45	0.50	0.30	0.17	0.06	0.0033	528	121051	37.6	13.79

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Gas Fuel Suitability (GFS)# 86416
Methane (CH4) = 1.1710
Ethane (C2H6) = 93.1985
Propane (C3H8) = 1.0120
Carbon Dioxide (CO2) = 4.6180
Hydrogen Sulfide (H2S) = 0.0005